# iTETRIS: the Framework for Large-Scale Research on the Impact of Cooperative Wireless Vehicular Communications Systems in Traffic Efficiency

**Javier GOZALVEZ[1], Siebe TURKSMA[2], Lin LAN[3], Oscar LAZARO[4], Fabio CARTOLANO[5], Eric ROBERT[6], Daniel KRAJZEWICZ[7], Ramon BAUZA[1], Fethi FILALI[8], Matthias RÖCKL[7], Jeremie LEGUAY[6], Carlo MICHELACCI[5], Jaap VREESWIJK[2], Julen MANEROS[9], Ainara GONZALEZ[4], Massimiliano LENARDI[3]**

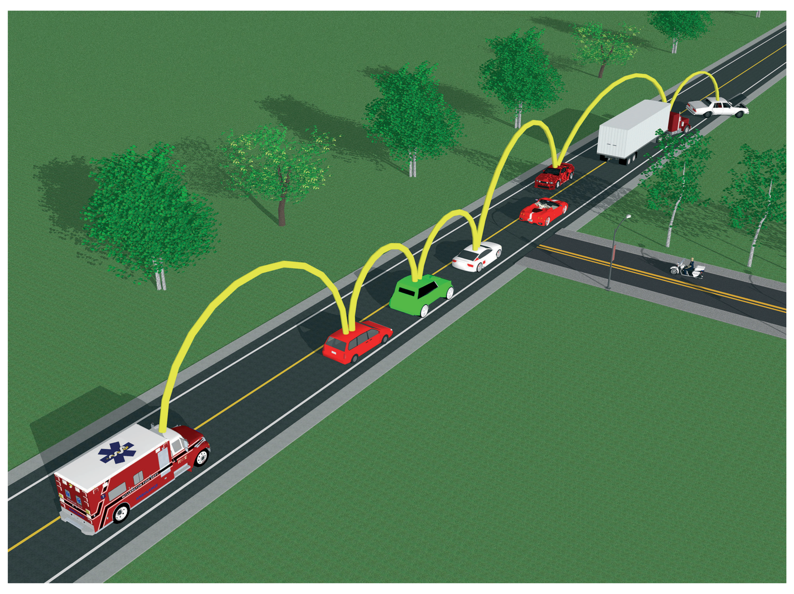
[1]Uwicore, University Miguel Hernández of Elche, Spain [2]Peek Traffic, Netherlands [3]Hitachi Europe, France [4]Innovalia Association, Spain [5]Municipality of Bologna, Italy [6]Thales Communications, France [7]DLR, Germany [8]Eurecom, France [9]CBT, Spain

Cooperative vehicular ICT systems have been identified as an attractive technology to improve traffic management and safety, while providing Internet on the move. To ensure the efficiency of cooperative vehicular ICT systems, it is crucial that the communication protocols are adequately designed and optimized, and that the applications using such communication capabilities are tested under realistic conditions. In this context, this work presents the EU-funded FP7 iTETRIS platform that is being created to allow for a realistic and accurate evaluation of the design and impact of cooperative vehicular communication systems and traffic management policies under realistic large-scale scenarios.

## 1. Cooperative ICT Systems and the iTETRIS Project

One of the most ambitious European goals to reduce road accidents, traffic congestions and transportation pollution is the development and future deployment of cooperative vehicular ICT systems. Through the use of wireless vehicular communications, cooperative systems will be able to assist the driver through the dynamic exchange of messages between vehicles (Vehicle-to-Vehicle -V2V- communications) and between vehicles and infrastructure (Vehicle-to-Infrastructure -V2I- communications). Such exchange of messages will allow detecting road dangerous situations and road traffic congestion.

Among the set of European cooperative vehicular research activities, the FP7 iTETRIS project (http://ict-itetris.eu/) aims at analyzing the potential of cooperative vehicular technologies to improve road traffic management through V2V and V2I communications and cooperative traffic management policies. To this aim, iTETRIS is working on implementing an open-source integrated wireless and traffic simulation platform that will be able to emulate large-scale traffic scenarios using the city of Bologna as a testbed.

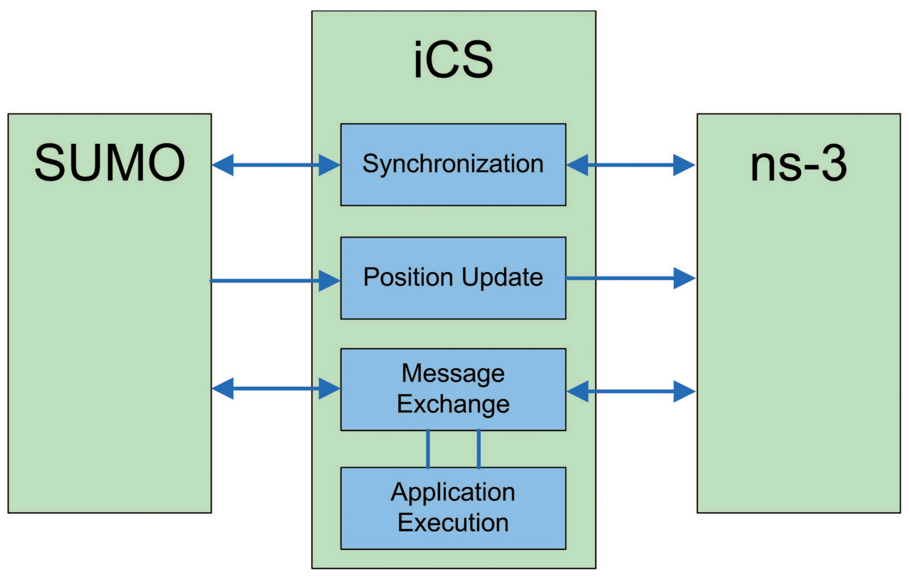


## 2. iTETRIS Simulation Platform

iTETRIS integrates two widely used open source platforms, SUMO (http://sumo.sourceforge.net/) and ns-3 (http://www.nsnam.org/). The software integration is being designed to reduce computational costs, and allow for scalable large-scale accurate simulations.

- **SUMO** is an open-source microscopic platform developed by the German DLR laboratory that emulates traffic movement continuously in space and discretely in time.

- **ns-3** is an open-source wireless communications simulation platform. The adoption of ns-3 over other platforms has been based on its capabilities to perform large-scale simulations and its support for multi-radio/technology nodes.



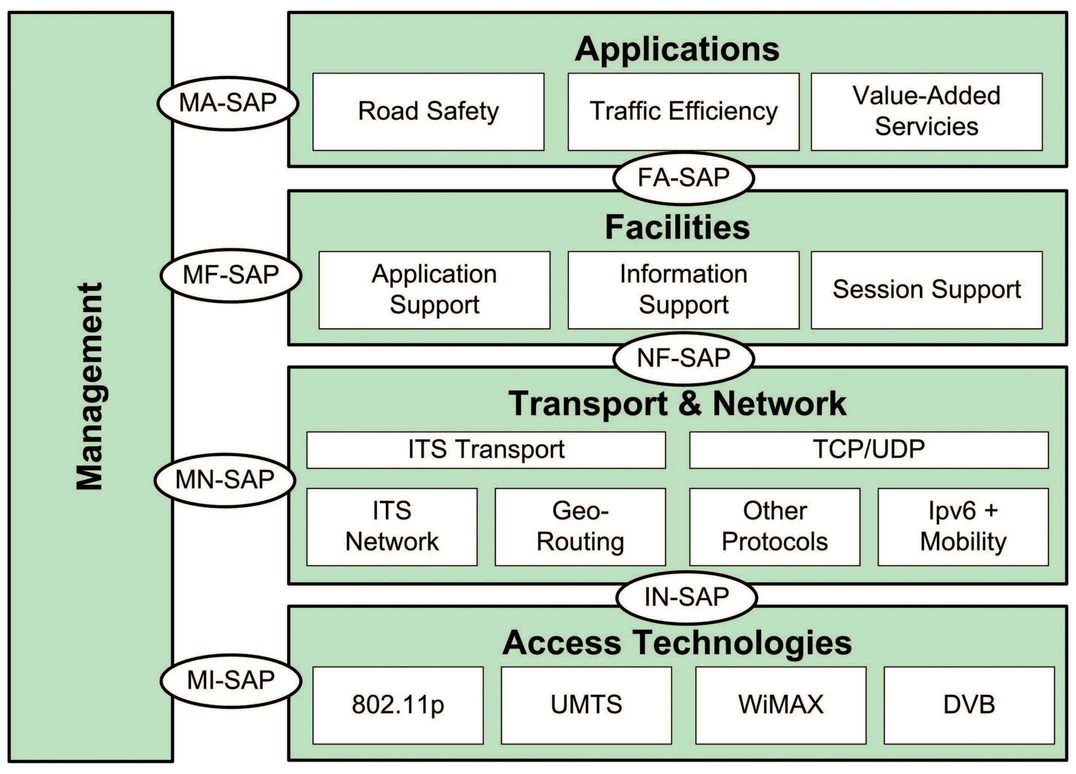

- The **iCS** (iTETRIS Control System) implements and hosts a set of traffic efficiency applications. These applications monitor vehicular traffic conditions through the information provided by SUMO and ns-3, and take accordingly distributed or centralized cooperative traffic management strategies to improve traffic conditions. The iCS also takes care of the synchronization of the whole iTETRIS platform.

## 3. ITS Communications Architecture

To ensure the alignment of the iTETRIS platform with the major international and research standardization efforts, the platform is developed following the recently published baseline European ITS communications architecture.

This architecture has been developed by the European specific support action COMeSafety, as a joint effort with the projects COOPERS, CVIS and SAFESPOT, the Car2Car Communication Consortium, ETSI, IETF and ISO, and also with input from IEEE, CALM and SAE.

The proposed architecture considers three different subsystems (vehicle, roadside and central) that can communicate over a wide range of wireless or wired communication media.

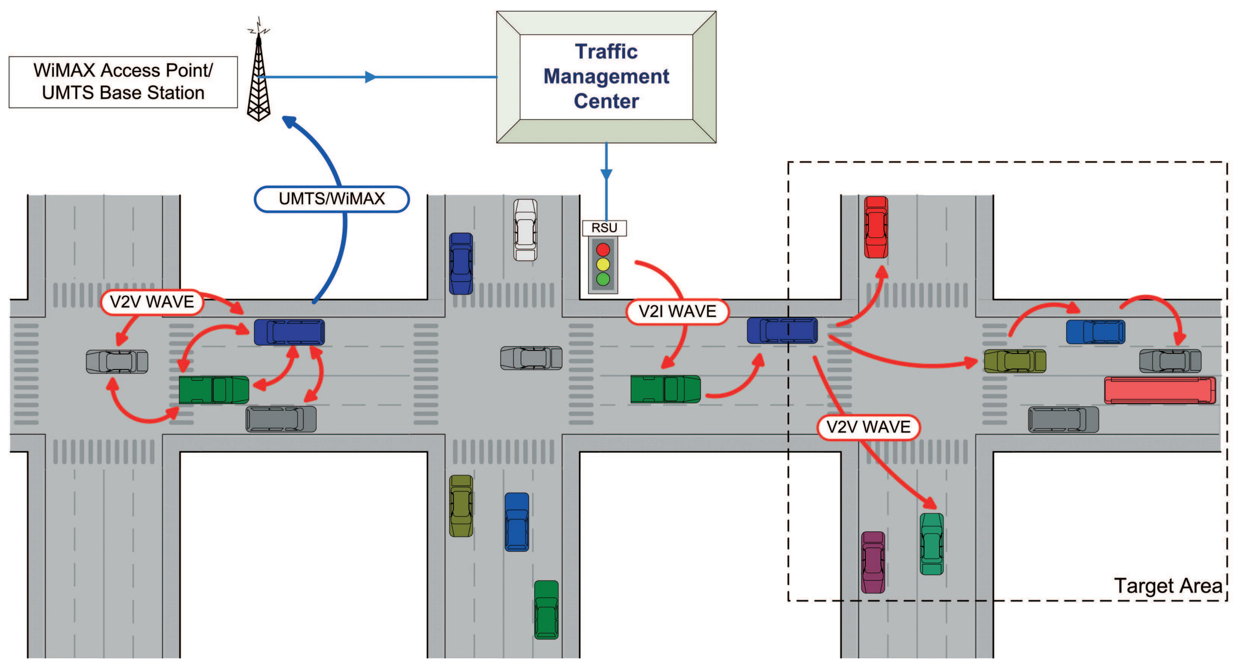



## 4. Cooperative Traffic Management Applications

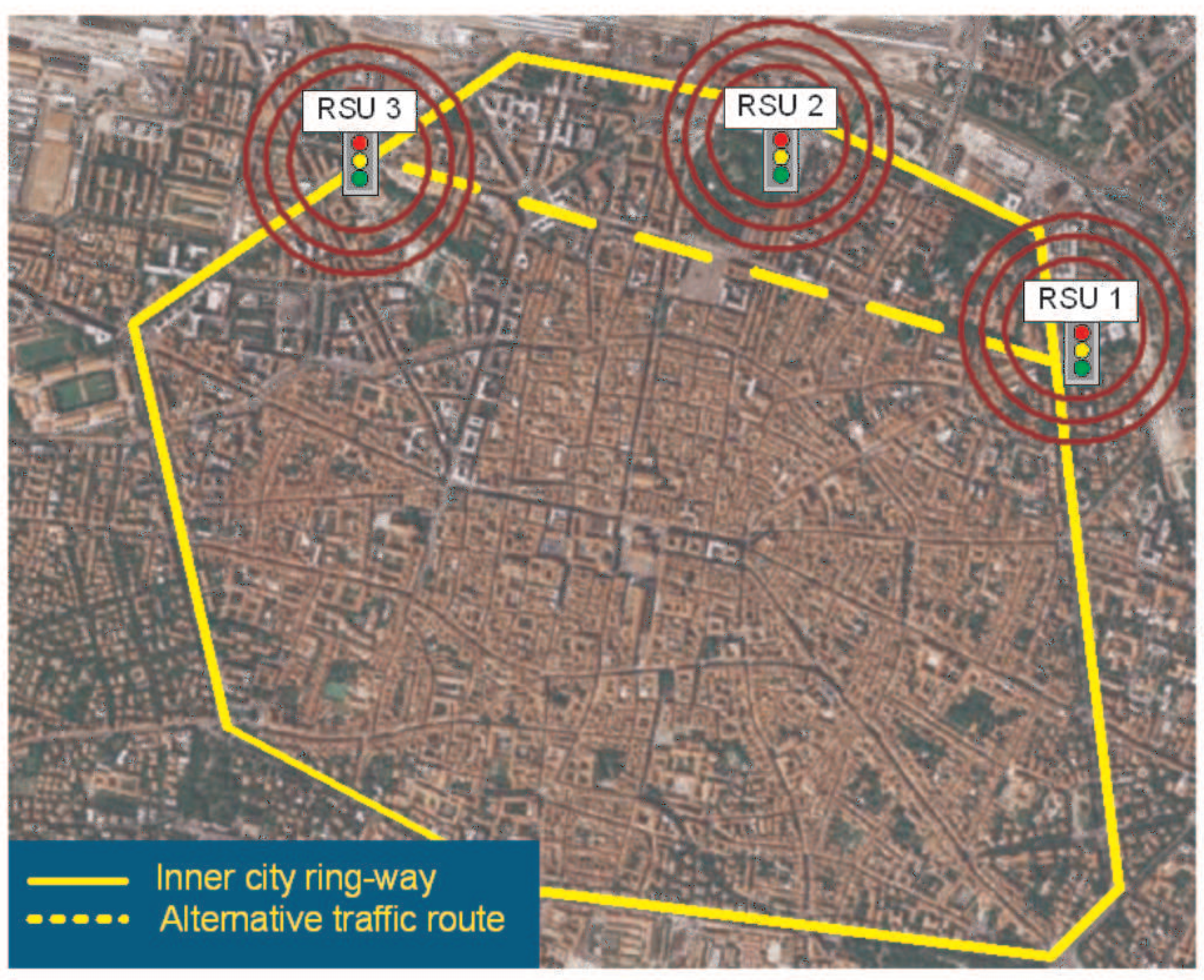
The dynamic exchange of messages between vehicles, and between vehicles and infrastructure, will allow the deployment of new dynamic and intelligent traffic management applications. In this context, iTETRIS has defined a set of use cases and cooperative traffic management strategies, that include among others:

- **Traffic conditions estimation:** The V2I communications capability could complement current traffic flow detection solutions by, for example, providing more accurate turning ratio information. This improved traffic estimation would allow increasing the capacity of intersections by better adjusting traffic light timings. In addition, the information received through cooperative vehicular communications could also help identifying malfunctioning loop detectors. Finally, the vehicles' capacity to dynamically communicate with each other and exchange position and movement information, can also provide the means to detect current traffic conditions without the need to further deploy any additional traffic detectors such as video cameras or inductive loops.

- **Traffic re-routing and flow optimization:** The use of cooperative V2X communications can also allow re-routing vehicles based on current traffic congestion levels. Providing alternative routes to drivers can be achieved through V2I communications or directly through geo-routing protocols using V2V communications in case no communications infrastructure is available. In addition, it is important to note that the use of V2I communications provides the capability to propose alternative routes to only a subset of vehicles, for example less pollutant vehicles, in comparison to Variable Message Sign (VMS) panels.




## 5. Case Study: City of Bologna




To develop and test the cooperative vehicular communications and traffic management applications, the Italian city of Bologna was selected as case study for iTETRIS given its medium-size, traffic problems, and strong support for the use of ICT technologies to improve traffic management.

Various traffic scenarios are being characterized and parameterized through the Bologna traffic database for their accurate reproduction in the iTETRIS platform (Inner city, inner city ring-way, and highway and orbital road).

One of the use cases to consider in iTETRIS is related to travel times monitoring. The figure shows a scenario in which:

- A roadside unit (RSU) is deployed at every major intersection.
- RSUs gathers traffic information provided by passing vehicles.
- Each RSU communicates with the traffic management center (TMC).
- The TMC has a thorough and up-to-date knowledge of the current traffic conditions.
- Upon detecting a traffic congestion, the TMC may recommend vehicles alternative routes through V2X communications.

## 6. Use Cases

iTETRIS is defining a set of use cases aimed at demonstrating the impact of cooperative vehicular systems on traffic management. The iTETRIS use cases are:

UC1 Distributed traffic jam detection
UC2 Centralized travel time estimation
UC3 Bus lane management
UC4 Limited access warning
UC5 Request based personalized navigation
UC6 Regulatory and contextual speed limit information
UC7 Emergency vehicle priorization

## Acknowledgements

This work has been partly funded by the European Commission through FP7 ICT Project iTETRIS: An Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions (No. FP7 224644). The authors wish to acknowledge the Commission for their support.