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IT Based Vehicle Tracking System for Effective Management in Public Organizations

Can Aydin[a*], Cigdem Tarhan[a], Vahap Tecim[a]

a Dokuz Eylül University, Department of Management Information Systems, Dokuzçeşmeler Buca- Izmir 35160, Turkey

Abstract

With today's changing public management approach, it's intended for public institutions to offer more efficient and effective services with a lower cost. In this study, the extent of performance improvement has been revealed in accordance with the determined performance criteria using transportation services information technologies in public institutions. The institution's current performance was evaluated. It became evident that public institution's needed an information system to keep vehicle fleets under control. The impact of the vehicle management application was repeated using the performance assessment made above. It was determined there was a minimum of 25% decrease in vehicles cost and expenses.

Keywords: Management Information System, Information Technology, Vehicle Tracking System, Performance Criteria, Decision Support System

1. Introduction

In recent years the search for an effective and efficient government approach has led to the questioning of how public institutions are run. The assessment that government operations are slow and resource usage is inefficient has revealed the necessity of a transformation within public administration. In accordance with the transformation of public administration in recent years, information technology (IT) has been used in order for public resources to be used efficiently, effectively and economically in line with intended purposes. There are many studies related to information technology (IT) use in the public sector by Bilgin (2004), Cevik (2008), Ates (2007) & Kurnaz (2007).

* Corresponding author. Tel.: +90-232-301-0788; fax: +90-232-420-10-25.
E-mail address: can.aydin@deu.edu.tr

However, in literature there are no sufficient studies related to the measuring of performance impact and IT use in public institutions. In this concept, this study is considered to be an opportunity for new research. In the last 25 years, along with the increase of population the public sector has grown rapidly. While the ratio of public expenditure to GDP was 18% in 1980, this ratio increased to 28% in 2013 by IIA Report (2012). Expenditures on information technology have increased at the same rate as public expenditures. According to IHS Global Insight's 2011 study, while the ratio of IT expenditure to the total public expenditure is 2.7% in the USA -the leader of IT investments- this ratio is 0.4% in our country by IIA Report (2012). Therefore, the need for decision makers to measure whether large IT disbursements contribute to the improvement of public institution's performances has arisen.

IT plays an import role in the enhancement of efficiency and effectiveness in public administration in various ways by NASCIO (2006) & NASCIO (2007). Firstly IT, automates tasks that need manual and intensive labor, procurement and human resources management. The further extensive use of current assets of automation public institution's and human resources that come along with the spreading of IT helps protect the expenditure a significant amount. Secondly, IT provides various information regarding public personnel and citizens public administration. In this context, there are very few experimental studies related to revealing the value of IT or the approval of arguments in public institutions by Pang et al. (2011).

Improvements of current indicators recovered by performance evaluations made within the institution are among the primary objectives of the organization. Within this scope, methods such as quality management, development of human resources, following and implementing new technologies, improving team work, good governance, and executive precaution can be mentioned in relation to performance enhancement by Holzer and Yang (2004). With developing technology making management operations more complex, the use of new technological possibilities that will provide an effective service with information systems will be inevitable. Besides this, in recent years new technologies have started to be used effectively through qualified personnel employment. Consequently, the reconfiguration of public institution information technologies has introduced the concept of public administration in accordance with social and technological developments beyond classic bureaucracy by Yıldırım (2010). The aim within the context of this study was to insure an increase in the performance values within the institution in the scope of following new technology and application.

In recent year's innovations in the area of technology can be summarized under three main headings: mobile applications, the growth of online software as a service and cloud computing services by Laudon and Laudon (2010). Day by day more businesses are carrying their software from PC or desktop computers to online environments. Public institutions have made significant progress regarding the use of this online software. One of the complicated management operations that stand out is monitoring and management of public institution vehicles. The increase in the number of vehicles and costs in the recent years has shown that in terms of large-scale organizations, having an effective vehicle tracking and management information system in order for vehicles to be used more efficiently is of vital importance. When analyzing literature there are many studies in the field of the use of information technologies in public institutions. In this context, the effects of information technology use in the logistic sector on company performance were examined by Tekin et al. (2005). A survey was given to companies operating in the logistic sector to reveal how much they benefit from information technology. As a result of the survey, it was considered necessary for companies to primarily make use of management information systems and fleet vehicle tracking satellite systems in the field of information technology. In light of the above-mentioned information; due to the aim of public institutions to make use of information systems just as much as companies, this study serves as reference in regard to the necessity of an effective vehicle tracking and management system. Another study is the e-government applications as part of the reorganization in public administration made by Balci and Kirilmaz (2009). In scope of the study, the priority evaluation of e-government objectives made by the State Planning Organization was set forth. In context of these objectives, it is seen that the planned vehicle tracking and management information system coincides with e-government target priorities such as the improvement of service quality, enhancing internal productivity, increasing transparency, paperwork elimination, improvement of the decision making process, increasing revenues. In light of all these studies; by using an efficient vehicle tracking and management system and utilizing information systems in public institutions, the enhancement of corporate performance is provided. Besides, the fact that no studies have been made on the subject of efficient vehicle tracking and management information systems in public institutions has encouraged us. Also having the study done in line with the strategic objectives determined by the institution employees, has made it used much more efficiently than the system that will be established by taking the individuality and package vehicle tracking systems.

In this context with vehicle tracking and management information system, a radical change in work processes within the institution and precautions such as time and cost savings resulting from new technology applications will ensure the institution work more efficiently and effectively. In order to measure the extent of the effect, the performance criteria applied to the existing system was compared by reassessment.

2. Theoretical Background and Hypothesis

Public institutions are gradually growing along with the development of our country. However, often a cumbersome bureaucratic structure comes along with public institutions that grow unreliably. As a result, problems such as clumsiness, paperwork, increasing costs, inefficiency have started to arise. Internal and external auditing in Turkey is conducted far from the performance auditing concept. Similarly, not being able to benefit from information technology sufficiently has led to problems in the current system. IT has three different roles in institutions that can be listed under automation, disclosure and transformation by Anderson et al. (2006). The first role, automation is to perform business processes automatically without using manpower. The disclosure role is the decision makers using the data collected by the IT infrastructure and having the public be informed of this information. Lastly the role of transformation is getting the institution to change their decisions. The applications within this study assume these three roles. When literature is analyzed it is seen that the automation and disclosure roles lower in-house costs.

In our country there are many projects that aim to increase efficiency by switching to automation using IT. For example by Informatics Association of Turkey (2005), the Ministry of Justice completed the Nation Judiciary Project with the aim of finalizing cases as quickly as possible and with minimum cost. With this project, the Ministry of Justice's entire data was transferred to a central database, business processes were redesigned and these processes were transformed into web applications. This helped create a fast, functional, effective, reliable and transparent jurisdiction mechanism. With this project, The Ministry of Justice has cut back 459 million Euros over the past decade by National Judiciary Informatics System (2014).

Another IT-based project is the Land Registry and Cadastre Information System (TAKBIS). The aim of this project is to transfer all the land registry and cadastre records to a computer environment, for all operations to be carried out using IT infrastructure and with this to provide an effective tracking and control of private or public property. Like other e-government projects, in this study data has been digitized from paper and system automation has been implemented. In this context in-house costs have decreased by Gungor et al. (2009).

Corporate performance measurements have to be made in order for productivity of public institutions to be determined. Performance measurement is the comparative evaluation of the input, output and outcome of a programme or activity. Improvement can be seen by comparing indicators used in performance management and indicators obtained from the current situation and improvements made by Balci (2009). It has been observed that in the early 2000's performance management has been brought to the agenda of public institution's and applications have been implemented in real life. Bilgin (2004), Cevik and friends (2008) have taken a theoretical approach to performance management in public institutions. Also, the studies of Ates (2007) and Kurnaz (2007) that touch upon corporate performance management in municipalities are mostly examined with regard to performance management applications. Akdogan (2007) has indicated, a service quality measurement using a performance evaluation system when evaluating the effectiveness of activities conducted by the government. Therefore the hypothesis put forward within the scope of this study is: "IT has a positive contribution to the performance increase in public institutions."

The measurability of the services provided in public institutions is very hard. For an effective performance evaluation, numeric data needs to be converted in order for services to be measurable. With Robert Kaplan's "If you cannot measure you cannot manage, If you cannot define you cannot measure." approach, the results of work done and services given within an institution need to be evaluated and measured according to the underlying performance indicators. Accordingly, the level of realization of criteria for the work done such as good-bad, successful-unsuccessful or figures can be deduced based on these evaluations by Ozer, 1997. For a reliable evaluation the aforementioned criteria such as good-bad, successful-unsuccessful need to be digitized like other numeric criteria. In this context first of all the performance criteria of the institution needs to be determined. In order to determine the performance criteria, the manner of work and work processes of the institution must be uncovered. In this scope, the existing work processes of the institution were laid out.

Failing and problematic areas in the work processes were determined. Within this study, in order to evaluate the current operation performance the determination of the above-mentioned criteria was ensured. The performance

criteria used when managing performance within an institution is determined in the strategic action plan. In this study however, due to a performance criteria not being determined within the strategic action plan, the criteria was determined as a result of interviews with corporate employees. Accordingly, 12 performance criteria were collected under the titles labor, cost, and service (Table 1.).

Table 1. Institutional performance criteria.

Criteria	Type (per year)
1.Number of full-time employees staff	Labor
2.Total working hours of employees	Labor
3.Total expenditure enterprises (vehicle maintenance and repair)	Cost
4.Total capital	Cost
5.Total fuel costs	Cost
6.Total visited road	Cost
7.Number of expired vehicle inspection	Cost
8.Number of expired traffic insurance vehicle	Service
9.Number of expired periodic maintenance of vehicle	Service
10.Number of "out of route" alert	Service
11.Number of complaints about inability of vehicle	Service

In accordance with the corporate performance criteria determined above, the conversion of services to measurable values was ensured. Thus what needs to be done in order to increase institution performance and the methods that need to be followed can be seen. In accordance with the corporate performance criteria determined above, the conversion of services to measurable values was ensured. Thus what needs to be done in order to increase institution performance and the methods that need to be followed can be seen.

3. Methodology

The study area is Dokuz Eylul University (DEU), which is the second biggest public organization in Izmir and in Aegean Area (Fig. 1). Its annual budget is approximately 200 million Euros. DEU is a public organization which maintains education activities in 17 different campuses in Izmir (Fig. 2). This study performs within supporting services department in DEU. Supporting services is in charge of the maintenance and repair of 103 vehicles which include 53 automobiles, 7 minibuses, 13 buses, 4 trucks, 16 vans, 2 ambulances, 1 fire brigade, 4 tractors in the university. Nevertheless supporting services department performs vehicle management process manually without using any information technology.
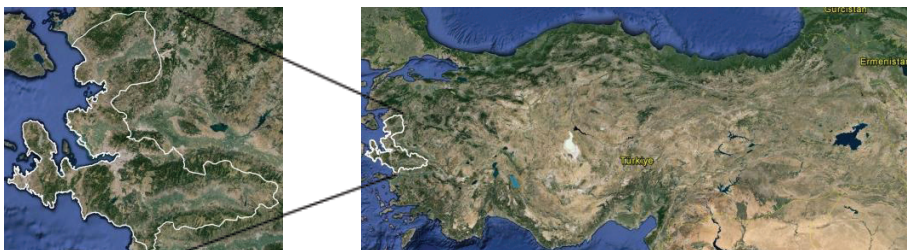

Fig. 1. Study area, Izmir, Dokuz Eylul University.

This phase will describe how to improve the system after revealing existing system process and define organization performance criteria. In this context, the system should design and manage systematically to develop a more efficient system due to the intended system being an information system. System development life cycle is used to make system development systematical. Waterfall model which was put forward in 1970 by Royce, is used

as a process model during software development process due to having understandable phases and at the same time quality requirements are more important according to budget and time constraints (Fig. 3).
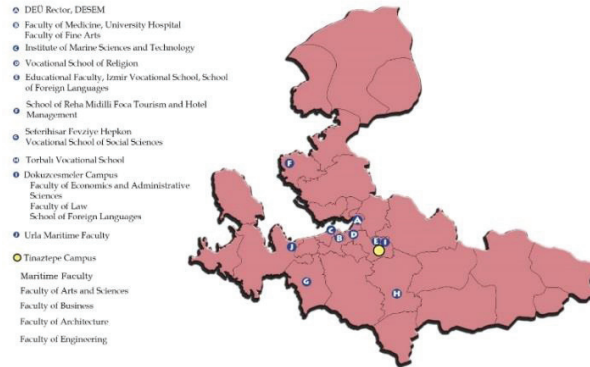

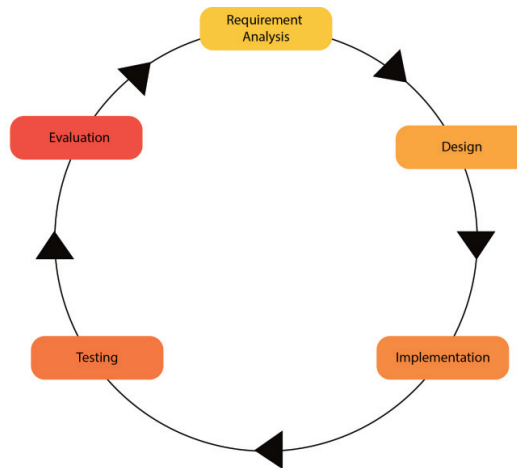Fig. 2. The campus locations of Dokuz Eylul University.

Fig. 3. System development life cycle.

The aforementioned institution operations are analyzed during describing problems phase which is the first phase of the system development life cycle. Halting points are defined in institution and described organizational schema. In this context vehicle management process are made manually within the institution. We observed that vehicle costs are increased due to delaying maintenance and non-performing penalties. For this reason designing and actualizing of vehicle tracking and management system are become a necessity. Institutional performance criteria are designed, demonstrated by numerical expressions and discussed which modules are located in the system at the end of interview with experts (Table 2).

Vehicle tracking and management information system general framework are defined during system design (Fig. 4). Vehicle location, speed and distance data which comes from mounted GPS devices on vehicle are handled into the system. These coordinates are inserted into the database after using some transformations. After, several queries are made from database using reporting tools. Finally active vehicle tracking, license and insurance tracking operations, maintenance and repair reports are achieved for vehicle tracking and management from the website.

Table 2. Institutional performance criteria results.

Criteria	Number (per year)
1.Number of full-time employees staff	5 person
2.Total working hours of employees	8 hour (day)
3.Total expenditure enterprises (vehicle maintenance and repair)	45.000 TL
4.Total capital	90.000 TL
5.Total fuel costs	250.000 TL
6.Total visited road	45.000 km
7.Number of expired vehicle inspection	5 pcs
8.Number of expired traffic insurance vehicle	15 pcs
9.Number of expired periodic maintenance of vehicle	8 pcs
10.Number of "out of route" alert	9 pcs
11.Number of complaints about inability of vehicle	12 pcs

Fig. 4. Vehicle tracking and management system methodology.

3.1. Data acquisition methods

While examining the systems general framework; the first phase is acquiring location data from vehicles. In this context vehicle tracking devices are mounted onto all vehicles in institution. GPS (Global Positioning System) and GPRS (General Radio Packet Service) modules exists in each vehicle tracking devices. First the GPS module communicates with the satellite to get the location data and then this data is sent to the server using GPRS modules. Socket programming protocol are used for providing communication between vehicle tracking device and server. Socket programming provides data transfer between two devises using IP (Internet Protocol) and Port interaction. Socket programming protocol substantiates between client and server. The client sends the connection request to the server and the server grabs this data. Socket programming protocol realizes the connection procedure between two devices in a two different ways. For example in literature, there are two connection protocols known as TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) for data transfer between client and server. The most important difference between these protocols is TCP guarantee data transmission besides UDP protocol. For instance TCP are used as data transmission protocol in World Wide Web which large data packets that are transferred exactly and expected to reveal major problems regarding data loss during transmission. At the same time UDP protocol makes a smaller amount of traffic than TCP protocol. In the light of the above information, UDP protocol is used for requirement small amount data packet and decreasing cost at the same time tolerating data loss (Fig. 5).
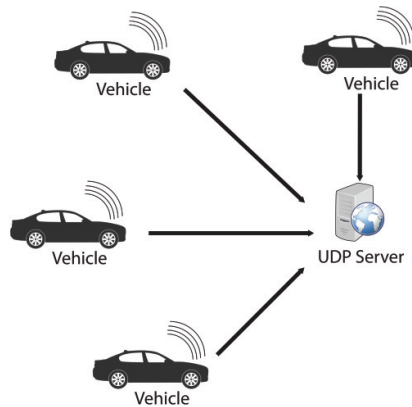
Fig. 5. Data transmission between vehicles and UDP server.

Data packet transferred from the vehicle tracking device to UDP server with GPRS protocol as in Fig. 6. This data packet consists of speed, data, direction, satellite number, distance and altitude data except location data. Some commands are sent to device to start data transfer between device and server. In this concept different commands are used for retrieving different types of data. For example 'VZ' command which is periodic data transfer based on time will be sent for getting data content such as in Fig. 6. The tracking device sends location data and other types of data every 20 seconds. Using many different commands like, periodic data transfer based on distance, over speed, remote emergency situation and remote engine stop process can be made with vehicle tracking device.
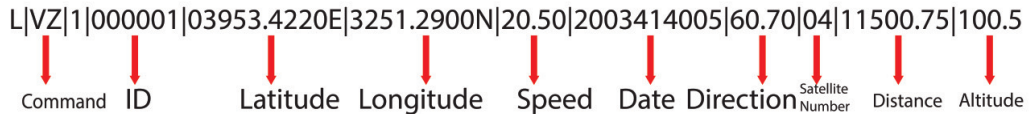

Fig. 6. Structure of data packet.

As seen latitude and longitude information is sent by the device in kilometers format. However this data which is in kilometer format should be transformed into degree format. While transforming data first we separate it from the first two digits and the other digits divided with 60 as seen in Algorithm 1. After, the first two digits and the divided part are combined and result in the final location data in WGS 84 coordinate system.

Algorithm 1 Coordinate Transformation

Inputs: *E Latitude*, N *Longitude*, *X* Latitude result, Y Longitude result
1: **for** i=0 to *N*
2:   **if** *E* exists **do**
3:       $E_1 = E:2$
4:       $E_2 = 2:E$
5:       $E_3 = E_2/60$
6:       $X = merge(E_1, E_3)$
7: **if** *N* exists **do**
8:       $N_1 = N:2$
9:       $N_2 = 2:N$
10:      $N_3 = N_2/60$
11:      $Y = merge(N_1, N_3)$
12: **end**
13: **return**

3.2. Vehicle tracking and management system

Several analysis studies are realized during defining requirements in sight of institution needed during designing system components in tracking and management information system. In this context we decided to make some components such as vehicle selection, new vehicle and task registry, and vehicle selection based on date and department. Vehicle selection realized according to license tag, date and department. New vehicle and task registry modules are designed for using updated data in system. New assignment module is carried out manually on paper form within the organization. We decided to put this operation online because this process is difficult to follow. At the same time the system calculates task stats weekly and monthly and compares them with the monthly gasoline consumption thus this comparison provides more efficient usage of the vehicle. The other statistics reports are insurance and inspection expired vehicles, periodic maintenance expired vehicle, change of camshaft expired vehicle. All these reports are designed with interviewing expert in institution through the requirements. Report modules are determined with needs of experts and have played an active role in solving problems. Originality of statistics reports arise from system development process is gone individually with experts (Fig. 7).
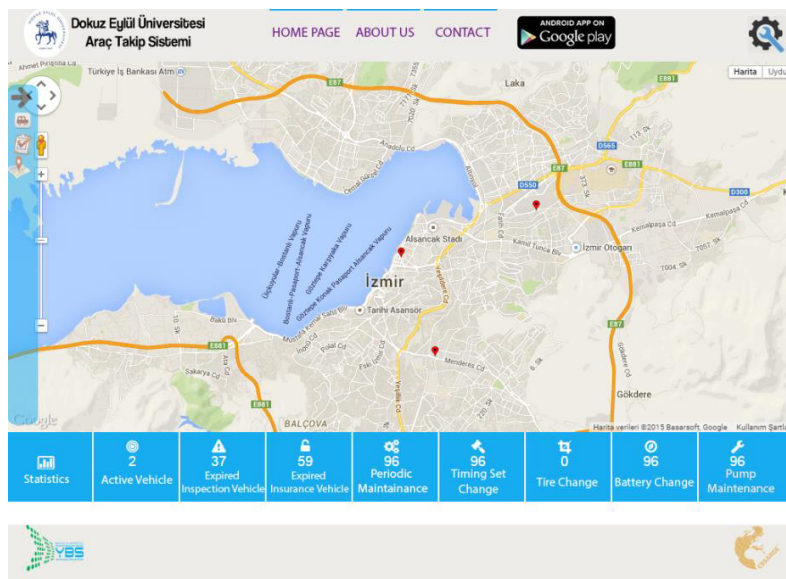

Fig. 7. Statistics reports of vehicle tracking and management system.

In the first stage of the vehicle tracking and management system is inserted into incoming data from vehicles into the system. After realizing coordinate transformation of incoming location data from the vehicle; in the same packet speed, distance and IMEI data are acquired from incoming data packet. Location data is inserted into the database after processing of incoming raw data. MySQL database is chosen because it is open source and suitable to use with the other programming languages which are used in this project. "users" table for system users, "institution" table for departments, "campus" table for campuses of the university, "job" table for assignments of drivers, "vehicle" table for information about devices, "vehicle_location_log" table for keeping instant location of vehicle are created with taking into consideration the system requirements during database design (Fig. 8).
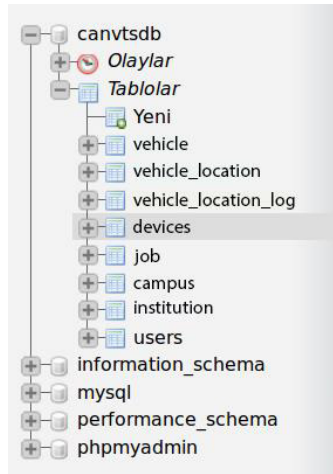
Fig. 8. Database structure

4. Application

The vehicle tracking and management system is composed of three parts: active vehicle tracking, insurance inspection -monitoring procedures and the maintenance – repair parts. All of these reporting procedures are designed in accordance with the specified corporate performance criteria. Besides it provides instant report opportunity to reach all information about vehicles.

4.1. Tracking process of active vehicles

The reporting of the vehicle tracking, which vehicles are working actively outside of working hours by the managers, is an important role for effective management. Thus, as long as the signal is received from the device in the vehicle, this section is monitoring. At the same time, this report gives an opportunity to see active vehicles when a demand is processed. So, the problems about the vehicles between managers and employees could be solved. With this study, it is observed that the number of complaints, total fuel costs, total km and out of route usage problems are reduced (Fig. 9).

4.2. Approval, traffic insurance and inspection process

The increasing number of vehicles causes the increasing costs in the organizations at the same rate. The costs are based on two main fees: vehicle inspection and traffic insurance. Both of them are paid annually. Increasing number of vehicles in the organizations makes it difficult to follow both expenses. In this context, overdue, and yet unpaid traffic or car insurance fees increase vehicle costs. For this purpose, it is followed by the managers using statistical reports can be done easily (Fig. 10). The reduction of vehicle inspection and insurance payments delayed the number of vehicles result in the reduction of total operating costs. Public organizations usually aim to provide the best service to citizens with limited budgetary means. Because of this, reducing the cost of drying the organization aims to provide performance criteria specified by providing a more efficient operation.

4.3. Maintenance and repair operations

It is aimed to use the available resources in the best way via reporting tool as well as license, insurance and inspection process. Thus, periodic maintenance of the vehicles, the timing set, tools such as tire and battery replacement and maintenance of the pump are provided for timely maintenance and repair work. There are certain

limitations of each statistical report. For an example, each vehicle tools in-organization inspection or periodic maintenance at different dates. Likewise, each agent or tire replacement timing set on different dates and intervals. When the number of vehicles considered in the organization of managers has become impossible to manage this complex structure. Moreover, DEU has 17 different campuses in Izmir, because of this, managing these vehicles from a single center is also becoming increasingly difficult. All this work is delayed or canceled in the institution of vehicles increases drying costs seriously. Through this reporting, a significant reduction of costs and an increase in the cost of the service quality of organizations have been identified. The system automatically becomes one of the most important aspects of the use of information technology. Thus, maintenance and repair operations are provided to efficiently perform consistently at the right time by following all of the tools necessary procedures. The automatic system provides eliminating the human error at the lowest level.

Fig. 9. Active vehicles

Fig. 10. Statistics reports

5. Discussion and Conclusion

The scope of the study demonstrates whether Information Technology increases the efficiency of public organizations. Firstly, the needs of the organization are determined and then measured its performance indicators. The interviews with the organization's employees are used in order to determine the needs, so, IT based vehicle tracking and management system is established in terms of the needs. With the starting of this system, the organization's predetermined performance indicators, car costs and corporate expenses have been found to be re-assessed by a decrease of 25% (see in Table 3).

The results of the study proved the study's hypothesis, "IT infrastructure has a positive contribution to the performance increase in public institutions." Additionally, the system allows the users to perform "automate" and "informate". The "automate" means that saving the coordinate information automatically into the system and then providing information about the update status of the vehicles. At the same time, many reports are produced during

the "informate" process for decision makers in order to manage the vehicle efficiently. During the study, a decrease is observed from the cost of vehicles in terms of fuel consumption and corporate expenses and also the penalty costs. As discussed earlier, the Ministry of Justice is an example of this result. With IT based National Judiciary Informatics System project, the ministry has saved 459 million Euro in 10 years. It is clearly stated that IT based studies cause reduction in costs of the organizations.

Table 3. Institutional performance criteria comparison between 2014 and 2015.

Criteria	2014 values	2015 values
	Number (per year)	Number (per year)
1.Number of full-time employees staff	5 person	5 person
2.Total working hours of employees	8 hour (day)	8 hour (day)
3.Total expenditure enterprises (vehicle maintenance and repair)	45.000 TL	33.000 TL
4.Total capital	90.000 TL	65.000 TL
5.Total fuel costs	250.000 TL	200.000 TL
6.Total visited road	45.000 km	35.000 km
7.Number of expired vehicle inspection	5 pcs	-
8.Number of expired traffic insurance vehicle	15 pcs	-
9.Number of expired periodic maintenance of vehicle	8 pcs	-
10.Number of "out of route" alert	9 pcs	2 pcs
11.Number of complaints about inability of vehicle	12 pcs	2 pcs

This study also provides staff satisfaction. The organization's employees are more than the number of vehicles. The limited number of the vehicles increase demand in the organization. Moreover, mismanagement of these limited vehicles is another subject of complaints in the organization. In this context, following the vehicles instantly by managers provides the vehicles to be used only for duty. Thus, the increase of performance values was achieved in-organization.

During system design and realization, the package software is not used. Instead of them, the system design was prepared by working with organization's staff. This makes the system unique and flexible. At the next step of the study, it is going to be planned that spatial based route control and report. Additionally, this system is going to be tested in another organization, so, it will have the opportunity to compare the results of different organizations.

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