D6.3 Impact analysis

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1 INTRODUCTION

1.1 *EXECUTIVE SUMMARY*

This deliverable summarizes the economic impact which results from using GNSS based train positioning with ERTMS/ETCS with the respect to using the traditional balise based train positioning system for each player and stakeholder in the signalling industry.

This deliverable is the result of Task 6.3.

The Task 6.3 (Impact analysis) is aimed at quantifying the economic effects for each stakeholder involved. Collecting input from previous Work Packages, the analysis defines the relations among stakeholder in terms of supply of hardware and services, and identifies the impact in terms of investment costs, operating costs and savings along a determined time horizon.

The focus is on players such as not only infrastructure managers and railway undertakings but also the signalling and satellite sectors.

The liaison of the consortium with a variety of operators under the UNIFE umbrella will enable to get comprehensive input which will be used both at this stage and for the overall economic evaluations.

The liaison of the consortium with a variety of operators enables to get comprehensive input which is used both at this stage and for the overall economic evaluations. In the case, where industry providers and/or rail operators are not in the position to disclose such input, the analysis is performed considering realistic ranges of data and deriving outcome variations (sensitivity analyses).

1.2 *DEFINITIONS AND ACRONYMS*

Acronym	Meaning
BTM	Balise Transmission Module
CAPEX	CAPital EXpenses
CBA	Cost Benefit Analysis
ERTMS	European Rail Traffic Management System
EGNOS	European Geostationary Navigation Overlay Service
ETCS	European Train Control System
GSA	European GNSS Agency
IM	Infrastructure Manager
OBU	On-board Unit
OPEX	OPerating EXpenses
PA	Public Administration
RBC	Radio Block Centre
RU	Railway Undertaking

TAL	Tracking Area Location determination system
TLC	Telecommunications
VBR	Virtual Balise Reader
KPI	Key Performance Indicator
TELCO	Telecommunication Company
TSS	Train Signalling Supplier

2 THE BUSINESS MODELS

A business model is the rationale of how an organization creates, delivers, and captures value. It is obviously part of the business strategy construction of the organisation and it necessarily implies a set of relationships with all the other organisations and entities in the industry.

When left free of self-organising, organisation in an industry elaborates own business strategies and business models that maximise their own value, under the market and the regulatory conditions, that is respecting regulations and facing the market power of other organisation in the market. It is the case that different business models in an entire industry could arise when changing the starting regulation and the relative powers of the organisations in the market.

The aim of this chapter at trying to imagine a comprehensive business model for the signalling systems industry, having the goal of maximising the widespread dissemination of such new technologies that show the best social impact, that is the best KPI from the CBA.

2.1 THE INDUSTRY PLAYERS

INFRASTRUCTURE MANAGER

Infrastructure managers (IMs) are organisations which provide sections of railway infrastructure to Railway Undertakings to operate their trains on. Infrastructure managers are also responsible to provide the rules, procedures, interfaces and instructions needed for the safe and efficient operation of trains on the rail network.

In their role the Infrastructure Managers are also responsible for the ground equipment needed for the signalling system (balises, lineside signals, radio networks etc.) and the signalling system itself (e.g. the interlockings, RBCs, traffic management systems). IMs have to provide the installation and maintenance of the equipment, as well as to operate it.

RAILWAY UNDERTAKINGS

Railway undertakings (RUs) are organisations operating trains to provide transportation services to third parties.

They are responsible for the provision and maintenance of the rolling stock, including the on-board equipment required by the signalling system selected by the respective Infrastructure Managers.

RAILWAY SIGNALLING SUPPLIERS

Railway signalling suppliers are organisations which manufacture and often also install the signalling system equipment. Signalling suppliers might under contract from IMs or RUs also provide maintenance of the signalling equipment.

Some RSS already provides all the services for signalling, including maintenance, when the contract requires this. Now, with SAT positioning Signalling, the Railway signalling suppliers will also include navigation service in their statement of work; in the contract the responsibility will be from the Railway signalling suppliers, but they could also subcontract this activity.

EUROPEAN COMMISSION / GSA

The Commission / GSA have to provide a guaranteed railway related augmentation service similar to EGNOS in order to allow a safe and reliable satellite based ETCS system.

2.2 THE INDUSTRY PRODUCTS AND SERVICES

GROUND EQUIPMENT

The ground equipment includes all the units that are installed along the railway lines (e.g. balises, lineside signals, track vacancy proving systems, radio networks) as well as in centralised locations (e.g. interlockings, RBCs, traffic management systems etc.).

With the introduction of GNSS on railway lines the ground equipment will be significantly reduced by eliminating balises and possibly also track vacancy proving systems, but it might include new elements such as GNSS augmentation systems.

ON BOARD EQUIPMENT

The on-board equipment includes all the units that are installed on the trains, such as (train control systems (e.g.ETCS) and train radios.

With the introduction of GNSS for signalling purposes the on-board equipment will have to include GNSS related equipment, such as satellite receivers and possibly receivers for an augmentation system.

SATELLITE SIGNAL AND AUGMENTATION SERVICE

The STARS project investigates how GNSS can be introduced in safety critical railway signalling applications. In addition to the positioning system (e.g. GPS, Galileo and GLONASS) it might be necessary to also make use of an augmentation system, such as EGNOS or a local augmentation system, as a GNSS system without augmentation might not achieve the required performance in regard to accuracy and safety.

GNSS services (e.g. GPS, Galileo and GLONASS) as well as augmentation services (e.g. EGNOS and WAAS) are typically provided to the users by specific bodies entitled for these missions and in most of the cases they are provided free of charge. Since geostationary satellites used to distribute augmentation services are however poorly visible on many railway lines it might be necessary that augmentation information is forwarded to the mobile users by the trackside signalling system via radio.

TELECOMMUNICATION SERVICE

The TLC signal is a crucial component in the ERTMS since it allows the continuous data transmission between the RBC and the trains. At this stage, GSM-R is used by ECTS, which might however be replaced by a successor system in the near future. The TLC network is typically operated by the IM.

2.3 THE POSSIBLE BUSINESS MODELS

Two different business models can be hypothesized and then compared from the points of view of the market organisation, the value generation and distribution and the efficiency in the innovative technology dissemination.

2.3.1 Business model A

In the traditional business model, the TSS produces and sells the signalling equipment to the IM (ground equipment) and to the RU (on board equipment). The customers (IM and RU) become owners of the equipment but can decide to buy from the TSS the related maintenance for a determined time frame.

The RU also needs the satellite signal and the related augmentation service that can be bought or received for free (when envisaged, as assumed for the EGNOS signal) from the satellite signal providers.

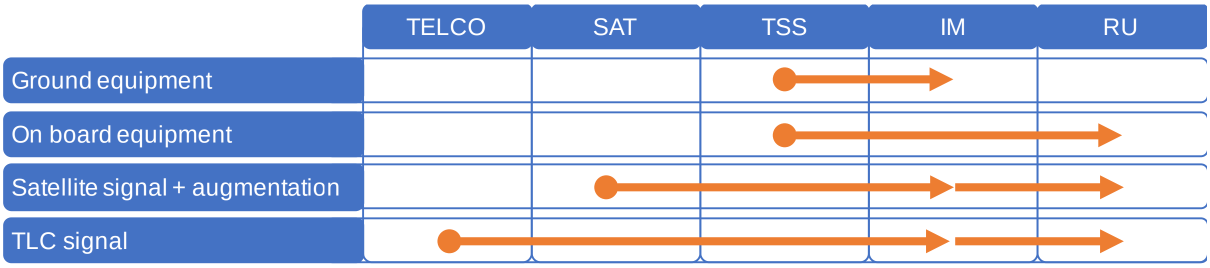

Figure 1: Business model A - players relationship

2.3.2 Business model B

In a different business model, the TSS evolves its mission from just producer and seller of signalling equipment to a provider of turnkey complete signalling solution. The TSS becomes in this way the only one interface of the IM and RU to which provides at first the equipment, then, through a global service contract, the related maintenance and the operating services like the satellite signal, the related augmentation service and, when the TLC will migrate to a multi bearer technological solution, the telecommunication signals too.

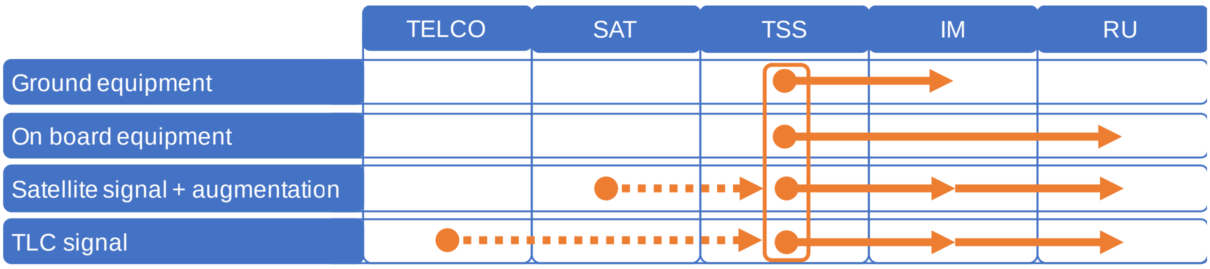

Figure 2: Business model B - players relationship

3 THE METHODOLOGY

In this section, the results of the CBA carried out and explained in D6.2 are summarized and shown for each player or stakeholder. The most important players involved in the analysed investment project are infrastructure managers, railway undertakings and train signalling suppliers.

Investment and operating costs and benefits are accrued only by two of the stakeholders, that is, by IMs and RUs. TSSs enter the game only as equipment or service providers. Since this fact, the CBA impacts will be deeply analysed only from the point of view of the IMs and RUs. The impact of the TSS will be analysed later with respect to the possible increase or decrease of turnover depending on the different industry business model that could dominate the market. A first analysis related to the impact on the TSS is performed assuming that all the maintenance operations are externalised by the IMs and RUs to the TSSs.

Since these analyses involve the points of view of private operators, conversion factors are not applied.

The following table shows the reference for each cost item. Each cost or benefit item is related to the stakeholder who bear it or that receive the related benefit.

	Borne by	Paid to
CAPEX GROUND		
ETCS planning, installation, interfacing	IM	TSS
RBC	IM	TSS
TAL-Server	IM	TSS
Track Database	IM	TSS
Digitalization campaign	IM	TSS
EGNOS	IM	TSS
Physical balises	IM	TSS
CAPEX BOARD		
ETCS	RU	TSS
BTM	RU	TSS
VBR	RU	TSS
OPEX GROUND		
RBC	IM	Internalised / TSS
TAL-Server	IM	Internalised / TSS
Recalibration of track database	IM	Internalised / TSS
Physical balises Dense area	IM	Internalised / TSS
Physical balises Medium area	IM	Internalised / TSS
Physical balises Isolated area		
OPEX BOARD		
OBU modules	RU	Internalised / TSS
EGNOS	RU/IM	TSS(=>SAT) / SAT

Figure 3: Reference of each item to the related stakeholder

Following the approach highlighted above and related to the consideration of the impact on the TSSs, the analysis will be carried out considering that both the OPEX ground and board are paid to TSSs and then are not internalised by the IMs and RUs.

The analysis is performed for each case study related to the sort of line (Local line; Regional line; Main line) but only for the case study related to the “medium area”. The remaining case studies related to the lines in dense or isolated area are not analysed since the CBA show very little differences with the respect to the results of the medium area case.

4 THE IMPACT ANALYSIS RESULTS

4.1 LOCAL LINE

This section shows the impact analysis of the investment in the case study of the Local line, from the financial point of view of the infrastructure manager and of the railway.

The following table summarizes the NPV differences between the investments envisaged in the project scenario and in the baseline scenario and the related breakdown.

The column TOTAL highlights the comprehensive cost and benefit differential, regardless the stakeholder bearing the figure. It comes from the CBA shown in D6.2 and, as explained in the methodological paragraph, it is computed without considering the conversion factors.

The columns IM and RU are the breakdown of the column TOTAL, that is, all the items are ascribed to the related stakeholder, whether it is IM or RU.

The TSS column represents the turnover of the TSS, under the hypothesis described above in the methodological paragraph.

Borne by	Paid to	IMPACT ANALYSIS - Local Line		TOTAL	=	IM	+	RU		TSS
				∂ Cost		∂ Cost		∂ Cost		∂ Revenues
			CAPEX GROUND	**373.813**		**373.813**		**-**		**- 373.813**
IM	TSS		ETCS planning, installation, interfacing	-		-		-		-
IM	TSS		RBC	-		-		-		-
IM	TSS		TAL-Server	- 23.576		- 23.576		-		23.576
IM	TSS		Track Database	- 23.576		- 23.576		-		23.576
IM	TSS		Digitalization campaign	- 37.722		- 37.722		-		37.722
IM	TSS		EGNOS	-		-		-		-
IM	TSS		Physical balises	458.687		458.687		-		- 458.687
			CAPEX BOARD	**- 169.749**		**-**		**- 169.749**		**169.749**
RU	TSS		ETCS	-		-		-		-
RU	TSS		BTM	-		-		-		-
RU	TSS		VBR	- 169.749		-		- 169.749		169.749
			OPEX GROUND	**116.193**		**116.193**		**-**		**- 116.193**
IM	TSS		RBC	-		-		-		-
IM	TSS		TAL-Server	- 3.997		- 3.997		-		3.997
IM	TSS		Recalibration of track database	-		-		-		-
IM	TSS		Physical balises Dense area	-		-		-		-
IM	TSS		Physical balises Medium area	120.190		120.190		-		- 120.190
			Physical balises Isolated area	-		-		-		-
			OPEX BOARD	**- 172.665**		**-**		**- 172.665**		**172.665**
RU	TSS		OBU modules	- 172.665		-		- 172.665		172.665
IM/RU			EGNOS	-		-		-		-
			TOTAL DIFFERENTIAL RESULT	**147.593**		**490.006**		**- 342.413**		**- 147.593**
			BCR	**1,19**		**6,51**		**0,50**		

Figure 4: Impact analysis - Local line

The analysis shows that the total positive differential impact of 147.593 € (in NPV terms) of the analysed project scenario with respect to the baseline scenario, ceteris paribus, is the result of a 490.006 € positive impact accrued by the IM balanced by a negative 342.413 € impact suffered by the RU.

Then, ceteris paribus, that is without any sort of vertical compensation between the stakeholders with a positive impact and the ones with a negative impact, the IM will have the incentive to invest in the new technology (in fact the BCR for IM is 6,61, that is bigger than 1) but the RU will have a loss from this decision (in fact the BCR for RU is 0,50, that is smaller than 1). It is obvious, since the fact that IM can save from the virtualisation of balises but the RU has to invest in a more complicated OBU.

As shown in D6.2, the project scenario shows a general benefit (NPV > 0 and BCR >1) and it would lead to the decision of investing in the project scenario (satellite-based ETCS) instead that in the baseline scenario (traditional balise-based ETCS). Unfortunately, the impact analysis highlights that this general benefit comes from a positive impact for an actor (IM), that would be in favour of the innovative investment, and a negative impact for the other actor (RU) that would be against the analysed investment. The only way to aligning incentives, that is to induce also the RU to be in favour of the investment, would be that the IM shares part of its accrued benefits with the RU, so that both the actors have some benefit.

The TSS turnover impact is negative for 147.593 €, that is, the TSS industry would produce less in the project scenario with the respect to the baseline scenario. It is obvious, since - for example, within other items - the project scenario envisages less balises to be bought and installed.

4.2 Regional line

This section shows the impact analysis of the investment in the case study of the Regional line, from the financial point of view of the infrastructure manager and of the railway.

The following table summarizes the NPV differences between the investments envisaged in the project scenario and in the baseline scenario and the related breakdown.

The column TOTAL highlights the comprehensive cost and benefit differential, regardless the stakeholder bearing the figure. It comes from the CBA shown in D6.2 and, as explained in the methodological paragraph, it is computed without considering the conversion factors.

The columns IM and RU are the breakdown of the column TOTAL, that is, all the items are ascribed to the related stakeholder, whether it is IM or RU.

The TSS column represents the turnover of the TSS, under the hypothesis described above in the methodological paragraph.

Borne by	Paid to	IMPACT ANALYSIS - Regional Line		TOTAL	=	IM	+	RU		TSS
				∂ Cost		∂ Cost		∂ Cost		∂ Revenues
			CAPEX GROUND	**811.532**		**811.532**		**-**		**- 811.532**
IM	TSS		ETCS planning, installation, interfacing	-		-		-		-
IM	TSS		RBC	-		-		-		-
IM	TSS		TAL-Server	- 23.576		- 23.576		-		23.576
IM	TSS		Track Database	- 23.576		- 23.576		-		23.576
IM	TSS		Digitalization campaign	- 37.722		- 37.722		-		37.722
IM	TSS		EGNOS	-		-		-		-
IM	TSS		Physical balises	896.406		896.406		-		- 896.406
			CAPEX BOARD	**- 373.447**		**-**		**- 373.447**		**373.447**
RU	TSS		ETCS	-		-		-		-
RU	TSS		BTM	-		-		-		-
RU	TSS		VBR	- 373.447		-		- 373.447		373.447
			OPEX GROUND	**230.888**		**230.888**		**-**		**- 230.888**
IM	TSS		RBC	-		-		-		-
IM	TSS		TAL-Server	- 3.997		- 3.997		-		3.997
IM	TSS		Recalibration of track database	-		-		-		-
IM	TSS		Physical balises Dense area	-		-		-		-
IM	TSS		Physical balises Medium area	234.885		234.885		-		- 234.885
			Physical balises Isolated area	-		-		-		-
			OPEX BOARD	**- 379.862**		**-**		**- 379.862**		**379.862**
RU	TSS		OBU modules	- 379.862		-		- 379.862		379.862
IM/RU			EGNOS	-		-		-		-
			TOTAL DIFFERENTIAL RESULT	**289.112**		**1.042.420**		**- 753.309**		**- 289.112**
			BCR	**1,17**		**5,86**		**0,50**		

Figure 5: Impact analysis - Regional line

The analysis shows that the total positive differential impact of 289.112 € (in NPV terms) of the analysed project scenario with respect to the baseline scenario, ceteris paribus, is the result of a 1.042.420 € positive impact accrued by the IM balanced by a negative 753.309 € impact suffered by the RU.

Then, ceteris paribus, that is without any sort of vertical compensation between the stakeholders with a positive impact and the ones with a negative impact, the IM will have the incentive to invest in the new technology (in fact the BCR for IM is 5,89, that is bigger than 1) but the RU will have a loss from this decision (in fact the BCR for RU is 0,50, that is smaller than 1). It is obvious, since the fact that IM can save from the virtualisation of balises but the RU has to invest in a more complicated OBU.

As shown in D6.2, the project scenario shows a general benefit (NPV > 0 and BCR >1) and it would lead to the decision of investing in the project scenario (satellite-based ETCS) instead that in the baseline scenario (traditional balise-based ETCS). Unfortunately, the impact analysis highlights that this general benefit comes from a positive impact for an actor (IM) that would be in favour of the innovative investment, and a negative impact for the other actor (RU) that would be against the analysed investment. The only way to aligning incentives, that is to induce also the RU to be in favour of the investment, would be that the IM shares part of its accrued benefits with the RU, so that both the actors have some benefit.

The TSS turnover impact is negative for 289.112 €, that is, the TSS industry would produce less in the project scenario with the respect to the baseline scenario. It is obvious, since - for example, within other items - the project scenario envisages less balises to be bought and installed.

4.3 MAIN LINE

This section shows the impact analysis of the investment in the case study of the Main line, from the financial point of view of the infrastructure manager and of the railway.

The following table summarizes the NPV differences between the investments envisaged in the project scenario and in the baseline scenario and the related breakdown.

The column TOTAL highlights the comprehensive cost and benefit differential, regardless the stakeholder bearing the figure. It comes from the CBA shown in D6.2 and, as explained in the methodological paragraph, it is computed without considering the conversion factors.

The columns IM and RU are the breakdown of the column TOTAL, that is, all the items are ascribed to the related stakeholder, whether it is IM or RU.

The TSS column represents the turnover of the TSS, under the hypothesis described above in the methodological paragraph.

Borne by	Paid to	IMPACT ANALYSIS - Main Line		TOTAL	=	IM	+	RU		TSS
				∂ Cost		∂ Cost		∂ Cost		∂ Revenues
			CAPEX GROUND	**701.447**		**701.447**		**-**		**- 701.447**
IM	TSS		ETCS planning, installation, interfacing	-		-		-		-
IM	TSS		RBC	-		-		-		-
IM	TSS		TAL-Server	- 23.576		- 23.576		-		23.576
IM	TSS		Track Database	- 23.576		- 23.576		-		23.576
IM	TSS		Digitalization campaign	- 37.722		- 37.722		-		37.722
IM	TSS		EGNOS	-		-		-		-
IM	TSS		Physical balises	786.321		786.321		-		- 786.321
			CAPEX BOARD	**- 678.994**		**-**		**- 678.994**		**678.994**
RU	TSS		ETCS	-		-		-		-
RU	TSS		BTM	-		-		-		-
RU	TSS		VBR	- 678.994		-		- 678.994		678.994
			OPEX GROUND	**202.043**		**202.043**		**-**		**- 202.043**
IM	TSS		RBC	-		-		-		-
IM	TSS		TAL-Server	- 3.997		- 3.997		-		3.997
IM	TSS		Recalibration of track database	-		-		-		-
IM	TSS		Physical balises Dense area	-		-		-		-
IM	TSS		Physical balises Medium area	206.040		206.040		-		- 206.040
			Physical balises Isolated area	-		-		-		-
			OPEX BOARD	**- 690.658**		**-**		**- 690.658**		**690.658**
RU	TSS		OBU modules	- 690.658		-		- 690.658		690.658
IM/RU			EGNOS	-		-		-		-
			TOTAL DIFFERENTIAL RESULT	**- 466.163**		**903.490**		**- 1.369.652**		**466.163**
			BCR	**0,85**		**3,15**		**0,50**		

Figure 6: Impact analysis - Main line

The analysis shows that the total negative differential impact of 466.163 € (in NPV terms) of the analysed project scenario with respect to the baseline scenario, ceteris paribus, is the result of a 903.490 € positive impact accrued by the IM balanced by a negative 1.369.652 € impact suffered by the RU.

Then, only the IM will have the incentive to invest in the new technology (in fact the BCR for IM is 3,15, that is bigger than 1) but the RU will have a loss from this decision (in fact the BCR for RU is 0,50, that is smaller than 1). But the decision of investing in the new technology would lead to a general loss and there is no way to align the incentives, in fact, the loss of the RU is bigger than the benefit of the IM, so that any sort of direct compensation between the two actors can bring both to have a benefit at the same time.

The TSS turnover impact is positive for 466.163 €, that is, the TSS industry would produce more in the project scenario with the respect to the baseline scenario.

5 MAIN FINDINGS

As highlighted in the D6.2, the Cost Benefit Analysis shows that - in the case studies of the local and of the regional line - the project scenario, that is the investment in a satellite-based ETCS technological solution, is better, under the public and general point of view, with the respect to the investment in a traditional balise-based ETCS technological solution. The case study of the main line, instead, highlighted a negative CBA, that is, that there is no convenience in investing in the innovative solution.

The impact analysis per stakeholder is a tool helping to understand how the general benefit is allocated among the stakeholders. It is helpful because a general benefit could be the result of a benefit accrued by a stakeholder and loss suffered by another. In this case there is no alignment of incentives and, if both the stakeholders are entitled of the decision making, without any sort of compensation, no good decision could be taken.

It is what happens in the case study of the local and regional line. In both the cases, the CBA highlight a total positive impact, that is, though, the result of a big benefit accrued by the IM and a loss suffered by the RU.

In this case the impact analysis also hints at the solution: since the loss for the RU is lower than the benefit for the IM, there is a chance of aligning the incentive through a compensation from the IM to the RU at least equal to the loss RU would suffer. In this way both the stakeholder would have a benefit and decide, together, for the investment in the innovative satellite-based ETCS technological solution.