



CiViTAS

Cleaner and better transport in cities

ELAN

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Implementation status report on first 11 bus stops equipped with real time information

ELAN Deliverable No. 1

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	WP3 Demand management		WP9 Project coordination
	WP4 Influencing travel behaviour		WP10 Project management
	WP5 Safety, security & health		WP11 Research and Technological Development
	WP6 Innovative mobility services		WP12 Impact and process evaluation
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1. SUMMARY

Measure 8.4. – Real Time Information for Staff and Passengers is realized by company Telargo as measure leader in cooperation with partners Javno podjetje Ljubljanski potniški promet d.d. (LPP) and City of Ljubljana (COL).

Passenger expectations have risen greatly over the past years. Whether it is for increased services, cleaner vehicles or more accurate information, passengers rightly demand the highest in quality services to enhance their journey experience. Key to this information are real time passenger information systems, which provide accurate departure and arrival times, enabling travellers to plan their journeys and thus make better use of their time.

Hence, main objectives of respective measures are:

- to provide staff and passengers with real time information about public transport services at different locations on the CIVITAS-ELAN corridor.
- to equip 33 bus stops with remotely managed Electronic real time information displays

This document is upgrade of Deliverable that was initially prepared and reported on implementation of real time bus arrival information system on first test display at bus stop Konzorcij (Deliverable “Implementation status report on first bus stop equipped with Real Time Passenger Information”). Some of the information that was already presented in previous deliverable is also included here (chapters Introduction to the project and Description of the system), just to deliver comprehensive document.

This report presents the implementation of 23 electronic displays in the city of Ljubljana by which the following milestones were achieved:

- equipment of 11 + 10 bus stops with remotely managed LED
- implementation of direct communication technology at the bus stops for higher information accuracy

The next step in order to fulfil set objectives is to equip additional 12 bus stops in year 2011.

2. INTRODUCTION TO THE PROJECT

2.1. City of Ljubljana

Ljubljana, the capital of Slovenia and the cultural, trade and scientific centre, is the coordinating city of the CIVITAS ELAN project. The city has 275.000 inhabitants, 47.000 are university students. In addition more than 130.000 commuters travel to the city each day.

It is situated at a crossing, where West European influence meets with influence of the Central Europe, Balkans and Mediterranean. On the intersection point where foreign interests overlap since centuries, its influence contributes to geographic and climatic as well as cultural diversity.

Creating almost one third of entire Slovenian trade and having about one quarter of all employed people, Ljubljana strongly influences dynamics of entire region and Slovene economy.

High urban density in city center with 27,000 people living in an area of 5 km², very high concentration of activities in star shaped city topography, underdeveloped public transportation system and modest use of public transport facilities - low level modal split contributes to air pollution, noise, traffic jams, congestion problems and decreases the quality of living.

2.2. Ljubljana Public Transport Company (LPP)

The Ljubljana public transport company is a public company, established by Holding of Ljubljana for offering public transportation services in Ljubljana and neighboring regions. The buses cover 21 city routes and 35 suburban routes. In Ljubljana public transport they carry about 80 million passengers per year with 210 buses on road (urban transport).

Public transport service is denoted by vast dynamics in transportation and daily as well as seasonal fluctuations in the number of passengers.

LPP is striving to provide as modern, comfortable, safe and reliable transportation as possible to the citizens of Ljubljana as well as those living in suburban municipalities who come to work or school to Ljubljana on a daily basis. By purchasing new, modern, air-conditioned and environmentally friendly buses, providing regular training for drivers, timetable optimisation and many other projects and measures, they are already able to provide quality public transportation service; by implementing long-term goals, they would like to achieve that public transport in Ljubljana and the surrounding areas becomes even more reliable and comfortable and thus the best choice for travelling around the city.



Figure 1: Ljubljana Public Transport operated by Javno podjetje Ljubljanski potniški promet d.d. (LPP)

One of the measures that can help achieving the goals written above is also implementation of real time bus arrival information.

LPP is together with Telargo and COL partner in measure 8.4. - Real Time information for staff and passengers.

2.3. Public Transit Management and real time information before Civitas Elan

Ljubljana Public Transit Company LPP wanted to modernize their fleet operations to ensure higher quality of service including all involved parts from planners, supervisors, analysts and passengers, thus they have published public tender in 2004 and have selected Real time public transit management solution offered by Telargo, comprising at minimum the following functionalities:

- Delivers one stop fleet and route monitoring interactive dashboards to efficiently support fleet operators in their daily tasks of monitoring and regulating traffic under constantly changing traffic conditions: route performance monitoring in real time, current bus position on respective route, bus intervals, planned schedule comparison (ahead of schedule, delayed), detailed route / vehicle / stop information, driver history overview (graphical format and on digital maps)

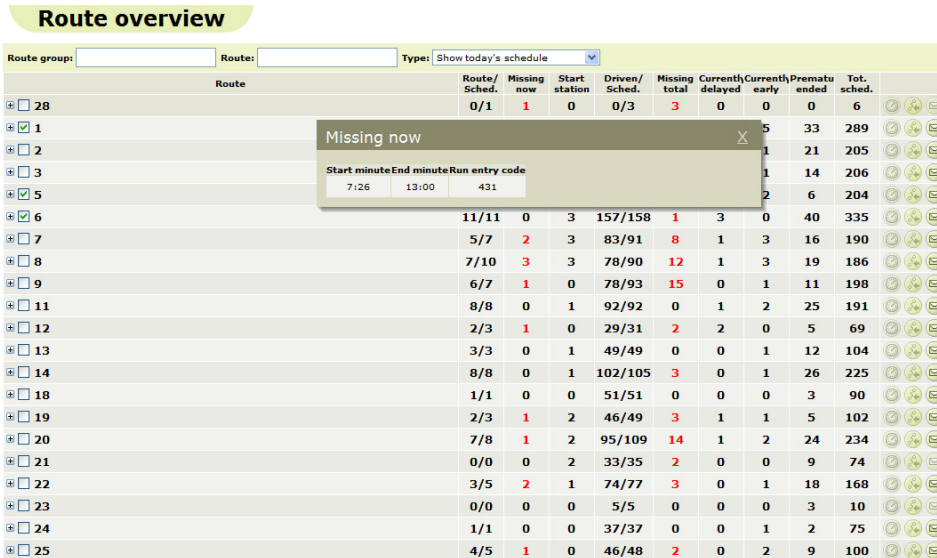


Figure 2: Public Transit Center route overview – real time data



Figure 3: Routes (lines) with buses and bus stops presented on line diagram (real time information on vehicle's position)

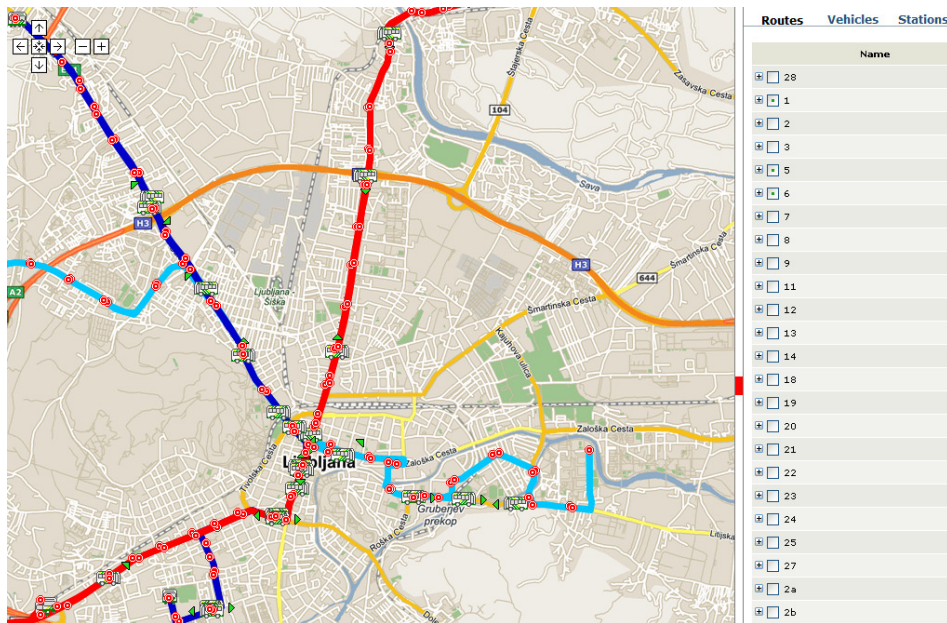


Figure 4: Map overview – vehicles, routes, stops

- Incorporates powerful solution enabling flexible event management (set up event parameters, trigger alarms) and thus informs dispatcher of any alarming situation; it provides event overview in real time and event history overview
- Equips drivers with tool to be promptly informed about their performance, enable safe communication with back office and quick reaction in unpredictable circumstances
- Effortlessly integrates with existing systems (e.g. scheduling and planning systems, etc.) and provide the access to vehicle and bus stop real time data
- Reduces the costs related to its bus fleet with a comprehensive set of data mining and analysis tools based on actual data enabling advanced traffic system planning, scenario building and flagging operational deficiencies
- Increases Security for bus drivers and Passenger: make sure that dispatcher or fleet operator can always call any bus driver and ensure good voice communication or messaging, as well as identify where all buses is located
- Provides real time bus arrival information to passengers over various media: web, wap and SMS



Figure 5: Bus arrival information accessible on dedicated web site



Figure 6: Passenger send SMS to inquiry about next bus arrivals

On Board Equipment

In order to provide the above features Telargo has equipped buses of Ljubljana Public Transport (LPP) with Telargo On board equipment:

1. AVL device (Telargo Mobile Unit) which combines the functionalities of GPS positioning, data acquisition and transmission over GSM/GPRS and telemetry with a variety of further expansion and integration options; certified according to international standards and is fully compatible to be mounted into buses.
2. GPS/GSM combined antenna

- Handset and RFID card – driver interface that enables driver login/logout, input of applicable run/route information (this is very important for bus arrival system; accuracy of predictions) voice and messaging communication with dispatchers (back-office), status selection, etc.

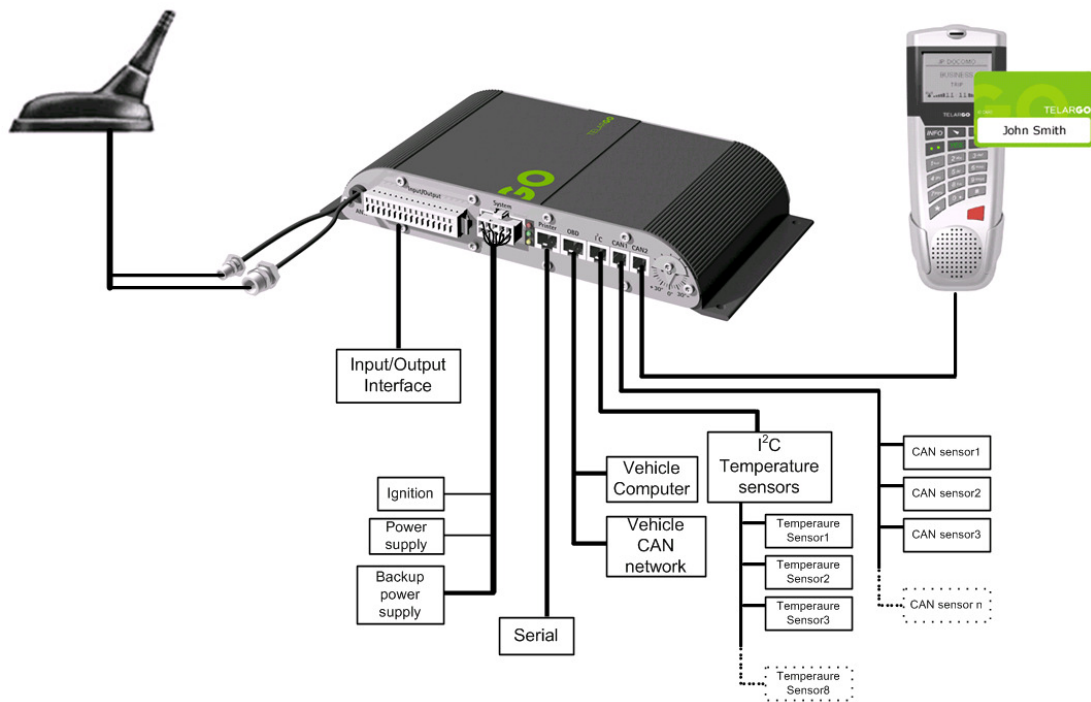


Figure 7: Telargo On Board equipment

The goal of the project is to upgrade the existing system, develop communication protocol and implement real time bus arrival information also at bus stops on electronic displays so that bus stops in Ljubljana would look something like presented on the below mock-ups.

Company Telargo was contacted by Project Astute (Advancing Sustainable Transport in Urban Areas to promote Energy Efficiency; <http://www.astute-eu.org/>) and was invited to present current bus arrival solutions offered to LPP passengers (accordingly video was prepared). Implementing Real time electronic displays on bus stops in Ljubljana as part of Civitas Elan project was mentioned.



Figure 8: Current bus arrival solutions offered to LPP passengers presented in video created within EU Astute project

2.4. Bus arrival information for passengers on bus stops before Civitas Elan

Passengers waiting on bus stops have the access to the following bus arrival information:

- list of routes (lines – route number and direction) that run through the bus stop

- scheduled bus arrival intervals for each route, day of the week (work day, weekend, holiday, etc.) and particular time period (00:00, 05:00, 05:00 – 07:00, etc.)
- more frequent bus stops have information how to use LPP bus info service (text messaging)



Figure 9: Bus arrival information available at bus stop before Civitas Elan

3. DESCRIPTION OF THE SYSTEM

3.1. Real time bus arrival system – overview

Although Automatic Vehicle Location (AVL) systems are initially deployed to increase the efficiency of transit operations, data from AVL can also be used for real time information and thus also present the basis for real time bus arrival system.

Important feature of Mobile Unit (in particular in relation to Real Time Bus Arrival Information System) is accurate and reliable bus positioning. Telargo Mobile Unit constantly determines vehicle's position using GPS receiver and performing dead reckoning based on gyroscope. A data compression algorithm is implemented to compress location data and provides for exact trip recording.

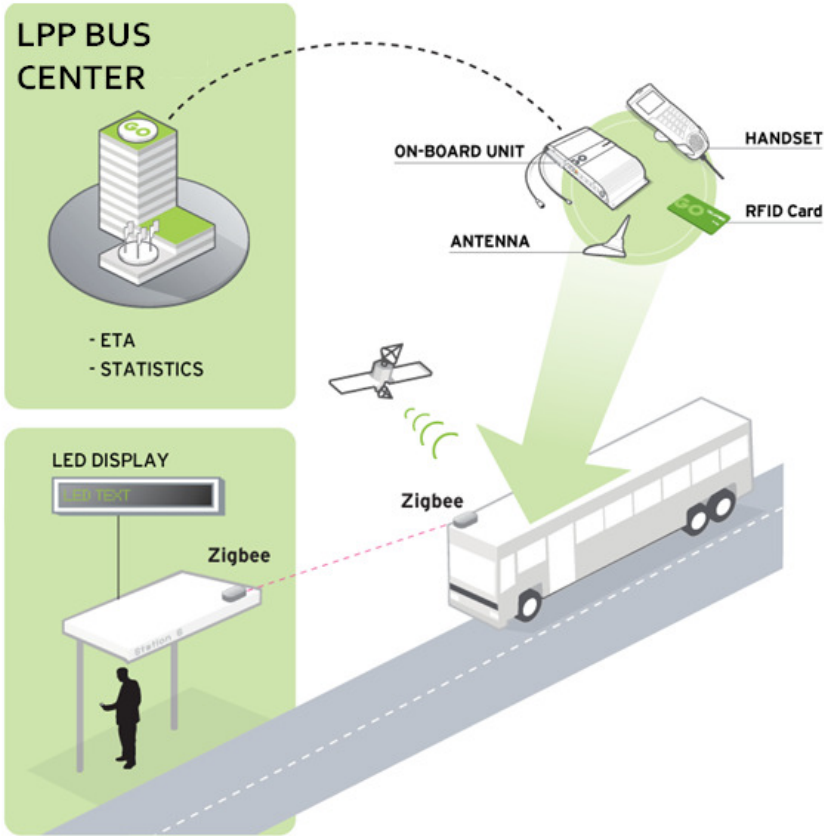


Figure 10: Real Time Bus Arrival System as adopted for implementation at bus stops

All data gathered by Mobile Unit (related to vehicle, route/ travelled lines, driver) are transferred to Control Center which is an application server from a map server, a communication server and data-bases. It provides secure and easy access to fleet data through the internet.

For users to access public transit management data in real time as well as review historical information, web based application was developed – Public Transit Center. It presents an essential tool for

fast and effective management of public transit fleets and for providing additional services to your passengers.

Telargo Mobile unit sends gathered data to Bus server where the statistics and ETA is calculated. Telargo bus arrival time system - prediction tool executes ETA calculation and predictions including various prediction accuracy analysis and ETA performance standard analysis. The accuracy of our prediction tool was tested on existing clients and proves high accuracy of predictions.

Implementation of direct communication technology

Additionally, it is very important for public transit operator that passengers can rely on real time information displayed on the bus stops such as bus arrival and departure to/from the station. This can be very challenging task particularly in very busy environments. To overcome the problem Telargo has developed a solution of a smart station which uses ZigBee to communicate with the buses.

The main benefits of the proposed solution is that the departure events are cleared as soon as bus leaves the bus stop or station, it provides for quick information exchange between the bus stop and vehicle and vice versa as well as new information quickly replaces the old one.

Telargo has developed a smart bus solution where the bus also directly communicates with the bus stop. Using dedicated short range transceiver installed on the bus, with the same type of transceiver deployed at bus stops, it is possible to pinpoint the moment vehicle approaches the bus stop (distance of triggering is flexible; up to 100 meters). When a bus enters the range of such a transceiver, the transceivers talk to each other via a ZigBee wireless connection. The transceiver on the bus provides the unique ID number associated with that specific vehicle, as well as its route number, to the transceiver at the bus stop. The data is interpreted by the Telargo system, after which the LED display informs passengers waiting at the bus stop that the vehicle has arrived at the station and that the vehicle has departed. This is the unique example of ZigBee communication with the bus stop.

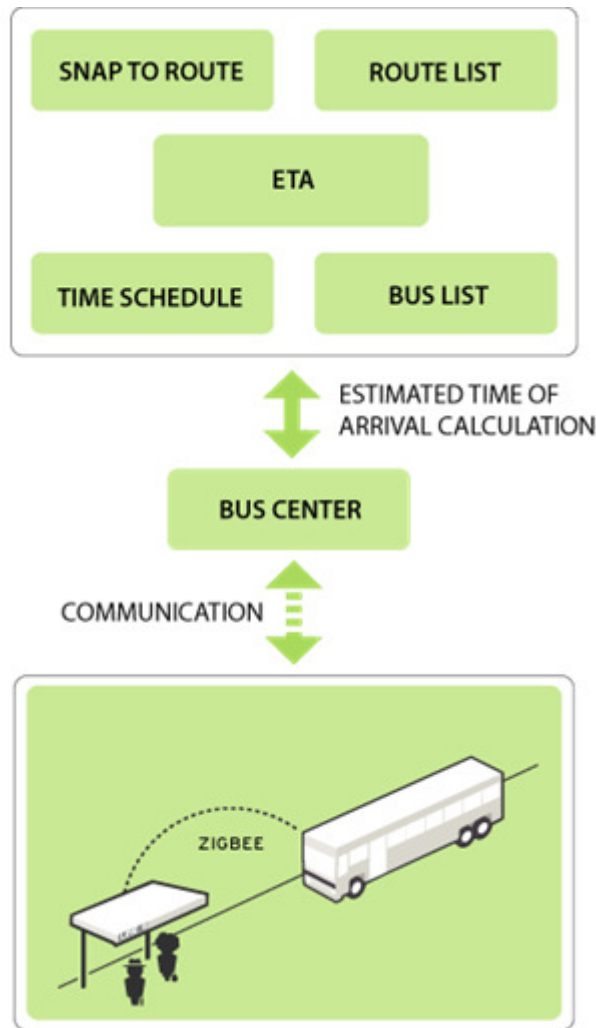


Figure 11: Dedicated short range communication

3.2. Bus arrival predictions

The position of the vehicle is acquired by the Telargo Mobile Unit (TMU) every second. From the GPS and gyroscope position as well as odometer of the bus the advanced algorithm in the Telargo mobile unit performs dead reckoning and on route matching. This way the position of the bus is matched on route every second with the precision of 5 meters.

This on route data is send to the server every 30 seconds. Besides this data also arrival and departure times form stops, door opening times and route durations are transmitted to the server. Based on this data the statistics are bulk and ETA is calculated on the server. The data is send over primary communication channel (default GPRS). However if the communication channel is temporary not available (mobile network problems, malfunctions, poor GSM signal, etc..) then the position is sent over backup channel (SMS messages or other, where applicable). In case the position is sent over backup channel, the data exchange between TMU on the Bus and the Bus Center can take up additional time. Bus Server and Statistics is run as a background service and communicate with the external user interfaces including information for passengers, route monitoring and third party interfaces.

3.3. ETA Calculation

Arrival time is recalculated every 30 seconds for all new data and current traffic situation. For calculating the arrival the statistics tables are used. Arrivals are calculated for all buses currently on route and for scheduled busses in advance.

3.4. Prediction transmission to the electronic displays

Estimated time of arrivals predictions information is transferred to Electronic displays on bus stops via Ethernet network. All the predictions can be available for distribution to other servers or any other storage facilities. The announcements “arrived”, “departed” are communicated over dedicated short range communication.

4. PLANNING

The activities in the planning phase were mainly two-fold; the activities related to the AVL system, predictions and system integration and on the other hand the activities dedicated to the preparation and execution of public tender procedure. Thus the planning phase included the following activities and tasks:

- review of present AVL system with backup system utilized by LPP (in particular the server components and bus center) in order to provide for real time passenger information data transfer and integration with electronic display has been conducted
- the AVL (Automatic Vehicle Location) and fleet management system currently utilized by LPP was enhanced, in particular bus centre and ETA (estimated time of arrival) prediction calculations program was upgraded to provide for accurate and reliable real time arrival predictions
- communication protocol for system integration between bus centre and bus stop was designed as well as the protocol of direct communication between PT fleet and bus stop
- study to define electronic display connection, communication protocols and direct communication equipment configuration has been prepared
- implementation of test electronic display at bus stop Konzorcij and study of the results



Figure 12: Part of the planning phase was also implementation of test electronic display at bus stop Konzorcij; however the test display didn't already include dedicated short range communication technology

Activities related to preparation and execution of public tender procedure:

- expert commission was established to carry out public procurement procedure from the technical perspective as well as oversee the correctness of procedure and compliance with legislation

- members of commission were Civitas Elan partners (Telargo, LPP, COL), Public procurement office (COL) as well as other experts from LPT and Javni holding
- the commission had regular (almost weekly) meetings to review and amend technical specifications, ensure that all aspects are covered and included specifications are enough detailed, also we had to assure that specifications are not discriminatory and they can be met by various vendors, criteria to approve the tender was defined (emphasis were placed on vendor experience – signed references)
- finally type of electronic displays was determined, in particular per deputy mayor opinion (single face 6-line and single face 2-line displays were confirmed)
- in order to estimate procurement costs, several proposals/quotations were obtained from domestic and foreign companies interested in this tender; based on received information estimated cost breakdown structure was prepared (equipment components price, installation costs per each foreseen bus stop with regard to already established infrastructure – electricity, optics)
- from the legal perspective the contract (framework agreement) was prepared, reviewed, amended (in particular regarding the scope of agreement, definition of warranty/after warranty maintenance service, project delivery time plan, etc.)
- as part of tender documentation the protocol specification document was prepared “communication with control center for public transit management” public procurement tender was published on “enarocanje” portal as well as on OJEU portal on 29.12.2009; potential bidders were invited to submit they proposals till 15th of February
- in the mean time some additional questions, requests for clarification were received and the commission has prepared adequate responses
- 3 proposals were received; all the proposals were thoroughly analyzed and evaluated against the requested requirements and minimum technical specifications.
- The result of analysis and evaluation was the report and final award decision of most favorable bidder signed by mayor

Once the vendor of electronic displays was selected the necessary activities related to construction, electrical and installation took place. Namely, COL in cooperation with LPP and JP LPT defined the final micro-locations of electronic displays on bus stops; thus several site visits were performed. Also COL in cooperation with JP LPT provided for electrical and optical network as well as provided the connectivity to respective network till Ethernet level.

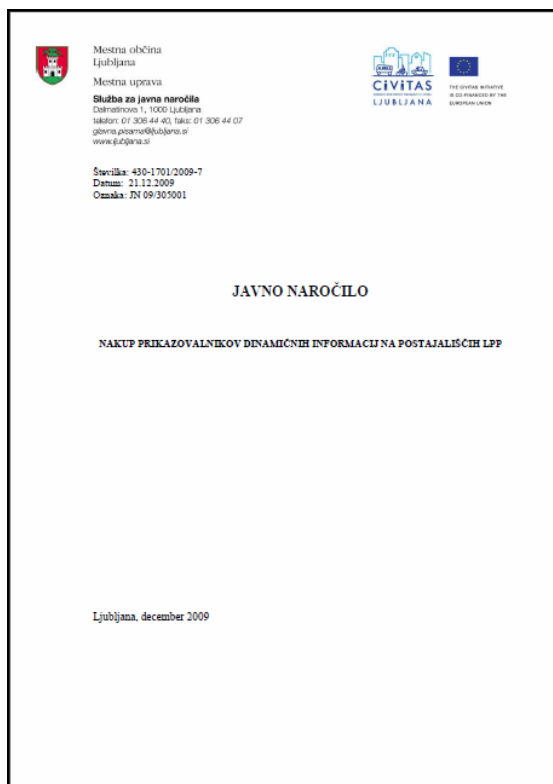


Figure 13: The final version of tendering documentation – first page

2. OPIS PREDMETA JAVNEGA NAROČILA

2.1. PREDMET JAVNEGA NAROČILA

Predmet razpisa je nakup in montata prikazovalnikov dinamičnih informacij na avtobusnih postajališčih mestnega potniškega prometa.

Predmet razpisa zajema dobavo in montato zunanjih elektronskih prikazovalnikov na postajališčih na predpripravljenem stojno mesto, integracijo programske opreme prikazovalnika s komunikacijskim protokolom za prenos podatkov, ki ga definira pomodnik obstoječega sistema sledenja vozil in kreiranja napovedi prihodov na postajališta (ustrezna dokumentacija je priložna razpisu) ter programsko orodje, ki se namesti pri izvajalcu javnega mestnega potniškega prometa preko katerega v on-line načinu kreira različna dinamična obvestila za prikaz na prikazovalnikih na postajališčih in sicer za posamični prikazovalnik ločeno ali skupno za izbrano skupino prikazovalnikov (od enega do vseh).

Obvezno število prikazovalnikov, ki jih naročnik kupi pod pogoji (tehnični in dokontni prevzem, garancija, reference) za dogovorjeno vrednost ter drugi pogoji, kot so definirani v priloženem okvirnem sporazumu, vključno s storitvami servisiranja v splošni garancijski dobi in ostalimi pogodbenimi storitvami je:

Tip prikazovalnika	1. faza	2. faza	3. faza
1. šest (6) vrstični enostranski	15	5	/
2. dva (2) vrstični enostranski	10	29	55
Skupaj	25	34	55

Naročnik in dobavitelj sta soglasna, da so navedene količine blaga okvirne. Naročnik se ne obvezuje, da bo naročil celotno količino blaga. Naročnik si pridržuje pravico, da zmanjša oziroma poveča število prikazovalnikov po posameznih fazah v skladu z dejanskimi potrebami in razpoložljivimi finančnimi sredstvi.

2.2. SPLOŠNO

Na avtobusnih postajališčih ljubljanskega potniškega prometa je potrebna postavitve zunanjih prikazovalnikov informacij o prihodih avtobusov na postajališta.

Namen prikazovalnikov informacij je takojčim potnikom posredovati informacije o točnih prihodih avtobusov po posamezni liniji na avtobusno postajališče v realnem času ter druge dinamične storitvene informacije.

Z namestitvijo postajališčnih elektronskih prikazovalnikov informacij želimo predvsem povečati znanje v javni prevoz, povečati delež uporabe javnega prevoza, čakanje na avtobus ob zmanjšanem prihodu bo postalo za potnika znojnije, kar pa se bo povečal občutek varnosti zlasti v nočnem času.

Pri implementaciji napovedi prihodov avtobusov na postajališta gre za nadgradnjo obstoječega sistema za satelitsko spremljanje lokacij avtobusov ljubljanskega javnega potniškega prometa.

5/8

2.3. TEHNIČNE SPECIFIKACIJE – LASTNOSTI ZUNANJIH ELEKTRONSKIH POKAZOVALNIKOV NA POSTAJALIŠČIH

Pomljena strojna oprema mora v celoti izpolniti naslednje zahteve:

- Osnovni tehnični podatki zunanjih prikazovalnikov na postajališčih:
 - temperaturno območje delovanja od -20°C do +60°C
 - relativna vlaga do 90%
 - stopnja mehanske zaščite najmanj IP54
 - ustrezna zaščita proti vandalizmu; LED diode morajo biti zaščitene pred mehanskimi poškodbami
 - ohišje prikazovalnikov mora biti zgrajeno iz neajrnoče plotovine ali drugega ustreznega materiala
 - barva ohišja prikazovalnika mora biti enaka obstoječi barvi postajališčnih nadstropnic, torej v skladu z zahtevano posneto barvo urbane opreme Mestne občine Ljubljana (ANTHRAZIT GRAU-RAL 7016)
 - vključevati mora gelno-hladilno snov za ustrezno regulacijo temperature
 - zunanji izgled vseh prikazovalnikov mora biti enak ne glede na fazo dobave.

➤ Vidljivost:

The screenshot shows a web browser window with the URL <http://www.enarocanje.si/pregleddobjave.asp?IzpObrazec=105142>. The page header includes the logo 'eObjave eNarocanje' and 'Uradni list Republike Slovenije' (Official Journal of the Republic of Slovenia) with the Ministry of Finance logo. Navigation links for 'aktualno', 'povezave', and 'kontakt' are present.

The main content area is titled 'OBVESTILO O NAROČILU' (Notice of Tender) and features a blue 'Blago' (Goods) icon. The notice details are as follows:

- Blago**
- Racunalniški zasloni in konzole**
- Datum objave: 29.12.2009**
- Številka objave: JN10706/2009**

The tendering authority is identified as 'ODDELEK E NAROČNIK' (Department E Tenderer):

- L1) IME, NASLOVI IN KOORDINATE (E) TOČKA(-E):** MESTNA OBČINA LJUBLJANA, MESTNI TRG 1, Kontakt: Irena Stopar, V roke: Irena Stopar, SI-1000 LJUBLJANA. Tel. 01 306 44 33. Faks 01 306 44 07. E-pošta irena.stopar@ljubljana.si. Internetni naslov naročnika (URL) <http://www.ljubljana.si>

Additional information includes:

- Dodatne informacije je mogoče dobiti pri:** Enako kot pri zgoraj navedeni(-h) kontaktni(-h) točki(-ah).
- Specifikacije in dopolnilno dokumentacijo (vključno z dokumentacijo za konkurenčni dialog in dinamični nakupovalni sistem) je mogoče dobiti pri:** Enako kot pri zgoraj navedeni(-h) kontaktni(-h) točki(-ah).
- Ponudbe ali prijave za sodelovanje je treba poslati na naslov:** Enako kot pri zgoraj navedeni(-h) kontaktni(-h) točki(-ah).

The tender type is:

- L2) VRSTA NAROČNIKA III GLAVNA(-O) PODROČJA(-E) DEJAVNOSTI:** Regionalni ali lokalni organ.

The tendering authority is 'Javna uprava' (Public Administration). A note states: 'Naročnik izvaja postopek v imenu drugih naročnikov: ne.' (The tenderer carries out the procedure on behalf of other tenderers: no.)

Sidebars on the left and right contain various links and advertisements, including 'Portal javnih naročil', 'UL info tok', 'dobra praksa', 'AMBICIJ AKADEMIJA', and 'SEMINAR S KNJIGO'.

Figure 15: Public procurement of electronic displays published on Slovenian web site e-narocanje dedicated to publishing public procurement notifications

This notice in TED website: <http://ted.europa.eu/udl?uri=TED:NOTICE:361674-2009:TEXT:EN:HTML>

SI-Ljubljana: computer screens and consoles

2009/S 251-361674

CONTRACT NOTICE

Supplies

SECTION I: CONTRACTING AUTHORITY

I.1) NAME, ADDRESSES AND CONTACT POINT(S)

Mestna občina Ljubljana
Mestni trg 1
Attn: irena Stopar
SI-1000 Ljubljana
SLOVENIA
Tel. +386 13064433
E-mail: irena.stopar@ljubljana.si
Fax +386 13064407

Internet address(es)

General address of the contracting authority <http://www.ljubljana.si>

Further information can be obtained at: As in above-mentioned contact point(s)

Specifications and additional documents (including documents for competitive dialogue and a dynamic purchasing system) can be obtained at: As in above-mentioned contact point(s)

Tenders or requests to participate must be sent to: As in above-mentioned contact point(s)

SECTION II: OBJECT OF THE CONTRACT

II.1) DESCRIPTION

II.1.6) Common procurement vocabulary (CPV)

30231000, 30231300

Description

Computer screens and consoles.
Display screens.

SECTION IV: PROCEDURE

IV.3) ADMINISTRATIVE INFORMATION

IV.3.3) Conditions for obtaining specifications and additional documents

Time limit for receipt of requests for documents or for accessing documents 3.2.2010 - 14:00

IV.3.4) Time-limit for receipt of tenders or requests to participate

15.2.2010 - 09:00

IV.3.6) Language(s) in which tenders or requests to participate may be drawn up

Slovenian.

Figure 16: Procurement notice published in OJEU



Figure 17: An example of electronic display from the received proposal

5. REALIZATION

With the help of Civitas Elan project, Ljubljana is finally placed on the map of European cities which offer the passengers and citizens real time information on bus arrivals via electronic displays at bus stops.

In mid-July 2010, the 24 bus stops were equipped with electronic displays; 14 six-line displays and 10 two-line displays.

Nr.	Ime postaje	Display type
1	Bavarski dvor - Kozolec	6-line
2	Bavarski dvor - Kora bar	6-line
3	Konzorcij	6-line
4	Razstavišče	6-line
5	Razstavišče	6-line
6	Drama	6-line
7	Hotel Lev	6-line
8	Tržnica Moste - v mesto	6-line
9	Kino Šiška	6-line
10	Kino Šiška - smer Vižmarje	6-line
11	Gornji trg - center	6-line
12	Križanke (Zoisova) - smer Rudnik	6-line
13	Tivoli	6-line
14	Tivoli	6-line
15	Kolodvor - smer Zaloška	2-line
16	Klinični center - smer center	2-line
17	Astra v center	2-line
18	Astra iz centra	2-line
19	Stadion	2-line
20	Stadion	2-line
21	Žale - smer mesto	2-line
22	Poljanska-smer mesto	2-line
23	Strelišče - smer mesto	2-line
24	Aškerčeva - smer mesto	2-line

Table 1: Bus stops equipped with electronic displays offering passengers dynamic real time information on bus arrival



Figure 18: 6-line electronic display at bus stop Razstavišče



Figure 19: Electronic display at bus stop Konzorcij



Figure 20: Electronic bus stop display at bus stop Bavarski dvor, one of the most frequent bus stops



Figure 21: The objective of the project is also to implement direct communication technology for higher information accuracy – the system announces “prihod” (eng. arrived) when bus is at the bus stop

The main factors for decision which bus stops should be equipped first was the location along the Civitas Elan corridor, bus stops with highest flow and number of passengers, the criterion was also

current infrastructure available at the bus stop (electricity and Ethernet network) in order to minimize the costs of construction and electrical works.

The scope and content of the dynamic real time information

The purpose of information displays for passengers waiting at bus stop is to provide accurate information on bus arrivals for each line that runs through the bus stop in real time and other dynamic information such as notification of detours, changed line and similar.

The following information is presented on electronic display:

- route number
- direction
- predicted arrival time (minutes or “arrival”/ “prijod” “departure” / “odhod”)
- other passenger information (detour announcements)
- in case of a communication error, LED displays applicable message

Display supports different modes of presentation: stationary and scrolling (speed is configurable).



Figure 22: 2-line electronic display; the material of display housing is rustless metal; the color of housing needs to comply with current bus stops color

With the implementation of electronic displays also new feature was presented at Public Transit Center which is utilized by traffic controllers and dispatchers. Namely, the bus stops presented on Line Track (line diagram where routes with buses that ply that particular route are displayed in real time) that are equipped with electronic displays are marked blue in order to be distinguished from the rest of bus stops and thus quickly perceived by dispatchers.

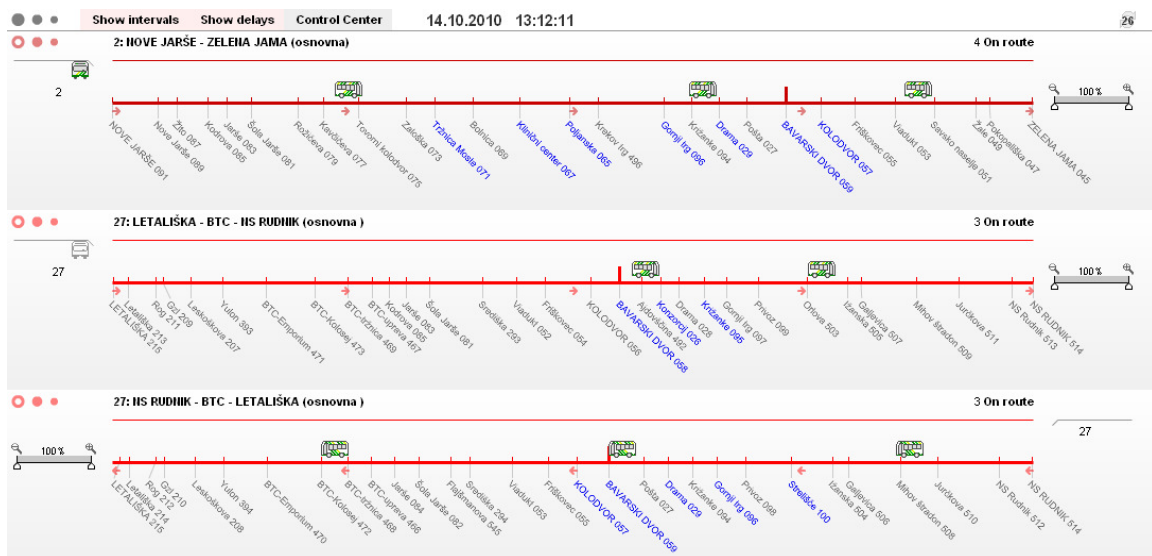


Figure 23: Routes with respective bus stops; bus stops equipped with electronic displays are marked blue

Short cut to selected bus stop where dispatcher receives real time information; added is also information on content displayed on LEDs

Station overview

About station	
Super station: (057)	
Station: KOLODVOR	
Routes through station	
23: KOLODVOR - ZOO ()	Distance
12: BEŽIGRAD - VEVČE (osnovna)	0 km
12: BEŽIGRAD - VEVČE (Žale)	1,71 km
27: 27B BLEIWEISOVA - BTC - LETALIŠKA (osnovna)	1,72 km
27: 27K BLEIWEISOVA - KOLOSEJ (osnovna)	1,74 km
23: ZOO - KOLODVOR ()	1,76 km
9: TRNOVO - ŠTEPANJSKO NASELJE (osnovna)	4,29 km
27: NS RUDNIK - BTC - LETALIŠKA (osnovna)	4,57 km
2: NOVE JARŠE - ZELENA JAMA (osnovna)	6,94 km
25: MEDVODE - ZADOBROVA (osnovna)	9,56 km
	13,53 km

Next arrivals	
LJ LPP-193: 27: NS RUDNIK - BTC - LETALIŠKA (osnovna)	13:47
LJ LPP-166: 2: NOVE JARŠE - ZELENA JAMA (osnovna)	13:51
LJ LPP-123: 12: BEŽIGRAD - VEVČE (osnovna)	13:53
LJ LPP-191: 27: NS RUDNIK - BTC - LETALIŠKA (osnovna)	14:00
LJ LPP-411: 25: MEDVODE - ZADOBROVA (osnovna)	14:04
LJ LPP-137: 2: NOVE JARŠE - ZELENA JAMA (osnovna)	14:08
LJ LPP-148: 2: NOVE JARŠE - ZELENA JAMA (osnovna)	14:25

Vehicles on the station	
No vehicles on station.	

Led contents at 13:46		
27	LJ LPP-193	1 min
2	LJ LPP-166	5 min
12	LJ LPP-123	7 min
27	LJ LPP-191	15 min
25	LJ LPP-411	18 min
2	LJ LPP-137	23 min

Station overview

About station	
Super station: (059)	
Station: BAVARSKI DVOR	
Routes through station	
27: 27B BLEIWEISOVA - BTC - LETALIŠKA (osnovna)	Distance
27: 27K BLEIWEISOVA - KOLOSEJ (osnovna)	1,26 km
23: ZOO - KOLODVOR ()	1,29 km
9: TRNOVO - ŠTEPANJSKO NASELJE (osnovna)	3,81 km
6: DOLGI MOST - ČRNUČE (osnovna)	4,09 km
14: VRHOVCI - SAVLJE (osnovna)	4,81 km
7: PRŽAN - NOVE JARŠE (Letališka)	6 km
7: PRŽAN - NOVE JARŠE (osnovna)	6,08 km
27: NS RUDNIK - BTC - LETALIŠKA (osnovna)	6,08 km
5: NS PODUTIK - ŠTEPANJSKO NASELJE (osnovna)	6,46 km
19: BARJE - TOMAČEVO (Barje-NOVE ŽALE)	6,6 km
19: BARJE - TOMAČEVO (osnovna)	6,69 km
14: VRHOVCI - SAVLJE (Bokalce)	6,69 km
20: FUŽINE - NOVE STOŽICE (osnovna)	6,7 km
2: NOVE JARŠE - ZELENA JAMA (osnovna)	7,6 km
13: SOSTRO - CENTER STOŽICE (osnovna)	9,08 km
6: DOLGI MOST - ČRNUČE (Vnanje Gorice)	9,57 km
6B: VNANJE GORICE - ČRNUČE (osnovna)	9,57 km
6: DOLGI MOST - ČRNUČE (Vnanje Gorice - D.M.)	9,8 km
8: GAMELJNE - BRNČIČEVA (osnovna)	9,83 km
25: MEDVODE - ZADOBROVA (osnovna)	10,47 km
11: ZALOG - BEŽIGRAD (osnovna)	12,59 km
11: ZALOG - JEŽICA (Zalog-Bežigrad)	13,05 km
11: ZALOG - JEŽICA (osnovna)	13,07 km
11: ZALOG - JEŽICA (Obvoz ŠRC STOŽICE)	13,1 km
20: FUŽINE - NOVE STOŽICE (Zalog-nedeljska)	13,11 km
11: ZALOG - BEŽIGRAD (Zalog-Bavarski dvor)	13,43 km
	13,6 km

Next arrivals	
LJ LPP-166: 2: NOVE JARŠE - ZELENA JAMA (osnovna)	13:49
LJ LPP-101: 19: BARJE - TOMAČEVO (osnovna)	13:49
LJ LPP-419: 6: DOLGI MOST - ČRNUČE (osnovna)	13:51
LJ LPP-444: 6: DOLGI MOST - ČRNUČE (Vnanje Gorice)	13:55
LJ LPP-204: 7: PRŽAN - NOVE JARŠE (Letališka)	13:56
LJ LPP-408: 11: ZALOG - JEŽICA (osnovna)	13:57
LJ LPP-191: 27: NS RUDNIK - BTC - LETALIŠKA (osnovna)	13:58
LJ LPP-399: 20: FUŽINE - NOVE STOŽICE (osnovna)	14:01
LJ LPP-411: 25: MEDVODE - ZADOBROVA (osnovna)	14:02
LJ LPP-246: 14: VRHOVCI - SAVLJE (osnovna)	14:03
LJ LPP-206: 6: DOLGI MOST - ČRNUČE (osnovna)	14:04

Vehicles on the station	
LJ LPP-101	13:49:0

Led contents at 13:48		
19	LJ LPP-101	1 min
2	LJ LPP-166	1 min
6	LJ LPP-419	2 min
7	LJ LPP-204	8 min
6	LJ LPP-444	8 min
11	LJ LPP-408	8 min
27	LJ LPP-191	9 min
20	LJ LPP-399	13 min
25	LJ LPP-411	13 min
14	LJ LPP-246	14 min
6	LJ LPP-206	15 min
2	LJ LPP-137	17 min
13	LJ LPP-327	20 min
8	LJ LPP-237	23 min
20	LJ LPP-412	24 min
11	LJ LPP-243	25 min
2	LJ LPP-148	34 min
11	LJ LPP-353	36 min

Figure 24: Overview of bus stops Bavarski dvor and Kolodvor ; added is LED content view

6. OBSERVATION AND EVALUATION

Bus arrival predictions reliability and accuracy was executed already at bus stop Konzorcij when the test electronic display was implemented, as well as the control of predicted bus arrival information displayed on LEDs and testing the reliability was performed:

- utilizing Bus Stat Analyst SW tool
- control of displayed information on the field

Bus arrival prediction reliability and accuracy was evaluated and tested. For this purpose Bus Stat Analyst SW tool developed by Telargo was utilized, as well as practical control of prediction accuracy was executed by Telargo. To calculate (test) bus arrival accuracy the following was taken into account:

- selected bus stop on which predictions will be calculated/tested
- compare predictions at some various distances from selected station with actual arrival to that station

Prediction error increased as the square root of the distance between the bus position and the station. Thus there were two regimes:

- bus near selected station: large relative error in predicted arrival time,
- bus far from selected station: relative error smaller.

Using Bus Stat Analyst we have compared predictions at various distances from this stop. Some of short and long range predictions accuracy can be seen in following graphs.

a) Long Range predictions:

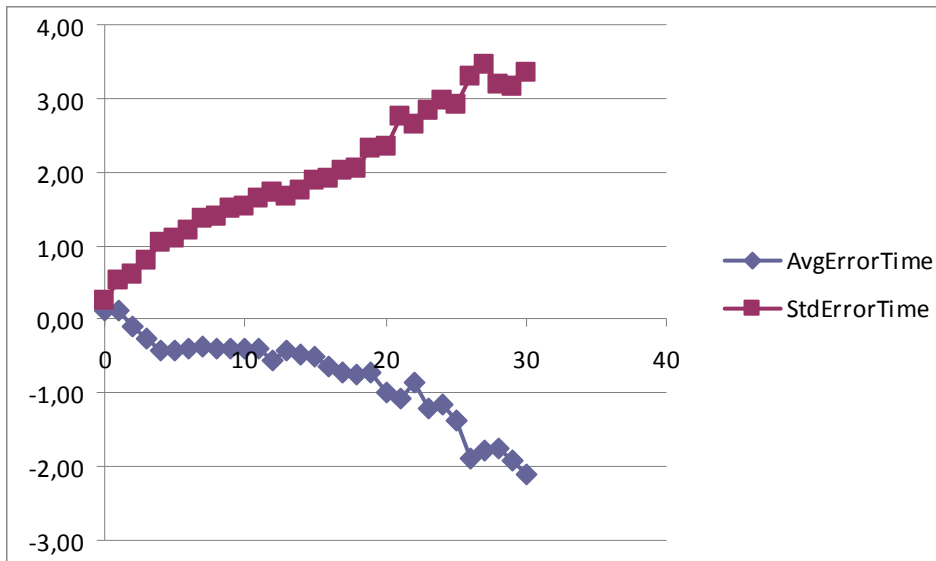
The larger the distance between the bus and the station is, the larger is the error of the predicted ETA to that station. This error is due to the large number of random sources (waiting at traffic lights, fluctuation of the number of passengers entering/exiting bus...) that are smoothed out in the statistics on which the predictions are based. Thus the width of ETA error grows as square root of the number of sources, which is roughly proportional to the distance or the number of stations in-between the bus and selected station for which we test ETA. Therefore the relative error which is absolute error in ETA divided by the ETA decreases as the distance between the bus and the station increases.

b) Short range predictions:

We performed short range test. These tests are important, since for the station LED displays the short range accuracy is vital.

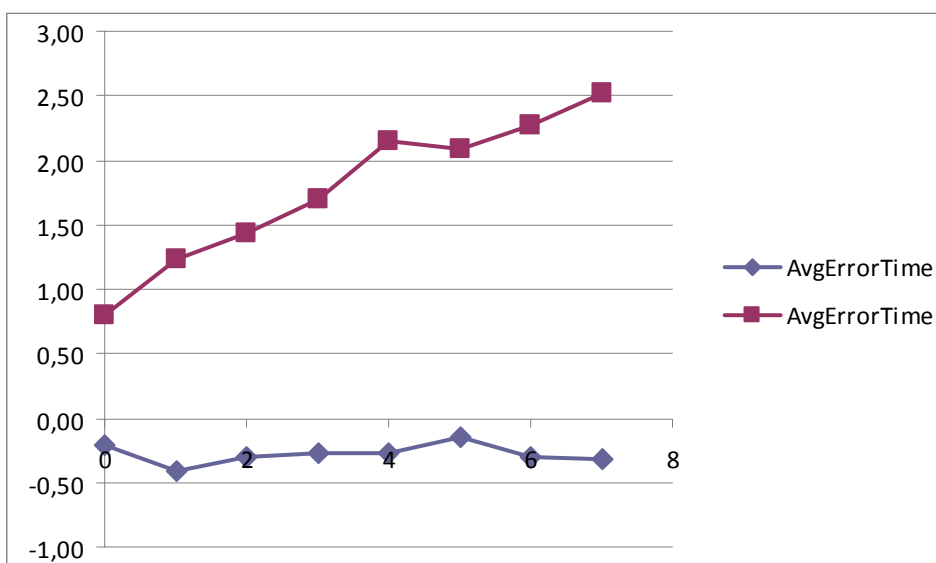
One of the reasons for prediction error (data delay) is also the following: data/predictions from BusStats are updated every 30 seconds; however data can be delayed for at least ~5-20s due to time needed for data transmission between: bus (AVL unit- Mobile Unit) – Bus Server – Bus Stat – Bus Server – LED display on bus stop.

1.) analysis of prediction accuracy with regard to vehicle's time distance from the bus stop Bavarski dvor



2.) analysis of prediction accuracy with regard to vehicle's distance (km) from the bus stop Tržnica Moste

N	km from station	AvgErrorTime	AvgErrorTime
2321	0	-0,22	0,80
2271	1	-0,42	1,23
1680	2	-0,30	1,43
1420	3	-0,27	1,70
707	4	-0,27	2,15
423	5	-0,15	2,09
322	6	-0,30	2,27
329	7	-0,32	2,52



6.1. Control of displayed information on the field

The control of displayed information was performed by LPP's controller and Telargo. The controls included the following observations:

1.) correct bus stop ID

Once the electronic displays were implemented, it had to be checked that all displays show information for correct bus stop. It was noticed that in some cases the bus stop ID codes were incorrect (in case where the bus name is the same in both directions).

Nr.	ID code	Bus stop #	Bus stop name	Comment
1	1977	59	Bavarski dvor - Kozolec	
2	1976	58	Bavarski dvor - Kora bar	
3	1944	26	Konzorcij	
4	2090	172	Razstavišče	
5	2089	173	Razstavišče	
6	1947	29	Drama	ID code needs to be corrected; communication module data adjusted
7	1943	25	Hotel Lev	
8	1989	71	Tržnica Moste - v mesto	ID code needs to be corrected; communication module data adjusted
9	1936	18	Kino Šiška	
10	1937	19	Kino Šiška - smer Vižmarje	
11	2014	96	Gornji trg - center	ID code needs to be corrected; communication module data adjusted
12	2013	95	Križanke (Zoisova) - smer Rudnik	ID code needs to be corrected; communication module data adjusted
13	1940	22	Tivoli	
14	1941	23	Tivoli	
15	1975	57	Kolodvor - smer Zaloška	ID code needs to be corrected; communication module data adjusted
16	1985	67	Klinični center - smer center	
17	2087	170	Astra v center	
18	2088	171	Astra iz centra	
19	2085	168	Stadion	
20	2086	169	Stadion	
21	1966	48	Žale - smer mesto	ID code needs to be corrected; communication module data adjusted
22	1983	65	Poljanska-smer mesto	
23	2018	100	Strelišče - smer mesto	
24	1949	31	Aškerčeva - smer mesto	ID code needs to be corrected; communication module data adjusted

Table 2: Example of bus stop ID code control

2.) arrival information

Arrival information displayed per minute was also controlled; the example of such control is presented below:

	route 2	route 9	route 11	route 20	route 25
time	announcement (min; Arrival, departure)				
16:44	3	5	6	5	NN
16:45	2	3	6	4	NN
16:46	2	3	5	3	NN
16:47	1/ prihod	3	4	3	14
16:48	odhod	prihod	3	2	13
16:49	12	NN	2	prihod/odhod	14
16:50	12	NN	1 10	NN	12
16:51	11	NN	prihod 9	NN	12
16:52	10	NN	7	6	11
16:53	9	6	7	6	10
16:54	8	6/5	6/5	5	9
16:55	8/6	5/4	5	4	9/7
16:56	6	4/3	4/3	3	7/6
16:57	6/5	3/2	3	2	6
16:58	4	2/1	2/1	1	5
16:59	3	1	prihod/odhod	prihod/odhod	3
17:00	2	prihod	17	NN	2
17:01	2	odhod	16	NN	2
17:02	1	NN	15	NN	1 / prihod
17:03	1	NN	14	7	NN
17:04	prihod	NN	13	6	NN
17:05	11	NN	12	5	NN
17:06	10/9	8/7	11	4/3	NN
17:07	9/7	6	10	2	NN
17:08	7	5	8	1	NN
17:09	7/3	5/3	8/6	prihod	NN
17:10	3	3	6	NN	NN
17:11	3	3/2	6	NN	16
17:12	3	2/1	5 18	NN	15
17:13	3/2	1	4 17	7	14
17:14	2	prihod	3 16	6	13
17:15	2/1	NN	2 15	5	12
17:16	1	NN	1 13	4	11
17:17	prihod/odhod	NN	prihod/odhod 13	3	10
17:18	13	NN	12	2	9
17:19	12	NN	11	1	8
17:20	11	6	10	prihod	6
17:21	9	5	8	NN	5
17:22	9/8	4/3	7	7	4
17:23	8/7	3	6	6	3
17:24	6	3/2	5	5	2
17:25	6/5	2 6	4	4	1
17:26	5	1 4	3	4/3	prihod/odhod
17:27	4/3	prihod/odhod 3	2	2/1	NN
17:28	3	2	1	prihod	NN

17:29	2	1	prihod	14	odhod	NN
17:30	1	prihod/odhod	14/13		NN	NN
17:31	prihod	NN	13		NN	NN
17:32	13	7	12		7	NN
17:33	12/11	6/5	11/10		6	NN
17:34	11/10	5	10		5	NN
17:35	10	5/3	9		4	NN
17:36	9	3/2	7		3	NN
17:37	9/8	2/1	7		2	NN
17:38	7	1/ prihod/odhod	6		2	NN
17:39	6	NN	5		prihod	NN
17:40	5	NN	4	17	NN	NN
17:41	4	NN	3		NN	NN
17:42	3/2	NN	2		NN	16/15
17:43	2/1	NN	1		7/6	14
17:44	1	7	prihod/odhod		6	13
17:45	prihod/odhod	6	12		5	12



Figure 25: Example of bus arrival information accuracy control; Bus 1 arrived on the bus stop – is such information also presented on electronic display?

Based on the control the following observations were made:

- 1.) bus stop ID code

Each bus stop has dedicated ID code which is used to define which predictions needs to be transfered to applicable electronic display

Action executed: code was checked per each bus stop

2.) dedicated short range communication modules have to be activated

Since entered bus stop ID codes were not correct for some bus stops, also dedicated short range communication modules were not activated for the correct bus stops

Action executed: dedicated short range communication modules have been activated for applicable bus stops

3.) departure announcement

In some cases the departure announcements are triggered too late.

Action executed: the applicable triggering distance of departure event needs to be defined on case by case basis and not the same for all bus stops.

4.) package »timeout«

It has been established that timeout between packages is too long, which affects the accuracy of predictions.

Action executed:

The application was modified in order to shorten the timeout between packages sent over dedicated short range modules, which improved the response of sent/received packages and accuracy respectively.

5.) trip order entry

The correct trip order needs to be entered by driver in order the correct and accurate prediction is generated.

Action executed: in case incorrect trip order is entered (or if it is even missing), the Public Transit Center informs the dispatcher and then dispatcher asks driver to enter the (valid) trip order code.

6.) equipment

The equipment (electronic display, short range module) needs to be working properly in order to display accurate predictions.

Action performed: if the equipment is not operating properly, it is replaced.

7. DISSEMINATION

Dissemination activities related to test electronic display were already presented in previous Deliverable.

Implementation of 24 dynamic passenger information displays in Ljubljana was positively accepted and welcomed by passengers and citizens (as reported in various articles, news, etc. in media; feedback received on designated email address by public transit operator; small survey conducted by national radio, etc.). There were some remarks on the micro-locations of 6-line displays (e.g. at bus stop Bavarski dvor) and the improvements that need to be made with announcements (in particular short – distance).

The measure was presented in various media also prior to implementation, since media reported on procurement of electronic displays:

Odštevanje minut do prihoda avtobusa

Potniki bodo še letos na večjih postajališčih seznanjeni s časom prihoda avtobusov

Potniki bodo še letos na večjih postajališčih seznanjeni s časom prihoda avtobusov, kar bo med drugim olajšalo prestopanje z urbano

Slovenija - sobota, 24.04.2010 Tekst: Peter Pahor

LJUBLJANA - Na Ljubljanskem potniškem prometu (LPP) so z družbo Swarco Futurit podpisali slabih 300.000 evrov vredno pogodbo za nabavo prikazovalnikov informacij na avtobusnih postajališčih.

Zadnje objavljeno



V LPP so prikazovalnik prihodov avtobusov

testirali med lanskim evropskim tednom mobilnosti. (Foto: Luka Cjuha/dokumentacija Dnevnika)

Gre za dalj časa načrtovani projekt napovedovanja prihodov avtobusov, ki se je začel že leta 2005 z uvedbo sistema talktrack za sledenje avtobusom in storitvijo LPP-bus info, s pomočjo katere lahko prihode avtobusov preverite prek SMS-sporočil, portala WAP ali spleta.

Franc Možina z oddelka za gospodarske dejavnosti in promet Mestne občine Ljubljana (MOL) nam je povedal, da bodo prvi prikazovalniki, ki bodo prihode avtobusov sporočali tudi na postajališčih, predvidoma dobavljeni do konca julija. V prvi fazi bo podjetje Swarco družbi LPP dobavilo 15 šestvrstičnih zaslonov, ki jih bodo namestili nad streho postajališča, in 10 dvovrstičnih zaslonov, ki bodo stali nad klopjo postajališča. "Na Bavarskem dvoru se prekriva 13 linij, pred Gospodarskim razstaviščem 9 in pred Korzorcijem 6. To so najpogostejše prestopne točke, poleg teh bodo v prvi fazi prikazovalniki postavljeni še na postajališčih Drama, Kolodvor, Hotel Lev, Klinični center, Astra, Stadion in Pošta. V drugi fazi bomo opremili postajališča, kjer se križa štiri ali pet linij, v tretji fazi pa že postajališča z dvema ali tremi linijami," pojasnjuje Možina.

Prestopanje bo postalo lažje

Kot pravi, si na MOL in v LPP želijo potnike bolje informirati o prihodih avtobusov, kar je z uvedbo urbane, ki omogoča 90-minutno brezplačno prestopanje, postalo še bolj aktualno. Po Možinovih besedah bodo namreč

Figure 26: Article in Slovenian daily newspaper Dnevnik, 24.4.2010: Odštevanje minut do prihoda avtobusa

Once the implementation was executed the material (report/ article with some photographic material) was prepared; the content was also published on Civitas Elan Ljubljana web site:

<http://www.civitasljubljanasi.si/novice/ljubljanska-avtobusna-postajalisca-z-novimi-prikazovalniki-ki-napovedujejo-prihod-avtobusov>

as well as some media used the material for their articles.

POVZETEK

S pomočjo projekta Civitas Elan se je Ljubljana končno zapisala na zemljevid evropskih mest, ki skrbijo za obveščeno čakajočih potnikov s posredovanjem informacij o prihodih avtobusov v realnem času na elektronskih prikazovalnikih.

V sredini julija 2010 se je na postajališča mestnega prometa namestilo 25 prikazovalnikov dinamičnih informacij, in sicer 15 šestvrstičnih prikazovalnikov, ki stojijo na nadstrešnicah postajališč ter 10 dvovrstičnih zaslonov, ki so nameščeni pod streho postajališč, nad klopmi.



Nakup prikazovalnikov delno financira Evropska unija v okviru projekta Civitas Elan

Prikazovalniki so postavljeni na najbolj pretočna in prestopna postajališča, kjer se križa najmanj 5 linij, hkrati pa je bil kriterij pri izbiri postajališč za postavitev prikazovalnikov tudi opremljenost postajališč z ustrežno infrastrukturo kot so električni priključki in optično omrežje.

Potniki lahko spremljajo napovedi prihoda avtobusov preko zaslonov na sledečih postajališčih: Bavarski dvor (obe smeri), Konzorcij, Razstavišče (obe smeri), Drama, Hotel Lev, Tržnica Moste, Pošta, Kino Šiška (obe smeri), Gornji trg, Krizanke, Tivoli (obe smeri),

Figure 27: Report on the implementation for PR purposes

← → X 24ur.com/novice/slovenija/lpp-s-prikazovalniki-za-spremljanje-avtobusov.html

Customize Links Free Hotmail SideStep Windows Marketplace Windows Media Windows

LIGA PRVAKOV

Slovenija Lokalne volitve Črna kronika Svet Gospodarstvo IT Nega in zdravje Vreme C

LPP s prikazovalniki za spremljanje avtobusov

Ljubljana, 15.07.2010, 13:00 | P.J. 12 Komentiraj Pošlji Tiskaj Velikost pisave

LPP je na najbolj frekvenčne avtobusne postaje v Ljubljani poskusno montiral prikazovalnike, kdaj bo prišel avtobus. Uporabniki lahko že zdaj to preverijo preko spleta ali po telefonu.



prikazovalniki se samodejno prižgejo, ko se približuje avtobus.
(Foto: Aljoša Kravanja)

V sredo so na MOL poskusno montirali prikazovalnike na postajališčih mestnega avtobusnega prometa, so sporočili z LPP. Trenutno so namestili 15 prikazovalnikov na najbolj frekvenčnih postajališčih, še 10 pa jih bodo namestili do konca tedna. Prikazovalniki so zdaj na postajališčih Bavarski dvor, Konzorcij, Gospodarsko razstavišče, Drama, Kolodvor, Tržnica Moste, Astra, Stadion, Žale, Pošta, Poljanska, Strelišče, Aškerčeva in Remiza.

Uporabniki mestnih avtobusov imajo sicer že zdaj možnost preko spletne strani LPP, telefonskega klica ali SMS-a preveriti, kdaj bo prišel avtobus. Novi prikazovalniki pa so nadgradnja tega sistema, še pravijo v LPP.

Prikazovalnike je dobavilo podjetje Swarco Lea. 25 prikazovalnikov in njihova postavitve je stala okoli 200.000 evrov. Če pa bodo stroški postavitve manjši od predvidenega zneska, bo MOL nabavila še dodatne, pravijo v LPP.

Figure 28: Example of Measure Implementation announced in media: one of most visited news web portal in Slovenia www.24ur.com, 15.7.2010

The implementation of electronic displays in Ljubljana draw attention also from other cities and organizations, thus cooperation activities with other international projects and programmes took place:

- TELARGO was in contact with Regional Environmental Center for Central and Eastern Europe in Hungary which is collecting case studies about local initiatives of public authorities where energy-efficiency was improved through information technology and where interested in the project of the Municipality / Public Transport Company of Ljubljana, in which they modernised the public transport service using the IT solutions of Telargo. Telargo prepared information on implemented solutions for Ljubljana public transport with emphasis on implementation of electronic displays.
- TELARGO was contacted by Mrs. Brotto, member of ACTT Treviso project team. City of Treviso – ACTT Treviso participates in project CIVITAS CATALIST and wants to improve the level of citizens services creating an information system with digital panels placed in the bus-stops and showing real time bus travel situations. ACTT Treviso will come to Ljubljana to study visit

- The measure and its results will be presented by Geographical Institute as good practice examples within CATCH_MR project (Cooperative approaches to transport challenges in metropolitan regions).
- The measure will be also presented as good practice example within Citynetwork project (EU project which includes partners from Slovenia and Austria)

8. NEXT STEPS

Implementation of electronic displays with dynamic passenger information is the first of a kind in Ljubljana and is very well accepted among the passengers and citizens of Ljubljana. As well as it also draw attention from other cities and Ljubljana case will be presented as best practice in other EU projects.

Thus it is planned to equip additional bus stops with electronic displays also next year 2011 (according to executed public procurement the number of bus stops equipped with electronic displays will exceed the number planned within Civitas Elan project).

Next steps involve also:

- control of predicted bus arrival information displayed on LEDs and testing the reliability and accuracy of the shown information
- further dissemination activities; e.g. we are expecting colleagues from ACTT Treviso to visit Ljubljana as part of study visit within Civitas Catalist project to view how telematics system can improve the level of citizens services creating an information system with digital panels placed in the bus-stops and showing real time bus travel situations.