

United Nations/Latvia Workshop on the
Applications of Global Navigation Systems
14-18 May 2012

Keynote Presentation:
**Multi-GNSS Opportunities and Challenges to
GNSS-enabling Technologies and their
Applications**

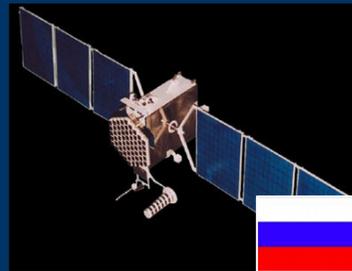
Vidal Ashkenazi
CEO, Nottingham Scientific Ltd

Global SatNav Systems (GNSS)

▶ GPS



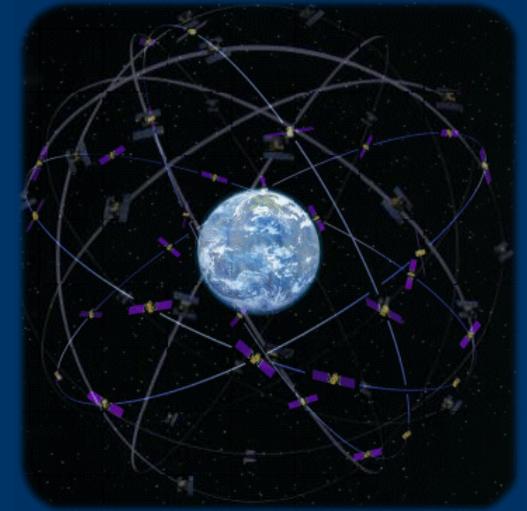
▶ Glonass



▶ Galileo

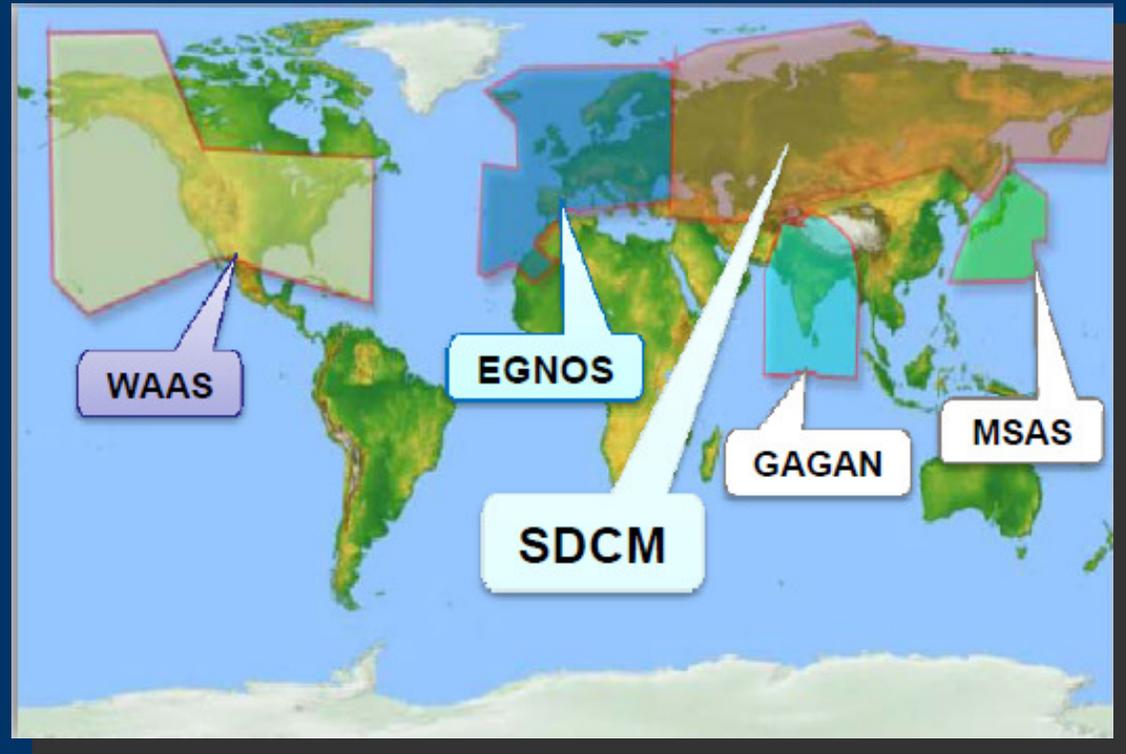


▶ Beidou Compass



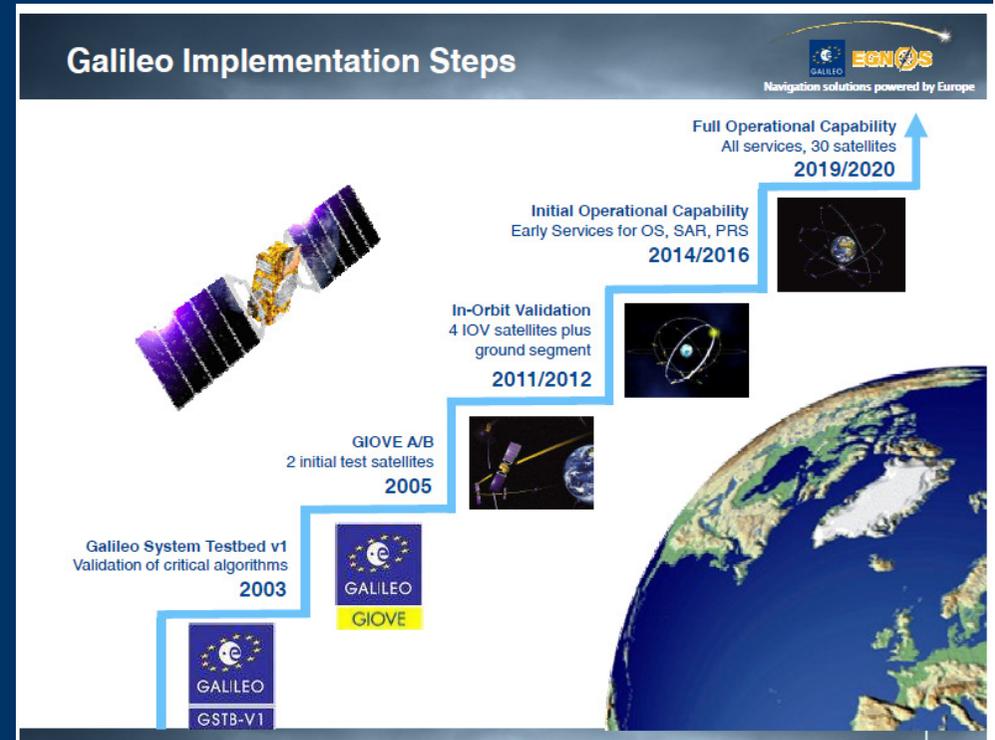
Regional Augmentation Systems

- ▶ WAAS
- ▶ EGNOS
- ▶ SDCM
- ▶ Japanese
- ▶ Indian
- ▶ Others in the Future



Galileo: Present and Future

- ▶ Concept and Reasoning
- ▶ Edinburgh 2001: Withdrawal of SA
- ▶ Difficulties with the US**
- ▶ Compatibility and Interoperability
- ▶ IOV: 2 launched/2 in 2014
- ▶ IOC: ~2014-2015 (14 more)
- ▶ FOC: ~2020 (30)



Interagency GPS Executive Board

Washington DC

February 28, 2002

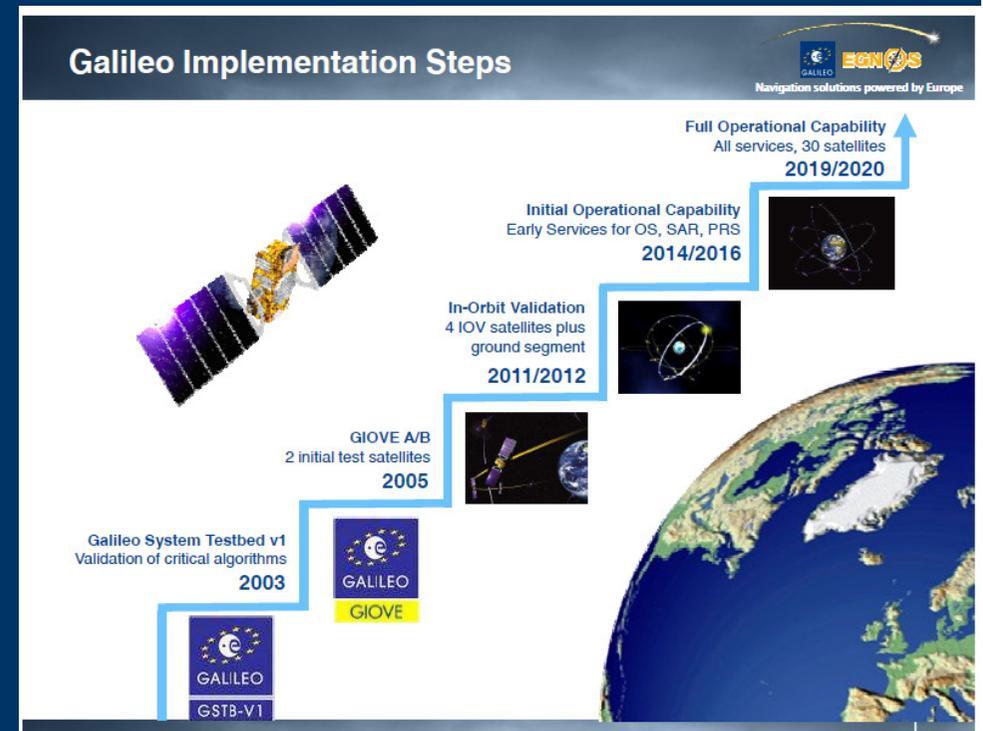
Galileo: Friend or Foe ?

Vidal Ashkenazi

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Galileo: Present and Future

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GPS Navigation and Positioning

Current Popular Applications

- ▶ Car Navigation (GIS)
- ▶ Bus Timetables
- ▶ Train Timetables
- ▶ Fleet Monitoring



Current Popular Applications

- ▶ Average Accuracy ($\sim 5m$)
- ▶ Non-critical ($< 95\%$ accuracy correctness)
- ▶ No integrity Requirements (not critical)
- ▶ Freely Available to All
- ▶ Latest Leisure Gadget (Golf)



Critical Applications

- ▶ Safety-Critical
 - Civil Aviation & Train Positioning
- ▶ Security Critical
 - Police, Emergency Services, etc
- ▶ Financial Critical
 - Timing at Stock Exchanges
- ▶ Taxation and Insurance
 - RUC & Car Insurance



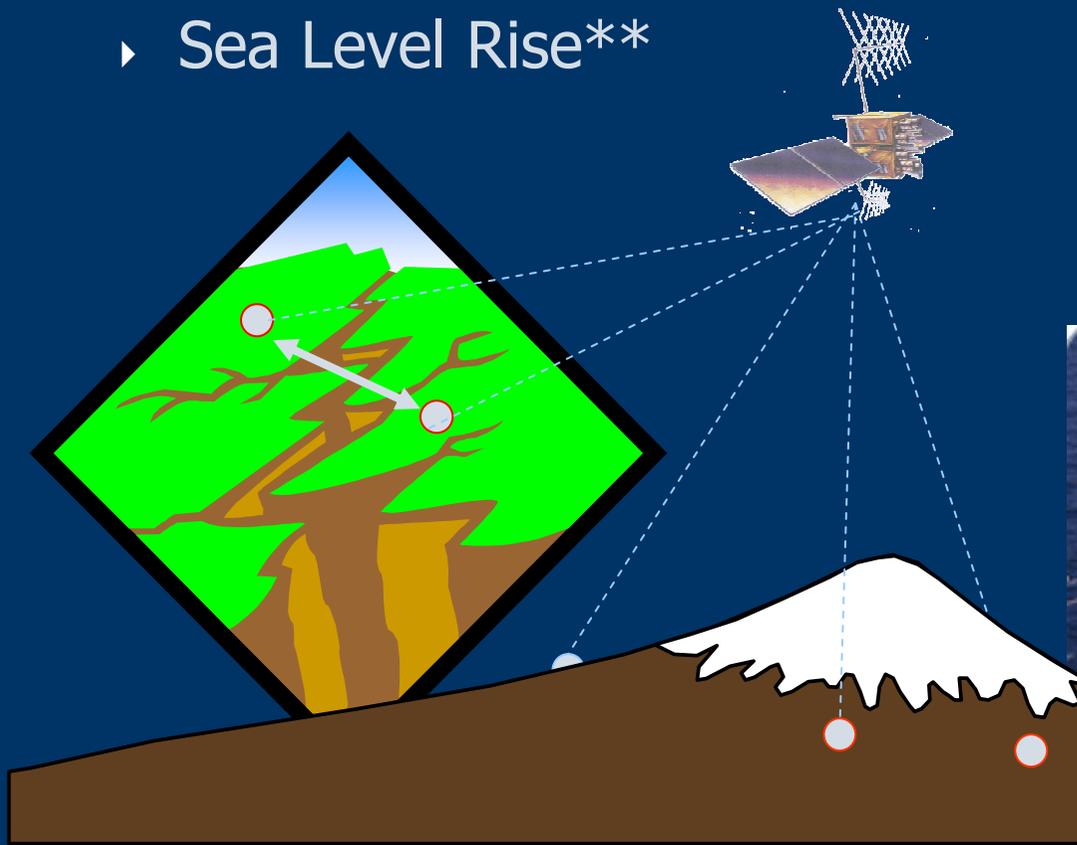
Civil Aviation

- ▶ Landing at Airports
- ▶ 99% integrity not sufficient
- ▶ Worldwide Coordinate System**
- ▶ WGS 84: Eurocontrol & FAA



Earliest GPS Positioning Applications

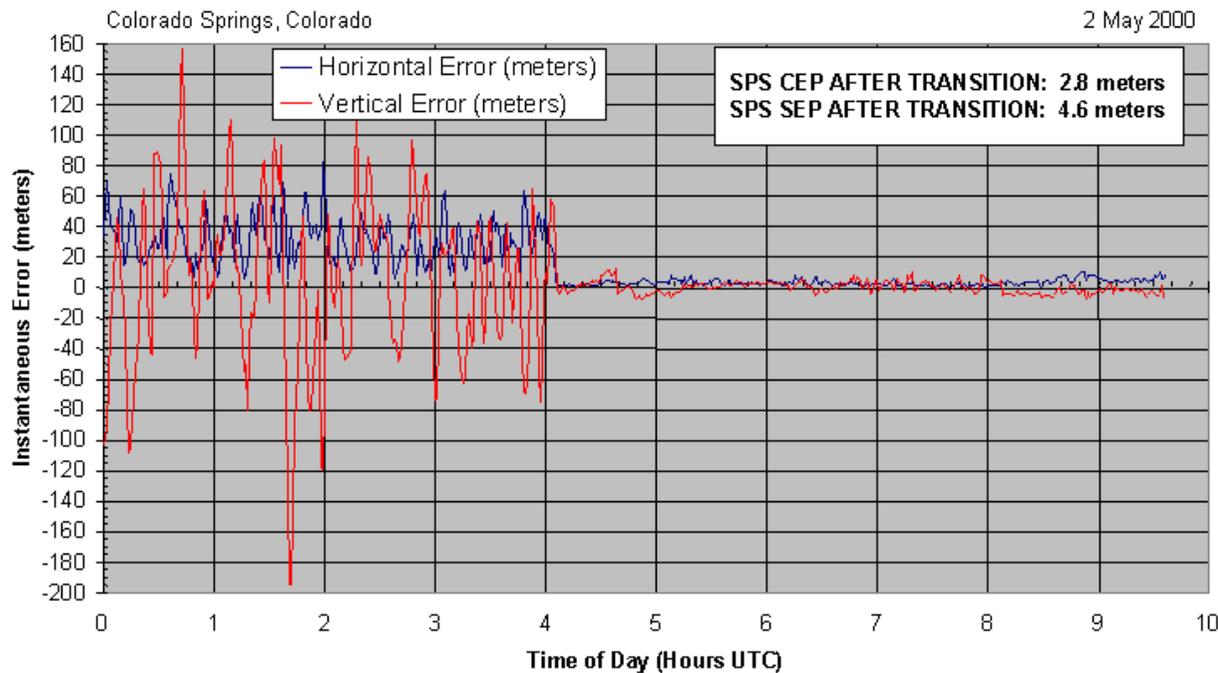
- ▶ eg Crustal Dynamics
- ▶ Dam Deformations
- ▶ Offshore Surveying
- ▶ Sea Level Rise**



An Early Challenge: Selective Availability Solutions: DGPS and Carrier phase



SA Transition -- 2 May 2000



Civil Aviation

- ▶ Landing at Airports
- ▶ 99% integrity not sufficient
- ▶ Worldwide Coordinate System*
- ▶ WGS 84: Eurocontrol & FAA*
- ▶ Re-Surveying of all major Airports**
- ▶ Heights still “Barometric Heights”



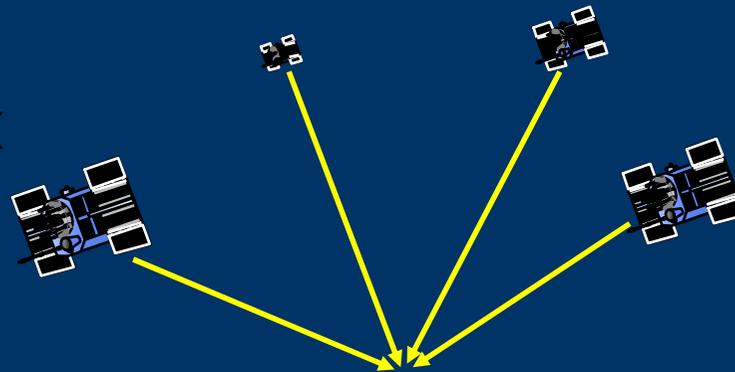
Rail Transport (Critical)

- ▶ Track Identification
 - ▶ Trains coming out of Tunnel and/or Station
- ▶ Increased Track Capacity
 - ▶ More trains per km
- ▶ Balises and Virtual Balises



Road Transport (Critical)

- ▶ RUC instead of Car Tax
- ▶ Insurance PAYD
- ▶ Improved Efficiency
- ▶ Reduced Carbon Emissions
- ▶ Future Car Navigation



Invoices

Date	Inv. No.	Amount (ex VAT)	Amount (inc VAT)	Show Invoice
2-Jun-2003	6273	E 120.00	E 141.00	HTML PDF
19-Jun-2003	6426	E 10.00	E 11.75	HTML PDF
30-Jun-2003	6508	E 15.00	E 17.63	HTML PDF
2-Jul-2003	6639	E 0.00	E 0.00	HTML PDF
10-Sep-2003	7489	E 80.00	E 94.00	HTML PDF
Total Invoiced: E 264.38				

Cleared Payments

Date	Type	Amount	Cleared
2-Jun-2003	WorldPay	E 141.00	Y
19-Jun-2003	WorldPay	E 11.75	Y
3-Jul-2003	WorldPay	E 17.63	Y
10-Sep-2003	WorldPay	E 94.00	Y
Total Received: E 264.38			
Total Owning: E 0.00			

Expected Payments

Date	Type	Amount	Cleared
Total Expected: E 0.00			

Security Critical



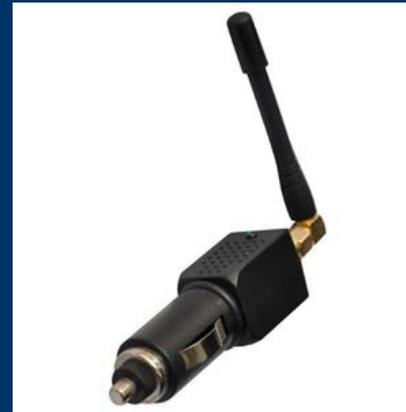
Financial Critical (timing)



40.00	27.08	+0.46	2.09%	1.40M
26.07	22.47	-1.26	-5.12%	8.842M
21.71	23.37	+12.40	3.27%	1.104M
22.59	22.74	+0.74	0.78%	82.022M
23.97	23.37	+0.42	1.69%	7.433M
391.70	377.43	+0.30	1.22%	
95.67	93.96			
25.32	24.74			
24.89	24.35			

Challenges to GPS: Jamming

- ▶ Unintentional Interference
- ▶ Ionosphere or Man-made
- ▶ Jamming for Malicious Purposes
- ▶ Like attacking PCs with viruses
- ▶ Very easy to buy Jammers on the Internet



GJ5 GPS L1, L2, L5 Jammer + 2.4G Wifi Bluetooth Blocker



\$ 320.00
excl. Shipping Costs
Print product data sheet 
Shipping time: 3-4 Days

 ADD TO CART

Challenges to GPS: Spoofing

- ▶ Worse than Jamming
- ▶ Not yet fully developed (civilian)
- ▶ Valuable or Dangerous Cargoes



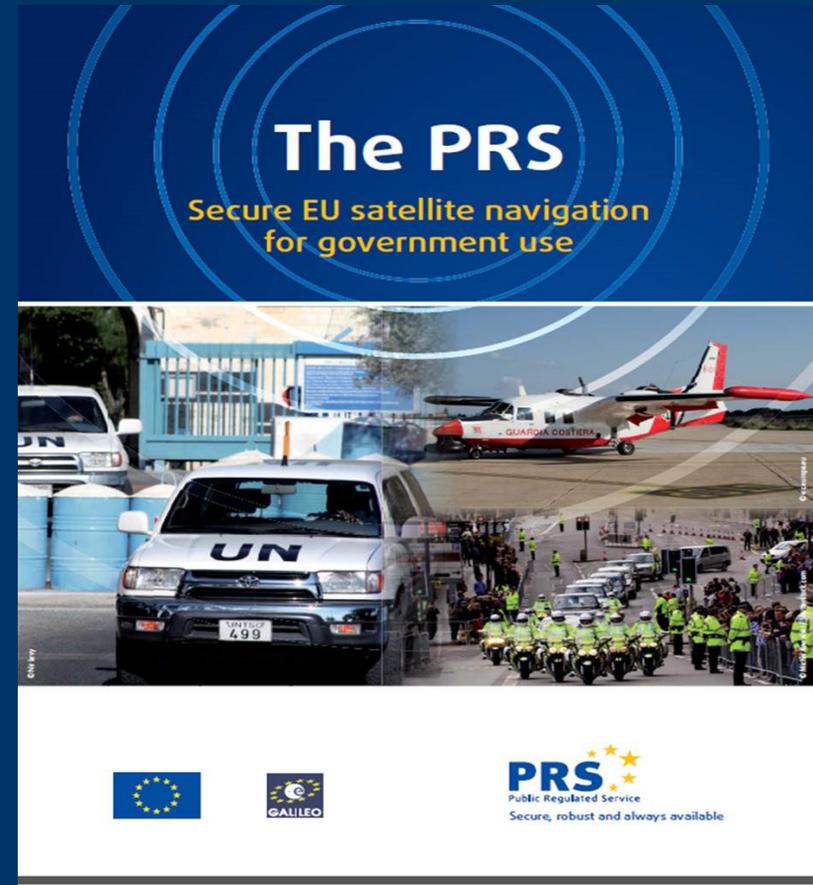
GPS Military Code (P-Y)

- ▶ Full Resistance to Spoofing
- ▶ Through Authentication
- ▶ Some Resistance to Jamming of Low-End Receivers
- ▶ Much Higher Resistance to Jamming of High-End Receivers
- ▶ Available to US Military and NATO



Galileo PRS

- ▶ Currently being developed
- ▶ Legislation by EU Parliament
- ▶ On 25 October 2011**
- ▶ Created much Controversy
- ▶ PRS Usage Not Finalised yet



Rules for Access to the PRS

- ▶ The service will be available for critical civilian applications,

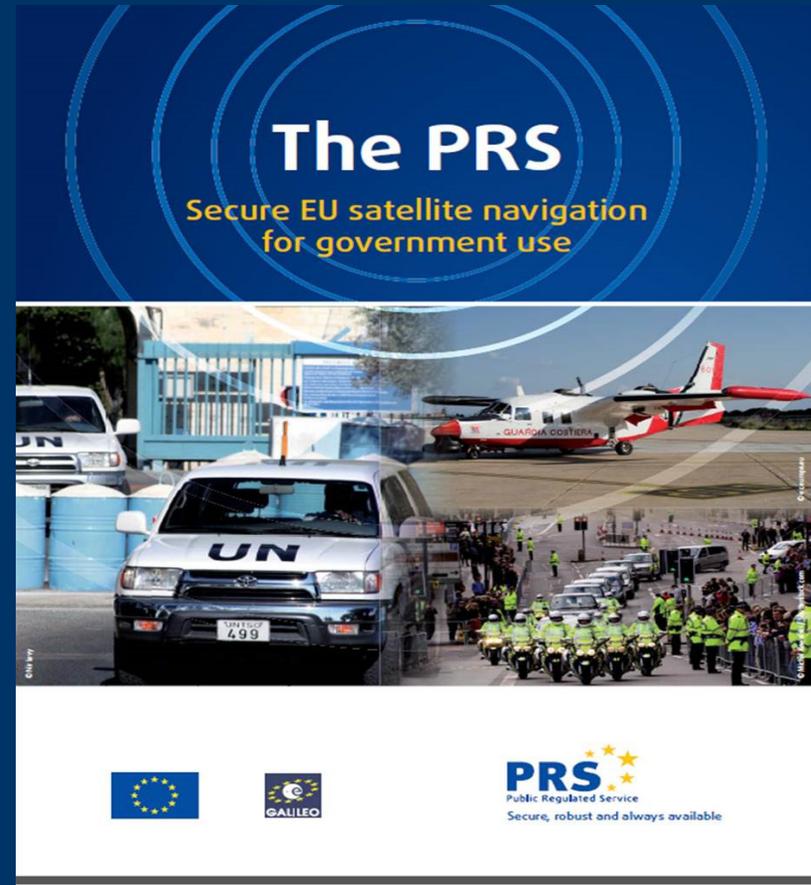
“subject to each EU member state taking its own sovereign decision on which PRS users to authorize”

and which uses to be made of PRS, including uses relating to security. Furthermore,

“it should be possible for certain third countries to become PRS participants through separate agreements concluded with them.”

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Multi-Constellation Future (~2020)

- ▶ ~ 100 Satellites
- ▶ Positioning in City Centres
- ▶ Higher Resistance to Jamming and Spoofing ??
- ▶ Emergence of Multi-Constellation GNSS Receivers**



Software Defined Radio GNSS

- ▶ Radio Frequency front-end grabs and digitises the GNSS signals
- ▶ All acquisition, tracking and PVT is carried out in separate Software
- ▶ Increased flexibility over traditional Hardware Receivers
- ▶ Ready for testing and adopting New Signals and New Frequencies
- ▶ Developing Novel Applications, eg:
 - ▶ Jamming and Interference Detection
 - ▶ Real-time Test Facilities**

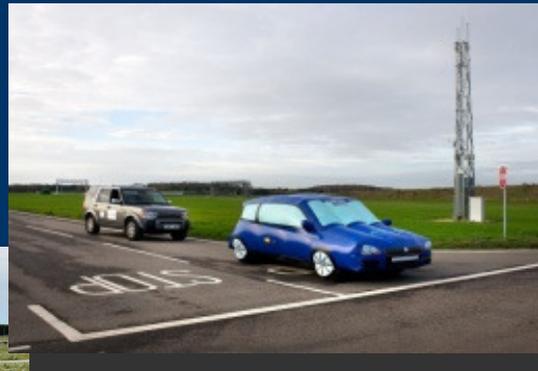




ITS Development & Test Centre

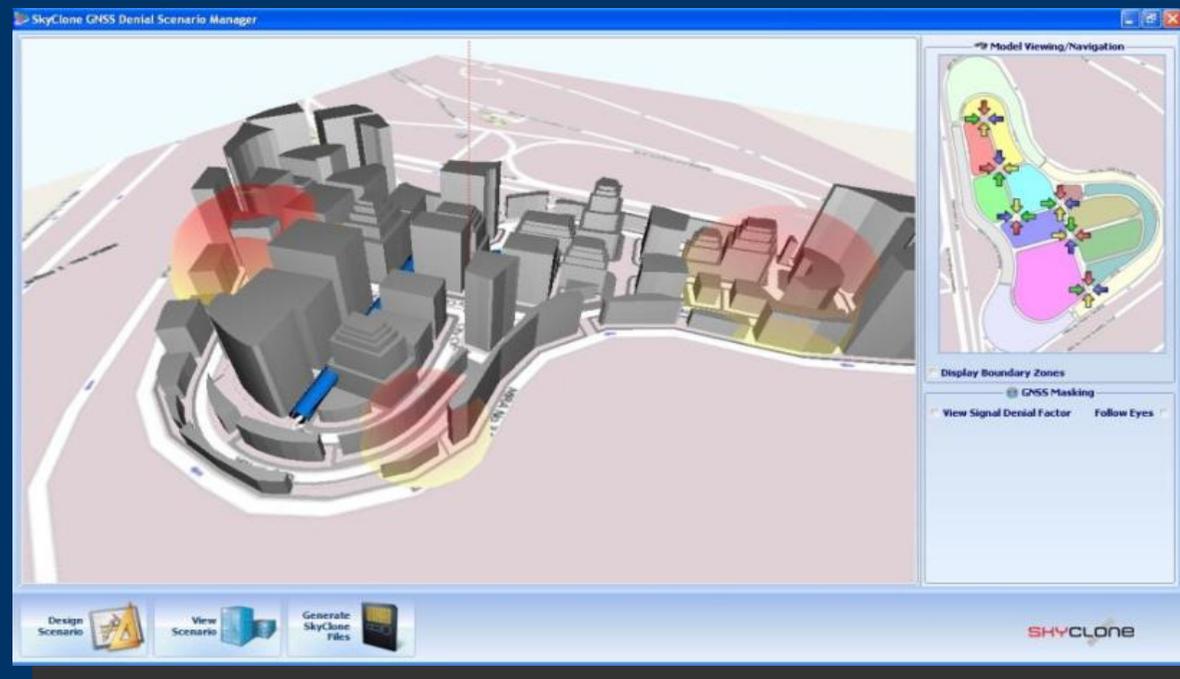


- 4km Track Circuit
- Straights
- Curved Sections
- Banks/Gradients
- Motorway Stretch
- Lay-bys
- Crossroads
- Roundabouts
- T-junctions

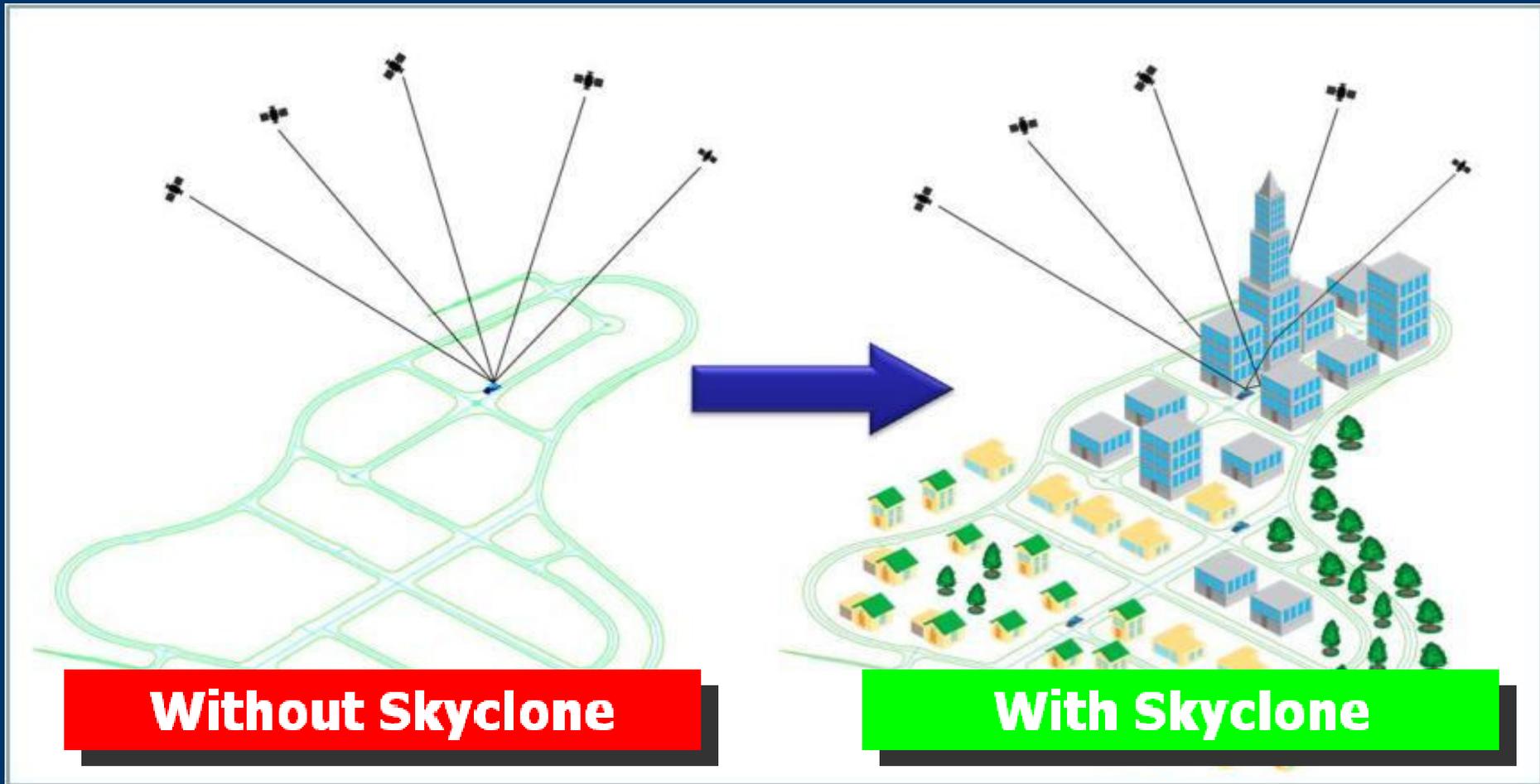


GNSS Denial for Testing

- ▶ System developed for ITS testing on an open-field site
- ▶ Modifies the received GNSS signal according to “Virtual City”
- ▶ Re-broadcasts the RF signal
- ▶ Intentional and controlled Spoofing



Skyclone Concept



Conclusions

- ▶ Satellite Navigation has always faced **Challenges**
 - ▶ Few Satellites in Orbit
 - ▶ Selective Availability (SA)
 - ▶ Compatibility and Interoperability of Systems
 - ▶ Too few Satellites in Urban Areas (city canyons)
 - ▶ Natural Interference (eg solar radiation)
 - ▶ Signal Jamming and/or Spoofing
- ▶ Market driven **Solutions** have always been found
- ▶ This will continue to be the case for the current Challenges of Jamming and Spoofing

Thank you!

Paldies!

Vidal Ashkenazi
CEO, Nottingham Scientific Ltd

www.nsl.eu.com