RFID-Based Maintenance at Frankfurt Airport

The airport's operating company integrated RFID and a mobile application with its asset management systems. Benefits include better planning, control, and documentation of technicians' work as well as improved process quality.

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RFID has received a great deal of press in recent years, especially since the first business applications emerged and the world's largest retailers began to put the vision of smart items into practice. Although many companies have explored RFID technology's value for tracking materials throughout the supply chain, few have reported on how RFID supports their management and operation of assets and facilities.

Europe's second largest airport in Frankfurt, Germany, handled more than 50 million passengers and almost 500,000 aircraft arrivals and departures in 2004. The airport's operating company, Fraport AG, knows that the quality of its facility management processes is crucial in guaranteeing travelers trouble-free operations, maximum security, and convenience. Fraport decided to test RFID's benefits in this area and started a pilot project in 2003. This article summarizes not only the technology Fraport tested at Frankfurt Airport but also the process-flow and facility-management changes it adopted.

Mobile applications for maintenance processes

Managing the operations of large infrastructure facilities such as office buildings, industrial plants, and public utilities requires close monitoring of thousands of technical objects, which can be spread over large physical spaces.[1] When damage or failure is reported, the facility management crew must move fast and make the right decisions to rectify the problem. Reactive or emergency maintenance is a "firefighting" strategy; it's particularly troublesome because of its unexpected nature and the high cost of stalled production lines or infrastructure operations.[2,3] Loss control is the most critical issue in these cases. To reduce the probability of breakdowns, companies pay attention to planned or preventive maintenance.[4] In critical areas, where failures pose a significant threat to life and limb, safety and security regulations specify maintenance intervals. An internal facility management crew, supported by external contractors or members of the original equipment manufacturer's service organization, usually performs the maintenance activities.

Industrial facilities are complex systems. The success and efficiency of maintaining them depends on

- precise and timely information on the objects to be maintained,
- real-time transfer of information on critical incidents, and
- fast access to the knowledge and means necessary to overcome these problems.

Because RFID facilitates the identification, localization, and monitoring of physical objects, it goes beyond alternative technologies such as

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bar-code scanning that have been in use for years. Facility managers are particularly interested in applying it to problems such as easy identification, decentralized data storage, fraud prevention, structured documentation, and paperless information management.

Easy identification

In many cases, technical equipment doesn't carry unique identification, either directly on the object or in the respective asset management system. If the object is equipped with a carved or printed serial number or a bar code label, the ID code is often relatively inaccessible because of line-of-sight problems—for example, if the object is integrated in a wall or installed on the ceiling. Furthermore, traditional ID techniques aren't always robust when used in industrial environments—for instance, because of heat, abrasion, or chemicals.

Decentralized data storage

Keeping historical data on physical objects (previous maintenance, including when spare parts were exchanged) is necessary to perform maintenance and repair tasks appropriately. Because network connectivity is often unavailable, for instance in the field or in metallic environments, decentralized storage of this data can give technicians at least some basic information on the facility beyond its ID number.

Fraud prevention

The reliability of maintenance activities is a key issue in business-critical environments. Contractors who are doing inspections face increasing cost pressures, so fraud can arise. Even if bar-code scans are required to prove that contractors complete their work accurately and on time, reliable control is hardly feasible because bar codes can easily be copied and scanned at different times and places. The same holds even more so for checklist marks that might not be regarded as proof. In the context of technical-facility management, this kind of fraud results not only in financial losses but also in security problems and questions of liability in the event of machine failures.

Structured documentation

High-quality documentation of maintenance activity is necessary for both facility managers and the maintenance crew. Systems that only require technicians to write a few sentences of free text when tasks have been completed usually lead to responses such as "Machine X is back on line; problems have been fixed." Such information won't help prevent future failures. It's much better to rely on structured ontologies and problem codes, using text only for exceptions that these structures don't cover. Furthermore, structured responses are the foundation for automated reporting on problem class, time consumption, necessary knowledge and tools, and so on.

Paperless information management

Traditional service management generates tremendous amounts of paper that in many areas must be archived for years to allow for traceability or to comply with safety regulations. Digital management of all this data can eventually reduce administrative costs significantly. Moreover, improved accessibility to information can lead to further analysis and optimization, as well as additional services and products that make use of these results.

Facility management at Frankfurt Airport

Larger commercial airports such as Frankfurt Airport resemble small cities or municipalities: they provide the necessary facilities and infrastructure for the airlines and tenants to function correctly as well as comprehensive services and amenities for travelers, including shopping, entertainment, and conference facilities. Frankfurt Airport covers an operational area of 19 square kilometers, with more than 420 buildings housing 7,000 technical systems and infrastructure installations. In addition, there are more than 150 km of roads, 650 hectares of apron surface including the runways, and more than 65 km of baggage conveyor routes and the elevated, automated passenger transport system.

Fraport has 12,000 employees. Its real-estate and facility management division provides comprehensive commercial, technical, and infrastructure services and handles the maintenance of all vehicle and special airport equipment. This requires close collaboration with around 460 companies, among them airlines, retailers, and service providers. In its capacity as airport operator, Fraport is required to regularly inspect the airport's primary technical components, service or repair them, and provide records to prove it. The continual optimization of technical systems supporting quality, security, and safety measures is a top priority, particularly as Fraport expands its already extensive infrastructure at the airport to meet future demands.

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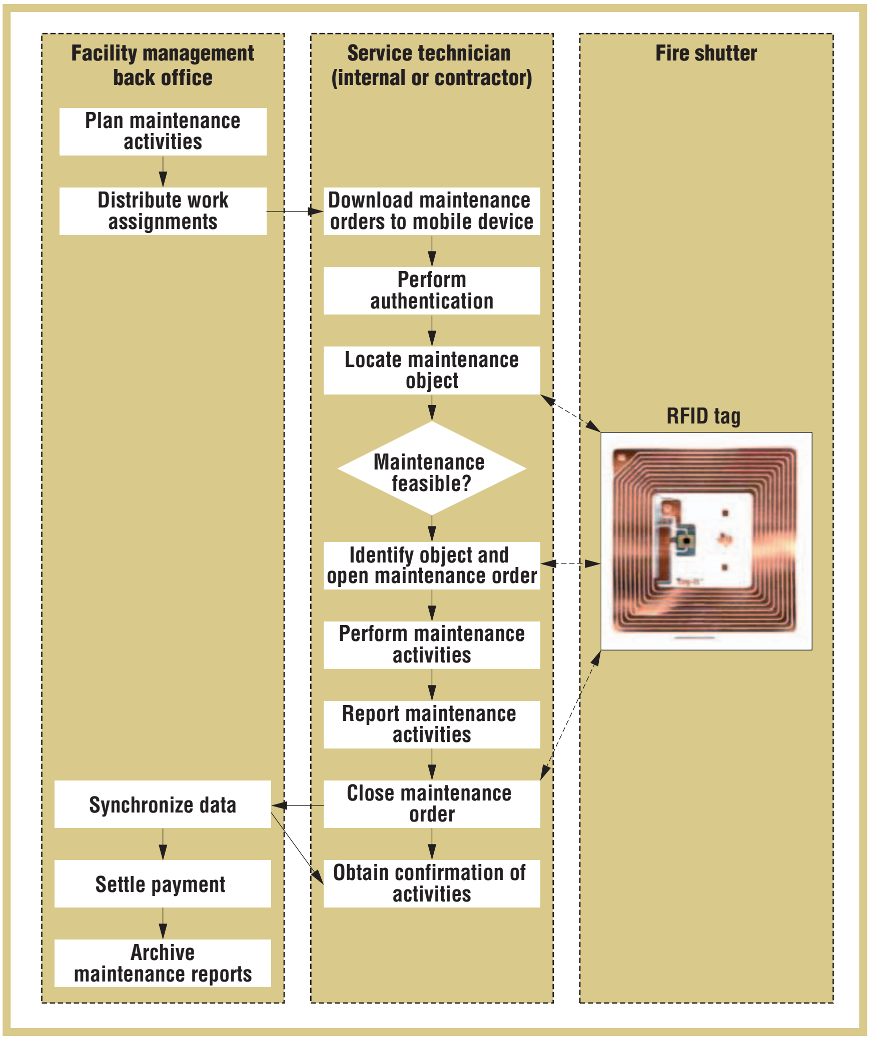

Figure 1. Fraport's new maintenance process.

Maintenance processes

To protect against fire, the airport's air-conditioning and ventilation system has 22,000 fire shutters and numerous fire doors and smoke detectors. The fire shutters close automatically in the case of fire, preventing flames and poisonous gases from spreading to neighboring areas. As fire protection is of high safety relevance, German law requires each fire shutter to be inspected at least annually. If any trouble arises, the maintenance interval is reduced to six months for the following two years. Since the tragic fire at Düsseldorf Airport in 1996, German legislation has imposed additional requirements on maintenance documentation. To prove compliance with German law, airport operators must archive maintenance documentation for 10 years.

In the past, the service technicians received their daily work assignment on paper—a list of fire shutters to be inspected and the respective maintenance orders. First, they had to find and access each fire shutter, which might be difficult to get at, perhaps a couple meters above the ground. After the inspection, the technicians handwrote lengthy maintenance reports as proof that they'd actually done the inspection. In the evening, they handed in completed maintenance reports to the office clerks, who in turn entered the report into the back-end system and forwarded it for archiving. In the case of defects, an overhaul had to be planned.

This paper-based process proved to be error prone, and manual data entry was time-consuming. With the paper-based archive, obtaining detailed information on actual maintenance history was a tedious process, since the information system captured only the core information. Because maintenance reports were often poorly structured or information was missing, many additional inquiries arose. Fraport hires contractors to perform most inspections and pays them on the basis of the number of fire shutters they inspect. In the past, Fraport had to double-check about 10 percent of all incidents to verify the quality of the contractors' service.

In early 2003, Fraport implemented a new maintenance process, replacing the paper-based process with mobile and RFID technology (see figure 1). Service technicians now use mobile devices to access daily maintenance plans and carry out work orders. The company equipped all fire shutters with RFID tags that store maintenance-related information, such as the last inspection date. Each morning, the service technicians download their assignments to their mobile devices. When performing a maintenance activity, they authenticate themselves by scanning their user information from a badge equipped with an RFID tag. The system must identify each technician to verify that the maintenance activity actually occurred. Using the mobile device's RFID reader, the technician can also identify and access the RFID tag on every fire shutter. Following legitimization and login, a controlled step-by-step dialog begins. This ensures that maintenance takes place in accordance with a series of precisely defined process steps. Defects must be registered using comprehensive damage codes. Once the maintenance activity is completed, the technician scans the RFID tag a second time, and the activity's date, start time, and duration are also stored on it. After this, nothing can be changed, thus protecting the maintenance record from unauthorized manipulation.

Fraport's transponders provide 2 Kbytes of read/write memory—more than enough to hold all maintenance-related information, which currently amounts to just 72 bits. The tag stores static data such as its transponder ID, an equipment ID from the SAP back end, and the object's technical ID code. It also stores dynamic information, such as the date and time of the last maintenance. Although ISO-compatible transponders that support various security mechanisms are available on the market, Fraport chose not to use them. It considered unauthorized manipulation of tag data a negligible threat, because only the technicians who are assigned to a task can access the object tags, and the RFID-equipped tags are usually inaccessible to the public. Moreover, only the people who are logged into the back-end system can load task lists onto the mobile devices.

The service technician documents each maintenance procedure and the equipment's condition seamlessly on site via the mobile device. At the end of the shift, the technician transfers all data into the central back-end system via a docking station connected to the LAN, and the external contractor receives an electronic activity confirmation (as a PDF file). The result is exact documentation of when and by whom a certain fire shutter was inspected and the kind of malfunction observed.

Technology selection and architecture

The system architecture supporting Fraport's new maintenance process for fire shutters consists of RFID tags on the fire shutters, mobile devices equipped with an RFID reader and a mobile application, and middleware connecting a back-end asset management system.

The metallic environment in some parts of the airport and the metal components in most technical equipment rule out using the standard RFID hardware that is used in typical retail logistics scenarios. First, Fraport had to design its RFID transponders so that it could access them on metallic surfaces. Second, the harsh industrial environment makes increased chemical and physical robustness necessary.

Figure 2. Custom transponder for tagging metallic equipment.

Figure 3. The mobile device for service technicians.

Fraport decided to use custom transponders that operate in the high-frequency band based on the ISO 15693 standard (see figure 2). To increase the tag's life span, the company uses a soft polyurethane resin to cover the standard label. Furthermore, a ferrite layer on the back of the label separates it from the metal surface. To ensure that the entire system doesn't depend only on RFID, a bar code is printed on the label as redundant ID information in case of system failures.

The information that is stored in the tag's memory includes a unique ID number from Fraport's asset management system. The tags also had to have some read/write memory for local data storage of the last maintenance activity. The mobile readers' maximum range for reading the RFID tags and bar codes is only 3 cm, thus guaranteeing that the technician passes by each fire shutter.

Because the typical technicians aren't IT-proficient and because their working conditions are unusual (for example, one-handed scanning on a ladder 7 meters high), the mobile devices had to be easy to use and robust. In addition, a minimum period of operation corresponding to a service technician's typical shift had to be guaranteed. Last but not least, weight and size were also important selection criteria. Fraport eventually selected a custom-made, handheld PC developed for industrial use and maximum robustness. The device includes both an RFID reader and a bar-code-scanning module as well as a VGA display (see figure 3).

The Mobile Asset Management (MAM) application contains a client and a server module. The server is implemented on top of SAP's Web Application Server and has access to the back-end system via Remote Function Calls, SAP's proprietary interface to the system's business objects. The server mediates between the mobile client and the SAP back end (see figure 4).

At the beginning of each workday, users replicate their task lists and any other necessary information onto their mobile devices. The MAM server retrieves all this information from the SAP-based asset management system and sends it to its clients. The data that each user collects is first buffered by the mobile client and later replicated back to the back-end system when the user connects the mobile device to the LAN. Throughout this process, these mechanisms remain completely hidden from the user—that is, the MAM client interface's look and feel are exactly the same as if the user had an uninterrupted connection to the system.

Fraport's experiences

Using this system of RFID-based identification of fire shutters, Fraport achieved

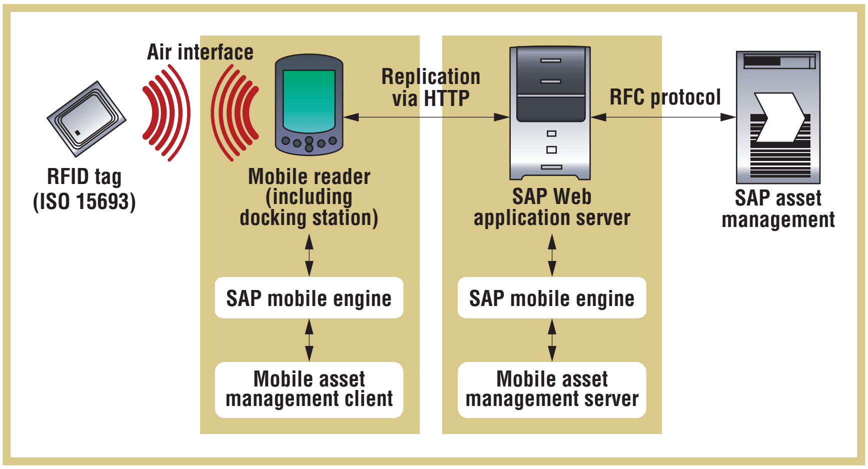

Figure 4. System architecture.

several improvements. First, in terms of efficiency, by accessing existing maintenance data and identifying objects using the mobile device, the technician avoids manual data entry, which speeds up inspection. Recording the reported data on the mobile device and synchronizing data daily with the enterprise resource planning (ERP) system significantly reduced the time needed for the process, from several days to just one day. The electronic assignment of maintenance orders to service technicians sped up the assignment process. Fraport reduced maintenance times by eliminating the time-consuming distribution of paper, instead electronically recording the data on site and then synchronizing with the ERP system.

Second, process quality improved. In the past, recording handwritten notes of identified faults often led to queries for the technicians, both from the back-office workers who had to record the data in the ERP system and from the service personnel in charge of eliminating observed dysfunctions. Making the catalog of faults stored in the system available to the technicians via the mobile device has eliminated these queries. Introducing the mobile solution has thus led to an optimized redistribution of tasks between service technicians and the head office.

Finally, the major benefit for Fraport is the consistent and comprehensive documentation of all maintenance work. This reduces the costs and potential risks that incorrectly performed maintenance poses. This also means that Fraport employees no longer have to do additional inspections of external contractors' work.

Fraport analyzed and quantified the benefits it achieved using a set of performance indicators, including speed, material costs, fault rate, number of checks, and so on. In the past, the inspection of 22,000 fire shutters, for instance, resulted in 88,000 pages of paper documentation that had to be archived for several years. The RFID-based mobile solution eliminated this cost completely. Fraport has also recognized various intangible benefits such as improved staff motivation and a positive impact on its corporate image.

Like other RFID pioneers, Fraport found that it had to solve several key issues to ensure reliable use of RFID technology in a productive business environment. This applies to the specific requirements regarding tags as well as to the company's mobile devices and connecting middleware. The fact that RFID readers are compatible only with tags from specific manufacturers demonstrates the need for globally accepted standards. Fraport sees RFID technology as a major driver for enhancing business processes in facility management, which means that the related business software must cover functionality for RFID-based maintenance scenarios. This—as well as the need for a large partner that can influence standardization—was a major argument in favor of Fraport's collaboration with SAP.

In terms of implementation and rollout strategy, Fraport used a stepwise approach starting with a pilot project. First, it had to prove the feasibility of RFID-based maintenance of fire shutters. The company is now extending this solution to other applications; potential uses include maintenance activities that are also subject to statutory documentation requirements such as fire doors, conveyor flaps, smoke detectors, and air-conditioning and ventilation filter systems. A host of mobile equipment such as passenger stairways, towing vehicles, and trailers must also be maintained. Pinpointing their locations has sometimes been hard, so RFID could be helpful in this regard, too.

RFID technology offers value simply by reducing search times. Technicians can verify the exact identity of the object in front of them much more easily and faster than ever before. RFID technology also eases the consistent recording of maintenance and repair history at the level of every single maintenance object, which is the basis for proving compliance with compulsory maintenance schedules and safety regulations. By reducing manual documentation and errors, workforce productivity goes up. Third, these object histories help provide a better understanding of the reasons for errors and are therefore extremely useful for quality management. Last but not least, the data gathered by this means could be used in predictive-maintenance applications that try to extrapolate future problems and failures before they occur.

Fraport's example illustrates the potential of RFID and mobile-computing technologies for improving the maintenance and repair of many different kinds of facilities. Although the technology is mostly regarded as a tool for improving process efficiency, this case study demonstrates how RFID enables significant improvements in process quality, which in turn increases security for travelers and airport personnel.

From a long-term perspective, RFID and complementary sensor technologies might eventually have even bigger effects on the nature of maintenance services: the more information becomes available on facilities in almost real time, the better and faster a service provider can react—maybe even before a problem occurs. Against this background, technologies could contribute to entirely new business models that are oriented toward availability. In the future, for example, service providers could get paid for guaranteeing a certain level of machine availability rather than for repairing machines.

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