

TUTORIAL I



SENSORCOMM 2018

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“Visible light communications in smart road infrastructures”

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- IPL/2017/SMART_VeDa/ISEL.

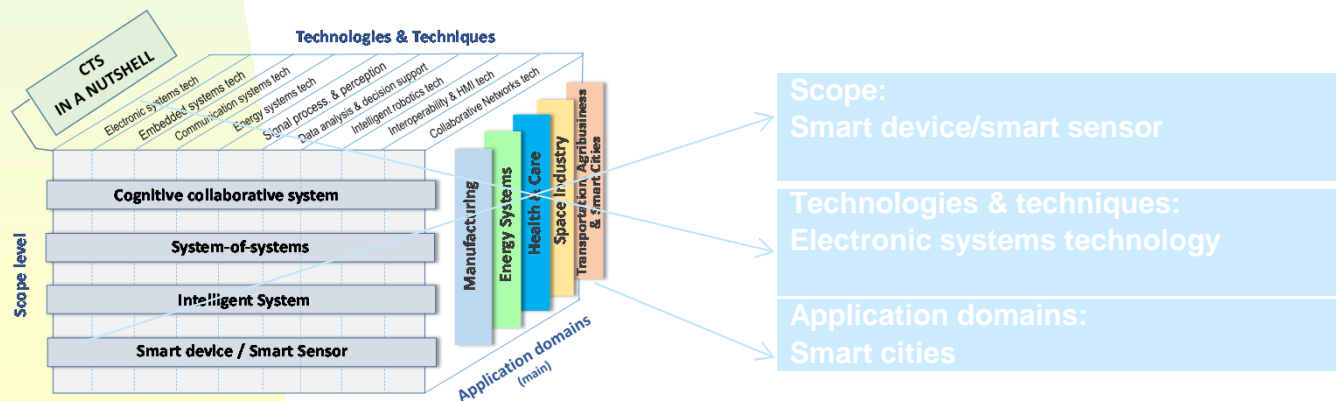




Manuel Augusto Vieira was born in Portugal. He graduated in Electronic and Telecommunication Engineering by Instituto Superior Técnico (IST) of Lisbon from the Technical University of Lisbon. In 2004, he received the Master of Science in Electronic and Computers Engineering by the Superior Technical Institute of Lisbon and in 2012 its PhD by the New University of Lisbon. The title of the thesis was "Three transducers for one photodetector: essays for optical communication"

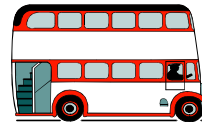
- Currently he is Assistant Professor in Electronics inside the Electronic Telecommunication and Computer Department of ISEL, Lisbon, Portugal and investigator in the M2P group of CTS-UNINOVA.
- The major research interests are related with traffic control, vehicular communications, operations management, stochastic control, optimization and discrete event dynamic systems, scheduling, inventory control, simulation infinitesimal perturbation analysis, queuing networks.
- He was director of the traffic department of the City Hall of Lisbon for more than twenty five years. In this context he has been involved in several national and international projects, namely:
 - Control between urban traffic control (GERTRUDE) and public transport vehicle location (SAEIP) systems.
 - Admission Regulation of Traffic to Improve Public Transport in Urban Areas
 - Requirements and options in the field of Integrated Road Safety, Information and Navigation System- IRIS.
 - Microwave communications for traffic monitoring and pricing "PAMELA.
- Mobile wireless communication networks have been experiencing enormous advances throughout its successive generations. So, at the moment its research activities are related mainly to the communication between vehicles (V2V), vehicles and infrastructures (V2I) and road infrastructure and the vehicles (I2V) using visible light (VLC).

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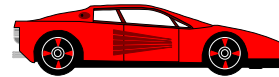


I Work Area:

ADMISSION REGULATION OF TRAFFIC TO IMPROVE PUBLIC TRANSPORT IN URBAN AREAS



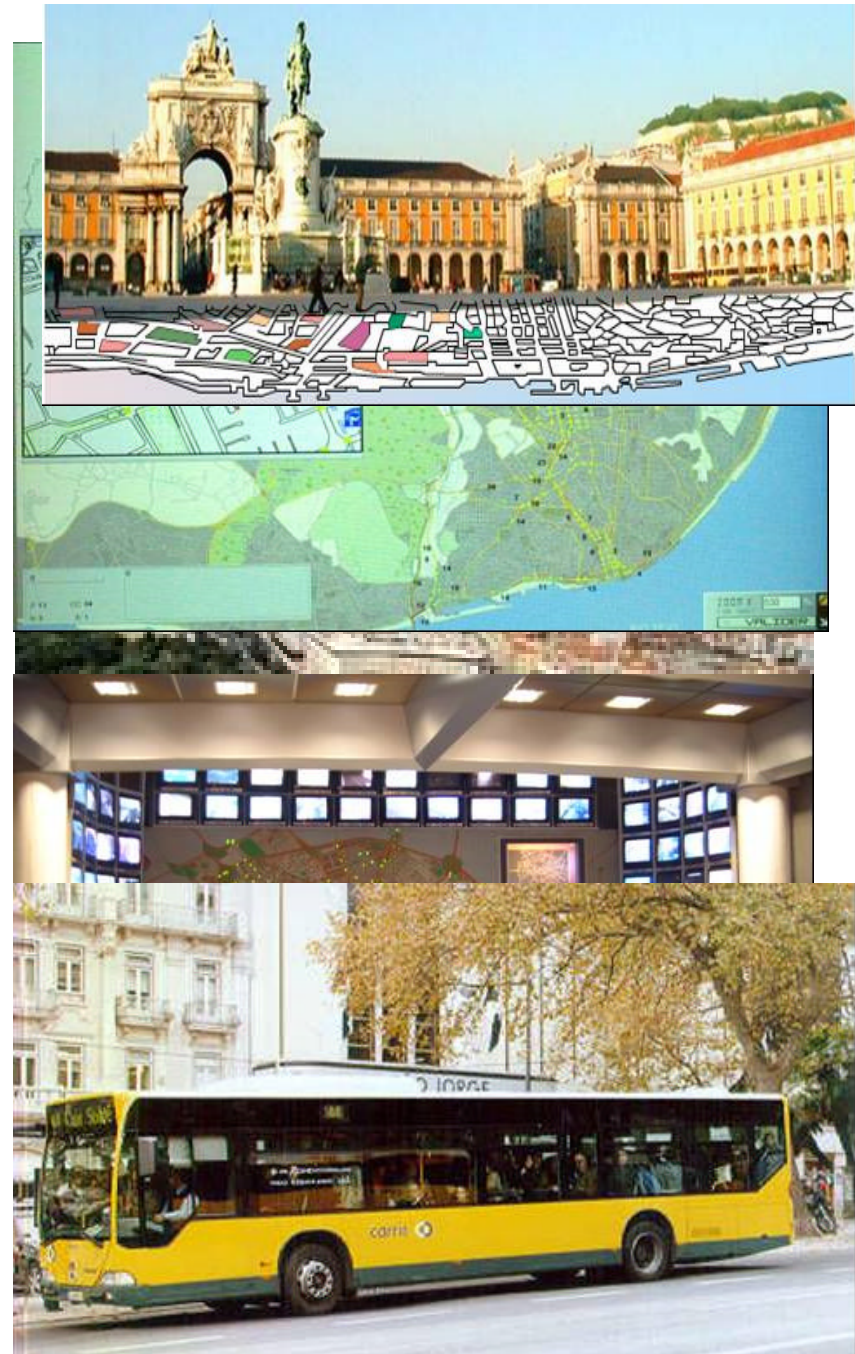
The travel speed balance of a bus, in a fixed route, and correlated it with the in-car volume controlled through traffic lights.

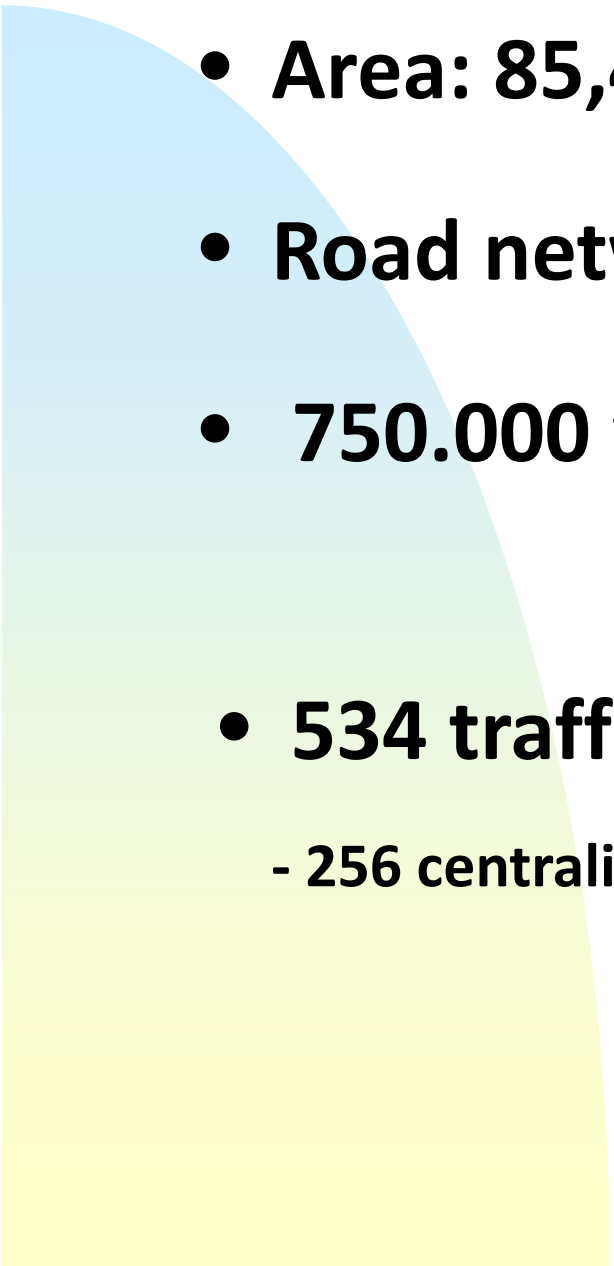


Benefits in bus travel speed were possible through a feed-back real time cooperative control between urban traffic control and Public transport vehicle location systems

OUTLINE

- Introduction and Motivation
- The problem
- The approach
- The experiment
- Conclusions



- 
- **Area: 85,47 Km²**
 - **Road network: 1.575 Km**
 - **750.000 vehicles/per day**

 - **534 traffic lights intersections :**
 - 256 centralised



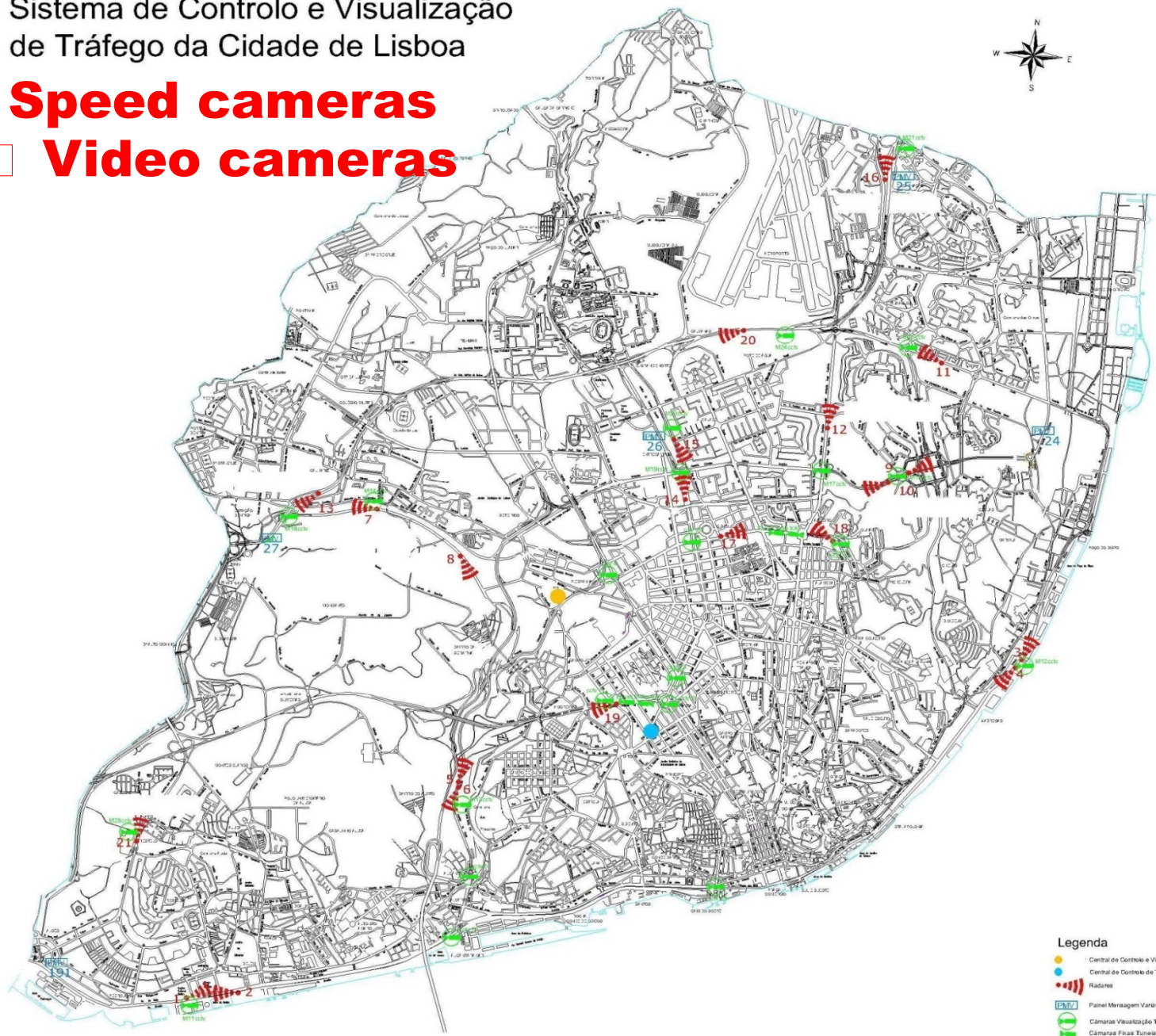
Motivation:

- **traffic monitoring**
- **speed control, enforcement system**
- **increase road safety**

21 radars, 21 cctvs, 26 VMS

Sistema de Controlo e Visualização de Tráfego da Cidade de Lisboa

- Speed cameras**
- Video cameras**

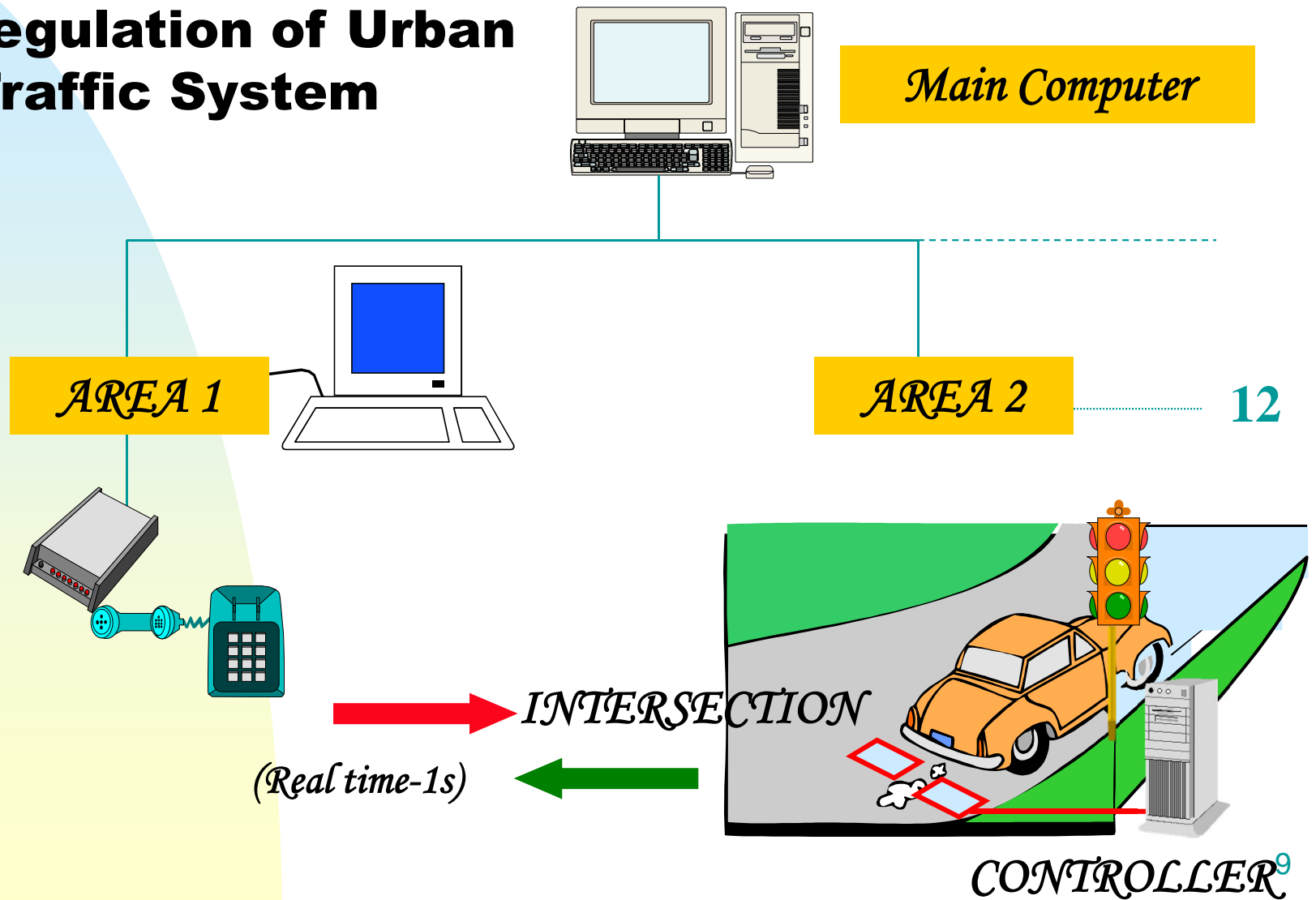


- Legenda**
- Central de Controlo e Vigilância de Tráfego PM
 - Central de Controlo de Tráfego - DGT
 - ⋮ Rádio
 - PMV Painel Mensagem Variável
 - 📹 Câmaras Visualização Tráfego
 - 📹 Câmaras Fitas Túneis (Av. João XXI e M. Fontes)



G.E.R.T.R.U.D.E.

Electronic Management and Regulation of Urban Traffic System



Zone Control Strategy

-First level (MACRO)



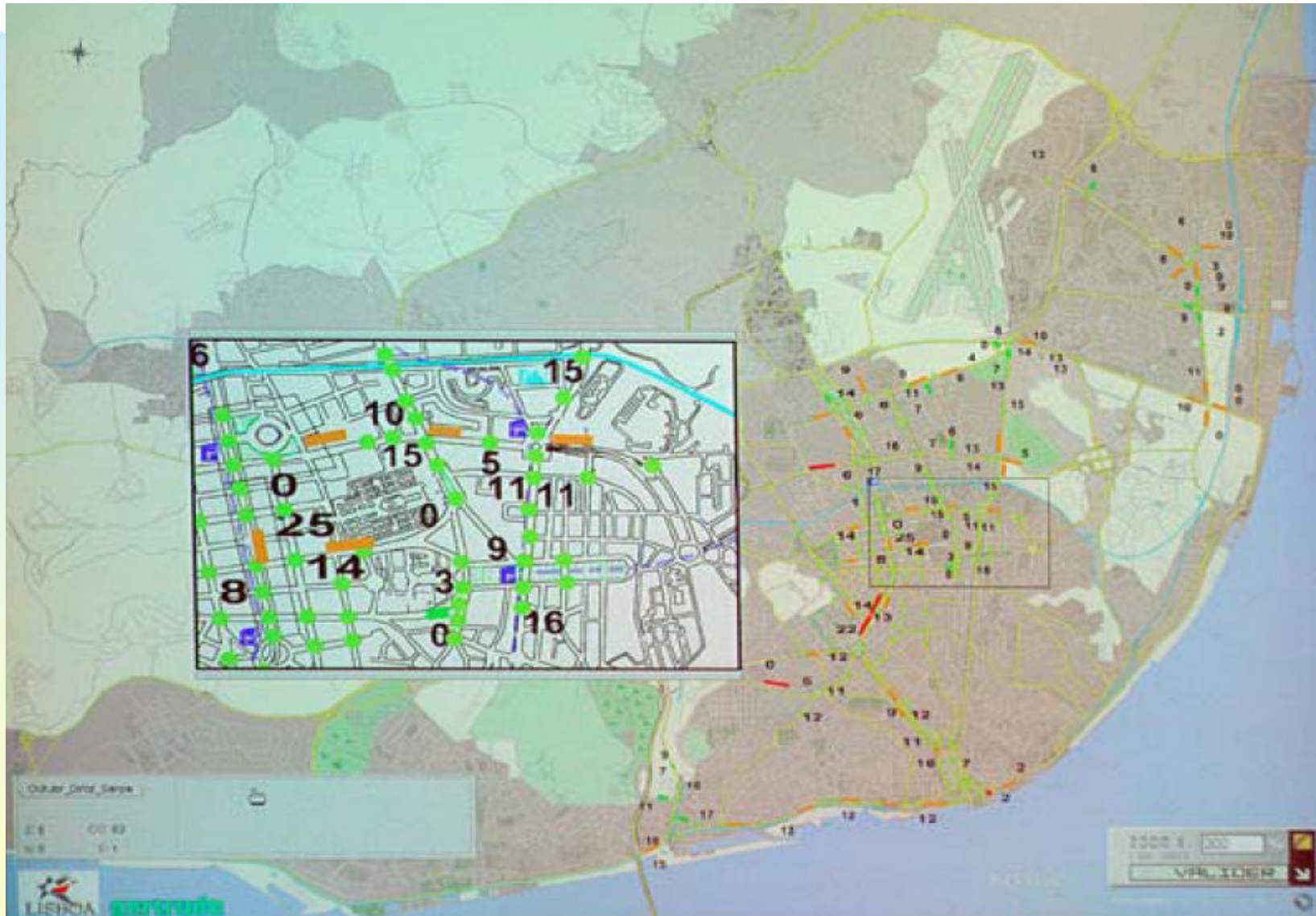
New cycle
Road parameters
Last cycle

Strategic sensor network

-Second level (micro)

Dynamic sensor network.

GERTRUDE SYSTEM



Results:

- Reduce the pollution;
- Reduce congestion;
- Increase road safety



Traffic Management Systems

S O S

The overall picture cars

Explosive

Increasingly being used for daily transportation
Increase in their number

Road network

DEFICIENT

Mainly radial, discontinuities, etc
Incomplete circular axes

Public transport supply

Inadequate

Maladjusted supply and demand
No quality monitoring

Urban growth

Chaotic

Services in the town

Housing moving away from town

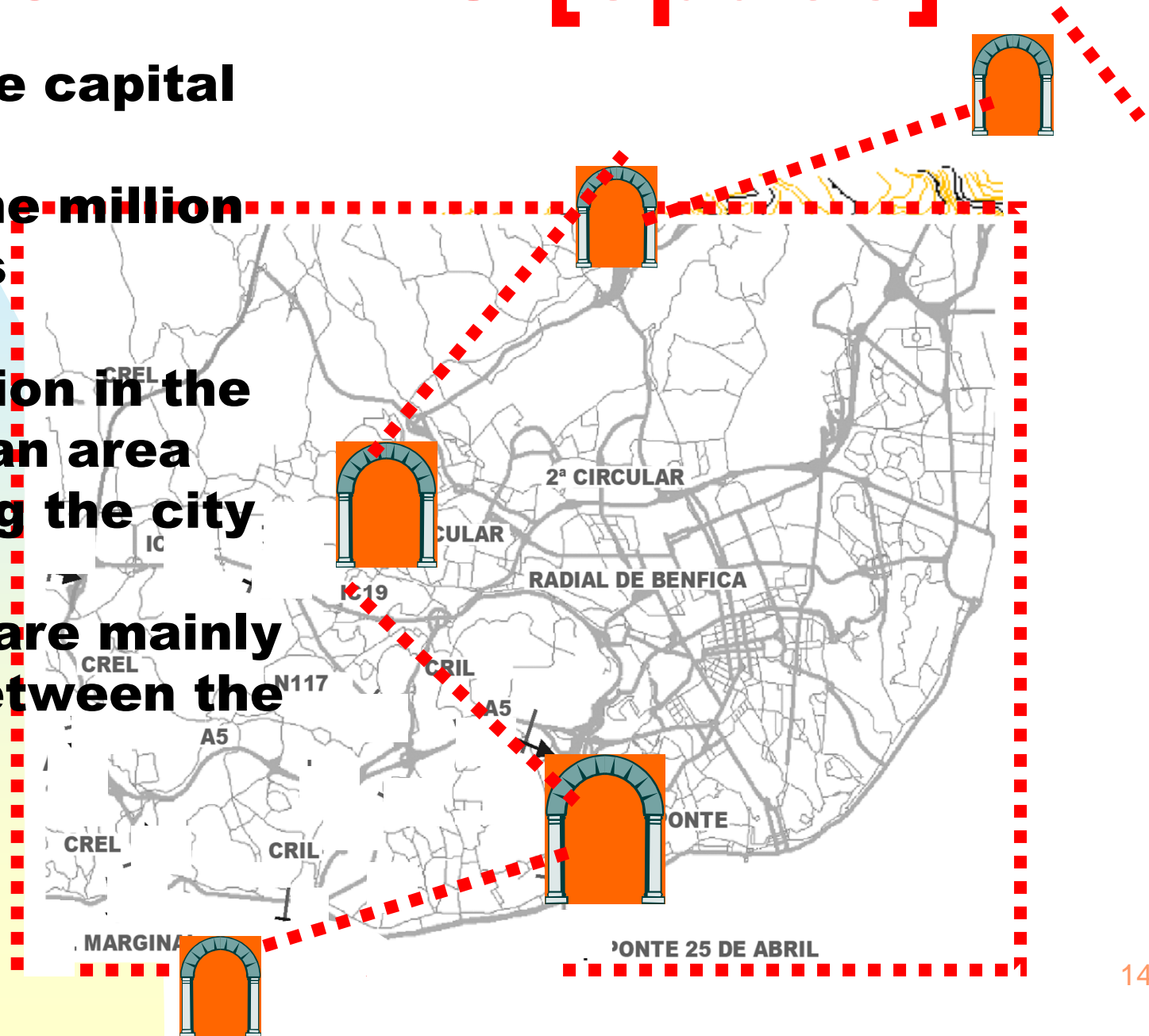
CITY OF HILLS [space]

Lisbon – the capital city .

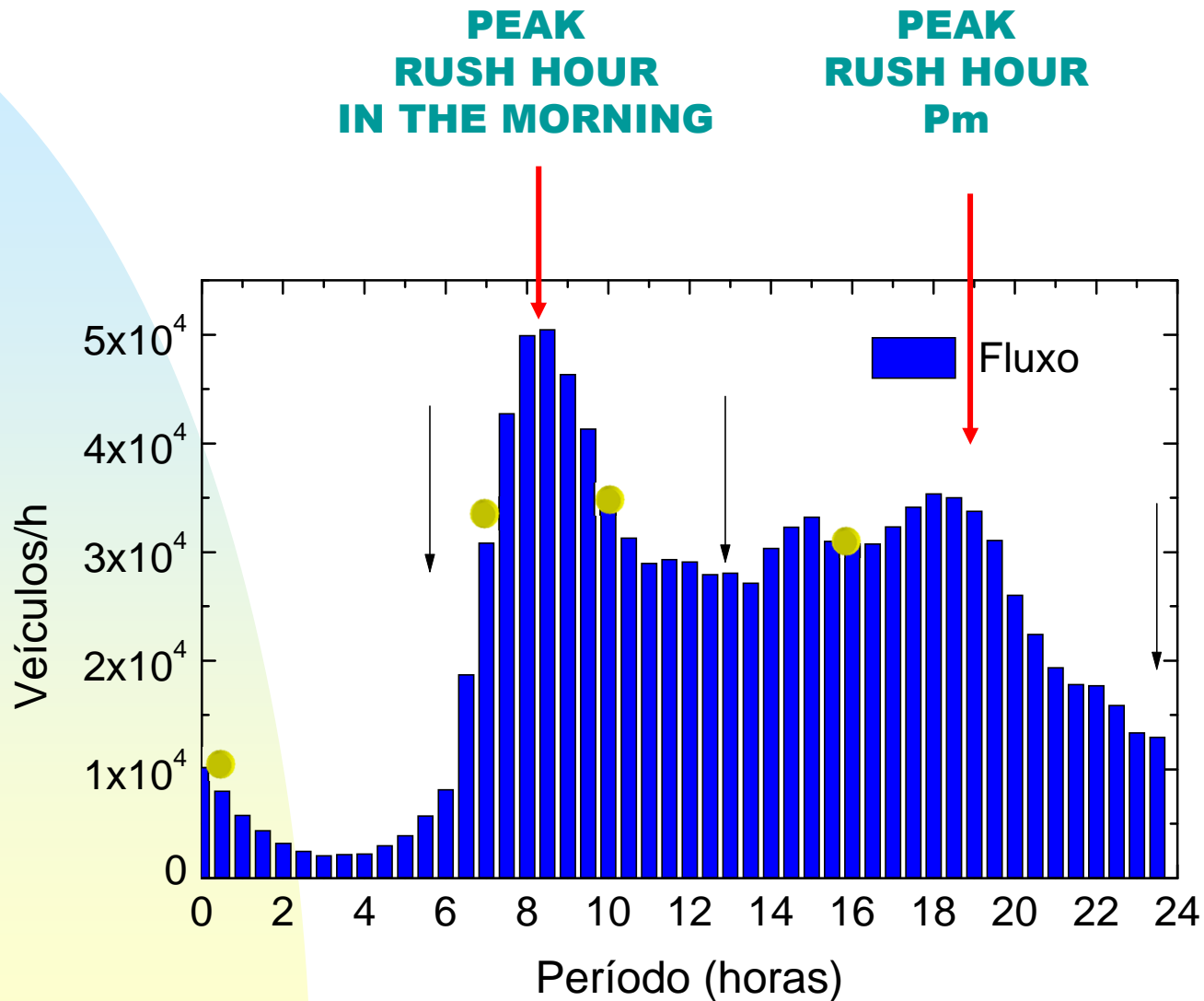
Close to one million inhabitants

Over 3 million in the metropolitan area surrounding the city

The roads are mainly radial in between the major hills



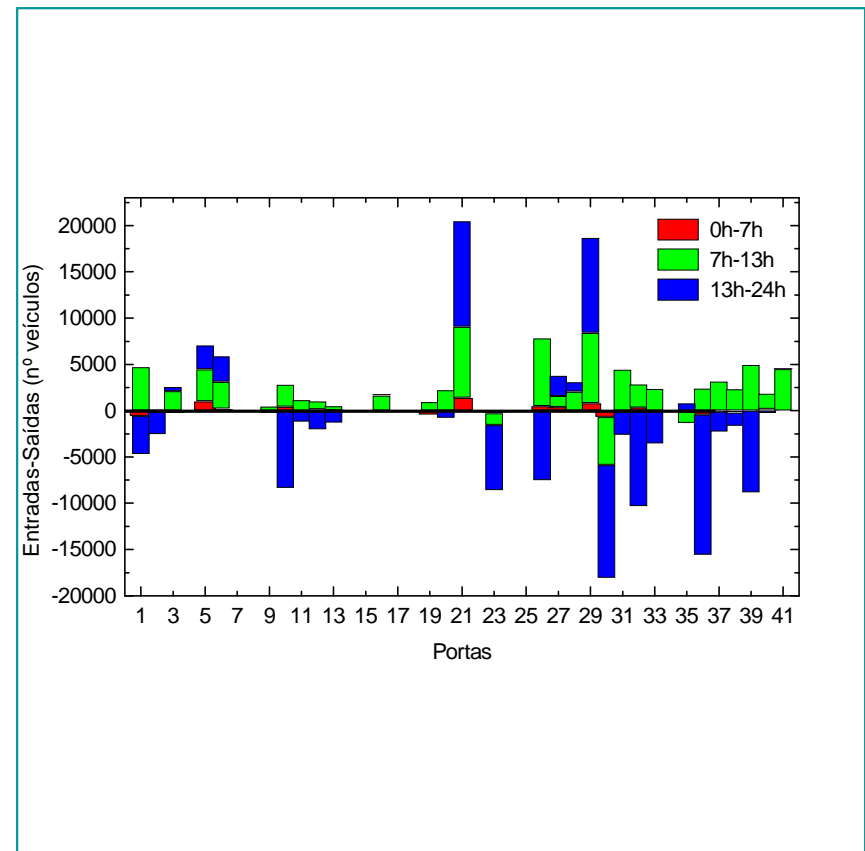
CITY OF HILLS [time]



• Hourly traffic variation at the main gates of the city of Lisbon.

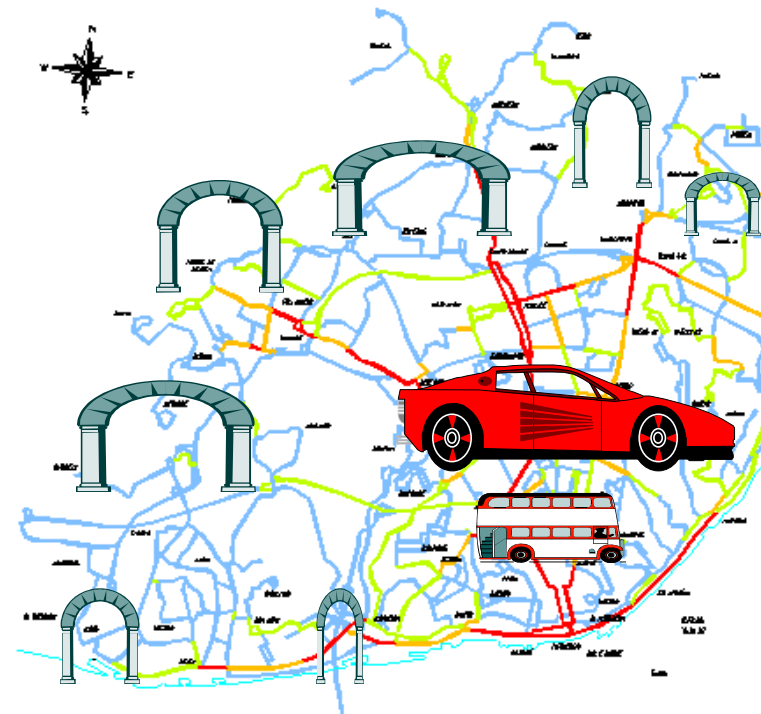
Daily flow balance

- City has a wide network of sensors
 - ◆ Entry gates, traffic lights, roundabouts, etc.
- One day picture of flow balance at all the gates



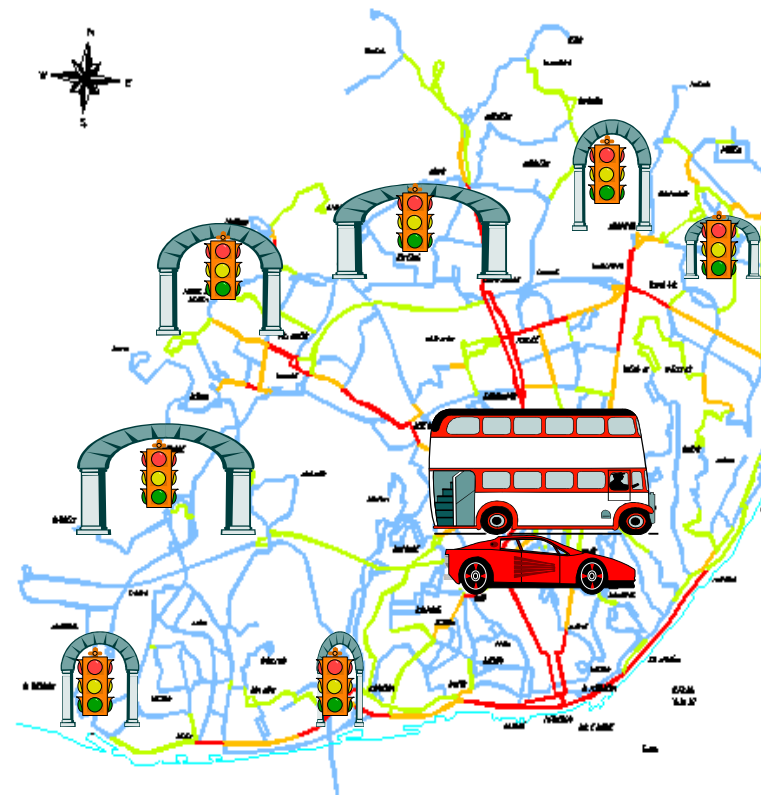
The problem

- All gates wide open
- Daily “invasion” of private cars
- No tradition of car pooling
- Average circulating speed of buses is below 15 Km/h (less than 9.4 miles/hour)
- Public Transport “crushed” by the pressure of private transport



The alternative view

- Main objective: to reduce the pressure exerted on the Public Transport (PT) by the Individual Transport (IT)
- What is the influence of IT over the average speed of PT?

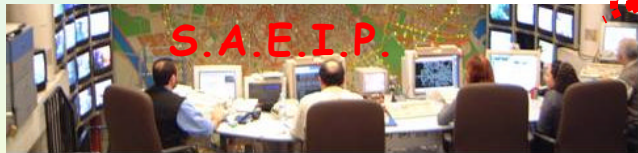


Field Trials

Bus route under observation

CAIS DO SODRÉ CAMPO GRANDE

Troço	Chapa	Tempo Circulação (min)	Tempo Comercial (min)	Início	Paragens
CAIS SODRÉ - ROSSIO	6	4	4	02-09-2002	2
CAIS SODRÉ - ROSSIO	7	5	5	5:36 02-09-2002	2
CAIS SODRÉ - ROSSIO	8	5	5	5:49 02-09-2002	2
CAIS SODRÉ - ROSSIO	1	6	6	6:01 02-09-2002	2
				6:13	



C. Sodr�-Rossio	1710m
Rossio-Marqu�s	1760m
Marqu�s-Saldanha	890m
Saldanha-Entrecampos	1550m
Entrecampos-Campo Grande	1330m
TOTAL	7240m

Campo Grande- Entrecampos	1300m
Entrecampos- Saldanha	1570m
Saldanha- Marqu�s	890m
Marqu�s Rossio	1870m
Rossio- C. Sodr�	1310m
TOTAL	6940m

Field Trials (strategic gate A5)

CT 24 - Gate under observation

880 vehic /h

Av. Fontes P. Melo

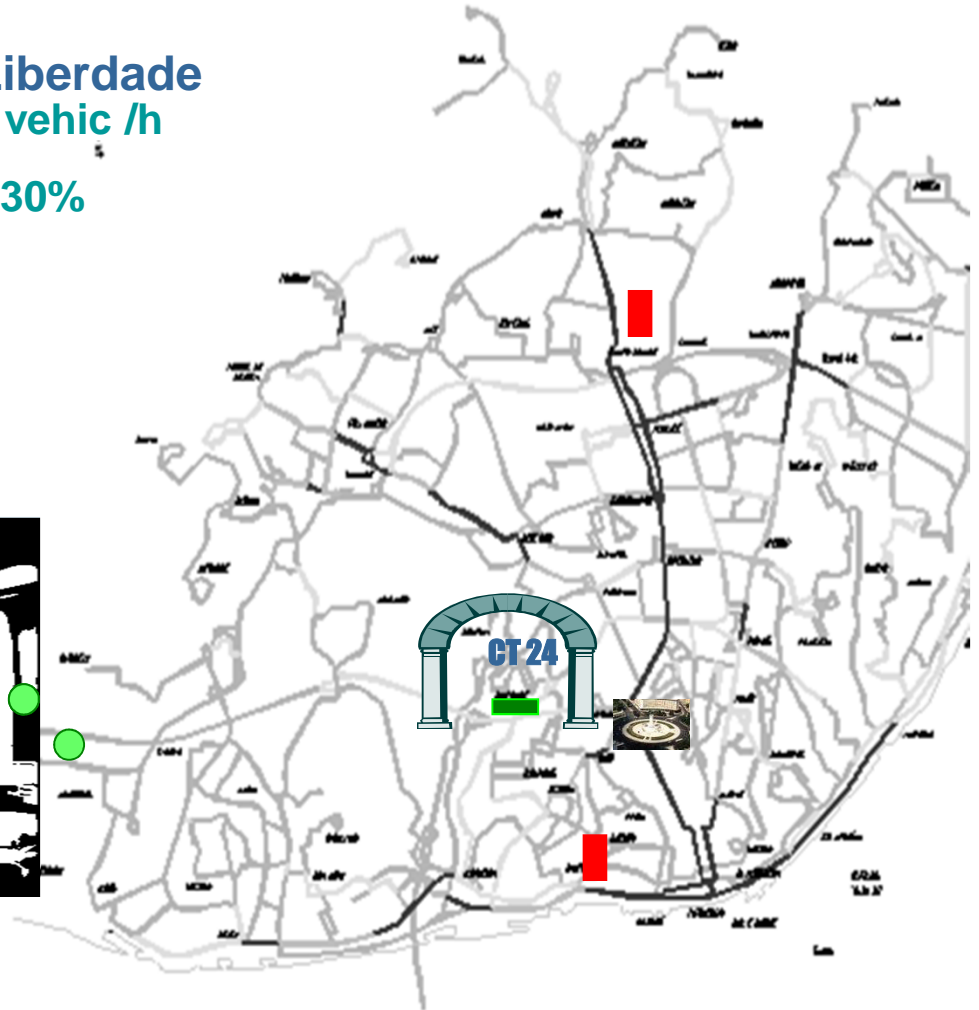
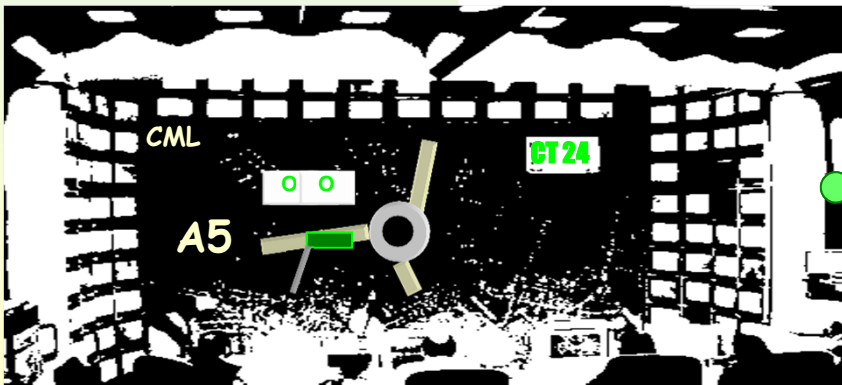
40%



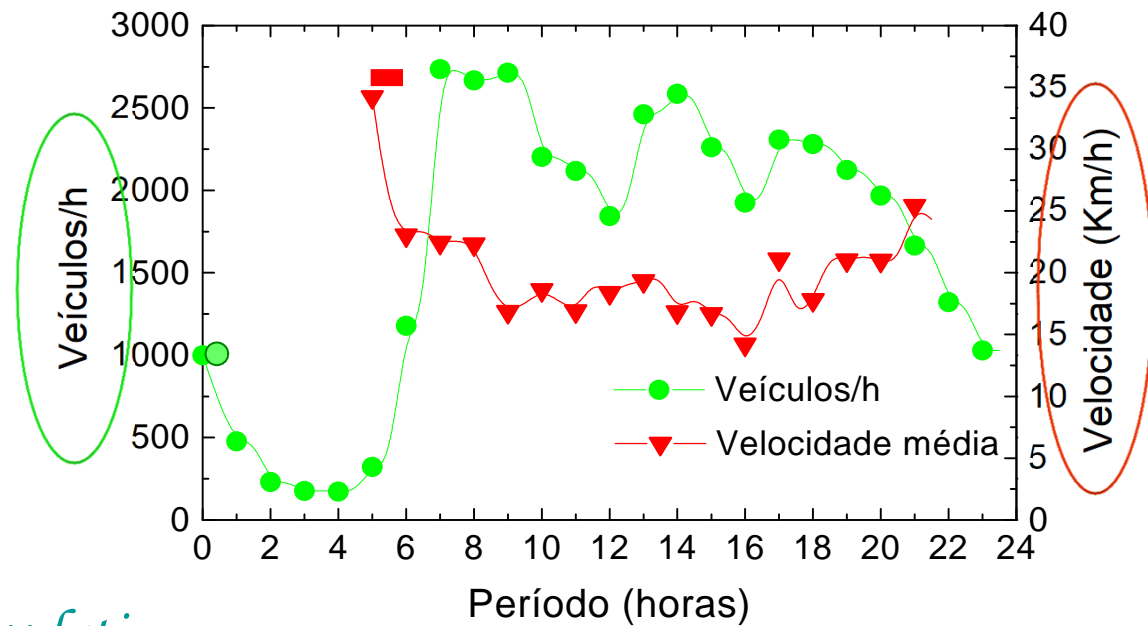
Av. Liberdade
660 vehic /h

30%

Av. Joaquim A. Aguiar
2.200 vehic /h



Correlation (Bus Travel speed / In-car volume)

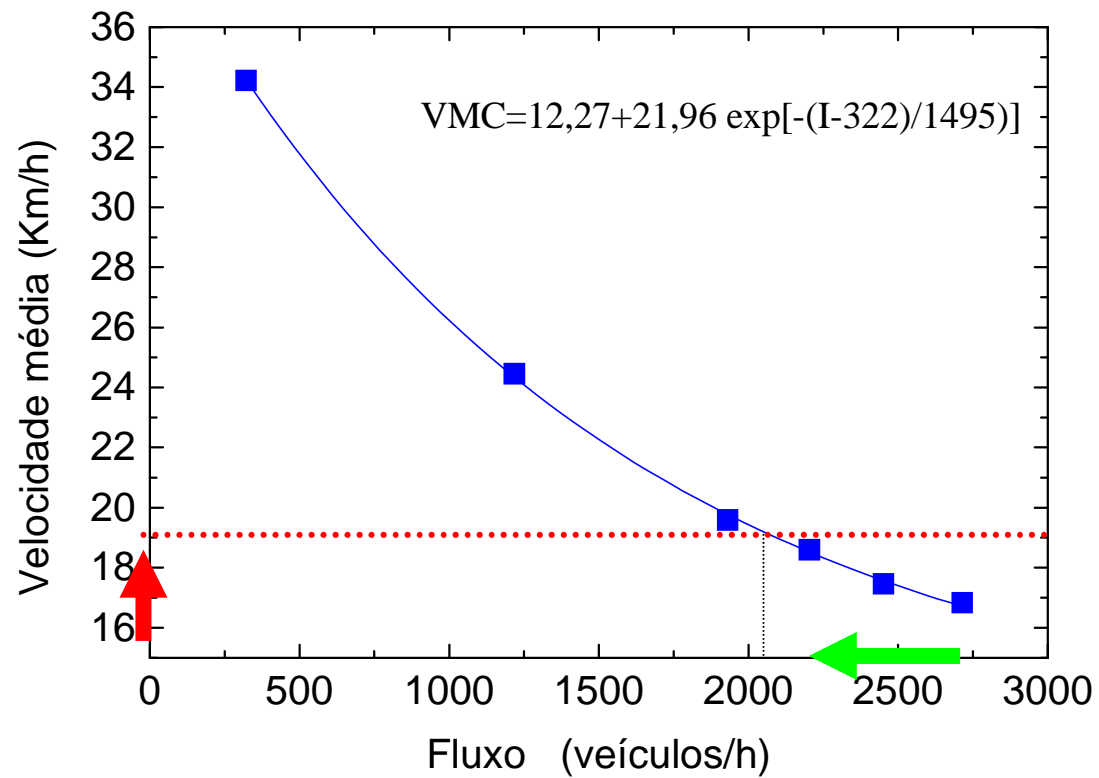


- *Coefficient of linear correlation*
- *Auxiliary measures*

Cars/hour vs. Bus speed

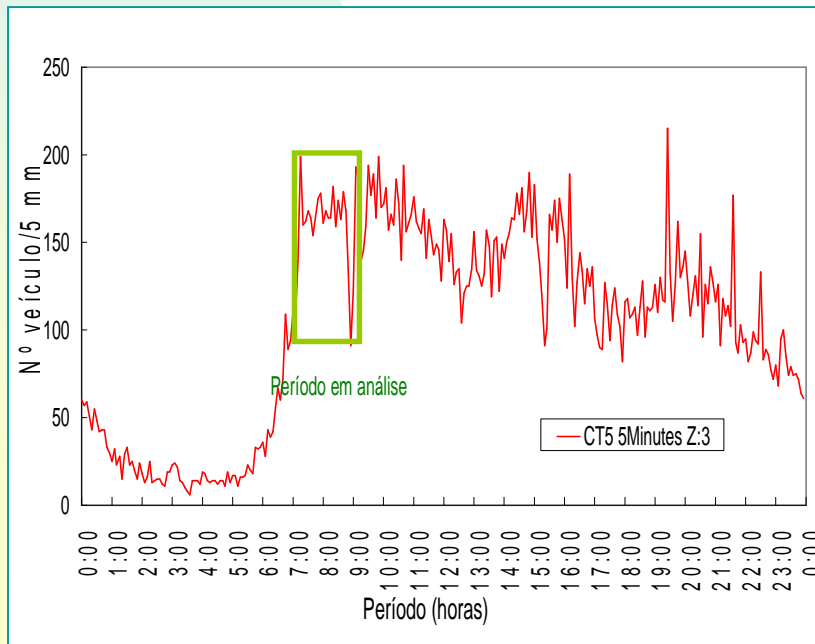
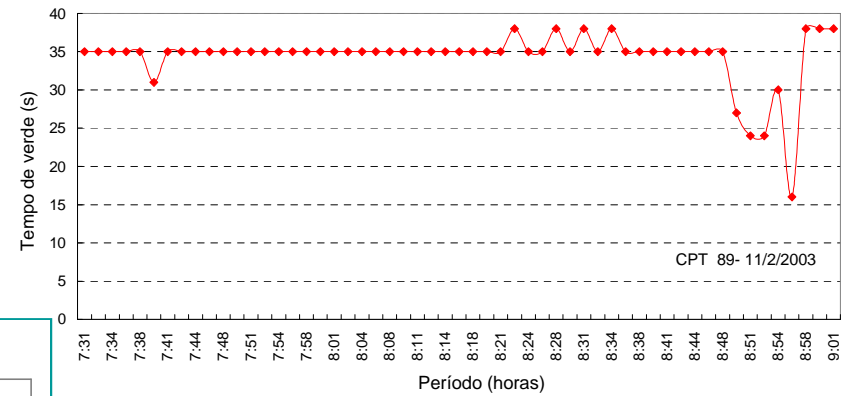
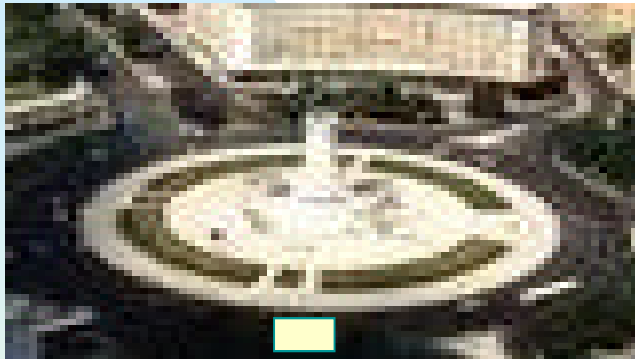
Speed as a function of in-flow rate

Speed as a function of in-flow rate



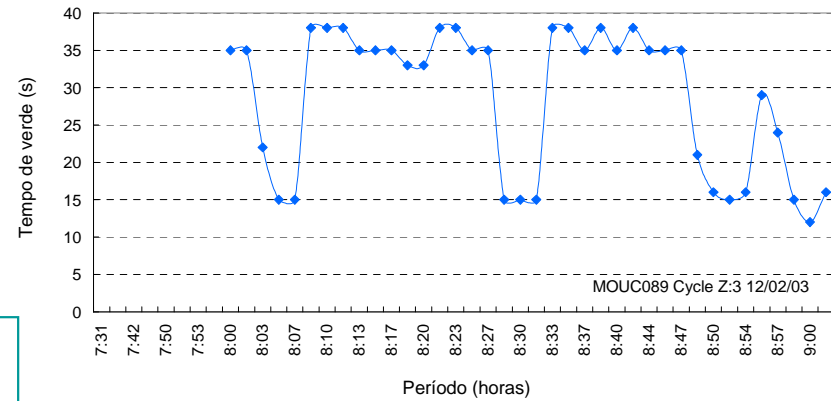
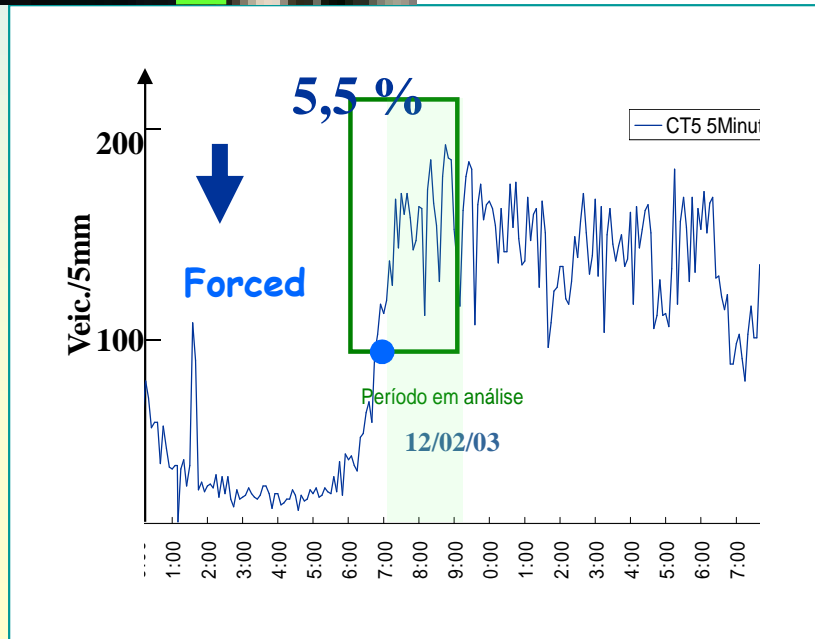
Flexibility of actuated controller

– no action



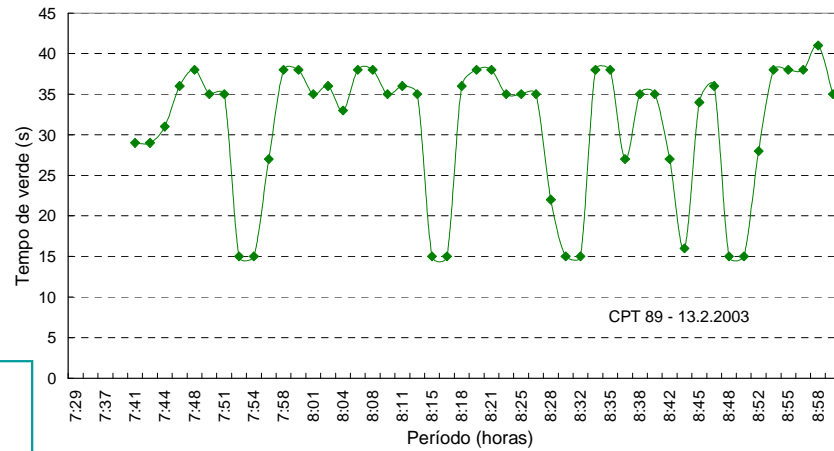
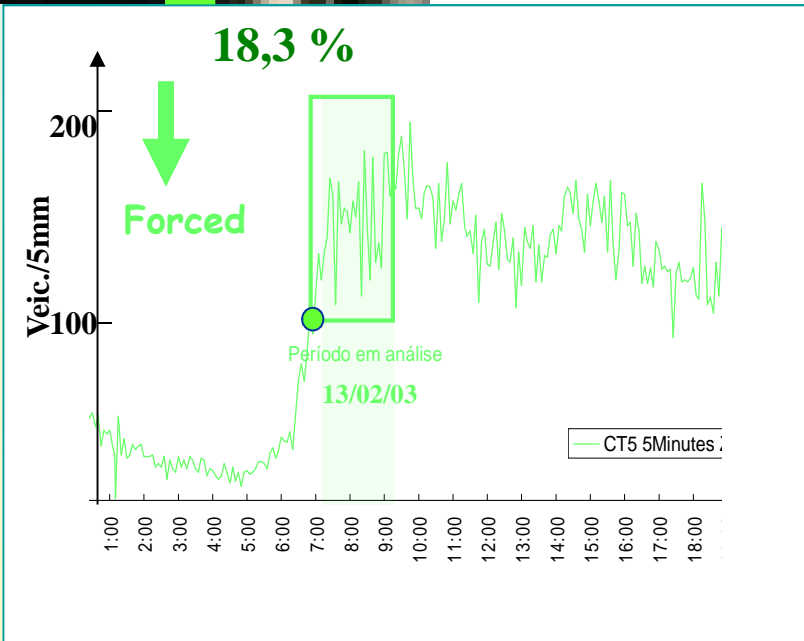
Flexibility of actuated controller

– mild action



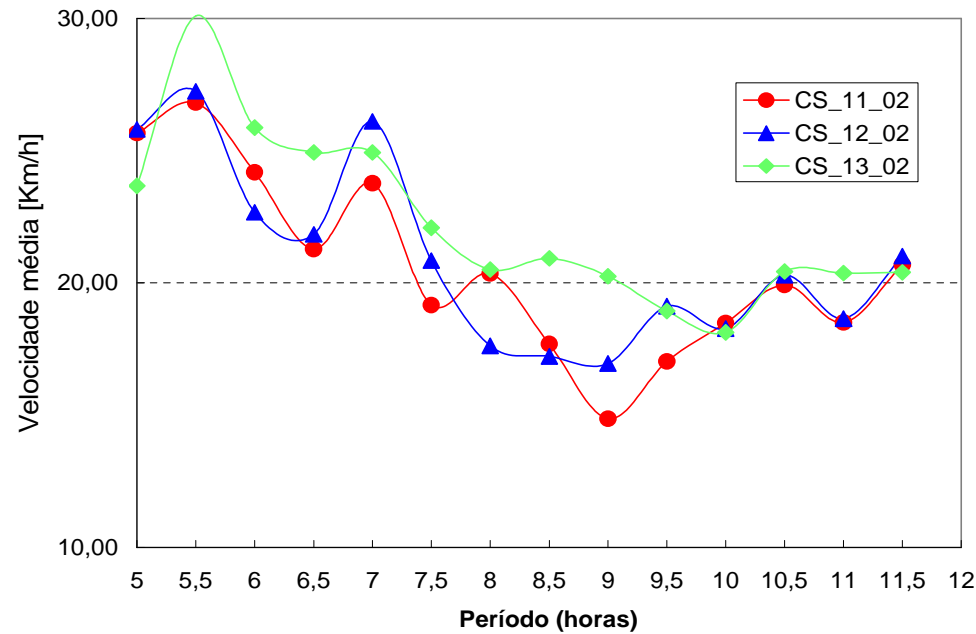
Flexibility of actuated controller

– stronger action



BENEFITS IN BUS TRAVEL SPEED

Campo Grande – Cais do Sodré



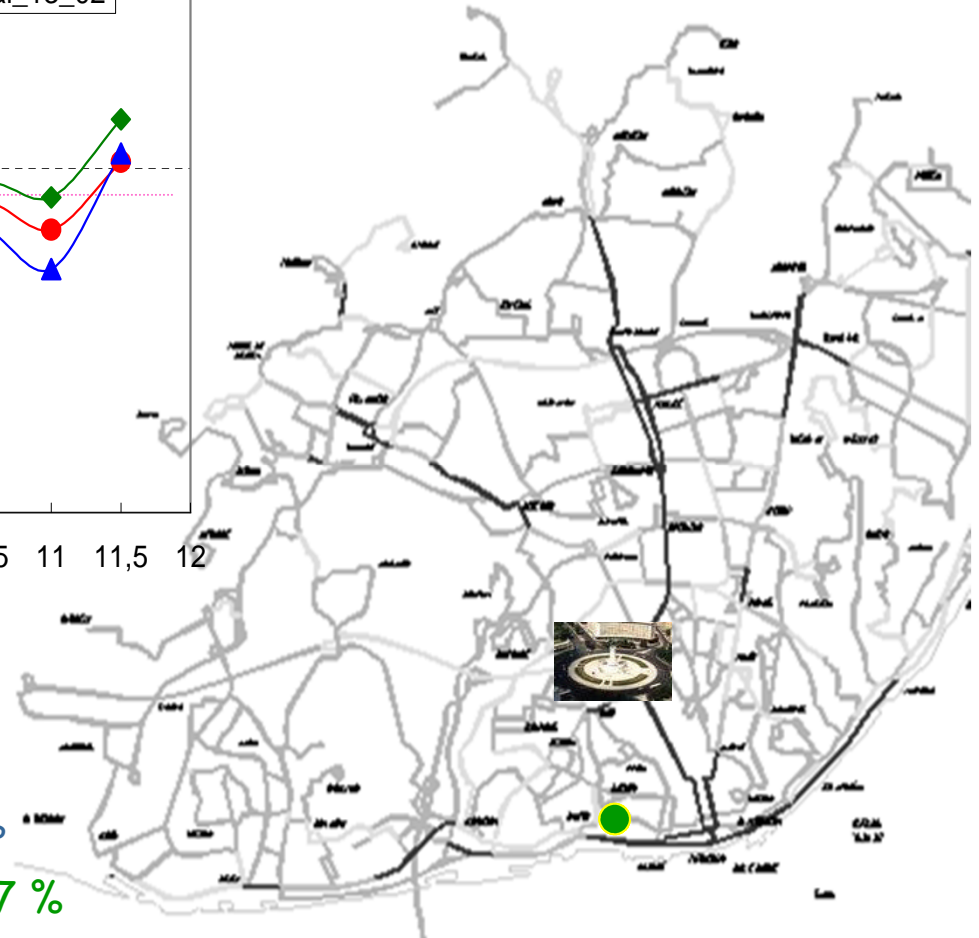
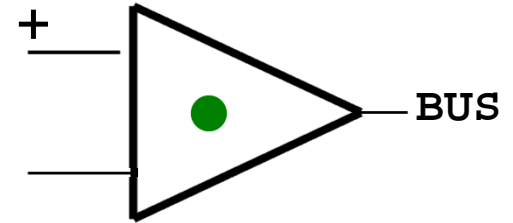
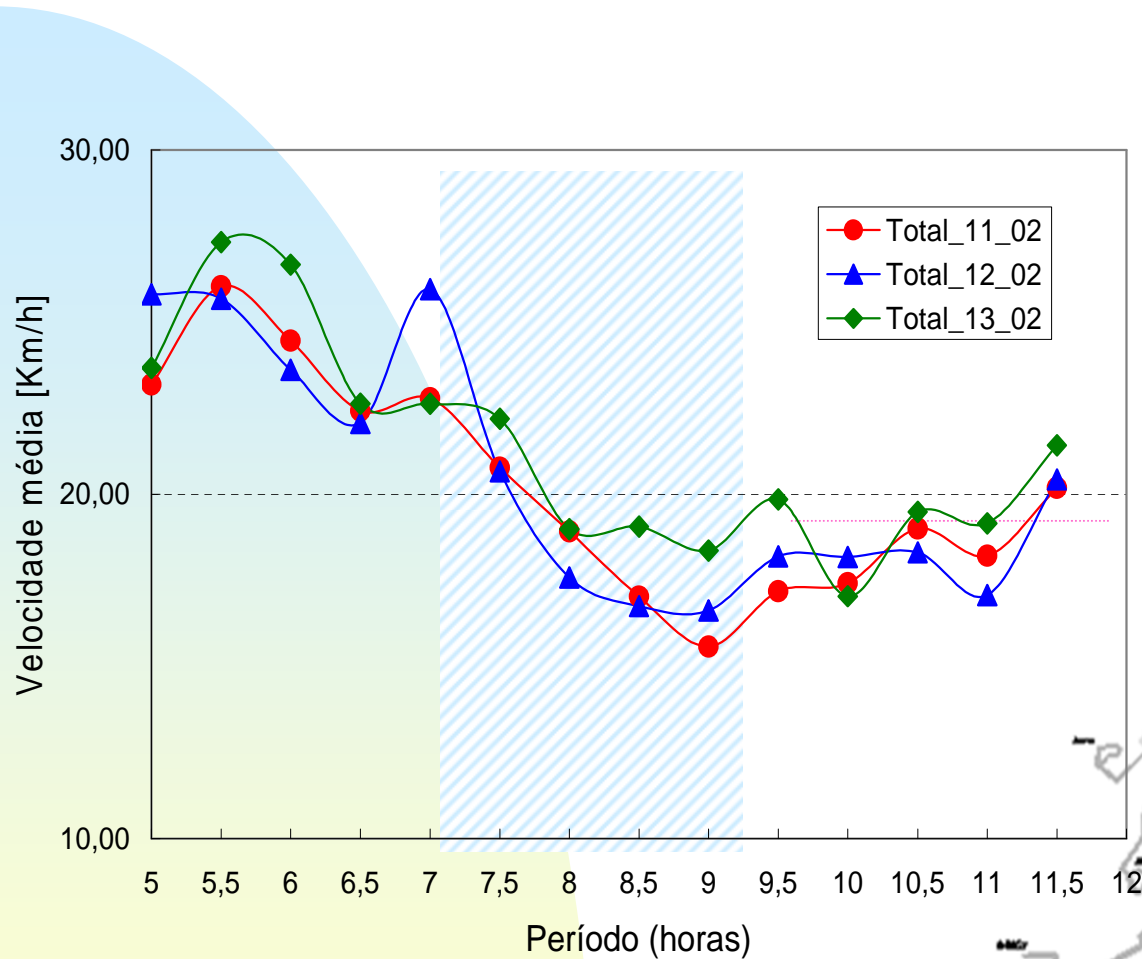
Vmin 15Km/h

Vmin 13 % ↑

Vmin 36 % ↑

BENEFITS IN BUS TRAVEL SPEED 2 Km/h

Amplification of the priority measures installed



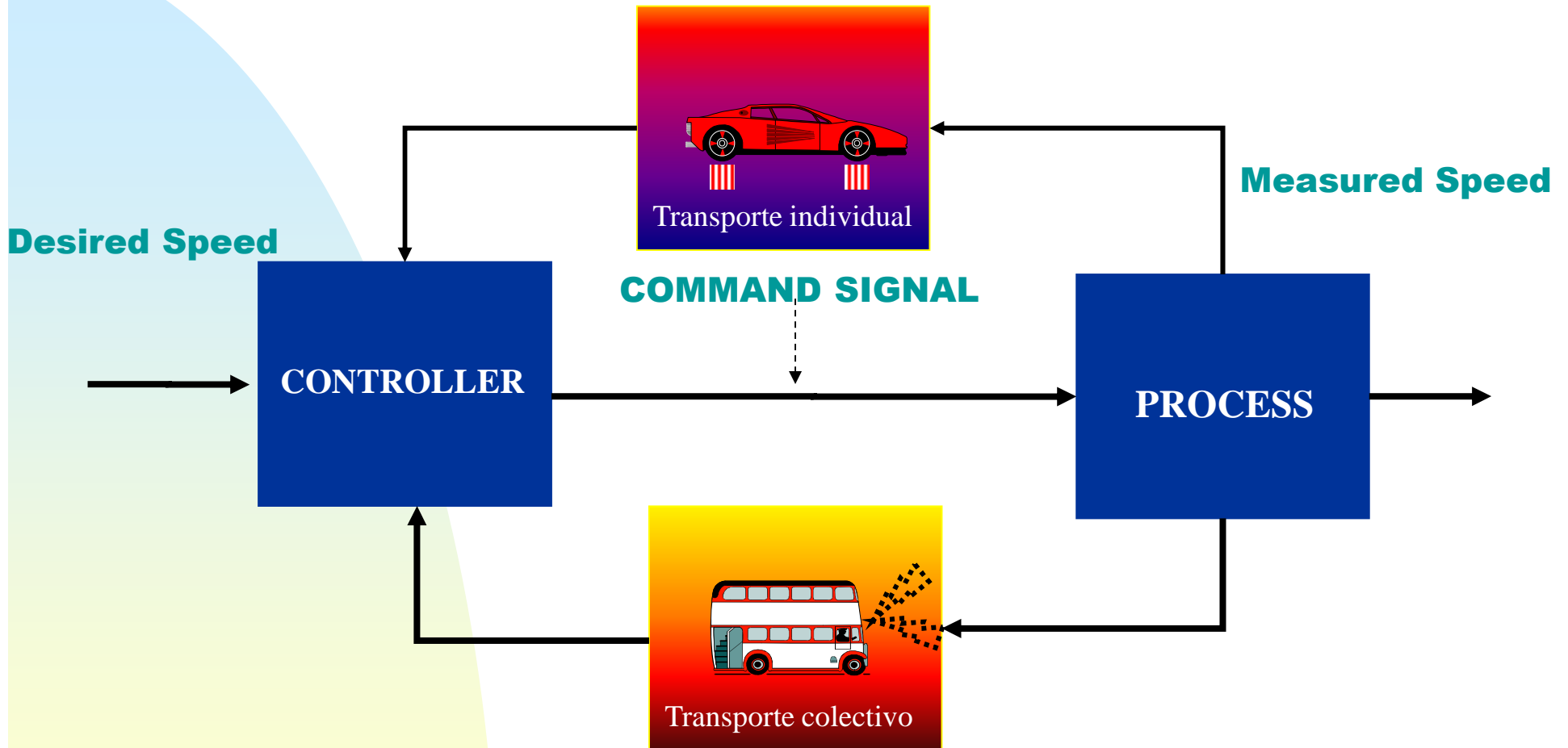
Vmin=15km/h; delay =1,86 min/km

Vmin 17km/h (13%) ; delay reduction of 20%

Vmin 19km/h (36%) ; delay reduction of 45,7 %

CONCLUSIONS

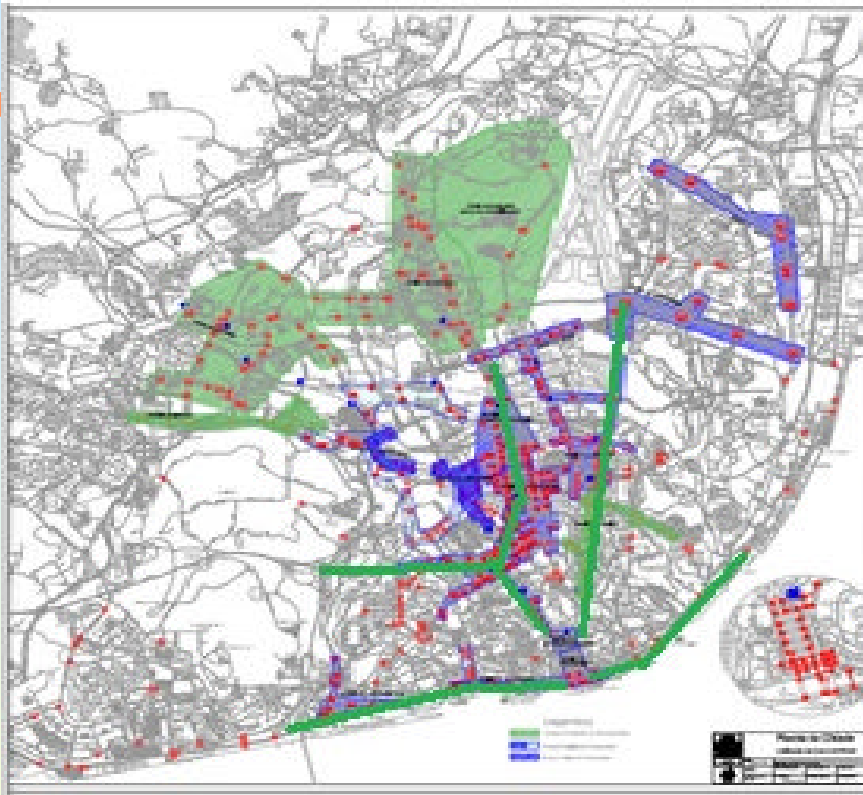
A feedback real time cooperative control



Implementation of an integrated system
Closed Loop Control Individual Transport
Public Transport (Process Controller)

Paradigm shift in traffic control strategies

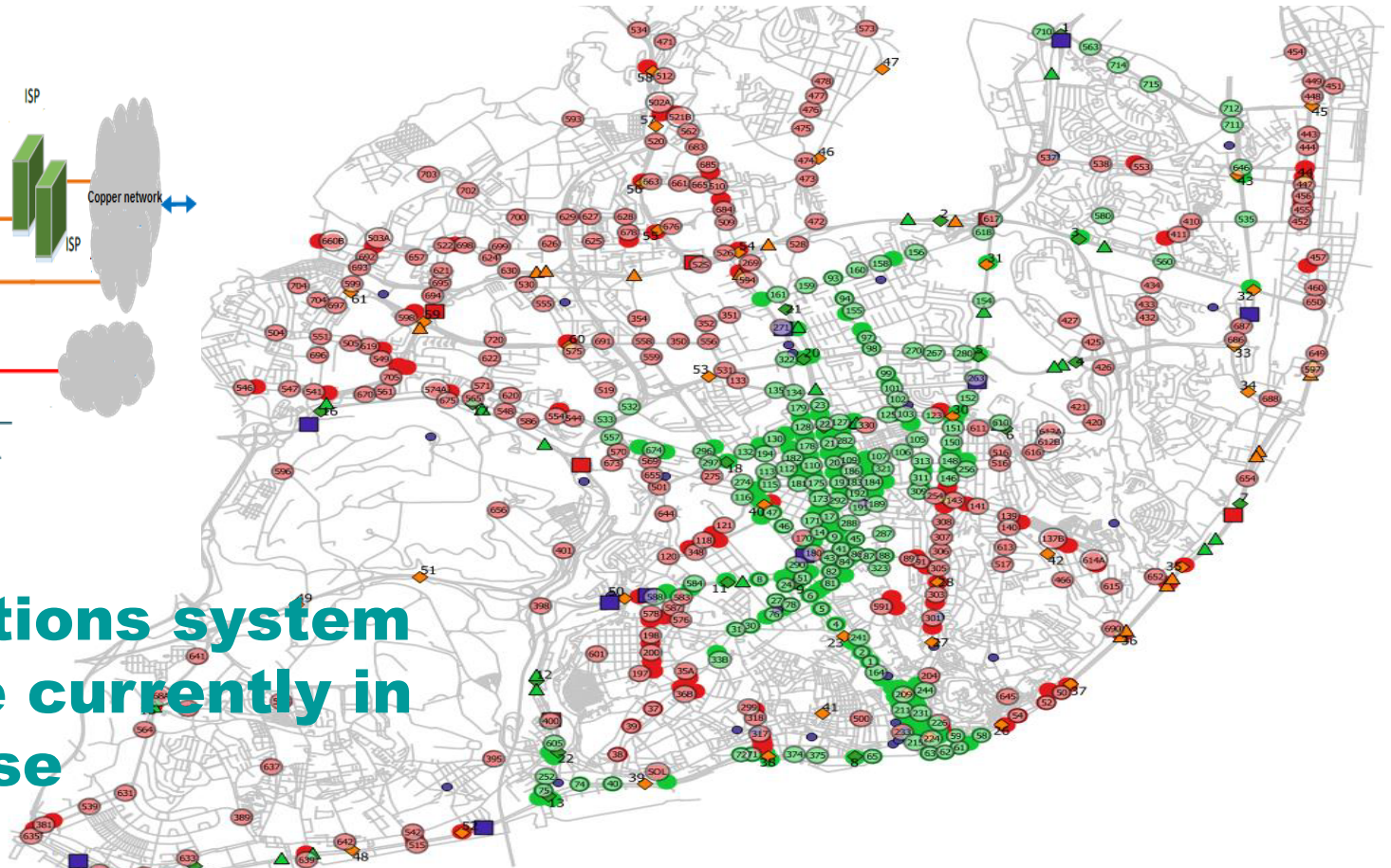
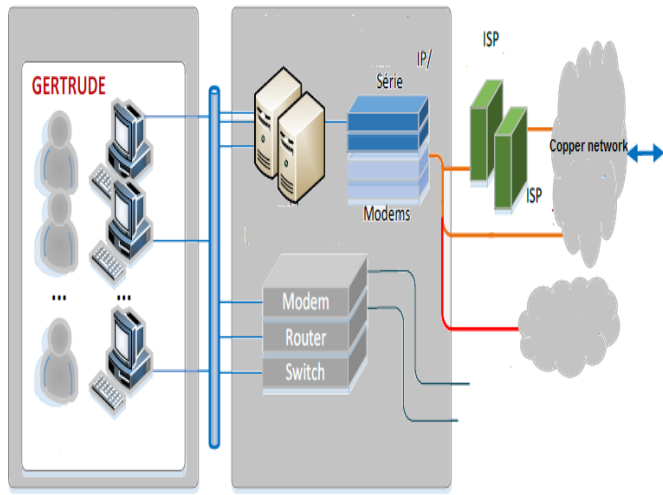
NEW MENTAL MAP



**1980s strategy
(associating the radial
tendency of the road
network)**



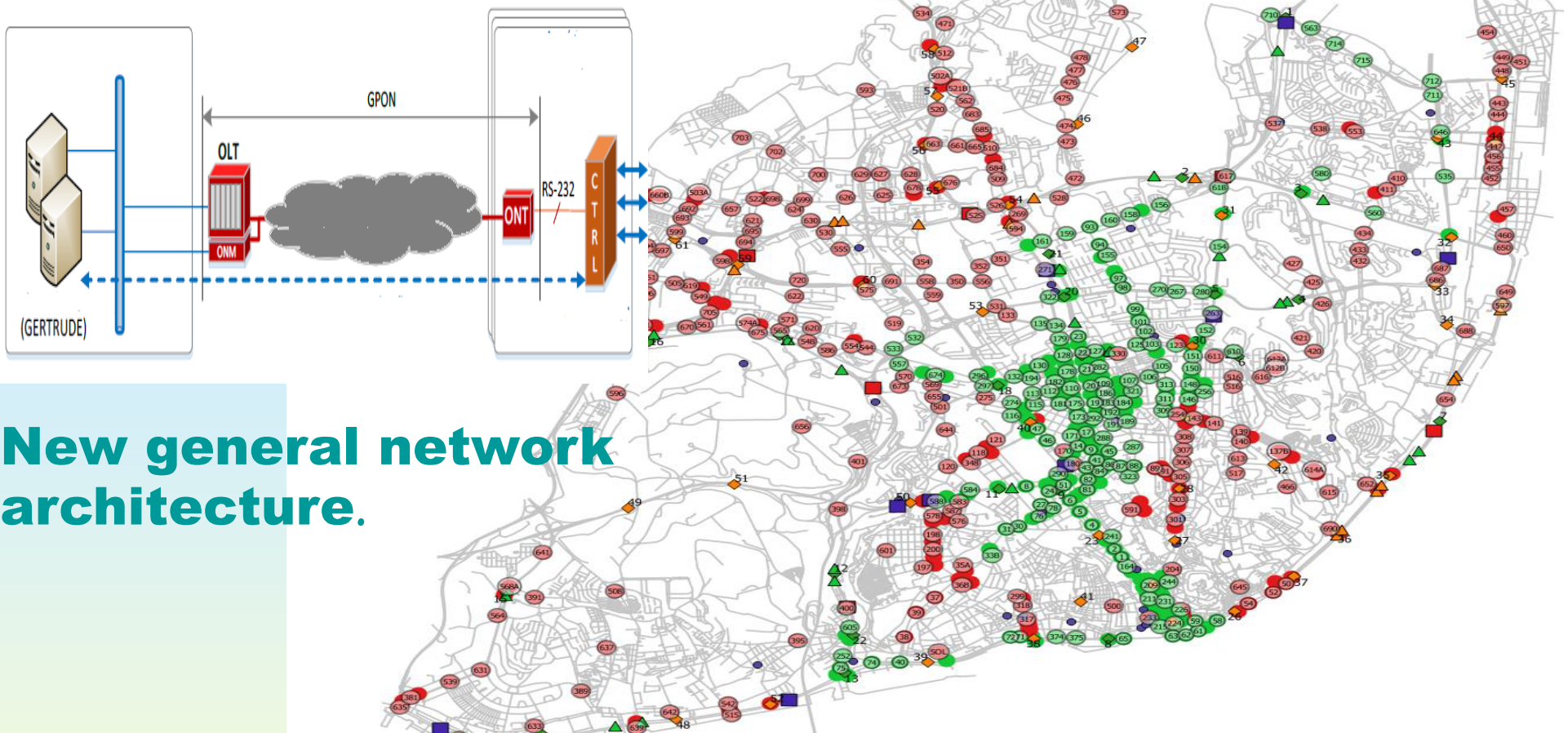
**Strategy New Municipal
Master Plan (increasing
the importance of the
circular axes)**



Communications system architecture currently in use

The communications network ensures the interconnection to a set of ITS:

- Traffic light infrastructure devices
- Variable Message Panels (PMV);
- Speed cameras;
- Video cameras for traffic control;



New general network architecture.

The communications network ensures the interconnection to a set of ITS:

- **Traffic light infrastructure devices**
- **Variable Message Panels (PMV);**
- **Speed cameras;**
- **Video cameras for traffic control;**

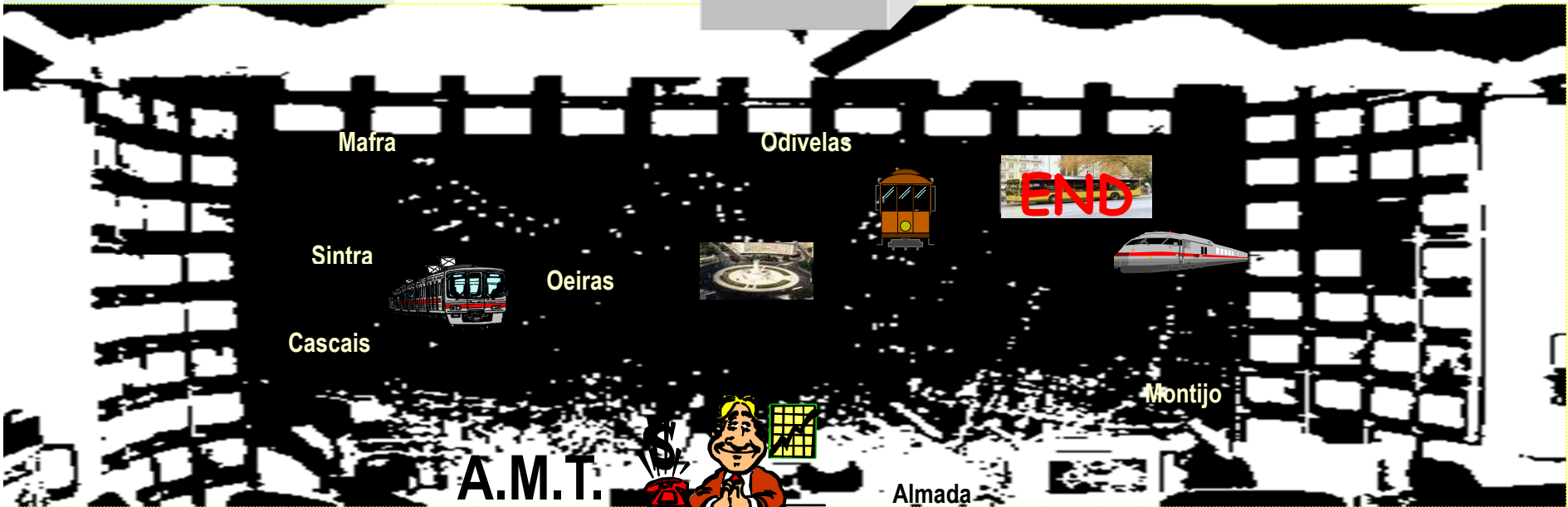
FUTURE DEVELOPMENTS



Velocity network average >20km/h <20km/h	Reliability indicator + 0,5min -0,4min	BUS
Door debit <40.000 veic/h >40.000 veic/h	Congestion indicator 0,99min/Km 1,86min/Km	TRAFFIC

Integration on the same computing platform

“There are no favorable winds for those who do not know where they are going”.



- High Quality of Service in the Public Transportation System

T1 Tutorial description

This tutorial, entitled

”Visible light communications in smart road infrastructures”, reports four work areas:

Admission Regulation of Traffic to Improve Public Transport in Urban Areas

Essays for optical communications

Indoor positioning using a-SiCH technology

Connected cars: road to vehicle communication through visible light

EUROPEAN MOBILITY WEEK

16-22 SEPTEMBER 2018

Theme 2018 - "Multimodality"

Mix and Move!



EUROPEAN MOBILITY WEEK 2018 is focusing on 'multimodality' - the mixing of transport modes within the same journey or for different trips