Hybrid RFID-GPS Real-Time Location System for Human Resources: Development, Impacts and Perspectives

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Abstract

Radio Frequency Identification (RFID), including Real-Time Location Systems (RTLS,) and Global Positioning Systems (GPS) are technologies that have evolved considerably in the past few years. These technologies have the potential to provide a means by which organizations can follow employees in real time. However, this permanent surveillance might have unpredictable impacts on the employee and on the organization itself. We followed the systems development research process to build a hybrid RFID-GPS system, allowing for the real-time location of human resources both indoors and outdoors. We tested this system in the security service of a Canadian university and we explored the impacts on the workgroup and its employees. Our results showed that this kind of system can work in a genuine context, and that it has distinct impacts on the individual and on the organization which are usually not observed with more traditional information systems.

1. Introduction

In recent years, important developments have emerged in the field of Real-time Location Systems (RTLS), a particular type of Radio-Frequency IDentification (RFID). The same has applied to wireless and mobile technologies. Organizations have been using these technologies for many purposes. For example, on-board systems and GPS technology are major breakthroughs in transportation fleet management (vehicle tracking, speed, waiting time, etc.) [1]. In addition, RFID technology enables parcel tracking [2, 3], pharmaceutical product returns management and counterfeit identification [3], shipment tracking and tracing [2]. In fact, positioning technology is becoming increasingly diversified: GPS or A-GPS, passive RFID, active RFID (or RTLS), smartcards, cellular phones, on-board systems, gyroscopes, infrared-based systems, Wi-Fi, etc. If traditionally these technologies have been used to trace mainly goods and products, recently, organizations have started to use them to locate users, employee and customers. [4]. In fact, technologies that track, trace and locate are emerging, diverse, and are developing considerably [2, 5-7].

Real time people tracking has sparked much controversy [6]. A great deal of research has focused on the tracking of customers, either on the web or by the use of secondary data [e.g. 8, 9, 10]. However, little has been done on the tracking of employees in organizations. Yet this practice is growing in importance in organizations today. Therefore we believe that this issue and its impacts warrant in-depth study.

On one hand, organizations want to know where their employees are and what they are doing when they are at work [11]. If, under normal circumstances, real time tracking of employees at all times might seem questionable, it may be completely relevant in other contexts. As such, we were working with a security service that wanted to track, in real time, their security guards in order to ensure their safety and the security of the organization's resources. RTLS technologies have allowed organizations to follow, in real time, the precise location of their employees within buildings or outside, but not both at the same time. In a context where security guards patrol both indoors and outdoors, it seems fundamental to be able to follow them within, as well as outside buildings. Inspite of the fact that there are many RFID/RTLS technologies currently on the market (Axcess, Wavetrend, Ekahau, RF-Code, Passport Technology, etc.), it has been very difficult to get the right technological combination allowing real time tracking of employees, both inside and outside of buildings. This is because the existing technologies are not effective in reliable indoor and outdoor tracking of mobile resources. For example, GPS are only effective outdoors and cellular network positioning does not provide sufficient spatial accuracy for indoor tracking

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[7]. Conversely, active RFID technologies (RTLS) capable of providing accurate indoor locations are growing in numbers and represent an affordable and efficient alternative solution for indoor positioning, which might fill the gap that is not addressed by other technologies today [5]. Therefore, the development of a GPS/RTLS integration system may constitute an important technological opportunity that could provide companies with the full potential of both positioning technologies [12].

Keeping an eye on employees continuously, on the other hand, might have unpredicted impacts on the individuals and on the organization. Because real time people tracking is an emerging practice, research in this area is still underdeveloped [6]. Thus, it is very important to expand our understanding of the characteristics of positioning technologies and the ways they can be used. We also need to develop a better understanding of their impacts on individuals and organizations.

Consequently, the purpose of this research was to explore, in a genuine context, the impacts of a novel human resource tracking technology on a workgroup as a whole and on the individuals within this workgroup. To do so, we developed a hybrid RFID/GPS system for both indoor and outdoor real-time positioning of human resources for a security service of a Canadian university. We tested the prototype and explored the impacts of the technology in an experiment involving the majority of the security guards employed by the service. The results showed that such a system can function within a real work context, and that it has particular impacts on the individual and on the organization. These impacts were different from those usually observed with more traditional information systems.

The following section presents a literature review dealing with positioning technologies and their impacts. Our research methodology, a combined approach of system engineering and semi-structured interviews, is presented in the third section. A detailed description of the prototype development process and of its experimentation is presented in the fourth section, and the fifth section defines the impacts and concerns observed, which are more thoroughly discussed in the sixth section. We conclude with the theoretical and practical implications of this study.

2. Literature Review

RFID and other RTLS technologies are known as facilitators of real-time tracking [12]. Yet, electronic tracking of employees, a particular form of electronic work monitoring, can be considered as a specific type of surveillance that is challenging for companies that are using it [11, 13]. Surveillance can take many different forms: application sharing, video surveillance cameras, hidden microphones, telephone monitoring of employee conversations, computer-based monitoring of employee keystrokes [11, 14], and email and internet monitoring [14]. However, the introduction of real-time location systems offered a new form of surveillance that expanded the scope of surveillance to troubling proportions.

There has only been limited research regarding the use of RTLS technologies in surveillance activities [6]. Some examples of research in this domain are the taxonomy of location systems proposed by Hightower and Borriello [7], a discussion about the implications of using RTLS technologies for user organisations, technology providers and policy makers by Clarke [6] and finally, a classification scheme of positioning techniques by Caron et al. [5]. What is clearly shown in this literature is that managers have a broad choice of RTLS technologies that can be adopted by their organization to track people or goods, either inside or outside of buildings. Moreover, this literature clearly establishes that no technology, used alone, enables the location of people or goods both inside and outside of buildings.

What is less clear, however, is that organizations also face different choices related to their usage of these technologies. For example, they can choose to use them to control people, or they can decide to take advantage of them to optimize their decision-making process. In either event, it is very difficult to predict what the reactions of the tracked people will be. Yet, even if an organization chooses not to use these technologies to control its employees, they may still be reluctant to be continuously tracked. On one hand, traceability enabled by real-time positioning technologies can have negative effects, especially when it facilitates the invasion of people's privacy [4], which contributes to increase the employees' levels of stress. It might also bring about a certain form of discrimination in the workplace, employee mistrust, and a decline in productivity [15]. On the other hand, positioning technologies can also be valuable for people and organizations using them. For example, it might be useful, in the health care sector, to be able to follow patients that have problematic diseases such as those with memory loss. Another important example of the beneficial aspects of such technologies would be in the security industry where they could help to ensure a safer work environment for the security staff and also the safety of the public. In fact, other studies have shown that perceptions of the impacts related to the use of tracking technologies could be highly context specific [9].

Consequently, our experimental and exploratory study aims to provide answers to three specific research questions:

1. Is it possible to develop an efficient human resource tracking system, with the integrated ability to track employees both indoors and outdoors in an actual context? What would the key features of this system be?
2. What are the impacts of a human resource tracking system on individuals?
3. How does a human resource tracking system impact the workgroup?

3. Methodology

Our study is based on the *system development research process methodology,* proposed by Nunamaker *et al*. (1991) [16]. This approach combines the use of four research strategies: theory building, systems development, experimentation, and observation that are integrated into a coherent research process, consisting of five structured steps. The first step of the methodology is the formulation of the research questions and the identification of the strategy to adopt in order to answer these questions. The second step of the process deals with the development of the system architecture. This step defines the functionalities of system components and the interrelationships between them. The third step is to analyse and design the system. At this stage, the database/knowledge base scheme and processes are being developed to carry out system functions. The fourth step is to build the prototype. Finally, the fifth step consists in monitoring and evaluating the system. The monitoring can be carried out through case studies, laboratory experiments or field experiments. Then the case studies or experiments can be evaluated through interviews, in order to acquire relevant theoretical learning.

We have rigorously followed the five steps of the process to carry out our study. The following section describes how we applied the system development research process methodology.

4. Developing the System and Analysing the Impacts

4.1 Constructing a Conceptual Framework

In order to clearly define our research problem, the context of our experiment should be explained. This study was conducted in the security service of a Canadian university. The security service employed twelve full-time guards, four part-time guards and ten others who worked on a temporary basis. The campus covered 0.64 square kilometres and was home to about fifty buildings. The campus was divided into three main sectors, each one assigned to a specific guard, who was responsible for patrolling it and to respond to all emergency calls from that sector. Around-the-clock patrols and surveillance were provided on the campus and scheduled into three eight-hour shifts and two twelve-hour shifts, all of which overlapped. In addition, a security guard was present at all times at the control station.

Before beginning his shift, each patrol guard consulted the surveillance report prepared by the previous guard. Then the guard started patrolling his sector. The patrol route was at each guard's discretion. During evening and night shifts, the patrol guards had to call-in regularly (every 30 minutes) to the control station to report their position. However, several risks for the security guard are associated with this work practice. For instance, a patrol guard might find himself in a situation where he would be unable to report his position; he could become unconscious, or be under the control of a malevolent individual. In sum, any emergency situation could occur and prevent him from using his radio to report his position to the guard at the control station. If, for instance, the endangered security guard had an emergency button he could press, it would only inform the control station that a patrol guard is in distress, without any further indication of his position. In such situations there is no efficient means, at the control station, to locate the distressed guard on the campus. Consequently, sending reinforcements in time and to the correct location might almost be impossible. Therefore this practice might greatly compromise the guards' safety and the security of the campus.

One possible solution to this issue would be the use of a security guard tracking system enabling the guard at the control station to locate all the patrol guards at any given time. Thus, in an emergency, it would be possible to send other patrol guards to the distressed guard's precise location, and to ensure his safety, as well as the campus' security. This system could also help the guard at the control station to coordinate interventions by identifying which patrol guard is the closest to the emergency scene, and direct that guard to respond. Given the fact that security guards patrol both indoors and outdoors, and knowing that, as discussed above, there are no means currently available to accurately track individuals in these situations, the development of such a system for security services is clearly relevant.

4.2 System Architecture

A positioning system design to solve these issues should enable tracking of patrol guards, in real time, within buildings, and to follow their position outdoors on the campus. Consequently, we developed a system that met these requirements, and tested it in the context of the university campus security service described above. Finally we evaluated the impacts both on the workgroup and on the security guards using it.

4.3 System Analysis and Design

There are different ways to locate a person. For instance, a GPS uses a GPS receiver that picks up emission signals sent by a plurality of satellites and a trilateration process to determine a position. Yet, one of the disadvantages of GPS systems is that they cannot provide indoor tracking [17]. Similarly, cellular telephone networks can identify the approximate position of a mobile device by detecting which cell is being used by the device [6]. The accuracy of this technology is still inadequate (around 200 metres) and depends largely on the size of the cell.

Moreover, there are several technologies that provide indoor tracking, such as, the technologies based on active (RTLS) radio-frequency identification (RFID). RFID only provides short-distance radio signal transmission to RFID readers. Once picked up by a reader, the signals are relayed to a computer to be processed. RFID tags can be active or passive [12]. Active tags have their own energy source and send their identification and position, which are necessary data to ensure real-time tracking. Passive tags have no battery and are activated by using the power generated by the magnetic field of the radio-waves of the reading sensor. Thus, they are only activated when they are near a reading sensor, which reduces their scope. Consequently this becomes a constraint on real-time tracking situations.

Another active RFID approach is based on the use of radio-waves of WI-FI technologies [17]. As opposed to the traditional RFID approach, the WI-FI approach does not require the installation of specific aerials or receivers; it just needs to get connected to the existing WI-FI network. This positioning method usually consists in gathering signals, and mapping their distribution. Then, the positioning model resulting from this procedure can be applied to the identification of the position of an object or a person [17].

In fact, these examples reveal that there are different ways to determine the position of a person. In the context of our study, we have taken into account several characteristics specific to the university campus, to choose among these technologies. First of all, we had to ensure that the entire campus was covered with the chosen tracking technology. Secondly, because of financial constraints, we eliminated the methods requiring the purchase of expensive RFID antennas. Finally, we discarded the solutions based on cellular identification because of their poor accuracy.

Bearing these characteristics in mind, we focused on GPS and RTLS technologies. On one hand, GPS is a very accessible technology, but limited to outdoor positioning. On the other hand, 90% of the buildings located on the main campus were already provided with Wi-Fi access at the time of our study. But this access remained limited to the inside of the buildings. Consequently, we decided to design and develop a hybrid GPS/RTLS (or active RFID) solution for security guard tracking.

Tracking device. For outdoor tracking, we integrated GPS receivers into the microphones of radios that were similar to those usually used by the security patrol guards. In the course of the experiment, the participating guards were given Kenwood TK-3180K2 radios equipped with Kenwood KMC-38GPS microphones. The GPS receiver in the microphone reported its position through radio-waves, on a given frequency. For indoor tracking, we chose the Ekahau RTLS hardware and software solution that offers real-time people tracking anywhere there is Wi-Fi coverage. This solution was chosen among other RTLS tracking solutions, because the necessary equipment (Ekahau beacons) and software licences to develop the prototype were already available.

Data transmission. In order to design the system architecture, we identified three different themes: functional architecture, technological architecture and data architecture. We chose the UML language for the modelling. Due to space considerations, all the UML diagrams will not be included here. However, we decided to present the UML activity diagram that shows the use of the system (figure 1).

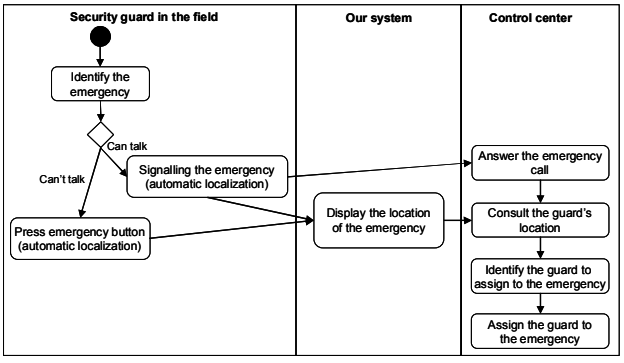

Figure 1: UML Activity Chart

In the absence of our system, when a patrol guard was in distress and could not report his position, the guard at the control station could only roughly estimate the position of the distressed patrol guard according to the information he had sent to the control station during his last report. With the new system, the position was automatically available in real-time.

When the patrol guard was inside a building on the campus, the Ekahau beacon would send the data relative to the received radio-waves signals to the positioning device. The positioning device would then calculate the guard's position using a calibrated spatial model. When the patrol guard was outdoors on the campus, the GPS receiver would calculate his position using trilateration of signals coming from satellites. This data would then be sent to a middleware (*Global Eyes,* from Mercanstream Technologies) that would process the raw positioning data and transmitted them back to the data server. Finally, *JMap* software (Kheops Technologies) displayed the position of the guard in a Web browser by superimposing the positioning data on a map of the campus (outdoors) or on a map of each building (indoors).

4.4 Building the Prototype

The prototype was built in three important steps. First of all, the entire campus was mapped. The exterior features of the campus were already available in geo-referenced *shapes* spatial files. The plans of the buildings were originally in DWG format (AutoCAD), and were converted into *shapes* files and then geo-referenced.

Secondly, the positioning model was built, and adapted to the Ekahau system (indoors tracking); that is to say, the most likely movements to occur inside buildings were schematically represented as "rail" shapes. Then, the positioning model was calibrated by physically recording the radio-wave signals at various sample points (every 3 to 5 metres) on each floor of the campus buildings, so as to ensure high positioning accuracy.

Thirdly, the software interface was programmed using the JMap developing toolkit. The necessary telecommunication and positioning equipments were acquired, and finally rigorous functional tests on the global system were carried out in our laboratory, before deploying it at the control station and into the hands of security guards.

4.5 System Monitoring and Evaluation

The security guards were contacted through a letter to solicit their participation in this study. Twelve guards accepted to participate by carrying the equipment device during their working shifts, and attending an interview afterwards. The prototype experiment was carried out from November 27th through December 11th 2006. Before each working shift, a member of the research team was present to proceed with the installation of the device and to explain how the software worked to the guard at the control station. We collected positioning data from 40 out of the 42 working shifts that occurred during the experiment. Most of the time, 2 or 3 guards would carry the device in each working shift.

Once the experiment was completed, semi-structured interviews were conducted with the active security guards, whether at the control station, or while the guards were patrolling. We also conducted interviews with some of the security service directors so as to evaluate the impacts of the system on the organization. The interviews were recorded and transcribed. The analysis was achieved through an iterative process of coding, and until saturation. The observations and notes taken by the members of the research team during the experiment were transcribed and similarly analyzed. This evaluation of the system was meant to determine how the system could be improved, and to measure the potential impacts on individuals and on the organization. The results are presented in the next section.

5. Results

This section begins with the introduction of the results related to the system characteristics, followed by the presentation of the observed impacts on individuals, and ends with the observed impacts on the workgroup.

5.1 System Characteristics

The experiment presented here confirms that it is possible to develop a system that satisfies all of the important characteristics described above, such as real-time tracking as well as indoor and outdoor tracking. In this regard, the patrol guards' perceptions about the different characteristics of the system were surveyed.

The guards expressed their satisfaction with the equipments used (radio and tags), and added that they did not interfere in their work, suggesting another important characteristic of such a system – transparency. Moreover, the patrol guards suggested two modifications regarding the functioning of the radio, to make its use more convenient. Indeed, they mentioned a shrill sound signal occurring when the GPS receiver was out of range. Some patrol guards also found it uncomfortable hearing crackles when the radio was sending positioning data to the system, that is to

say, every five minutes or when the guard would release the radio transmit key. The guards stressed the importance of solving these problems before considering a permanent use of the system, which reinforces the idea that transparency is of great importance.

With regards to the system software used by the guard at the control station, the ease of use of the interface, along with the suitability and utility of the functionalities offered were often pointed out by the guards. The only modification suggested was to display the building number of the premises on the building plans.

As for the information characteristics, two concepts were highlighted during the interviews, i.e.: information accuracy and exactness. These elements were directly influenced by the technological choices we were forced to make, especially concerning the refresh frequencies (5 minutes for the GPS, and 15 seconds for the Ekahau tag), and some physical limitations on the campus we encountered (Wi-Fi network only covered 90% of the campus).

5.2 Individual Impacts

We tried to better understand the impacts of the system on the security guards. More precisely, we asked them what their impressions were about what they had experienced. Then, we asked whether they would be interested (or not) to keep on using such a system, and the reasons for their respective choices. It appeared that organizational directives, along with the perception of usefulness, of privacy invasion and of procedural justice were key elements in helping to better understand the guards' intention to adopt such a system.

Perception of utility. One of the first things we found out was that the specific characteristics of the system largely influenced the guards' perceptions with respect to the system's usefulness for supporting their work. Indeed, some of the guards mentioned that, within the context of the experiment, the inaccuracy of information, mainly due to too slow refresh rates, made them doubtful about the usefulness of the system.

> *"It does not take long to understand that the refresh rate is too slow to track a person 'step by step', so the use of this system in the case of emergency calls is doubtful". (guard #9)*

Others took into account the fact that the proposed system was a prototype. Consequently, they came to the conclusion that a real-time tracking system like the one they had tested could be very useful, whether to improve the communication between the patrol guards and those at the control station, or to increase the patrol guards safety. Finally, some guards mentioned the usefulness of such a system to optimize reinforcement dispatch by identifying which patrol guard is the closest to the emergency scene.

> *"When there is an emergency call, we were able to identify that he [a specific patrol guard] is the closest, and this functionality appears to be useful ". (guard #12)*

Organizational directives. The persons interviewed often talked about the influential power of the organizational directives (conditions associated with the use of the system) on their behaviour towards the system, and about their intention to keep on using it on a continuous basis. These conditions determine «who » (who has access to the data), « how » (how the collected data are being used) and « why » (what are the intentions of the other persons who have access to the data, as supervisors for example).

Within the framework of our experiment, we somewhat controlled for this variable. Indeed, to ensure the participation of the guards, we chose to deny access to the data to the supervisors and other executives of the security service. The only persons authorized to consult the security patrol guards' movements were the guards at the control station and the research team. In real life, the situation might have been different. The participating guards told us that they would have felt uncomfortable to participate in the experiment if their superiors had had access to the data. Fundamentally, it is the way the superiors want to use the collected tracking data that makes the difference with respect to individual impacts.

> *"It would have certainly made a difference, in other words, if the boss had said: We use the system, and have full access to everything that is going to happen. In that situation, less of us would have participated. I might have refused as well! What matters is: what is the purpose at the very end?" (guard #3)*

Some of the guards even said that they would not accept to carry a tracking device system in the future, unless their superiors were perfectly clear about their intentions on the use of the data.

Perception of privacy invasion. A third concept that was highlighted in the interviews was privacy invasion. When the guards were asked if they felt that their privacy was invaded during the experiment, most of them answered that it had not been the case. But, we found some inconsistencies in their responses, pointing in the opposite direction.

For example, the security guards first said that they did not feel that their privacy was invaded, because they did not see this question as relevant in their work context and that « *they had nothing to hide»*..

"No, it is not really my private life because I am working, and I am paid to do the job". (guard #3)

But sometimes, later in the interviews, some indications eventually revealed that they did feel an invasion. These indications could be words like: to spy, eye, big brother, etc. For instance, when guard #6 was asked, immediately from the beginning of the interview, if he had felt that his privacy was invaded, his answer was no, but later he said:

"It is just as if there was an eye constantly watching you, that's what's most embarrassing". (guard #6)

Perception of justice. The fourth concept emphasized in the interviews was justice (or fairness). Most of the guards found it fair to be tracked by a real-time positioning system. Yet, for some others, there was a close link between the justice concept and organizational directives. As a matter of fact, these guards thought that it was perfectly fair to be tracked, as long as the system was not used to question their work. They underlined the fact that they believed the situation to be fair as long as the system was used as an additional tool to support the positioning of guards in distress. But if the system were to be used to question the relevance of their choices or to ask them to justify their movements, they would consider it to be profoundly unfair to be tracked this way. They would lose confidence in their work, which they considered unacceptable.

"Question: Did you think it was fair to track the guards' position?

Answer: Yes, but we must remain careful. We should never be asked: What were you doing there?" (guard #2)

Finally, some of the guards mentioned that the lack of accuracy and exactness of the positioning data, due to the slow refresh rates, made the whole tracking process unfair in their eyes. Indeed, they were anxious about the fact that the persons consulting the data might reach false conclusions with regard to their work.

"It's fair [to be tracked], but the slow refresh rate could make somebody say: Ah, the guard remained there 10-15 minutes. But in fact it was not true. It was due to the wrong delay, so no [it is not fair]" (guard #9)

5.3 Issues facing the workgroup

Our third research question deals with the issues of such a tracking system on the workgroup. The results of the study indicated that the security guards identified some very useful characteristics in the system. They particularly emphasized the importance, in emergency situations, of rapidly obtaining the information necessary to support decision-making. For instance, to know the position of each patrol guard at a glance, so as to identify which guard is the closest to the response situation, appears very useful and absolutely relevant to them. Nevertheless, since no real emergency situation occurred during the experiment, they didn't have the opportunity to ascertain whether or not their perceptions were well reasoned.

Moreover, the campus being small in size, the guards were not convinced that they would improve their response capacities. However, they were convinced that in similar contexts, with larger areas to patrol and more patrol guards, this system would assuredly improve response times.

"Only once is enough for it to be decisive: at some point, if you need someone quickly. [With this system], the guard at the control station is able to see if there is someone right beside […]. You must make a quick decision. You turn back and look at the screen. You see that there is a guard 30 seconds away from the place you want to send a response…Yes indeed, it could be interesting ". (guard #4)

Finally, one of the supervisors of the security service stressed the importance of using the resulting information to improve work processes. In his opinion, the information retrieved from the system could help optimizing patrol routes. In other words, the system could create a patrol plan that would ensure coverage of the whole area, while minimizing the guards' movements. This would result in cost savings, along with better security on the university campus.

"It could impact the patrol routes. For example, one of my current tasks is to identify what is essential to do during the patrols for each sector, how long in each building, etc. Visualization would provide a picture of what is currently taking place. Visualizing that [the data provided by the system], I could see how, a week ago, the five guards, who were on duty from Monday to Friday, performed their evening patrol, how long they staid in the buildings, which floors were patrolled... I could do all this from my office, but actually, I will have to go on the field. It would surely help a lot to create patrol plans.

6. Discussion

In this study, we employed a methodology inspired both by system engineering and semi-structured interviews. This approach allowed us to develop a hybrid RFID/GPS system providing both indoor and outdoor real-time human resource tracking, and with the capacity to evaluate the related impacts on individuals and organizations. We believe that our experimental study which followed a "theory in-use" approach instead of a "theory espoused" one [18], was appropriate to find relevant answers to our three complementary questions.

In fact, our results proved that it is technologically possible to develop an innovative real-time tracking system using RTLS technologies and GPS. The respondents suggested a few improvements to the prototype so as to make it fully operational. In particular, they suggested to modify the refresh rate, and to improve the accuracy and exactness of the system. Since the study was carried out within an experimental context, we had to make technological choices that influenced the system characteristics. However, the respondents stressed the importance of bringing about the necessary changes before the permanent implementation of the system to ensure its adoption. The guards' recommendations reinforce the importance of implementing a system with as little functional defects as possible, so as to avoid users' reluctance and encourage its use [2].

In addition, our results brought out a key point, on which all the security guards agreed, that is, the importance of clear organizational directives. The organization's and the superiors' intentions regarding the use of this system, quickly appeared to weigh heavily in the guards' decision on whether or not to adopt the system. The idea that the superiors might have access to the data made several security guards very uncomfortable. Some others were more open, but clearly expressed their need to know the true intentions of the organization with respect to the system, and more particularly relative to the use of the data. The importance given to organizational directives also appeared with regards to perceptions of justice and of privacy invasion. As some other authors have also observed in similar contexts [9-11], the perception of privacy invasion and the perception of justice are essential to understand individuals' reaction towards certain types of information systems. We will discuss each of these concepts in the following paragraphs.

Privacy protection is defined as the right for individuals, groups or institutions to determine for themselves when, how, and to what extent information about them is communicated to others [19]. One of the major characteristics of privacy protection, for individuals, is the right to move anonymously [19]. Consequently, tracking the position of a person is considered sensitive information that directly affects privacy [20]. We found contradictions in the interviewee's responses regarding the perception of privacy invasion. These contradictions can be explained by imagining a pair of scales in which, on one side, there would be the perceptions of privacy invasion, and on the other side the perceptions of individual security (benefit) Individuals will accept to be tracked as long as the perceived benefits exceed the inconveniences [10]. Therefore, using the system as a working tool to ensure the guards' safety made it acceptable for several guards to give up a little of their privacy, which they considered less important than their own security. Yet, the perception of privacy invasion became very important for the guards had the system been used to control their work.

The perception of organizational justice relates to people's concerns regarding the systems that affect them at work [21]. There are at least two types of organizational justice: distributive justice and procedural justice. The first one deals with the justice of the result. It is inspired by the equity theory, according to which individuals compare their "effort / remuneration" ratio with that of others [21]. Whereas procedural justice refers to the perceived justice of politics and processes used in decision-making [21]. Therefore, when the processes leading to a decision appears to be fair to a person, the latter is usually more satisfied with the decision rendered than a person who sees the same processes as unfair [21]. Surveillance and tracking systems mainly refer to procedural justice, as they are part of the tools used to evaluate work. Within the framework of our study, the security guards considered that the use of the system as a means for evaluating their work would have been absolutely unfair. Moreover, they apprehended the informal judgement their managers or colleagues might formulate about them, on the basis of erroneous information provided by the system and, consequently, felt that the tracking was unfair. Conversely, the use of the system as a means to support their work was considered as perfectly fair.

Lastly, we focused on evaluating the potential impacts of such a real-time tracking system on organizations. The respondents indicated that the usefulness of such a system was mainly to rapidly provide vital information to support decision-making in emergency situations. The respondents mentioned that the ability to immediately know the security guards' position in an emergency, would contribute to improve the security service response times. In fact, they underscored that the broader the area to cover and the greater number of people to be tracked, the more useful

the system would be. Finally, the supervisors mentioned their interest in using the data provided by the system to analyse the patrol patterns and thus to optimize the efficiency of the patrol, and thus, optimize the use of human resources and improve the global safety of the area.

6.1 Limits of the Study

The results presented herein must be evaluated within the limits of the study. We must reiterate that the prototype was tested in a real, but controlled, environment and for a short period of time. No emergency situations occurred during this period, which limited the global scope of our experiment. Yet, the guards referred themselves to past experiences so as to infer the potential usefulness of the system. It may also be possible that working in an experimental context, the guards may not have used the system as seriously as they would have in real life. We decided not to change the guards' working practices during the experiment, which might have limited the potential benefits related to the use of the system. Therefore, care should be taken when generalizing the results of this study to other organizational contexts. Finally, we chose not to allow the supervisors to have access to the data, which may be considered a limit to generalization. However, this choice proved to be relevant since it not only encouraged the guards to participate in the study, but it also emphasized the influence of the organizational directives on the guards' adherence to such a system.

6.2 Managerial and Theoretical Contributions

Various research avenues are now opened and the implications of our study are numerous.

First of all, our community would benefit from a better understanding of the underlying reasons why some guards refused to be tracked in our experiment. Since only one non-participating guard accepted to share his reasons for not being part of the study, in this paper, we were unable to provide, any satisfactory explanation for this issue.

Moreover, we noticed important contradictions in some of the participants' responses, particularly in relation to the perception of privacy invasion. We believe that in order to better understand how the tracking systems impact the perception of privacy invasion, it is necessary to study the source of these contradictions. Some of our observations indicate that individual characteristics could be an important determinant in perception of privacy invasion, as observed by other researchers [22]. We believe that this issue should also be explored in future research. This could help us to develop tracking systems that may be accepted more easily by users.

Also, our results proved that this system could be useful in various contexts in which indoor and outdoor tracking is necessary. The system could support, for example, crisis management when actions need to be coordinated (civil crisis, police response, fire, etc.) [5]. It could also be useful in hospitals, whether to track high-risk patients, or health care professionals. In fact, the system we have developed could easily be adapted to other contexts. A better understanding of the adoption process for this type of system could support the success of its implementation, as well as the realization of potential benefits for individuals and organizations.

Finally, managers wishing to set up such a system in their organizations should, so as to fully capitalize on the potential benefits, draw particular attention to the employees' perceptions of the way the organization will make use of the system and the generated data. Such systems should clearly be presented and used as tools meant to support the work of employees and not used as control tool. Therefore, the planning of the implementation processes should incorporate intensive communication activities aimed at clarifying the organization's intentions, in order to build trust and acceptance of these systems.

To conclude, within the framework of this research, we have developed a unique and innovative system that combines dynamic mapping, GPS positioning and RTLS positioning. One of the most important issues resulting from use of this type of system is whether or not the privacy breaches that may arise would be compensated for by an improvement of collective safety. Within the current national and international contexts where, on one hand, authorities impose security measures – for example counter-terrorism or gun control -, and on the other hand, individuals claim their legal right to privacy, this matter appears particularly relevant. Consequently, this should be subject of further exploration, and we encourage academic community to work in this direction.

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