STARS
SATELLITE TECHNOLOGY
FOR ADVANCED
RAILWAY SIGNALLING

Prague, 27th of November 2018
Final event

WP-6 Impact analysis

Claudio Brenna (Bocconi university - Milan)

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 687414

Objectives and expected output

The main objective is the **economic evaluation of the introduction of EGNSS technologies into the railway domain** and to define the **RoadMap for the implementation** of the EGNSS solution and its go to market.

- Is it convenient from the public (and the private) point of view to introduce EGNSS technologies into the railway domain?
- What are the conditions under which this convenience exists?
- If it is convenient, what should be the next implementation steps?

Scope and structure

D 6.1

D6.1 - Economic model and scenarios

Task 6.1 - Definition of economic model, scenarios and case studies

D 6.2

D6.2 - Cost benefit analysis

Task 6.2 - Cost-Benefit Analysis: quantification of the public convenience of the project solution, per each case study

D 6.3

D6.3 - Impact analysis

Task 6.3 - Impact analysis: quantification of the private economic effect for each stakeholder

D 6.4

D6.4 - Implementation plan

Task 6.4 - Implementation plan: definition of the Implementation Plan and projection of the CBA at the European level

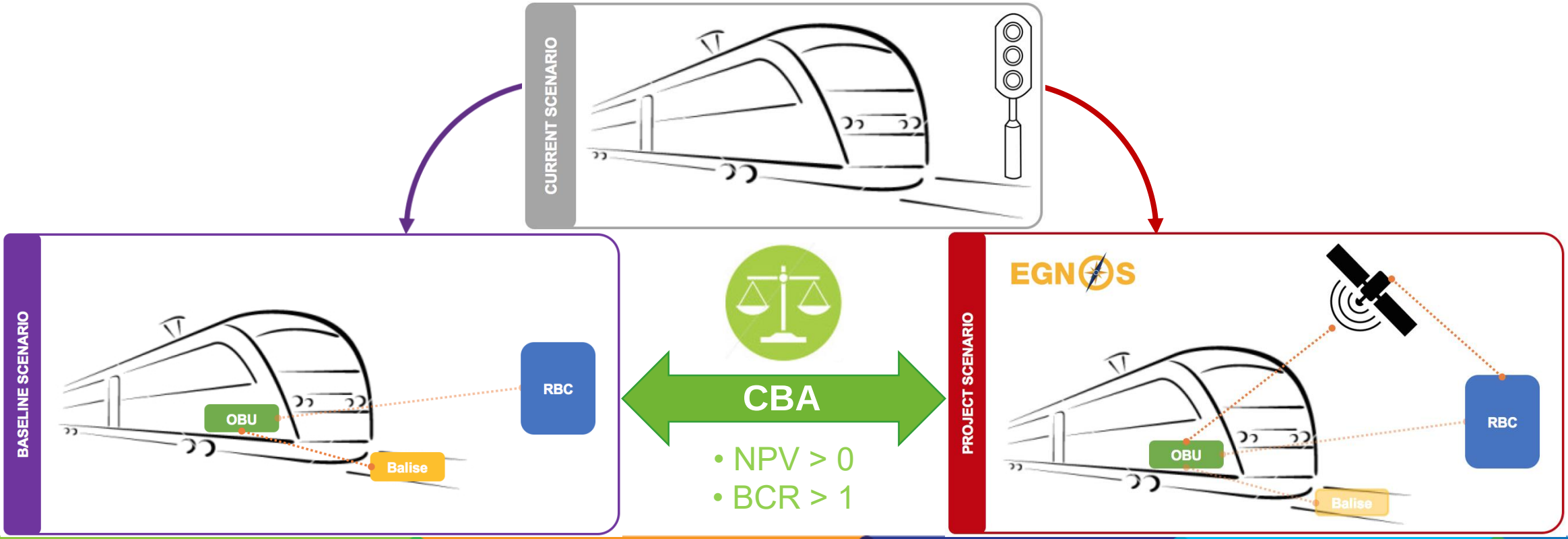
D 6.1

Economic model and scenario

CBA compares 2 scenarios and tells which one is better

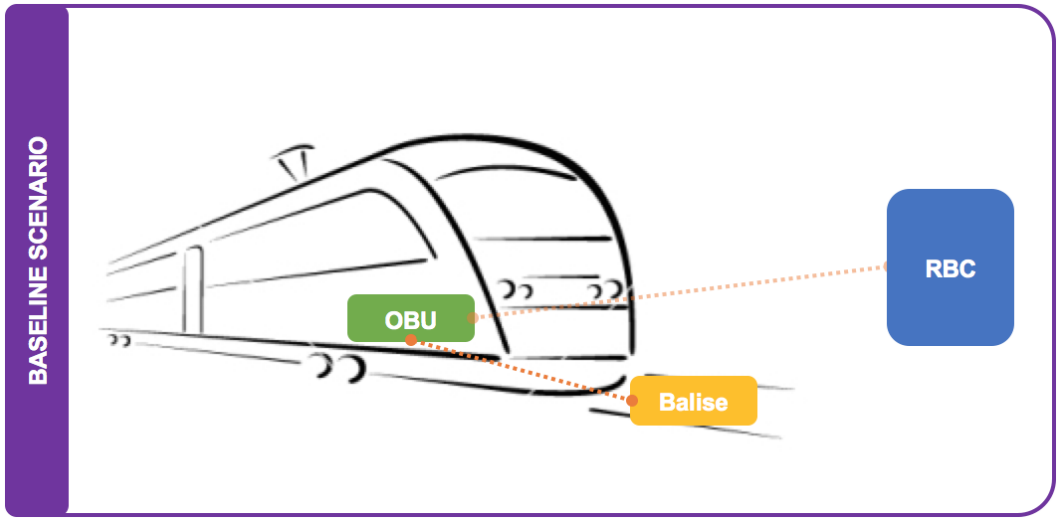
→ BASELINE SCENARIO: what happens (cost and benefit) if no technological innovation is introduced

→ PROJECT SCENARIO: what happens (cost and benefit) if a technological innovation is introduced

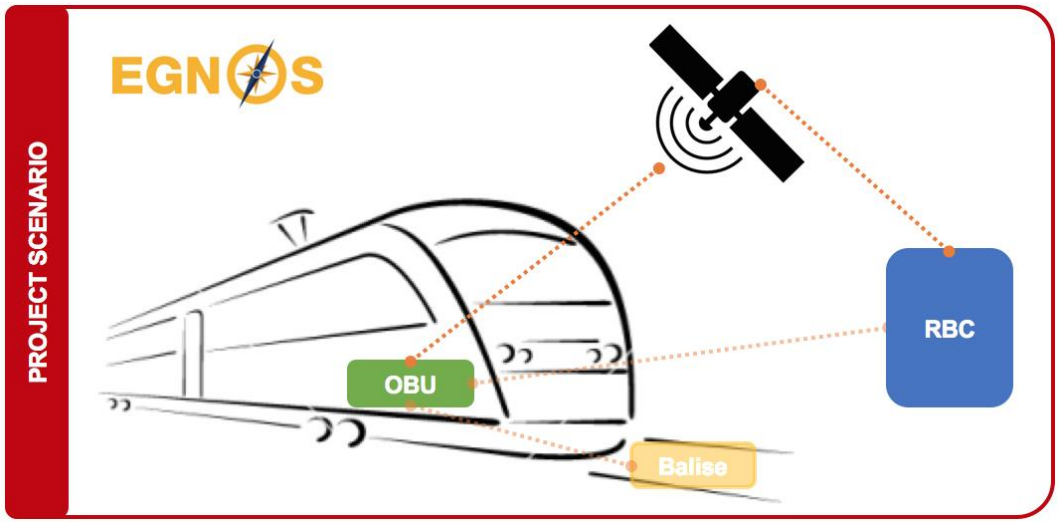


D 6.1

Assumed architecture and methodology



- RBC
- Phisical balises
- OBU with BTM



- RBC
- Virtual balises (when possible) + physical balises (when not possible)
- OBU with BTM + VBR
- TAL server
- Track database + digitalization campaign
- EGNOS / augmentation service (free)

D 6.1

Case study definition

3 case studies has been defined, to which most of the European railway lines could be referred to.

They differ for some different parameters: • % of double track; • density of the balises; • % of the virtualizable balises; • Production on the line; • Productivity of the fleet used on the line; • % of dedicated fleet.

- **LOCAL LINE** case study (very simple and lucky line: single track; isolated; perfect GNSS signal; …)
- **REGIONAL LINE** case study
- **MAIN LINE** case study (very complex line: double track; some tunnel and junctions; …)

The CBA is repeated for each case study, so that it can appraise the impact of the EGNSS technology in different environment.

D 6.2

CBA - Main preliminary findings

Under the base assumptions, the GNSS-based solution has the potential to generate a positive Benefit/Cost ratio for the railway system as a whole, in the Local and Regional case studies, whereas the results are negative for the case studies in the Main lines.

	ENPV	Cumulated flow	BCR	Project solution convenient under the base assumptions
CUT OFF VALUE	***> 0***	***> 0***	***> 1***	
Local; Dense	420.689	567.337	2,11	YES
Local; Medium	442.105	607.525	2,17	YES
Local; Isolated	468.876	657.760	2,24	YES
Regional; Dense	237.839	232.895	1,16	YES
Regional; Medium	279.693	311.434	1,18	YES
Regional; Isolated	332.011	409.607	1,22	YES
Main; Dense	- 422.173	- 708.512	0,85	NO
Main; Medium	- 385.458	- 639.618	0,86	NO
Main; Isolated	- 339.565	- 553.502	0,88	NO

D 6.2

CBA - Main preliminary findings

- **LOCAL** - total impact: **positive**

The conditions for achieving a BCR>0 are the followings:
- The share of virtual balises needs to be > 69% - 75%
- The additional cost of adding the VBR functionality to the on-board equipment needs to be < 72 - 77 k€ per unit
- The saving achieved for a virtualized balise needs to be > 66-203 €

- **REGIONAL** - total impact: **positive**

The conditions for achieving a BCR>0 are the followings:
- The share of virtual balises needs to be > 62% - 68%
- The additional cost of adding the VBR functionality to the on-board equipment needs to be < 40 - 45 k€ per unit
- The saving achieved for a virtualized balise needs to be > 916-1.054 €

- **MAIN** - total impact: **negative**

The conditions for achieving a BCR>0 are more challenging:
- The additional cost of adding the VBR functionality to the on-board equipment needs to be < 19 - 22 k€ per unit
- The saving achieved for a virtualized balise needs to be > 1.960 - 2.101 €

*the first end of the ranges are valid for the “Dense” areas, the last for the “Isolated” areas

D 6.2

CBA - Main preliminary findings

SENSITIVITY ANALYSES have shown that:

- in order to assess the economic feasibility of the GNSS-based solution, it is always more relevant to evaluate the share of virtualisable balises and the cost of the additional on board modules rather than the savings in operating costs.

- The convenience of the project solution as compared to the traditional solution is less dependent on the yearly savings for the operation of balises (OPEX) than it is on the amount of CAPEX born for equipping the trains and of capex saved for installing balises.

- This shifts the question of the economic convenience of the solution from a geographically diverse item (such as the maintenance cost of balises) towards factors that depend on the **technological advancements of the solution's development**.

D 6.3

Impact analysis - Main preliminary results

From D6.2 (CBA) we know that…

TOTAL result < 0
=> Not efficient to invest on main line

TOTAL result > 0
=> Efficient to invest on regional e local lines

TOTAL DIFFERENTIAL RESULTS BREAKDOWN, PER STAKEHOLDER

		TOTAL	=	IM	+	RU		TSS
Main Line		- 466.163		903.490		-1.369.652		466.163
Regional Line		289.112		1.042.420		- 753.309		- 289.112
Local line		147.593		490.006		- 342.413		- 147.593

Then…

- we will invest only on lines that are referable to the local and regional line case studies
- we will focus the impact analysis on these 2 case studies

D 6.3

Impact analysis - Main preliminary results

TOTAL DIFFERENTIAL RESULTS BREAKDOWN, PER STAKEHOLDER								
		TOTAL	=	IM	+	RU		TSS
~~Main Line~~		~~- 466.163~~		~~903.490~~		~~-1.369.652~~		~~466.163~~
Regional Line		289.112		1.042.420		- 753.309		- 289.112
Local line		147.593		490.006		- 342.413		- 147.593

IA for IM > 0
=> IM will be willing to invest on the satellite solution. In fact, it saves!

IA for RU < 0
=> RU will be not willing to invest on the satellite solution. In fact it losses

But …

saving of IM > loss of RU

=> Shifting part of the saving accrued by the IM to the RU will induce both the player to sustain the investment

D 6.4 Implementation Plan of a GNSS-based solution for ETCS

Assumptions and limitations

- The GNSS application in ETCS is limited to Level 2-3, and SIL4 is required.
- ETCS is an open standard, based on the requirement to ensure interoperability between constituents from different suppliers, and this must be true for a GNSS application as well.
- GPS and/or Galileo require to be coupled with a subsystem and a module for both the augmentation (e.g. EGNOS) and the detection of local feared events.
- If EGNOS shall be used, it must be free of charge for railway applications (as it is for aviation), and integrity monitoring data must be sent by other means than geostationary satellites.
- If an adequate replacement shall be used instead of EGNOS, requirements must be set, regarding usability, standardisation, interoperability.

D 6.4

Implementation Plan of a GNSS-based solution for ETCS

Issues to be solved to reach the operating phase for an ERTMS system based on GNSS

- Definition of the expected EGNSS services performances in relation with well-defined railway mission scenarios
- Development of a technical solution for the Virtual Balise concept (cfr. Shift2Rail TD 2.4 Project)
- Definition of a certification and qualification plan that will allow demonstrating that the overall system (ERTMS + GNSS) will satisfy the expected operational performances for the identified missions scenarios
- Validation that the overall system (ERTMS + GNSS) fulfils the applicable safety, security and accuracy performances
- Definition and agreement at European level of the necessary contract for the free provision of the EGNOS railway service
- Specification of the evolution of ERTMS/ETCS standards integrating the EGNSS contribution
- Publication of the changes to ERTMS/ETCS in a future release of the TSI, in order to allow infrastructure managers to implement the concept and to require railway operators to equip their vehicles accordingly, and the supply industry to develop and certify the new products.

D 6.4

Implementation Plan of a GNSS-based solution for ETCS

Short-medium term Implementation Plan

	Milestone	Year of fulfilment
M1	Definition of system requirement specifications and system atchitecture	2020*
M2	Development and laboratory demonstration of fail-safe train positioning subsystem	2021*
M3	On-site demonstration	2022*
M4	Development of laboratory tool chain and GNSS receiver	2022*
M5	Implementation of a terrestrial communication link standard or equivalent solution	To be discussed with stakeholders
M6	System integration	
M7	Certification and operational readiness review	

**current planning for Shift2Rail*

The modification of the TSI, in order to include the possibility of satellite-based ERTMS in the regulatory framework, is the main driver impacting the timeframe for the actual deployment.

Thank you for your attention…

Claudio Brenna - claudio.brenna@unibocconi.it

Giuseppe Siciliano - giuseppe.siciliano@unibocconi.it