Smart city transport applications in Limassol, Cyprus: major enablers to sustainable urban mobility

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Abstract

This paper describes the rational, the objectives, the procedures and the methodologies followed in the case of Intelligent Transport applications for the city of Limassol in Cyprus. These applications are part of the ITS and C-ITS system that is being developed in the city but the main message here, is the need to coordinate any smart city transport applications with the objectives and provisions of the overall sustainable urban mobility objectives for the area. The paper presents first the existing ITS and C-ITS applications that are in operation in the area. It then presents the methodology followed, and the results obtained, for the definition of the new ITS measures and actions that were proposed. Then, the paper presents in summary form the measures that were defined as of high priority and of immediate implementation. At the end, an example is given of the functional specification sheet that is produced for each of the ITS application proposed.

Keywords

Smart-city, ITS, C-ITS, Limassol, SUMP, urban mobility

1. Introduction

One of the main concepts of the current EU Transport policy is the concept of "sustainable urban mobility" which primarily means mobility that is fully aligned with the environmental objectives that are in existence in the area concerned and more globally. By consequence, every urban area in the EU has to formulate and implement specific plans for all necessary infrastructures and services that will transform its existing transport and mobility system into a "sustainable" one. These plans are known as "sustainable urban mobility plans" or SUMPs. A "Smart city" can be considered as a long-term vision of an urban area aiming at reducing its environmental footprint and at creating better quality of life based on a number of advanced Information Technology (IT) applications. A smart city, as a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business can therefore also be perceived as an overall "strategy" to cope with the traditional urban problems such as traffic congestion, pollution, energy consumption, waste treatment, etc. It goes beyond the use of information and communication technologies (ICT) for better resource use and less emissions and includes smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population.

The European Commission has established the *European innovation partnership on smart cities and communities (EIP-SCC)*[2] which is an initiative to bring together city administrations, industry, small businesses (SMEs), banks, research institutions and others. The partnership builds on the engagement of the public and private sector, the industry, and other interested groups to develop innovative solutions and participate in smart city governance in the EU. Clearly, the development and deployment of the so-called Intelligent Transportation Systems (ITS) as

Models and Methods for Researching Information System in Transport, Dec. 11-12, St.Petersburg, Russia
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well as their interconnection through the connected ITS – or C-ITS - is the main tool to utilize in building the transport systems of the smart cities of the future. The main ITS and C-ITS services for urban mobility in the forthcoming years in Europe are summarized in Figure 1. A significant issue will be, systems standardization and systems integration and interoperability as, already, very many EU urban areas have throughout the years, implemented ITS applications in accordance to SUMPs that they have developed previously.

Limassol is the second largest urban area in Cyprus after Nicosia, with an urban population of approximately 185 000 and a metropolitan area one of approximately 240 000. The city completed its Sustainable Urban Mobility Plan in 2019 [2] and is moving now to its implementation which together with IT applications in other sectors (i.e., besides transport) will lift it to smart-city status. The proposed ITS measures for Limassol were fully aligned with the approved measures of the Limassol SUMP study and they were reported and described in detail in Deliverable 8 of the study, entitled "Technical Modelling Report with Scenario Evaluation" and specifically the preferred scenario 6.

This paper presents the main IT applications that were proposed for the city of Limassol together with the proposed steps and procedures for their approval and implementation. The importance and value of using Information Technology in developing C-ITS applications is important and has been quantified at more than 50% of the total value of the applications [4].

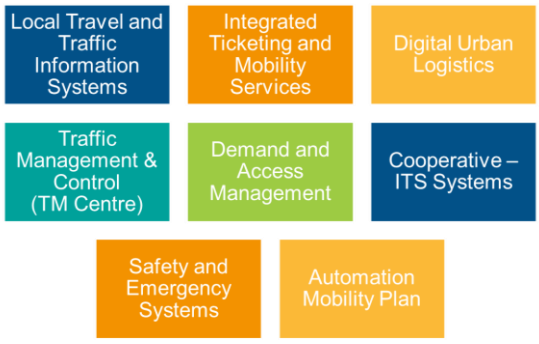

Figure 1: Current EU supported ITS Services in Urban Environment

2. Existing ITS and C-ITS systems

2.1. The Cyprus National ITS Master Plan

The Cyprus ITS national master plan has been conducted in the time period 2007 – 2009 by the Public Works Department (PWD) of the Cyprus government. The plan included specific measures and systems in the areas of:

- Advanced Traffic Management.
- Advanced Traveler Information Services.
- Temporary ITS Systems for construction zones – mobile systems such as CCTV, Variable Message Signs, Radar Detectors to manage traffic around and through road construction zones.
- Priority to specific vehicles at Signalized junctions
- Weigh in motion System (to facilitate the enforcement of limits to axle weight for lorries).
- Parking Availability System (provision of information to road users on parking availability in car parks that are monitored by the system).
- Public Transport – Ticketing System (for the electronic issuing and validation of bus tickets).
- Public Transport – Fleet Management & Passenger Information Services.
- ITS systems to be deployed for specific Bus Terminals (e.g., the new bus Terminal in Solomou Square, Nicosia).

Since the formulation of the national ITS master plan, the following systems have been actually implemented in Cyprus (mainly in the capital city, Nicosia, but many of them in Limassol too):

- **Advanced Travelers Information Services.** The information provided regards the traffic conditions, events, and incidents on the main road network of the island. All information produced

is made available by the web portal DIAVLOS (Figure 2).

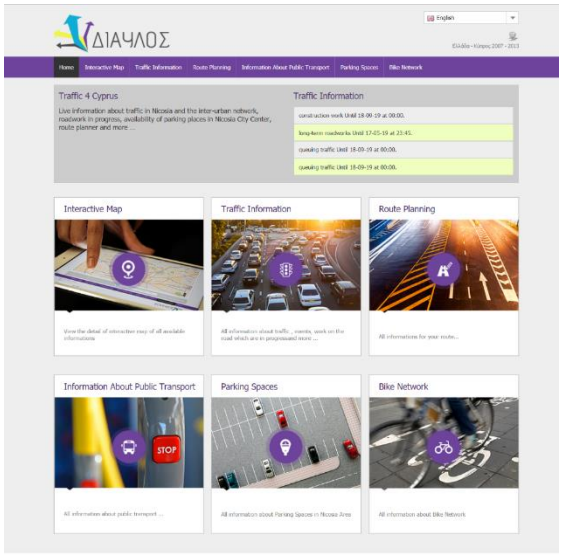

Figure 2: Home Page of the Diavlos central traffic information system

- **Public Transport: Fleet Management & Passenger Information Services.** This system has been installed also for the urban and rural bus lines of Limassol.
- **Public Transport – Ticketing System.** The system includes also the urban and rural bus lines of Limassol.
- **Parking Availability System.** A real-time parking availability system has been installed for 5 Municipal parking areas in Nicosia in the framework of DIAVLOS portal and this system is fully expandable and foreseen to be installed in the city of Limassol.

2.2. ITS in Limassol

A central traffic management and info-mobility system set up in the city of Limassol manages the following sub-systems:

1. **Traffic detection units recording traffic flows, average speed and traffic composition.** Permanent traffic counters and Bluetooth devices have been installed throughout the years and in the framework of DIAVLOS, MIELLE and PRODROMOS projects. So, traffic levels, average speed, traffic composition and travel times are monitored and stored in real-time. Such data are available and managed by the PWD Traffic Management and Control Center (TMCC) in Nicosia. Also, CCTV cameras for visual monitoring of traffic conditions and traffic incidents (limited geographical coverage) is installed.
2. **Vehicle Actuated Traffic signalization system.** The SCOOT system has been installed in 90 intersections in Cyprus which provides advanced functionalities for traffic-actuated traffic signals operation, traffic signal optimization in an arterial or a specific selected network. The system for all traffic signalized intersections in three (3) cities of Cyprus: Nicosia, Limassol and Larnaka is centrally managed by the PWD Control Room.
3. **Bike reservation / bike sharing system.** A bike reservation/bike sharing system has been introduced in Cyprus and specifically in Limassol. The service operator is *NextBike* Cyprus which enables cycling around the city. A public bike sharing system is available in Limassol with bikes available 24/7. A web-portal is available for users to reserve their bikes according to the real-time bike availability in various stations within Limassol.
4. **Bus Fleet Management System.** An Automated Vehicle Location (AVL) System is installed in the entire urban and rural bus fleet of Limassol. This system is expected to optimize bus operation and time-schedules of the Limassol bus operator, while the Ministry of Transport, Communication and Works will be able to centrally monitor the service level of bus operation. The system is under initial operation.
5. **Bus Travelers Information System.** Based on the installation of the Automatic Vehicle Location system in the entire urban and rural bus fleet of Limassol, a dynamic travelers' information system is installed for the provision of dynamic bus time-schedules and bus arrivals. The dynamic information is made available via on-board dynamic displays, LED signs at bus stops and a web-portal application. The system is on final implementation stage.

6. **Bus Ticketing System**. An advanced bus ticketing system with smart cards and web-service reservation/ purchase system is installed for the Limassol Bus Operator. The Ministry of Transport, Communication and Works will be able to receive reports on the actual transaction of bus services.
7. **National Single Access Point.** A National Single Access Point for Cyprus is at procurement stage by the Ministry of Transport, Communication and Works. The National Single Access Point was expected to be completed by the end of 2020; the system is developed in accordance with the requirements of the EU Directives 2015/962/EU and 2017/1926/EU regarding the provision of EU-wide real-time traffic information services and EU-wide multimodal travel information services respectively. As a first step, this system will cover the TEN-T network of Cyprus, but it can be also cover in future the transportation network of Limassol (e.g., as an expansion project).

3. The proposed Smart City implementation in Limassol

3.1. Methodology

The proposed ITS measures for smart-city Limassol had to be fully aligned with the urban mobility measures proposed in the Limassol SUMP study (scenario 6) and build upon the existing ITS infrastructures that were already in place. As such they fell in the following categories of measures that were defined according to the (improvement) objectives they wanted to achieve:

- Improving the layout / structure of the Public Transport (PT) network to better respond to the desire of movements and promote the complementarity of the city's transport systems.
- Improving - upgrading the PT services offered.
- Affecting the costs of using the PT system.
- Help develop emissions-free zones in environmentally sensitive or congested areas in the city center and other sensitive locations by discouraging the use of cars in these areas while at the same time facilitating the traffic around them and increasing of the availability and level of service of PT lines inside them.
- Affecting the operating costs of car and/ or the costs of using a car.
- Increasing the road safety.
- Improving environmental conditions.
- Increasing the public space to citizens.

For each of the above category of measures, specific proposed ITS measures were defined accompanied with supportive material such as maps, figures etc. This definition was based on the experience from other European urban areas, the need to utilise and expand the existing ITS infrastructures in the area as well the projects in existence or in the pipeline for the whole of the country. Following the identification of the potential ITS measures for each of the above categories, a prioritization exercise was carried out by taking into account the expected benefits, best ITS practices, the local characteristics as well as the possible budget limitations. The systems assessed as of "high priority" were the most suitable for short-term implementation and were recommended for application in parallel with the adoption of the relevant urban mobility measures of the preferred scenario 6 of the SUMP study. Since technology is evolving, the time-horizon for the implementation of ITS measures is relatively long. Usually for ITS, a seven-year time period is considered as the average time required from conception to implementation. So, the high priority systems should be at least expected to be implemented in the study area in a shorter time period depending also on the implementation timeline of their related SUMP measures.

Within each of the priority categories a small number of "early winner" projects were also selected. These were ITS measures that could be implemented in even shorter time periods than the priority ones since they were without the need to fulfil many bureaucratic pre-requisites or dependent on other implementation activities. This overall methodology followed is shown in Figure 3.

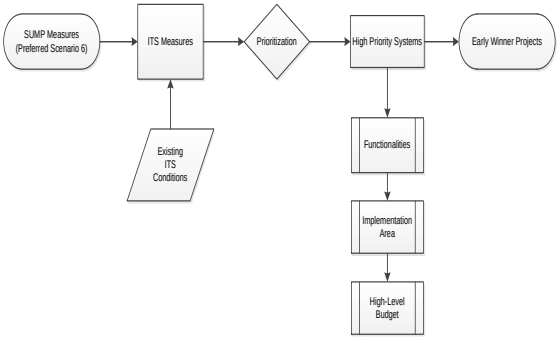

Figure 3: The methodology for defining and selecting the smart-city Limassol ITS measures.

3.2. Proposed high priority ITS measures

According to the above methodology the following ITS measures were assessed as of high-priority per category:

A) Improving the layout / structure of the PT network to better respond to desire of movements and promoting the complementarity of transport systems:

i. *Dynamic Bus Display Signs*. These were to be applied in: the main bus terminal located in central CBD, transportation centers / intermodal stations, Park & Ride places. The dynamic display signs should provide real-time information about bus arrivals and bus departures in integration with the bus fleet management system currently installed in public transport services of Limassol.

ii. Improvements in the existing bus fleet management and web-based public transport travelers' information system that are already installed in Limassol.

B) Upgrading of the PT services

i. *Bus Priority System.* Exclusive bus lanes in the seaside boulevard of Limassol are proposed. The lanes should also provide bus priority at the traffic signalized intersections in order to minimize intersection bus delay and increase bus schedule reliability.

ii. *Bus Lane Enforcement System.* This ITS measure will detect and penalize the private vehicle drivers who use illegally the bus lane.

C) Affecting the costs of using the PT system

i. *Advanced ticketing system.* This was already proposed by previous studies and it was further refined and delineated. It is currently being installed in Limassol.

D) Development of emissions free zones

i. *Advanced Urban Traffic Control (UTC).* The upgrading and re-activation of a pre-existing SCOOT system (vehicle demand actuated) was proposed. This upgrading consisted of: the procurement of new traffic controllers; some additional works of maintenance of the existing inductive loops; installation of new traffic detection units; new telecommunication infrastructures; and finally, the expansion of the SCOOT system's geographical coverage.

ii. *Traffic Detection.* Installation of various types of devices for permanent recording of traffic flows, traffic composition, average speeds (e.g. inductive loops, radars, cameras) as well as recording of travel times such as Bluetooth devices. Floating car data was also recommended to be used with location data by mobile devices or on-board units within the vehicles. The system should be integrated with the Ministry's Traffic Management and Control Center (TMCC) in Nicosia and the available existing software applications (such as MISTIC).

iii. *Variable Message Signs (VMS).* Installation of VMS in critical

intersections within the Study Area in order to provide real-time information to drivers about traffic conditions, programmed events and road incidents. The system should also be integrated with the TMCC of Nicosia and the available existing software applications (MISTIC).

iv. *Incident Detection.* Installation of Automatic Incident Detection (AID) cameras in critical intersections and/or black spots within the whole of the urban area. The system should be integrated with the Ministry's TMCC and relevant software applications.

v. *CCTV monitoring.* This refers to the monitoring of critical road intersections within the CBD so that the TMCC Operator can visually monitor the pertaining traffic conditions and queues as well as to validate traffic incidents/ events on the road network.

E) Affecting operating costs of car and/ or costs of using the car

i. *Integrated Parking Guidance System.* Provision of parking availability compared to supply and demand. This system refers primarily to the provision of dynamic parking availability for off-street parking areas in the core CBD of Limassol in order to minimize spent time for parking and to reduce traffic congestion.

ii. *Advanced Parking Payment System.* Provision of modern parking reservation and payment systems for on-street parking, so that the occupancy and the parking duration of each parked vehicle in a dedicated parking slot is monitored dynamically.

F) Increasing the road safety

ITS measures in this category (e.g., speed-limit enforcement systems) have not been identified as having high-priority at the moment either because their expected benefit was not considered as substantial or because of budget limitations. They were recommended as "normal" priority measures.

G) Affecting environmental conditions

Currently, there is a bike reservation/ sharing system in operation in Limassol. Expansion in terms of geographical coverage and integration of this system with the TMCC was recommended but other than this, no other high priority ITS measures have been identified.

H) Increasing the public space to citizens

The high priority measures that have been identified earlier in the category "emissions free zones" are also expected to support this category, so no additional high-priority measures were proposed.

3.3. Detailed functional specifications of the systems proposed

Of interest is that for each specific measure of the above list, a very detailed functional specification Table was formed giving all the necessary functional specifications and other details such as objectives, functionality, implementation area, approximate cost, duration, benefits and pre-requisites for implementation. The following figure shows all the items of information supplied and is shown as an example of a useful and necessary information to collect about any proposed ITS measure before actually moving on to procurement and implementation.

System Name:

SUMP Measure(s) to which it fits:

Urban ITS Service served:

System Objective:

System Description (detailed description of the system proposed with objectives, functional characteristics, and so on – as an example of the type of info given here, the following text refers to the CCTV cameras installation measure):

The scope of CCTV cameras is either to view, in real-time, any traffic events or incidents, or to verify a specific traffic event or incident after receiving some relevant notification (such as traffic variables indications by traffic detectors, receiving a notification by police or local council or citizen).

The recommendation is that CCTV cameras that are not required for traffic counting or other continuous processing should be PTZ so that the operator will be able to monitor larger road stretches, using a single camera. Through PTZ cameras, the covered surveillance area is expected to bed widened considerably as opposed to a situation where static cameras are used. The positioning of CCTV cameras depends heavily on their intended use. The main scope for Limassol should be to achieve visual surveillance of critical traffic signalized intersections such as highly congested intersections as well as intersections where dedicated bus lanes are in operation. In future, the CCTV system can be further expanded in order to achieve a significant adequate coverage of primary road arterials in Limassol.

The system should support the following key functions:

- A user-friendly GUI allowing the TMCC operator to control the cameras' parameters. Basic camera management and monitoring functionalities should be provided by the Advanced Traffic Management Software and integration to this software is necessary. Through the central GUI, operators should be able to have an overview of the system, as well as access to the system's components. The locations of the cameras should be mapped in relevant cartographic format on the TCC's base GIS.
- Accessibility rights for each authorized user in terms of available functionalities and specific camera use.
- Live video image feeds as well as video recording and playback capabilities are necessary. A timeline and log of each recorded event should be kept, and operators should be able to attach notes to each file.
- Different camera states (such as viewing, recording, or stand-by) should be easily monitored.
- Standard viewing functionalities such as Pan-Tilt-Zoom control, 360o navigation/rotation of cameras or lens, switching camera view, multiple/parallel camera views, and shared views between users should be available.
- Pre-defined states and pre-sets of PTZ cameras should be configurable in order to move the cameras accordingly.
- Data processing functionalities providing flexibility of creating or editing any event or incident.
- Generation and management of reports.
- Generation and management of alarms.
- Printouts of various reports can be undertaken (including time of recording, user and any operator's notes)
- Diagnostic functions for provision of dynamic information related to the state of equipment should be provided.

The data transmission from the on-site equipment to the TMCC should be conducted through a high-speed connection, such as a fibre optic network.

The main activities for system development are the following:

- Installation of CCTV/ PTZ at critical intersections.
- Installation of CCTV management system or integration with the existing PWD TMCC software system.
- Basic hardware equipment for system hosting.
- System configuration.
- Pilot/Test period.
- Brief training session.

Implementation Area (with maps and points of installation):

Integration Needs:

Estimated duration of implementation:

Estimated benefits:

Benchmarking:

Pre-requisites for implementation:

Estimated implementation cost:

Figure 4: Example of useful and necessary information to collect regarding any proposed ITS measure.

3.4. Longer term smart city concepts and services proposed

Other smart city innovatory measures and services which are suggested to be examined for the longer term were the following:

- Mobility as a Service (MaaS) operations based on future 5G communications and enabling multi-modal mobility should be examined for introduction. These services will provide user-centric information and travel services such as navigation, location, booking, payment and access in order to satisfy seamless mobility as a service.
- Autonomous Transportation Systems. Fully autonomous public transport (bus) services should be the first option

to consider followed by a fully autonomous individual mobility (cars).

- Big and Open Data. Collection, management and freely available traffic data storage and computing capacity should be provided to enable all sorts of new services to be developed by entrepreneurs.
- Cooperative Transport Systems. These are planned to be fully deployed with priority the vehicle to infrastructure communication (V2I) and vice versa (I2V). The publication of the European Strategy on Cooperative Intelligent Transport Systems (C-ITS), of the European Commission [3] is expected to form the basis for the future strategy of the Limassol municipality on this domain.

More complex IT smart city applications will be considered, within the urban environment to materialize the many inter-related urban transportation functions that are being applied.

4. Conclusions

Public administrations and municipalities across Europe are striving to plan and implement Intelligent Transport Systems applications with a view to integrating them within their smart-city concept of the future. They are facing a challenging task to harmonize sustainable urban development, i.e., the need for environmental protection, offering job opportunities and preserving better living conditions, with the need to achieve good mobility services based on Information Technology and Intelligence. This paper explained the way these tasks were handled in Limassol the second largest city of Cyprus.

The key message and conclusion from this case is the need to combine the provisions and requirements of a Sustainable Urban Mobility Plan (SUMP) with the provisions and requirements of the high-level technological applications that are necessary for the development of a “smart” mobility system as part of the smart-city concept of the future. This combination of tasks should be the major prerequisite in all future smart-city developments. It is also of interest to note that within the context of a real-world smart city application a most difficult aspect is the selection and prioritization pf the measures to be employed. Prioritization is a particularly critical phase in the whole process and has to be carried out with due respect to the local conditions and the objectives of the local authority concerned.

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