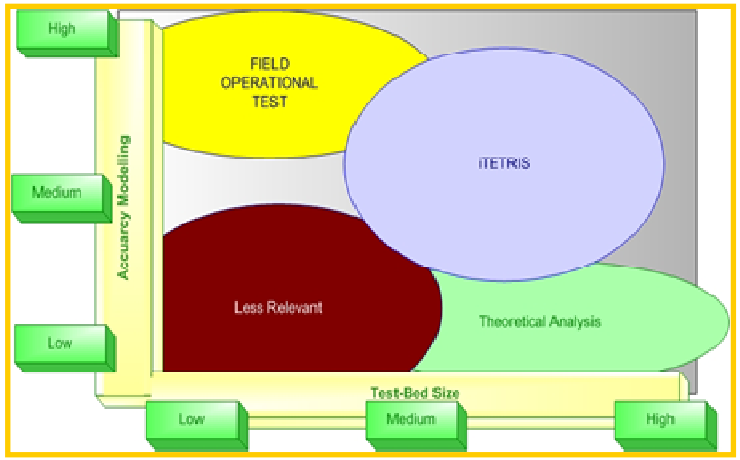
iTETRIS:
The Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions

13 November 2009, NEARCTIS Workshop, London

Focus / Vision

- Vehicular communication and traffic simulation platform
  - SUMO (traffic) + ns3 (network) + coupling (management)
- New technologies and solutions for mobility management
- Sustainable, open
- Long-term (beyond the project)
- Large scale (city level)
- Accurate, multidimensional evaluation of cooperative ICT



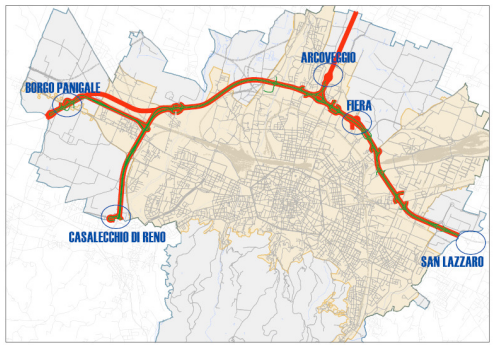
Area of Realization

City of Bologna, Italy

	Inhabitants	Area (km²)
Pedestrian Areas	~ 12,000	0.88
Limited Traffic Zone	~ 45,000	3.20
City Centre	~ 53,000	4.51
Municipality Area	~ 373,000	140.85
Overall demographic size	~ 650,000	

WP100 – Traffic Scenarios

- Traffic scenarios analysis
- Traffic congestion analysis
- Overall strategy definition
- Focus on existing technologies
- Realistic future improvements
- Wireless vehicular cooperative systems



WP100 – Traffic Scenarios

Pasubio – A. Costa

Problems:

Analyse and solve the impacts on the mobility of a big event such as a football match or a concert

Emergency vehicle priority since the hospital is close

Goals:

To manage the traffic in an area that offers few alternative routes

Traffic light priority to the emergency vehicle

Strategies:

To increase the capacity of the intersection changing traffic light timing

To suggest to postpone time departure, informing drivers of congestion, in order to keep flow lower than the road capacity

To inform vehicles coming from external areas of the congestion and to recommend them alternative routes

To change the traffic regulation (e.g. allowing some kind of private vehicles to use bus-lanes)

Bus lanes management

To limit access to a specific zone

WP100 – Traffic Scenarios

Inner city ring-way

Problems:

This scenario extends the previous one and covers the following traffic condition: traffic congestion, loop malfunctioning and lane closure.

Goals:

To find the best way to solve the congestion and reduce travel time

To detect congestion situations in real time

Travel time estimation

Strategies:

To increase the capacity of the intersection by changing traffic light timing

To suggest an alternative route by covering the ring way clockwise or anti clockwise direction

To allow access to LTZ zone for some kind of vehicles

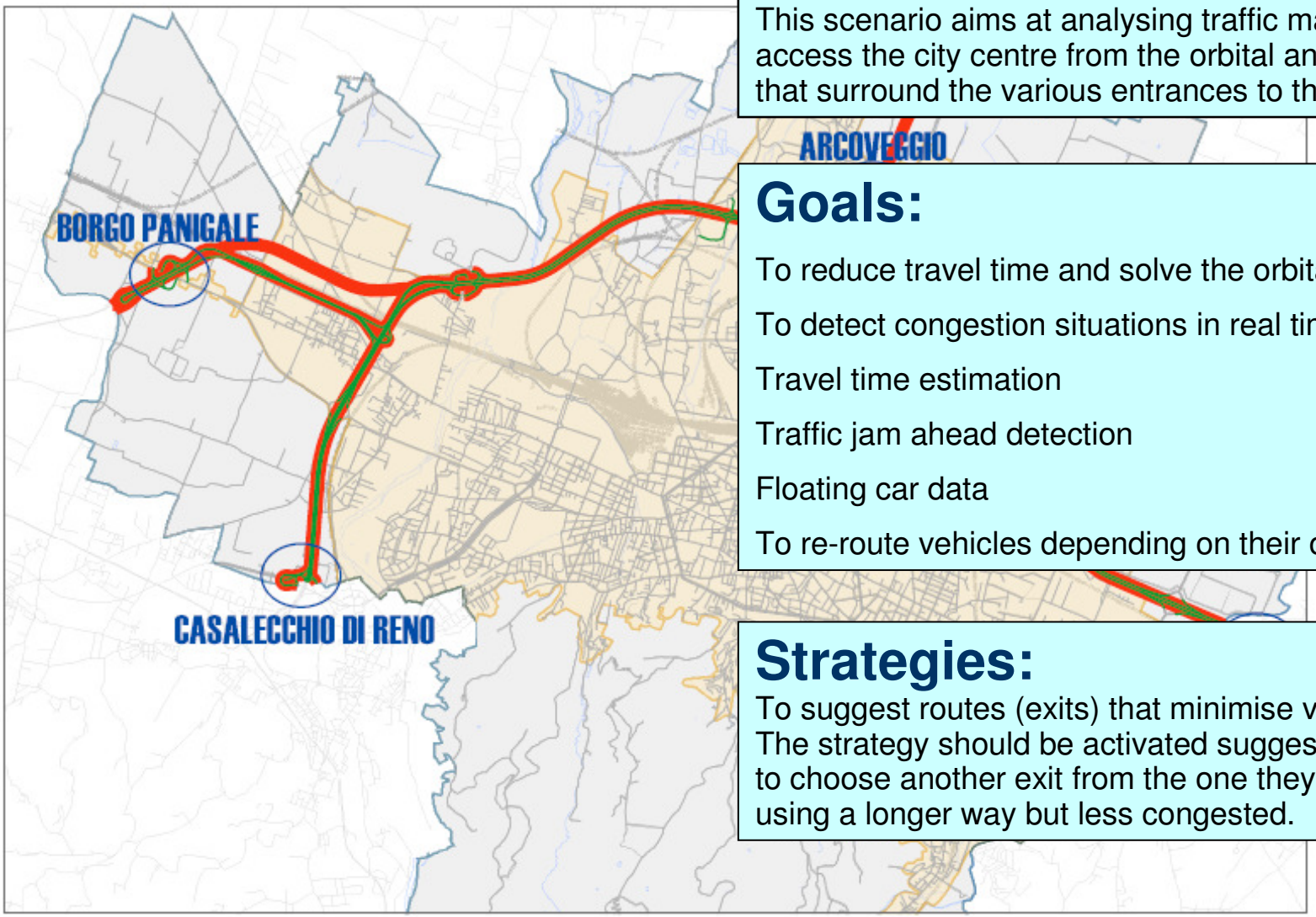
To inform vehicles coming from external areas of the congestion and to recommend them alternative routes

To allow some kind of vehicles (car pooling, low emission vehicles) to cross the restricted area

Speed advice to pass green light without stopping

WP100 – Traffic Scenarios

Orbital + Highway



Problems:

This scenario aims at analysing traffic management to access the city centre from the orbital and highway streets that surround the various entrances to the city.

Goals:

To reduce travel time and solve the orbital congestion

To detect congestion situations in real time

Travel time estimation

Traffic jam ahead detection

Floating car data

To re-route vehicles depending on their own destination

Strategies:

To suggest routes (exits) that minimise vehicles' travel time. The strategy should be activated suggesting some vehicles to choose another exit from the one they were going to take using a longer way but less congested.

WP200 – Traffic Policies and Protocols

- Definition of traffic metrics for quantifying overall traffic network performance
- Development of routing strategies relying on cooperative technology
- Development of traffic control strategies based on co-operative technology
- Definition of adequate interfaces and settings between the proposed co-operative traffic control strategies and the communication protocols (for simulation)

WP200 – Traffic Policies and Protocols

- 16 network metrics
- 11 intersection metrics

Most relevant measures	Mean relevance
Mean travel time	2.0
Mean waiting time	2.0
Mean number of stops	2.0
Number of stops	2.0
Mean waiting time in front of junction	2.0
Total travel time	1.7
Total waiting time	1.7
Mean noise/exhaust/other emissions	1.7
Number of accidents	1.7
Mean noise/exhaust/other emissions	1.7

2 = very relevant
1 = relevant
0 = neutral
-1 = irrelevant
-2 = very irrelevant

WP200 – Traffic Policies and Protocols

- Traffic condition estimation strategies:
  - Traffic jam ahead detection (distributed method)
  - Identification of malfunctioning loop detectors
  - Floating car data (decentralized)
- Traffic management strategies:
  - Bus lane management / limited access warning
  - Regulatory and contextual speed limit information
  - Emergency vehicle
  - Traffic light adaptation by ITS service centre
  - Induction loop replacement
  - Postpone departure time for road network balancing

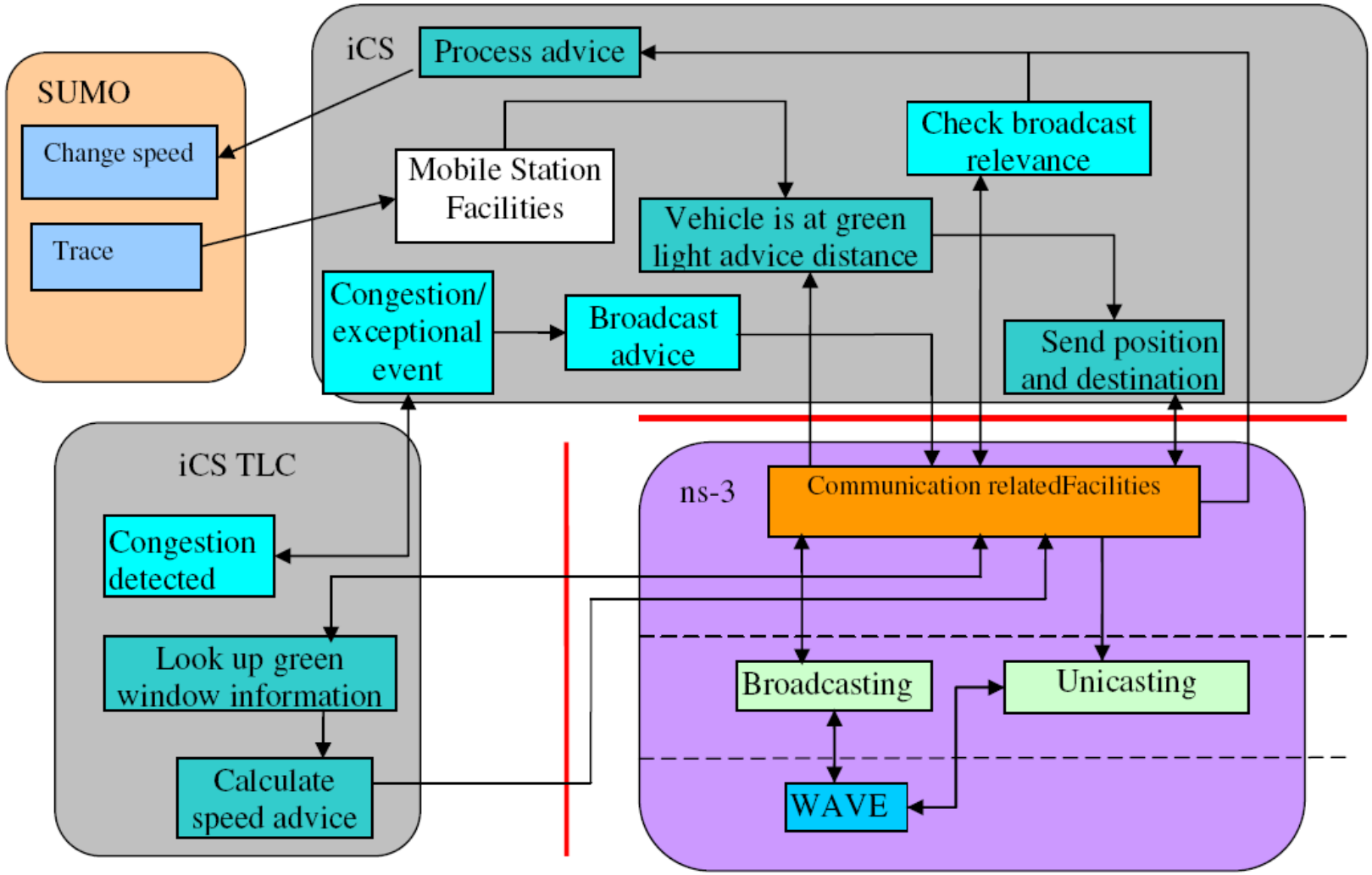
WP200 – Traffic Policies and Protocols

Name	S6: Regulatory and contextual Speed Information
Description	Vehicles can get a speed advice for making a green light without stopping. This advice is generated using information about the green planning of the traffic light. This way a vehicle can be prevented from stopping, saving fuel and reducing emissions. Vehicles get notified about the existence of the speed advice application in the ITS Roadside Stations via ITS Roadside Station CAMs. When the ITS Roadside Station is servicing the application, the vehicle can request a speed advice with a unicast message. The vehicle should then supply where it comes from and where it is heading for, so that the ITS Roadside Station can calculate an advice for the right queue and returning it through a unicast message. In case of traffic jams, or dangerous situations ahead (S1 and S2 respectively) the regulatory or advice speed can be lowered as well. This information should be broadcasted by upstream ITS Roadside Stations using a broadcast message. The information will contain the start and end point of the speed limit change, the speed itself and if it is an advice or mandatory.
V2X message	▪Cooperative Awareness Message (CAM) also including service advertisement ▪Speed request message ▪Personalized speed recommendation message •Global speed recommendation message
Actors	▪ITS Vehicle Station ▪ITS Roadside Station
Wireless communication mode	•I2V periodic broadcasting of CAM messages for service advertising •V2I unicasting for requesting the recommended speed ▪I2V unicasting for returning the recommended speed ▪I2V periodic broadcasting of global speed recommendation

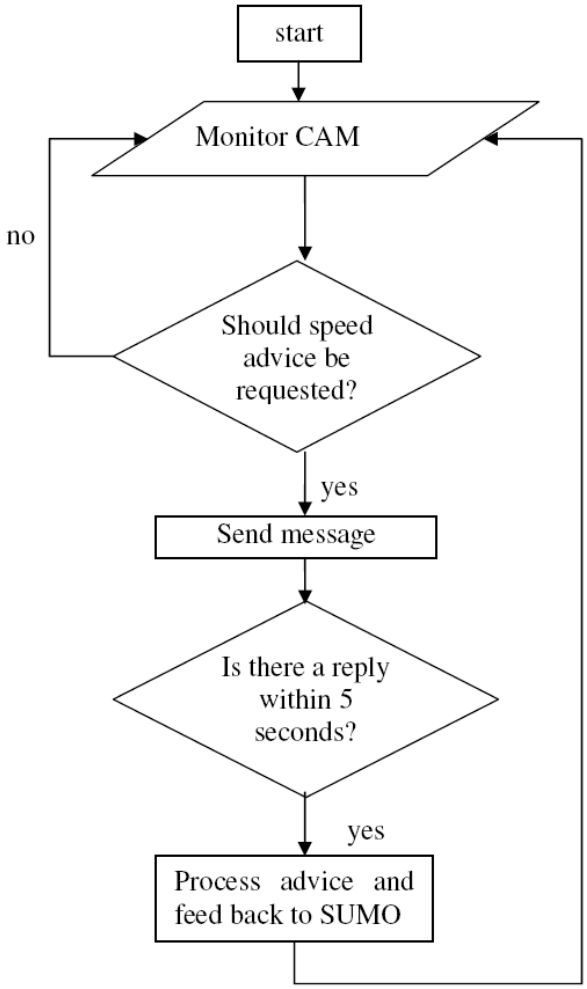
WP200 – Traffic Policies and Protocols

Required network	IEEE 802.11p (WAVE)(RECOMMENDED) (UMTS and WiMAX as alternative solutions)
Communication range	Up to 500m (WAVE Single-hop broadcasting and unicasting)
Expiry time	▪5s for personalized green light case (when a timestamp is added to the message) ▪60s for global speed recommendation broadcasting
Dissemination	▪Broadcasting ▪Unicasting
Transmission frequency	▪2Hz for CAM service advertisement ▪personalized speed recommendation on demand ▪global speed recommendation every 60 seconds
Subtopic	Speed information
Evaluation	Most important goal of these applications is to make the **traffic flow smoother** resulting in less **CO2 emissions** and fewer **stops**. Therefore this should be the main criterion to evaluate the applications. **Travel times**, on the other hand should not be influenced significantly (i.e. more than 5%) in a negative way.
Remarks	Implementing the green light speed advice should be done using a fixed distance to the stop-line where the advice is requested to make implementation easier. The other speed advices are quite specific for every situation considering the map and important locations on it and will therefore be more work to implement.
iTETRIS scenario	▪Ring way/Irnerio ▪Pasubio/A.Costa

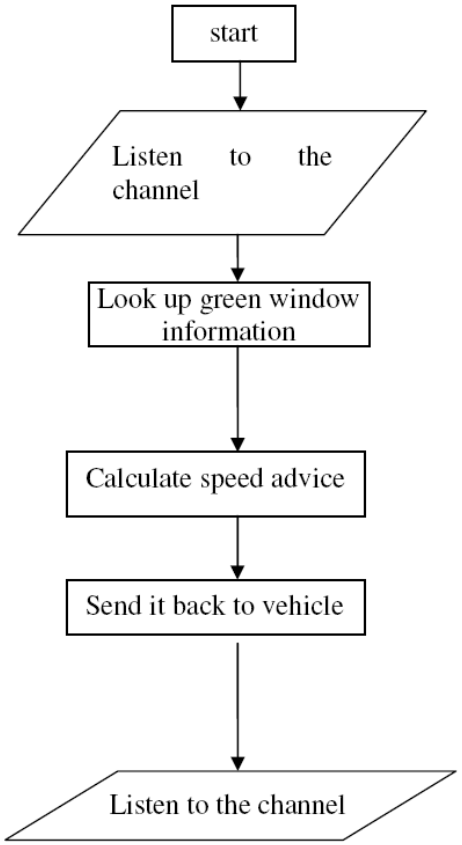
WP200 – Traffic Policies and Protocols



WP200 – Traffic Policies and Protocols

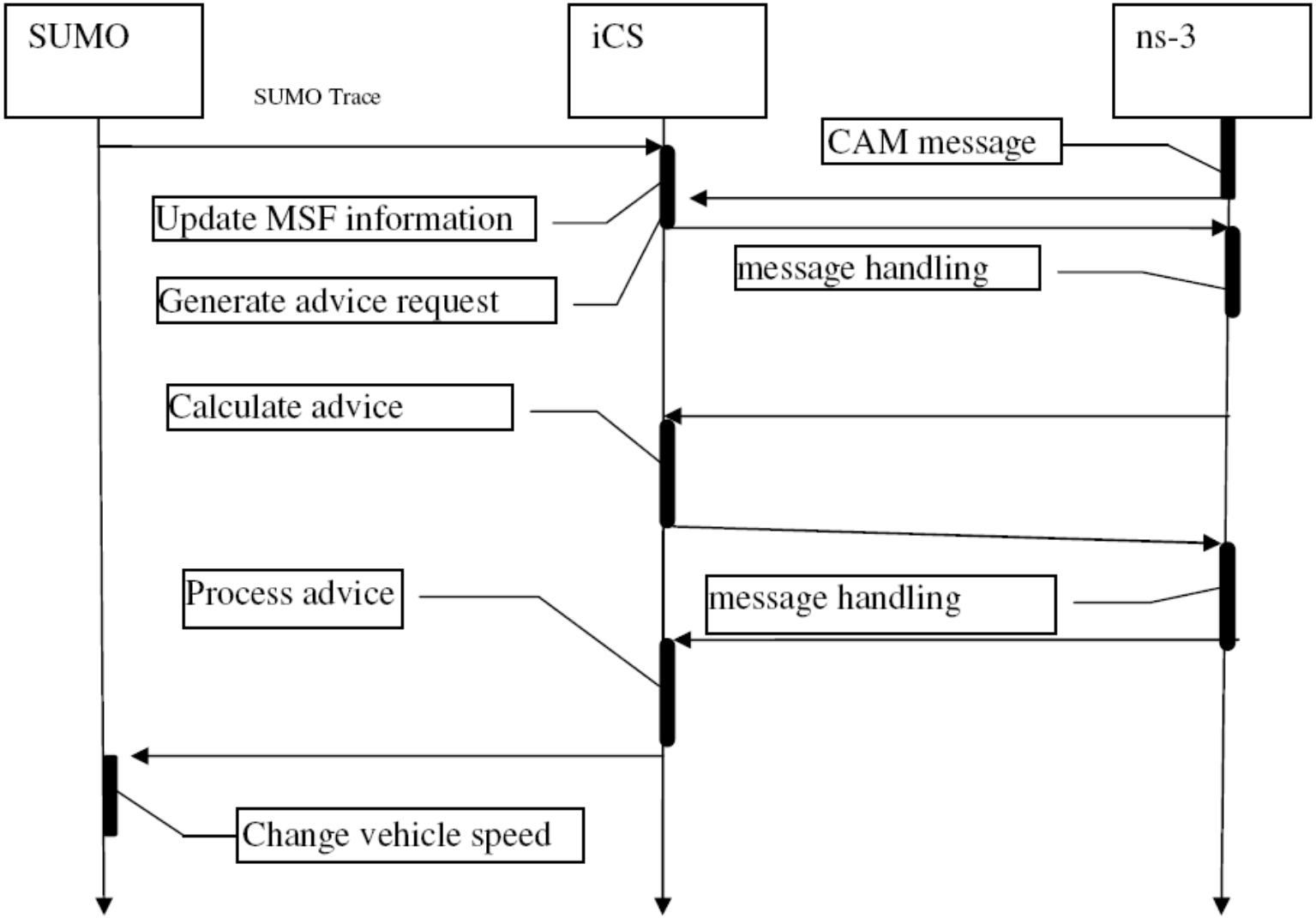


iCS advice application



iCS TLC

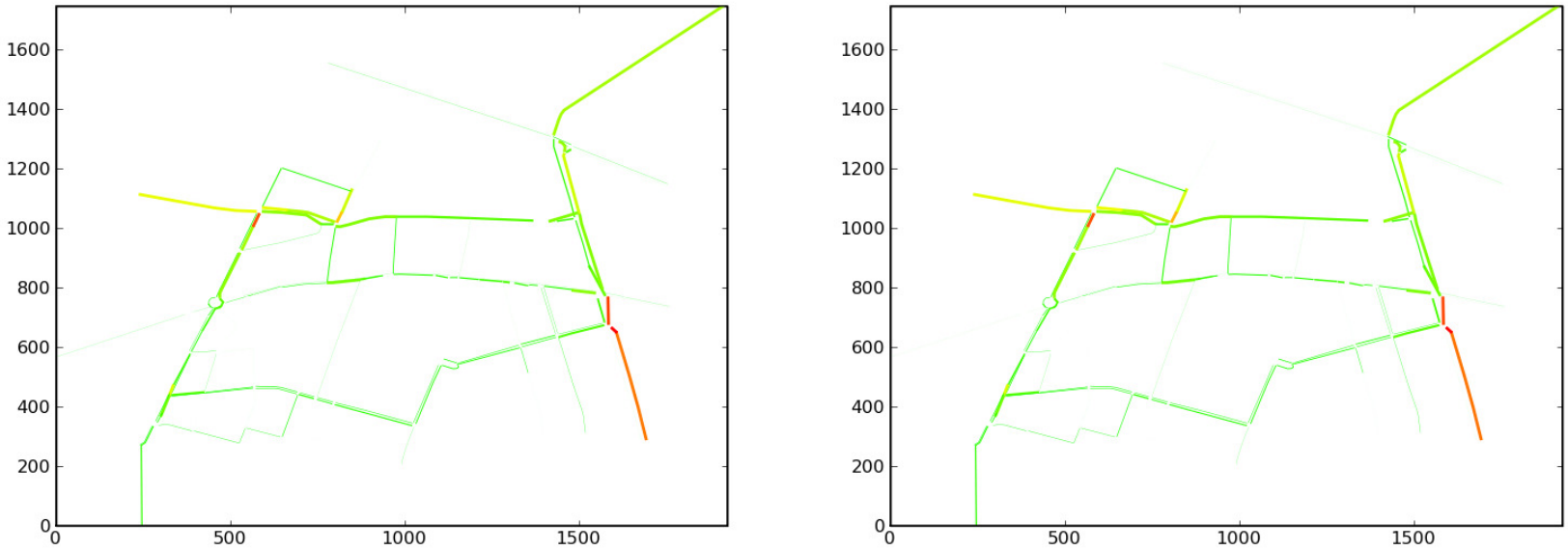
WP200 – Traffic Policies and Protocols



WP300 – Traffic Modelling

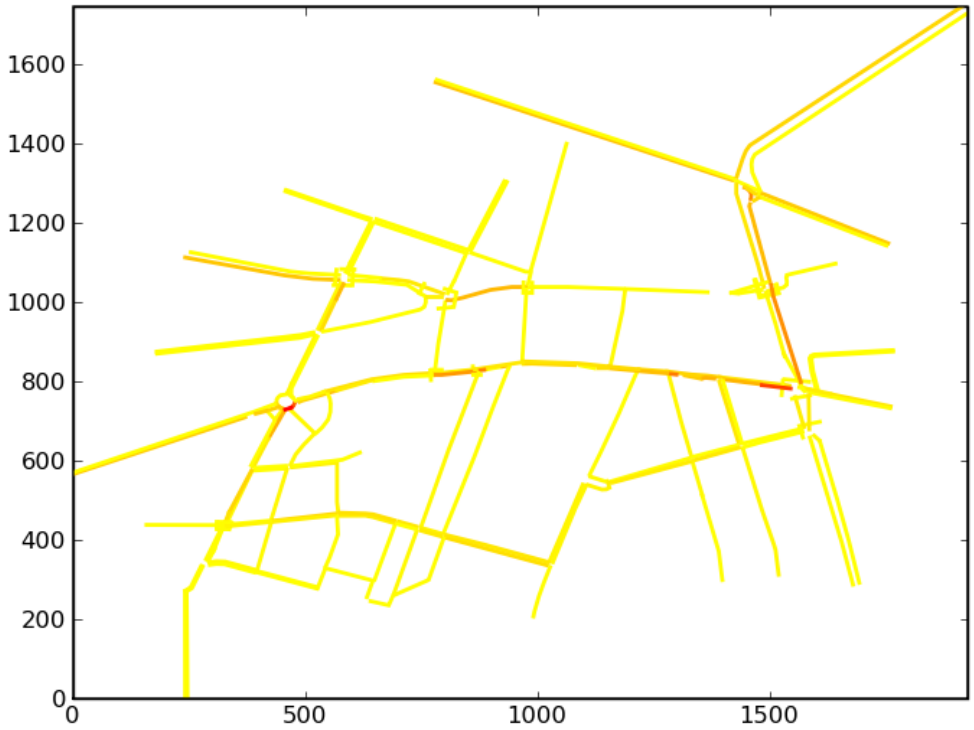
- Measurement of environmental effects of the management strategies developed in iTETRIS
- Harmonoise noise emission implementation
- HBEFA-based pollutant emission implementation
  - Computation of emissions of CO, CO_2, PM_x, NO_x, HC
  - Computation of fuel consumption
- Evaluation of the traffic's environmental impacts
- Documentation in deliverables, SUMO web pages:
  http://itetris.org/
  http://sumo.sourceforge.net/

- Evaluation example:
  - CO_2 emissions for scenario “A. Costa”
  - One time with normal emissions
  - One time with “electro-busses” (bus emissions=0)



Coloured by normalised CO_2 emissions; green: 0, red~=1100g/m/s

- Evaluation example:
  - Difference in CO_2 emission

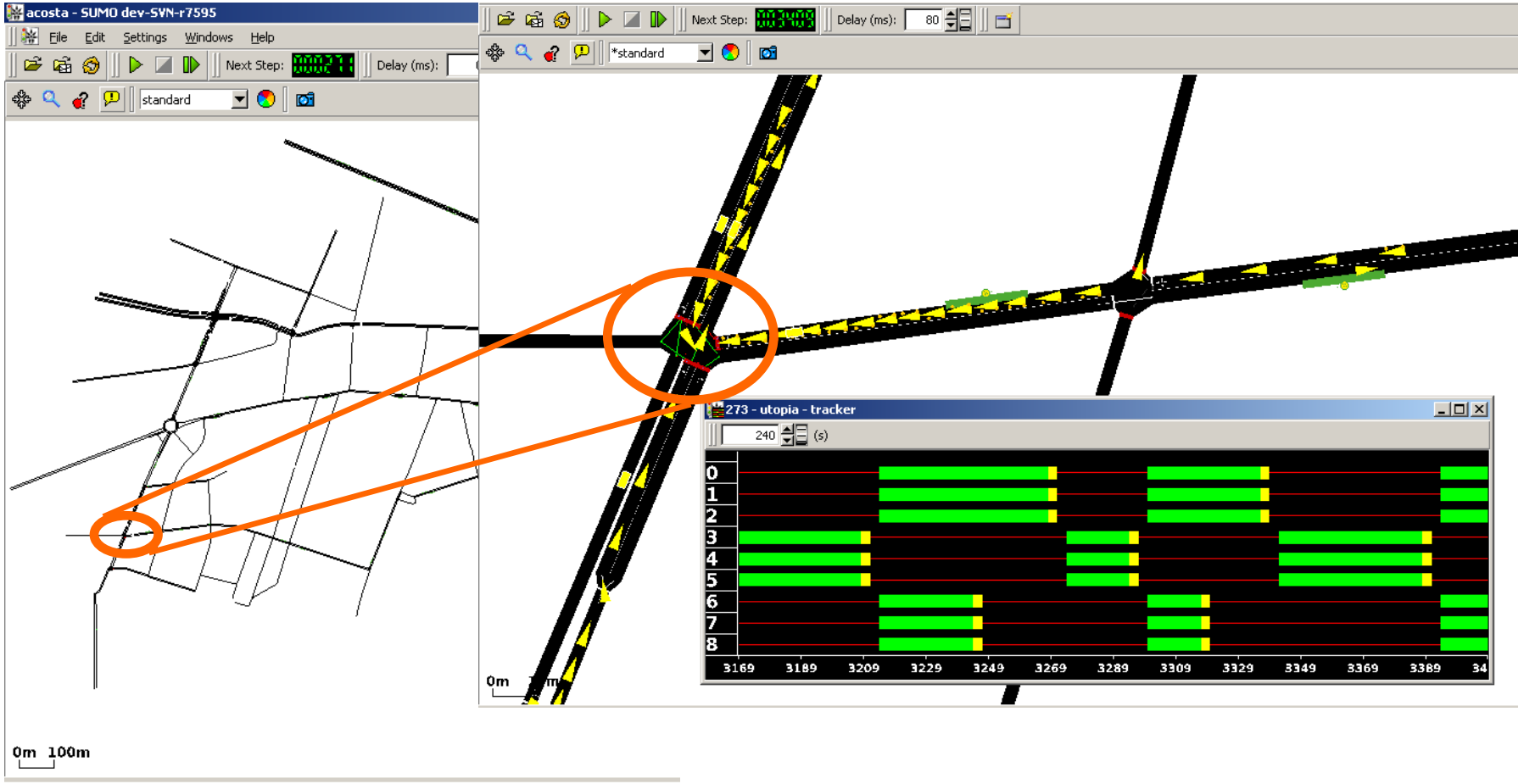


red: 142 g/m/s

WP300 – Traffic Modelling

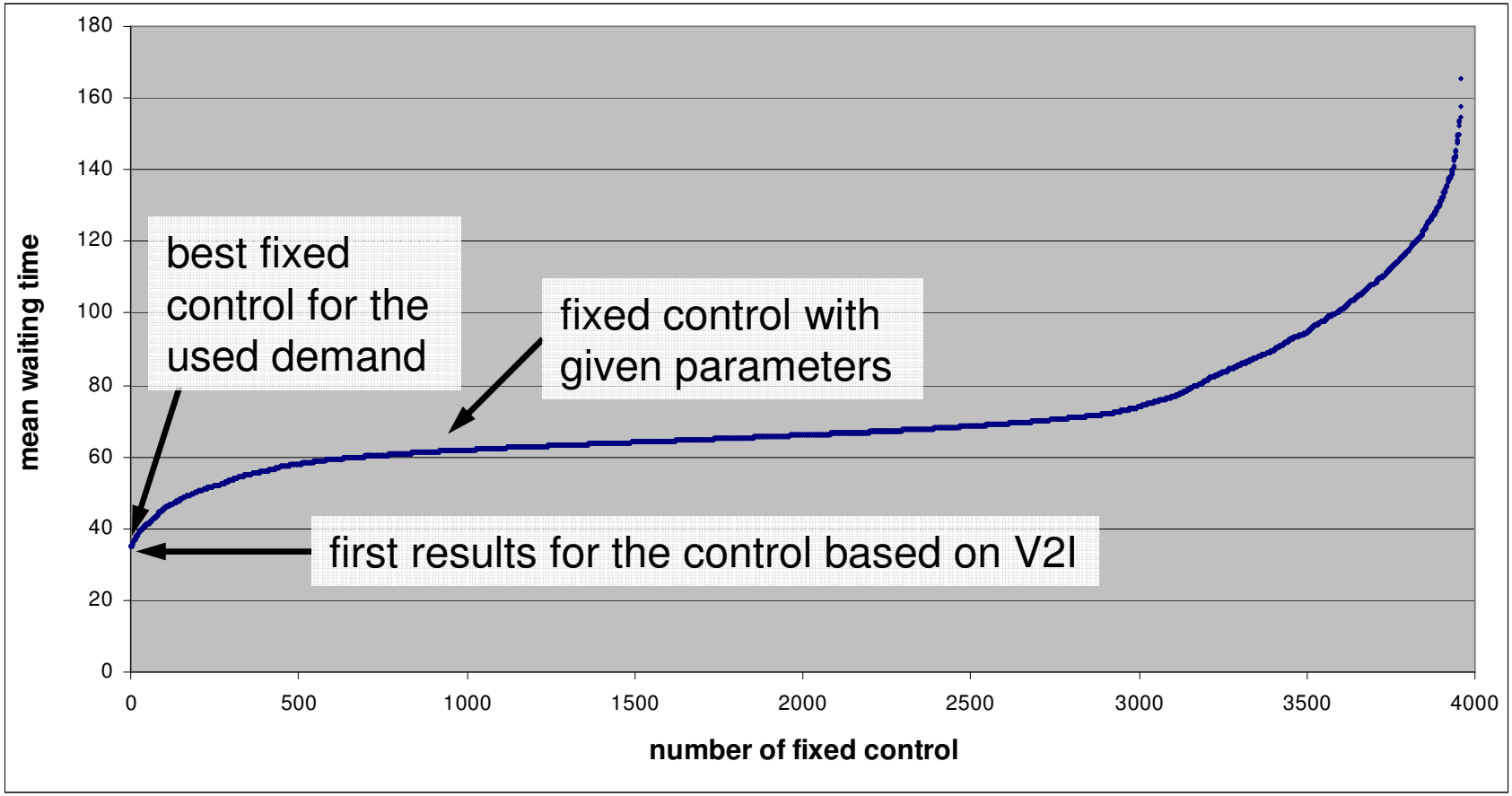
- Vehicle (re)routing, traffic lights, ADAS
  - Justification: open the traffic simulation for allowing the simulation of traffic management strategies based on these functionalities
- Common problem:
  - Many different algorithms, approaches, paradigms, methods
  - → Hardly possible to implement them all
- Common solution: interfaces to external applications
  - Allow to access and change the state of simulated objects for example traffic light states, or vehicles
  - → Clean simulation, no overhead

Example: junction n. 273, “Irma Bandiera – XXI Aprile”



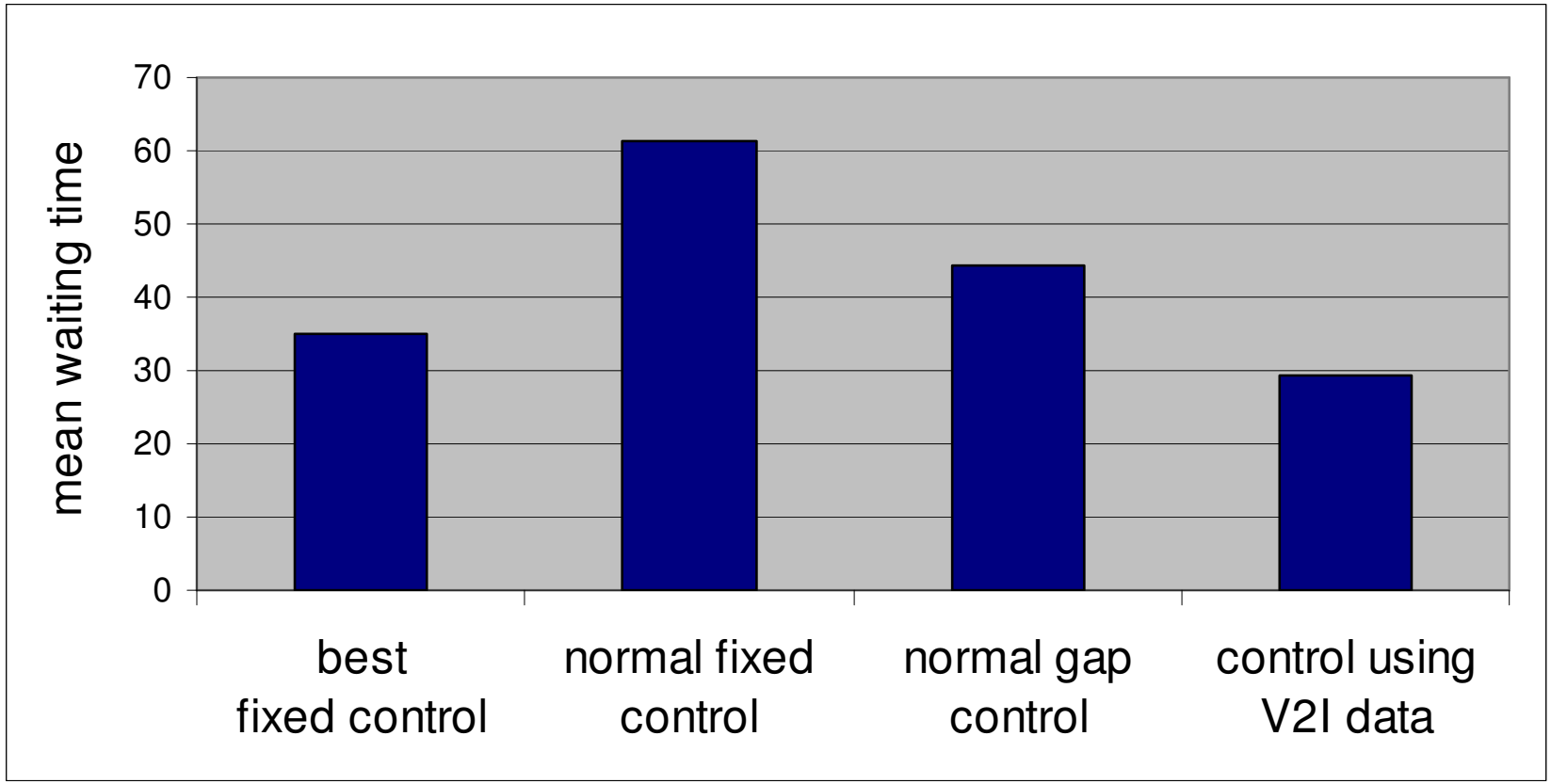
First results:

Control based on V2I-data compared to fixed controls



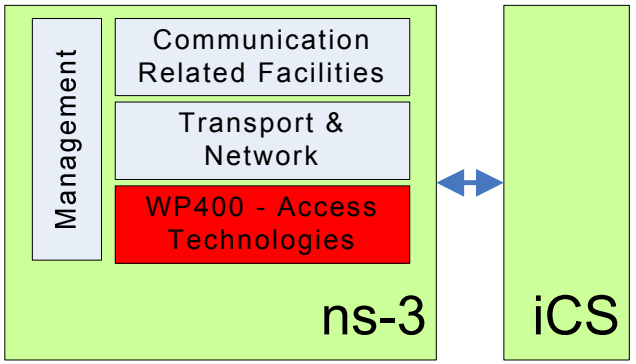
First results:

Mean waiting time for different control strategies



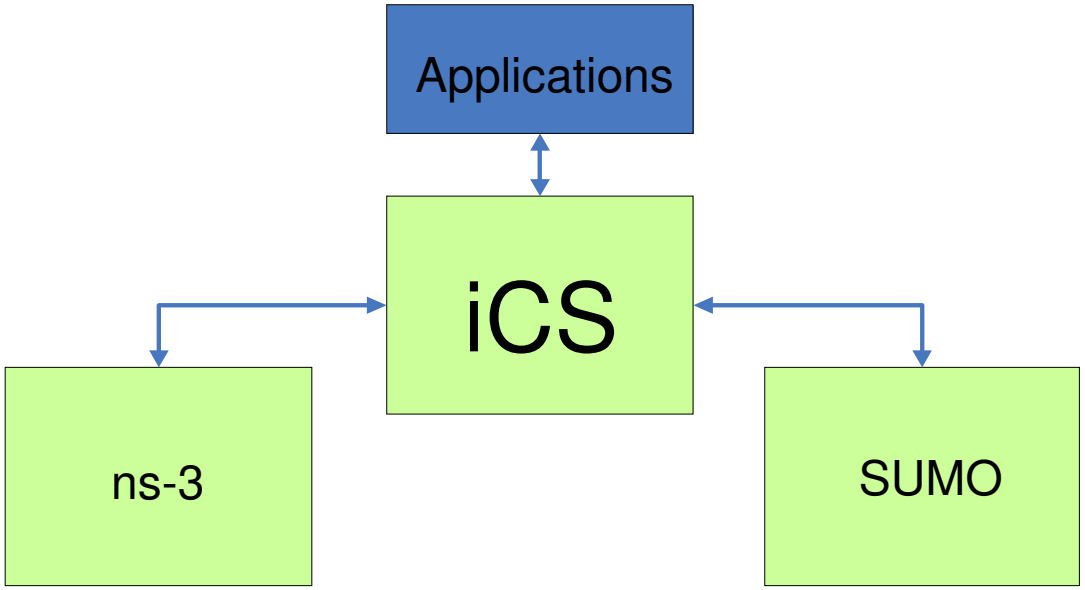
WP400 – Wireless Communication

- Subtasks:
  - 802.11p wireless modeling
  - V2I 3G wireless modeling
  - V2I WiMAX wireless modeling
  - V2I DVB wireless modeling

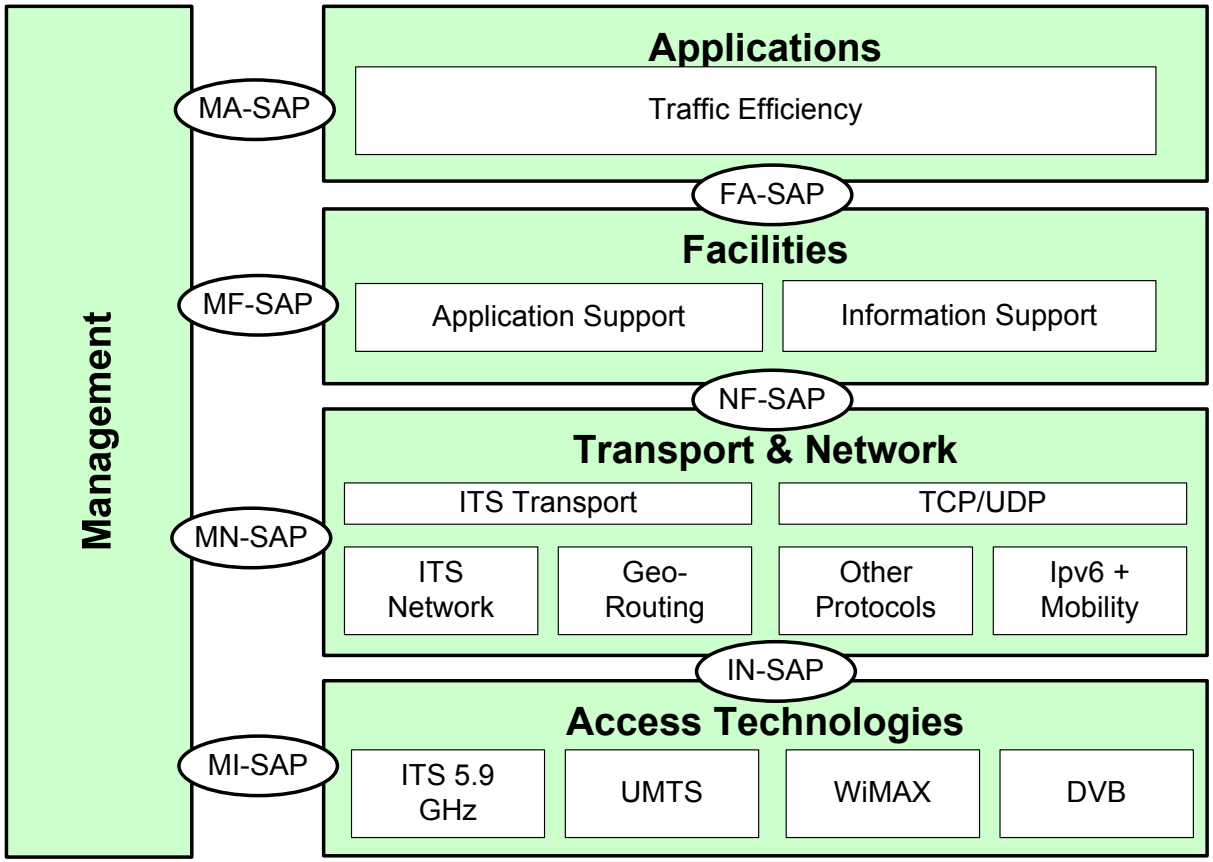


- Innovation:
  - Comprehensive 802.11p V2V communication modeling
  - Heterogeneous wireless modeling to research on advanced V2I and V2V combined strategies
  - Inclusion of accurate V2V and V2I radio channel models
  - Inclusion of the radio propagation effects through link-level simulations

- 3-block architecture + applications
  - Design and modularity overtakes performance
- iTETRIS Control System (ICS)
  - Synchronises the platforms in time and space



- ETSI ITS compliant architecture assures the reusability and the prevents isolation



Other Packages

- WP600: Routing and data distribution strategies
  - Efficient and realistic information dissemination strategies
  - Cooperative detection of traffic information
  - Networking simulation platform
  - Testing of networking platform in a large scale VANET
  - Testing of information dissemination efficiency
- WP700: Integration of V2V and V2I communication capabilities
  - Road side deployment scenarios
  - Infrastructure networking and applications
  - Infrastructure impact with gradual V2V implementation
  - Disruption tolerant network solutions