

FIG
2018
ISTANBUL

Presented at the FIG Congress 2018
May 6-11, 2018 in Istanbul, Turkey

XXVI FIG CONGRESS

8-11 May 2018, İstanbul

GNSS in Cadastral Surveying: State of the Art and future perspectives in the framework of Galileo

R. Capua

EMBRACING OUR SMART WORLD WHERE THE CONTINENTS CONNECT:
ENHANCING THE GEOSPATIAL MATURITY OF SOCIETIES

Organized by



Main Supporters



Platinum Sponsors





Motivation of the Study

- Cadastral surveying need affordable GNSS high accuracy systems
- GNSS RTK/NRTK Reference Station Networks (Augmentation) are honerous (maintenance, firmware update and recovery)
- GNSS PPP (Precise Point Positioning) allows the development of High Accuracy Scalable Service Levels
- Galileo will provide High Accuracy services by satellite
- Autonomous vehicle needs high accuracy: interoperability
- Receivers: toward low cost and smartphone High Accuracy
- A Vision of the future for GNSS Cadastral Surveying

Organized by



Main Supporters

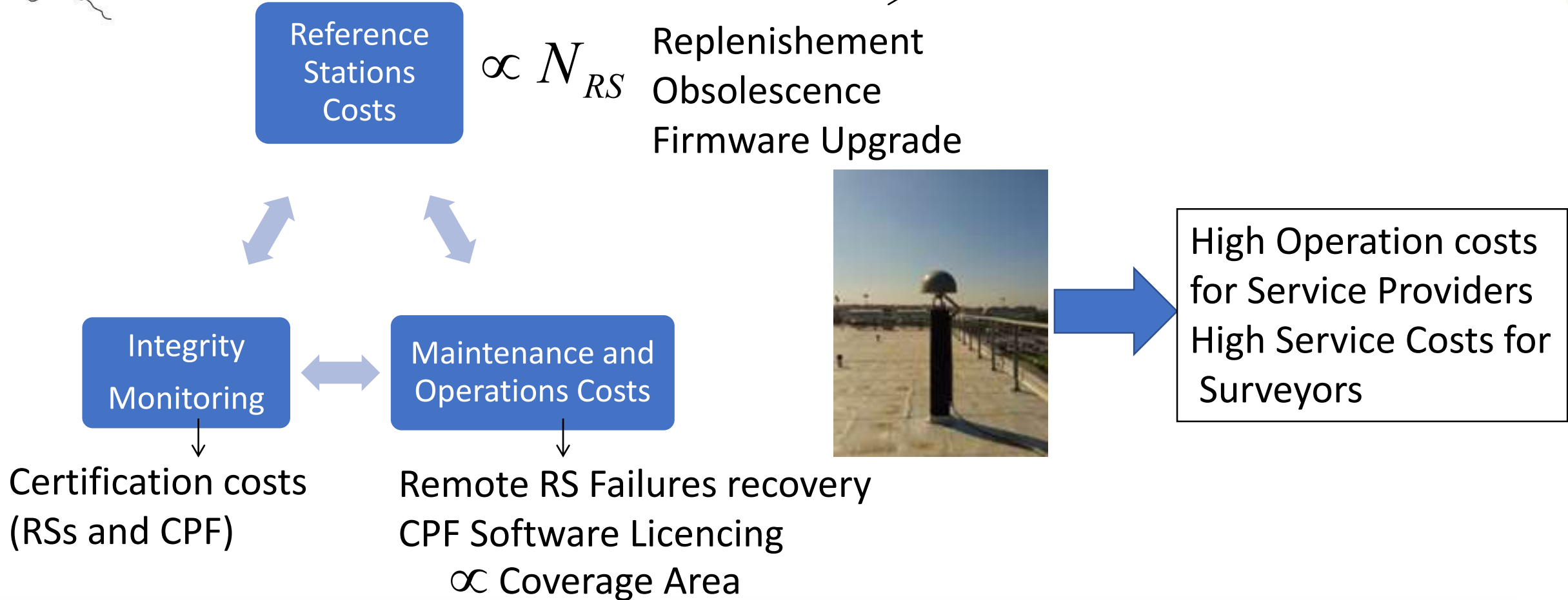


Platinum Sponsors





GNSS Local Augmentation Constraints



Organized by



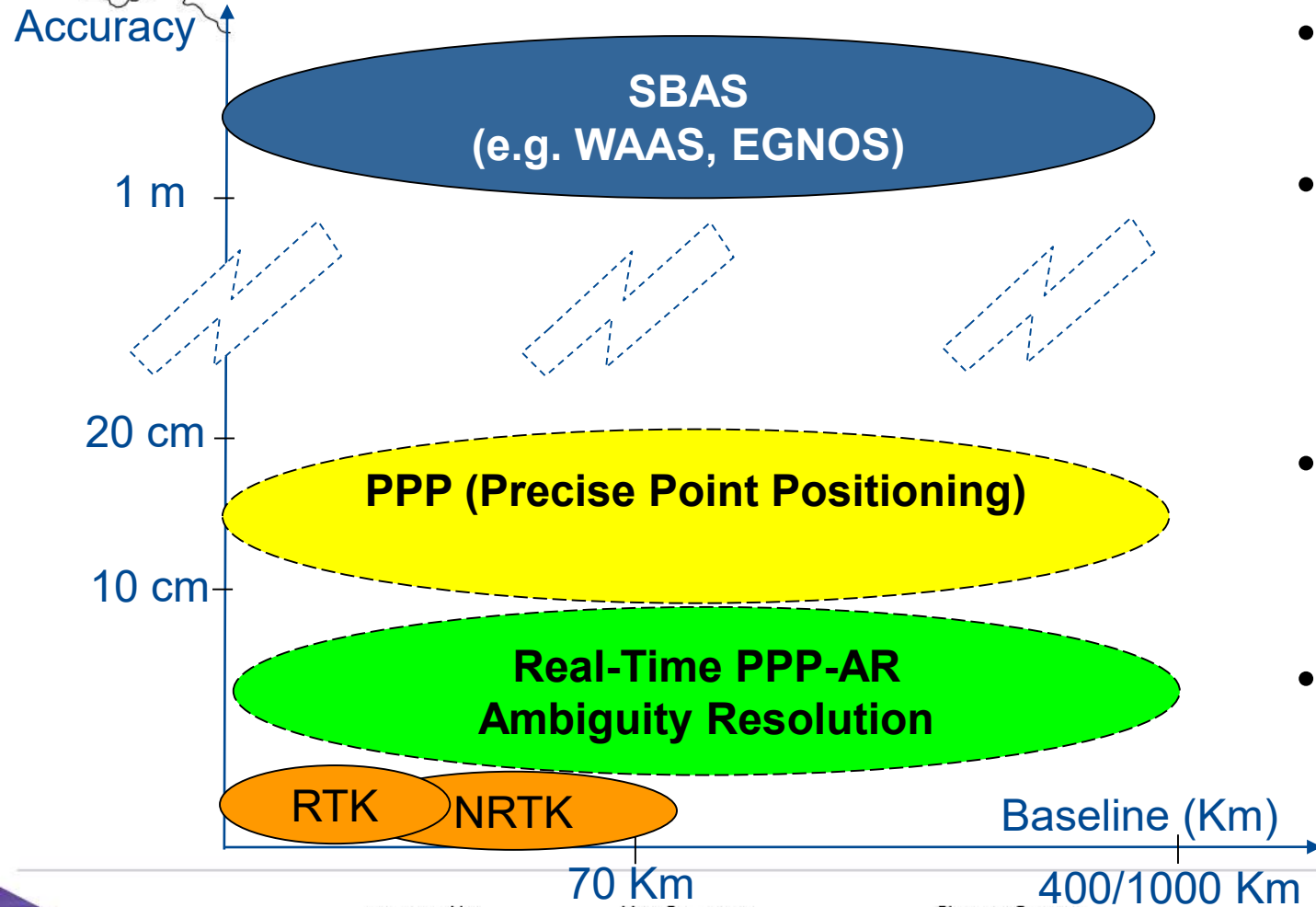
Main Supporters



Platinum Sponsors



High Accuracy Augmentation State of the Art



- **SBAS:** Pseudorange Ionospheric and orbit corrections
- **RTK/NRTK:** PR and CP Corrections calculated by a Dense Network of Reference Stations (e.g. 70 Km); Rapid Ambiguity Resolution
- **PPP:** Single errors to be estimated by a sparse World/continental RS Network; long convergence time
- **PPP-AR:** Rapid Ambiguity Resolution through innovative techniques and densification

Organized by



Main Supporters



Platinum Sponsors





PPP Hints

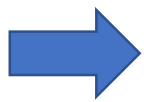
Single GNSS Receiver solution

$$P_{fk}^i = \rho_k^i + c(dt_k - dt^i) + T_k + \frac{f_1^2}{f_f^2} I_1 + \underline{b_{Pfk}^i} + \varepsilon_{Pi}$$

$$L_{fk}^i = \rho_k^i + c(dt_k - dt^i) + T_k - \frac{f_1^2}{f_f^2} I_1 + \lambda_f N_{fk}^i + \underline{b_{Lfk}^i} + \varepsilon_{Li}$$

$$b_{Pfk}^i = b_{Pfk} - b_{Pf}^i$$

$$b_{Lfk}^i = b_{Lfk} - b_{Lf}^i$$



Satellite Code and
Phase biases needed
for Ambiguity
Resolution

Needed by a Global Networks and LA:

- Precise Ephemeris and Clocks
- Satellite Code and Phase Biases (for AR)
- Precise Ionospheric Delay (for AR)



Organized by



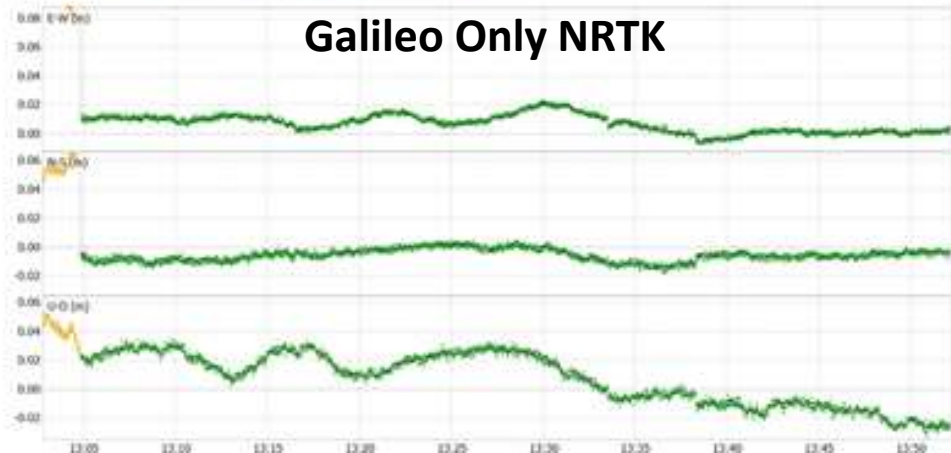
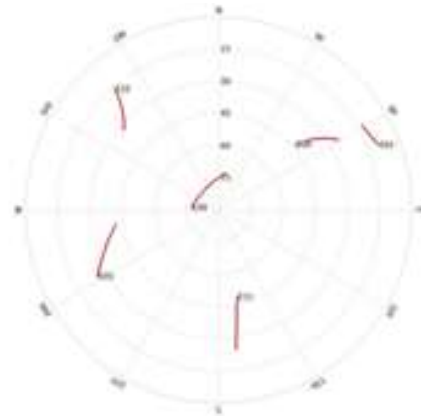
Main Supporters



Platinum Sponsors



Galileo Commercial Services EU Decision



Galileo Only NRTK

Organized by



Main Supporters



Platinum Spon



HAS ADOPTED THIS DECISION:

Article 1

The Annex to Implementing Decision (EU) 2017/224 is amended as follows:

- (1) the text in the row entitled 'General specifications' and in the column headed 'CS high precision' is replaced by the following: 'Supply of high precision data in order to obtain a positioning error of less than two decimetres in nominal conditions of use';
- (2) the text in the row entitled 'Access to the service' and in the column headed 'CS high precision' is replaced by the following: — free access';
- (3) in the row entitled 'Deployment of the service' and in the column headed 'CS high precision', the words '— Initial commercial operating phase between 2018 and 2020' and '— Full commercial operating phase from 2020' are replaced by the words '— Initial signals supply phase between 2018 and 2020' and '— Full service supply phase from 2020'.

Article 2

This Decision shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

Done at Brussels, 2 March 2018.

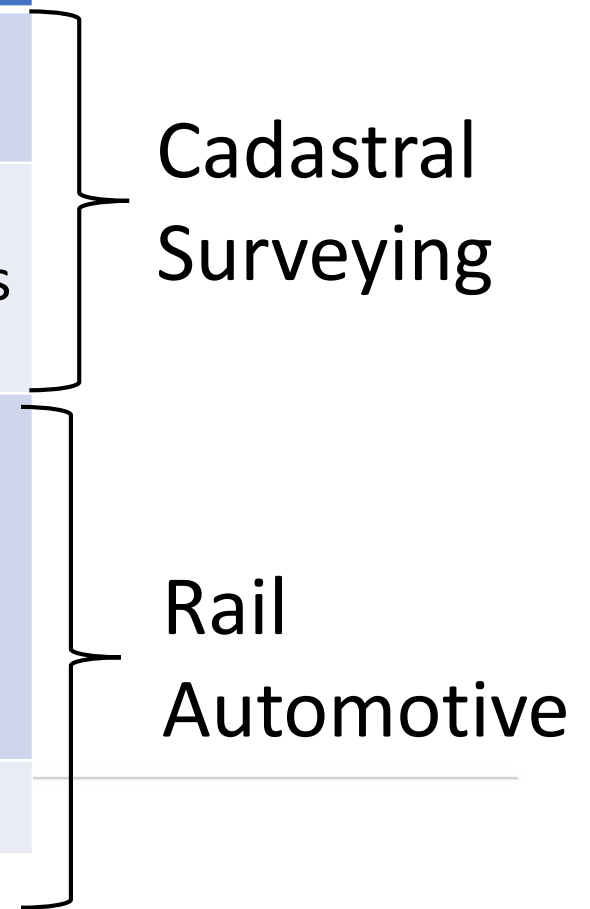


For the Commission
 The President
 Jean-Claude JUNCKER



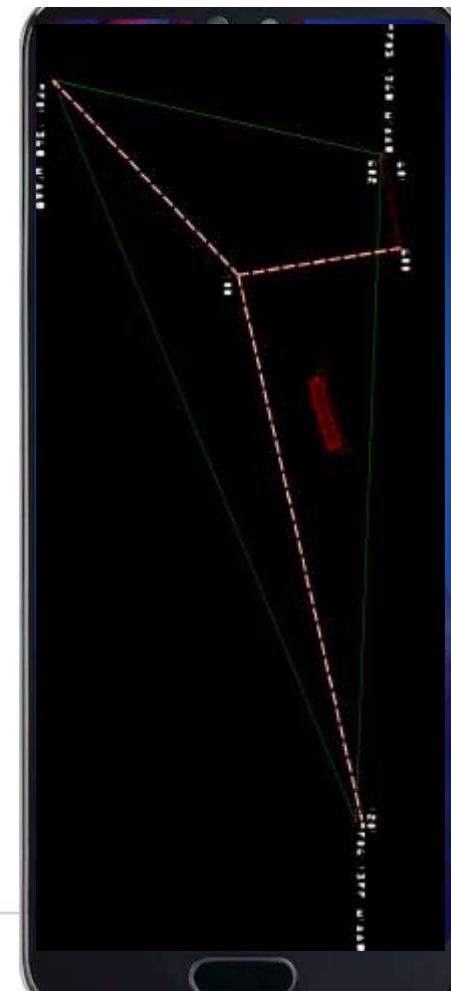
High Accuracy Service Levels

Service Level	Accuracy	Integrity	Mode
SLA 1	10/20 cm	-	Long convergence: Global Augmentation (Galileo CS)
SLA 2	< 5 cm	-	Post-Processing and Real-Time: Local precise atmospheric errors estimation
SLA 3	< 5 cm	SIL-4 (THR=10 ⁻⁹ /h)	Real-Time: atmospheric errors estimation and <u>Integrity Monitoring Certified Local Augmentation Service Providers</u>
SLA 4	< 5cm	>SIL-4	“



High Precision on a smartphone

- Google announced raw GNSS measurements output from smartphones and tablets running Android N
- Smartphones Processing constraints:
 - Nonzero and drifting bias in the carrier-phase measurements
 - High Pseudorange noise (tens of meters)
 - Carrier Phase affected by frequent outliers
- Currently sub meter-level positioning
- GNSS antenna highly susceptible to multipath
- Battery Duty cycle
- Multifrequency Chipset announced (e.g. Broadcomm, ST Microelectronics, others)



Organized by



Main Supporters

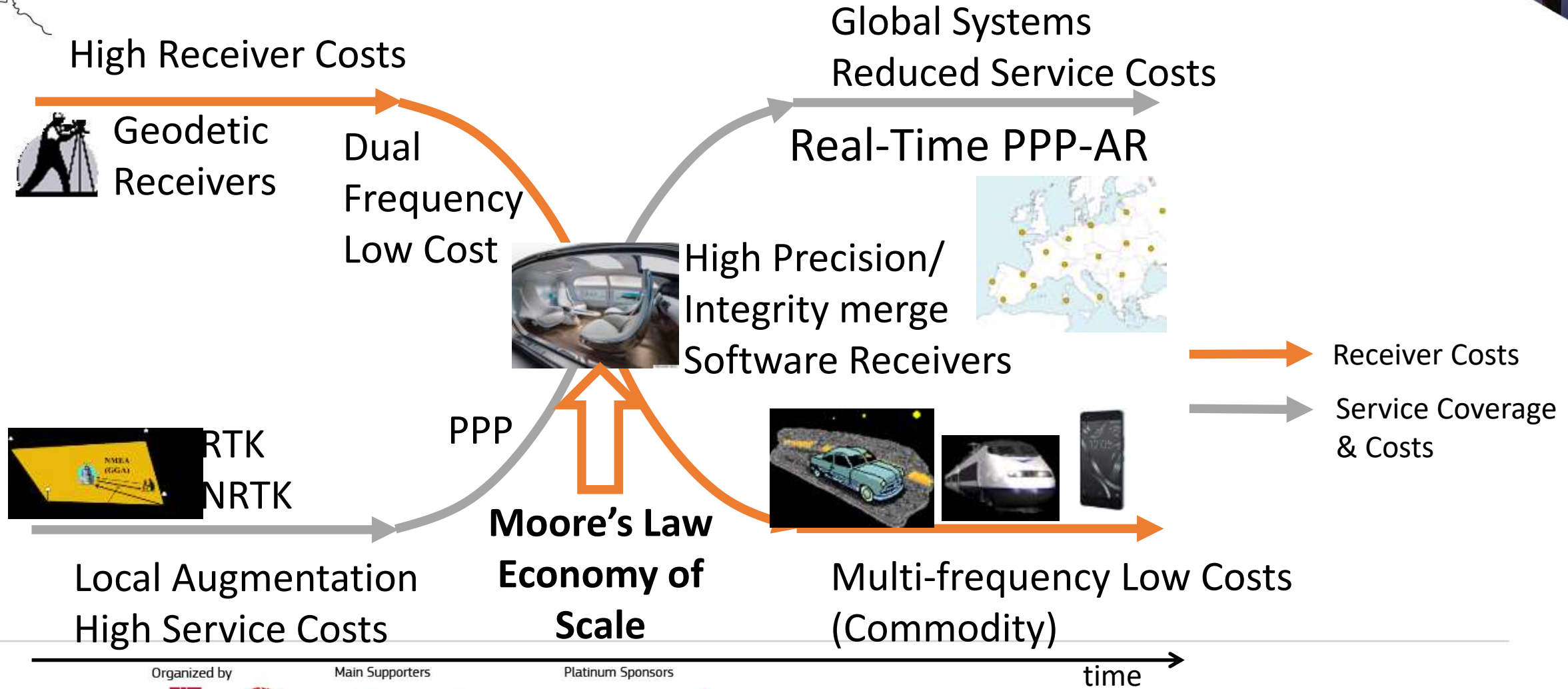


Platinum Sponsors





A Vision of the Future



Organized by



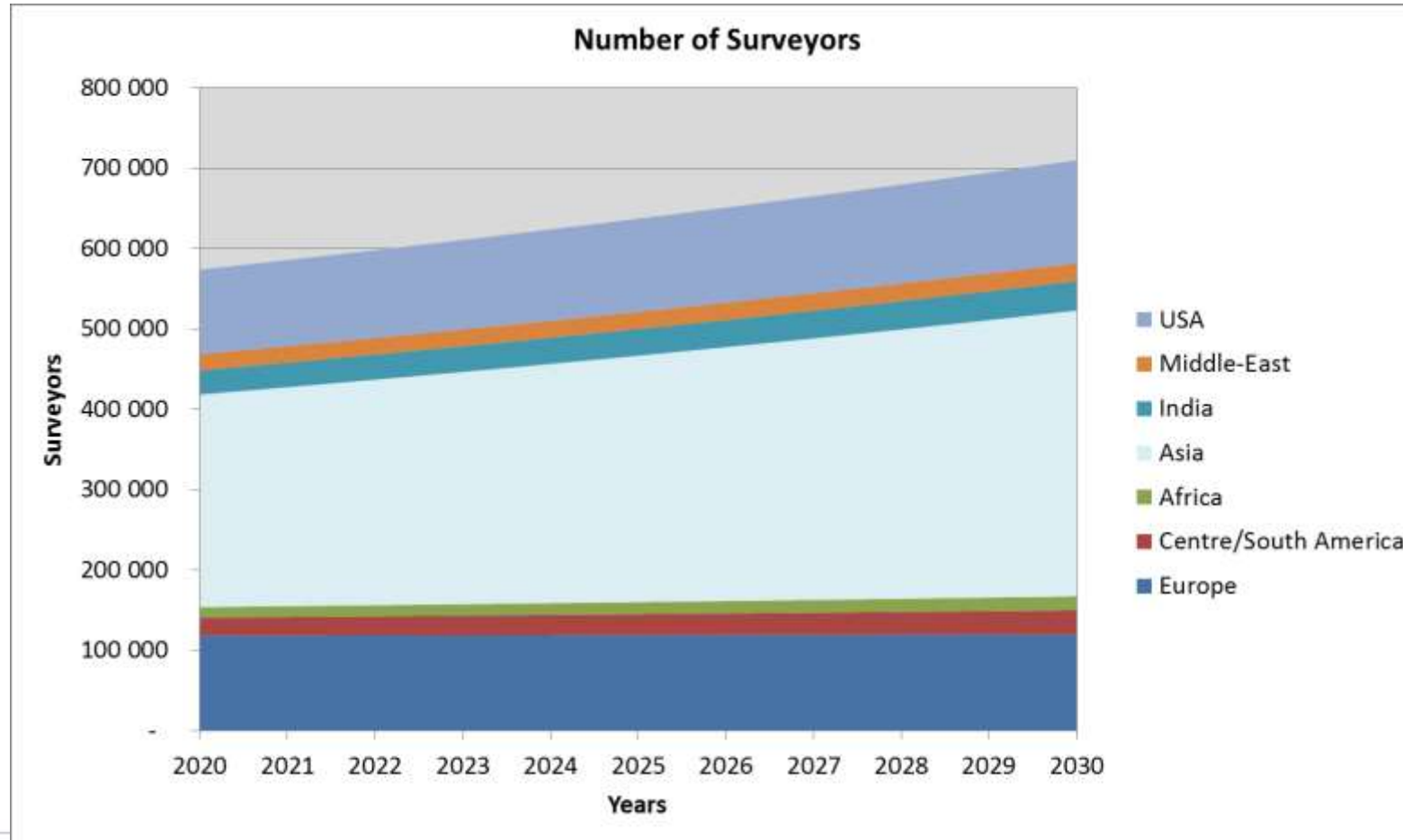
Main Supporters



Platinum Sponsors



Cadastral Sector Market



Organized by



Main Supporters



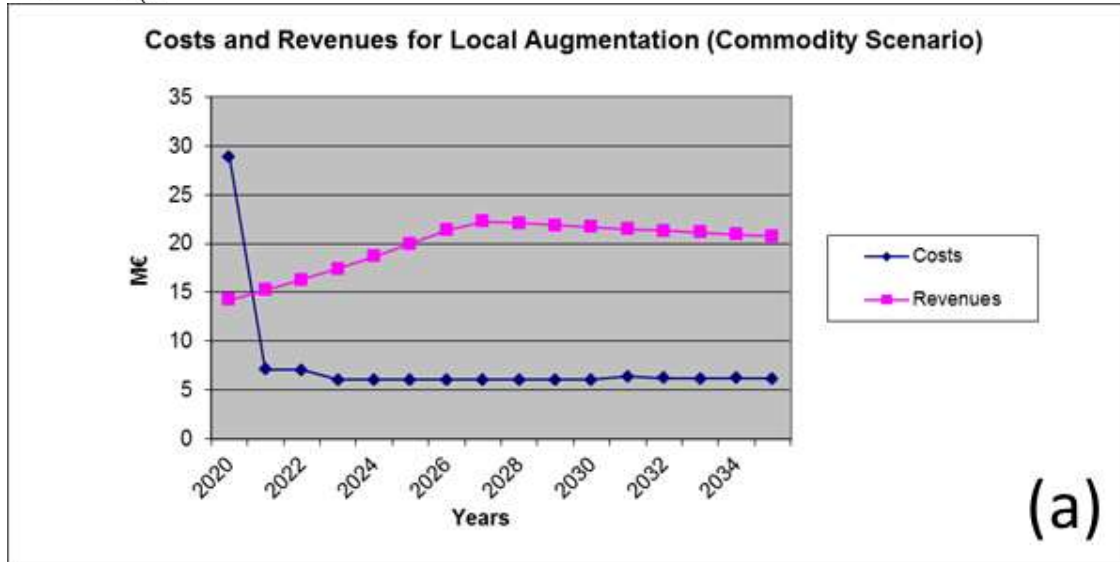
Platinum Sponsors



time

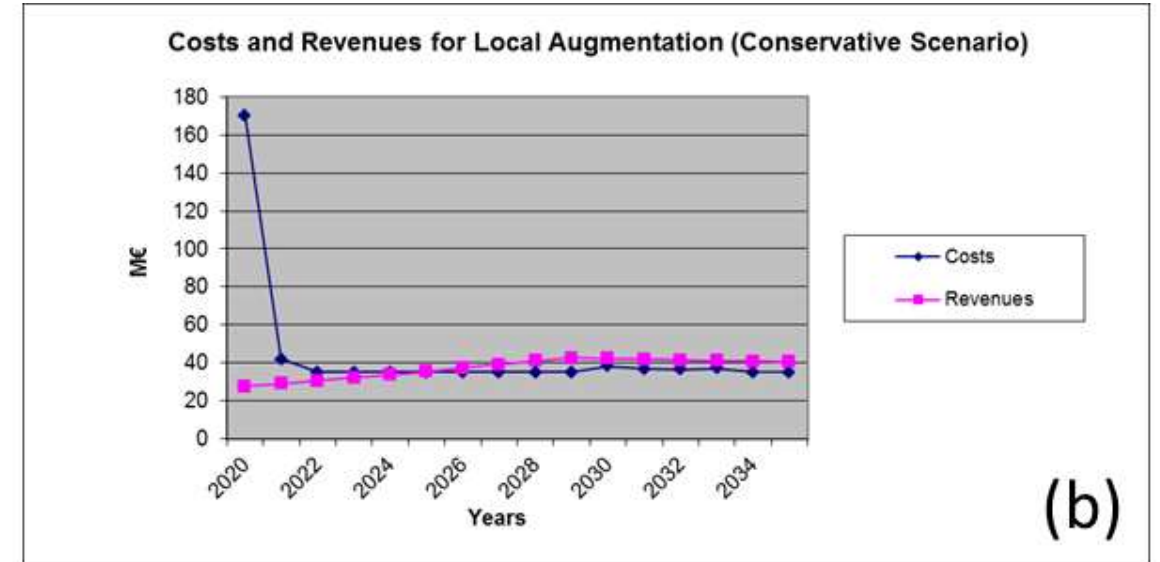


Costs and Revenues



Commodity Scenario

- Economy of scale for receivers activated
- PPP, NRTK and Cooperative approaches
- Local Augmentation Cost sharing
- High accuracy on Smartphone
- Regulation supports for Automotive



Conservative Scenario

- Local augmentation only (RTK/NRTK)
- Sectorial Augmentation infrastructures
- No cost sharing

Organized by



Main Supporters



Platinum Sponsors

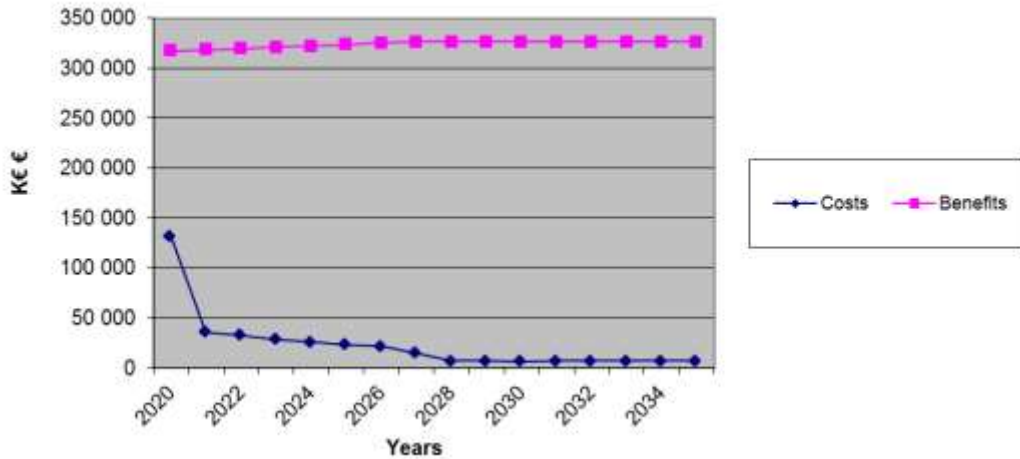




Costs and Benefits

Innovation Impact	Surveyors	Citizens	NMA
Improved Survey Efficiency	Reduction of Surveying costs, easier receiver setup	Reduction of Cadastral Transaction time	Improved Map Update Rate
Reduced Augmentation Service Fee	Reduction of Surveying Costs	Reduction of Cadastral Transaction Costs	Reduction of NMA Cadastral Surveying or Map Update Validation costs
Improved satellite visibility and Surveying efficiency	Reduction of Surveying Costs (reduced Hidden Point Sureying)	-	Reduction of Surveying Costs (reduced Hidden Point Surveying)
Local Augmentation Implementation Cost Sharing	Reduction of Annual Fee	Reduction of Transaction Costs	Reduction of costs for Institutional surveying

Costs and Benefits for Surveyors



Cost/Benefits NPV = 2.512 b€

Organized by



Main Supporters



Platinum Sponsors



Conclusions and Recommendations

- Galileo Commercial Services will allow the definition of scalable High Accuracy Services
- A Global Augmentation Network to be densified for real-time PPP-AR
- Commodity Scenario is more affordable than the Conservative one in terms of Costs and Revenues
- Cost Sharing for the Augmentation infrastructure with the Automotive sector
- Benefits for surveyors: reduced costs, reduced Hidden Points, improved GNSS availability
- Cost/Benefits Analysis for Surveyors and Citizens leads to 2.5 b€ NPV
- International Cooperation and Pilot Projects

Organized by



Main Supporters



Platinum Sponsors

