1st of August 2011

European Transport Safety Council

STudents Acting to Reduce Speed

STARS

BuS sTops Aimed to be Really Safe

FINAL REPORT

Anastasios Koutoulas / Konstantinos Papoutsis

ARISTOTLE UNIVERSITY OF THESSALONIKI

HELLENIC INSTITUTE OF TRANSPORT

Index of contents

Abstract

Speed management is one of the ways to boost road safety level in a road part that encounters such problems. Speed management also uses many tools that are implemented like infrastructure intervention, road policing, traffic calming measures, in-car IT systems, awareness campaigns and finally proper education.

One of the speed reduction measures is the combined use of rumble strips and horizontal marking. This combination was used in our case in the framework of ETSC-STARS program. We managed to involve a variety of stakeholders like CERTH/HIT (main financial contribution and dissemination actions with the assistance of Municipality of Thessaloniki), 3M Hellas (donation and dealer stocking), Martsos Co. (implementation operator), TREDIT SA (legal advice) and AUTh (as members of the Master Science Program in Transport Systems). After many modifications in the initial plan, dealing with huge bureaucracy and after shifting to urban area location we implemented a low cost, innovative in the Greek legislation terms and easy-to-apply project.

Taken speed measurements before and after the implementation of our idea we proceeded to the assessment of the results. We have made a scientific approach addressing issues on accident data, speed values comparison and explaining the results in mobility terms, statistical questionnaires and environmental impact.

Finally, acknowledging the size of the difficulties encountered we are glad to have implemented our idea and we feel thankful to all stakeholders who contributed in our effort.

Acknowledgements

Having finalized our project, we would like to say a few things about all the people who contributed in one way or another to implementing our project. Practically, all that authorities and companies constitute the list of project stakeholders.

Firstly, we would like to thank Mr. Ilyas Daoud, STARS project manager, whose assistance was really significant during this year. He was an excellent technical consultant and very capable project manager.

We are also grateful that we co-operated with a very open-minded man, a leading professor whose contribution had many aspects, not only as being the main financial contributor on behalf of HIT/CERTH, but also helping us to reach local authorities and giving us technical advice on our idea. This is Prof. Mr. G. A. Giannopoulos, the Director of HIT/CERTH, who contributed to our effort, motivating us to go even further for this project.

We would also like to thank the Directors of the Master Science Program of A.U.Th., “Planning, Organization and Management of Transport Systems”, the former Director Prof. emeritus G. Giannopoulos and the current Director Prof. M. Pitsiava-Latinopoulou who also gave us the permission to use the speed radar.

Also, we feel grateful to Mr. Christos Michail, Sales Executive of 3M Traffic Safety Systems Division, whose generous donation of an extra roll of rumble strip, led us to a better implementation of our project.

Of course, we must acknowledge the contribution of company MARTSOS Co. and especially Mr. Dimitris Martsos whose staff has done a great job in working on the field. Without their technical excellence we would not be able to implement our project properly.

Also we are very thankful to Mrs. Bakoula, transport engineer of TREDIT S.A, specialized in road safety legislation, whose legal advice helped us to plan a proper and legitimate project.

We should also thank:

1) The municipality of Thessaloniki and especially Mr. George Dimarelos, transport engineer and Special Executive on behalf of the Municipality, who offered a great assistance in giving us the permission to use the road part

2) All the authorized employees of the Regional Administration of Central Macedonia whose agility of handling our case was stunning and helped us a lot in terms of time pressure

3) The Direction of the administration of traffic police in Thessaloniki who was very willing and understanding and helped us a lot at the last phase of our effort to obtain the permission to manage the road works.

1. Road Safety and Speed Management

1.1 What is speed management?

Road safety is a sensitive transport sector that cares about ensuring safety of all users of the road infrastructure. The users of road infrastructure are drivers, pedestrians, passengers of public transport and generally all road users in various ways.

There are many ways to secure road travelling and road land usage. Infrastructure measures, road safety campaigns, demand management studies, road policing and Intelligent Traffic Systems. The most appropriate and efficient way to forward road safety is the proper training of young and older drivers. This can be achieved through campaigns that are addressed to all road stakeholders.

A tool of the road safety sector that deals with managing the speed of vehicles in order to raise the level of road safety in a selected road part is called speed management. Speed management comes with a variety of measures that are implemented and aim to adjust vehicles speed.

The key is not only to reduce speed, because sometimes the slow speed can cause accidents to the same extent as high speed. The key to the solution is adjustment than reduction. That's why we use the term 'management' than 'reduction' or 'limit'.

There are many ways to manage speed of vehicles. It depends on the road part, how serious is the problem, the funding that should be invested on the project, etc. The more substantial of them are:

- ✓ Infrastructure (construction measures)
- ✓ In-Car and On Road Intelligent Transport Systems
- ✓ Speed Calming (that comes with the proper traffic signs or traffic calming measures as speed humps, etc.)
- ✓ Speed management and awareness campaigns
- ✓ Road policing
- ✓ And last but not least, Proper Education and Wise Training especially to young drivers.

Every road safety and speed management action should be followed by dissemination actions and awareness campaigns to sprawl the new road safety measure that is implemented. In our case, the dissemination actions will be made by the department of public relations of CERTH/HIT.

In STARS project, we were free to select our idea. Of course, it should be in line with STARS specifications and standards. In order to apply a low-cost, innovative project we considered catching speed calming measures or campaign/training sessions to finalize our STARS project. Our team insisted on installing a speed calming measure which will be applied on road and have quantifiable results.

1.2 Rumble strips and 'how to' implement

One of many traffic calming measures is rumble strips on the road surface. Rumble strips are engraved or embossed stripes on the road that are formed by the use of specific strips of about 10 to 12 centimeters wide. That strips have a non-slip surface and they stick on the road surface in groups of six pieces each one, in vertical position to the direction of vehicles' movement. The axial distance between two rumble strips is from 30 to 60 cm.

- The 3M ™ rumble strips are made of laminated elastoplastic white reflective and non-slip material and they are applied perpendicular to the direction of the road. The kit consists of two strips that are applied together and they form a thick piece of about 5.5 mm height on the road in order to create an effect of noise and vibration that causes the driver to slow down the speed.

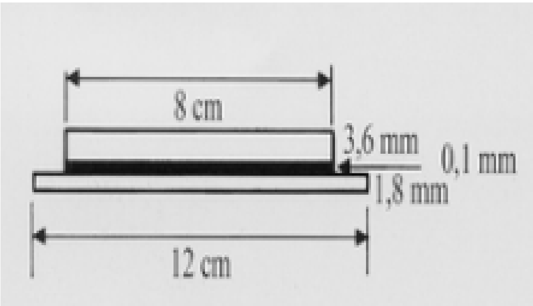


Figure 1: Rumble strip dimensions

<u>Technical Features:</u>

Rubber support

• Non-slip particles

• Glass microspheres with a refractive index of 1.5

• No resin on the surface

The initial slip resistance of the item is 48 SRT and the indicators of the retroreflectivity are:

- Angle of view: 2,29 °
- Inlet angle: 1,24
- 500 mcd/lux*mq

Dimensions	Width (cm)	Thickness (mm)
QS 16 (support basis)	12	1,8
QS 32 (band strip)	8	3,6

How to Use

Before making the implementation to ensure that the surface is dry and clean, that oils, fats and dust and all kinds of impurities are removed and it has not rained in the previous 24 hours. The temperature of the road surface is at least 15 ° C.

The adhesive (3M Primer E44) must be applied out two times on the road surface and once on the back of QS 16, while not forgetting to remove the laminate liner. It is important to proceed with the second pass only when the first level becomes dry. When the second pass has dried, we can apply the strip and the roll. Spray Adhesive 3M Spray 80 on the support has already been applied on the back of the band 32 by removing the QS liner protection and making sure that both surfaces are dry and clean to apply. Shake the can of 3M ™ Spray 80 holding it 12-18 cm away from the surface. Wait at least 4 minutes before joining the parts. The maximum time for joining is 30 '.

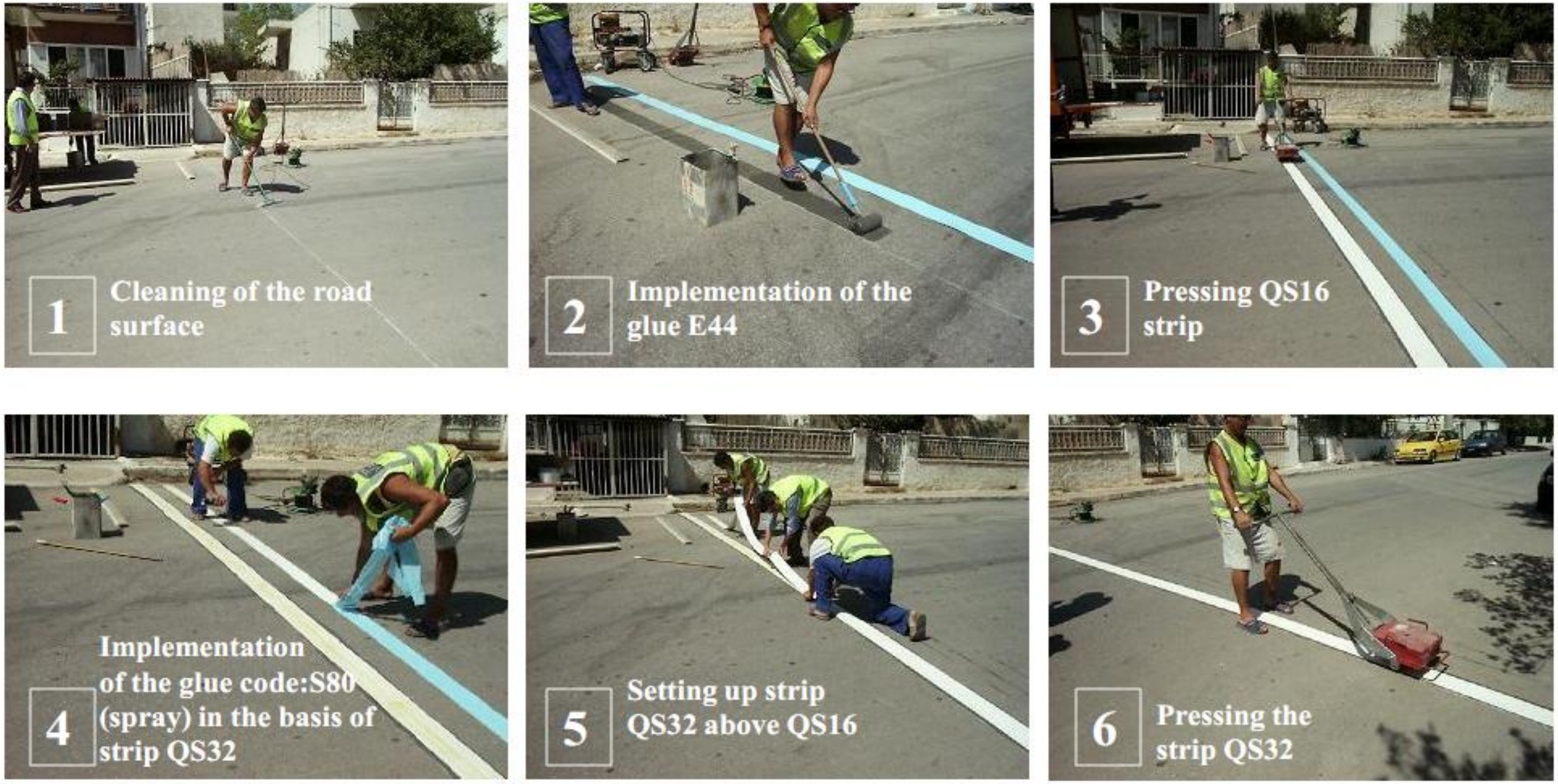
It is important to roll the strip after the implementation of QS 16, and after the application of the QS 32. Open the road part to traffic as soon as possible.

The duration of effectiveness of 3M rumble strips, if you follow all the instructions carefully or however, in the presence of one of our technical staff, depends on the following elements:

1) Traffic conditions
2) Implementation procedures

3) Type of pre-existing signaling
4) Type of road surface

Implementation of rumble strips on road surface



2. Project buS sTops Aimed to be Really Safe ('STARS')

2.1 Definition of the problem

From the beginning of our project Master Plan, we focused on the public transport passengers' safety while they are waiting the bus at the bus stops. Many accidents have taken place due to drivers' speeding. These accidents usually involve cars that crashed into bus stops and as consequences there are injuries and deaths.

The problem gets worse when there are schools around the area and thus students use the public transport, spending a lot of time waiting the buses. Considering such sensitive cases, the team thought that ensuring passengers' (and also students') safety by trying to manage speed in road parts with public transport service is a keystone in raising the level of road safety in urban and suburban roads.

There are many examples of accidents occurred involving bus stops in Thessaloniki. For instance, on the 1st of March 2010 a car crashed into a bus stop at 110, Langkada str. in the urban area of Thessaloniki. Two pedestrians who were waiting the bus were injured [1]. A month later, and specifically on the 20th of April 2010, a car crashed into a bus stop just where we initially wanted to implement our project, before the junction of 'Green Traffic Lights' on Georgikis Sholis ave.. The fatalities were a woman dead and three other women injured. Some years ago a serious accident occurred when a car hit a student crossing the street just opposite the 14th High School of Thessaloniki at G. Papandreou and Sofouli junction. Unfortunately the student lost his life. Affected by these cases we were motivated to apply a project on speed management fostering road safety close to bus stops and especially to schools.

We tried to retrieve further information and statistics concerning the accidents involving bus stops but they cannot be categorized because every incident has different features. So we were unable to find such information.

2.2 The response

2.2.1 Initial Idea

Our idea has the title 'STARS' but coming from the phrase "buS sTops Aimed to be Really Safe". The initial idea would be implemented in a suburban area located just outside Thessaloniki city, on the way to airport.

At first, someone would think to secure the bus stops by constructing metal crash barriers. Although, it comes as a solution, this practice would let drivers speed even more because it would modify the functionality of road. The road would look like a close highway while minimizing the public transport service. So we should do something that refers to managing speed.

So 200 (or 400) meters before the exact point of the bus stop, the surface of the road would have a yellow or orange painting, covering the whole road surface of the specific direction. One hundred (or two hundred) meters before the bus stop, the yellow or orange color would turn into red just like a traffic light. Along the bus stop it was proposed a change on the road surface not only concerning the color but the material as well. As far as the color of surface concerns, it could be light brown. The road could be formed with paving stones, concrete or another material, that enables the drivers to feel a very soft vibration and generally feel the sense of moving on different type of road. By this way drivers could have the opportunity to recognize that they approach a bus stop and by the different colors which is the distance from them and reduce their speed inchmeal. The above rationale of our action was preserved irrespective of whether we changed our initial idea.

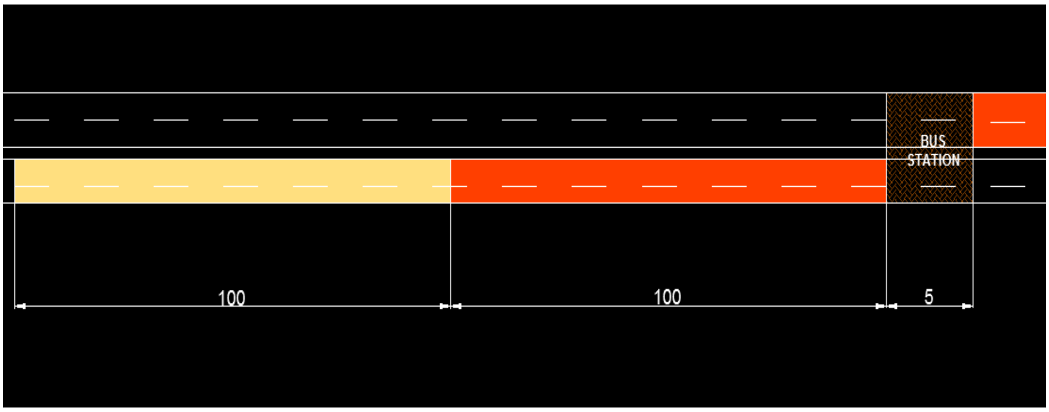


Figure 2: Schematic depiction of our initial idea

2.2.2 Second idea

After consulting and making the finance plan of our idea, as described before, we reached to a second project idea leaving outside the red color as well as the construction part. So at about 80 meters from the bus stop the road surface would be painted in white color. After 25 meters distance the road would have yellow color. At about 30 meters before the bus stop, we proposed the implementation of 8 rumble strips having distance of 2,5 meters each other. Along the bus stop area no speed management tool would be implemented. In fact, this idea had weaknesses concerning legitimacy. Consequently, we proceeded to our next and the final one step.

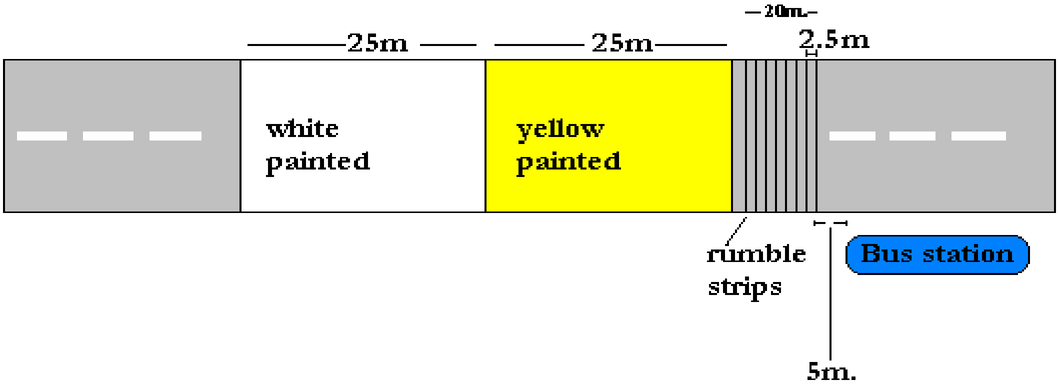


Figure 3: Schematic depiction of our secondary idea

2.3 Differences between first and second idea

The differences between the initial idea and second version are the following ones:

1. First idea: 200m before the bus station and for a distance of 100m, it is recommended to use orange or yellow color on the surface of the road (by using asphalt in orange or yellow color)
   New idea: 80m before the bus station and for a distance of 25m, it is recommended to use white paint
2. First idea: For the last 100m before the bus station the color of the road surface could be red
   New idea: For the next 25m the use of yellow paint

3. <u>First idea:</u> Along the bus station it is proposed a change on the road surface not only concerning the color but the material as well. As far as the color of surface concerns, it could be light brown. The road could be formed with paving stones, concrete or another material, that enables the drivers to feel a very soft vibration and generally feel the sense of moving on different type of road
   <u>New idea:</u> 20m before the bus station the use of eight rumble strips (the distance between each rumble strip will be 2.5m.).

2.4 Why we modified our idea

We had a great issue according to legitimacy affair. The Greek legislation on road constructing is very strict so we should occasionally update our idea. To sum up, the reasons that we took into account in order to modify our initial idea are the following:

- Lack of legitimacy in our idea according to the Greek legislation (formal Road Traffic Legislation)
- Lack of finance of the municipality of Thessaloniki and regional administration because the initial project had as a requisite a large amount of money
- The urban area in which team’s idea would be implemented could not be associated with the initial speed management plan due to road safety issues.

3. Description of our area

Due to lack of interest of local authorities and the multiple changes taking place in administration because of municipal and regional elections, we decided to look forward for a new area, inside the urban area of Thessaloniki. So with the cooperation of Mr. George Dimarelos, a transport engineer, elected in the municipality of Thessaloniki, who acquired the responsibility of transport and traffic affairs in the new administration, we ended up in choosing an area located in eastern suburbs of Thessaloniki, dealing with critical problems regarding the road safety sector.

Our study area is in the eastern side of the urban area of Thessaloniki. The direction of the way is to the east and it is one way street. It is a main urban road with constant flow of vehicles having also a functionality of local collector road easing the local travels. It contains four traffic lanes 3,5 m. each one of them. Sometimes there are vehicles parked on both sides of the road. The land uses are almost absolutely residences with the exception of a high school and some offices as well as stores. There is adequate road marking and in the end of our road part there are traffic lights.

The maximum traffic volume (aka peak times) is met in morning hours, between 9-10 am., and basically 9-11 pm.. The parking characteristics of the project area are: a) medium level of parking demand which gets higher in afternoon time and b) the rotation of parked vehicles is higher in morning hours. This leads us to assume that it is a sparsely populated area which transport needs are easily met and it does not face any significant transportation issues. As far as speeding concerns, the speed limit is 50 Km/h whereas in front of school it becomes 30 km/h. There are speed management equipments including a speed radar showing the speed of the upcoming vehicle (installed in 2008), and cats-eye speed management measure implemented a short distance before our implementation area. The public transport service is covered by using the bus stop “High School”. The public transport buses that stop are number 8 (ends at IKEA transit hub), 33 (ends in Kalamaria centre) and 78 (ends at airport). Many students use the specific bus stop to move eastern.

Figure 4: Panoramic view of our study area. G. Papandreou road part just after the junction with Sofouli str. moving eastern

Figure 5: Panoramic view (vertical to the previous photo) of study area. The cat's-eye (2007) and speed radar(2008) equipment are previously installed

In the photos below we can see a street view of our project implementation area. The bus stop 'High School'(or Gymnasio) consists of a light-blue colored pole engaged with a small plate indicating the buses that stop at the specific bus stop.

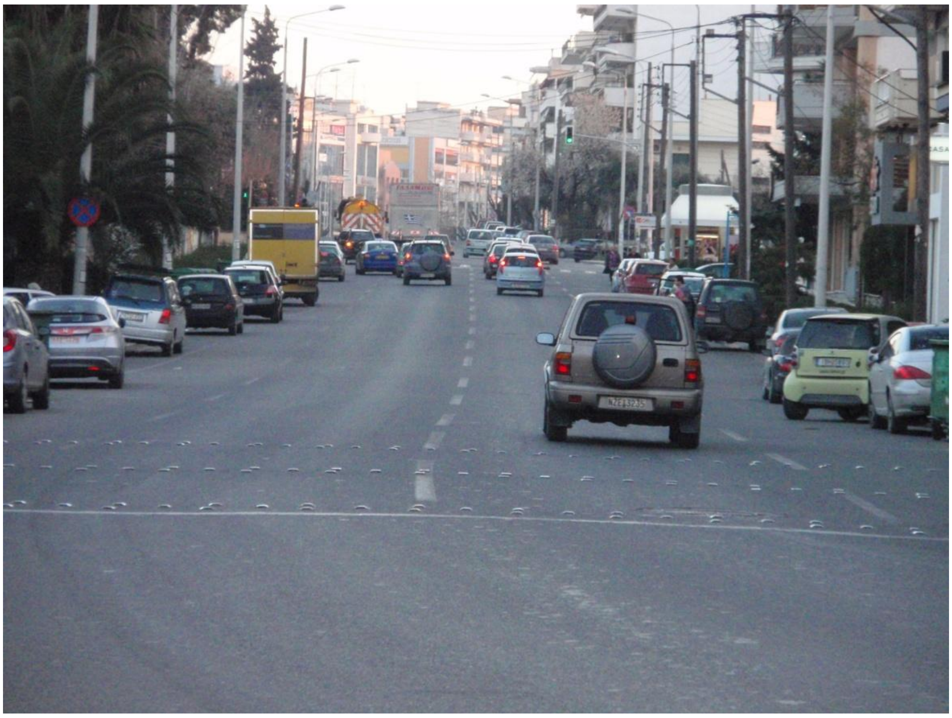


Figure 6: Street view of our study area. We can also see the cats-eye equipment

Figure 7: Street view of our study area in a peak hour (late afternoon)

Figure 8, 9: Street views of our study area. In the second picture on the left we can see the bus stop 'Gymnasio'

Figure 10: Street view of our study area (empty road part)

3.1 Reasons that we selected the specific area

The main causes why the team chose the above road part to apply its idea is:

- The street which would take place the road works includes special roadside land use like the 14th High School of Thessaloniki. Many students use the public transport bound to east side of the city. The bus station is opposite the school and it is called 'High School'. Special attention has to be paid by the drivers in such area.

- Many years ago a serious incident took place. An accident happened and the fatalities were a dead student. Since then the local authorities have not took the appropriate care in the part of road safety.

- Recently, a speed radar was installed a few meters before the works area. Many drivers ignore it and continue exaggerate speeding. So the speed management equipment needs to be updated in that area by adding new measures to ensure high level of road safety.

- The road etching requires extra speed management measures either by road marking and signing or by road construction measures. There is a long curve with low visibility.

4. Our final idea – implemented!

After analyzing what we wanted to do, where it could be done properly, and taking advice basically on the financial part and also on the legal part, we decided to sum up on a financially sustainable, as innovative as it gets, and in line with legitimacy. **Our final idea was:**

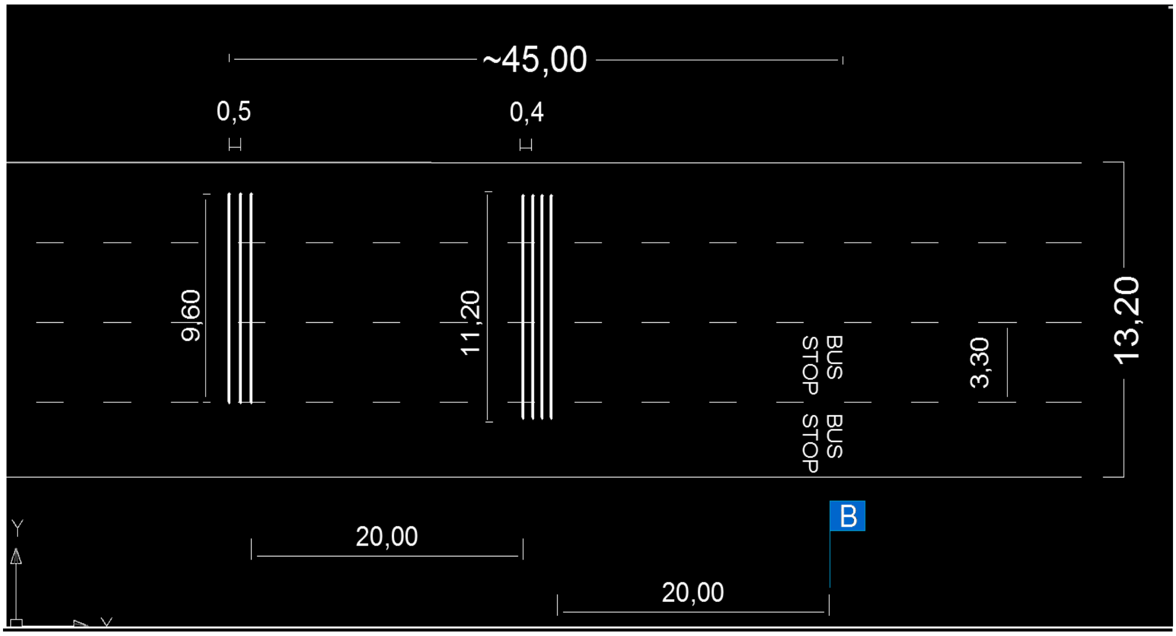


Figure 11: Draft plan of our final idea. It should be implemented exactly as it appears

Initially a set of three layers of rumble strips was installed, covering almost three traffic lanes. The length of each layer was 9,6 m. and the distance of each other was about 0,5 m. After 20 m. of empty road area, an extra set of four rumble strips was applied covering over 3 traffic lanes. The length of each one was 11,20 m. and the distance between each other was 0,4 m. So the implementation of those rumble strips covered mainly the left traffic lanes which are meant to be the fastest ones according to vehicle speeds.

After a gap of 20 m. we approach the bus stop area. So just in front the bus stop the label 'bus stop' was painted on the road surface as seen in the draft above. Last moment change was the accurate location of the label 'BUS STOP'. The first one would be painted at the center of road surface covering the middle traffic lanes. Considering that a driver would see the label 'BUS STOP' and could stop the vehicle using emergency braking confused by the word 'STOP' led us to a light modification of our project.

Finally the project was implemented on Sunday 24 of July 2011, from 6.00 am to 11.00 am considering to have limited influence on traffic. From 6 am to 9 am the staff blocked two traffic lanes and we left the other two traffic lanes operational. After finishing the first phase we continued to the second by blocking the other half of the road part to complete the works. Fortunately, nothing went wrong and the works have been absolutely successful and also had time accuracy.

Below we can see some pictures and photos from the implementation works of the project and its final status after the completion of works.

Figure 12: 'Bus stop' labels applied on the road

Figure 13: The first set of the three rumble strips and in the back the second set of four rumble strips

Figure 14: The second set of rumble strips and in the font the label 'BUS STOP'

Figure 15: Public transport using the new equipment

4.1 Potential of effectiveness

Analyzing our aspect, why the handling of these traffic measures would raise the level of road safety by limiting the exaggerate speeding in that area, firstly it should be highlighted that the use of rumble strips and on road surface marking ('BUS STOP' label) is the most innovative combination of measures in accordance to the strict Greek legislation.

Our initial idea encompassed a wide use of colors (red and yellow) painted on road surface as well as a construction of speed hump in such way that it would allow a smooth passing over by the vehicles. So in the beginning we had imagined a traffic light painted on the surface of the road. After many entanglements with the legislation we reached our final idea totally different from the initial one in order to be in line with the law. It is understood that maybe the use of rumble strips is widely spread in many countries across the world, but our innovative idea had to be modified and adjusted in the Greek terms.

Practically speaking, the use of rumble strips and horizontal signing linked with the existing measures composes a variety of on-road speed management tools that ensure high visual road information consisting of road safety measures. This has a psychological impact on driver's behavior by fostering him to limit his speed. As we know, the less visual information exists on the road the greater becomes the speed of vehicles (i.e. highways).

In addition to the fact above, rumble strips take advantage of their feature to create a distinctive sound while passing over them. The greater the speed of the vehicle the more annoying gets the noise. This sound comes from the proper height of a rumble strip (about a centimeter from the ground), their density – the more dense the more effective – their width and finally their interaction with the vehicle's tires.

The label 'BUS STOP' painted on road plays an important role in terms of drivers' information. It is not considered to be a speed management tool but it aims to inform the drivers who have already limited their speed as an impact of the rumble strips that there is a bus stop which is probably used by students of the school.

Moreover, the delineation of the road is odd in terms of road safety. There is a long curve with low visibility to the project area. Although there is a traffic light to the top of the curve, there is an exaggerate speeding especially when a driver be availed by the green wave. So the implementation of extra speed management measures in that area will boost the level of road safety.

4.2 Analytical budget

The effort retrieving a financial support in such cases is the most critical issue of the project. It requires open-minded people whose contribution will be given more in favor of science and less to expect a profit.

Principal financial support: From the beginning of our route, the Director of Hellenic Institute of Transport on behalf of the Hellenic Institute of Transport (CERTH/HIT), Professor Mr. George Giannopoulos, was willing to grant financial support to our project. His contribution had many other aspects including technical advice and assistance in reaching local authorities.

Donations: While we were trying to supply ourselves with the proper materials we had some telephone contacts with the 3M Hellas, a worldwide organization and the sole in Greece who supplies roadwork materials to the regional technical companies. Their gentle donation had to do with an extra roll of rumble strip so as the project would be done even more properly and achieving further efficiency.

The technical company responsible to implement our idea on the road was MARTSOS S.A., one of the biggest companies in Greece. Their courteous donation was the label 'BUS STOP' just in front of the bus stop called "High School''.

Our total cost divided into materials and labor cost.

Item	**Number of Items**	**Total meters(m.)**	**Price/Item(or meter) in €**	**Total Price in €**
Rolls of rumble strips (25m. each one)	2	50	378,00	756,00
Donated: Roll of rumble strips	1	25	0,00	0,00
Labour costs		75	7,00	525,00
Donated: Labor cost of BUS STOP painting				0,00
Total without VAT (Value Added Tax)				1281,00
Value Added Tax (Total x 23%)				294,63
Total Final Budget				**1575,63**

Figure 16: Budget

5. Evaluation of the results

5.1 New road accident data / Statistical evaluation

After implementing our project, the next step would be the evaluation of the project impacts. There two main methods of assessing our results: the technical evaluation and the social one. The technical procedure can be elaborated in two ways. On the one hand, comparing accident data and on the other hand by taking speed measurements of the vehicles passing our study area, before and after the implementation of the project.

As far as the first way, we could not obtain accident data by the police because there is not such detailed data. There is only a very general database and not a regional or urban data. But even if we could have such information, it could be hard to evaluate our results because it could take a very long time in order to inspect and compare the data during the before-after evaluation. It could take surely two years of accident recording to reach to a safe conclusion regarding the effectiveness of our idea.

Thus we will try to introduce a new database from now on, having assistance of the traffic police, including accidents that will occur after the implementation of our project. Our target is to minimize the number of the car accidents that happen in the study area. Taking advantage of the new speed management action, it would be a good point to begin accident recording.

5.2 Speed measurements evaluation / Technical assessment

The basic way of evaluating a speed management project is to measure vehicle speed in the area and figure out if the project reaches its initial target. In our case, we took speed measurements from the vehicles after finishing the road works just using the same method as before the implementation of the project.

The speed measurements taken before the implementation of the project realized on Tuesday 24 of May 2011 and it consisted of two time periods. We paid attention to choose peak hours in order to distinct drivers' behavior before and after the applied idea. The weather conditions were good. The temperature was 20,5 °C in the mourning (09.00-10.00) and 26°C in the afternoon (15.00-16.00). The number of measurements was two hundred for each period of time (about an hour).

The second phase of measurements took place on Tuesday 26 of July 2011 just two days after project implementation. The weather conditions during the measurement were very good. The weather was sunny and the temperature was about 26 °C in the morning and 33 °C in the afternoon. Both times, the person who measured with the use of speed radar had a clear view to the upcoming vehicles. The two red spots were the planned locations that we could stand and measure speeds. We finally selected the second position (the right one in the picture) because of the clearest view we could achieve to the desirable spot (we shot at vehicles which were passing over the rumble strips), the safer and more secure place to stand even for the team and for the vehicles, and the fact that we could not be visible by the drivers so they should not brake fearing that there is a police speed radar.

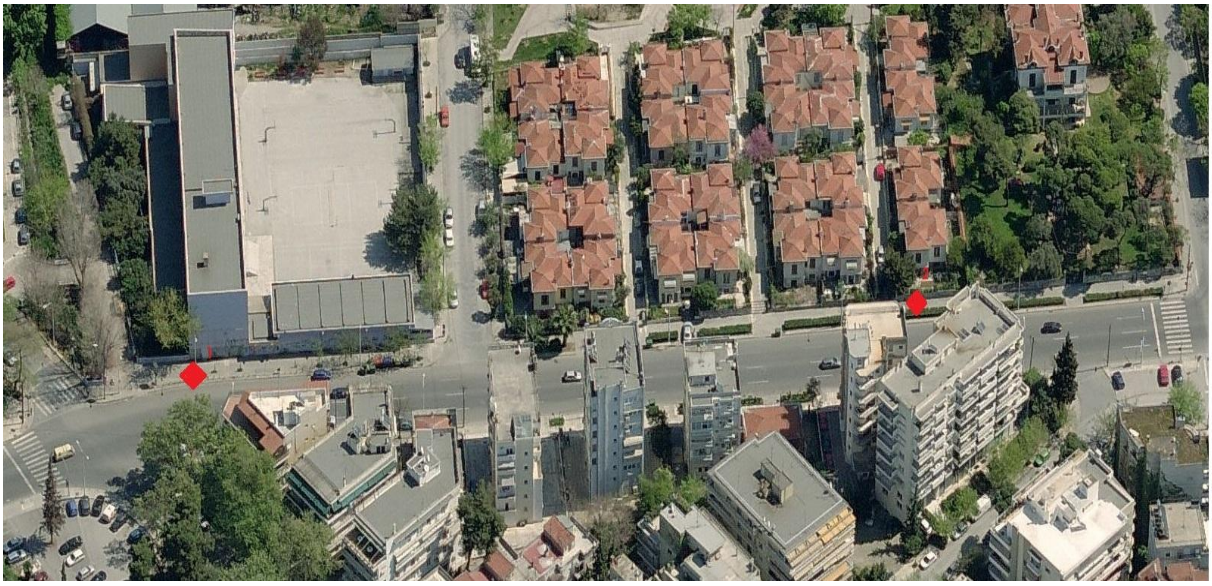


Figure 17: Panoramic view of study area indicating the two initial places of speed measurement

Therefore, having statistical data from the situation before and after we compared and tried to explain our results. The matrixes and diagrams below highlight the case.

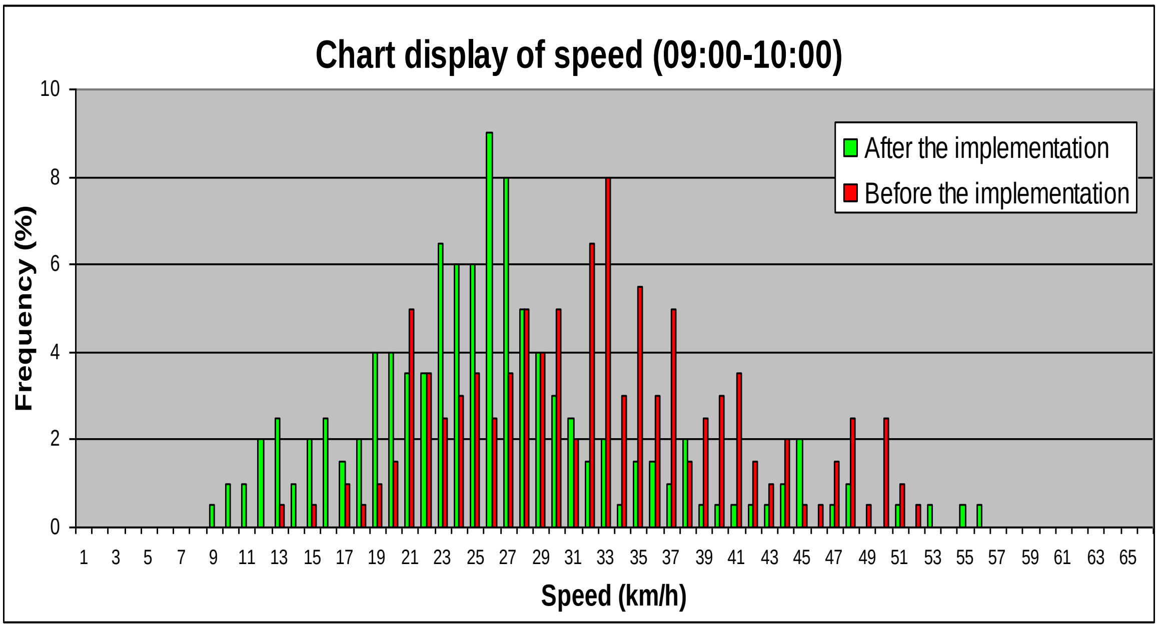


Figure 18: Chart showing the differences in speed measurements between before and after the implementation status (09.00 – 10.00)

As indicated by the diagram above, from measurements taken place on Tuesday 26/07/2011 at 09.00 am, the higher value of speed is 56 km/h and it is captured after the implementation of the project. However, the range of the speed measurements is between 13 km/h and 52 km/h referring to speeds before the implementation of the project. After the implementation we have a wider range beginning from the value of 9 km/h and ending to the value of 56 km/h. The higher speed frequency before the implementation is on the value of 33 km/h whereas after the implementation is on the value of 26 km/h. Also the higher density of speed values is met between 19 km/h and 31 km/h after the implementation. Talking about the status before the implementation of the project the higher density of speeds is met between the values of 24 km/h and 41 km/h.

From the above statistics we can assume that our intervention on the road had obvious results on limiting the wave of high speeding in that area, from the initial value of about 34 km/h to the value of 26 km/h. Furthermore, overall numbers are not very high due to the fact that measurements took place in peak time such as morning times and afternoon times as seen below. So the increased traffic volume led to lower speeds. Besides this, the lower speeds are due to the fact that there are traffic lights just before the speed measurement point so they indicate vehicle acceleration after a green light.

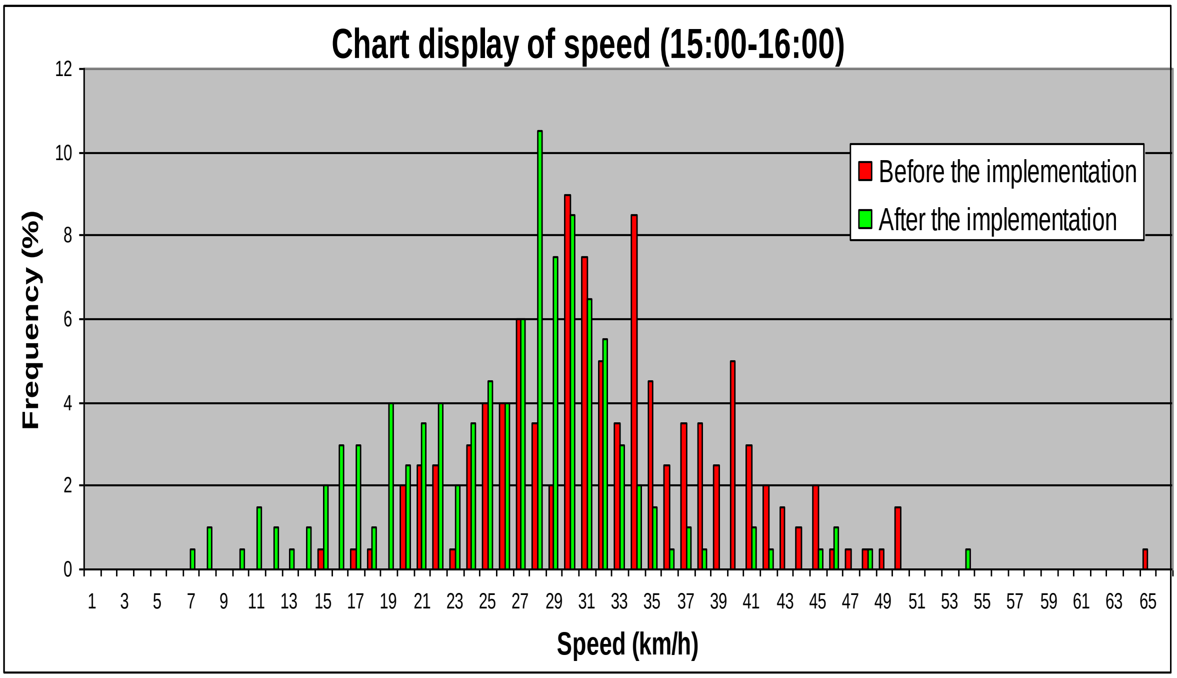


Figure 19: Chart showing the differences in speed measurements between before and after the implementation status (15.00 – 16.00)

The same characteristics of speed are detected on the measurements taken place at 15.00 pm in the evening on the same day (Tuesday 26/07/2011). The speed average after the implementation of the project is even lower in the evening because of the high traffic volume. Tuesday is considered to be a high-traffic day in terms of vehicle traffic and pedestrian congestion because the shops are open and the markets are working. So, apart from our project effectiveness the speeding is influenced by traffic volume.

Analyzing the chart, the main outcome that can be reached is the majority of speed values before the implementation of the project is over 29 km/h and many measurements are pointed in the range between 30 km/h and 43 km/h. So the idea had an influence by 'moving' this dense wave of speed measurements even lower, between 19 km/h to 31 km/h.

The cumulative percentage of speed shows that the statistical allocation of values is normal before the implementation of the project. After the latter one, there has been critical allocation of speeds, not as normal as the initial one, resulting to a great amount of speed measurement in a lower level and the rest even lower. This is taking place only in the afternoon. The morning both allocations (before/after) are almost normal. The charts below are evident of the situtation.

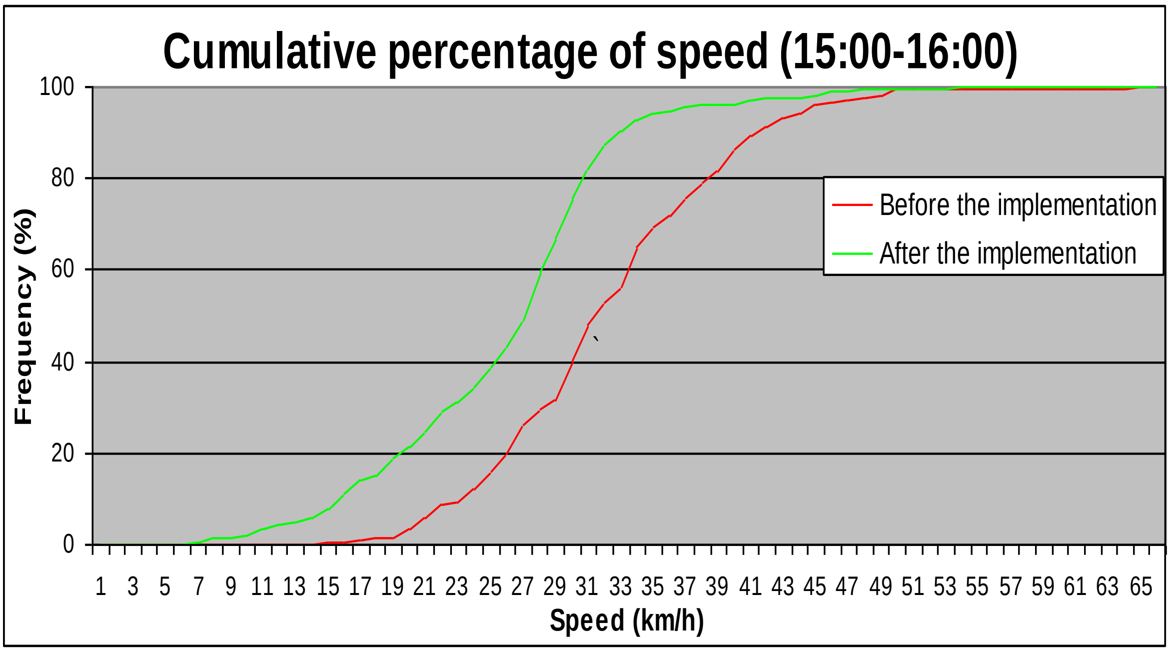


Figure 20: Chart showing the cumulative percentage of speed comparing the status before and after project implementation (15.00 – 16.00)

The outcomes can be better understood by monitoring the cumulative percentage of speed, for both periods of measurements. The minimum speed which leads to high frequency percentage (analyzing the above chart) declares that there is a great amount of speed values in having reached a high frequency. Practically, the sharp increase (about 45%) of the frequency percentage between 27 km/h and 31 km/h indicates that there are many measurements between this speed gaps.

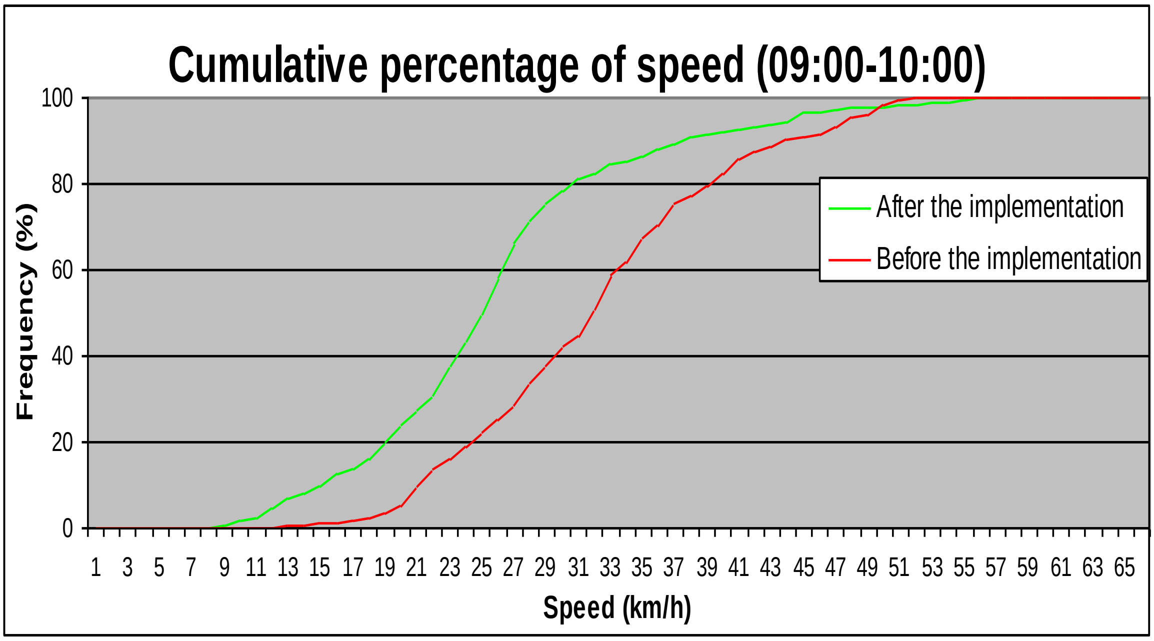


Figure 21: Chart showing the cumulative percentage of speed comparing the status before and after project implementation (09.00 – 10.00)

To sum up, the above matrix reflects the effectiveness of our program in absolute numbers. It also includes all available and necessary information of our measurements and their results. As we can clearly see, there is a deviation between the initial average speed and the revealed one after the implementation. The gap is of 6,3 km/h. Below we can also define the minimum and maximum value of speed of each period of measurement and the number of measurements which is 200 per hour. Average speed capture was about 3 vehicles per minute.

The project had the expected influence on drivers' speed. The final deviation is a speed reduction of 12,27% analyzed in 12,28% in the morning hours and 12,26% in the afternoon hours. To achieve a wider reduction in speeding we should apply construction projects and maybe costly ones. The reduction was perceptible due to the fact that the measurements were done just two days after the implementation of the project and the drivers were not used to the new status-quo of the road. Perhaps, many of them were passing by for the first time after the project being implemented.

Variables	Mean	Minimum	Maximum	Number of measurements
Before the implementation 09:00-10:00	51,495 km/h	32 km/h	71 km/h	200
Before the implementation 15:00-16:00	51,605 km/h	34 km/h	84 km/h	200
Before the implementation - Average	51,550 km/h	32 km/h	84 km/h	400
After the implementation 09:00-10:00	45,170 km/h	27 km/h	74 km/h	200
After the implementation 15:00-16:00	45,275 km/h	26 km/h	73 km/h	200
After the implementation - Average	45,223 km/h	26 km/h	74 km/h	400

Figure 22: Brief analysis of the average speed values measured each period

5.3 Revealed – Stated preferences / Socioeconomic assessment

A third way to evaluate a measure regarding its popularity is to make questionnaires of revealed and stated preferences. The target group would be inhabitants of the specific area, and of course students because of the High School which is nearby our project implementation area. Students are mainly the target group that will benefit from the speed management measure implemented just opposite their school.

Therefore, it should be investigated amongst students if they feel safer, what they think about this road safety measure, what else should be done (furthermore or instead of the 'STARS' idea). The revealed preferences show how they feel about the new speed management measure (scanning their opinions after the implementation of the project) and the stated preferences show what else should be done in pedestrians safety and speeding sectors (responding on what they want to be done in the future). This research should be conducted also to the residents of that area.

We did also a mini research to understand drivers' behavior. Intending to test drivers' behavior we asked ten of them who passed from that area how they felt. Two of them declared that the measure had no effect on their behavior so they continued their route. Seven of them told us that they didn't brake but they didn't even accelerate. They didn't press the accelerator in order to achieve smoother rolling over the rumble strips. So their speed has been lightly reducing for a while. One of them said that he slightly pressed the brake.

After analyzing the results we may clarify the public opinion in road safety terms, see whether the 'STARS' idea had a positive impact on inhabitants' opinion and make future plans in order to improve the level of road safety in that area. The above procedure can be described as 'social assessment' of our idea.

5.4 Environmental impacts

From that point of view, it could be useful to refer to the environmental impact of the implementation of our project and assess the environmental implications caused by the expected speed reduction in our works area. The impacts of the project implementation are: the environmental emissions of any sprayers used in the process, the environmental impact of the use of thermoplastic material as a component of the rumble strips, the asphalt strains caused by the application of the rumble strips, any noise produced by the works, and the excessive COx emissions that will be probably created by the extra traffic volume that will occur during project implementation. Besides this, we should consider the total amount of (extra) gas emissions that will be created if the drivers who approach the rumble strips lightly break their vehicles. The last case could be measured in a long period of time so it will be compared with older data.

The sprayers which were used have a temporary effect on the environment. The thermoplastic material and all the particles that compose the round strips are in line with the European (CE) and Greek (ELOT EN 1436) standards. The asphalt strains are insignificant due to the light load of materials that are used. There was no noise during the construction that's why the traffic police accepted the implementation period from 7 to 11 in the morning. Although, many years ago habitants staying close to road parts equipped with rumble strips made many complaints about the noise coming from the tyres passing over rumble strips. Nevertheless minimizing the height that a rumble strip reaches, fostering speed reduction in that area and using new materials conduct to noise reduction of interaction. Because of the time, the flow of vehicles was almost at zero level. So the traffic congestion and the upcoming environmental impact were at the minimum point. To clarify the real environmental implications that take place in the area, there shall be measurements of COx emissions as well as other gas emissions coming from vehicles. This should take a six month period to be concluded. No destruction of greenery took place.

In fact, we cannot expect significant changes regarding emissions coming from the vehicles but in such cases, when there is a road construction projects, an environmental impact assessment should be elaborated to investigate any environmental effect induced by the project.

6. Literature

1. World Health Organization-FIA Foundation-Global Road Safety Partnership-World Bank, "Good Practices in Speed Management-A road safety manual for decision makers and practicioners", Geneva 2008.

2. Organization for Economic Cooperation and Development – Transport Research Centre – European Conference of Ministers of Transport, "Speed Management", OECD publisment, 2006.

3. Stelios Efstathiadis, Transportation Solutions "INFRASTRUCTURE MEASURES on operational speed reduction - CASE STUDY", of the his presentation in the framework of European project STARS organized by ETSC, Brussels, September 2010

4. Véronique Feypell-de La Beaumelle, "Speed Management – Role of signing, Marking, and Signs", Lessons from the OECD/ITF report, of the her presentation in the framework of European project STARS organized by ETSC, Brussels, September 2010

5. Charikleia Lekka – Prof. Socrates Basbas, "Evaluation of Radar Speed Signs in urban areas - The case of G.Papandreou - T.Sofouli street junction (Municipality of Thessaloniki)", Master Diploma thesis, Interdempartmental Master Science Program "Planning, Organization and Management of Transport Systems", A.U.Th., Thessaloniki, October 2010

6. Koutoulas Anastasios – Prof. Magda Latinopoulou-Pitsiava, "The use of traffic calming measures in the configuration of a speed management policy. Study case: the hierarchy of road network of Pylaia", Master Diploma thesis, Interdempartmental Master Science Program "Planning, Organization and Management of Transport Systems", A.U.Th., Thessaloniki, October 2010

7. Papoutsis Konstantinos – Prof. Magda Latinopoulou-Pitsiava, "Functional remodeling of suburban roads through the implementation of measures of speed management. Case study of Thessaloniki – Peraia's road part", Master Diploma thesis, Interdempartmental Master Science Program "Planning, Organization and Management of Transport Systems", A.U.Th., Thessaloniki, October 2010

8. Velli-Pekka Kallberg, Heather Ward and Richard Allsop, Richard Van Der Horst, Andras Varhelyi, "Strategies and tools for speed management on European roads"

Websites

1. http://www.voria.gr/index.php?module=news&func=display&sid=11426 [1]
2. http://www.athina984.gr/node/95222 [2]
3. http://www.nist.gov/eeel/oles/diettraf.cfm
4. http://auto.howstuffworks.com/car-driving-safety/safety-regulatory-devices/question396.htm
5. http://solutions.3m.com/wps/portal/3M/el_GR/EU2/Country/
6. www.etsc.eu/stars.php

7. List of stakeholders

Organisation of the program:

European Transport Safety Council (ESTC) – STudents Acting To Reduce Speed (STARS)

http://www.etsc.eu/stars.php

Student (team) representative:

ARISTOTLE UNIVERSITY OF THESSALONIKI

Aristotle University of Thessaloniki – Interdepartmental Program of Master Science Studies 'Planning, Organization and Management of Transport Systems'

www.auth.gr http://pgtransport.civil.auth.gr/

Main financial contribution and dissemination actions:

Hellenic Institute of Transport/Centre for Research and Technology Hellas (HIT/CERTH)

http://www.hit.certh.gr/

Donator and stock dealer:

3M HELLAS

http://solutions.3m.com/wps/portal/3M/el_GR/EU2/Country/

Legal advice:

Transeuropean Consultants for Transport, Development and Information Technology S.A

http://www.tredit.gr/

Implementation operator:

MARTSOS Co. – Signing / Road Marking

http://www.martsos.gr/

Dissemination actions and local authorization:

Municipality of Thessaloniki

http://www.thessaloniki.gr/portal/page/portal/DimosThessalonikis

Technical advice and local authorization:

Regional Administration of Central Macedonia

Road safety and security ensuring and local authority:

Administration of Traffic Police in Thessaloniki

http://www.hellenicpolice.gr/newsite.php?&lang=

Local public transport authority:

Organization of Urban Public Transport of Thessaloniki

http://www.oasth.gr/

Annex A

STARS program annual report (October 2010 – July 2011)

October 2010: Our working group began its planning and drew up our project Master Plan responding to answers such as when, with whom, what should be done, where and how. Firstly, the team had a meeting with Prof. Mr. Giannopoulos, Director of CERTH/HIT, who found our idea very interesting and was willing to contribute on behalf of CERTH/HIT not only financially but also giving us technical advice.

Afterwards, we tried to clarify the characteristics of our study area. The only setback that occurred was the municipal and regional elections, and there was a critical impression of an administrative change here in Thessaloniki region.

November 2010: Consulting transport management/consultants company TREDIT S.A., we came up to modifying our initial idea due to the fact that there was a lack of legitimacy. First of all, according to the Greek legislation it is prohibited to use red painting on the road surface. The use of yellow color was permitted only in special case and it wasn't clear if our idea encompassed them.

The fact that we had seen the red and also green color on the road surface in some cities around Greece was not safe enough to handle it in our idea. Afterwards, we were informed that these colors were used in very special cases and it would be a lengthy process in terms of bureaucracy.

Furthermore, the initial idea referred to a slight rise of the road surface, such as speed hump, but only using structural materials. The basic one is brown concrete paving stone which is normally used in woonerf roads. By setting out a budget, the group realized that our idea had been too expensive to be implemented. Taking advantage of the two previous causes, the study team decided to change its planning.

In the end of the month and after the elections and with the assistance of Mrs. Pitsiava – Latinopoulou (the director of our Master Science program in A.U.Th.) the team was informed by the Municipality of Pylaia that there was not any responsibility for this part of road. Then we turned to the Regional Administration of Central Macedonia. Unfortunately, we were told that even though there was lack of finance, they could not help us because of understaffing.

December 2010: After reaching to a deadlock, the team tried to find connections with the new municipality of Thessaloniki. Taking into account Prof. Giannopoulos advice, we discussed with Mr. George Dimarelos, a transport engineer and part of the new city council also responsible for traffic and transport issues, who was very willing to help us in various ways. Team next step was to locate a road part that meets our idea requirements. After a short brainstorming we came up to a road part of G. Papandreou ave. between Sofouli str. junction and Ploutonos str. junction.

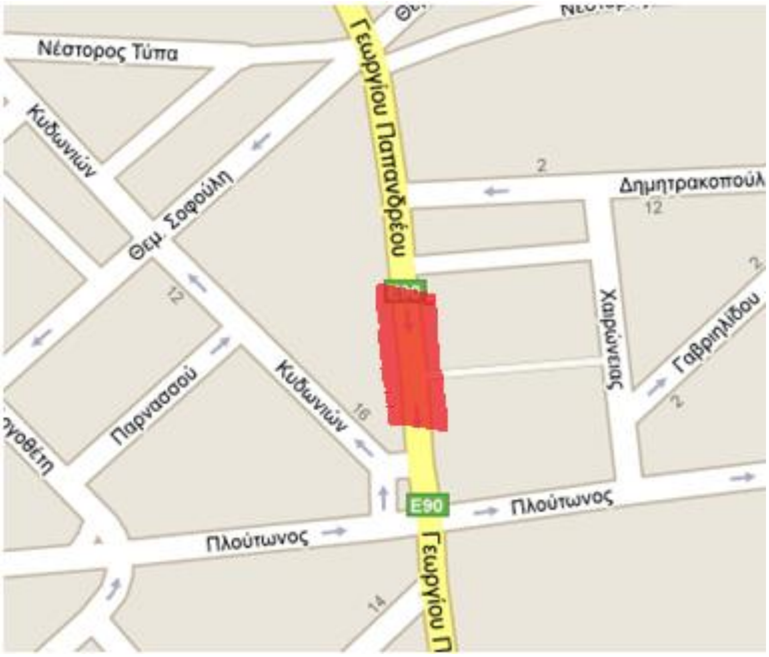


Figure 23: The red mark indicates implementation area

January 2011: In the beginning of 2011 we tried to collect information and data for the specific road part. Much information retrieved from a diploma thesis of team's colleague Lia Lekka whose diploma thesis was associated with speed management on the same road part. Lia's thesis was very analytical and extended that helped us to fully understand the aspects of speeding in that area.

Taking into consideration the fact that If we wanted to use red color on the road we should had made a letter to the Ministry of Infrastructure requesting to modify the Greek legislation, and this could lead to a huge time cost, we decided to change the characteristics of our idea. Besides this, the type of the speed hump that we wished to use was a little bit dangerous to be implemented it in that area. Recognizing that our idea was out of legitimacy and there will boost the budget, our effort focused on the changes we should do.

February 2011: The next step was to make the new idea's budget. The individual costs were:

a) The total labor cost
b) Paint buckets according to team's planning (white and yellow)
c) Rumble strips materials

Then there was a meeting with the municipality stakeholders trying to clarify if it is possible for the municipality to cover the total labor cost and the paint buckets cost. The municipality of Thessaloniki gave its initial affirmation on behalf of Mr. Dimarelos. Having on our side Prof. Mr. Giannopoulos as a contributor to our project we started the Master Plan of the 'administrative routing' in order to acquire the essential permissions for using the specific road part. We thought then that we are legal but things went wrong.

March 2011: Consulting again some transport engineers (with expertise in Greek traffic safety legislation) who are associated with TREDIT S.A., we were informed that even the extended use of white and yellow color in road surface is prohibited by the Greek Law. The yellow color is only accepted but in special occasions, but this did not involve full painting on the road surface. This changed our mind because we thought that our idea even with the use of yellow color would be in line with the law.

Scrolling back to the beginning of the route, we started our new effort to find something innovative, low cost and primarily matching the strict Greek legislation. So after a short period of brainstorming we came up to using rumble strips, and road painting. The label 'BUS STOP' would be applied on the road surface, just in front of the bus stop "High School" and put transversally to the direction of the road. About ten meters before about a dozen of rumble strips would be installed to complete a packet of speed management measures in that area.

We also planned the connections we had to put up in order to finish our project. We divided our project into two categories: the administrative session and the technical session. The administrative one encompassed a tactical 'administrative route' in order to receive the authorized permissions for the implementation of the project. The technical one, included the coordination of the stakeholders whose contribution had to do with the technical part of the project (meetings with the company who would be occupied with the road works – on road implementation of the project and communication with the sales department of the company who would supply us with the appropriate materials (rumble strips).

April 2011: Having regular communication with the Director of CERTH/HIT, Prof. Mr. Giannopoulos, and ensuring our budget and that our idea was under the Greek legislation, we had several meetings with the municipal authorities in order to acquire the permission from the municipality of Thessaloniki.

On the 19th of April, there had been a meeting with Mr. Dimarelos, Mr. Daoud and our team in the new City Hall building. Mr. Dimarelos expressed his support on behalf of the municipality by guaranteeing great assistance. After the above meeting, we guided Mr. Daoud to the study area and finally we had a meeting in the conference facilities of CERTH/HIT.

After the 20th of April in Greece there had been Easter holidays and our project activities were paused.

May 2011: On the 10th of May the Vice Mayor of Thessaloniki gave his permission on behalf of the municipality of Thessaloniki. Because of the fact that the road part which will be examined is a part of the basic road network, the final authorization was up to the regional administration of Central Macedonia. So the next step was convincing the authority.

June 2011 – July 2011: After many meetings and submitting technical plans and drawings as well as small traffic management studies, the team managed to overcome difficulties and by 8th of July there was a formal authorization by the regional administration of Central Macedonia. Just after this, we visited the administration of traffic police of Thessaloniki to obtain the final permission for the road works. In the 18th of July we had the final permission to use the road part and manage the road traffic.

Annex B

Letters of support

Municipality of Thessaloniki
Directorate of Traffic Affaires
Department of Traffic Projects
7, Paparigopoulou str., 54630, Thessaloniki, Greece

To: Anastasios Koutoulas,
Konstantinos Papoutsis

Date: 29 of July 2011

Subject: Support to ‘STARS’ final report

To whom it may concern,

The city of Thessaloniki has thousand years of history coming from ancient Greece up to now. The new elected administration of the city council is trying to disseminate and communicate Thessaloniki’s cultural sign to the rest of the world whereas a lot of effort is being done to follow traditional culture and be up-to-date to the modern trends regarding academic and research progress, open government, fair and equal access to mobility, environmental awareness, health and safety.

In the framework of the research awareness as well as of the need to ensure safety of road users in the urban network, our municipality will underpin every initiative is coming from young researchers of our city. Therefore it is not only our intention but it comes as a high duty to support the idea called ‘STARS’ of Mr. Koutoulas Anastasios and Mr. Papoutsis Konstantinos to implement a project concerning security for the passengers waiting at the bus stops and safety for the drivers passing along the street. Considering the risk that students face while trying to cross the street and during waiting to the bus stop, we are aware of the problem and we support our citizens idea to implement this low cost and innovative project. This idea is pursued by a strong group of stakeholders such as CERTH/HIT, 3M Hellas, TREDIT S.A., etc.

Our first step was to pleasantly give municipality’s authorization to use this road part (G. Papandreou – Sofouli) as the application area. Talking as a transport engineer and admitting the positive impact that the project achieved after being informed about the statistical reduction of vehicles speed in that area, I will forward the proposal to the city council and implement the project ‘STARS’ to other places of the urban network that deal with the same safety issue.

Accordingly, speaking on behalf of the municipality of Thessaloniki, I undersign and strongly support Mr. Koutoulas and Mr. Papoutsis idea called ‘STARS’ and submitted during ETSC – STARS contest.

Yours sincerely,

George Dimarelos
Transport Engineer
Executive Administrative in Transport Affairs, Municipality of Thessaloniki

3M Hellas Mepe
20, Kifisias Ave
151 25 Maroussi
Tel:210-6885300
Fax:210-6859506

Athens, 1 August 2011

LETTER OF SUPPORT

In the project of "Bus stops aimed to be really safe" performed by the students of Civil Engineering Department of the Aristotle University of Thessaloniki, for the project STARS of the European Transport Safety Council, we acknowledge our support as Traffic Safety Systems Division of 3M Greece and sponsor with the necessary 3M TSS materials, to achieve their goals.

The students have applied 3M Bande Sonore (Sound Stripes), in order to alert drivers to reduce their speed when approaching the bus stop.

We wish the students best results for their participation in the STARS project.

Best regards,

Antigoni Xioni | Country Business Leader
3M Display & Graphics Safety Security & Protection Services
Athens, 20 Kifissias | 15125 Maroussi Greece
Office: +30 210 6885215 | Mobile: +30 6946060833
axioni1@mmm.com | www.3M.com

Annex C

What is the speed radar gun and how it measures speed

A normal radar set sends out a radio pulse and waits for the reflection. Then it measures the doppler shift in the signal and uses the shift to determine the speed.

Laser (or lidar, for light detection and ranging) speed guns use a more direct method that relies on the reflection time of light rather than doppler shift. You have probably experienced the reflection time of sound waves in the form of an echo. For example, if you shout across a canyon, the sound takes a noticeable amount of time to reach the bottom of the well and travel back to your ear. Sound travels at something like 1,000 feet (300 meters) per second, so a deep well or a wide canyon creates a very apparent round-trip time for the sound.

A laser speed gun measures the round-trip time for light to reach a car and reflect back. Light from a laser speed gun moves a lot faster than sound -- about 984,000,000 feet per second (300,000,000 meters) or roughly 1 foot (30 cm) per nanosecond. A laser speed gun shoots a very short burst of infrared laser light and then waits for it to reflect off the vehicle. The gun counts the number of nanoseconds it takes for the round trip, and by dividing by 2 it can calculate the distance to the car. If the gun takes 1,000 samples per second, it can compare the change in distance between samples and calculate the speed of the car. By taking several hundred samples over the course of a third of a second or so, the accuracy can be very high.

Figure 24, 25, 26: Speed radars and how they work. The right one speed radar was the specific model used by our team, and was politely ceded in the framework of our project by the Department of Civil Engineers (Aristotle University of Thessaloniki)

Figure 27: Police officer measuring vehicle speed

The advantage of a laser speed gun (for the police anyway) is that the size of the "cone" of light that the gun emits is very small, even at a range like 1,000 feet (300 meters). The cone at this distance might be 3 feet (1 meter) in diameter. This allows the gun to target a specific vehicle. A laser speed gun is also very accurate. The disadvantage is that the officer has to aim a laser speed gun -- normal police radar with a broad radar beam can detect doppler shift without aiming.

Annex D

Photos during the implementation of the project: