RISING

indooR localizatIon and building maintenance uSing radio frequency Identification and inertial NaviGationion

Definition of the scenario and identification of the information

RISING_D1_V4.0

09/11/2015 Version 4.0

Authors: Nicolás Serrano, Josune Hernantes

Revised by: Roberto Setola, Francesca De Cillis, Federica Pascucci

Table of contents

Forward

The project will investigate the feasibility of using RFID technology to improve the activities of first responders during emergency missions in indoor/deep indoor environments. This document defines the scenario where the RISING solution is going to be tested and the information to be stored in the RFID tags to provide crucial information to first aid staff such as, the actual presence of hazardous materials and resources.

1 Scenario

The scenarios where the RISING solution can be applied are indoor or deep indoor environments. Examples of these scenarios can be official buildings, railway and metro stations, chemical plants, hospitals, research centers and others.

The scenario selected to test the effectiveness of the RISING solution is a large and complex indoor environment. A pilot test will be performed on the service floor of the Campus Bio-Medico general hospital. The hospital presents quite a large map composed of 3 self-similar square-like blocks interconnected (see the figures 1 and 2). Specifically, the trial will be held at the Service floor located at the 2nd floor underground, representing a deep indoor scenario. It covers over 19.000 square meters and over its ceiling an extensive number of hazmat pipes are located. The pipes' stopcocks are vital during the emergency management to stop any hazmat release or explosion, which could involve the emergency team. In the Service floor, there are also stockrooms of chemical /biological material and thermal, cryogenic, electric and medical-gas plants are located. So the pilot is a representative example of the different types of scenarios where the solution can be applied. The RISING framework will equip the Service floor with some RFID tags to support emergency responders to localize themselves and possible resources/hazmat.

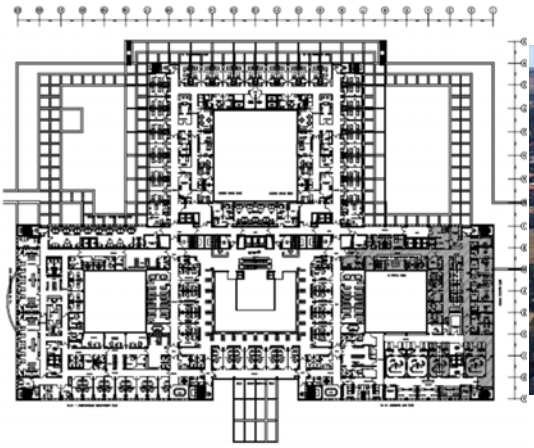

Figure 1. A floor plan of the Campus Bio-medico hospital

Figure 2. Aerial view of the Campus Bio-medico hospital

2 RISING system architecture

Pre-installed RFID devices in large and complex indoor environments can provide crucial information to first responders about the position of elements such as pipes, hazardous materials and emergency exits. This information is extremely useful when first responders need to deal with emergency situations and allows preventing and reducing their exposure to dangerous situations. For this purpose, maintenance operators will be in charge to store this information into RFID tags which are deployed in suitable locations inside the scenario.

Nevertheless, the feasibility of the RISING system depends both on the reliability of the stored information and on the proper performance of the user equipment. In relation to the former concern, it is worth noticing that RFID tags are usually equipped with a limited memory capacity. For this reason, the RISING framework envisages the use of a database, which includes additional information other than data stored into tags. The supporting activity offered by the database to maintenance operators is mainly devoted to guarantying an adequate level of confidence and keeping up-to-date the information stored into tags.

The figure 3 shows the architecture of the information system. In an emergency situation first responders will only be able to read information of the RFID tags using a RFID reader and displaying this information on a tablet. This information provided by the RFID tags will be sufficient to help first responders to know the location of the useful resources and potential hazards of the environment. In these situations, no new information will be added to RFID tags.

On the other hand, during the performance of maintenance activities additional information stored in the database needs to be updated to write it afterwards on RFID tags. This update process can be carried out using a computer or a tablet and a RFID reader/writer.

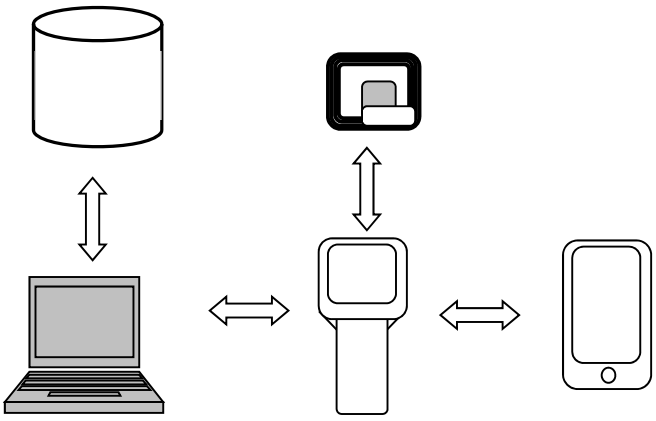

Figure 3. RISING system architecture.

In the following sections the information stored in both, the database and RFID tags, will be described.

3 Information on the database

This section describes the different entities stored on the database.

3.1 Sites

The database may contain information of the location of RFID tags in different buildings or floors, belonging to the same or to different organizations. Therefore, the database may manage different RISING systems located in different places or sites. The "Site" concept will be used to define a system in the scope of the Rising project. The "Site" is used to manage different "sites" independently in the same database. The RFID tags do not have information about the Site.

A "Site" can be a complete building, several buildings, a complete floor, a set of floors or only a section of a floor for example, when the floor is too large to perform the complete maintenance. Each "Site" is registered on the database with a name to identify its elements (e.g. Building Johnson floors 1-4).

The fields that define a **Site** on the database are:

- **Site id**: it's the ID of the building, floor or installation.
- **Name**: name describing the site.
- **Geographical coordinates**: information of latitude and longitude to define where the site is located.
- Creation date: the date of the site record creation. This field will be used as logging of the system and to develop a security control.
- Creation user: user id to identify who has created the record of the site. This field will be used as logging of the system and to develop a security control. If there isn't a security control, the user name will be stored.
- Update user: user id indicating the identity of the last user in charge of information updating.
- Update date: the date about the last information updating.
- Map of the site (optional): file including the plan of the floor or building.

3.2 Tags

Each site will include information about the tags and their location, describing:

1) General information about the tag;

2) Information about resources;

3) Information about hazards.

The general information provides the identification code of the tag, its geographical coordinates and general management information apart from the date when the last updated has been carried out. More specifically, the general information can be structured in the following way.

For each RFID tag, the database will contain the next information:

- **Site id**: it's the ID of the site described previously.

- **EPC URI**: the Pure Identity "Electronic Product Code" "Uniform Resource Identifier" of the tag. Example: urn:epc:id:sgtin:0614141.112345.400. This information is used to code the 14 bits defined in the REFIRE codification.
- **Geographic coordinates**: absolute geographical position of the tag with latitude, longitude and altitude. This information is used to code the 91 bits defined in the REFIRE codification.
- **Lamp classification**: includes the floor, indication of mezzanine, room and lamp. This information is used to code the 22 bits defined in the REFIRE codification.
- **Tag classification**: to indicate the type of the RFID tag (passive, active, ...). This information is used to code the 2 bits defined in the REFIRE codification.
- **Accuracy**: power and direction of the electromagnetic field. This information is used to code the 8 bits defined in the REFIRE codification.
- **Creation user**: user id to identify who has created the record of the tag. This field will be used as logging of the system and to develop a security control. If there is not a security control, the user name will be stored.
- **Creation date**: the date of the tag record creation. This field will be used as logging of the system and to develop a security control.
- **Update user**: user id indicating the identity of the last user in charge for information updating.
- **Update date**: the date about the last information updating. This information is used to code the 15 bits defined in the REFIRE codification.
- **Verification user**: user id indicating the identity of the next user in charge for information updating.
- **Verification date**: the date about the next information updating.
- **Verification date**: the date about the next information updating.
- **Tag Identification bits**: the id provided by the tag manufacturer. It is recorded on the database when the physical tag is assigned (12 bits).

3.3 Elements (POI)

RFID tags will also contain information about the different Points Of Interest (POI), resources and hazards, available on the scenario close to the actual position of the tag. Appendix B shows a list of the elements that can exist in the indoor environment.

For each one of these POI, the information provided are: the category, relative location, type, subtype and a numerical value (they are explained in the next list).

Information about the management of each element will be also included, such as users and dates of creation, modification and verification.

- **POI ID**: numeric id to identify the element which information is saved in the tag.
- **Category:** the main classification of the element, it's the kind of POI. Examples of categories are: emergency exits, fire hoses, extinguishers, fire axes, biological hazards,

toxic gases and flammable gases. This information is used to code 6 bits that will be stored on the RFID tag. It allows 64 different categories. The table to define the codification of this field and next ones are explained on section 3.4.

- **Geographic coordinates**: absolute geographical position of element with latitude, longitude and altitude. This information is not stored on the RFID tag, it is stored to calculate the relative location and for maintenance purposes.
- **Relative location**: The relative location will show if the element is close (less than 3 meters) or far (3-7 meters) with respect to the tag. Additionally, the relative position of the item will also be defined: behind, down, left and right. Thus, the item position will be coded in the following way: Here, Left close, Left far, Right close, Right Far, Front close, Front far, Back close, Back far. This information is used to code the 4 bits that will be stored on the RFID tag enabling 16 different categories.
- **Type of element:** a category may consist of different types of elements. For example, the flammable gases category includes different elements such as acetylene, ammonia, hydrogen, propane, propylene and methane. This information is used to code the 6 bits that will be stored on the RFID tag. It allows 64 different types.
- **Subtype of the presence of the element:** for a category of an element (example flammable gases), the element can be present in different ways, for example for flammable gases it can be a pipeline or a deposit. This information is used to code the 2 bits that will be stored on the RFID tag. It allows 4 different forms.
- **Numeric value:** this number provides information of the subtype of the element. For a pipe it refers to the diameter of the pipe, while for a deposit it is the volume of the deposit. As the information is going to be stored on the RFID tag, the value stored is a code for an approximate value of the real value. For example, for pipelines, the possible values from 0 to 7 correspond to the diameters: ½ inch, 1 inch, 2, 4, 8, 16, 32, and 64. This information is used to code the 4 bits that will be stored on the RFID tag. It allows 16 different values.
- **Comments:** any extra comment about the characteristics of the element.
- **Creation user**: user id to identify who has created the record. This field will be used as logging of the system and to develop a security control.
- **Creation date**: the date of the tag record creation. . This field will be used as logging of the system and to develop a security control.
- **Update user:** user id indicating the identity of the last user in charge for information updating.
- **Updated date**: the date about the last information updating.
- **Verification user**: user id indicating the identity of the next user in charge for information updating.
- **Verification date**: the date about the next information updating. .

3.4 Tables for codification

To register the master data and their binary codification, the next tables will be used:

The table **Category** has the next elements:

- **Category id**: it's the ID of the category (ex: 17).
- **Name**: name describing the category (ex: flammable gas).
- **Code**: codification on the category (ex: 000111).

The table **Type** has the next elements:

- **Type id**: it's the ID of the type (ex: 1023).
- **Category id**: it's the ID of the category of the type (ex: 17).
- **Name**: name describing the type (ex: hydrogen).
- **Code**: codification on the type (ex: 000011).

The table **Relative location** has the next elements:

- **Relative Location id**: it's the ID of the location (ex: 23).
- **Name**: name describing the type (ex: left close).
- **Code**: codification on the relative location (ex: 0001).

The table **Subtype** has the next elements:

- **Subtype id**: it's the ID of the subtype (ex: 47).
- **Category id**: it's the ID of the category of the subtype (ex: 17).
- **Name**: name describing the subtype (ex: pipeline).
- **Code**: codification on the subtype (ex: 01).

The table **Numeric value** has the next elements:

- **Numeric value id**: it's the ID of the numeric value (ex: 35).
- **Subtype id**: it's the ID of the subtype of the Numeric value (ex: 57).
- **Name**: name describing the numeric value (ex: 2 inches).
- **Code**: codification on the numeric value (ex: 0011).

4 Information on RFID tag

The RFID tags will be coded based on the information of the database. The proposed codification follows the standard defined in the "GS1 Standards and encoding proposals" document developed by the REFIRE project.

For the fixed message, 152 bits will be used.

From the REFIRE specification:

Field	**Bits**
EPC URI	14

Geographic coordinates	91
Lamp classification	22
Tag classification	2
Accuracy	8
Date	15
Total	**152**

There are 4 bits for the manifest. This is the number of POI stored in the TAG.

In the variable part, for representing different POI (resources and/or hazards) the next codification will be used:

Field	**Bits**	**Different values**
Category	6	64
Relative location	4	16
Type	6	64
Subtype	2	4
Numeric value	4	16
Reserved	6	
Total	**28**	

So, the structure of the information of the tag is:

- 152 bits for the fixed message
- 4 bits for the manifest
- 28 bits for each element

With a user memory capacity of 448 bits, there is space for 10 elements:

5 Maintenance activities

Besides the information to support emergency operators, the RISING system must provide the information to carry out maintenance activities to keep the information of RFID tags updated. Maintenance activities are crucial since the reliability of the RISING system depends on the accuracy of the stored information and the proper performance of the implemented equipment.

The database will record the maintenance activities carried out, recording the time and details of incidents happened during the maintenance activities.

In each site different types of maintenance can be carried out using different schedules. A maintenance operation includes a list of tags to be verified and a list of elements (the elements next to the tags included in this maintenance task). The information of the types of maintenance is:

For each type of maintenance:

- **Site Id**: this numeric id represents the site where the maintenance task is carried out;
- **System maintenance**: this Boolean value defines if value is true that the maintenance operation is compulsory for the good working order of the Rising system. If the value is false, it is other type of maintenance, but not compulsory for the Rising system operation.
- **Description:** a description of the type of maintenance to be performed, for example "legal required maintenance", "six-monthly verification", etc;
- **Period of recurrence**: it defines the unit of time (days, weeks, months or years) to carry out the maintenances activities;
- **Number of periods between maintenance:** the number of times that a maintenance task needs to carry out over one year. It depends on the period of recurrence;.
- **Last maintenance**: date when the last maintenance activity has been carried out;
- **Next maintenance**: date when the next maintenance activity is expected according to the recurrence period;
- **List of tags**: list of tags that have been checked during the maintenance task;
- For each element classified as hazard or resource:
    - **Element ID**: numeric id to identify the type of element which information is saved in the tag;
    - **Action to be performed**: examples: verify, refuelling, etc.

The system also records every maintenance operation performed in the site and the operation performed with the tags and elements of this maintenance.

For each maintenance procedure performed, the following information will be stored:

- Type of maintenance (from the types of maintenances previously defined);
- Date and user ID who has performed the maintenance;
- For each tag:
    - Tag ID
    - Verified (0/1) if the tag has been verified;
    - Updated (0/1) if the information of the tag has been updated;
    - Information updated: description of the information updated.
- For each element:
    - Element ID;
    - Completed (0/1) if the action has been performed with this element;
    - Comments.


RISING

Appendix A: Interview with Operative Division Officer

Date: July the 7th, 2015

Attendants: Operative Division Officer (ODO) and Nicolas Serrano

Dibisio Operatiboko Ofiziala / Oficial de la División Operativa (Operative Division Officer)

Prebentzio, Su Itzalketa eta Salbamendu Zerbitzua / Servicio de Prevención, Extinción de Incendios y Salvamentos (Prevention Service, Fire Fighting and Rescue)

Donostiako Udala / Ayuntamiento de San Sebastián (San Sebastian town hall)

During the interview, Tecnun explained the content of the RISING project and asked feedback about the information that first responders consider helpful to visualize when they are in an emergency situation.

The main point that ODO commented was that the information to be displayed to the emergency operators must be very simple. For example, there is no need to inform about all the resources available in the building since the emergency responders usually carry their own material. So, information about fire hoses, extinguishers, fire aces, etc. is not useful.

On the other hand, ODO assured that having a map of the floor would be very valuable since they don't usually have this information, just only for some public buildings. Currently the emergency operators, only use the information provided by the people they meet at the emergency site so a floor plan including information about emergency exits would be a very nice resource. Although, there are not currently standards about floor plan representation for emergencies.

Regarding the different hazards, he considers there is no need to have detailed information about them. It is enough differentiating between hazards that are dangerous by the fire and hazards by themselves.

An important issue that ODO commented is to consider including information about the location of people inside the building.

Other comments about the RISING system were that the RFID tags and operator equipment (readers, IMU, Smart Devices) must be fire resistant. And, it would be nice to display useful information on the firefighter mask (some commercial mask use a similar system for other pieces of information) or in the thermal camera that they are using currently.

Appendix B: List of elements

The next list shows the different categories of POI. This list can be extended in the future updating the category table.

Categories:

Emergency exit	000001
Fire hose	000010
Extinguisher	000011
Fire axe	000100
Biological	000101
Toxic gas	000110
Flammable gas	000111
Energy	001001
Radioactivity	001001
People	001010

The next lists show codes for relative position.

Relative position:

here	0000
left close	0001
left far	0010
right close	0011
right far	0100
front close	0101
front far	0110
back close	0111

back far 1000

Next lists show data for the types and subtypes of the category “Flammable gas”.

Types of element Flammable gas (000111):

acetylene 000001

ammonia 000010

hydrogen 000011

propane 000100

propylene 000101

methane 000110

Subtypes of Flammable gas (000111):

pipeline 01

deposit 10

The next lists show data of values for the subtype “Pipeline”.

Different numeric values of Pipeline (01):

½ inch 0001

1 inch 0010

2 inch 0011

4 inch 0100

8 inch 0101

16 inch 0110

32 inch 0111

64 inch 1000

Example of an element on the database and RFID tag

Field	**Bits**	**Represents**
Category	000111	Flammable gas

Relative location	0001	Left close
Type	000011	hydrogen
Subtype	01	Pipeline
Numeric value	0011	2 inches
Reserved	6	
Total	**28**	