



2333-14

Workshop on Science Applications of GNSS in Developing Countries (11-27 April), followed by the: Seminar on Development and Use of the Ionospheric NeQuick Model (30 April-1 May)

11 April - 1 May, 2012

EGNOS Use in Road Applications

DI FAZIO Antonella
*Telespazio S. p. A.
Via Tiburtina 965
00156 Rome
ITALY*



EGNOS Use in Road Applications

GNSS Scientific Applications

Workshop on Science Applications of GNSS
in Developing Countries
Trieste, 18 April 2012

EGNOS services for road applications

Galileo services

Use cases

The technical European standard

Outlook and perspectives

EGNOS services for road applications

Services	Open	Free to air; mass market; better than GPS	
	Commercial	High accuracy; encrypted; professional market	
	Safety of Life	Integrity and authentication of the signal	

operational

pre-operational

operational






EGNOS services for land and mobility applications:

EGNOS OS (from SiS)

EGNOS CS (from EDAS)

*The majority of the receivers available on the market (mass-market and automotive chipsets) is EGNOS-ready
(labelled “GPS/EGNOS-enabled” or “GPS/SBAS-enabled”)*

Galileo services

Open Access	Free to air; Mass market; Simple positioning	
Commercial	Encrypted; High accuracy; Guaranteed service	
Safety of Life	Open Service + Integrity and Authentication of signal	
Public Regulated	Encrypted; Integrity; Continuous availability	
Search and Rescue	Near real-time; Precise; Return link feasible	

Galileo will provide highly accurate, guaranteed positioning services.

Galileo will also give the ability to authenticate the origin of the signal.

The GNSS receiver market is providing new-generation chipsets capable to receive signals from different constellation, for example GLONASS and early Galileo satellites in addition to GPS and SBAS/WAAS.

EGNOS OS for road applications

EGNOS OS added value wrt GPS alone

- free to users from the satellites' open signal
- enhanced GPS position accuracy *by approx. 3 metres*



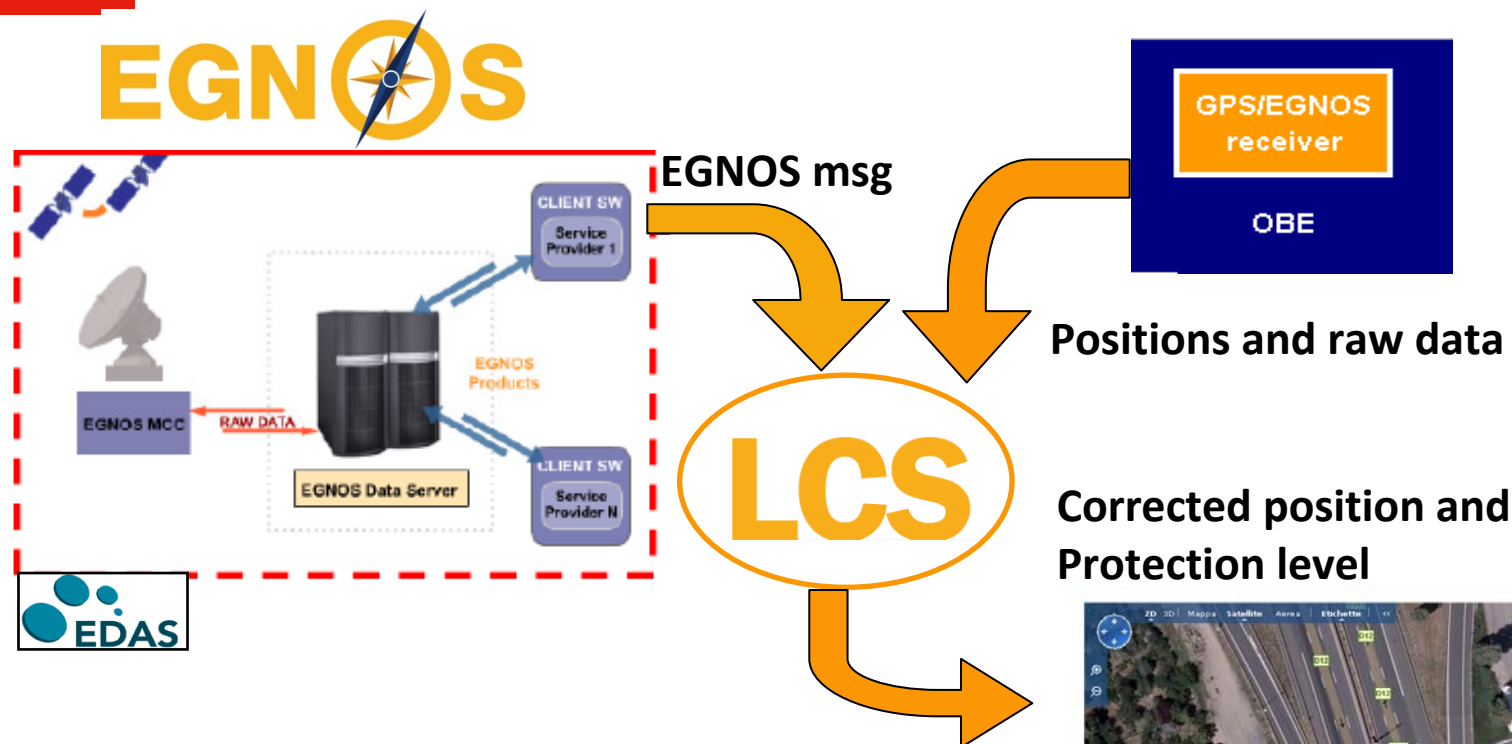
GPS

GPS + EGNOS

static tests conducted by eni



EGNOS CS for road applications (1/2)



EGNOS CS added value

- controlled access, distributed by EDAS via terrestrial networks
- enabling to augment the performances of the EGNOS OS through EGNOS CS/EDAS based solutions (e.g. the LCS)



EGNOS CS for road applications (2/2)

EGNOS CS added value wrt GPS alone (through the LCS)

- improves the availability of the EGNOS OS
- (wrt EGNOS OS) further enhances GPS position accuracy *by approx. 4 metres*
- processes the EGNOS integrity into the “protection level”, providing the qualification/ confidence in the position information



Use of GPS + EGNOS OS + EGNOS CS & **LCS**

- More accurate latitude and longitude
- Horizontal Protection Level (HPL)/level of confidence/position guarantee

EGNOS CS added value wrt GPS alone:

- Higher accuracy
- Higher availability
- Level of confidence/position guarantee

Dynamic tests (1/9)

**Conducted along extra-urban and urban road networks/ driving environments/
critical and interesting stretches**



Using EGNOS-ready technology available on the market:

- GPS/EGNOS off-the-shelf receivers and antennas
- Commercial device for the automotive markets
- Proven solution EGNOS CS/EDAS enabled

Dynamic tests (2/9)

On-Board Unit (OBU)

Product ready for the automotive market/infomobility applications

Automotive OBU integrating off-the-shelf GPS/EGNOS receivers and antennas with compact dimensions/easy installation



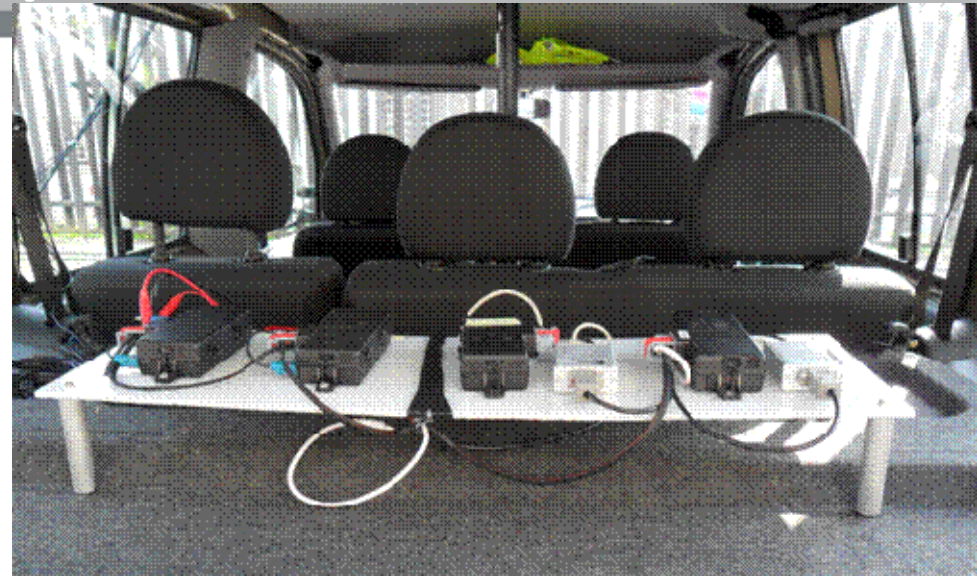
True path measurement:

- A reference trajectory, “*true path*”, was calculated in post-processing, through a kinematic differential GPS method, by using GPS L1 and L2 carrier phase measurements, combined with INS (Inertial Navigation System) measurements.
- The differential GPS L1 and L2 carrier measurements were collected using a reference receiver installed near each test location with an inter-receiver distance not exceeding 20 km. The GPS reference receiver was geo-referenced via a dedicated GPS network solution (based on a continuous/24h at least for two days data collection campaign). A NovAtel FLEXG2-V2-L1L2 has been used as a GPS reference with a NovAtel dual frequency antenna (GPS-702GG).
- An integrated precision GPS/INS system (OxTS * RT2002 dual frequency GPS/INS system) has been used as rover. The combination with INS is aimed at having smooth trajectories free from jumps, even in difficult GPS environments.

* Oxford Technical Solution

Dynamic tests (4/9)

Test configuration



Two identical OBUs, integrating a u-blox5 GPS/EGNOS receiver, one using GPS only and one using GPS+EGNOS (two pairs of OBUs have been used) installed in a test vehicle and connected to a common external GPS antenna



Dynamic tests (5/9)

- Different types of vehicles (commercial light vehicle and car)
- Two types of antenna:
 - a standard patch antenna for automotive applications
 - a Novatel 702-GG L1L2 amplified antenna for professional applications



Dynamic tests (6/9)

GPS/INS IMU for true path



Case: unique antenna



Case: standard antenna

4 T-Box OBUs (2 * GPS, GPS + EGNOS)

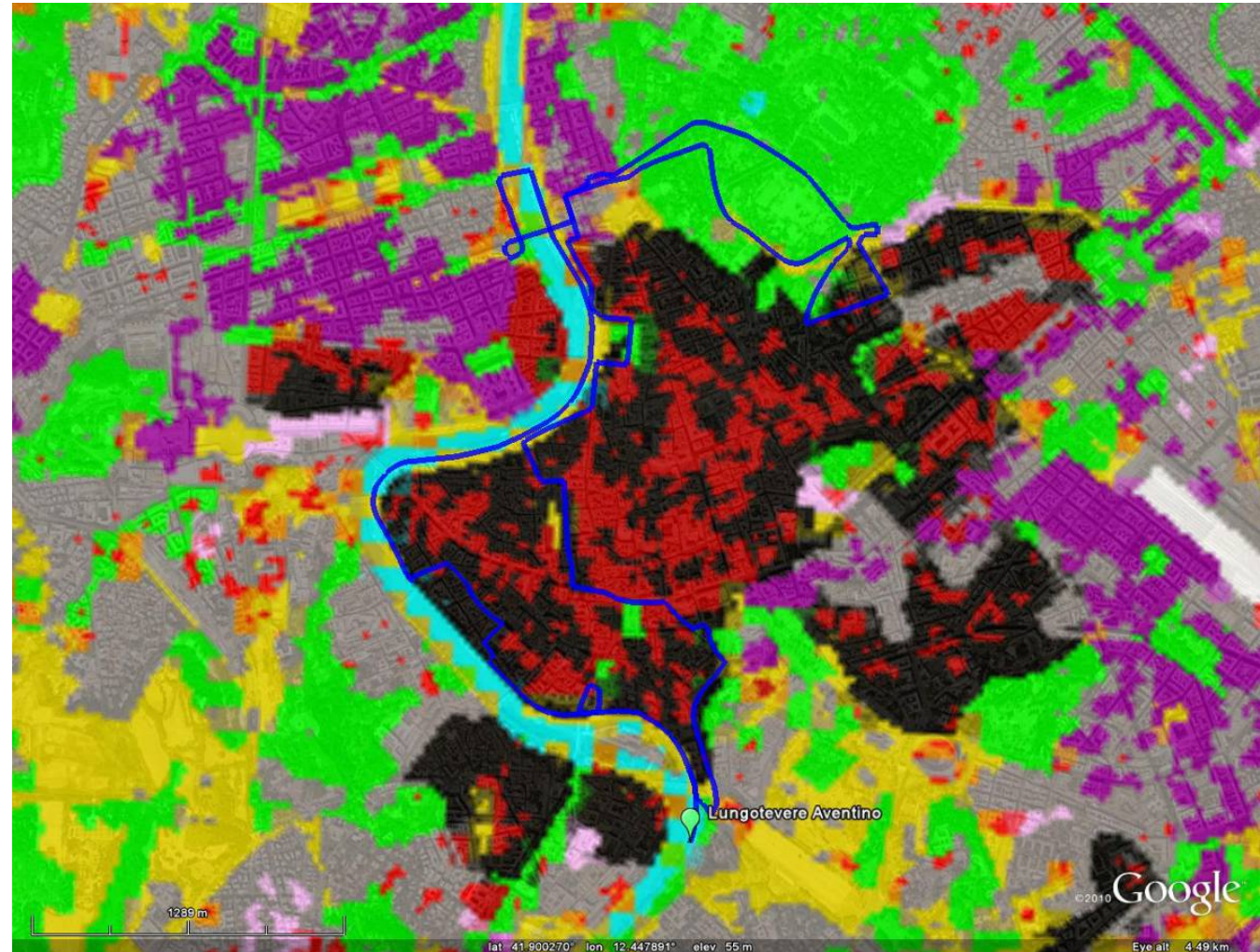


Dynamic tests (7/9)

Five driving environments

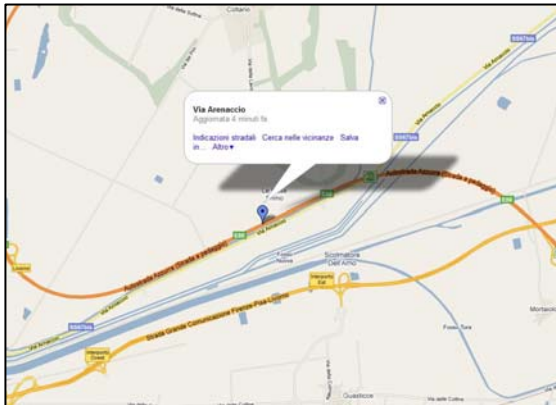
Environment	Description		Speed & Dynamics
	Road Type	Details	
Urban 1	Deep Urban	Roads in downtown core flanked by high-rises	Limited speed. Frequent starts and stops
Urban 2	Urban Thruway	Major Multilane roads with nearly constant 3-4 storey buildings and occasional higher buildings	Medium speed. Mainly free-flowing, occasional traffic jam
Urban 3	Major Urban Roads / Local Roads	Suburban streets. Similar to urban thruways with lower density of buildings.	Medium speed. Frequent starts and stops.
Extra-urban 1	Freeway/ Motorway	Open-sky view and occasional overpass	High speed. Free-flowing, mainly straight
Extra-urban 2	Rural Thruway / Major Extra-urban Roads	Rural road with occasional buildings	Medium speed. Free-flowing and mainly straight

In order to accurately indentify the appropriate driving environment, the trial paths were matched on “*clutter maps*” categorizing the different driving environments (example of a trial path in the city of Rome)

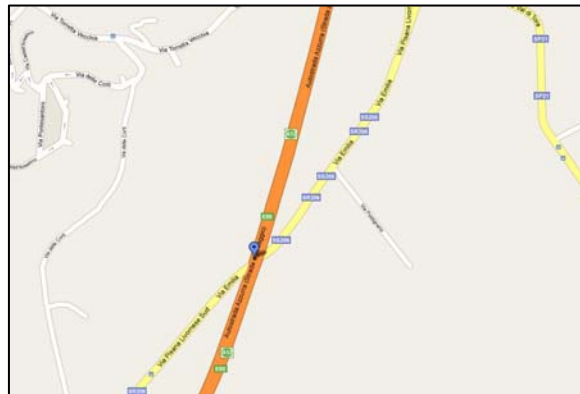


Dynamic test (9/9)

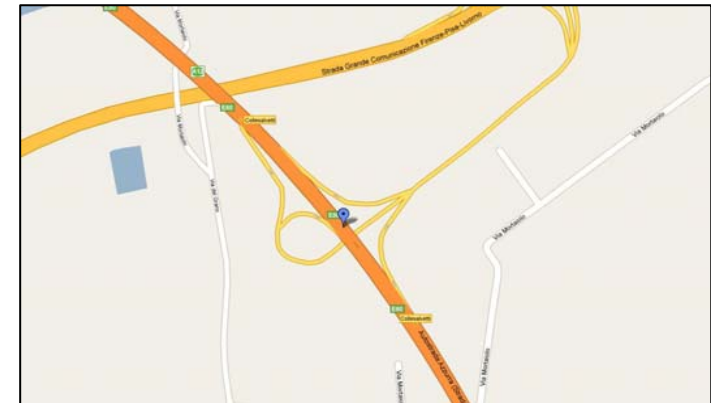
Different critical points and interesting stretches



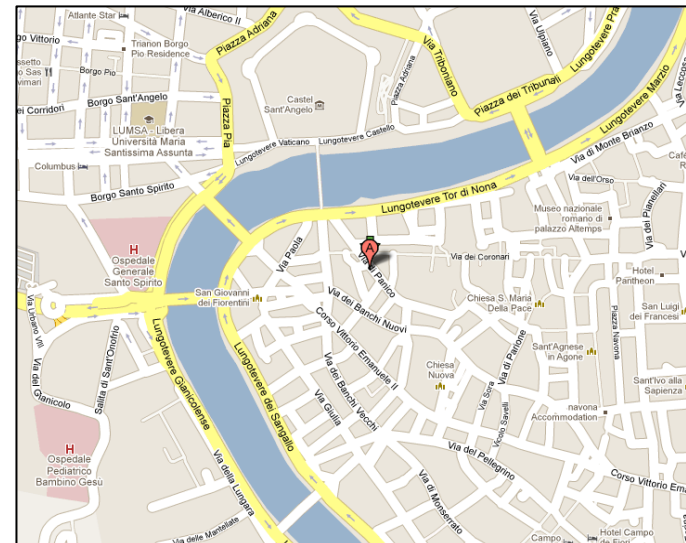
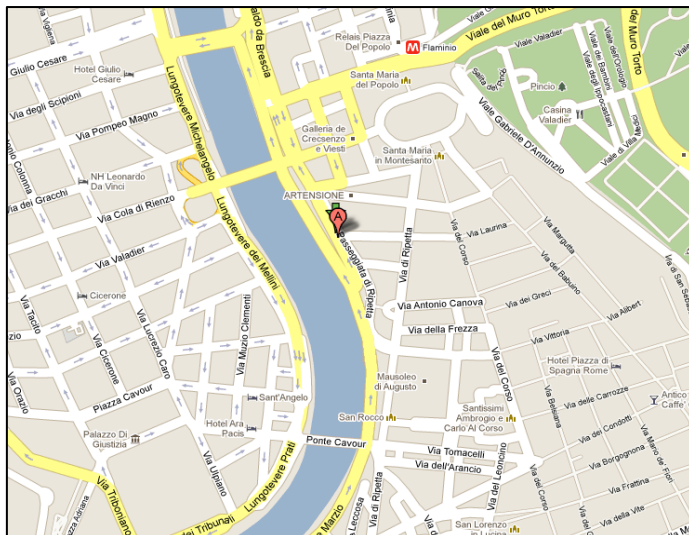
Close/ parallel roads



Intersection



Ramp



LTZ gate

Dynamic test results (1/8)

Performances assessment

Measurements of:

- Horizontal accuracy of the position wrt to a reference trajectory (true path)
- HPL
- Cases GPS vs GPS + EGNOS OS vs GPS + EGNOS CS/ EDAS
- Standard tools for data analysis (e.g. GPSTk, GrafNav, PEGASUS)

Dynamic tests results (2/8)

EGNOS OS enhances position accuracy wrt GPS:

Accuracy improvement wrt GPS ranges from **0,1 m to 3,7 m** (on average, also in case of dense tall buildings/ foliage conditions/ urban roads)

EGNOS CS/EDAS further enhances position accuracy wrt GPS and provides level of guarantee of position/ capability to qualify position data:

- Horizontal accuracy improvement wrt GPS ranges from **0,1 m to 4 m** (on average, also in case of dense tall buildings/ foliage conditions/ urban roads)
- “Protection level”

These results are independent from the type of receivers.

The type of antenna (professional amplified antenna versus standard patch antenna) has some impacts on the position accuracy (measured with GPS and with GPS + EGNOS OS): better performances in the case of the a Novatel 702-GG L1L2 amplified antenna for professional applications.

Dynamic tests results (3/8)

EGNOS OS and EGNOS CS/EDAS key performance values (average) for horizontal accuracy and protection level

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
2,0	1,4	1,1	9,1

EGNOS OS → higher accuracy wrt GPS

GPS (m)	EGNOS OS (m)
1,4	1,0

Extra-urban environments

GPS (m)	EGNOS OS (m)
7,4	3,4

Urban environments

EGNOS CS/EDAS → higher accuracy wrt GPS + qualification/ confidence on the position

EGNOS CS (m)	EGNOS CS HPL (m)
0,9	8,8

Extra-urban environments

EGNOS CS (m)	EGNOS CS HPL (m)
1,8	10,9

Urban environments

Availability
96,91%

Number of positions for EGNOS CS/EDAS processing

Dynamic tests results (4/8)

Higher independence from the GPS/EGNOS receiver technology

GPS/EGNOS receiver 1	GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
	2,0	1,4	1,1	9,1

GPS/EGNOS receiver 2	GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
	3,0	1,9	0,8	8,8

GPS/ EGNOS receivers already implement “EGNOS standard” * customization

EGNOS CS/EDAS services for road require “EGNOS standard” customization (proven technology/ solutions available)

* MOPS

Dynamic tests results (5/8)

Extra-urban - Highway



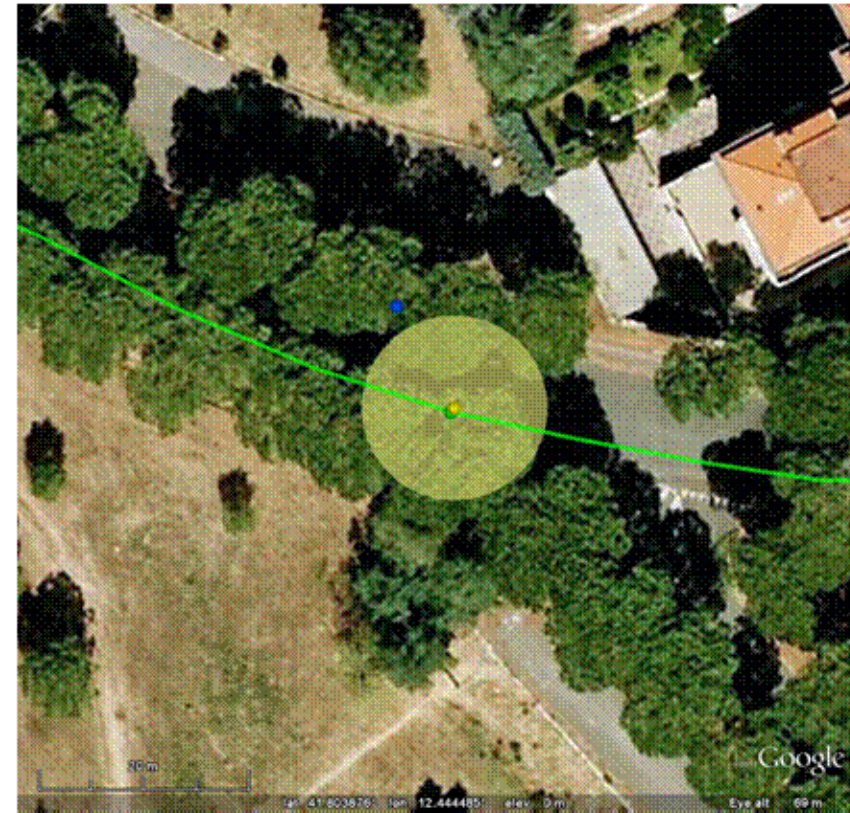
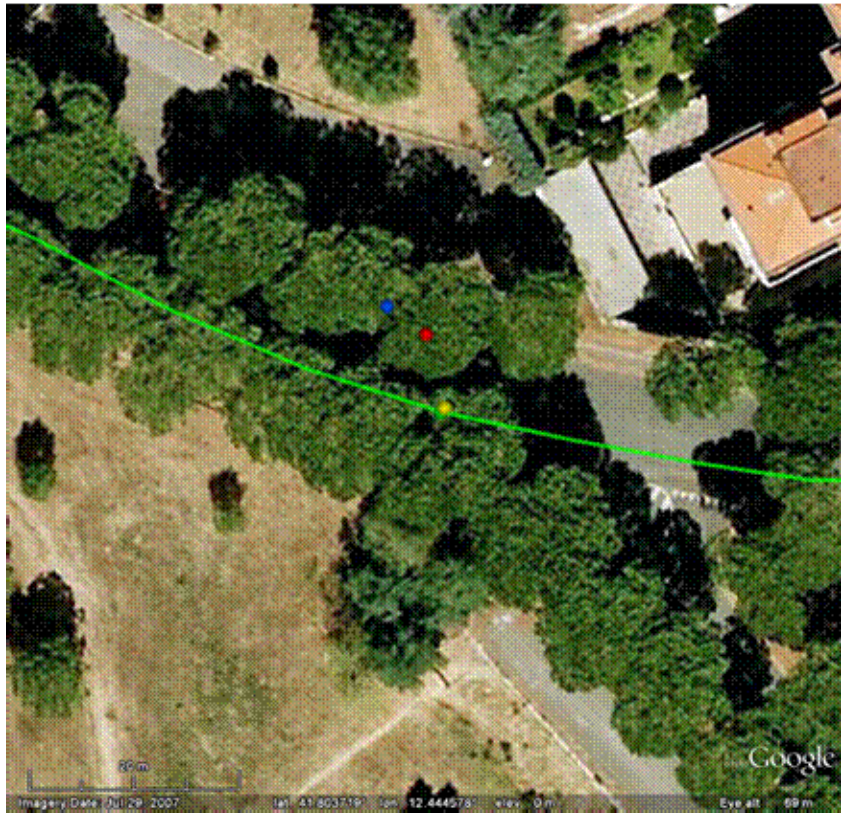
True path ●

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
7,4	3,4	0,9	8,8

HNSE gives the horizontal accuracy of the measured position wrt true position
 HPL gives the confidence on the position/ horizontal coordinate

Dynamic tests results (6/8)

Urban - Trees



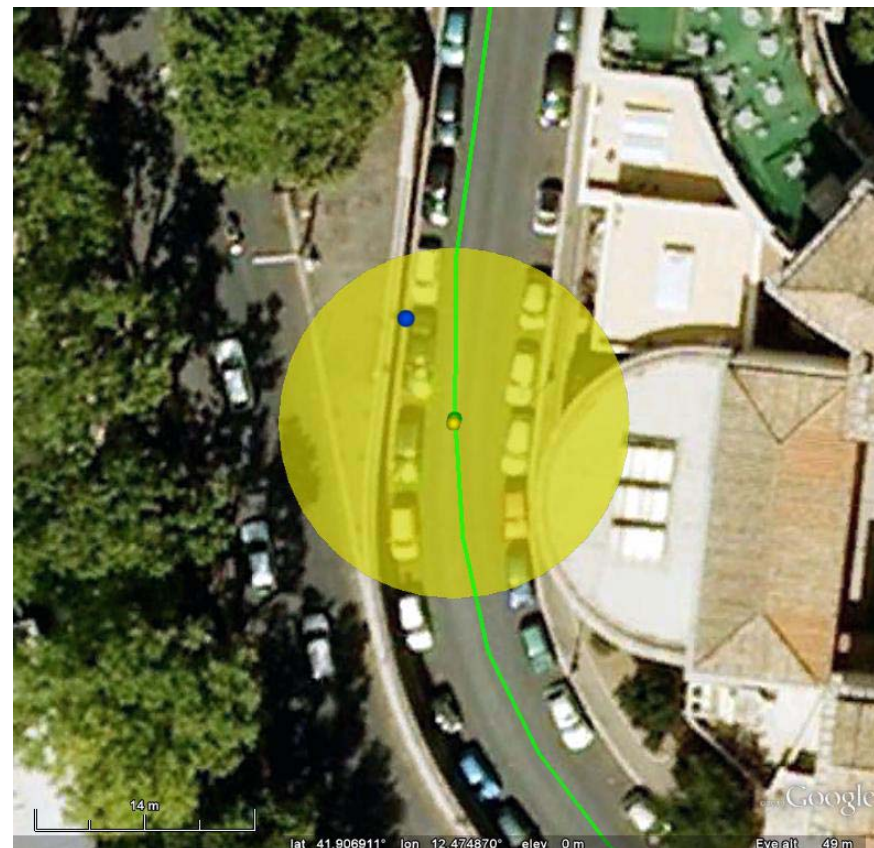
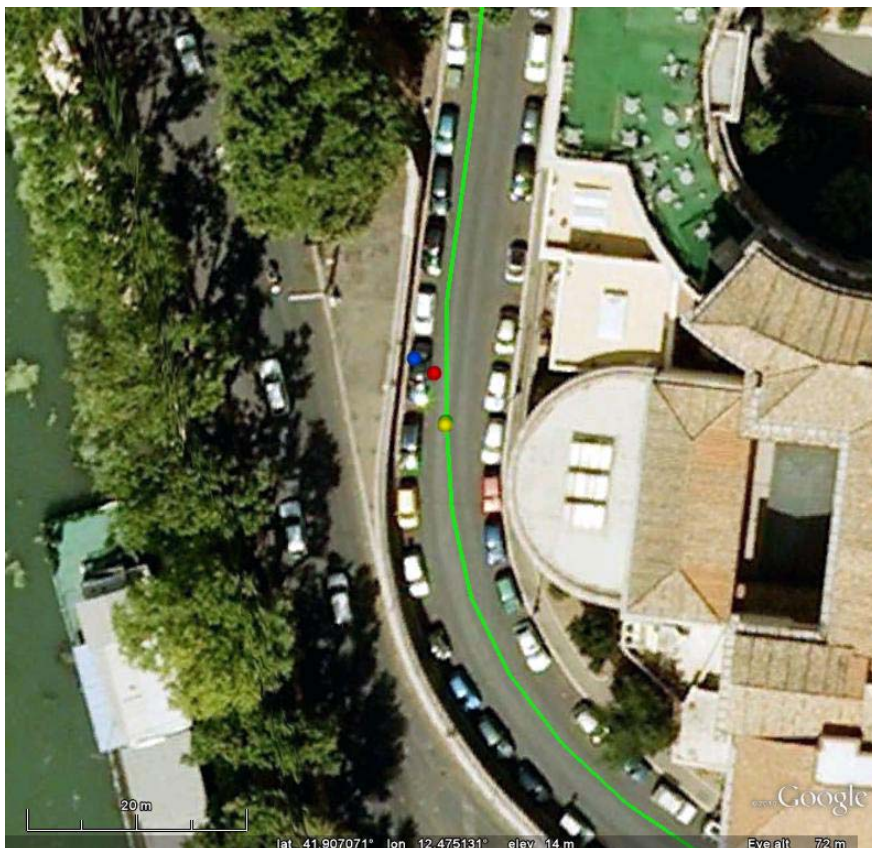
True path ●

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
11,3	7,5	0,5	8,9

HNSE gives the horizontal accuracy of the measured position wrt true position
HPL gives the confidence on the position/ horizontal coordinate

Dynamic tests results (7/8)

Urban - Medium density



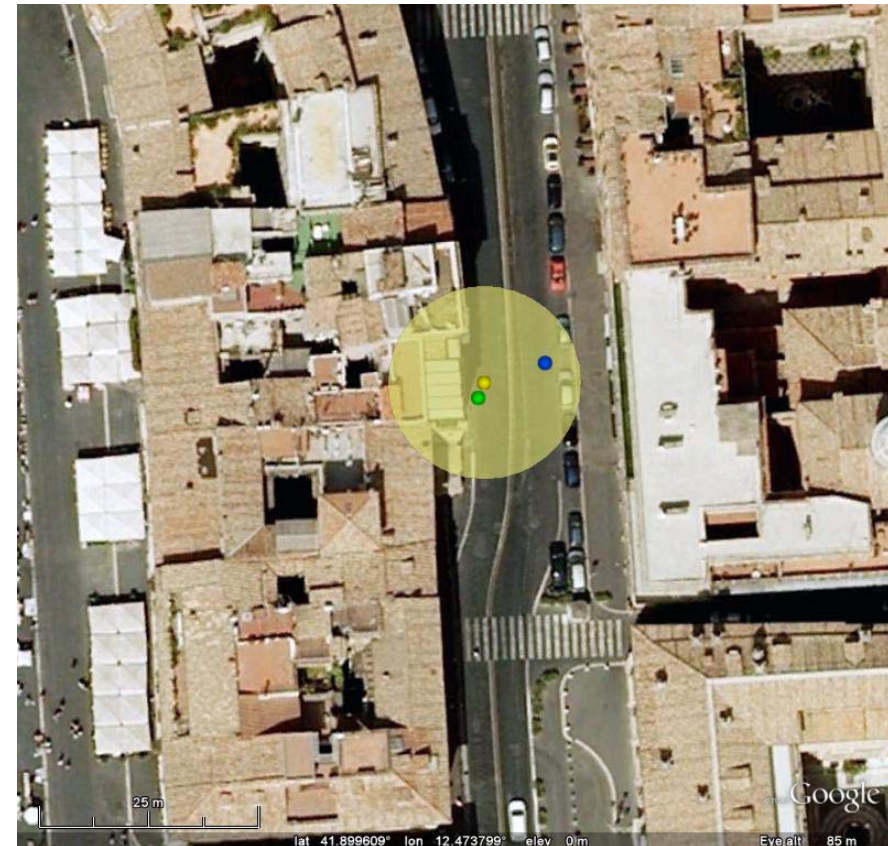
True path ●

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
6,0	4,2	0,3	11,3

HNSE gives the horizontal accuracy of the measured position wrt true position
 HPL gives the confidence on the position/ horizontal coordinate

Dynamic tests results (8/8)

Urban - High density



True path ●

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
8,5	6,0	1,8	10,9

HNSE gives the horizontal accuracy of the measured position wrt true position

HPL gives the confidence on the position/ horizontal coordinate

Use cases

Use in real operations + added value/benefits validation

Use cases in extra-urban road applications - Toll Charger (TC):

- Toll charger/ tracking & tracing of third-party service fleets
- ETC Service provider/ road charging



Use cases in urban road applications - Urban mobility agency:

- City/ Tracking & tracing of touristic coaches
- City/ Tracking & tracing/ monitoring of access/ circulation in LTZ zones
- City/ Tracking & tracing/ monitoring of vehicles for goods delivery
- City/ Tracking & tracing of LTP fleets



Use cases: road charging

TC 1 → road charging

TC 2 → tracking & tracing of third-party service fleets, i.e. the specialised third-party fleets subcontracted by the road operator to perform road maintenance and monitoring operations. The road operator has the need to tracking & trace such operations, for supervision/control and administration purposes. Tracking & tracing is done by means of satellite navigation based devices installed on the service vehicles, data are used to control the subcontract service performance and validate the invoices issued by the third party.

COA → Tourist Coaches Electronic Permit, related to the monitoring of tourist coaches traffic, according to their specific regulation and needs. Presently, this is done on a paper-permit basis, however EGNOS can enable the possible use of GNSS, due to its incapability to provide a guaranteed positioning

LTZ → Limited Traffic Zones, related to the monitoring of vehicles transiting within specific urban areas; this application is not presently feasible with GPS, due to its incapability to provide a guaranteed positioning

LPT → Local Public Transport, related to the monitoring of buses for public transport. This is presently done via a GPS-based AVL/ AVM system, possible monitoring service enhancement/ additional benefits are achievable thanks to EGNOS

GOODS → Goods Delivery, related to the monitoring of vehicles for urban logistics. Presently such application is not possible in Rome, due to the absence of a suitable regulation for freight delivery in the urban areas.

EGNOS OS added value

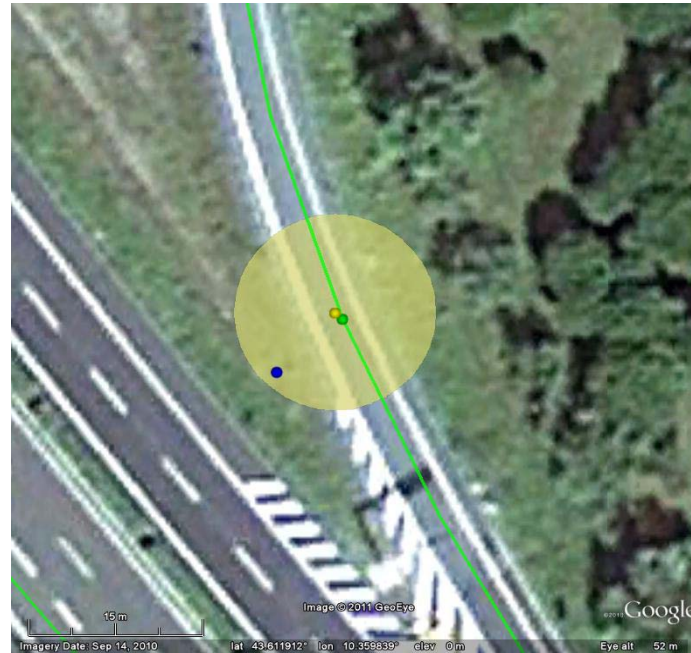
→ enhanced accuracy in the position / capability to give a value for the position nearer to the true position (i.e. minor error in the position measurement)

EGNOS CS/EDAS added value

→ capability to enable the implementation of solution, providing higher availability of the enhanced accuracy (thanks to the distribution of EGNOS data via alternative means wrt SiS) and qualification/ confidence in the position (thanks to the integrity processing)

Quantified benefits depend on the use case

Use cases: EGNOS added value (2/3)



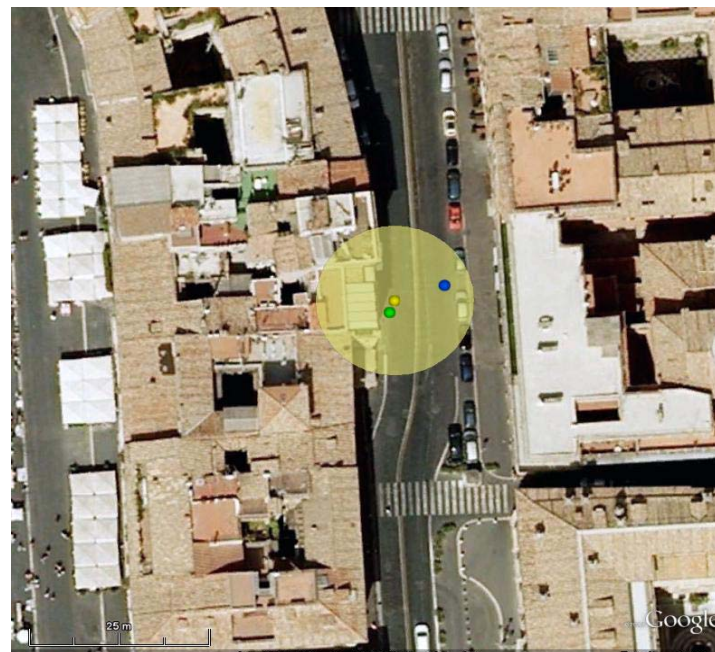
True path ●

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
7,4	3,4	0,9	8,8

Enhanced accuracy and “protection level” provided with EGNOS allow to:

- Distinguish two close/ parallel roads of different networks, typically tolled and not-tolled stretches (e.g. motorway very close and parallel to secondary lane, motorway and secondary lane crossing each other)
- Distinguish the position of the vehicle just after/ before a motorway intersection or ramp near the gates

Use cases: EGNOS added value (3/3)



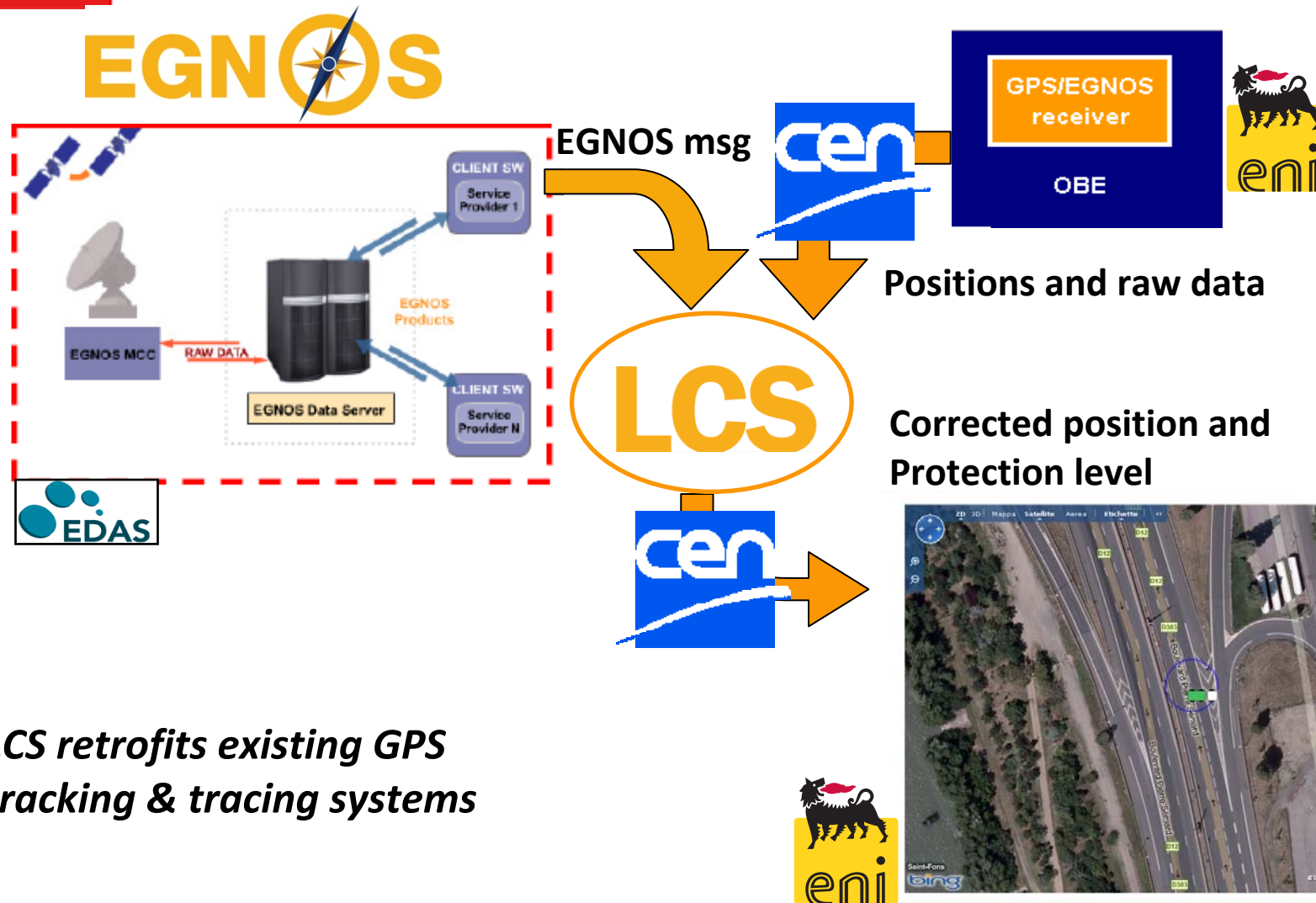
True path ●

GPS (m)	EGNOS OS (m)	EGNOS CS (m)	EGNOS CS HPL (m)
8,5	6,0	1,8	10,9

Enhanced accuracy and “protection level” provided with EGNOS allow to:

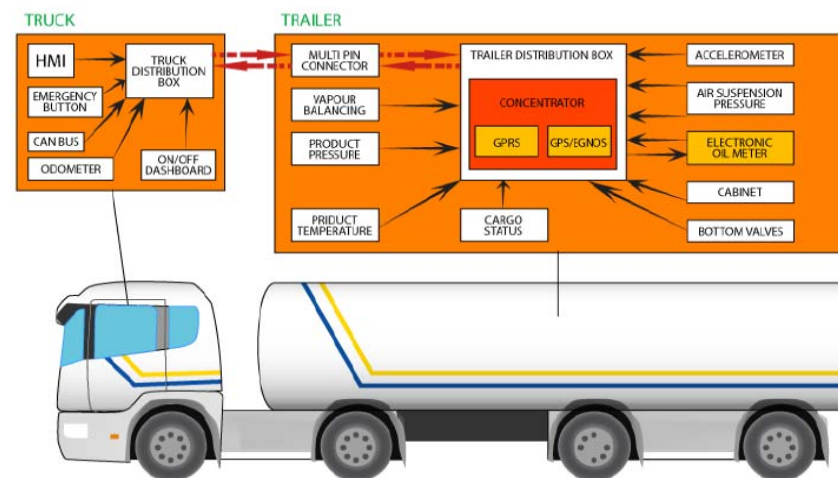
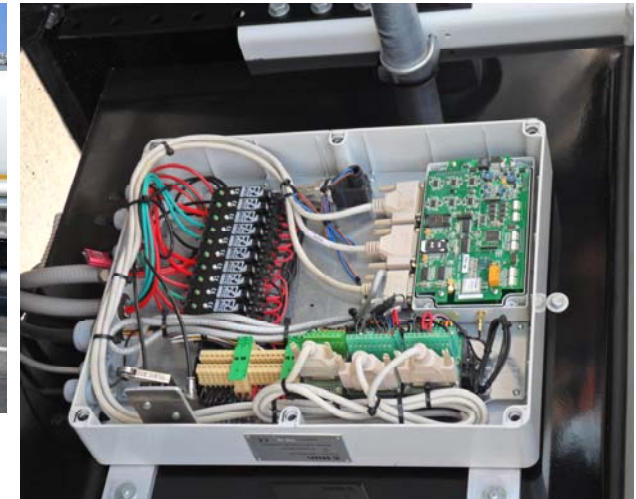
- Distinguish close/ parallel roads in various LTZ areas where different rules/ pricing schemes are applied
- Distinguish roads in dense urban areas inside/ outside the LTZ areas
- Monitor in real-time vehicles itineraries and stops, in line with permits
- Have a reliable positioning of urban regulated fleets

Use cases: tracking & tracing of dangerous goods transport (1/4)



LCS retrofits existing GPS tracking & tracing systems

Use cases: tracking & tracing of dangerous goods transport (2/4)



Two typologies: Baseline and Slim



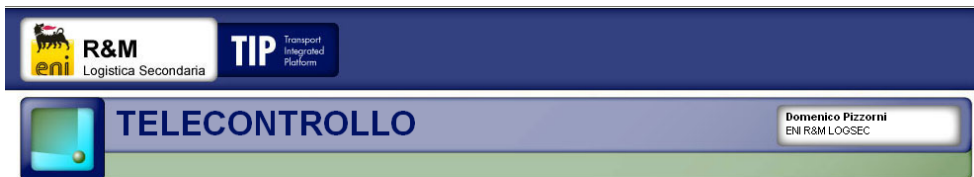
- ✓ EGNOS OS and EGNOS CS (through LCS) used in an operational business case by **eni**, a worldwide Italian oil & energy company
- ✓ Remote monitoring of tankers transporting hydrocarbon and chemical materials:
- ✓ Today about 300 vehicles, in Italy, France, Austria, Slovakia, Hungary, Romania, and Czech Republic
- ✓ By the end of 2012, extending to vehicles in Germany and in Switzerland and to the transport of aviation material
- ✓ Technical standard CEN Workshop Agreement CWA 16390:2012 publicly available



Use cases: tracking & tracing of dangerous goods transport (4/4)

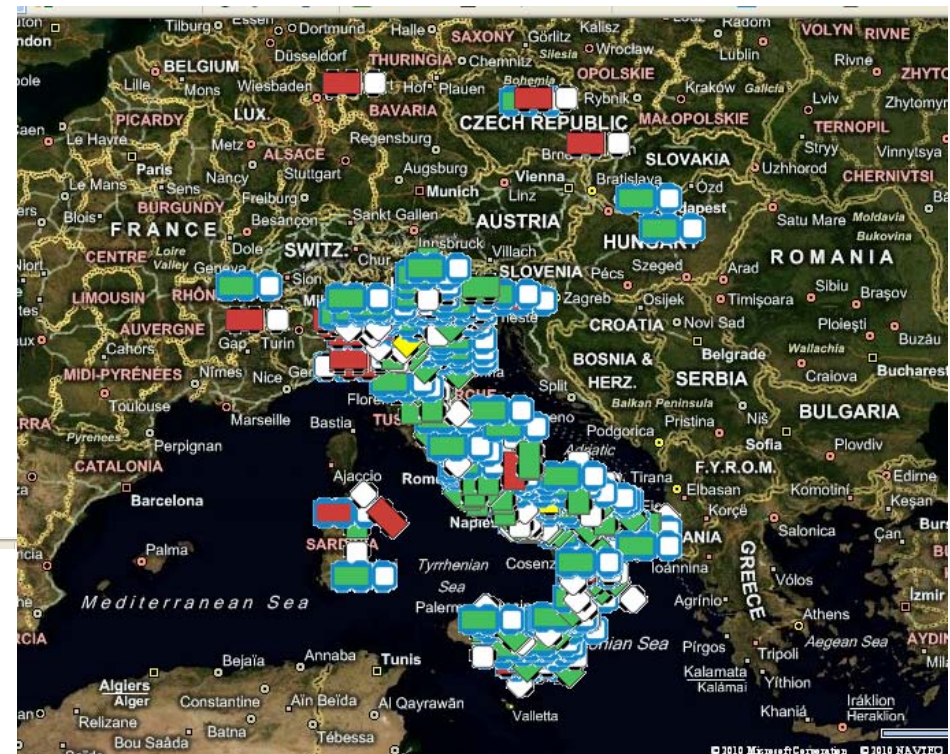
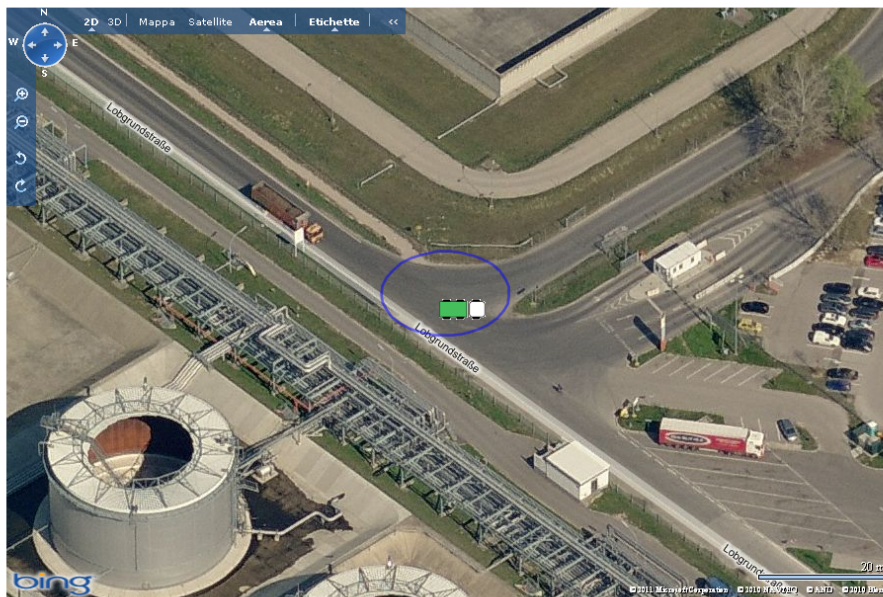


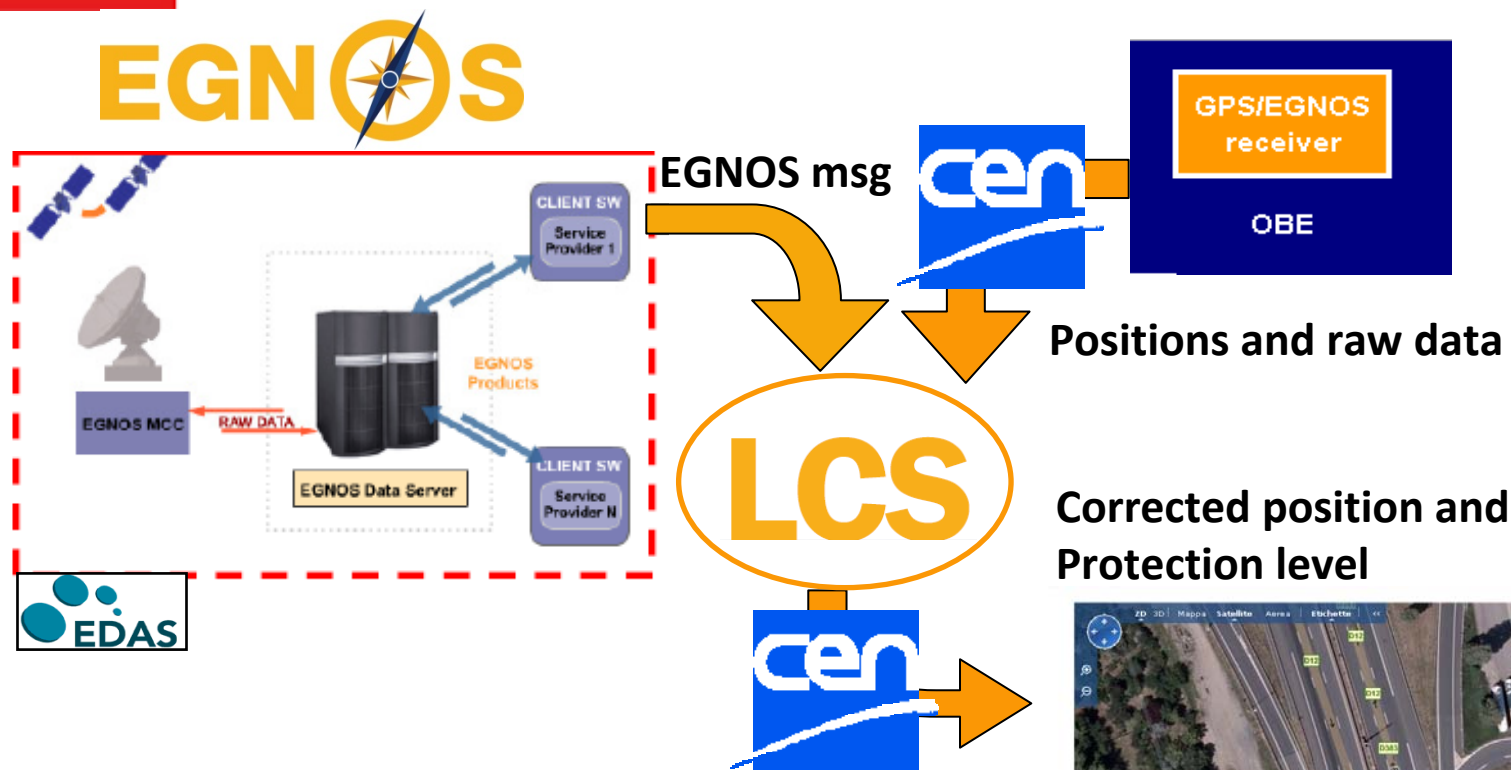
eni benefits from LCS for risk management, safety and commercial purposes



– *Accurate latitude & longitude*

– *HPL*





“Interface control document for provision of EGNOS CS/EDAS based services for tracking and tracing of the transport of goods”

<http://www.cen.eu/cen/Sectors/Sectors/ISSS/Pages/SCUTUM.aspx>



EU technical specification

Endorsed by EU stakeholders from industries, institutions and research sector

Enabling the development of products and applications based on the EGNOS CS/EDAS

Compliant with the guidelines of the UNECE/OTIF WG on telematics for dangerous goods

Applicable to Intelligent Transport Systems (ITS/CALM) and mobility applications (DATEXII and 3GPP/OMA)

–Exploitation in other land transport markets/applications, e.g.:

Freight multimodality (e.g. container transport)

Rail

–Extending European best practices and use cases in Europe's adjacent regions (e.g. area around the Mediterranean basin, as long EGNOS service extension is being implemented).

–Research for multi-constellation environment, Galileo at first. in particular in the future when Galileo satellites can be used in conjunction with GPS, for achieving higher satellite availability in all environments, and thus possibly higher performances.

–Research on use/added value of future Galileo authentication

Thank you

Questions ?

Contacts:

Antonella Di Fazio

antonella.difazio@telespazio.com