Automatic Traffic Enforcement Camera Operation, Based on a Business Intelligence System

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Abstract. Since 2012, a new automatic traffic enforcement camera project has been in operation in Israel. Several databases are included in this project, i.e. sensor data, traffic reports, and road accident records. In 2014 a business intelligence system was developed to obtain all the data from the sensors of the new project and to merge them with the existing data to run the project effectively and efficiently. The aim of this paper is to present the process and the configuration of the business intelligence system, and to present the improvements in all measurements. In this paper we demonstrate the importance of a business intelligence system for operating, engineering, researching and managing aspects of a project.

Keywords: Business intelligence · Automatic traffic enforcement cameras · Traffic police

1 Introduction

The new project of automatic traffic enforcement digital cameras, which detects red-light offenders and speeding drivers, was established in Israel in 2012. Each enforcement site includes electromagnetic loops in the road as sensors of the passing vehicles, and a pole next to the road, which is connected to the sensors. There is an option to install a camera in the pole to record the offences. At the end of 2015 there were around 150 poles and 100 cameras. The data collected from the sensors in each operated site is data per vehicle, which pass on the electronic loops. The data includes time, location, the vehicle's length, a measurement if the vehicle performs an offence, and validation indexes of the data. This database includes around 40 million records per month, therefore it increases rapidly. After two years of gathering these records, it was recognized that a business intelligence (BI) system is crucial for analyzing this database and to merge this new database with other existing databases of traffic reports and road accident records, to optimize the project's benefit for maximal quantity and quality tickets for better deterrence to reduce the number and severity of accidents. To run the project effectively and efficiently, three levels of users have to use this BI system: (1) The control and operation unit that wants to detect timely problems in the flow for

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operating the project smoothly. (2) The research unit responsible for two aspects of strategic and tactical planning: camera mobile planning between the poles in the planning horizon and determining the enforcement's speed level per camera, per period according to the limitation of the resources. (3) The project management's aim is to reduce the bottlenecks and waste in the system. The BI system has to operate throughout all the stages: Detect the sensors' operations, obtain the sensors' data, present the data, convert the data into information, help the different units obtain knowledge from the information, and in the last stage help the workers perform actions to improve the output from the project. The aim of this paper is to present the process and the configuration of the business intelligence system, which was built specifically for the automatic traffic enforcement camera project, and to present the improvements in all measurements as the results. This paper is organized as follows: Sect. 2 is devoted to a literature review. Section 3 describes the stages of building the BI system. Section 4 presents the configuration of the business intelligence system. The results are presented in Sect. 5. The final section summarizes the paper and makes suggestions for further developments.

2 Literature Review

In this section, we discuss research in the literature that is covered in this study, including road safety and automatic traffic enforcement cameras (Sect. 2.1), and business intelligence (Sect. 2.2). To the best of our knowledge, this is the first time an integration of the two subjects has been presented.

2.1 Road Safety and Automatic Traffic Enforcement Cameras

Approximately 1.25 million people die each year as a result of road accidents worldwide. These road accidents cost approximately 3%–5% of the countries' gross national product [1]. One of the causes of road accidents is traffic offences and speed is one of the main violations that contribute to road accidents, mainly severe ones. For example, for every 1 km/h decrease in the average speed, there is an estimated 4% reduction in the number of accidents [2, 3]. In general, on average, 40–50% of drivers drive faster than the posted speed limit [2, 4–6]. In addition, larger differences in speed between vehicles are related to a higher accident rate [7]. Therefore, an effective road safety strategy needs a balanced approach on three aspects: engineering, education, and enforcement [8].

In this paper, we focus on police enforcement. Traffic police has limited resources, therefore it tries to maximize the benefits from available resources and use effective operation methods. Speed offences can be enforced manually in the form of a police officer with a laser gun who gives a ticket on site, or generates an automatic ticket where the vehicle is spotted as an offender and the owner of the vehicle gets a ticket in the post. Because the traffic police currently has limited resources, they are assigned to tasks that cannot be automated [2, 5, 8].

In 1958, the world's first speed measuring device and the first speed camera used to enforce traffic law was introduced. Since then, many countries have been using speed and red-light enforcement cameras [9]. However, the automatic enforcement camera technology, like any resource, is expensive and cannot be deployed everywhere at all times [5]. Therefore, operational methods should be developed as is described in this research.

2.2 Business Intelligence

Organizations have rapidly increasing volume, velocity, and variety of data from many resources and it is necessary to analyze it and make decisions. Business Intelligence (BI) tools help the organization in this aspect [10].

BI systems are a combination of operational data (gathering and storage) and analytical tools for knowledge management at several levels in the organization, i.e. the planners and the decision makers. The BI systems are based on techniques, technologies, methods and applications that analyze and visualize the data to help understand the business performance and make better future decisions to increase value and performance, by time and quality [11, 12]. BI improves the efficiency and effectiveness of the process chains inside the business on one hand, and strengthens the business's relations with customers, suppliers and competitors, and improves strategic and tactical decisions on the other hand [11, 13–15]. The BI system helps the organization in the dynamic business environment with incomplete information, multiple sources of information, and noisy data. It gives a fast response, despite the complexity and several objectives and possible solutions [16]. In addition, the BI system helps to forecast future trends, to implement plans, and to achieve goals in a proactive way [11]. There are several definitions of BI in the literature, as mentioned above. The best definition for our case study is from [10] - A system comprised of both technical and organizational elements that presents its users with historical information for analysis to enable effective decision making and management performance.

BI systems are currently moving from "data-aware" information systems to "process-aware" information systems, because in many organizations the "workflow management" or the "business process management" is the key factor for success in the dynamic and knowledge-intensive world, to improve performance indicators such as cost, quality, time, and flexibility. Therefore, businesses are increasingly interested in improving the quality and efficiency of their processes and the BI systems are changing into a Process-Aware Information System (PAIS) to react to changes in its environment in a quick and flexible way. PAIS helps to manage and execute operational processes involving people and information sources. PAIS uses process mining on the "recording events" or the "event logs" and provides support with the control-flow, based on various forms of analysis (e.g., simulation, monitoring, delta-analyses) and using a constraint-based process modeling approach. There are several options for PAIS. In the workflow management systems, mainly a Person-to-Application (P2A) system is being used, since its primary aim is to make people and applications work in an integrated manner [17–20].

Best practice examples for BI/PAIS systems are mainly from the telecommunications, retail, aviation, finance, healthcare, and automotive industries. The objective is to increase the quality of the service units in these industries: call centers, check-in and production processes [18, 19, 21].

The BI literature has been silent on how BI creates business value and only a few studies have been published on BI for a working team at a macro level [22]. Our paper strives to contribute to these subjects. We will describe in this paper our novel BI system for the automatic traffic enforcement camera project as a Process-Aware Information system (PAIS) for several units working as one team for the project, for business value.

3 The Stages of Building the BI System

The new digital automatic traffic enforcement camera project was started in 2012 by the Israel traffic police together with a private company as a PPP (public-private-partnership) project. The private firm that won the contract is responsible for the equipment's installation and the operation aspects (the electromagnetic loops, the poles, the cameras and its illumination, and the relevant software). The traffic police is responsible for the enforcement operation aspect (fixing the enforcement speed level per camera, detecting the offences and producing the traffic tickets, sending the tickets to the vehicle owners, answering letters from the drivers, and prosecuting the ticket in court). A byproduct of the project is the traffic parameters data, which is gathered from the installation of the sensors in the roads, for each of the passing vehicles on the electromagnetic loops. This huge database was gathered by the private company only. In mid 2014, a decision was made that all the data from the sensors collected from all the passing vehicles is important for improving the enforcement by combining it with tickets and road accident data. Therefore, a BI interface was selected and the relevant human and technology resources were allocated to build it on Qlikview, the organization's existing BI platform. There were three stages in the process of building a BI system for this project.

3.1 Definition of Needs

The new imported data from the sensors is a unique database of information that will be used for three learning purposes: (1) management– summary, trends, and irregular data represented in tables, graphs, and maps as management and control reports; (2) operations – balance and control of the loads at each working station in the enforcement system (encoders, prosecutions, answering drivers' queries, etc.); (3) researchers and engineering – in-depth investigation of the data over time combined with other BI platforms for road accidents and traffic tickets. Each of the purposes was analyzed and the workers were asked what their needs were. An evaluation of all the needs gave rise to the idea of building several screens that will be suited to all the users, each user with his needs to operate the system: view, drill down, quick output for presentation or to use in other software for further analytic work.

3.2 Building the Database According to the Information Definition

The strategic decision was to “pull” all the historical data to date and include all the record fields from the sensors and import them weekly to the BI system. Therefore, we now have all the data for all the vehicles that pass on the electromagnetic loops. Each vehicle’s record include these fields: location of the vehicle (site number, lane number, and driving direction), time of the event, for vehicles that cross a junction – the color of the traffic light (red, yellow or green) and the crossing time from the beginning of this color, traveling speed, vehicle length and validation parameters for the speed and length data. This database is added to the other databases at the organization: road accidents and traffic tickets as a whole and especially at the project sites, and the current status of the project operation (operated cameras, level of enforcement per camera). Merging all databases gives us the option to “push” analytic results to the different units in the process. Figure 1 demonstrates the project’s UML (Unified Modeling Language) diagram.

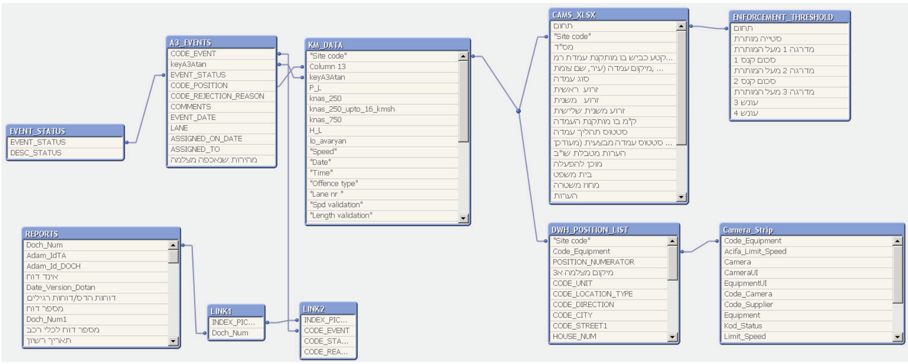


Fig. 1. The UML diagram

3.3 Analysis of the Data

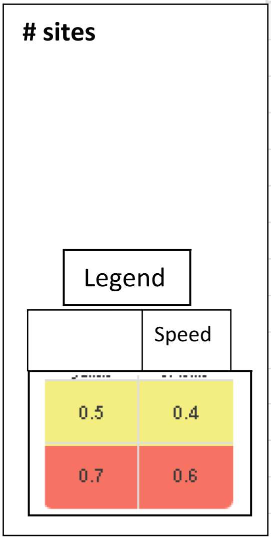
Several designated screens were developed for all the management-operational-research aspects with comparable GUI (graphical user interface) for the different users. In the next chapter, the configuration of the screens will be demonstrated.

4 The Configuration of the BI System

Several screens were developed in this new BI (business intelligence) system based on the process characterization from the previous chapter to address the needs of all the users, taking the sensors’ data into information presentation, formatting it into knowledge that will help to perform actions in the automatic traffic enforcement camera project. All the screens are dashboards with interactive graphical displays. The users can have a high-level view or click to choose a specific parameter or different display (graphical, table, or export to Excel).

4.1 A Statistical Data Screen

This is the default home page of the BI system, when a user enters the system. It is a table presentation of the statistical data per site as shown in Fig. 2. Each site is a row in the table. The columns are the statistical values that are important for road safety and enforcement policy. The parameters in the columns are: the speed limit, traffic count (number of vehicles crossing the electromagnetic loops per chosen period), total measurement days per chosen period, average speed, the percentage of vehicles driving above the speed limit, standard deviation (Stdev), and the speed on the 85th percentile of the speed distribution. The size of the table is flexible and can be decided by the user: selective periods, select several sites by group (type of camera, type of road, etc.) or a specific site and selective statistical parameters. The table can be sorted according to each of the parameters in the columns. Exceptional values like the percentage of vehicles driving above the speed limit and the standard deviation have been colored according to severity: no color – low importance; yellow – medium concern, and red – high concern.



Year	2015						
Speed limit	Traffic volume	# of days	Average speed	% above speed limit	Stdev	Stderr	% 85th
70	2,620,368	221	69	0.00%	12	0.00737	80.00
110	4,164,865	147	95	0.00%	13	0.00616	105.00
100	8,892,543	239	91	0.00%	15	0.00506	102.00
100	15,883,502	304	89	15.30%	16	0.00400	101.00
80	2,288,483	186	74	0.00%	13	0.00844	85.00
70	628,835	46	70	0.00%	16	0.01990	83.00
80	1,849,907	110	76	35.70%	13	0.00988	87.00
90	1,729,470	107	84	0.00%	11	0.00856	93.00
100	10,514,687	142	77	10.73%	27	0.00821	98.00
90	11,019,025	258	87	43.08%	17	0.00502	99.00
80	5,426,460	357	75	31.28%	14	0.00590	86.00
70	1,507,166	58	74	64.49%	14	0.01139	86.00
80	1,607,826	282	77	45.31%	17	0.01368	90.00
80	4,014,267	351	78	38.56%	11	0.00556	87.00

Fig. 2. The statistical data screen (Color figure online)

Two models run in the background: (1) summarizing the sensors' data log into the statistical parameters per period and (2) coloring the uncommon and high parameters for visibility.

This screen enables engineering to understand the drivers' behaviors versus the road design. It gives the operation unit recommendations on where to mobilize a camera from an out of order site to a site with the highest percentage of offences. The research unit can evaluate the influence of enforcement on the road safety parameters.

The goal of the enforcement project is to reduce the average and deviation of speed, mainly on the sites that are marked with color.

4.2 Traffic Count and the Offences Distribution Screen

This screen graphically displays information and knowledge for the traffic police, of the entire picture of the speed offences in the project as shown in Fig. 3. First is the “big picture”, how many offenders there are. Figure 3a demonstrates that in 2015 around 14% of the vehicles that cross the enforcement sites drove above the speed limit, and are therefore offenders. It also showed the total number of vehicles passing the sites, totaling around 350 million. In Israel there are around 3 million registered vehicles [17], thus on average a vehicle passes the project’s sites around 117 times per year. Figure 3b zooms into the offender distribution according to level of offence, from low offence with fine and no points, to severe offence with court summons. Figure 3b demonstrates the total offender distribution and Fig. 3c demonstrates a zoom of each site with the offender distribution. This screen gives management a holistic look at the offences in the project and zooms in to specific sites. The goal of the enforcement project is to reduce the number of offenders, mainly the offenders in the top end of the speed distribution.

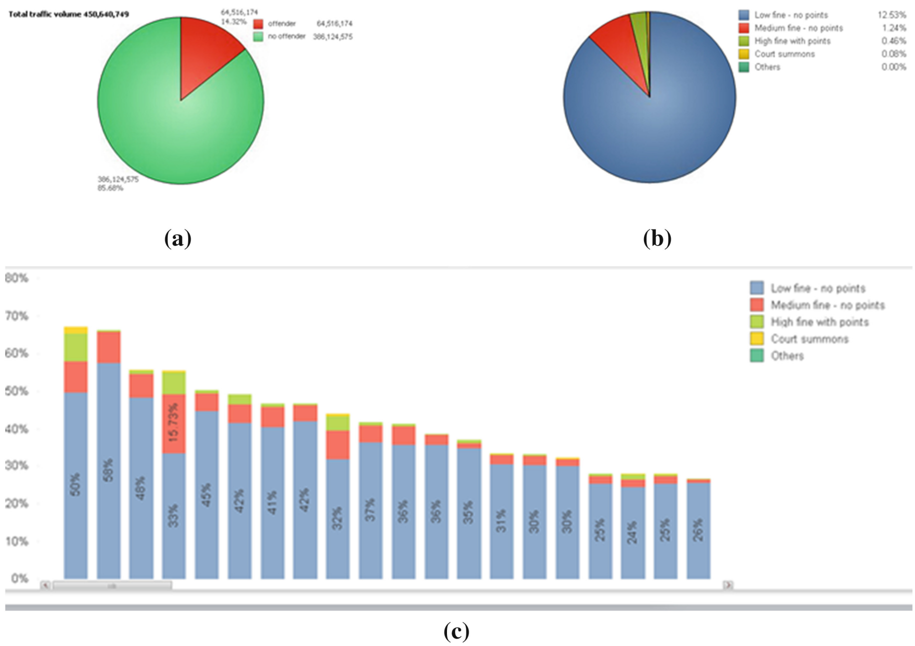


Fig. 3. (a) Speed no offenders/offenders distribution. (b) Speed offenders distribution. (c) Speed offenders distribution per site

Two models are running in the background: (1) summarizing and coloring the offences groups per site and per period and (2) summarizing and coloring the sensors' data log into offenders and non-offenders pie.

4.3 A Control Panel

A graphical presentation for irregularity in the data is presented in this screen. The model that runs in the background is a summary of all the vehicles in the sensors' data log per month and year. The information is summarized so that it can be seen visually from the graphs. For example, in Fig. 4 the operation users can see the month when the cameras were operated and the number of events per month. This specific camera began to be operated in mid August 2012 to November 2013 and then for brief periods in January–February 2015 and October–December 2015. With this information, the operation unit can follow the operation plan and supervise the private company work. For example, is it according to the plan that there are no events in 2014 and in March–September 2015? The research unit can analyze the decrease in the number of events between November 2012–2013 and November 2015. Or why is there a decrease in the number of vehicles passing this site in January 2013 and 2015?

Fig. 4. Monthly operational data

4.4 An ID (Identity Card) of a Site

This screen is a drill down into a specific site with a graphical presentation of all the important information for engineering, control, and research units. The road safety parameters are demonstrated in several aspects according to desired information for the enforcement in this site. Figure 5 shows all the graphs that are shown together on the same screen, to see the "big picture". The screen is divided into four graphs: (a) speed distribution; (b) traffic count per hour; (c) the distribution of vehicles entering the junction on a red light and its speed and (d) the distribution of vehicles entering the junction on a yellow light and its speed. For each graph, a model is run in the background per site and per period to create the specific distributions from the parameters in the sensors' data log: (a) creating a speeding distribution; (b) creating a traffic count distribution; (c) creating traffic count and speeding distributions when the red traffic light is operated; (d) creating traffic count and speeding distributions when the yellow traffic light is operated;

This data can help the engineers to understand driver behavior according to the traffic light schedule and the junction's construction. From Fig. 5a we can see that there

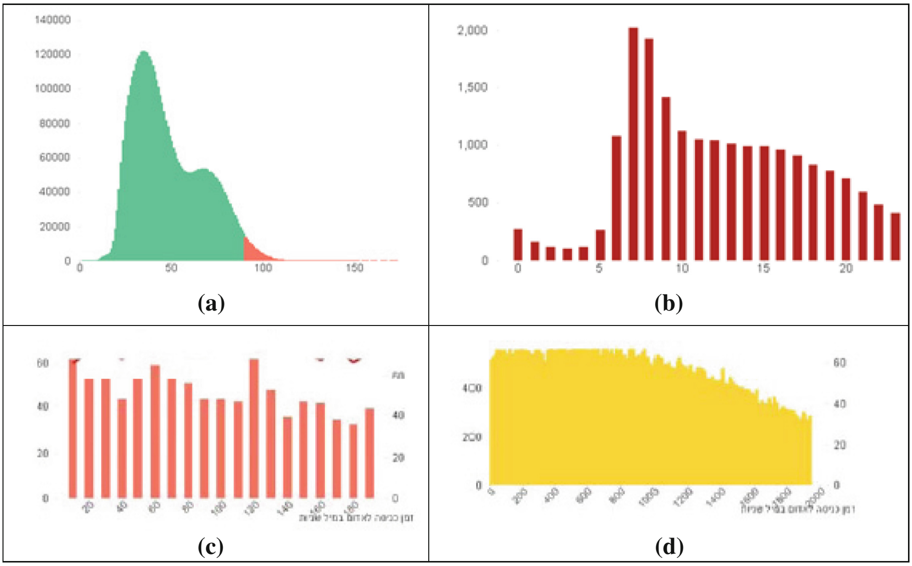


Fig. 5. (a) Speed distribution per site. (b) Traffic count per hour per site. (c) Number and speed of vehicles entering on a red light. (d) Number and speed of vehicles entering on a yellow light (Color figure online)

are few speed offenders at this site, and their offences are on the low fine level (up to 100 km/h) above the speed limit (90 km/h). On the other hand, there are many vehicles that cross the junction on a red light (Fig. 5c). Each figure can be easily changed to another display, for example: the traffic count (Fig. 5b) divided into days, zoom in to a specific range of the x-axis scale, or different periods.

4.5 A Geographic Information System Presentation

Another useful presentation is a Geographic Information System (GIS) (Fig. 6). Here, the automatic enforcement site is presented with its surroundings – other locations of traffic tickets are presented. The data can be easily filtered by time or type of ticket. The model that runs in the background is a geographic model that displays each ticket's location on the map. This presentation can help the decision maker with a decision to operate other enforcement resources in this neighborhood.

4.6 A Simulation Screen

This screen is a What-If screen (Fig. 7) with a friendly user interface. In this screen, the users can enter an optional enforcement level per site and the model that runs in the background calculates the new scenario. It changes the different parameters in the flow of the production line per all the operation units, i.e. the predicted percentage of drivers

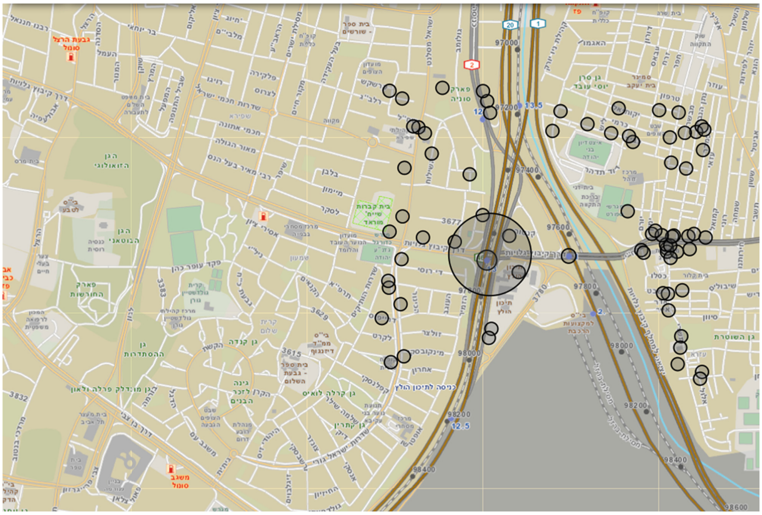


Fig. 6. A GIS screen

who will get a fine that will want to go to court and the predicted number of court summons that will be canceled. A graphical speed distribution (similar to Fig. 5a) is presented to help the users with the decision. In this screen the users can check different alternatives. The parameters entered by the user are combined with the databases of traffic flow, traffic distribution, and traffic tickets. A mathematical calculation is made in the background to present the information required for the final decision, i.e. the overload at the court, the difference in the number of tickets. The result is a sensitive analysis for understanding the effect of the new planned enforcement level on the number of traffic tickets per type and the load this causes the different working units in the process (encoders and traffic courts).

4.7 The Raw Data Screen

Figure 8a presents an example of the raw data including all the fields for a specific month and a specific site. Each raw data represents a vehicle that crosses the electromagnetic loops. The fields are: date, time, the day of the week, the time the vehicle crosses the junction in the light cycle (red-yellow-green), the vehicle's lane, the length of the vehicle and the validation of this measurement, the speed of the vehicle and the validation of this measurement, and whether the vehicle is an offender. In addition, a model runs in the background to create a pivot table, as shown in Fig. 8b, based on the raw data table. This screen is for researchers to export the raw data to statistical software for further analysis, and to help decision makers regarding optimum enforcement levels.

All the screens above have the advantages of a BI system: Default presentation for the manager level "what you see is what you get", with maximal relevant data and information on the main screens. From the operational, engineering, and research

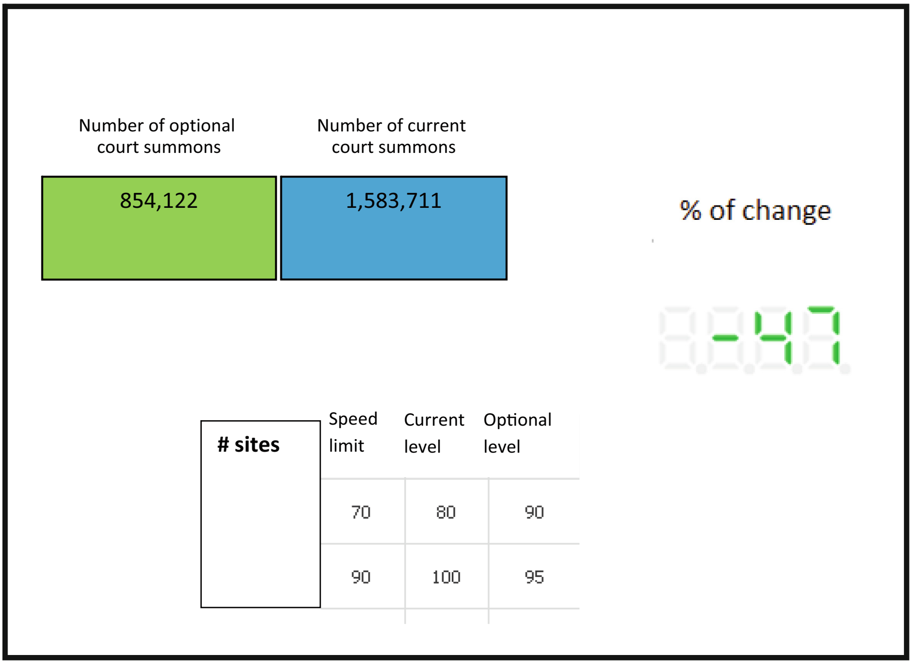


Fig. 7. A simulation screen

"Date"	"Time"	"Green time"	"Yellow time"	"Red time"	"Lane nr "	"Length"	"Length validation"	"Offence type"	"Speed"	"Spd validation"
2016/09/08	05:34:29	18710	0	0	3	379	"V"	"no violation"	31	"V"
2016/09/03	16:04:33	9310	0	0	3	379	"V"	"no violation"	31	"V"
2016/09/02	12:40:08	7820	0	0	1	379	"V"	"no violation"	31	"V"
2016/09/07	19:47:20	10130	0	0	1	379	"V"	"no violation"	31	"V"
2016/09/06	06:15:23	47990	0	0	1	379	"V"	"no violation"	31	"V"
2016/09/07	18:03:04	3470	0	0	2	379	"V"	"no violation"	31	"V"
2016/09/03	17:24:30	6190	0	0	2	379	"V"	"no violation"	31	"V"
2016/09/03	22:42:07	11440	0	0	2	379	"V"	"no violation"	31	"V"
2016/09/02	13:44:52	10170	0	0	2	379	"V"	"no violation"	31	"V"
2016/09/05	05:28:36	15130	0	0	2	379	"V"	"no violation"	31	"V"
2016/09/08	19:22:28	610	2500	0	3	379	"V"	"no violation"	49	"V"
2016/09/04	06:08:49	32360	0	0	1	379	"V"	"no violation"	49	"V"
2016/09/03	20:32:07	12780	0	0	2	379	"V"	"no violation"	49	"V"
2016/09/07	05:21:54	21380	0	0	1	379	"V"	"no violation"	50	"V"
2016/09/08	15:47:30	35260	0	0	1	379	"V"	"no violation"	50	"V"
2016/09/08	10:03:50	25430	0	0	2	379	"V"	"no violation"	50	"V"

(a)

=class([...	Passing
	194,390
0 <= x < 10	25,733
10 <= x < 20	913
20 <= x < 30	14,451
30 <= x < 40	24,473
40 <= x < 50	24,155
50 <= x < 60	22,862
60 <= x < 70	23,025
70 <= x < 80	26,681
80 <= x < 90	21,755
90 <= x < 100	8,272
100 <= x < 110	1,700
110 <= x < 120	303
120 <= x < 130	45
130 <= x < 140	17
140 <= x < 150	5

(b)

Fig. 8. (a) The raw data screen. (b) A pivot table from the raw data

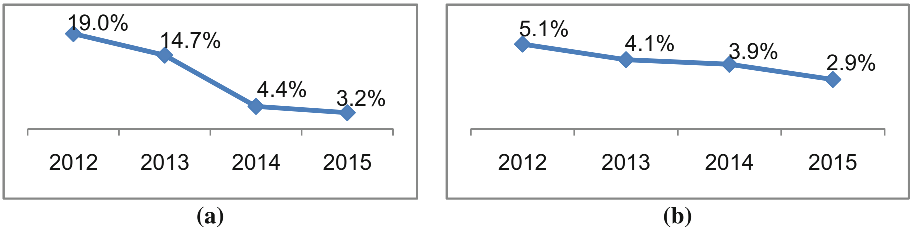


Fig. 9. (a) The percentage of cancelled tickets. (b) The number of requests for court summons

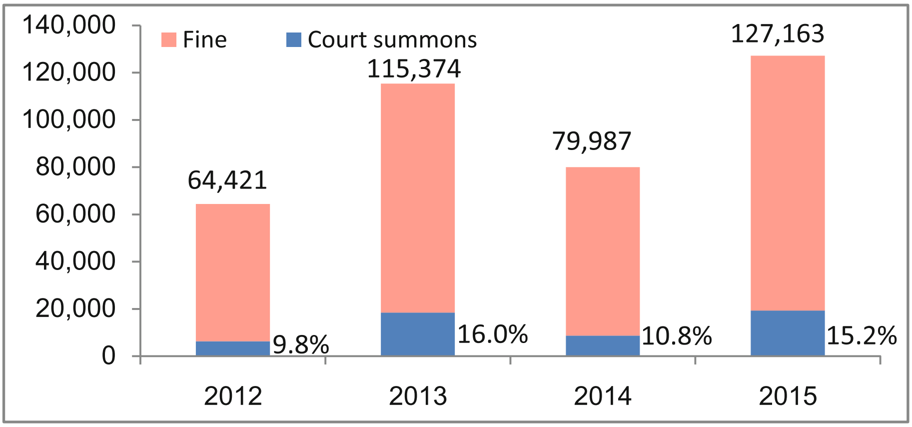
aspects this BI system is an intuitive graphical user interface (GUI). It enables data analysis after selecting a specific parameter in a specific field, drill down to a time frame, specific location, etc. In addition, there are available bookmarks that can be saved with important drill down information for future use. With this BI system, the researcher can present the data in several displays, export it to statistical software, and merge it with other BI systems.

5 Results

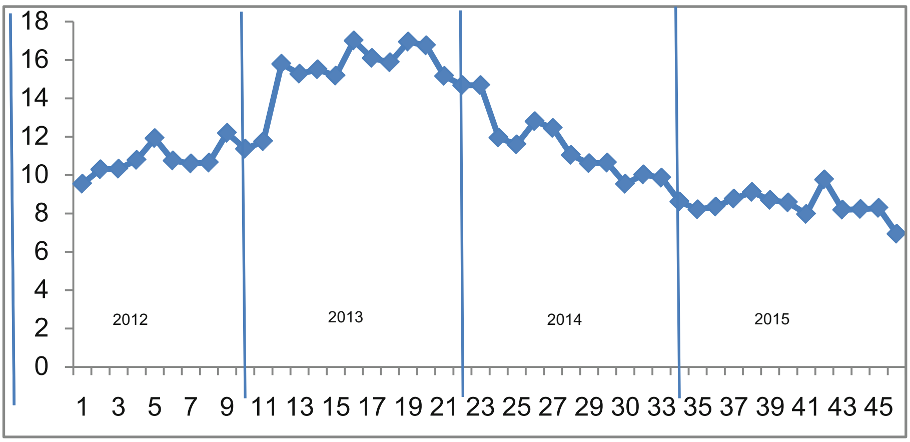
The development of a BI system for the automatic traffic enforcement system is a huge step in the project's development from several aspects: (1) For management – to get a "big picture" of the project – total traffic passing through the project, percentage of offenders per type, severity, time, location, type of vehicle, etc.; (2) for operations, the BI system helps to determine the level of enforcement in each camera, determine the mobility of cameras between the poles and the necessity of poles; (3) helping maintenance, for example to discover if an electromagnetic loop or a camera are not working; (4) helping engineering discover sites with exceptional offenders; exceptional time frame, traffic volume, vehicle types; (5) helping researchers explore this database to check for trends, forecasting and simulation; (6) connecting this BI to other BIs of road accidents and traffic tickets to understand the "big picture".

Here are some examples that demonstrate the importance of a BI system and the improved effectiveness of the automatic traffic camera enforcement project with the BI system: (i) The process flow is now smoother for two measurements: the number of canceled tickets decreased from 19% at the beginning of the project in 2012 to 3% in 2015 (Fig. 9a), meaning fewer events entering the encoder and request units. In addition, the number of requests for court summons decreased from 5% in 2012 to 3% in 2015 (Fig. 9b), meaning a lower load on the traffic courts and request unit. (ii) More quality tickets are produced in the process. Here are some examples: the number and percentage of court summons tickets increased from 6,291 tickets as 9.8% in 2012 to 19,294 tickets as 15.2% in 2015 (Fig. 10a). The deterrence improved by shortening the time between the offence and the conviction in court (Fig. 10b).

In Fig. 10b we can see the decrease in the gap between the average number of months between the offence (the traffic ticket) and the court date. At the beginning of the project it increased dramatically to a gap of 17 months. Today, after using the BI



(a)

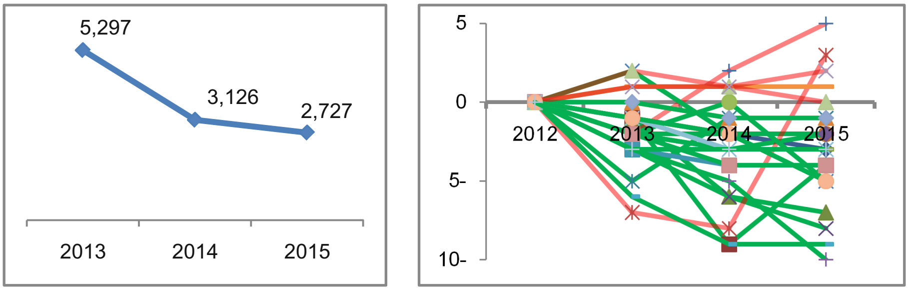


(b)

Fig. 10. (a)The nominal number of court summons and its percentage of the total number of tickets. (b) The average monthly gap between court date and the offence

system, it is even less than during the initial months of the project and stands at around 7 months (half of this period is a constant time of sending the ticket by mail), and with more traffic court summons than ever in the project.

The project's efficiency can be evaluated from the deterrence aspect as well. There are only 14% speed offenders (Fig. 3a) and most of them in the low fine category above the speed limit (Fig. 3b). Also, the number of red-light offenders (an offence where all offenders are caught) is reduced. In Fig. 11a we presented the number of red-light offenders for nine cameras that were operated throughout the years. The number of offenders was reduced from around 400 tickets per month to less than 300 tickets per month. In Fig. 11b, the 85th percentile of speed was calculated per 25 cameras that



(a) (b)

Fig. 11. (a) The number of red-light tickets per 9 cameras. (b) The 85th percentile of speed distribution change over the years at 25 sites (Color figure online)

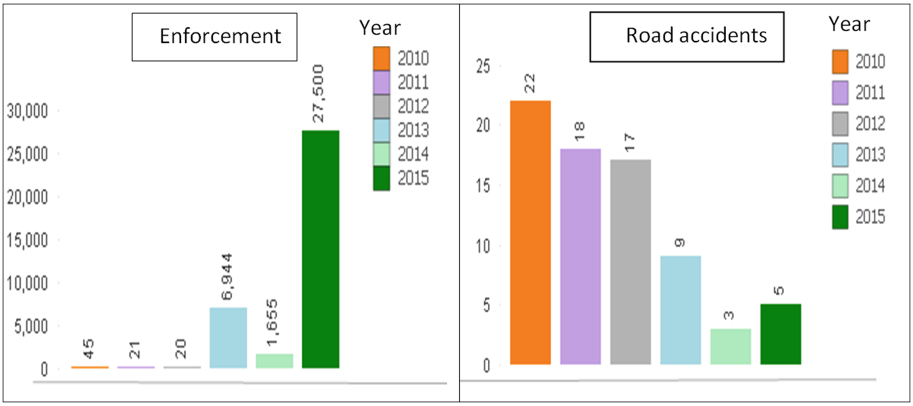


Fig. 12. Road accidents and traffic tickets per year per site

were operated throughout the years. In most sites, the 85th percentile of speed was reduced. In Fig. 12 a specific site is evaluated. Data on road accidents per year (on the right) and data on traffic tickets per year (on the left) are presented on the same screen. It can be seen that the number of road accidents was high until the year 2012 and then it started to decrease. One optional explanation is the installation of automatic traffic enforcement there at the end of 2012.

6 Summary and Further Development

In this paper we presented the stages of building a new BI system for the new automatic enforcement cameras project as PAIS. The large amount of data that is gathered each day from the sensors and the electromagnetic loops in the roads was the trigger to build this advanced BI system to efficiently and effectively operate the new automatic enforcement system. This BI system takes the data and converts it to information and knowledge. The connection of this BI system to other BI systems (road accident and traffic tickets) leads to a holistic view of the drivers-enforcement-offences-road accidents flow and helps to optimize enforcement based on the current resources.

This new BI system helps all the units involved in the process: the operational unit with control elements in the process, the engineering unit with analytical presentations on the different sites, the flow and the behavior of the drivers, the research units with data mining analytics, and the management who can visually see the 'big picture' with excellent insight into the process, to make the correct decisions. The final output of the BI system is the determination of the enforcement level in each camera and the mobility plan of cameras between the poles.

There are some lessons and best practices acquired with the operation of this BI new system. First, as in [21], the knowledge from the information affects tactical decisions for setting the enforcement speed level, and the strategic decision for moving the cameras between the poles and acquiring more cameras and poles. Second, the business processes were improved. On the one hand, the capacity of maximum tickets was accomplished (around 130 thousand tickets per year, in 2015) (Fig. 10a). On the other hand, there are fewer tickets waiting for court summons and a shorter average monthly gap between court date and the offence (Fig. 10b). Third, the project's visible influence as fewer offenders (Fig. 11) and fewer road accidents (Fig. 12).

In the future, this BI system will include data from the vendor operating the cameras (pictures of the vehicles, statuses of the events) and the customers: the courts and the call center that answers the drivers' queries. In addition, from the research unit, there is a demand to connect the data from the BI system with a linear programming model to automatically determine the enforcement level and mobility of the cameras.

References

1. WHO (World Health Organization): Road traffic injuries. Fact sheet N°358, May 2016
2. Elvik, R.: Speed limits, enforcement, and health consequences. Ann. Rev. Health **33**, 225–238 (2012)
3. Elvik, R.: A re-parameterisation of the Power Model of the relationship between the speed of traffic and the number of accidents and accident victims. Accid. Anal. Prev. **50**, 854–860 (2013)
4. Organization for Economic Co-operation and Development (OECD): Speed management (No. 55921). Organization for Economic Co-operation and Development, Paris (2006)
5. Elvik, R.: Speed enforcement in Norway: testing a game-theoretic model of the interaction between drivers and the police. Accid. Anal. Prev. **84**, 128–133 (2015)
6. De Pauw, E., Daniels, S., Brijs, T., Hermans, E., Wets, G.: An evaluation of the traffic safety effect of fixed speed cameras. Saf. Sci. **62**, 168–174 (2014)
7. Aarts, L., van Schagen, I.: Driving speed and the risk of road crashes: a review. Accid. Anal. Prev. **38**, 215–224 (2006)
8. Wijers, P.J.: Automated enforcement, get it right, make it safe. In: 16th Road Safety on Four Continents Conference Beijing, China, 15–17 May 2013
9. Gatso. http://www.gatso.com/en/about-gatso/history/. Accessed 23 May 2016

10. Işık, O., Jones, M.C., Sidorova, A.: Business intelligence success: the roles of BI capabilities and decision environments. Inf. Manag. **50**(1), 13–23 (2013)
11. Bahrami, M., Arabzad, S.M., Ghorbani, M.: Innovation in market management by utilizing business intelligence: introducing proposed framework. Procedia - Soc. Behav. Sci. **41**, 160–167 (2012)
12. Negash, S.: Business intelligence. Commun. Assoc. Inf. Syst. **13**, 177–195 (2004)
13. Chen, H., Chiang, R.H.L., Storey, V.C.: Business intelligence and analytics: from big data to big impact. MIS Q. **36**(4), 1165–1188 (2012)
14. Elbashir, M.Z., Collier, P.A., Davern, M.J.: Measuring the effects of business intelligence system: the relationship between business process and organizational performance. Int. J. Acc. Inf. Syst. **9**, 135–153 (2008)
15. Cody, W.F., Kreulem, J.T., Krishna, V., Spangler, W.S.: The integration of business intelligence and knowledge management. IBM Syst. J. **41**(4), 697–713 (2002)
16. Nenortaite, J., Butleris, R.: Improving business rules management through the application of adaptive business intelligence technique. Inf. Technol. Control **38**(1), 21–28 (2009)
17. Aalst, Wil M.P.: Process-Aware Information systems: lessons to be learned from process mining. In: Jensen, K., Aalst, Wil M.P. (eds.) Transactions on Petri Nets and Other Models of Concurrency II. LNCS, vol. 5460, pp. 1–26. Springer, Heidelberg (2009). doi:10.1007/978-3-642-00899-3_1
18. Weber, B., Reichert, M., Rinderle-Ma, S.: Change patterns and change support features – enhancing flexibility in process-aware information systems. Data Knowl. Eng. **66**, 438–466 (2008)
19. Reichert, M., Weber, B.: Enabling Flexibility in Process-Aware Information Systems, Challenges, Methods. Technologies. Springer, Heidelberg (2012)
20. Dumas, M., Van der Aalst, W.M., Ter Hofstede, A.H.: Process-Aware Information Systems: Bridging People and Software Through Process Technology (2005). ISBN: 978–0-471-66306-5
21. Watson, H.J., Wixom, B.H., Hoffer, J.A., Anderson-Lehman R., Reynolds, A.M.: Real-time Business Intelligence: Best Practices at Continental Airlines Information Systems Management (2006). Accessed 21 Dec 2006
22. Trieu, V.H.: Getting value from business intelligence systems: a review and research agenda. Decis. Support Syst. **93**, 111–124 (2017)
23. CBS (Central Bureau of Statistics): Press release 085/2016 (2016). http://www.cbs.gov.il/reader/newhodaot/hodaa_template.html?hodaa=201627085

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