**Malik Sabbah**

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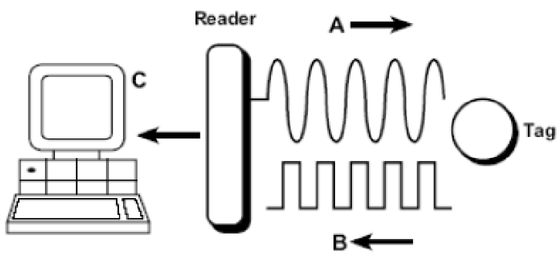
# RFID Integration in BIM and Material Handling

## Radio frequency identification technology:

RFID technology is employed to track objects. The system consists of an RFID tag that is attached to the object being tracked and RFID reader that identifies the tag when it is available within the range. An RFID tag transmits a signal through radio waves that in turn are received by an RFID reader, it is forecasted that this technology will replace the use of bar code for tracking purposes.

Depending on the application two types of RFID can be used:

Passive tags:

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Passive Tags

– No internal power supply

– Read only

– Unlimited life

– Smaller and lighter

– Cheaper

– Less data storage capabilities

– Limited read range

Active tags:

– Internal power supply

– Read/write functionality

– Limited life

– Larger and heavier

– Longer reading range

– More expensive

– Increased data storage capabilities

Electronic reading devices are used to communicate with tagged objects and acquire data regarding these items. The readers also contain an antenna for transmitting signals to desired tags. The distance that a reader can read a tag will vary from one system to another (depending mostly on the reader).

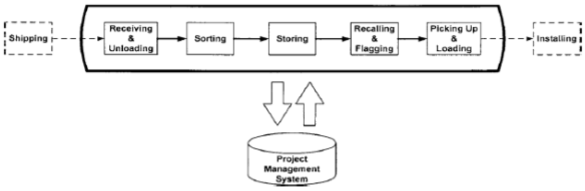
The frequency level at which an FRID system operates is also key contributor to a system's reading range, as well as increase the speed at which data is transmitted from the tag to the reader and the host computer. The radio frequency section of the electrographic spectrum spans from 3Hz to 300GHz.

| Generic band Name | Frequency Range | Comment |
|---|---|---|
| Low frequency | 120-135 KHz | Short range inductive application |
| High frequency | 13.56 MHz | Smart cards and labels |
| Ultra high frequency | 433 MHz | Active low power tags |
| | 860-960 MHz | Bandwidth major supply chain development |
| Microwave | 2450 MHz | Active tag technology gives longer range and fast data rates |

## Material management process without RFID

The materials management process for the project is comprised of a series of a activities or processes that ultimately lead to the installation of a component into the facility. Regardless of the method of shipment, every shipped component comes with its own specific material ID code. These codes are written on the surface of each component and are comprised of a series of numbers and letters. The entire receipt process and the entry of items into the materials management database was performed with a paper based manual method. The materials are accounted for and manually entered into the materials management data base system, so that construction activities could be coordinated depending on the availability of materials.

Afterwards components are taken to lay-down yards and placed within a specific grid. Components are sorted according to their characteristics and material identification code. With the help of color coding, components will be identified and located. When a construction crew is prepared to construct a certain section of the facility, the necessary materials have to be retrieved from the lay-down yards. For this, a superintendent coordinates with a field engineer and communicates the plans for assembling a certain area of the facility. The field engineer would generate withdrawal request (MWR), which list all of the necessary materials that the superintendent's crew needs in order to complete the specified scope of work. The MWR is sent to the materials management staff, when they develop a "pick ticket". The pick ticket lists the materials needed, along with the respective lay-down yard and grid location of the component. The materials management team then gives the pick ticket to the respective staff so they can locate the materials. Workers would take the pick ticket to the lay-down yards and visually locate the materials that were needed for installation. Once located, the components were flagged, organized and staged so the pick-up process would be more efficient. The materials would be loaded and transported to construction area where they will be handed to the construction team and the receiving foremen will sign off on the materials to assure that they have received them.

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Process Flow Chart

The issues presented for materials management revolve around the ability of personnel to locate and flag specific material, so they may be organized for convenient pickup and transport. When materials required for installation are not ready at the time they are needed, installation crew may become idle and nonproductive which can increase craft labor hours up to 16-18%.

## Bechtel's case study

Bechtel's $2.15 billion power plant expansion project requires a large sheer volume of materials on the construction site. The materials are an incredible amount of intricate components of steel, piping and other structural and functional components. Individual piping pieces can become very difficult to identify when they are closely stacked together. In addition, there is a limited number of colors that flagging comes in, it can be challenging for the picking crew to decide which materials are for their specific load if there are multiple loads marked with the same color flagging.

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RFID in Spool Storing Yard

The arrangement of the material yards is also a factor which can contribute to decreased efficiency in the flagging process, as well as the rest of the material management process. Another factor affecting the material management process was the weather conditions. The flagging process was made much more difficult since the materials would get covered in snow and the material ID codes must be uncovered with shovels or by hand.

Due to the problems associated with the manual tracking system, the decision was made by management to implement a full scale DFID/GPS based system for the entire on-site materials management process. This was the company's first full scale application of the technology.

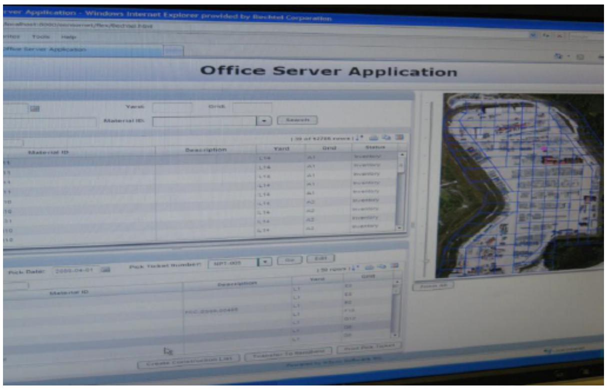
Bechtel hosed a number of RFID pilot tests. Bechtel's field test was performed over approximately three months on a twin-boiler project in Rockdale, Texas. Chief sponsors of the pilot were the Construction Industry Institute (CII) and FIATECH, and the research team was comprised of about two dozen individuals representing universities, construction firms, institutes, and technology vendors. The field tests compared the times of the typical paper based manual method of locating steel items, to the RFID/GPS based automated method for tracking down components in the lay down yards. The trial results found that the average time taken to locate a specific component with the manual process was 36.8 minutes. The average time taken to locate materials with the automated method was 4.6 minutes. Also, when using the manual method, 9.52% of material components "were not immediately found," compared to the 0.54% of the automated method. The research team regarded the success rate of the automated system to be quite significant considering the fact that the failure to locate critical items can lead to costly slowdowns, and sometimes even re-procurement

The tags utilized in this full scale implementation were active RFID tags. These active tags continually "wake up" and send out their ID information at pre-configured intervals (i.e. every 1 second, every 2 seconds, every 10 seconds, etc.). The active tags are Ultra High Frequency (UHF), and they operate on a 915MHz frequency level. The lifespan of the tags is generally five years. The physical dimensions of the tags measure about 5 x 1 x .85 inches and weigh about 50 grams. Tags with these characteristics and reading ranges cost approximately $25(US) each.

The reading units utilized in this application were a combination of RFID reader and Global Positioning System (GPS) receiver. The readers were mobile, handheld computers, or personal digital assistants (PDA), suitable for field readings. The readers' operate with Microsoft Windows. Approximately six handheld readers were utilized on the entire project; usually a team (i.e. iron-workers) would have its own reader which was designated for them each day. RFID/GPS readers such as those utilized in this study currently cost approximately $5,000(US).

The automated materials management process also used barcode scanners for association purposes. The scanners were mobile, handheld devices that utilize Bluetooth technology. The scanners operate on High Frequency (HF) radio waves at a 13.56 MHz frequency level. The scanners are rechargeable. The physical dimension of the barcode scanner is about 4.8 x 2 x 1.3 inches and weighs 132 grams. These barcode scanners currently cost around $450-$500(US).

Server software is also required for the system and it can cost approximately $35,000 – $50,000(US) depending on the software and the vendor.

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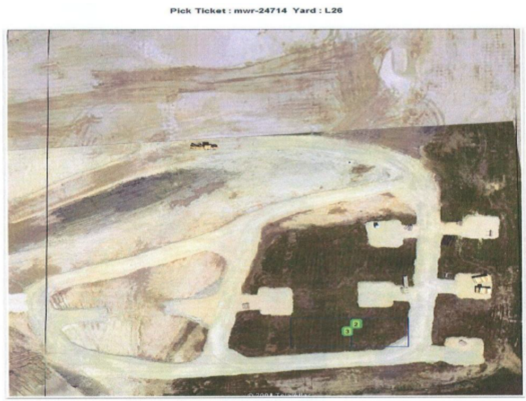
Server SW

With the RFID/GPS system in place, the goal is to make the material locating (flagging) process much easier and faster. With the automated system in place, after the Engineer has developed a material withdrawal request (MWR), the materials management office staff generates a pick ticket packet which included a list of the required materials and each item's specific yard and grid, as well as a supplemental image, which would give the workers the approximate location of each component within their respective grid, assigned by the GPS/RFID localization methods. The workers go to the correct lay down yard and grid, and go approximately to where the printed map had indicated the material's location to be within that grid.

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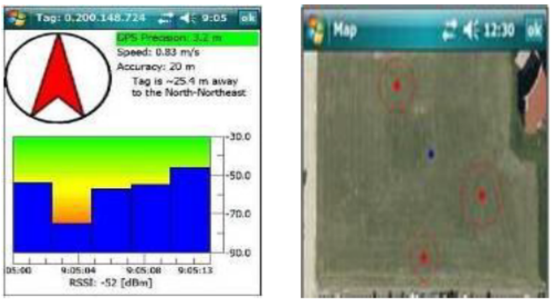
SW Showing Location of Spools

Once in the area, the workers utilize the RFID/GPS reader to narrow in and find the component. The reader could pull up two different modes for finding the items. The map view utilizes the GPS portion of the reader. The digital map of the yard can be displayed on the handheld screen and the GPS receiver will show where the employee is standing, and the projected location of the material. The employee's positioning on the screen is represented by a blue dot, and the material component is represented by a red dot. Another method was to set the reader into what was referred to as the Geiger counter mode. A Geiger counter is an instrument that can detect and measure radioactivity. The Geiger counter mode of the reader allows the worker to communicate only with the specific tag that is desired. The Geiger counter can be utilized within 150ft proximity from the tagged components. As the worker moves with the reader, the GPS receiver determines and gathers information on the location of the reader. The RFID portion communicates with the desired tag, and the reader utilizes localization methods based on the positions of the reader (gathered by GPS), and the received strength of signal from the desired tag at those positions (gathered by RFID). A compass pointed the employee in the direction of the tag with which the reader was communicating. The reader also emits audible "beeps" that becomes more rapid and in closer intervals as the reader gets closer to the tag, and the signal strength increases. When the reader is within a couple of meters from the tag, the compass would change to a cross-hair and display the words "WITHIN RANGE".

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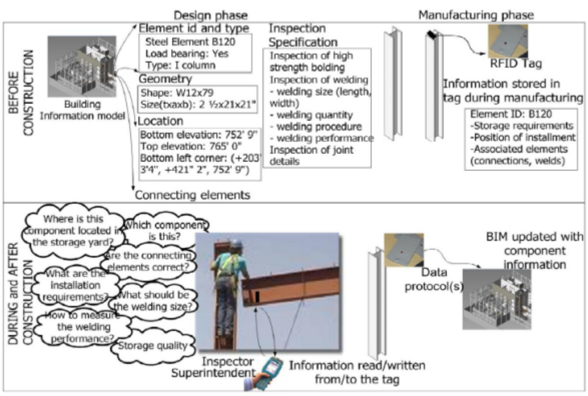
Mobile Device Screen

Once the reader is held next to the correct tag/material, the blue column bars fill the graphing area displayed on the screen. The worker then examines the material and the material ID, which is written on the exterior of the component, to assure that the material ID on the item matched the material ID listed in the pick ticket. As before, once the materials had been located, they could be organized, prepared for loading and transported to the construction area. The construction crew would sign off on the materials to assure that they had been received for installation. After materials were delivered, the tags would be removed from the material and placed in a bucket. The tags could then be recycled back to the material management office, where they would be disassociated from the material to which they were originally attached, and stored for possible reuse.

It is obvious that RFID, when integrated with BIM, provides opportunities to facilitate up to date information flow for components. Specific component information is generated and stored in BIM during design and manufacturing phases. Component related information items that are needed in subsequent phases, such as inspection details, connecting assemblies and components are stored locally on individual on-board memories (RFID tags) and these information items are made readily available for access at manufacturing and construction sites by the workers, inspectors and low-level management. Having this information stored on RFID tags will facilitate ease of access to-date digitally at operation level at job sites. Hence, it will enable utilization of rich data generated in BIM at operation level rather than exchanging information in documents. During construction, the as built information and historical information associated with each component is stored in the on-board memory. Since the tag is installed physically on the component, it is convenient to enter the related information directly to the tag as the worker/inspector is handling/checking the component by its side instead of entering this information to a report. Information can be stored on the component tags by different parties and then be transferred to BIM at any point in time to give an updated report of components historical information in an integrated environment for facilities management and higher-management.

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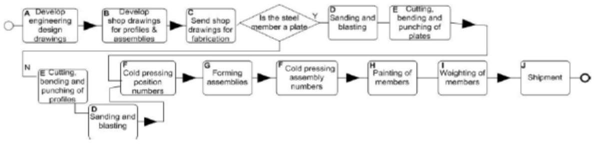
RFID in BIM and QA/QC

The first step to implement this vision is to identify which information items are needed in each subsequent phase during and after the design and manufacturing phases. For demonstration purposes structural steel has been taken as an example only.

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The above figure shows the process model for design and fabrication of steel profiles, plates and assemblies with each subtask given an identification letter. Within the current practice, first structural design and analyses steps are performed to determine structural member dimensions, cross sections and types. When the design is ready, shop drawings are prepared for the fabrication phase for each plate, profile and assembly. These shop drawings are sent to the factory and fed into cutting and shaping machines, and welded together to form assemblies. During these processes, the required component information is exchanged over documents. The figure also shows the points where information flows in the process model (bold arrow), these generated information are modified/used in the following task.

| Component type | Information items | Task in which the info is generated | Task in which the info is used | Is stored in BIM? |
|---|---|---|---|---|
| Plates /Profiles | Position number | A | E,F,G | Yes |
| | Dimensions (radius, length, width, thickness) | A | E | Yes |
| | Type (Profiles like L, C, U, Plate) | A | D | Yes |
| | # of copies of the same plate | A | E,F,G | CBC* |
| | Type and grade of material used | B | D,E | Yes |
| | Area of plate | A/B | G | CBC |
| | Weight of plate | A/B | G, J | Yes |
| | Assembly # where each plate belongs to | A/B | G | Yes |
| | Shape | A | E | Yes |
| | Offsets to the edges for cuts and bending points | A/B | E | Yes |
| | # of holes, dimension and location of holes | A/B | E | CBC/Yes |
| | Which machine to use for cutting?Cutting type | B | E | No |
| | Bending requirement for the element | B | E | Yes |
| Assembly/Assemblies | Assembly number | A/B | G | Yes |
| | Location (x,y,z) of each connecting positions | A/B | G | Yes |
| | Welding thickness, Bolt dimensions | B | G | Yes |
| | Total weight, Total area | B | G,J | CBC |

(https://maliksabbah.files.wordpress.com/2013/03/13.png)

The above table shows that design and fabrication information generated in tasks A and B are used mainly in subsequent tasks of cutting, bending, punching and forming assemblies. Not all information items generated are used in one task or in all tasks. Majority of design information is stored in BIM and BIM can be used as a platform to query and transfer required information to RFID tags. Given these, as the component goes through these tasks, required information can be stored on RFID tags, if changes occur, and these changes can be updated in tags.

Once information items flowing through the process model is identified, the next step is storing these information items in RFID tags, updating these information items as the component flows through its life-cycle and transferring the information stored in tags to BIM on a regular basis to have as-is and updated component information.

# References

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