TA to Connectivity in the Western Balkans

EuropeAid/137850/IH/SER/MULTI

Sub-Project

Code : CONNECTA-TRA-CRM-REG-02
Area: Connectivity Transport Reform Measures

Preparation of Maintenance Plans 2018-2022 for Road/Rail TEN-T indicative extensions to WB6

FINAL REPORT – Railways MPs

10 December 2018

MOTT MACDONALD CONNECTA CONSORTIUM

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Contents

List of Abbreviations

ALB/AL	Albania
AO	Administrative Order
BiH	Bosnia and Herzegovina
BP	Business Plan
CA	Contracting Authority
CNC	Core Network Corridor
CONNECTA	Technical Assistance to Connectivity in the Western Balkans
CONNECTA	The MMD led Consortium implementing CONNECTA
CRM	Connectivity Reform Measures
DG MOVE	Directorate-General for Mobility and Transport
DG NEAR	Directorate-General for Neighbourhood and Enlargement Negotiations
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIB	European Investment Bank
ETCS	European Train Control System
EU	European Union
EUD	EU Delegation
EUR	Euro (currency)
FR	Final Report
GIS	Geographic Information System
GPR	Ground Penetrating Radar
GSM	Global System for Mobile Communications
GSM-R	Global System for Mobile Communications – Railway
IFI	International Financing Institution
IM	Infrastructure Manager (refers to railways)
IPF	Infrastructure Project Facility
IR	Inception Report
IRR	Internal Rate of Return
ITS	Intelligent Transport Systems
KE	Key Expert
KoM	Kick-off-Meeting
KOS	Kosovo* (hereinafter referred to as Kosovo)
MED	Mediterranean (corridor)
MKD/MK/MAC	the former Yugoslav Republic of Macedonia
MNE/MON	Montenegro
MMD	Mott MacDonald
M&R	Infrastructure Maintenance and Renewal
NIPAC	National IPA Coordinator
NPV	Net Present Value
NKE	Non-Key Expert
OEM	Orient East Mediterranean (corridor)
OHL	Overhead Line
PBMC	Performance Based Maintenance Contract
PM	Project Manager
RAMS	Road/Rail Asset Management System

RFA	Request for Approval
RIA	Railway Infrastructure Asset
RI-AMS	Railway Infrastructure Asset Management Systems
RP	Regional Participants
S&C	Switches & Crossing
SEETO	South East Europe Transport Observatory
SNKE	Senior Non Key Expert
SRB/SER	Serbia
TA	Technical Assistance
TEN-T	Trans-European Network – Transport
TL	Team Leader
ToR	Terms of Reference
WB	World Bank
WB6	Western Balkans 6 countries

*This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.

SYNOPSIS

Project (sub-project) Title:	**Preparation of Maintenance Plans 2018-2022 for Road/Rail TEN-T indicative extension to WB6 (CONNECTA-TRA-CRM-REG-02)**
Project Code:	EuropeAid/13785/IH/SER/MULTI
Area:	Connectivity Transport Reform Measures in WB6
Contracting Authority:	European Commission - DG NEAR
Main Beneficiary/Monitoring:	South East Europe Transport Observatory - SEETO
End Beneficiaries:	Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Kosovo, Montenegro, Serbia
Context:	Regional
Consultant:	CONNECTA Consortium (led by Mott Mc Donald)
Administrative Order:	31 May 2017
Mobilisation of NKEs:	05 June 2017 (Kick-off Meeting with SEETO at 26 June 2017)
Sub-Project Duration:	16 (rev. 17) months
Anticipated completion:	31 December 2018 (rev)
Responsible Transport KE:	Kostas Georgiou

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We would like to thank the SEETO Task Manager Mr. Nedim Begovic, monitoring this CONNECTA sub-project, for helping to coordinate data collection and arranging meetings with stakeholders and Regional Participants, and also providing necessary advice. Additionally, we would like to thank national contact points for their support, inputs and contribution to the projects. Also, we would like to thank SEETO General Director Mr. Dejan Lasica for general support of the project.

In the course of this sub-project, the CONNECTA team would like to acknowledge the kind support and good collaboration of all Regional Participants and especially the ones acting as focal points (either from Roads Public Enterprises and/or line Ministries in the region), devoting time for meetings and interviews as well as providing data and assisting in reviewing reports.

Summary

The motivations behind the initiation of this Project and its goals are explained in detail in Chapter 1 (Introduction). However, in a nutshell, the key goals of the Project were to:

A.	perform thorough analysis of the current condition of the key railway infrastructure assets (RIA) in the WB6 region

B.	determine Maintenance & Renewal (M&R) needs, in terms of volumes of M&R works and related budgets, to improve the RIA to the acceptable level by European standards

C.	determine short and long-term actions, measures and initiatives (including regulatory) necessary to maintain the RIA condition at the required level for a longer period of time:

b) propose the optimal framework for performing RIA condition-measuring, assessment and consequential M&R needs determination and management in the future	a) propose an optimal organisational framework for performing and managing M&R works in the future, in order to secure required RIA quality at all times, for a longer period of time

With the above goals in mind, work in this Project was undertaken in the following order:

1. *Assessment of the current situation*, concerning:

    a. *Available information on the RIA condition*, including:

        i. Asset Register (AR) (Infrastructure Database (ID)), including design layout parameters and asset characteristics and installation dates, with corresponding catalogues,

        ii. Asset condition-measurements,

        iii. Operational information (e.g. traffic volumes and characteristics (speeds, axle-loads, annual tonnages, etc.),

        iv. M&R history (types, costs, locations, dates),

        v. Responsible Standards and Rulebooks governing the required RIA quality and consequential needs in M&R and other remedial activities.

    b. *Available information on the capabilities and manner in which M&R works are planned, managed, organised and performed*, including:

        i. Available mechanisation and their respective condition and usability

        ii. Share of responsibilities between Infrastructure Managers (IMs), Infrastructure Maintenance Contractors (IMCs) and responsible governmental institutions, e.g. Ministries

        iii. Financial sources available for RIA M&R, national and international, including opportunities and procedures for seeking loans from appropriate International Financial Institutions (IFIs)

2. *Identification of shortcomings*, deficiencies and consequential needs for establishment of the optimal M&R environment capable of guaranteeing stable and satisfactory RIA condition in the future

3. *Establishing an adequate Asset Register / Infrastructure Database (AR/ID)* for all Regional Participants (RPs) who do not have one, uniform in concept and format across all RPs

4. *Analysis of most successful M&R management frameworks in Europe* nowadays and proposing optimal ones (with required modifications) for the WB6 region (e.g. Performance Based Maintenance Contracting (PBMC), etc.)

5. *Analysis of the most successful modern Railway Infrastructure Asset Management Systems (RI-AMS) concepts* in the wold and proposing optimal ones (with required modifications and tailoring) for the WB6 region

6. *Utilising the established AR/ID to perform detailed analysis of the current RIA condition and consequential M&R needs and budgets for the designated programming period 2019-2023*.

7. *Formulating most pertinent conclusions and recommendations* for further improvement of RIA condition and its management in the WB6 region in the future.

In pursuit of the above goals and activities, the Project yielded several significant contributions to the overall railway infrastructure situation and M&R management in the region, primarily by:

A. Defining, creating and populating the Infrastructure Database (ID), i.e. the Asset Register (AR) for all RPs (except for ŽFBiH), which in itself is already a tremendous achievement, as no such database has ever existed in any of the RPs, while they represent the first and key prerequisite for modern Railway Infrastructure Asset Management and M&R Planning (occurring throughout the project, from the very start, to the very end – sketched out in Report 2 and completed in Report 5)

B. Analysis of Infrastructure Managers' (IMs') current M&R contracting strategies and recommendations including comparative analysis (PBMC), including the elaboration of the most suitable KPIs (*Key Performance Indicators*) (Report 3)

C. Analysis and Recommendations for setting up a Railway Infrastructure Asset Management System (RI-AMS) in the region, along with a detailed list of RI-AMS functionalities and tentative Tender Requirements for the procurement of RI-AMS (Report 4)

D. Support to RPs in preparing their own M&R plans for the period 2019-2023 reflecting their specific characteristics, effectively containing a tentative M&R plan for all RPs, and for all infrastructure domains (Track, Civil Works, Signalling and Electrical facilities), with full assessment of Railway Infrastructure Assets (RIA) condition-analysis and consequential M&R Planning for the period 2019-2023 and related Budget (Report 5)

__What is exceptionally important to be fully understood about the M&R plan for the period 2019-2023 produced in this Report is that this is most certainly NOT a MANDATORY M&R Plan, but the best possible plan that could be produced with the RIA data that were provided.__ However, unlike the RIA inventory, where most of the data was provided (except for ŽFBiH), most of the RIA condition-data were not provided at all (except for Track Geometry in SRB and MKD and, __in order for this plan to become a real, optimal and "workable" plan, i.e. a plan which could indeed be adopted and deployed in practice, all these RIA condition-data__ (explained in detail in chapter 6.1 of Report 5) __must be acquired and used to refine the M&R plan provided in Report 5 of this Project__. Without this refinement, this M&R plan is still quite rough as it effectively uses only RIA ages, i.e. RIA age-based Residual Service Lives (RSLs) as the indication of RIA condition and consequential need of renewal, and not even the accumulated-tonnage-based RSLs, let alone RIA condition-data, which were not provided by the RPs and as such cannot be considered as final and __certainly not as a plan that can be directly put into practice__, though a significant improvement of what was existing prior to this Project, and a first step towards a true, comprehensive plan, as would be produced by a full-scale RI-AMS.

__All the analyses and conclusions provided in this Project (and especially in Report 5), in terms of RIA quality and consequential M&R needs, are performed strictly on a technical basis__. What this means is that the condition of RIA was analysed based on valid and widely adopted railway engineering

practices, both in the region and internationally, and that in cases where this condition was assessed, according to these internationally accepted criteria, as no longer fit for safe traffic or in other words as causing too high a risk of negatively affecting rail traffic, their replacement, i.e. renewal, was foreseen. The reason why this is emphasised here is that ***the above approach is strictly technical, i.e. based on adopted railway engineering rules of practice, and does not take into account any geo-political, economic or other approaches, such as those related to the expected or desired increase in traffic volumes or other transportation strategies, either in the region, or in Europe as a whole***. Namely, it is long established in railway engineering practice that RIA towards their end of their Service Lives (SLs) start exhibiting erratic and thus unreliable behaviour, prone to various kinds of failures, which may or may not cause traffic disturbances and/or accidents. This is exactly how the expected maximum SL is established, i.e. it is experience-based and it effectively represents the point after which the particular RIA starts exhibiting too frequent failures (or a risk thereof) and thus causes too high a risk for traffic safety and other disturbances, so that it can be deemed that such RIA is no longer fit for usage and should be replaced. ***It clearly does not mean that on the particular anniversary of this particular RIA matching its SL such RIA would immediately completely collapse. Not at all***, and as most of the RPs in the WB6 region have already proven, RIA could indeed be retained for a number of years after the effective expiration of their SLs, but this is normally done with various kinds of "prices" and "consequences" mostly related to speed reductions, increased level of emergency maintenance, higher tolerance of traffic disturbances, reduction of line capacity and possible loss of customers to other traffic modes, etc. On the other hand, what the expiration of RIA SLs certainly means, is that such RIA cannot be considered to be of "satisfactory" quality according to well-established European and other international practices and as such suitable for "standard" traffic operating conditions normally required in Europe and on its main Corridors and Routes, e.g. for the tentative/indicative extension of TEN-T Core&Comprehensive network in the WB6 (C&CNWB).

Based on the above, the M&R works found to be necessary in this Report due to strictly technical reasons, i.e. RIA condition (RSLs), should be performed <u>only if sound and credible reasons are found for the traffic volumes in this region to grow significantly in the near future or if EU the itself, for whatever (e.g. strategic) reasons, desires to raise the quality level of rail infrastructure in the WB6 region and thus finance it accordingly itself</u>. Otherwise, if no sound grounds for traffic growth are found, or if the EU does not desire to finance the improvement of WB6 RIA on its own, regardless of the fact that the Routes/Corridors/Lines in this region will or will not be formally incorporated into the TEN-T network, the infrastructure in this region does not justify the (extremely) large budgets needed for these M&R works to be done.

Respecting the fact that the volume of M&R found to be necessary for the "Ideal" scenario was extremely large (***in fact, this "ideal" scenario reflects the M&R backlog that was piled up after several decades of M&R negligence***), a strategy had to be devised as to how to prioritise them, i.e. select from the "Ideal/Maximum" scenario 50% of more important M&R to be performed in the "Medium" scenario and 20% of most important in the "Minimum scenario", as well as distribute them among the years in the 5-year target period 2019-2023, (Table 1-Table 3 and Figure 1-Figure 5). For this prioritisation, various strategies and criteria can be defined (***and effectively, the best approach would be to apply those defined in chapter 4 of Report 5, e.g. the SEETO ones*** – but which could not be applied due to reasons explained in that chapter, primarily due to the lack of relevant information), but for all of them to be applied, it would require relevant data to be available in the first place. In that sense, the remaining possibilities for prioritisation were to use a ***"modified SEETO prioritisation strategy" that is simultaneously strongly recommended to be applied in the nearest possible future*** relying on the following parameters as prioritisation criteria:

- Core vs. Comprehensive lines
    - Line categories (national & UIC)
    - Overall Condition data (file: *OverallCondition.xlsx*), ranging from very poor (1) to good (4)), of course only for those RPs who populated and provided that file
    - Prioritisation indication in the requested file (*Route Priorities.xlsx*), of course, again, only for those RPs who populated and provided that file

Table 1: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Ideal/Maximum" scenario

Infrastructure Costs [EUR]		Track	S&C	Civil Works	Signalling	Electrification	TOTAL
ALB		177,802,372	3,075,000	?	0	?	180,877,372
BiH	BiH – ŽFBiH	?	?	?	?	?	?
	BiH – ŽRS	111,353,783	13,425,000	9,501,342	25,181,695	106,296,025	265,757,845
MKD		174,206,769	29,175,000	72,995,983	90,092,583	43,099,341	409,569,676
MNE		57,535,460	14,325,000	160,541,420	28,100,120	11,034,080	271,536,080
SRB		600,433,150	62,100,000	744,244,660	394,004,978	263,246,853	2,064,029,641
KOS		86,865,145	3,075,000	40,978,215	37,376,150	?	168,294,510
TOTAL WB6		1,208,196,679	125,175,000	1,028,261,620	574,755,526	423,676,299	3,360,065,124

Table 2: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Medium" scenario

Infrastructure Costs [EUR]		Track	S&C	Civil Works	Signalling	Electrification	TOTAL
ALB		111,675,257	1,537,500	?	0	0	113,212,757
BiH	BiH – ŽFBiH	?	?	?	?	?	?
	BiH – ŽRS	50,759,658	6,712,500	4,750,671	15,070,440	7,149,625	84,442,894
MKD		70,446,230	14,587,500	36,497,992	20,301,708	5,044,031	146,877,461
MNE		36,288,411	7,162,500	80,270,710	14,050,060	5,517,040	143,288,721
SRB		212,175,000	31,050,000	372,122,330	67,439,400	33,022,059	715,808,789
KOS		35,443,156	1,050,000	20,489,108	28,703,675	?	85,685,939
TOTAL WB6		516,787,712	62,100,000	514,130,810	145,565,283	50,732,755	1,289,316,560

Table 3: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Minimum" scenario

Infrastructure Costs [EUR]		Track	S&C	Civil Works	Signalling	Electrification	TOTAL
ALB		54,809,636	615,000	?	0	0	55,424,636
BiH	BiH – ŽFBiH	?	?	?	?	?	?
	BiH – ŽRS	15,269,161	2,685,000	1,900,268	15,070,440	7,149,625	42,074,494
MKD		33,435,641	5,835,000	14,599,197	20,301,708	5,044,031	79,215,576
MNE		20,122,638	2,865,000	32,108,284	5,620,024	2,206,816	62,922,762
SRB		91,917,857	12,420,000	148,848,932	67,439,400	33,022,059	353,648,248
KOS		17,302,134	675,000	8,195,643	0	0	26,172,777
TOTAL WB6		232,857,067	25,095,000	205,652,324	108,431,572	47,422,531	619,458,494

Tables can also be represented graphically, Figure 3-Figure 5, and short summary in Figure 1-Figure 2.
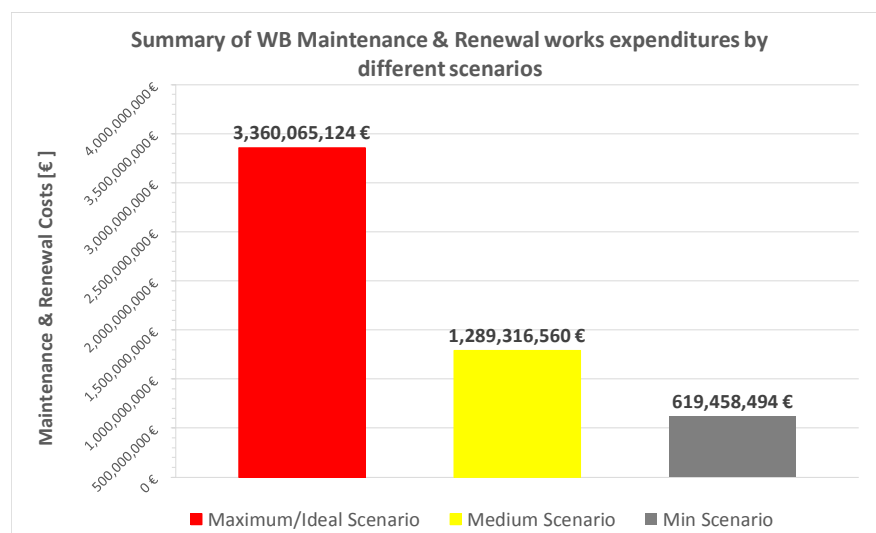

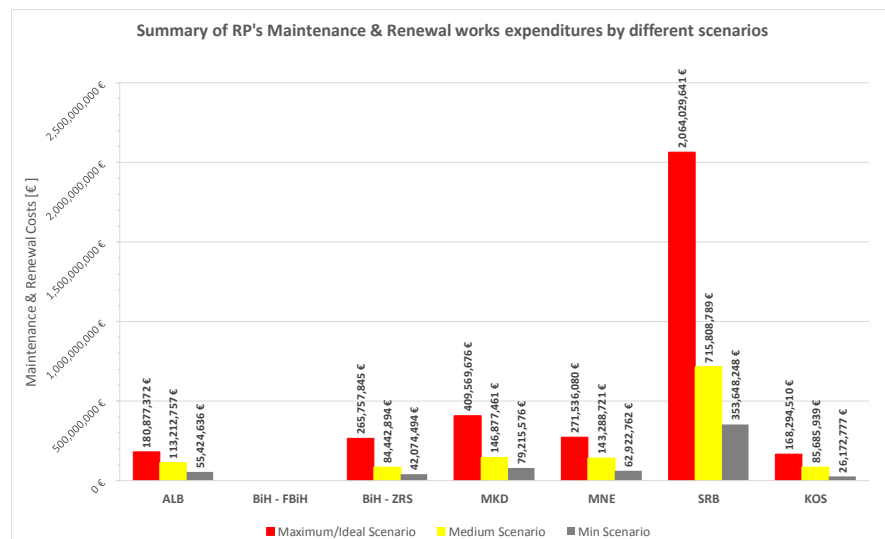*Figure 1: Rail Infrastructure 5-year (2019-2023) M&R Budgets for all 3 scenarios*

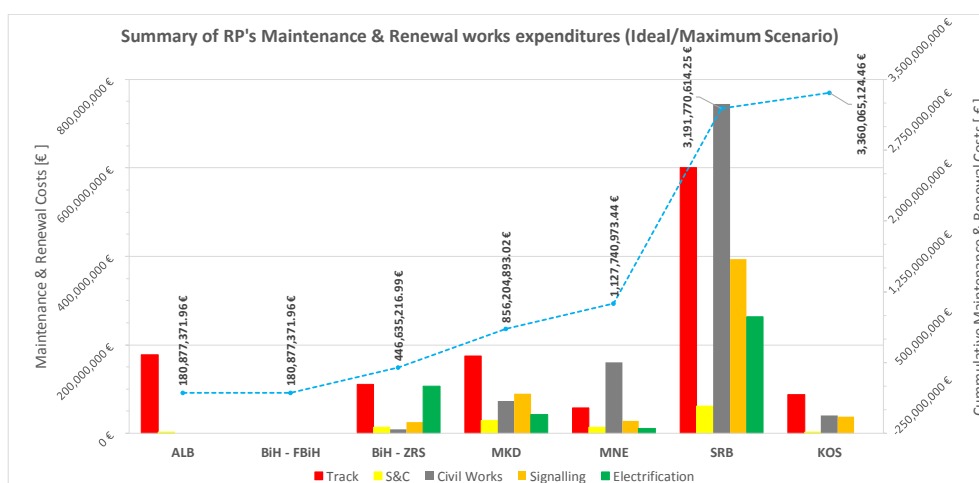*Figure 2: Rail Infrastructure 5-year (2019-2023) M&R Budgets for all 3 scenarios (per RP)*

Figure 3: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Ideal/Maximum" scenario (per RP)
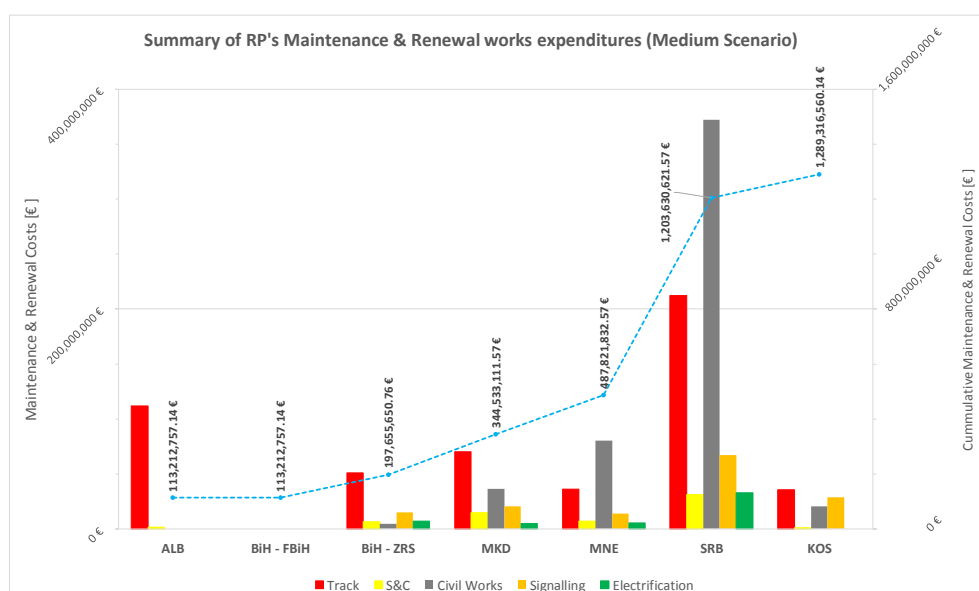

Figure 4: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Medium" scenario (per RP)
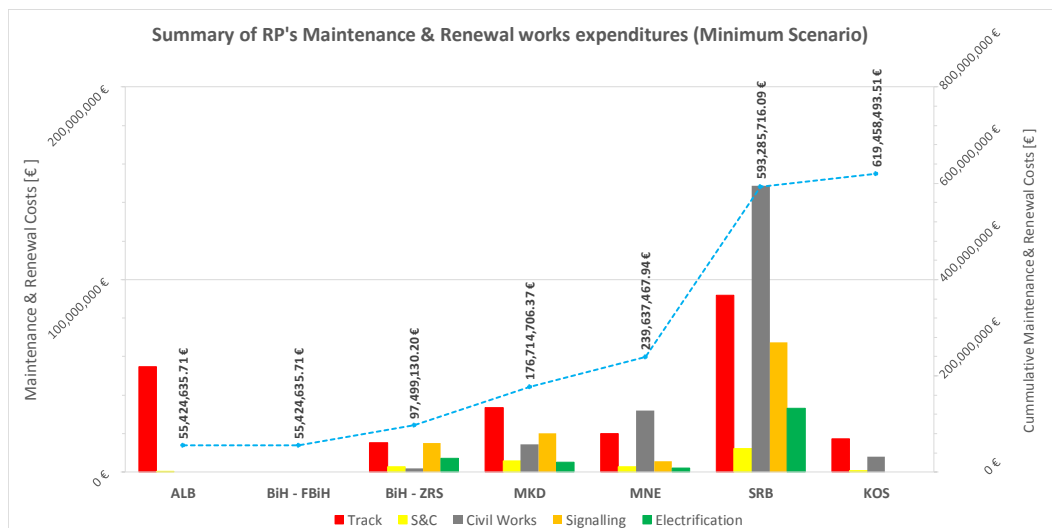
Figure 5: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Minimum" scenario (per RP)

An extremely important note, reflecting significantly on the mentioned budgets is that ***<u>no analysis of the substructure could be performed in this study, due to the fact that no data on it were found to exist</u>*** and no measurements at all (e.g. Ground Penetrating Radar) are being performed to check its quality. On the other hand, many track problems originate exactly from substructure, especially as the substructure is in most cases in its original form, from the times when the railway lines were constructed, which often means many decades ago, and when the material for embankments was used indiscriminately, i.e. it was not tested for its suitability for embankments, but instead, whatever material was found in the nearby cuttings was directly used for embankments/fills. Moreover, the lines were constructed for much lower axle-loads and annual traffic loads, which over the years were significantly increased and for which the substructure was definitely not adequate, all of which caused its further and accelerated deterioration. For that reason, many embankments are of (very) inferior quality, incapable of holding the current axle-loads and annual traffic loads, which is causing the majority of track problems. Finally, as reconstructions of the substructure have rarely (or never) happened since the construction of the lines, the geometry of the substructure (primarily width of the capping layer) is still as it was when the line was constructed, i.e. suitable for old-fashioned superstructure elements, primarily sleeper length. Thus, modern superstructure elements cannot be even installed on top of such inferior substructure, as capping layers are too narrow to hold it with required length of sleepers, width of the ballast shoulder, ballast depth/height and ballast slope (usually required as 1:1.5), –In short, in most cases, modern superstructure cannot even be installed on top of the existing substructure. ***Thus, if modern superstructure is to be installed, the substructure would first have to be reconstructed, which would require tremendous costs, a quick estimate of which could be that it could very well match the overall costs of superstructure (explained above in the previous paragraphs), if not even exceeding it.*** This would have to be taken into serious consideration when planning improvements of the railway infrastructure in the WB6 region.

Looking back over the entire Project and knowing that M&R of the whole transport (and especially rail) infrastructure is still one of the major challenges in the region, primarily with regard to the institutional framework and budget allocation to infrastructure asset preservation and the existence of structured processes, tools and skills for assets' condition-monitoring, analysis and consequential M&R planning where previous assessments concluded that 22.5% and 18.8% respectively of the indicative extension to TEN-T C&CNWB were found to be in need of maintenance and/or rehabilitation [8], ***the above-listed deliverables directly represent clear and objective confirmation of these previous assessments, as well as establishing sound basis for the improvement of this situation***. Indeed, ***this Project not only confirmed previous assessments, but made much more precise and, above all, significantly more objective assessment of the RIA condition and consequential M&R needs and budget, which proved to be even graver than the original assessments***.

Also, as it was already known before this Project, and which served as the initial motive for the performance of this Project, in order to ensure the sustainability of the rail network in the WB6 region, which plays an important role in the socio-economic development of the region, proper M&R is indispensable in order to maintain the required quality of service for its users, ensure economic and efficient rail transport system's cost, as well as preserve all RIA. In that sense, *this Project directly served its purpose, as it provided not only the most accurate assessment of RIA condition and M&R needs and budget yet, but also assessment of related traffic safety and provided direct solutions and proposals for the remediation of this situation, in the sense of strongly advocating far more frequent RIA condition monitoring, as well as concepts for M&R performance under the PBMC concept with the involvement of Infrastructure Maintenance Contractors (IMCs)*. This Project also *provided not only examples of the best PBMC practice in Europe*, but also clearly elaborated and *proposed optimal contractual relationships between the Infrastructure Managers (IMs) and IMCs, within the PBMC framework, based on most appropriate KPIs as controlling parameters, clearly elaborated and defined in the Project* (Report 3).

Moreover, in this sense, this Project undertook a detailed assessment of the institutional and budgetary framework for the rail M&R, proposed best practice solutions, considering the situation in the WB6 region and prepared a detailed M&R plan for 2019-2023 for the indicative extension of the TEN-T Road/Rail Core/Comprehensive Networks in the WB6. Such an elaborate M&R Plan, as delivered in this Project, can thus serve as direct support to the WB6 ministries responsible for transport and infrastructure, railway IMs in further planning and programming infrastructure M&R, as well as the SEETO Secretariat in monitoring the implementation of relevant transport measures in the framework of Connectivity agenda.
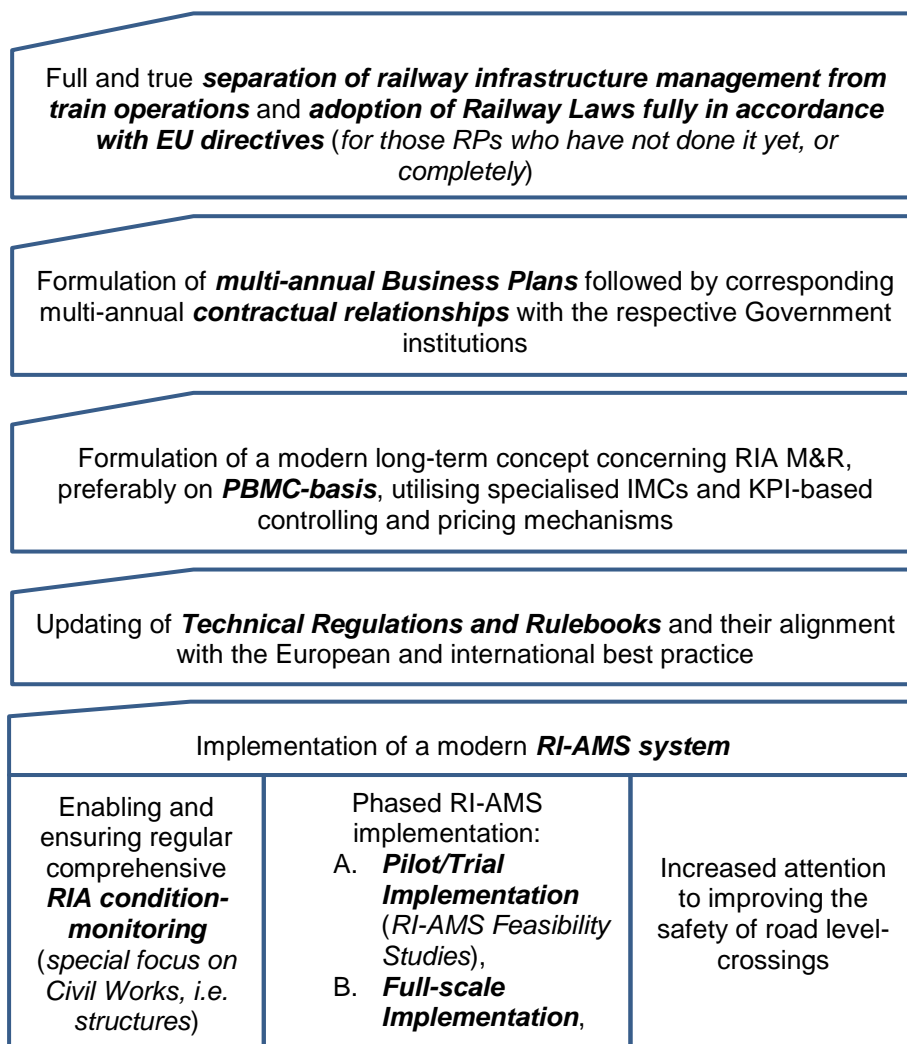
Thus, this Project directly served and provided invaluable support to the soft measure "Establishment of functioning maintenance system ensuring no section in poor/very poor condition by 2020" defined through the agreement by the WB Prime Ministers in Vienna (August 2015), provided a starting point and a cornerstone for improvement of the overall rail network condition in the WB6 region and laid down in detail the key related M&R systems to support and sustain such improvements.

In this way, the Project directly supported efforts for the establishment of the Core Network and modification of the Comprehensive Network in the Western Balkans (WB) and ensured they truly provide a structure for more concentrated development of infrastructure in the entire WB6 region, with the final goal of enhancing connectivity and mobility and joining WB with the EU TEN-T network.

Finally, key recommendations were made concerning the RIA condition, the ways in which they should be monitored, as well as how M&R works should be performed. Especially important here are the conclusions of Report 3 concerning the PBMC concept and the utilisation of Infrastructure Maintenance Contractors currently active in the region, e.g. ZGOP and RŽD-I (though both currently operating only in Serbia) as the volume of M&R works to be performed is indeed large and by far exceeds the current capabilities of WB6 RPs.

Tentative Action Plan

Based on the key conclusions and recommendations from the entire project and all of its Activities and deliverables, elaborated in detail in the respective Reports, the following tentative Action Plan could be formulated, leading towards the achievement of the key Project goals under "ideal" circumstances.

Full and true *separation of railway infrastructure management from train operations* and *adoption of Railway Laws fully in accordance with EU directives* (*for those RPs who have not done it yet, or completely*)

Formulation of *multi-annual Business Plans* followed by corresponding multi-annual *contractual relationships* with the respective Government institutions

Formulation of a modern long-term concept concerning RIA M&R, preferably on *PBMC-basis*, utilising specialised IMCs and KPI-based controlling and pricing mechanisms

Updating of *Technical Regulations and Rulebooks* and their alignment with the European and international best practice

Implementation of a modern *RI-AMS system*

Enabling and ensuring regular comprehensive *RIA condition-monitoring* (*special focus on Civil Works, i.e. structures*)	Phased RI-AMS implementation: A. *Pilot/Trial Implementation* (*RI-AMS Feasibility Studies*), B. *Full-scale Implementation*,	Increased attention to improving the safety of road level-crossings

Key insights and recommendations

The key insights and recommendations for the future and improvement of the current, relatively inferior condition of the rail infrastructure in the region were provided, stating:

1. *Condition-monitoring* - all RPs have for decades suffered from an inability to measure the condition of various railway infrastructure assets (RIA); some of them have been performing ad-hoc Track Geometry (TG) measurements, but very rarely, although the regulations of all RPs clearly stipulate a minimum of two TG measurements per year; in that sense, in the 5 years, only IŽS (SRB) have been measuring TG quite regularly, but with an outdated measuring car, so the measurements are quite questionable, whereas as for the others, MŽI (MKD) measured only twice, once in 2010 and in 2013, ŽRS (BiH) also twice, the second one being a donation and the quality of which was reported as very low rendering it unusable, KOS is measuring with a system that is reported as inaccurate and unreliable, and the others are not measuring at all. The intention would be, as a minimum, to acquire a TG system and to measure twice a year for at least 2 years (i.e. minimum 4 measurement runs) in order to establish deterioration trends and be able to truly say something about TG behaviour and consequential ballast and substructure quality and M&R needs. Ideally, TG would be accompanied by: vehicle/track

interaction monitoring, rail profile measurement system, rail corrugation measuring system and possibly Ground Penetrating Radar. An absolute ideal would be to add Overhead Line (OHL) geometry and wear measurements. However, TG is of paramount importance, so that would definitely constitute the minimum. The expected duration of such a project would be about 2 years. Direct benefits of the project would include:

a. Enabling the only manner for precise and objective determination of M&R works needs and prioritisation between them (determination of urgency levels).

b. Promoting contractual relationships between the responsible Ministries and Infrastructure Managers (IMs), as well as between Infrastructure Managers and Infrastructure maintenance Contractors (IMCs) (e.g. through PBMC concept), as *RIA condition-monitoring data are indispensable for the creation of infrastructure KPIs*, and which are of paramount importance for proper monitoring of the entire contracting process.

c. Precise and objective RIA condition-monitoring data forms indisputable grounds and arguments for the requests to International Financing Institutions (IFIs, e.g. banks) for funding of RIA M&R works as it promotes complete transparency and objectivity rather than subjectivity and "rule of thumb", which is how IFIs mostly perceive the IMs estimates and requests nowadays.

2. *Condition-analysis of Civil Works (structures)* i.e. bridges, tunnels, culverts, etc., where bridges are arguably the most critical (*Structural Health Monitoring - SHM*). The idea is to identify the most critical types of bridges, and based on that, the most critical single bridges, e.g. one bridge per RP, and to equip it with the necessary condition-monitoring systems, measure and follow the condition over a period of 2 years, analyse it and produce conclusions on bridge behaviour and appropriate M&R works and their urgency that would be valid and applicable to all other bridges of a similar type. *The e*xpected duration of such a project would be about 2 years.

3. *Testing of a RI-AMS system* i.e. *RI-AMS Feasibility Studies*; Considering the widely reported benefits of RI-AMS worldwide over the past couple of decades, stating M&R cost-reductions in the range of 5-15%, as well as significant improvements of overall RIA quality and consequential rail traffic safety, the idea is to use the asset register created in the current Project, bring in a suitable RI-AMS system (on the basis of Trial Licenses), and test the system on 30-50km long sections at each RP. The goal is for the RPs to understand what is needed to implement a RI-AMS, and the benefits RI-AMS can bring, how much it can improve the RIA M&R process, how much money it can save based on optimal M&R planning and how it can be used for M&R outsourcing (e.g. within PBMC), etc. Also, obviously, it should serve as the preparation for the subsequent full-scale RI-AMS implementation. Expected duration of such a project would be about 2 years.

4. *Updating of existing regulations and rule-books*; all RPs are utilising heavily outdated documents (normally from 1960-1970, and except for Albania, all others are still utilising old Yugoslav Railways (JŽ) documents). This is keeping them very far from modern best-practice, and thus incapable of catching up with modern European railways, especially in the domain of Condition-based M&R planning, and effectively incapable of adapting optimal M&R outsourcing and PBMC concepts. This is of paramount importance, as all WB6 RPs cannot even begin to expect to get closer to the European level, while adhering to the decade's old regulations. The project should first analyse all regulations, establish gaps and needs and perform prioritisation. This project could take two different paths: (1) update only the top priority documents (needing about 1 year), or (2) update all documents (needing up to 2 years).

5. *Improving the safety of level-crossings* (LCR) – there are still a tremendous number of LCRs present on the WB6 rail networks, including the SEETO Core & Comprehensive lines, the safety level of which is at best questionable and in many cases very low. Clearly, an ideal solution would be a grade-separation between road and rail, but that is again, clearly, very expensive and time and effort-

consuming. Nevertheless, the number and level of risk of these LCRs demands urgent action in the following senses:

a. Establish a database of LCRs, with all relevant characteristics and parameters, primarily pertaining to traffic safety, both road and rail

b. Identify several of the most critical LCRs whose behaviour and events (primarily incidents, or close-incidents) would be monitored more closely (a couple per each RP)

c. Investigate possible options for quick and cost-effective improvement of traffic safety (again both rail and road) on all LCRs (primarily those identified as most critical)

d. Investigate possibilities for permanent remote safety-monitoring and condition-monitoring of LCRs, all with the aim of increasing road and rail safety

1 Project Purpose and Objectives

1.1 Project purpose

The purpose of the project is to undertake an assessment of institutional and budgetary framework[s] for the road/rail maintenance, to propose best practice solutions with regard to the situation in the Western Balkans and to prepare the maintenance plan for 2018 - 2022 for the indicative extension of the TEN-T Road/Rail Core/Comprehensive Networks in the Western Balkans.

This project provided direct support to the Western Balkans' ministries responsible for transport and infrastructure, road authorities, railway infrastructure managers in planning, programming infrastructure maintenance and the SEETO Secretariat in monitoring the implementation of relevant transport measures in the framework of the Connectivity agenda.

1.2 Objectives

The soft measure: "Establishment of functioning maintenance system ensuring no section in poor/very poor condition by 2020" should focus on implementing a sustainable and optimized solution for managing and maintaining infrastructure assets, targeting the indicative extension of TEN-T Road and Rail Core/Comprehensive Networks.

Infrastructure maintenance for roads and rail network should be aimed at the preservation of assets and promotion of sustainability for the future. There is a need for a multi-dimensional approach to be taken in terms of institutional and operational management of the assets. This should include:

(i)   Institutionalizing sound asset management practices to enable countries to collect [data on and], manage and analyze conditions across Core/Comprehensive networks, which will then be used to optimize road/rail maintenance strategies;

(ii)   Maintenance Contracting Strategy to make use of Performance-based Contracts to introduce a cost-effective form of contracting aimed at preserving infrastructure assets.

The general objective is the improvement of infrastructure conditions in the indicative extension of the TEN-T Road/Rail Core/Comprehensive Network in the Western Balkans. Infrastructure improvements will lead to increased performance of the transport networks and increased competitiveness of the region.

2   Transport Sector Background

The TEN-T Regulation 1315/2013 forms the current legal basis for the development of the Trans-European Networks (TEN-T)[1]. The European Commission has concluded that the TEN-T network would be best developed through a dual-layer approach, consisting of a Comprehensive Network and a Core Network.

- The Comprehensive Network constitutes the basic layer of the TEN-T. It consists of all existing and planned infrastructure meeting the requirements of the TEN-T Guidelines. The Comprehensive Network is to be in place by 31 December 2050.

- The Core Network is a focused sub-set of the Comprehensive Network, overlaying it, to connect the strategically most important nodes, hubs, and links/routes of the Comprehensive Network.

Therefore, only parts of the Comprehensive Network are selected for the Core Network, which are essentially the components of TEN-T with the highest European added value in terms of addressing cross border missing links, key bottlenecks, and multi-modal nodes. The Core Network is to be in place by 31 December 2030.

In a future EU enlargement, the transport networks of future Member States would be required to be integrated into the EU TEN-T Network at any given time. Coherence between network development and compliance with EU regulations would undeniably enhance the integration process.

The Western Balkans Comprehensive Network is strategically located with regard to the European Transport system. It constitutes a physical transport corridor that enables the continuity of different parts of the TEN-T Network, providing connections for the Central European Countries to the Black Sea and further beyond to Asia. In June 2015, the transport infrastructure related Ministries of the WB6 and the European Commission (DG NEAR and DG MOVE) indicatively identified the main transport axes that will be connected to the existing TEN-T Core Network Corridors[2]. This was carried out in accordance with the application of the *"Planning methodology for the trans-European transport network (TEN-T)[3]"*, which sets out many of the specific criteria for identifying the network's Core nodes and subsequently, Core links in terms of connecting Core nodes.

The WB6 agreed on the alignment of their core transport networks, which shall be developed in line with EU recommendations. Independent of their anticipated future membership of the EU, these countries are already moving towards improving their transport systems in terms of both infrastructure and operational measures.

Furthermore, in June 2015 during the TEN-T Days in Riga, three of the nine identified Core Network Corridors (CNC) were proposed to be extended for the Western Balkans. The three identified CNCs are:

- the Orient-East Mediterranean (OEM) Corridor which connects central Europe with the maritime interfaces of the North, Baltic, Black and Mediterranean seas;

- the Mediterranean (MED) Corridor which links the Iberian Peninsula with the Hungarian-Ukrainian border,

- the Rhine/Danube Corridor which provides the main east–west link between continental European countries, connecting France and Germany, Austria, the Czech Republic, Slovakia, Hungary, Romania, and Bulgaria all along the Main and Danube rivers to the Black Sea.

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[1] Recently amended (Commission Delegated Regulation (EU) 2016/758 of 04.02.2016)

[2] as considered by Article 8 of the Regulation (EU) 1315/2013. The indicative extension of the TEN-T Network to the Western Balkans Region is articulated in EC Regulation 2016/758, which amended the TEN-T Regulation.

[3]Building the Transport Core Network: Core Network Corridors and Connecting Europe Facility {COM (2013) 940 final}

3 The Team of Non-Key Experts (NKE) and Scope of Services

3.1 The Rail Team of Non-Key Experts

The Team of Non-Key Experts, established for the scope of this specific project, consists of eight (8) Senior Experts, presented in the following table, as per the AO:

Position in ToR	Name	Category
1. Project Manager	Giorgos Xanthakos (GX)	SNKE
2. Railway Maintenance expert	Stasha Jovanovic (SJ)	SNKE
3. Railway Engineer	Tatjana Simic (TS)	SNKE
4. Economist-Financial expert	Ioannis Filopoulos (IF)	SNKE
5. Railway Institutional & BP expert	Dragomir Mandic (DM)	SNKE

This team was supplemented by four local SNKE which supported (horizontally) all three, on-going, connectivity reform sub-projects (ITS, Maintenance Plans and Road Safety), as follows:

- Emiljano Zhuleku for Albania and Kosovo
- Jovan Hristoski for the former Yugoslav Republic of Macedonia
- Amna Redzepagic for Bosnia and Herzegovina
- Dusan Savkovic for Serbia and Montenegro.

3.2 Scope of Services

According to the ToR (Chapter IV, Component 2), in **Activity 1**, the CONNECTA team was to analyse and assess the institutional aspect of current M&R practices of the TEN-T Rail Core/Comprehensive Network to WB6 countries. This meant analysis and assessment of relations, obligations, responsibilities and assignments of all institutions involved in M&R railway sectors in the beneficiary countries. It implied also analysis of capacity building and legal aspects of this matter.

In **Activity 2**, the CONNECTA team was to assess the institutional level of adherence to the State's railway strategy, particularly for railway infrastructure, with EU directives in the beneficiary countries. Particular attention was to be made to harmonization with Directives 2012/34. Also important is the assessment of the level of application of these Directives in existing legal documentation (Railway law, National program for railway infrastructure, Action programs or plans for railway, Network statement, etc.). The CONNECTA team's assessment was to cover regional Infrastructure Managers' Business Plans from an institutional standpoint.

In **Activity 3**, the CONNECTA team was to assist in the design and implementation of the Infrastructure Manager's (IMs) Asset Register (AR), i.e. the infrastructure database (ID), which is an institutional precondition for common railway Infrastructure M&R policy and strategy. The importance of adjusting the railway IM's ARs at RPs is well described in the ToR (Chapter IV, Component 2, Activity 3).

In **Activity 5**, the CONNECTA team was to analyse present contract strategies of regional IMs and from an institutional standpoint. The goal was to recommend common institutional strategy, as described in the ToR.

In **Activity 6**, linked closely with Activity 5, the CONNECTA team was also to analyse two different contractual arrangements between the State and IM from an institutional standpoint. Moreover, it was deemed very important to analyse their compliance with the basic principles laid down in Annex V (referred to in Article 30) of the Directive 2012/34.

In **Activity 7**, the CONNECTA team was to analyse and recommend Institutional Rail (Infrastructure) Asset Management Systems (RI-AMS) in the region based on a predictive maintenance strategy with minimum life cycle costs. Institutional Transport Authorities of beneficiary countries were also to take stock of the progress. Also, it was deemed important for institutions to ensure monitoring and measurement of RIA condition in the region. Additionally, a monitoring mechanism was to be foreseen in order to deal with the RIA and their condition.

Finally, in **Activity 8**, the CONNECTA team was to assist in preparation of the M&R Plan for 2018-2022 (shifted to 2019-2023). Within this, institutional involvement was deemed necessary to ensure active participation of all institution and bodies in beneficiary countries

The deliverables and their submission dates are indicated in the Table 3.2 below for each of the components.

Table 3.2. Submitted deliverables - Railways

Report No.	Report title	Draft	Final
1	Inception Report (common for Road/Rail)	07/07/17	02/08/17
2	Needs assessment and Scoping in WB6	26/12/17	31/10/18
3	Analysis of present contractual relations in WB6	02/03/18	31/10/18
4	Recommendations for setting up Railway Infrastructure Asset Management System (RI-AMS)	21/04/18	31/10/18
5	Maintenance Plan for budget scenarios	17/06/18	31/10/18

4 Rail Maintenance Plans

4.1 Background information

The complexity of today's railway sector imposes high and manifestly conflicting demands for railway Infrastructure Managers (IM). On the one hand, there is ever-growing demand for the increase in capacity and traffic volumes in order for railways to generate revenues, and on the other, the even fiercer demand for the reduction of costs, primarily in the domain of Infrastructure Maintenance & Renewal (M&R). These conflicting demands are placing tremendous pressure on the IMs who are effectively required to keep railway infrastructure assets (RIA) constantly available for the traffic and at the quality level required by the traffic, with the availability demands reaching values of 98%, but at the same time facing ever tighter budgets and shrinkage of investments for the RIA, with the threat that they only get smaller in future. As if this was not challenging enough, on top of all that, IMs are held highly accountable for all the investments they have labelled necessary and are required to justify and defend every single expenditure made on the ageing RIA, even the minutest, requiring ever more remedial interventions.

At the same time, in order to ensure the required RIA availability at the required quality level, IMs must thoroughly understand the behaviour of RIA in order to grasp the root causes of the problems occurring in order to accurately target the M&R activities and prevent repetitive interventions due to inappropriate actions causing costly reductions in availability. Ideally, thorough understanding of RIA conduct would eventually lead a step further to the ability of forecasting the behaviour, thus preventing a great deal of the failures causing traffic disruptions and enabling timely planning of necessary M&R action, thus at the end reaching double cost-savings by organizing the M&R activities in the optimal cost-effective manner.

However, understanding the behaviour of RIA is a far from trivial task. Infrastructure consists of a large number of objects & elements, of different age, type and manufacture, submitted to different volumes and types of detrimental influences, primarily railway traffic, as well as reacting differently to different types of remedial activities performed with different qualities. As a consequence of all this, each of these objects exhibits different behaviour under different circumstances, as seen via various RIA condition-parameters. Such a plethora of issues, aspects, combinations and interrelationships makes it practically impossible for IMs to perform their difficult managerial tasks efficiently, irrespective of their knowledge and experience.

This is why, according to the modern RIA Maintenance Management concept, in order to manage railway infrastructure properly, two things are an absolute must:

A. to improve the means by which the performance of the infrastructure is monitored and

B. to have reliable methods and means for the condition-assessment and prediction and consequential M&R planning.

At the same time, this directly describes the conceptual framework of a properly designed Railway Infrastructure Asset Management System (RI-AMS), which was also a direct subject of Activity 2.7, encompassed in Report 4, submitted in April 2018.

It must also never be forgotten that RIA represent by far the most expensive items in the railway industry, consuming M&R expenditure of monstrous proportions every year. For that reason, any reduction of this expenditure and extension of RIA service lives would have a significant impact on the overall RIA Management efficiency.

The process of determining whether, when, where and how to intervene and deciding on an optimum allocation of resources, while minimizing the costs, is very complex because [1].

- different track sections tend to behave differently under the effects of loading and environment;

- decision processes for M&R works are closely interrelated technically and economically;
- decision-making for M&R is based on a large quantity of technical and economic information, extensive knowledge and, above all, experience.

The essence of modern RIA Management is that it entirely relies on the diagnostic concept, meaning on the **condition-based** approach, as well as analysis of criticality and urgency for all key RIA.

4.1.1 Existing circumstances concerning M&R present in regional participants (RPs)

The exact circumstances concerning M&R planning and undertaking at the Regional Participants (RPs) were already established during the initial visits in September 2017, subsequent visits and all the documents received. Also, from other available documentation, primarily from SEETO, e.g. SEETIS (SEETO data base), The Regional Balkans Infrastructure Study (REBIS) Update [7], Report on rail maintenance on TEN-T Core Network in Western Balkans [8], as well as [9]-[11], it could also be understood that the level of seriousness and structure of their approach, as well as its sophistication, was not particularly high.

In that sense, a recent report from SEETO, namely "*Report on rail maintenance on TEN-T Core Network in Western Balkans*" [8], analysed three main topics regarding railway maintenance: current legislative and strategic framework, budget allocation and maintenance needs as well as their influence on the current condition of the network. This report summarised, in a comprehensive way, the current situation in WB6 stating: "*Even though many of the WB partners have transposed and implemented previous EU railway related legislation with provisions on maintenance and infrastructure development, they have not yet transposed the recast Directive. However, many of them are planning to do so in the upcoming period (e.g. the former Yugoslav Republic of Macedonia, Montenegro). Except for the former Yugoslav Republic of Macedonia which already has a railway strategy and the Republic of Serbia where the railway strategy is under approval, dedicated railway strategies do not exist and are mostly part of the wider national transport strategy[4]. As for the multi-annual contracts, a three-year multi-annual contract has been in implementation in the former Yugoslav Republic of Macedonia since 2011. During 2016, Serbian Railway signed a five-year multi-annual contract (MAC),). At the end of 2017, the Annex 2 of MAC was amended in the form of Annex 3, when the financial structure of the contract was changed and the financial resources amounting to 440 million RSD were added for emergency interventions on some railway lines. In February 2018 Annex 4 of MAC was also signed. Montenegro and Kosovo have prepared multi-annual contracts, but due to certain constraints in budgetary allocation for periods longer than one year, these contracts have not been signed yet. Most of the Regional Participants have separated infrastructure manager (except for Albania – that has partially transposed the SERA directive, including the separation of IM from RUs and future development strategy for the IM - and Bosnia and Herzegovina) from transport operations (railway undertakings).*

This is beneficial in order to focus on the activities of the infrastructure companies, improve their management and to prevent any cross-subsidization.

As for the condition, 26% of the Rail Core Network has been reported to be in very good and good condition, where approximately 70%-100% of designed speed can be achieved. The largest part of the Core Network is in medium condition (1,082 km), with larger variations in the maximum allowed speed. On these sections, approximately 42%-88% of designed speed can be achieved. 29% of sections have been reported to be in a poor condition, where on average 55% of designed speed can be achieved. Large variations in speed and condition exist on small stretches, influencing the reliability, speed and punctuality of railway undertakings. More systematic national and regional planning of rehabilitation projects and maintenance is needed to address this issue.

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[4] In that sense, SRB does seem to have some strategy for rail transport in the form of two documents: (1) "*National Program for the Development of Public Railway Infrastructure for the period 2017-2021*" and (2) "*Master Plan for Railways for the period 2012-2021*".

Routine maintenance expenditure does not match the maintenance needs assessed by the railway companies. When comparing 2015 to 2011, budget allocated for maintenance decreased in most of the Regional Participants (except Kosovo). However, this was not a trend over the five-year period, rather large variations in budget from year to year. As for investment maintenance and rehabilitation projects, Serbia has been heavily investing in rehabilitation of its network, followed by Montenegro and the former Yugoslav Republic of Macedonia, but due to previous period of under investing in railways as well as the maintenance backlog, these rehabilitation projects are in many cases not sufficient and further funds are needed for modernization and reconstruction."

From the available documents, it was also concluded that, for most of the RPs, there was a complete absence of almost any kind of track record of RIA Maintenance and Renewal (M&R) works over several decades, and, at best, an unsystematic and mostly *ad-hoc* approach to M&R is present. For this reason, it should be no surprise that the RPs' Networks are in a very poor condition, where [8] 18.8% of the indicative extension to TEN-T Rail Comprehensive network to Western Balkans (WB) are in need of maintenance/rehabilitation.

However, the actual and exact level of this poor condition, as well as the locations bearing the worst conditions endangering the safety of traffic, still remain greatly unknown. This is due to the utter lack of:

- Consistent information on the exact location of all the RIA
- Consistent information on the systematic and regular RIA condition measurements, especially over a longer period of time
- Methods, knowledge and means for large-scale systematic RIA condition-data collection
- Methodology, standards and tools for the processing and analysis of the collected condition-data for the purposes of scheduling appropriate M&R works (i.e. the RI-AMS)

In light of the above, it was precisely the aim and intention of this part of the project to:

- undertake an assessment of the institutional and budgetary framework for rail maintenance,
- establish infrastructure databases (ID), i.e. the infrastructure Asset Registers (ARs),
- propose best practice solutions, considering the situation in the WB, and
- propose optimal structure and functionalities for the Rail Infrastructure Asset Management Systems (RI-AMS) to be acquired ASAP and deployed at the WB6 RPs and to be working on top of the ID/AR established within this project,
- assist WB6 RPs in preparing the M&R plans for 2018 – 2022 (in the first part of the project this was changed to 2019-2023) for the indicative extension of the TEN-T Rail Core/Comprehensive Networks in the WB.

The intention was to perform this project in such a manner that its results provide direct support to the WB ministries responsible for transport and infrastructure, railway infrastructure managers in planning, programming infrastructure maintenance, as well as to the SEETO Secretariat in monitoring the implementation of relevant transport measures in the framework of the Connectivity Agenda.

4.2 Key project findings

4.2.1 Inception

Within the first month, in July 2017, the **Inception Report** was delivered, outlining the Project purpose and objectives, describing the Team of Non-Key Experts (NKE), the Project office and the overall organization, communications and reporting concepts. It also laid out the Project analysis, containing Project context, existing regional structures – transport, transport sector background information, maintenance in the regional institutional transport context, as well as the overview of the current situation in railway maintenance in WB6 and listing the key institutional stakeholders at RPs and at Regional Level.

The Inception Report also assessed the risks and listed key assumptions, as well as explaining the intended concept for the Inception phase, including the kick off meeting, mobilisation, project organization, collaboration with Stakeholders, review of relevant documentation, missions and surveys, and finally listed all the key findings and conclusions from the Inception Phase.

The key part of the Inception Report, however, was the detailed explanation of the intended Methodological Approach, containing review and analysis of current M&R practices and needs, existing circumstances concerning M&R present in the RPs, tailoring the modern condition-based approach to the concrete existing circumstances present in the RPs as well as the institutional aspect of the Project.

In that sense, the essence of this Methodology was the fact that by far the largest portion of M&R budgets at all railways is spent on track superstructure elements, i.e. rails, sleepers, fastenings and ballast, where also, the relative relationship between renewals and maintenance is about 70% vs. 30%, Figure 6.
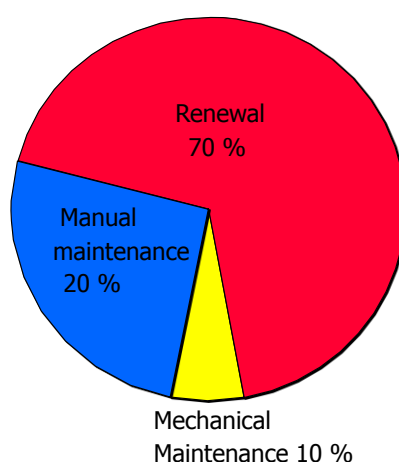

Figure 6: Total railway superstructure M&R costs on the Dutch Railway Network (ProRail), € 250 million per year for 4.500 km of tracks, price level 2006 [6]

This is why track superstructure was intended to be given most attention, with detailed analyses, based on assets' service lives (SL), and, where possible, asset condition-information, revealing assets' deterioration. However, as assets condition-information was later found to be quite scarce (only track geometry (TG) information was found to be existing for the past 5 years, and only in SRB (9 measurement runs) and MKD (2 measurement runs)), the prevalent focus had to be placed on the only remaining reliable information – assets SLs.

Once track superstructure necessary M&R works volumes and related costs were established, the intention was for the necessary M&R work volumes and costs of other RIA, i.e. civil works, signalling & electrical to be established on a bulk, in relative terms, with respect to superstructure M&R volumes and costs.

Finally, the Inception Report listed additional outputs of the project, as well as the relevant documentation, revised work plan and provided the minutes of the kick-off meeting (at SEETO).

4.2.2 Needs Assessment and Scoping in WB6

As planned and as per the ToR, the first Interim Report (**Report No. 2** in the entire Project) "*Rail Maintenance: Needs Assessment and Scoping in WB6*" was delivered in December 2017, following a series of visit to the RPs, and an extensive data-collection process, which started immediately after the initial visits were completed, as during those visits, it was established that virtually no ID/AR existed at any of the RPs, and without them, no RIA condition analysis could be performed and consequently no M&R plans could ever be produced.

An important conclusion that also came from the visits to the RPs was that it was realized that most of the M&R plans for the year 2018 were already prepared, thus that the horizon should have been shifted to 2019-2023 (instead of 2018-2022 as originally conceived), which was reported to SEETO and accepted by the Steering Committee.

In line with the Project's ToR, the purpose of Report 2 was originally set to:

- Review and analyse RPs' current M&R practices and needs thereof

- Analyse any existing RPs' Asset Registers (ARs), and structure the establishment of ARs for RPs where ARs were non-existent, in accordance with Article 30(7) of the Directive 2012/34/EU and inventory of data available in the region (structure of Infrastructure Database-ID).

- Assess RPs' Infrastructure Managers' (IMs') Business Plans (BPs) with respect to the requirements in accordance with Article 8(3) of the Directive 2012/34EU and provide recommendations for reviewing, preparing and monitoring compliant BPs.

The above was again fully in line with the soft measure "*Establishment of functioning maintenance system ensuring no section in poor/very poor condition by 2020*" defined through the agreement by the WB Prime Ministers in Vienna (August 2015), and basically intended to provide a starting point for improvement of the network condition and related M&R systems that should be supporting and sustaining such improvement.

The main challenge, however, in establishing M&R needs for the TEN-T C&CNWB was found to be the data (un)availability and (in)accuracy within the entire WB6 region. Initial findings showed that *most of the rail authorities did not perform regular infrastructure monitoring/measurements and that the RIA inventory data (i.e. ARs) were either non-existent, or not stored in a digital format, or/and often outdated*.

For the above reasons, in this period, until the submission of Report 2, the activities within the Rail domain, primarily focused on:

- Conducting a series of direct visits to the stakeholders/RPs in the WB6 region

- Ensuring full understanding on the part of the stakeholders of the aims, processes, outcomes and finally benefits of this Project, thus aiming at achieving their full "buy-in", which should guarantee their full support and commitment throughout the Project

- *Collecting the necessary information, documents and data, including:*

    o Institutional information

    o Business Plans and rail infrastructure development strategies

    o Economic/financial information

    o Valid Maintenance & Renewal (M&R) Regulations

    o *Infrastructure assets' (RIA) data* (primarily focusing on Asset Register, but also going beyond that, in cases where additional information (e.g. assets' condition-measurements) existed

    o Thorough understanding of the current M&R practices especially focusing on the identification of shortcomings and possibilities for future enhancements

- Utilizing the collected infrastructure data for laying the foundation for the design and implementation of the IMs ARs in accordance with the Article 30(7) of the Directive 2012/34/EU

Thus, the main benefits of that part of the Project were:

- ***Established foundation for the Railway Infrastructure Asset Register at all WB6 RPs***

- Identified missing data

- Established current M&R practices and their shortcomings with respect to processes, tools and skills, with indications for their future enhancements

- Established institutional aspects concerning M&R practices

- Established current regulatory framework for planning and undertaking M&R works

- Established current status of the Business Plans and their shortcomings, problems and needs for improvement

The key results of the activities performed in this period and laid out in detail in that Report were:

Infrastructure Data:

- ***There was a significant lack of funding provided for the RIA M&R, stretching decades into the past***

- Due to the previous item, ***there was a significant backlog in M&R works, reflected also in very low residual service lives of all RIA***, with some even going into negative values – i.e. the service lives have long been exceeded (i.e. ***RIA have long expired***) (Figure 7)

- The M&R backlog is of such a large scale that even if the funds for M&R were somehow miraculously instantaneously provided, ***they could not be realistically performed for quite a number of years***, especially if the RPs were to perform M&R works themselves, as traditionally done, i.e. without the introduction of Infrastructure Maintenance Contractors (IMCs) to outsource M&R to (this issue is to be analysed in more detail in the subsequent phases of the Project and to be reported in Report 3)

- RIA inventory data (i.e. ARs) mostly did not exist, ***but were nevertheless managed to be collected during the Project up to quite a satisfactory level*** (further improvements are needed, but the collected amount, level of detail and reliability of the data were generally found to be satisfactory); main groups of requested data, with respective percentages showing actually delivered data, are provided in Table 1 below (the situation is actually slightly better than represented in Table 4 as initial sets of data were received from ŽFBiH on December 4, 2017, but considering the volume of data and the amount of effort needed to sort them out, properly populate and reference and process in order to produce the results and statistics needed for this Report, it was too late for this data to be included in the Report 2, and the intention was for it be included in subsequent reports; for the same reason, the values of "0%" standing next to ŽFBiH data are actually inaccurate, but the real figure could have been established only after the data-analysis, for which, as said, it was too late, and thus could not have been performed for this Report, as it was already in its final stage of preparation).

- ***Most RPs do not perform regular RIA condition-monitoring, which left very little possibilities for performing objective condition-based M&R analyses***. For that reason, ***the analyses***

performed until then, and described in that Report, were mostly based on the RIA inventory data, where <u>RIA service lives</u> were found to be the most objective and reliable factor to be used. This was intended to be improved in the subsequent phases of the Project, if possible, i.e. if more precise and more reliable M&R assessments and plans/needs are to be performed, which is the ultimate goal of this Project

Table 4: Delivered Infrastructure data (Questionnaire + Data) with respect to the requested

Regional Participant		Network length [defined by SEETO]	Network length (Covered by data) [km]	Rails [%]	Sleepers [%]	Ballast [%]	Switches & Crossings [%]	Civil works [%]	Layout & Operating [%]	Electrical [%]	Signalling [%]	Overall condition data [%]	Other [%]	Total
Albania		396	380	96	96	96	80	0	60	100	0	0	5	57.78
BIH	ZRS	357	348	97	97	97	0	15	50	0	0	0	10	40.77
	ZFBiH	441	0	0	0	0	0	0	0	0	0	0	0	0
Kosovo		200	194	97	97	97	100	100	100	100	100	100	100	95.98
MKD		531	464	87	87	87	100	100	60	90	90	0	60	71.15
Montenegro		184	168	91	91	91	100	100	60	10	10	0	0	58.41
Serbia		1,723	1,723	52	0	38	75	100	60	95	95	40	60	61.92
TOTAL:		3,832	3,277	2,446	1,550	2,205								
			86%	63%	40%	57%								

M&R-related Regulations:

- M&R-related Regulations in all of the RPs have changed somewhat since the days when most of the RPs (with exception of those of Albania) belonged to the Yugoslavian Railway Network. This can be seen as both good and bad:

  - Good, as this means that most of the RPs still adhere to uniform (or at least similar) regulations,

  - Bad, because such regulations, being brought by the Yugoslav Railways, which disintegrated more than 20 years ago, and which were mostly created significantly prior to its disintegration, *are clearly outdated,*

  - Bad, because *most of the stipulations of the regulations* (outdated even if updated) *are mostly not followed*, due either to the lack of RIA condition-monitoring, or ultimately to the lack of funds received for both analysis of RIA condition, and primarily for the performance of the M&R works.

- For that reason, at the moment of delivery of Report 2, for the time being, relevant regulations were only identified and in subsequent phases of the Project, it was intended for them to be checked for compliance with the corresponding EU regulations, as well as for stipulations directly indicating the need of performance of M&R works and if the data required for their application are present.

Institutional aspects of M&R:

Albania: Albanian Railways (HSH) was found to be one of the public enterprises, which remained in the ownership and management of the Albanian state. Currently, the railway system in Albania was found to function as a single, state owned, monopolistic company, whose role was defined by the Railway Code, adopted in 2004. The company was found to have full rights on all sectors of railway, such as possession of railway infrastructure and operations, finance, human resource management etc.

The situation changed when the new Railway Law entered into force after 12 January 2018. This provided independent status of railway undertakings and the separation of the infrastructure management from its various transport operation activities. In line with all these radical reforms that came into force at the beginning of 2018, the Government of Albania was found to be considering and developing courageous moves to integrate private capital into Albania's railway infrastructure. This was found to be the only example among WB6 RPs where an RP is preparing itself for this solution at this moment.

Bosnia and Herzegovina (BiH): The complexity of Bosnia's state regulation was also found to be reflected in the railway sector. The legal framework for the railway sector was found to have established a "two-railway system". One railway system is Željeznice Federacije Bosne i Hercegovine (ŽFBiH) (or Railway of the Federation of Bosnia and Herzegovina - RoFBiH) in the Federation of Bosnia and Herzegovina (FBiH) and the second is Željeznice Republike Srpske (ŽRS) in Republika Srpska (or Railways of Republic of Srpska - RRS). BiH was thus found to be the only one of all WB6 RPs that has 2 state (entity) railway companies.

The entity governments were found to be majority owners of the railways located within their territory. They are responsible for its policy framework, performance oversight, and budgetary support. Both companies have been separated internally between infrastructure and operations but the account was found to be one, i.e. unique, for the whole company. Financing of the entire infrastructure (including M&R and traffic management) is based on annual contracts, but full and strict control of the spending of these funds and possible overflow to the operators was not found to be possible.

At BiH state level, two railway bodies were identified: (1) Bosnia and Herzegovina Railway Public Corporation (Bosansko-Hercegovacka željeznička javna korporacija – BHŽJK) under the Council of Ministry of BiH for the inter-entity coordination and (2) the Railway Regulatory Board (RRB), which is responsible for international regulation. The Governments of both Entities were found to be in the process of adopting Railway Laws that are supposed to be able to reform the rail sector and the separation of existing railway companies.

The former Yugoslav Republic of Macedonia (MKD) is the first in the WB6 region to have separated railway infrastructure and operation (08.05.2007). There were found to be two companies, PE Infrastructure Macedonian Railways (JP MZ Infrastruktura), and Transport Joint Stock Company Macedonian Railways Transport AD – Skopje (MZ Transport AD – Skopje).

There was also a Directorate for safety in the railway system – Safety Authority (under Ministry of Transport and Communication) and an Agency for regulation of the railway system – Regulatory body (under the MKD Parliament). MKD was found to have adopted a new Railway Law and Rail Safety Law in 2010, which meant that it was not possible for it to be aligned with EU directives 2012/34, as these were issued at a later stage.

Montenegro was found to have separated railway infrastructure and operations in 2008. At the moment in Montenegro there were found to be: one Railway Infrastructure company (Željeznička infrastruktura Crne Gore-ŽICG), two railway operators: (1) for Passenger transport (Željeznički prevoz Crne Gore) and (2) for Freight transport (Montecargo), as well as one Company for rolling stock maintenance (Održavanje željezničkih voznih sredstava a.d.), and a Directorate for railways. The new Railway Law was found to have been adopted in 2013.

Serbia was found to have separated the state-owned railway company Železnice Srbije, in 2015. At the moment in Serbia, 4 state-owned railway companies were identified: (1) for Infrastructure (Železnička infrastruktura Srbije a.d.), (2) for Passenger transport (Srbija Voz a.d.), (3) for freight transport (Srbija Kargo a.d.), and (4) for surplus property, inherited debts, and surplus of employees (temporary company, Železnice Srbije a.d.). There is also the Directorate for Railways (Governmental organization) as a separate organisation independent from the Ministry, from infrastructure manager and from any railway undertaking. The Directorate for Railways has the functions of a regulatory body, licensing authority and safety authority. The National Safety Authority was found to be a separate body from the Railway Directorate. The Railway Directorate is also responsible for issuing licenses and safety licenses certificates.

The Railway Law in Serbia was found to have been adopted in 2013 and amended in 2015. However, also, during the Project, "*Law on Railways*", "*Law on Interoperability of the Railway System*" and "*Law on Safety*

Railway Traffic" (which were supposed to be harmonized with the EU directives, including 2012/34) were adopted in May 2018.

Kosovo was also found to have separated railway infrastructure and operations in 2011. Two railway companies were identified: for infrastructure (Infrakos) and for operation (Trainkos), as well as one private company Railtrans. In North Kosovo, passenger traffic was found to be organized by the Serbian company Srbija Voz a.d.

A Railway Regulatory Authority was also identified, with its independent bodies (Licensing Department, safety Department, Market Regulation Department and Interoperability Department) and the Accident investigation Body which is under the Prime Minister's Office. Since the Law on Railways was adopted in 2011, it was found not be in line with the EU Directive 2012/34 issued later.[5]

The key observations concerning institutional aspects of all RPs could be summarized as follows:

- ***Very different institutional levels of restructuring the railway sectors exist***, ranging from not restructuring at all, as in BiH, via those still at the beginning of this process, as in Albania, up to those who started ten years ago as in MKD and Montenegro,

- Regardless of the differences stated in the previous item, ***all Railway Infrastructure is still effectively state-owned***,

- All RPs possess Regulatory Bodies (Directorates or Agencies), and some of them also contain Safety Authorities or Directorate for Investigation (e.g. in Albania, MKD, Serbia and Kosovo),

- ***In all WB RPs, Railway Law still does not comply with the EU Directive 2012/34, even in Montenegro where this Law was most recently adopted***,

- All RPs have a multi-annual (medium, three- or five-year, or long-term, e.g. ten-year Plans or Programs) for RIA M&R or modernization,

- ***Despite the previous item, in all RPs financing is still based on annual contracts***

Business Plans, financial aspects and their related aspects with M&R:

In the interim report delivered in December 2017 the financial position of the Albanian, Serbian and Montenegrin IMs was analysed, as the relevant documents were received for them. The analysis was based on the assessment of specific sections of Business Plans (BPs) dealing with financial issues, as well as their Implementation Programmes. The key conclusions identified were that:

- All three IMs were found to be in the process of integrating within their organisations the framework created by Directive 2012/34/EU, especially its financial dimension. This was found to be clearly noted through the development of BPs and Implementation Programs of the latter. However, the three IMs was found not to be at the same level of progress, with the Serbian IM (IŽS/IoSR) assessed as the most advanced, followed by the Montenegrin IM (ŽICG) and then the Albanian IM (HSH).

- All three IMs were found to have a negative financial position, since expenditure was found to be higher than revenue. However, this could be considered as normal even for some EU IMs, which was a reason behind the adoption and implementation of Directive 2012/34/EU. IMs were found to be in the process of changing their business behaviour as a result of signing contractual

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[5] Comment of KOS RP: the Law is in compliance with the Directive 2012/34 EU, because everywhere in the Law is written that the "*certain matter should be in compliance with the future SERA Directive*". This means that the Directive 2012/34 EU shall apply always.

agreements with relevant State authorities for infrastructure services. They were also found to be incentivised to increase revenues, e.g.: increase of prices in services offered, reduction of operational costs, as well as development of new markets (access fees to private users). These issues would have to be reflected within IMs multi-annual Business Plans and subsequent Implementation programmes.

- *All three IMs were found to be heavily dependent on State subsidies*, representing the major part of their revenues. On the other hand, *staff salaries and social advantages were also found to represent the major part of their expenditures*. In certain cases (IŽS and ŽICG) international lending was found to be considerable and necessary for their development.

- IŽS was found to have a ten-year Business Plan and a five-year Implementation Programme. The Serbian IM was found to have established a clear strategic framework focusing on the rationalisation of its operations, the reduction of its staff and the setting of a series of performance indicators, such as the decline of the Government subsidy in terms of GDP (currently 0.125% and should reach the level of 0.10% by 2027). Other performance indicators concern the establishment of financial performance ratios such as liquidity (quick, general), as well as profitability, cost-efficiency, activity and productivity. However, still staff salaries were found to constitute a major part of its operational expenditures and it is heavily dependent on State subsidy.

- IŽS's Implementation Programme was found to be spread out over a five-year period, including a comprehensive investment program aiming at the modernisation of the railway infrastructure, including projected financing from international lenders, such as EBRD, Kuwait development fund, etc.

- ŽICG's Implementation Programme was found to be made on an annual basis and not on a medium-term basis. At the same time, no setting of specific performance indicators was noticed, nor the intention to reduce the share of country's GDP dedicated to railways infrastructure. On the contrary, it was noticed that the Government subsidy has increased due to the inability of ŽICG to fulfil its loan obligations towards international lenders.

- A positive point for ŽICG was found to be the strategic intention to reorient its services: (a) by expanding its freight segment (b) examining the possibility of increasing prices of the services offered and decreasing costs and (c) setting financial performance indicators to achieve balanced budgets, without referring to the timing, or the indicators, however.

- As far as HSH is concerned, the main comment was that the company has not proceeded to the splitting of its operations into 3 sections, one of them to be the IM. The latter has to be given all necessary tools to perform its duties, i.e. multi-annual Business Plan, Implementation Programme. Both of them would have to include the setting of financial performance indicators.

Key recommendations concerning these issues included:

- *All three IMs have to proceed to a serious cost analysis in order to reduce their costs.* This can be achieved through the conduct of a cost benefit, sensitive analysis, which is highly recommended. As such, when all costs and benefits have been identified and quantified, net economic benefit can be determined by calculating the various projects and costs net present value, internal rate of return and benefit-cost ratio.

- HSH has to split up operations and create a separate IM in charge of managing railways infrastructure maintenance activities, which should be accompanied by a series of actions listed in detail in chapter 7.3 of the Report devoted specifically to these issues.

- Pricing methodology should be reassessed by the IMs, especially before signing contractual agreements with State authorities. In order to determine the charges for the use of the railway infrastructure, the base prices of the costs of the line maintenance and traffic management should be taken into account. Baseline values are calculated as the quotient of the total cost of the respective services divided by the total number of train/kilometres. Baseline values give rise to base limit values for line maintenance and traffic management services (a price calculation example is presented in detail in the chapter ***APPENDIX RAIL 07: EXAMPLE OF CALCULATION METHODOLOGY USED BY EU IMS*** devoted specifically to these issues) of the Report 2.

Key RIA (rails, sleepers & ballast) residual lives and related needs in renewal works:

Unlike the final assessment performed within Activity 2.8 and described in Report 5 delivered in July 2018, for the purposes of performing the preliminary assessment of the M&R for Report 2, delivered in December 2017, needs and related budgets on the WB6 network, the received RIA data were aggregated into the TEN-T Core and Comprehensive Network in Western Balkans (TEN-T C&CNWB) sections. It is important to stress, that such an aggregation, however, represented **a certain loss of accuracy** with respect to the RIA analysis, as instead of focusing on short RIA sections (like in Activity 2.8 / Report 5), where high accuracy of the analysis can be maintained, it was here raised to an upper/coarser level of SEETO sections, which are much longer, thus requiring sizable amount of averaging.

Nevertheless, in this initial rough preliminary analysis of the M&R works requirements in the region, the desired conclusions were managed to be drawn, focusing primarily on the **cumulative distribution curves of the residual service lives of the key track assets (rails, sleepers and ballast)**, present on each of the WB6 networks, each of the routes and the entire WB6 network as a whole, Figure 7, as they normally take up the majority of the M&R budgets and would thus serve as the best indicators of the overall situation.
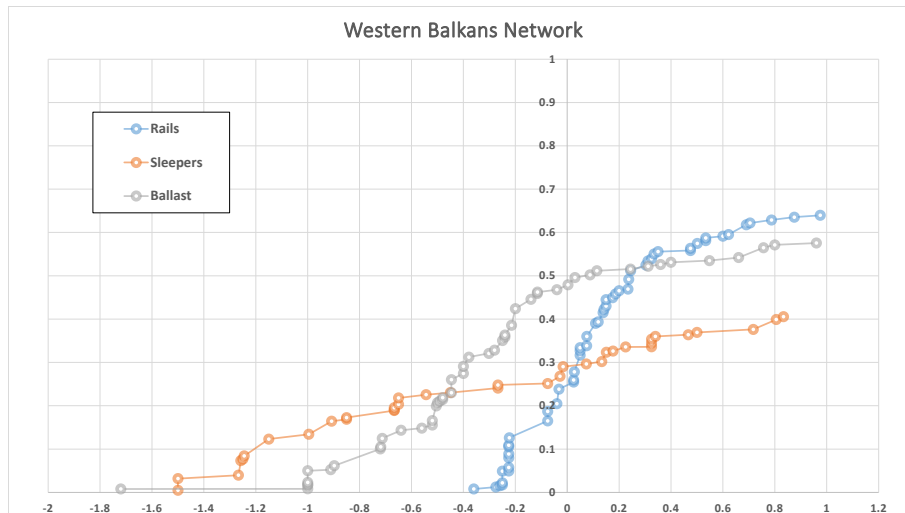

Figure 7: Cumulative distribution curves of the residual service lives of the key track assets (rails, sleepers and ballast) on the entire TEN-T C&CNWB (without ŽFBiH, as no data were received until the moment of writing the Report 2, and only 35% of Serbian network for which the data were received)

For proper understanding of the values provided in the subsequent tables and graphs, it is extremely important to note once again, that **not** all the data had been received at the time of preparation of Report 2 (e.g. no data were received from BiH, more specifically from ŽFBiH, and there were missing data from other RPs, e.g. in Serbia), and not all the RIA were equally "covered" by the received data (e.g. it could happen that for a given stretch of rails, all pertaining info was received, except for the year of installation, which eliminated the possibility of performing residual lives (RSL) calculation). For that reason, at the moment of

delivery of Report 2, the received data effectively allowed analyses to be performed only on the parts of the TEN-T C&CNWB listed in Table 4, with respect to the total size of about 3,832 km.

This analysis, in turn allowed the intended direct possibility for the **calculation of the M&R works' needs**, in the sense that it could be concluded that the sections with RIA whose service lives (SLs) have exceeded the expected/allowed ones (i.e. have expired), clearly represented the poorest (i.e. termed "very poor") sections, where (extremely) poor condition of RIA in combination with the lack of RIA condition-monitoring creates a very unreliable situation for the railway traffic, with increased levels of risks of accidents occurring on them, due to unpredictable RIA behaviour at such extreme ages. As could be seen from Figure 7, the percentage of such sections was found to be quite large, ranging above 30% of the entire network for some RIA, **which clearly demonstrated the severe consequences of the long-lasting negligence towards RIA M&R in the region**.

This directly indicated urgent M&R needs concerning RIA in "very poor" condition. Once all such "very poor" RIA were eliminated from the network, the next step would be to bring the network up to the usual level of average residual service life (RSL), which normally revolve around values of 40%, meaning that the average age of RIA is at around 60% of their expected service lives (SLs), all RIA in a condition better than that could effectively be considered as "good" or "very good".

However, to reach the RSLs of 40%, another round or a "front" of RIA replacement, a level of RSLs of 20% could first be taken, where such assets would effectively represent RIA in a "poor" condition. Finally, after all such RIA have also been replaced, the "front line" could be shifted further to the desired 40%, effectively aiming at the elimination of "medium" RIA. Following this approach, total needs in terms of rails, sleepers and ballast renewal works were estimated for the identified portion of the TEN-T C&CNWB, split into categories corresponding to rails, sleepers and ballast in "very poor", "poor" and "medium" condition, Table 5.

Table 5: Lengths of sections in "very poor", "poor" and "medium" condition on the entire TEN-T C&CNWB, by extrapolation (in kilometres)

	"Very poor"	"Poor"	"Medium"	TOTAL	% of network
Rails	914	841	375	2,130	56%
Sleepers & Fastenings	1,112	138	130	1,380	36%
Ballast	1,793	168	75	2,035	53%

It is clear that performing such an amount of RIA renewals would take quite some time, even if the funds were secured, as the current M&R capabilities of the RPs are not extremely high and would not be significantly increased even by the introduction of all regional IMCs. However, during this time, the rest of RIA, which currently may be in "poor" or "medium" condition, would also gradually shift towards the most urgent category of "very poor" RIA. This aspect needs further attention and elaboration in the subsequent phases of the Project.

It should be also noted that **activities in this period were primarily focused on the structuring of the data and their collection**. For that reason, these analyses, such as for rails, sleepers and ballast renewals, **as by far the costliest**, were currently performed only as preliminary, and merely for rough indicative purposes. For this reason, also, this procedure did not account for M&R needs or repairs of the major Civil Works (i.e. objects/structures such as bridges, tunnels, culverts, level-crossings, etc.), as well as Signalling and Electrical infrastructure. The reason for that was that they had not been subject to systematic and quantitative inspections for a prolonged period of time, so reliable records concerning their condition and remaining SLs do not exist. On the other hand, knowing that the track and its components (i.e. rails, sleepers & ballast) is by far the most valuable, costliest, and at the same time the one most exposed to the detrimental influences of rail traffic and accounts to up to 70-80% of the total M&R costs, the indicative assessment presented above may be deemed accurate enough to get the first impression of the current M&R backlog along the TEN-T C&CNWB and corresponding M&R works' needs. The intention was for

them to be analysed in more detail in the subsequent phases of the Project, once all the data are fully gathered, for the purposes of performing 5-year M&R plans, for Report 5.

4.2.3   Analysis of present contractual relation in WB6

As planned and as per the ToR, the second Interim Report (**Report No. 3** in the whole Project) "*Analysis of present contractual relation in WB6*" was delivered in February 2018, pooling the information gathered through a series of visits to the RPs during the Autumn of 2017 and an extensive subsequent data-collection and document-exchange process.

In the background research for Report 3, it was found out that the WB6 initiative provided further support to transport development as the economic generator of the region, while the Western Balkans Conference held on 28 August 2014 in Berlin provided a political framework for the more intensive development of transport infrastructure in the region. During 2015, further progress was achieved, notably the agreement by the six Western Balkan Prime Ministers in Brussels in April on the regional core transport network, and the further agreement (in Riga in June) on the core network corridors (the Mediterranean, Orient/East-Med and Rhine/Danube corridors were extended to WB) and a list of infrastructure projects and soft measures to be implemented by 2020.

Establishment of the Core Network and modification of the Comprehensive Network in the Western Balkans (WB) provided a structure for more concentrated development of infrastructure in the region with the aim of enhancing connectivity and mobility and joining WB with the EU TEN-T network.

On the other hand, the WB Comprehensive Network is strategically located with regard to the European transport system, constituting a physical transport corridor, which enables the continuity of different parts of the TEN-T Network, providing connections for the Central European countries to the Black Sea and further beyond to Asia. Thus, the TEN-T Core and Comprehensive Network in Western Balkans (TEN-T C&CNWB) consists of seven Routes and six Corridors totalling to about 5,370 km.

However, Maintenance and Renewal (M&R) of the transport infrastructure was still found to be one of the major challenges in the region, primarily with regard to the institutional framework and budget allocation to infrastructure asset preservation, as well as with regard to the existence of structured processes, tools and skills for assets' condition-monitoring, analysis and consequential M&R planning. Consequently, according to previous assessments, respectively, 22.5% and 18.8% [8] of the indicative extension to TEN-T C&CNWB were found to be in need of maintenance and/or rehabilitation, while the preliminary analysis results provided in the Interim Report 1 (Report No. 2 of the CONNECTA project, submitted in December 2017), suggested the percentage of Railway Infrastructure Assets (RIA) with exceeded service lives (SLs) and which directly represent the most urgent needs in terms of M&R (effectively renewals) to be ranging above 30% of the entire network.

The WB summit in August 2015 in Vienna provided a list of soft measures including specific timelines for each measure and progress with regard to their implementation was taken stock of during the Paris Summit, July 2016. Amongst soft measures at a regional level to be completed in the short period framework, preparation of the M&R Plan for 2018-2022 for Road/Rail Core/Comprehensive Networks in the WB6 was included.

Analysis of the present contractual relations States and IM for WB6 described in Report 3 proved:

- Railways in the Balkan area are comparatively traditional in nature with respect to the issues concerning maintenance and contracting strategy

- There is no consistent methodology among the WB6 RPs in defining multi-annual contracts.

- Current practice for maintenance contracting is similar in all WB6 RPs

Analysis of the Multi-annual contracts between States and IMs (Directive 2012/34 obligation for EU countries) provided the following conclusions:

- Only Serbia has a valid 5-year contract (not fully in compliance with the Directive 2012/34)

- Former Yugoslav Republic of Macedonia has a 3-year contract (expired in 2014)

- Albania, Bosnia and Herzegovina (Republic of Srpska) and Montenegro have multi-year Business Plans or Railway Development Strategies (Montenegro)

Analysis of annual contracts proved that all RPs have some form of Annual contracts with the IMs.

Although there was no specific provision in the ToR as such, the following important analyses were performed:

- analysis of the present conditions of infrastructure in accordance with contract strategy,

- conditions and benefits for maintenance transition from in-house to outsourcing and finally to PBMC,

- economic and financial analysis of present strategies at WB6 RPs and

- economic and financial experience in the EU for different maintenance strategies.

It was deemed that all these four analyses will be extremely useful for each and every one of RPs, for the definition of the contract strategy, but also and for definition of the common M&R policy of all WB6 RPs and SEETO.

In the second part of Report 3, before the comparative analysis, comments on the Article 30 and Annex V of Directive 2012/34 were provided. The comparative analysis showed that no RP had a valid contractual arrangement fully in accordance with Directive 2012/34.

Furthermore, Report 3 provided the economic and financial analysis of the present strategies in WB6 as regards maintenance, with emphasis on the relations of the railway stakeholders, i.e. between RPs and IMs. It stressed the practices of the stakeholders of 3 countries: Albania, Montenegro and Serbia. The analysis was conducted under the framework of Directive 2012/34/EC recast and the stakeholders attempted to harmonise their operations with the above-mentioned Directive.

The key conclusions of the analyses performed were the following:

- analysed WB 6 IMs have a negative financial position, since expenditures are higher than revenues. The difference is covered by State subsidy. Nevertheless, they are in the process of changing their business behaviour, as a result of contractual agreements signed with the RPs for infrastructure maintenance services;

- Development of multi-annual Business Plans was observed (covering the period 2017-2027), as well as implementation programmes developed by RPs, which is an important step in the right direction, i.e. towards the achievement of financial sustainability by the WB 6 IMs;

- At present, however, the Project team was unable to estimate whether the sums referred to in the contractual agreements signed between PRs and IMs can assist the latter in becoming financially sustainable.

- The Project team had no doubts that IMs are willing to implement their financial strategies, however it should be taken under consideration that the IMs are at the beginning of their Business Plan implementation;

- IMs were given incentives by their RPs to increase revenues. Thus, these have been reflected within their multi-annual Business Plans and subsequent Implementation Programmes;

- Finally, as regards compatibility with EU Directive 2012/34/EC recast standards - i.e. accounts separation, performance indicators, track changes – the Project team did notice the following: Serbia's IM, IŽS, is the most compatible of the WB 6 IMs, making a serious effort to follow the financial aspect of 2012/EC/34 recast, whereas Montenegro's IM, ŽICG, has started implementation, but still needs a lot to do before reaching compatibility with the Directive. Finally, Albania's HSH needs to proceed to a full restructuring of its operations, before being in a position to reach financial sustainability. In other words, a new separate IM company has to be created. The new IM has to develop a new comprehensive multi-annual Business Plan based on Directive 2012/34/EC recast principles. At the same time, the Albanian RP has to develop a subsequent implementation program for the future IM.

Furthermore, Report 3 analysed the economic and financial experiences (practices), costs and benefits in the EU for maintenance transition from in-house to outsourcing and finally to PBMC (Performance Based Maintenance Contract), with a focus on:

- Key principles of EU railways maintenance performance measurement;

- Brief history of outsourcing in EU railways maintenance;

- Multi-annual contracts and PBMC;

- Contractual agreements between Competent Authorities and IMs for maintenance purposes, with emphasis on performance issues,

- Performance measurement within PBMC,

- Modalities to calculate direct costs in PBMC;

- Costs model;

- Current charging practices in EU railways maintenance.

The analyses performed concluded that:

- There is no common approach on PBMC system implementation in the EU countries, as regards railways maintenance. There are only performance standards based on EPR (European Performance Regime). Thus, they focus on quality monitoring in terms of punctuality and delay causes;

- The information about the performance schemes is published in the network statements of various EU countries railways stakeholders;

- Few EU countries report that positive performance results can be attributed to their performance schemes, i.e. Bulgaria, Croatia, Denmark, Italy and Portugal;

- In all EU countries performance schemes include penalties;

- The methodology of calculation of penalties varies largely across countries, so it is difficult to establish pan-European general rules on penalties.

Report 3 laid down in great detail Dutch experience of outsourcing M&R works to Infrastructure Maintenance Contractors (IMCs). The Netherlands was chosen for the particular reason that it effectively represents (arguably the only) EU country where railway sector restructuring (in terms of splitting infrastructure ownership from train operation, as well as splitting infrastructure ownership from M&R) was completely/fully and, above all, successfully performed. Moreover, the Dutch example is extremely instructive and educational, as it was not devoid of problems, mistakes and poor decisions in a lengthy restructuring process since the 1990s, but in the end, all were recognized, properly addressed and ultimately corrected. For that reason, this experience can be seen as an excellent practice serving as guidelines for the future decisions of all WB6 RPs, as well as for the harmonization of these practices at the level of the entire WB6 (SEETO) region.

The analysis performed in Report 3 also concluded overall that the crucial issue for the rail infrastructure in the WB6 region will be the available M&R budgets in the years to come. The preliminary results of the RIA analysis performed so far in this Project, and reported in Report 2, as well as information received from the RPs during visits, clearly show that insufficient funds for M&R have been present in the entire region for decades.

However, the motivation for launching this Project, as well as its results, is aimed exactly at reversing this process. Also, it seems that not only the EU, but also the RPs themselves, have recognized the need to start caring much more for rail infrastructure, possibly also due to the need to satisfy the requirements for EU accession.

Around the EU, different models of railway infrastructure M&R management and performance were found to exist. In chapter 3.4 of the Report 3, dedicated specifically to this issue, a review of the conditions and benefits for maintenance transition from in-house to outsourcing and finally to PBMC was discussed from all relevant points of view:

- Creation of Infrastructure Maintenance Contracts through large projects,

- Personnel Issues,

- Lack of Railway Infrastructure Asset Management Systems (RI-AMS),

- Certification of Infrastructure Maintenance Contracts,

- Quality of M&R works,

- Diagnostics of track (and other RIA) quality,

- Warranty for M&R works performed,

- Remaining role of IMs - intervention maintenance & first-hand diagnosis,

- Available Machinery,

- Problem of IMCs going bankrupt and

- Issues with Public Procurement Laws.

The economic and financial analysis of present strategies in the three of WB6 RPs (for which the data were obtained), showed that all three RPs' IMs have a negative financial position, since expenditure is higher

than revenue. However, this is normal for IMs even in the EU. This was in fact the reason behind the adoption and implementation of Directive 2012/34/EU recast by EU railways authorities.

At the same time, all 3 IMs are also given incentives by their RPs to increase revenues. Such incentives include the following: (i) increase of prices in services offered, (ii) reduction of operational costs, as well as (iii) development of new markets (access fees to private users). Thus, they would have to be reflected within their multi-annual Business plans and subsequent Implementation programmes.

In parallel, the three IMs are heavily dependent on State subsidies, representing the major part of their revenue. On the other hand, staff salaries and social advantages are also representing the major part of their expenditures.

In certain cases (IŽS and ŽICG) international lending was found to be considerable, but needed for their development. In the view of the Project team, RPs were right to allow borrowing, due to the fact that without investment in railways infrastructure, the IMs would not be able to increase infrastructure-use prices.

A positive sign of achieving financial sustainability was found to be the fact that the three IMs have integrated within their organisations the economic and financial dimension of the framework created by Directive 2012/34/EU recast.

The conclusions of the Project team during the analysis of the economic and financial EU experiences (practices), costs and benefits for maintenance transition from in-house to outsourcing and finally to PBMC yielded the following recommendations to WB 6, with respect to the economic and financial aspects of M&R, as expressed within multi-annual contracts of PMBC are the following:

- Directive 2012/34/EC recast has to be transposed within national frameworks focusing on service facilities, i.e. charges and penalties.

- Nevertheless, emphasis should be put on the fact that most EU countries use the same charging principles for access to service facilities and rail-related services. However, there are some differences in charging principles for different service facilities in different countries. The "cost of providing a service" is not defined by law in many countries, while others understand it as OPEX and CAPEX. While OPEX and CAPEX are a generally accepted concept in economics and regulation, the costs that are allocated to OPEX and CAPEX differ in various EU countries.

- Development of country relevant methodology of penalties calculation to be included in PMBCs, based on various EU practices.

Current charging practices in EU railways maintenance were analysed for the following countries: Austria, Denmark, Croatia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Poland, Slovenia, Spain, Sweden and United Kingdom.

Comparative analysis of contractual arrangements for WB6 RPs in accordance with Article 30 (2) of Directive 2012/34 showed significant differences, which was expected from the standpoint of differences in the institutional reforms of the WB6 railway sector. However, what was not expected was that only one of the RPs would have a multi-annual contract between State and IM, and that it would be Serbia, which was only the fourth RP in line to perform the separation between IM and RU. And, moreover, this contract in Serbia is still not fully in accordance with EU Directive 2012/34, especially with Annex V of this Directive.

Needs reported by RPs for fully establishing their Asset Management Systems and railway infrastructure maintenance framework

An extremely important thing that emerged from the initial period up to the delivery of Report 2, starting with the visits, and extending over the extensive communication concerning data-provision, is that the RPs almost repeatedly came up with the following important requests, i.e. pointing out that they have indispensable need for the following forms of additional support from the Consultant:

- All RPs identified as the most crucial drawback and deficiency of their current M&R planning and undertaking processes, the fact that virtually no, or at best insufficient railway infrastructure assets condition-monitoring is performed in most of the RPs. ***The lack of condition-monitoring represents the most significant obstacle to performing modern and objective M&R planning.*** For that reason, RPs repeatedly requested that some form of prolonged support be found, where the Consultant would support the RPs in finding the most suitable and most cost-effective ways of performing condition-monitoring, starting first with mere Track Geometry measurements, but ideally extending onto the other important condition-monitoring, such as rail profile, ultrasonic rail inspections, rail corrugation, overhead line geometry, overhead line wire wear, Ground Penetrating Radar (GPR), etc.

- All RPs almost invariably identified the need for the Consultant to support them in the form of providing continuous support in the acquisition and implementation of a suitable Railway Infrastructure Asset Management System (RI-AMS).

- Support in checking the existing regulation and establishing its level of conformity and compliance with the relevant EU regulation.

- After the establishment of the discrepancies between the existing and EU regulations, RPs would require further support in adapting/updating existing regulation to be compliant with that of the EU.

- Support in the form of continuous advice at strategical level for the continuity of data collection (namely, the data-collection performed in this process must not be seen as complete and over; instead, it is a continuous process, as things are constantly changing on the network, and thus so do the related data, which constantly need updating, in order for the data in the database to be always up-to-date and relevant; for that reason, clear, yet strict formal processes must be established for regular collection of the new data, with proper recording of all relevant changes that occur on the network, which is exactly why the RPs expressed the need for assistance, in the form of advice and monitoring of this process. The gravity of this can be seen from the simple fact that after the great effort of collecting so much data, by which the current status of the network is properly described, if one change on the network goes unrecorded, the whole effort becomes compromised, as the data no longer are reliable and no longer reflect the real current condition on the network.

- Support in establishing procedures for systematic data-processing, including factual analysis if the RPs already have the required mechanisms, tools, personnel and skills to perform such analyses, and if not, analysis of what is missing and how could it be acquired, or what training might need to be undertaken, etc.

- Once the data-processing procedures are established, the RPs have requested that there be a period of at least a year during which their personnel (carefully selected by the RPs and trained by the Consultant) would perform these procedures under close supervision of the Consultant, to ensure maximum effects, as well as to ensure full understanding and skills-acquisition on the part of the RPs personnel.

- Support in thoroughly explaining to the RPs how a modern condition-based approach to M&R planning and undertaking should work, from a low level, to the highest of levels, identifying RPs weaknesses with respect to the performance of this concept and finding ways to overcome them, providing appropriate training of the RPs personnel, but also those of other bodies/authorities involved in this process, e.g. at Ministry level, or at the level of Regulatory Bodies, and establishing relevant regulations in that respect to formalize this entire process.

Having analysed the above requirements, it became clear, however, that they could not be performed within the current scope of the Project, but considering their importance and the desires of the RPs, the conclusion was that perhaps they could be further analysed by SEETO and some other form of solution could be found, e.g. by extending the scope of this Project, or setting up a new "follow-up Project", that would continue in the footsteps of the current Project and handle the above-stated requests of the RPs, along with perhaps some other aspects that SEETO, RPs and the Consultant may have identified in the meantime.

4.2.4 Setting up Railway Infrastructure Asset Management System (RI-AMS)

As planned and as per the ToR, the third Interim Report (**Report No. 4** in the whole Project) "*Rail Maintenance: Recommendations for setting up Railway Infrastructure Asset Management System (RI-AMS)*" was delivered in April 2018, gathering the related information about the current status and deployment of RI-AMS among the WB6 RPs from the series of visit to the RPs during the Autumn of 2017.

The purpose of Report 4 was to describe in detail Activity 2.7 of the ToR, i.e.:

- Analysis and recommendations for setting Railway Infrastructure Asset Management Systems (RI-AMS) in the region: predictive maintenance based on minimum life cycles costs is the preferred asset management strategy. The TA should take stock of progress, including the necessary monitoring and measurement of assets condition in the region.

In addition to this, the results of the activities performed within this phase of the project were also meant to serve as the direct foundation for sustainable M&R assessment needs in future in all RPs in the WB6 region.

In the background research for the purposes of Report 3 it was found out that Maintenance & Renewal (M&R) of railway infrastructure networks require significant investments. Average annual M&R expenditures per 1 km of tracks for West-European networks revolve around €50.000. In order to keep the Railway Infrastructure Assets (RIA) in a satisfactory condition, the manner in which the condition of every single RIA changes must be properly understood. Understanding this change in condition in fact means understanding RIA behaviour, which paves the way towards predicting it. In order to relate observed (captured) behaviour in the past with predicted behaviour in the future, Deterioration Models (DMs) are needed. Incorporating DMs in a suitable, powerful yet flexible Railway Infrastructure Asset Management System (RI-AMS) allows users (typically railways, i.e. railway Infrastructure Managers – IMs, as well as sometimes Infrastructure Maintenance Contractors – IMCs) to perform true long-term simulations of RIA behaviour, balancing effectively achieved quality with the costs of M&R works (as well as inspections and other consequences such as traffic disruptions, availability, etc.), enabling significant cost-savings at the end. In today's environment, cost-effective railway infrastructure can only be provided by means of regular monitoring of RIA performance and having reliable methods for prediction, planning and optimization, which are simultaneously the main goals of RI-AMS.

A prerequisite for installing a RI-AMS was found to be that data are available electronically in a well-structured form, which was already established within the previous phases of this Project. Getting existing data organized will also assist in the task of identifying which assets are owned by a particular IM, i.e. the regional RPs. Due to this most important requirement, a data organization scheme must be defined, in such a manner to be fully compliant with the RI-AMS best practice. For this reason, as an initial step towards properly implementing a RI-AMS, it was found to be highly recommended to establish a Railway

Infrastructure Assets (RIA) Register (also often termed RIA Inventory), which effectively represents a part of the Infrastructure Database (ID) that sits underneath the RI-AMS and serves as the main platform for all of its core functionalities. ***This step in RI-AMS implementation was already partially achieved within the previous phases of this Project (and fully completed by the end of the Project)***, which represents a significant facilitation of RI-AMS implementation and increases its chances of success.

Besides railway-dedicated RI-AMS, it was found that there are also several general-purpose Enterprise Asset Management (EAM) & Enterprise Resource Planning (ERP) systems on the market, claiming to be able to handle RIA management in the proper manner – i.e. the manner suitable to RIA peculiarities and traditional railway engineering manners in planning RIA M&R works. However, these general-purpose EAM/ERP were found to invariably fail when it comes to proper technical/engineering-type of analysis and management of linear/spatial assets such as RIA, due to EAM's/ERP's inherent utter incompatibility with the linear/spatial concept, i.e. EAM/ERP were simply never meant for that purpose, but for the factory-type of companies, with machines and spare-parts as assets. The second reason why EAM/ERP systems were found to always fail in the railway environment was due to the multi-dimensional behaviour of RIA, requiring completely specific handling in a well-established technical/engineering manner, utilizing Track Charts, Horizontal Alignment, Longitudinal & Cross Sections, but above all RIA Deterioration Modelling and consequential condition-based M&R planning.

RI-AMS are also very complex, which meant that IMs'/RPs' staff would require a significant amount of support, especially in the initial period, and that for that reason, it was found to be very important to select a system with good railway references and a RI-AMS supplier that has a proven record of providing first-class support to its clients, throughout the usually very long system utilisation period (normally at least 10 years), as well as regular maintenance and upgrades for its system.

Within the framework of Report 4, following the examination of the current situation in WB6 RPs performed during visits and interviews, explained in detail in Report 2, proposals for the optimal characteristics and functionalities of RI-AMS were presented in detail (Chapter 6 of Report 4 – "*Specification of main RI-AMS Requirements*"), as well as the most suitable methods of implementation.

It should be clearly noted that the overall ***intention was to propose implementation of a RI-AMS which can manage all RIA*** – track, overhead line, civil works (e.g. tunnels, bridges, culverts, level-crossings), stations, etc., and which will not be too demanding on existing RP computers and other IT and communication infrastructure, but instead be fully compatible with them, portable and accessible, and requiring minimum software installation and user training – which can only be achieved by a web-based system.

In that sense, it could clearly be concluded that ***RI-AMS must represent a markedly web-based solution with modern n-tier architecture***, as these features would significantly simplify software delivery, deployment, and maintenance processes across RPs, thus saving a significant amount of time and money. This way, RPs' individual users will also not have to run any proprietary software on their computers. Instead, they will be able to access RI-AMS modules and solutions through standard web-browser interfaces. As technology progresses, desktop and client-server applications will clearly continue to decrease in use. By starting immediately with a web-based platform, RPs will avoid the need and investment to migrate eventually to the web-based solution.

It was also concluded that RI-AMS user interfaces should be simple to use and require minimal training, while RI-AMS processing capabilities should be designed to maximize automation and not require hours or days of highly skilled RPs engineers preparing and/or manipulating data to achieve results. RI-AMS configuration should be designed to minimize effort for end-users and maximize automation, including data loading, data exchange with external systems, databases and file-storages, as well as analytical processing to produce report outputs.

Standard implementation of a RI-AMS was found to include several steps which were recommended to be realized during the process. Each step should be completed adequately before the next step is commenced. The main steps in the process are assumed to be

- Investigation of the existing M&R practices at RPs, i.e. decision-rules, regulations and standards, and their conversion into RI-AMS's decision rules (to be done in a close co-operation with the responsible RPs' personnel at all levels, i.e. both at the HQ and regional offices)

- Formalizing and unifying RIA inspection data-collection procedures

- Setting up of a detailed RI-AMS Implementation Plan

- Procurement and installation of a basic RI-AMS

- Customization of the RI-AMS according to specific RPs' requirements (if necessary)

- Initialization of an RIA inventory database within the ID

- Detailed considerations of the organizational aspects of RPs, and investigation of the optimal and most suitable forms of RI-AMS implementation and deployment at RPs' network

- Setting up RI-AMS Decision Rules and Thresholds in accordance to the RPs' M&R Policies, Decision-Rules and Regulations

- Setting up all other analytical and managerial procedures within RI-AMS for various User-types

- Stepwise implementation and testing of the RI-AMS within the RPs' organization

- Monitoring/Supervising the use of RI-AMS by RPs' Personnel in the initial phase until its becomes stable and reliable

- Production of the Final Implementation Report including:

  - Overview of all performed assessments, experiences and conclusions,
  - Recommendations for future activities & eventual organizational proposals in order to further enhance RI-AMS utilization and benefits it can bring to RPs,

- Commissioning/Acceptance run of RI-AMS, fully configured according to the RPs' requirements – i.e. with RPs' data, RPs' Analytical Procedures, RPs' Decision-Rules, Reporting Templates, etc.

- Stepwise training of users along with the implementation process

- Setting up the procedures for RI-AMS long-term management, maintenance and continuous support

It was also recommended to allocate an experienced RI-AMS Consultant to manage the implementation process. *A detailed list of RI-AMS Requirements was provided in Chapter 6 of Report 4* "*Specification of main RI-AMS Requirements*". *At the present stage the implementation costs were roughly estimated to be around 500.000 Euro* for each of the RPs except for Infrastructure of Railways of Serbia (IŽS), where, due to considerably larger network size, the estimated budget would be roughly double, i.e. closer to 1 mil. EUR, as well as for MZ-I (Javno Preduzeće Makedonski Železnici Infrastruktura, i.e. PE Macedonian Railways Infrastructure), where an RI-AMS has already been installed and used since 2010, so no RI-AMS installation is needed (though the improvements of the existing one are certainly possible, especially in terms of implementation of RI-AMS Inspection Recording Application (IRA)(described in detail in Chapter 3.10 of Report 4), as it was found out that one of the key drawbacks of MZ-I's existing RI-AMS is systematic RIA data-collection in a digital format and, which is thus also recommended).

However, considering the fact that RI-AMS are quite complex and extensive and that therefore, it is not easy for clients, e.g. IM or IMC, such as RPs, to immediately and clearly grasp the full extent of RI-AMS, its role within their organization and the benefits it can bring, instead of going directly for the full-scale implementation, an *attractive option is to perform a RI-AMS Pilot*, *or a trial-implementation, in the form of a RI-AMS Feasibility Study (described in detail in chapter 4.1 of Report 4)*.

For that reason, effectively, there are two courses of action that can be taken with respect to RI-AMS implementation:

A. *Pilot/Trial Implementation*, in the form of a Feasibility Study, followed by the full-scale Implementation, if the Pilot/Trial was successful and well received by the client, and

B. *Full-scale Implementation*, which can be performed either after the Pilot/Trial, or directly, without the Pilot/Trial

The purpose of performing a RI-AMS Pilot/Trial in the form of a Feasibility Study is to clearly demonstrate to the Client, i.e. railway RPs/IMs, the full potential and benefits of using RI-AMS applied on the RPs' existing data and within the existing RPs organizational (and decision-making) concept and environment. This way, after seeing direct evidence of the RI-AMS usefulness in the framework of their own working environment, RPs the final decision on whether to continue into the full-scale implementation and the eventual acquisition of RI-AMS licences will be much easier to make.

In other words, RPs should not be forced to engage in an extensive and costly network-wide roll-out, without first being offered the opportunity to see for themselves exactly what the RI-AMS capabilities are and what it can actually do for the them.

The expected duration of the RI-AMS Pilot/Trial is normally between 6-9 months, mostly depending on the RPs personnel response time (primarily concerning data collection and provision) and availability for collaboration and support to the RI-AMS supplier during the Pilot. The expected cost of a RI-AMS Pilot/Trial per each of the RPs (except for IŽS and MZ-I, where it is not necessary) would revolve around 100,000 EUR.

In terms of particular circumstances concerning RI-AMS implementation at different RPs, it should be simply stated that, with the exception of MKD, where an RI-AMS has already been installed at MZ-I (Javno Preduzeće Makedonski Železnici Infrastruktura, i.e. PE Macedonian Railways Infrastructure) in 2010 and used ever since, and Serbia, where a RI-AMS Pilot/Trial was performed at IŽS (Infrastruktura železnice Srbije, i.e. IoSR - Infrastructure of Serbian Railways) within the „System for the Analysis of Track Condition" project (Ref. EuropeAid/128325/C/SER/RS - 08SER012411), 2010-2013, in all other RPs the situation is identical, and that no attempt was ever made to perform either Pilot/Trial or full-scale RI-AMS implementation.

On the other hand, some significant obstacles to the implementation of RI-AMS were also identified, such as that all RPs identified as the most crucial drawback and deficiency of their current M&R planning and undertaking processes the fact that virtually no, or at best insufficient RIA condition-monitoring is performed at most of the RPs. ***The lack of condition-monitoring represents the most significant obstacle to performing modern and objective M&R planning, and thus RI-AMS***. For that reason, RPs repeatedly requested that some form of prolonged support be found, where the Consultant would support the RPs in finding the most suitable and cost-effective ways of performing condition-monitoring, starting first with mere Track Geometry (TG) measurements, but ideally extending onto the other important condition-monitoring, such as rail profile, ultrasonic rail inspections, rail corrugation, overhead line (OHL) geometry, OHL wire wear, Ground Penetrating Radar (GPR), etc.

For the above reasons, concerning the RI-AMS-related situation at RPs, the following could be proposed:

- For all RPs except MZ-I and IŽS, RI-AMS the implementation process should start with a Pilot/Trial implementation, ideally as a new/additional phase of the CONNECTA project, and as soon as possible, while the data collected and structured within this current CONNECTA project are still fresh and valid, which would significantly facilitate the performance of the RI-AMS Pilot/Trial,

- As for IŽS, utilising the conclusions of the RI-AMS Pilot/Trial performed within the „*System for the Analysis of Track Condition*" project, and the data collected and structured within the current CONNECTA project, it could immediately proceed to the tendering process for full-scale RI-AMS implementation, directly utilizing the RI-AMS requirements provided in Chapter 6 as tender specifications, as they have been precisely provided here for this very reason,

- As for MZ-I, as they already possess and utilise an RI-AMS, the conclusions, data-structure and decision-making procedures and rules (which will be completed and provided in Report 5 (R 2.5) Maintenance Plan for budget scenarios, Activities 2.4 & 2.8, due in Month 12 of the current project, i.e. June 2018) should be used to further enhance their existing RI-AMS and the manner of its utilisation, as well as the quality of the results it is producing. This should ideally be performed in the form of a Feasibility Study, very similar to those to be performed for all other RPs for the sake of RI-AMS Pilot/Trial, only here directed at enhancement of the existing RI-AMS, rather than exploring the optimal manners of implementation of a new RI-AMS, and thus also ideally within the framework of a next phase of CONNECTA project, tailored for MZ-I specifically. Besides this, in terms of enhancements of its existing RI-AMS, MZ-I could particularly benefit from the introduction of RI-AMS Inspection Recording Application (IRA) (described in detail in Chapter 3.10), as it was found out that one of the key shortcomings of MZ-I's existing RI-AMS is systematic RIA data-collection in a digital format.

All the above key aspects elaborated and described in detail in Report 4, directly empower all RPs to embark on a process of tendering and acquisition of RI-AMS at the earliest possible occasion. ***In that sense, it is worth mentioning that it is strongly recommended to first perform a RI-AMS Pilot/Trial***, as described in Chapter 4.1 of Report 4, as this would not only provide direct evidence and proof to the RPs of the benefits RI-AMS would bring them, but would possibly resolve many of the issues RI-AMS implementation would later encounter, thus reducing the future efforts needed and consequently the costs of the entire RI-AMS implementation as well.

4.2.5   Infrastructure condition and M&R Regulations analysis

As planned and as per the ToR, the fourth Interim Report (***Report No. 5*** in the whole Project) "*Rail Maintenance: Maintenance Plan for budget scenarios*" was delivered in July 2018, following the extensive data-collection process from the very start of the project and extending throughout the entire project, resulting in arguably the most valuable deliverable of this entire Project, and that is the establishment of the

Infrastructure Database (ID), i.e. the Railway Infrastructure Asset Register (AR) for all RPs except for ŽFBiH.

The importance of ID/AR was so high that in fact it effected the entire purpose and scope of Report 5, in the sense that effectively the majority of time and effort spent throughout this Project until this final phase was devoted to the most daunting, difficult and time-consuming issue of establishing ID/AR for all RPs. *The reason for the complexity and difficulty of this issue lay in the fact that none of the RPs, except for MŽ-I in MKD, had an AR, not even in paper-based form, let alone in digital form, and without an AR in digital form no consistent and comprehensive M&R planning could ever be performed. For that reason, and for the sake of all future analyses in this domain, it was concluded that by far the most important goal in this project is the establishment of the RPs' ARs. Approaching the later phase of this Project and this very report, this most important task was completed yielding uniformly structured ARs for all RPs (except for MŽ-I, for the reason mentioned above, and ŽFBiH which unfortunately until the very latest stage of this project did not provide the RIA data, despite multiple repeated requests).*

Having completed the ARs allowed the successful undertaking of the tasks 2.4 and 2.8, which effectively represented the original purpose and the scope of Report 5, including:

- Activity 2.8 - Support to preparation of the Maintenance Plan 2019-2023 that reflects the specific development characteristics and plans of each RP. This activity synthesises the analysis and recommendations developed under the previous activities.

- Activity 2.4 - Financial Analysis under different budget scenarios including cost breakdown by rail category (Corridor, Route). This analysis should be based on the IMs ARs that provide the corridor, where available (see above).

The reason why the above two activities have switched places in the order was that effectively Activity 2.8 presented an input to Activity 2.4, in the sense that the primary result of Activity 2.8, representing the strictly-technical analysis of the RIA condition and consequential M&R needs represented effectively automatically the "Ideal/Maximum" budget scenario, i.e. the one without constraints and where it is assumed that all M&R works needing to be performed from the technical reasons can indeed be performed, i.e. financed, thus effectively representing a form of a "wish list".

Furthermore, the two other remaining scenarios were effectively defined in relative terms with respect to the "Ideal/Maximum" one (Scenario 1), i.e.:

- Scenario 2: "Medium" scenario, i.e. assuming roughly half of the "Ideal/Maximum" budget is available, and

- Scenario 3: "Minimum" scenario, i.e. foreseeing only the most urgent M&R works and up to the level of RPs' abilities to perform works (e.g. depending on the total annual output of their available and operational machinery), effectively aiming at about 20% of the "Ideal/Maximum" scenario.

It should also be noted that all the analyses within Report 5 were also performed under several very important constraints and deficiencies identified during the entire project. Namely, that during the creation of RPs ARs, as described in Report 2, completed in December 2017, the following constraints were identified which hampered the performance of the analyses needed for Activities 2.4 & 2.8 and creation of the M&R Plans, to be reported in this document:
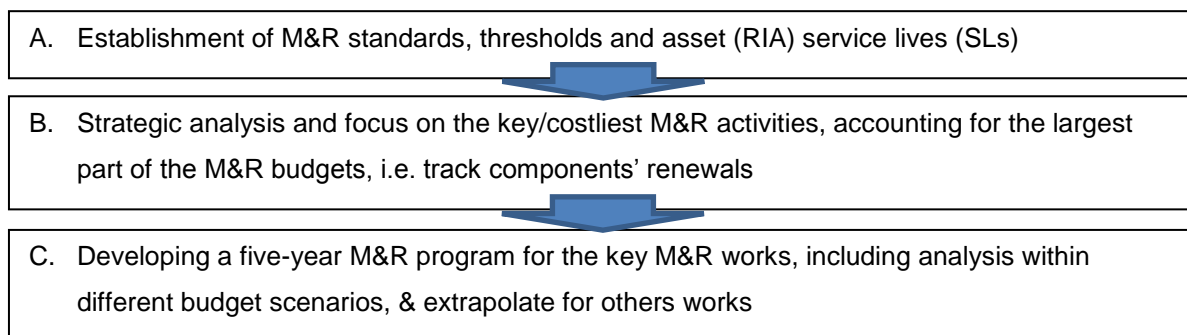
- As described in detail in Chapter 5 of Report 5, dedicated to the description of the "*Current situation concerning valid M&R regulation within WB6*", the intention was to check the available regulation, its state of being "up-to-date" and in line with the modern international practices as well as knowledge and

science in the domain of RIA condition-based M&R planning and the level to which these regulations are indeed respected and adhered to. In that sense, the following two important findings were made with respect to the regulation:
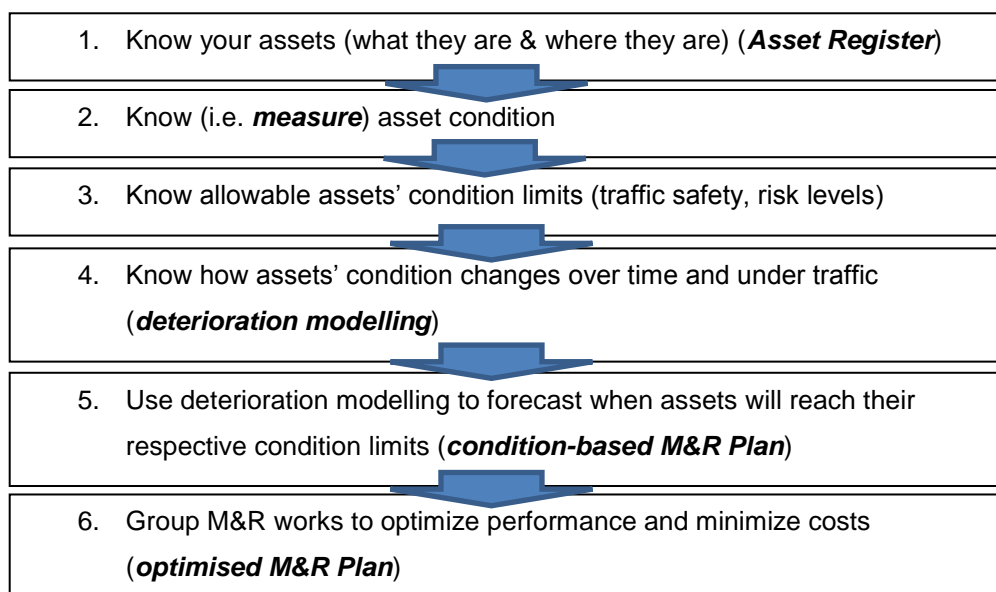
- o even though some of the RPs claimed to have updated their regulations in line with modern international practice, the reality was that it was found that a significant number of regulations were still not updated and dated from the time of Yugoslav Railways (with the exception of ALB, of course), often from the 1980s or even older, while even some of the regulations that had apparently been updated, were not updated properly nor thoroughly, and were instead mostly merely superficial "make-ups" of the old regulations, without truly researching and adopting modern international practices,

- o although even the non-(appropriately)-updated regulations did contain some references to the measuring and monitoring RIA condition (e.g. track geometry, rail profile, rail surface defects, ultrasonic inspection of rail internal defects, sleeper cracking (if concrete) or rotting (if timber), ballast contamination, etc.), and even though practically all RPs without exception adamantly declared full respect of and adherence to all valid regulations, the simple fact that most of the RIA condition-monitoring/measurements are clearly not performed (let alone regularly), easily disproves this. Instead, in reality, as most of the mentioned RIA condition-monitoring has not been performed (and many of those which are not mentioned, due to the regulation not being properly updated, and which certainly should be performed), many of the stipulations stated in the regulations could not be enforced. This, on the other hand, presented a serious problem for the analyses that were supposed to be performed in this part of the Project, as the intention was exactly to use those stipulations in the regulations to establish the M&R needs. This way, without the majority of RIA condition-data (except for Track Geometry (TG), which was regularly measured twice a year, as stipulated by the regulations, only for Serbia, and to an extent MKD, where it was measured twice in the past 10 years, i.e. in 2010 and 2013), unfortunately no precise and detailed RIA condition and deterioration analyses could be performed, but instead, M&R works' needs could only be established on the basis of RIA age and in some cases accumulated tonnage. This is quite unfortunate and should certainly be improved in the future, as age and accumulated-tonnage are not the best indicators of RIA condition and their suitability for traffic, but without condition-data that was the only option.

- In relation to the latter aspect of the regulation, the key observed constraint to proper (more accurate and more reliable) establishment of RIA condition with its effects on traffic safety and consequential M&R needs, is the utter lack of RIA condition-monitoring and the extreme negligence with which this very important aspect is treated in the WB6 region. It is clear that the reason for this is of a purely financial nature and not in the ill-intention of RPs, or lack of awareness among the RPs' personnel, but still, this is a problem that cannot be stressed enough, as *there can never be any effective M&R planning, and consequentially infrastructure in proper condition, suitable for traffic, without regular and appropriate modern condition-monitoring*. *It is of paramount importance if any of the RPs ever intend to improve the condition of their infrastructure and traffic safety. Therefore, this is the issue that must absolutely stay at **the very top of priorities of all RPs** and the one that must be the first to be resolved and **as soon as possible***.

This was effectively the most important Report in the entire Project, as it encompassed and sublimated all the hard work made throughout the entire project, all the data collected on the infrastructure elements, all the information gathered concerning the manner in which M&R works are performed, as well as financial and budgetary information.

Effectively, Report 5 and all the work performed behind it, as per the ToR, focused on providing the necessary support to RPs in preparing their own M&R plans for the period 2019-2023 reflecting their specific characteristics, through the following key steps:

A. Establishment of M&R standards, thresholds and asset (RIA) service lives (SLs)

B. Strategic analysis and focus on the key/costliest M&R activities, accounting for the largest part of the M&R budgets, i.e. track components' renewals

C. Developing a five-year M&R program for the key M&R works, including analysis within different budget scenarios, & extrapolate for others works

In that, the work behind Report 5, followed closely the Methodology laid out already in Report 2, issued in December 2017, as well as further enhanced and refined in the Report 5, as explained in its Chapter 6.2, consisting of:

1. Know your assets (what they are & where they are) (*Asset Register*)

2. Know (i.e. *measure*) asset condition

3. Know allowable assets' condition limits (traffic safety, risk levels)

4. Know how assets' condition changes over time and under traffic (*deterioration modelling*)

5. Use deterioration modelling to forecast when assets will reach their respective condition limits (*condition-based M&R Plan*)

6. Group M&R works to optimize performance and minimize costs (*optimised M&R Plan*)

In that sense, already in Report 2 dedicated to Needs Assessment and Scoping in WB6, delivered in December 2017, foundations were established for the creation of the M&R Plan for budget scenarios, in the sense that the following was achieved as indispensable prerequisites for the M&R Plan creation:

- Review and analyse RPs' current M&R practices and needs thereof

- Analyse any existing RPs' Asset Registers (ARs), and structure the establishment of ARs for RPs where ARs were non-existent, in accordance with Article 30(7) of Directive 2012/34/EU and inventory of data available in the region (structure of Infrastructure Database-ID).

During the initial work, as stated in Report 2, it was realized that the main challenge in establishing the M&R needs for the TEN-T C&CNWB would be the *unavailability and inaccuracy of data within WB6, as most of the RPs did not perform regular infrastructure monitoring/measurements, as well as that the RIA inventory data (i.e. ARs) were either non-existent, or not stored in a digital format, or/and often outdated*.

For the above reasons, from that moment until the creation of this Report, **the key focus of the activities within the Rail domain was placed on the <u>establishment of the sound foundation for the Railway Infrastructure Asset Register (AR) in all WB6 RPs</u>**, as without it, no M&R Plan could effectively be produced with any reasonable level of reliability.

The key results of these activities, which were also laid out in detail in Report 5, were:

4.2.5.1 Infrastructure Data:

- **There is a significant lack of funding provided for the RIA M&R, stretching decades into the past**

- Due to the previous item, **there is a significant backlog in M&R works, reflecting also in very low Residual Service Lives (RSL = MAX SL - CurrentAge) of all RIA**, with some of even going into negative values – i.e. the Service Lives (SLs) have long been exceeded (i.e. **<u>RIA have long expired</u>**)

- **The M&R backlog is of such a large scale that even if funds for M&R were somehow miraculously instantaneously provided, they could not be realistically performed for quite a number of years**, especially if the RPs were to perform M&R works themselves, as traditionally done, i.e. without introduction of Infrastructure Maintenance Contractors (IMCs) to outsource M&R to (this issue was analysed in more detail in Report 3). For that reason, one of the key conclusions is that **all the RPs must start seriously considering outsourcing M&R to professional IMCs as soon as possible**.

- As also already stated in Report 2, **RIA inventory data (i.e. the ARs) mostly did not exist, but were nevertheless managed to be collected during the Project to quite a satisfactory level** (further improvements are needed, but the collected amount, level of detail and reliability of the data was generally found to be satisfactory); main groups of requested data, with respective percentages showing actually delivered data, are provided in Table 6 below. As can be seen, data were almost complete for most of the RPs, except for ŽFBiH, which unfortunately, despite multiple requests, did not provide their data.

Table 6: Delivered Infrastructure data (Questionnaire + Data) with respect to the requested

Regional Participant		Network length [defined by SEETO]	Network length(Covered by data) [km]	Layout & Operating				Superstructure			Switches & Crossings	Civil works [%]	Electrical [%]	Signalling [%]	Catalogues [%]	Overall condition data [%]	Other [%]	Total
				Speeds [%]	Loads [%]	Curves [%]	Slopes [%]	Rails [%]	Sleepers [%]	Ballast [%]								
	ALB *	472	*383.0675*	100	60	100	100	99	99	99	0	100	100	100	65	0	100	64.13
BiH	ŽRS **	357	*361.966*	100	100	100	10	99	99	85	10	10	60	10	55	100	0	60.8
	ŽFBiH	441	*0*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	KOS	201	*194.308*	100	100	100	100	100	100	100	100	100	100	100	100	100	100	97.9
	MKD	531	*487.3735*	99	0	95	100	100	100	85	100	100	80	80	80	0	75	76.06
	MNE **	184	*192.862*	100	100	100	100	99	99	99	98	100	65	65	80.5	0	60	86.4
	SRB	1723	*1955*	99	100	100	100	100	80	100	80	99	95	95	90	100	90	93.56
	Total:	3909	3574.577	3550.2	2934	3550.2	3248.8	3565	3174.198	3441								
ALB				91	75	91	83	91%	81%	88%								

Line Pogradec-Korca (l=80km) is missing from the data since the railway line is not costructed yet.
Within the obtained data there were not any information about section VIII.09 (Lin-Qafe Thane)
MNE, ŽRS
**The discrepancy beetween the SEETO defined network length and length

- **Most RPs do not perform regular RIA condition-monitoring** - only Track Geometry (TG) was performed at some RPs:

    o at Infrastruktura Železnice Srbije (IŽS), Serbia, regularly, twice a year (9 measurements within the last 5 years),

    o in INFRAKOS (KOS), Kosovo also regularly, though with a vehicle that does not produce digital output, but only paper-based printouts, which is not usable for automatic condition-analysis

    o at Makedonska Železnička Infrastruktura (MŽI) The former Yugoslav Republic of Macedonia (MKD), twice over the period of last 5 years, i.e. in 2010 and 2013,

    o at Željeznica Republike Srpske (ŽRS), also twice over the period of the last 5 years, though no data were provided, despite repeated requests

- The above situation with condition-monitoring data left very few possibilities for performing objective condition-based M&R analyses. ***For that reason, except for IŽS and MŽI, the analyses performed and described in this Report were primarily based on the RIA inventory data, where RIA Service Lives (SLs) were found to be the most objective and reliable factor to be used***. This was already observed and stated in Report 2 and the intention was to improve this for the purposes of this Report. However, as stated above, the condition-monitoring data (i.e. TG only) was provided only by IŽS and MŽI, whereas as for other RPs, it proved to be either non-existent, or unusable, as in the case of KOS (being paper-based, thus not permitting digital analysis). This was quite a pity, as the intention was to use condition-monitoring data for detailed and accurate pinpointing of track locations which need more urgent M&R. This was done only for IŽS and MŽI, where TG data were used for planning Tamping (only for IŽS, as they provided 9 measurements over the past 5 years, i.e. 2 per year, whereas for MŽI only two measurements were provided and in 2010 and 2013, which was both too scarce and too far back to be used for planning Tamping), but in both cases TG data were also used for assessing the overall track condition, as well as for the prioritisation reasons when reducing M&R budget from the "Ideal/Maximum" scenario to "Medium" and "Minimum" one, i.e. for identification of track locations which had higher priority for M&R works to be performed on them urgently.

4.2.5.2 M&R-related Regulations:

- As already identified in Report 2, M&R-related Regulations and Rule-books in of the RPs have changed somewhat since the days when most of the RPs (with exception of those of Albania) belonged to the Yugoslavian Railway Network. This can be seen as both good and bad:

  o Good, as this means that most of the RPs still adhere to uniform (or at least similar) regulations,

  o Bad, because such ***regulations & rule-books***, being issued by the Yugoslav Railways, which disintegrated more than 20 years ago, and which were mostly created significantly prior to its disintegration, ***are clearly outdated***

  o Bad, because most of the stipulations of the regulation (outdated and not updated) are mostly not followed, due to either lack of RIA condition-monitoring, or ultimately due to the lack of funds received for both analysis of RIA condition, and primarily for the performance of the M&R works

  o Bad because even in cases where attempts were made to update the regulations according to the European standards, and especially for those regulations which were not updated at all, modern condition-based M&R planning (based on systematic and regular measuring of RIA condition and analysing it using deterioration modelling and rule-based M&R decision-making) was not adopted at all, nor even taken into consideration

- In this Report, relevant Regulations and Rule-books were identified and checked with RPs if they were indeed adhered to and how, i.e. which stipulations were exactly used for determining M&R needs, as well as if the data required for their application are present.

  o The result using outdated regulations and rule-books is that all WB6 RPs are effectively to a large extent using old-fashion documents which point them in the wrong direction when it comes both to RIA (re)construction, as well as M&R. Moreover, these old-fashion documents do not contain any of the modern knowledge concerning RIA behaviour, and thus also do not follow the modern concept of RIA condition-based M&R management at all. ***For this reason alone, a tremendous amount of funds is being lost in all RPs by following wrong/outdated M&R concepts***.

- A typical example is that none of the documents mention any of the modern RIA condition-monitoring techniques, except Track Geometry (TG) (*e.g. no mentioning of rail profile, rail corrugation, rail ultrasonic inspections, rail surface inspections, rail welds inspection, rail eddy current inspection, wheel/rail interface monitoring, Ground Penetrating Radar ballast inspection, track vision system inspection, overhead line (OHL) inspection, signalling systems' inspection, civil works (structures) inspection, tunnel profile and lining inspection, etc.*). For that reason, they cannot prescribe their utilisation for the determination of RIA health and consequential needs in M&R works.

- This on the other hand, also presents a serious obstacle to M&R outsourcing, as modern outsourcing concepts, such as PBMC (*Performance Based Maintenance Contracts*) are heavily based on the KPIs (*Key Performance Indicators*), and which are again heavily and primarily based on the current and desired RIA condition, respecting and maximizing RAMS (*Reliability, Availability, Maintainability and Safety*) factors, which in order to be established, prescribed and controlled, need first to be measured.

- For the above reasons, without proper and regular condition-monitoring, none of the RPs could be realistically expected to adopt modern RIA M&R management practice, nor thus catch-up with the European railways.

- In fact, one of **the first prerequisites for all WB6 RPs to adopt modern European railway infrastructure management practices and reduce the gap that separates them from the modern European railways, is to update their technical regulations and rulebooks and align them with European and international best practice**.

- For the above reasons, it is strongly recommended for all RPs to undertake updating of their regulations, either on their own, or ideally within the framework of some of the future CONNECTA phases. Whatever the manner in which the RPs undertake this task, its content should be the following:

  - Analyse thoroughly the key regulations and rulebooks documents and compare/benchmark with the modern European and international best practice, as well as with the relevant CEN norms and perform gap-analysis, starting primarily from:
    - Track (old JŽ regulations series 300+)
    - Traction (old JŽ regulations series 200+)
    - Signalling, electrical and telecommunication (old JŽ regulations series 400+)
    - All other regulations
  - Establish priorities in updating regulations
  - Update regulations

- Depending on the extent of the project, its duration would vary. The optimistic estimate is that in order to update all documents 2 years of work would be needed, while the pessimistic estimate would suggest 4 years is needed. For performing only the initial analysis, benchmarking, gap-analysis and prioritisation, 1 year would be sufficient. If, after gap-analysis and prioritisation, only the documents assessed as being of top-priority are to be updated, the estimate is that 2 years would be needed.

Based on the conclusions of the regulations' investigation as well as the collected data and created Asset Registers, data-processing for the purposes of establishing M&R plans for the 5-year period 2019-2023 was undertaken under 3 distinct scenarios: "Ideal/Maximum", "Medium" (roughly 50% of the "Ideal") and "Minimum" (roughly about 20% of the "Ideal").

All the analyses and conclusions thereof, in terms of RIA quality and consequential M&R needs, are performed strictly on a technical basis. What this means is that the condition of RIA was analysed based on valid and widely adopted railway engineering practices, both in the region and internationally, and that in cases where this condition was assessed according to these internationally accepted criteria as no longer fit for safe traffic, or in other words, as causing too high a risk of negatively affecting rail traffic, their replacement, i.e. renewal, was foreseen. The reason why this is emphasised here is that *the above approach is strictly technical, i.e. based on adopted railway engineering rules of practice, and does not take into account any geo-political, economic or other approaches, such as those related to the expected or desired increase in traffic volumes or other transportation strategies, either in the region, or in Europe as a whole*. The latter approach was included to an extent in the process, in the sense that all RP-s were requested to provide their perspective with respect to the relative importance of certain corridors, routes and lines, i.e. to describe their "prioritisation" thereof. In that sense, the first, "Ideal" scenario included all M&R works that were found to be necessary strictly on the basis of RIA condition and its implications for traffic safety, assuming all the financial funds (no matter how large) were already (or would certainly) made available. For this reason, this "ideal" scenario produced quite a high M&R budget for all RPs, as indeed, their infrastructure was in a very bad condition after decades of lack of M&R. *In fact, this "ideal" scenario reflects the M&R backlog that had piled up after these decades of M&R negligence*. On the other hand, the "Medium" and "Minimum" scenario, were created using precisely the prioritisation RP-s provided (for those RPs that did provide it), as well as Core vs. Comprehensive (where Core lines were given priority), line category and overall condition assessment, as also requested from RPs (though not provided by all).

What is exceptionally important to be fully understood about the M&R plan for the period 2019-2023 produced in this Report is that this is most certainly NOT a MANDATORY M&R Plan, but the best possible plan that could be produced with the RIA data that were provided. However, unlike RIA inventory, where most of the data was provided (except for ŽFBiH), since most of the RIA condition-data were still not provided at all (except for Track Geometry in SRB and MKD), in order for this plan to become a real, optimal and "workable" plan, i.e. a plan which could indeed be adopted and deployed in practice, all this RIA condition-data (explained in detail in the chapter 6.1) must be acquired and used to refine the M&R plan provided in this Report. Without this refinement, the M&R plan provided in this Report is still quite rough (as it effectively uses only RIA ages, i.e. RIA age-based Residual Service Lives (RSLs) as the indication of RIA condition and consequential need of renewal, and not even the accumulated-tonnage-based RSLs, let alone RIA condition-data, which were not provided) and as such cannot be considered as final and certainly not as a plan that can be directly put into practice.

Thus, as explained in detail in Report 2 of December 2017, the *RSL approach basically represents a strictly technical approach*, where it is long established in railway engineering practice that RIA towards their end of SL start exhibiting erratic and thus unreliable behaviour, prone to various kinds of failures, which may or may not cause traffic disturbances and/or accidents. This is exactly how the expected maximum SL is established, i.e. it is experience-based and it effectively represents the point after which a particular RIA starts exhibiting too frequent failures (or a risk thereof) and thus causes too high a risk for traffic safety and other disturbances, so that it can be considered that such RIA is no longer fit for usage and should be replaced. *It clearly does not mean that on the particular anniversary of this particular RIA matching its SL such RIA would immediately completely collapse. Not at all*, and as most of the RPs in the WB6 region have already proven, RIA could indeed be retained for a number of years after the effective expiration of their SLs, but this is normally done with various kinds of "prices" and "consequences" mostly related to the speed reductions, increased level of emergency maintenance, higher tolerance to traffic disturbances, reduction of line capacity and possible loss of customers to other traffic modes, etc. On the other hand, what the expiration of RIA SLs certainly means, is that such RIA cannot be considered to be of "satisfactory" quality according to well-established European and other international practices and as such suitable for "standard" traffic operating conditions normally required in Europe and on its main Corridors and Routes, e.g. for the tentative/indicative extension of TEN-T Core&Comprehensive network in the WB6 (C&CNWB).

Based on the above, the M&R works found to be necessary in this Report due to strictly technical reasons, i.e. RIA condition (RSLs), should be performed <u>only if sound and credible reasons are found for the traffic volumes in this region to grow significantly in the near future or if the EU itself, for whatever (e.g. strategic) reasons, desires to raise the quality-level of the rail infrastructure in the WB6 region and thus finance it accordingly itself</u>. Otherwise, if no sound grounds for the traffic growth are found, or if the EU does not desire to finance the improvement of WB6 RIA on its own, regardless of the fact of whether the Routes/Corridors/Lines in this region will or will not be formally incorporated into the TEN-T network, the infrastructure in this region does not justify the (extremely) large budgets needed for these M&R works to be done. Nevertheless, it should be emphasised that this analysis should also serve as a reminder that the existing infrastructure does not necessarily call for and justify large investment projects, but that instead significantly more money should be redirected to M&R, as if it is not done, the situation concerning the existing infrastructure will certainly not improve.

What the RIA M&R analyses showed was the following:

Average Residual Service Lives (RSL) (i.e. time left from the current age of the RIA to their expected maximum SLs, expressed in percentage of SLs, i.e. $RSL = (MaxSL - CurrentAge) / MaxSL$ for key track components (Ballast, Rails, Sleepers & Fastenings – BRSF) are provided on the Figure 8. For example, if current SL was 30 years, and expected SL was 50 years, RSL would be 50-30=20 years, i.e. 20/50=0.4, i.e. 40%.
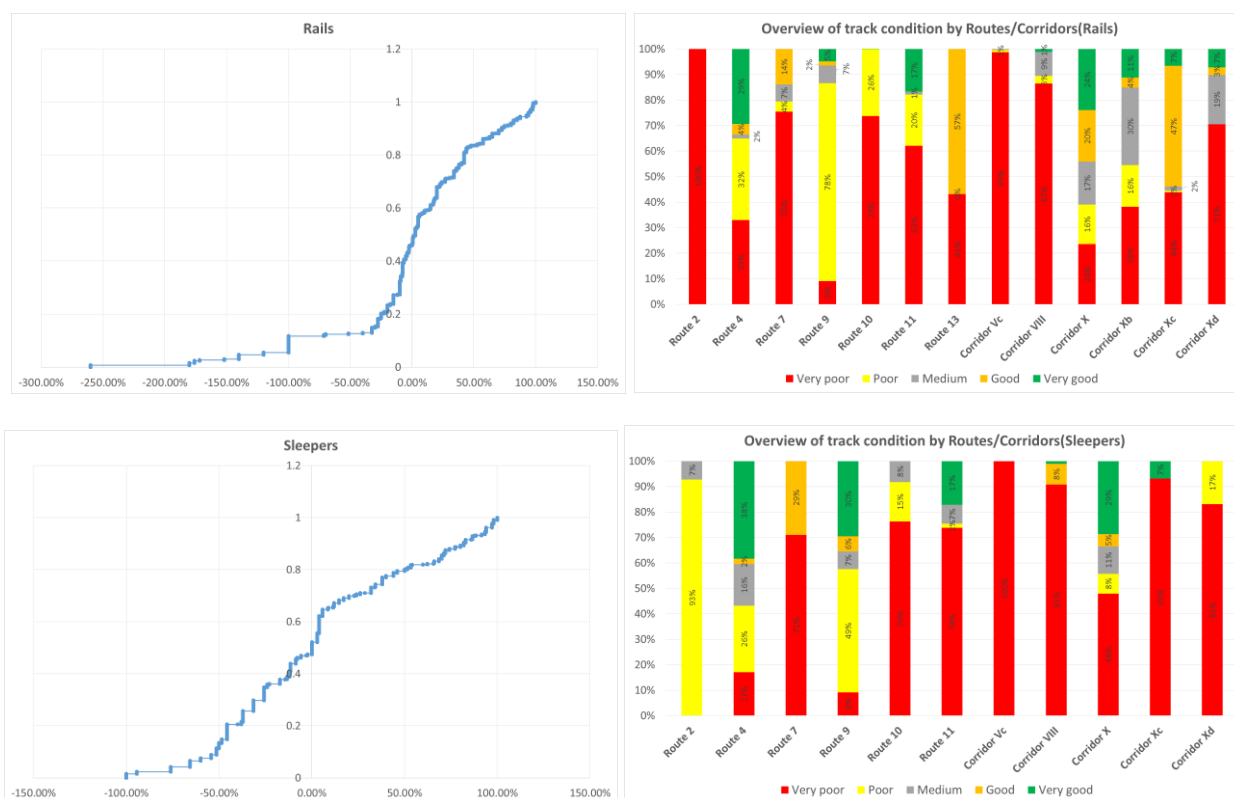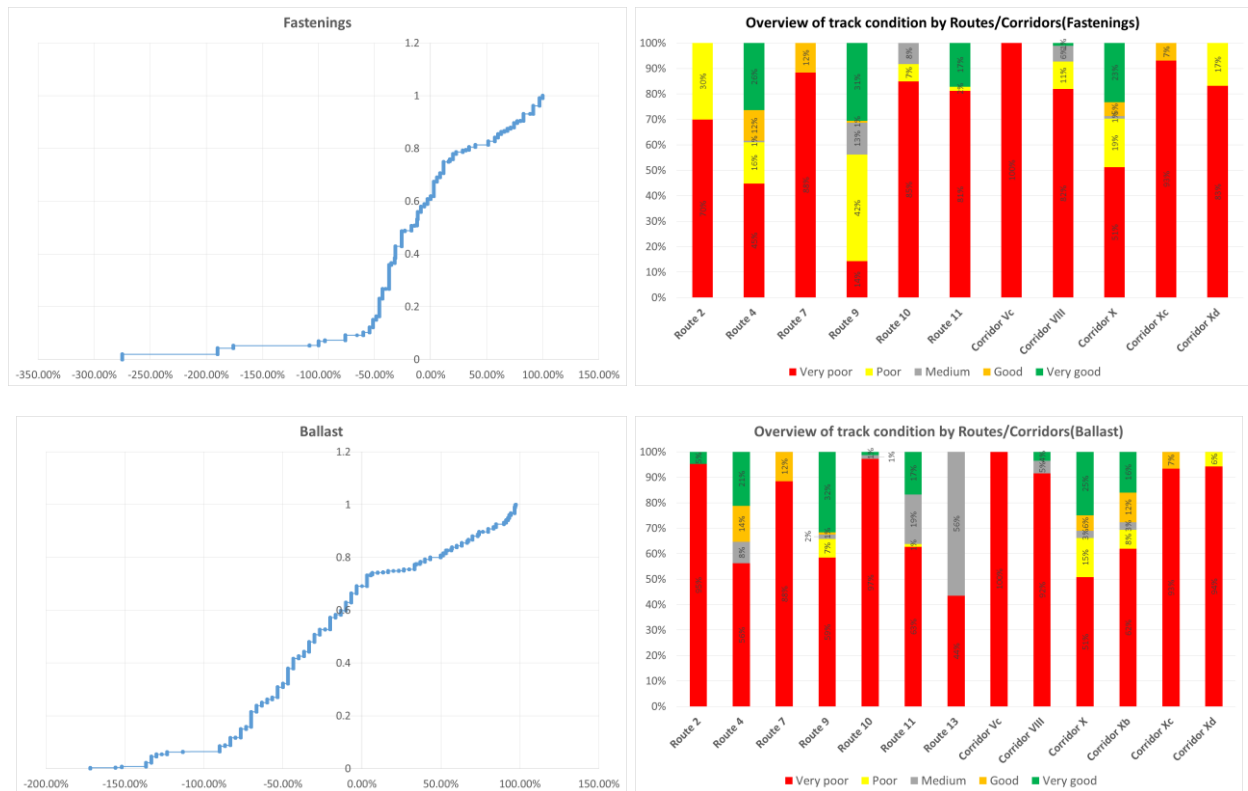
Figure 8: Cumulative distribution curves of the residual service lives of the key track assets (rails, sleepers, fastenings and ballast) on the entire TEN-T C&CNWB (without ZFBiH, as no data were received until the moment of writing this Report)

Namely, what Figure 8 clearly shows is that in case of WB6 RIA RSLs, largest portion of their cumulative curves lies in the negative domain, meaning that their SLs have exceeded their expected SLs. Moreover, what clearly speaks in favour of very aged RIA is the fact that the average BRSF RSL amount to, Table 7 & Figure 9:

Table 7: Average Residual Service Lives (RSL) of Ballast, Rails, Sleepers and Fastenings (BRSF) on the entire WB6 network

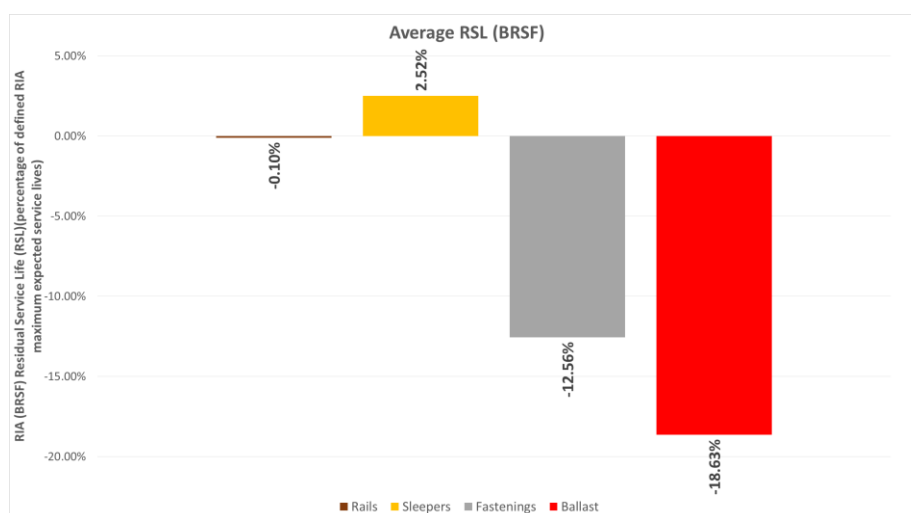| RIA	Rails	Sleepers	Fastenings	Ballast
Average Residual Service Lives (RSL)	-0.10%	2.52%	-12.56%	-18.63%

Figure 9: Average RSL of Ballast, Rails, Sleepers and Fastenings (BRSF) on the entire WB6 network

What Table 7 & Figure 9 show is not only that the average RSLs of all RIA, i.e. BRSF, has long exceeded the expected SL (as all RSLs are negative), but that the average BRSF RSLs are ranging between +2.52% (sleepers) and -18.63% (ballast), which means that barely any track components are left within the expected SL.

Again, it doesn't mean that these lines should be immediately closed for traffic, because they have long exceeded their expected SLs, and have nevertheless been operated since (probably with ever increasing amount of problems and failures, but used, nonetheless). So, as indicated before, this means that the significant portion of these RIA should be replaced if the intention is to bring the infrastructure to the condition considered as "normal" under European and international terms, i.e. for the purposes of the tentative/indicative extension of TEN-T C&CNWB, **but only if the traffic volumes (which are currently very low) would justify this – i.e. if some credible reasons are found for them to (significantly) rise in the close future**. If, however, that is not the intention, these RIA could remain in service, though fully conscious of their severely deteriorated condition, which of course increases significantly the risks of failures with or without consequences onto rail traffic. These risks may be mitigated and reduced to a certain extent by usual speed-reductions, tonnage-reductions, frequent emergency repairs, rerouting of traffic, or shifting traffic to other transportation modes, etc., but if the RP is fully conscious of all the above aspects and prepared to take every precaution necessary, frequent and vigilant monitoring of RIA behaviour, such infrastructure could continue being used in the severely reduced traffic mode, but could certainly not be considered adequate for European Routes and Corridors, i.e. tentative/indicative TEN-T C&CNWB extension.

The above approach, which was applied on the entire WB6 network, can also be broken down and applied on the Route/Corridor level, Figure 10, which provides even better insight into the current RSLs of all superstructure RIA, i.e. BRSF.
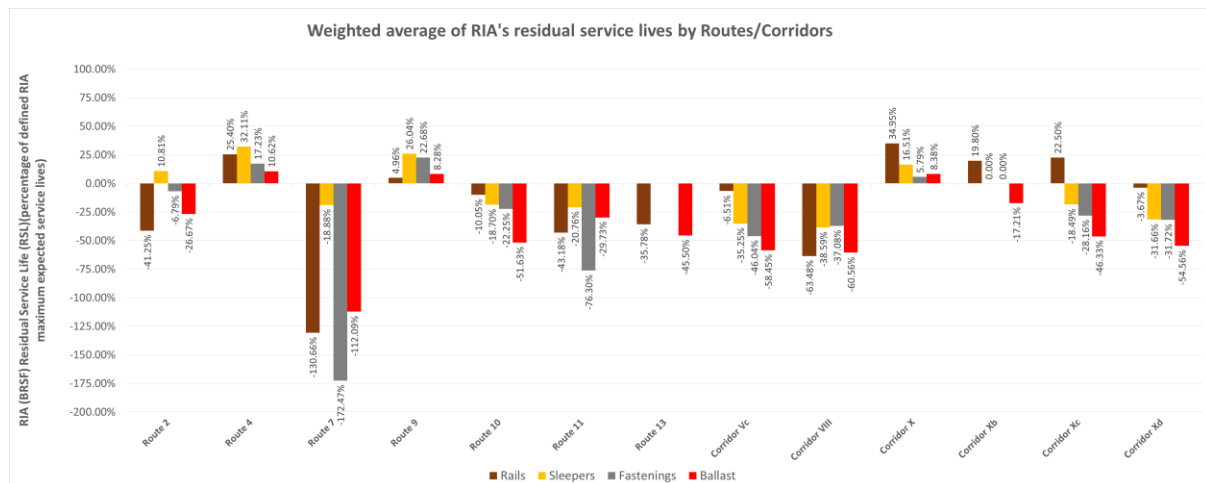

Figure 10: RIA (BRSF) RSLs broken down per Corridor/Route/Line on the entire WB6 network

In terms of RIA condition and actual volumes of consequential M&R works required as the remedy, following the logic explained in the December 2017 Report 2, where in the absence of concrete RIA condition-measurement data, RIA condition could only be indirectly established with respect to their RSLs, which in turn can be split in the following categories, Table 8:

Table 8: Relationship between RIA RSL and condition

RSL	< 0 %	0 – 20 %	20 – 40 %	40 – 60 %	> 60 %
Condition	Very poor	Poor	Medium	Good	Very good

Following the above concept, the following is obtained for the BRSF on WB6 network, Figure 11:
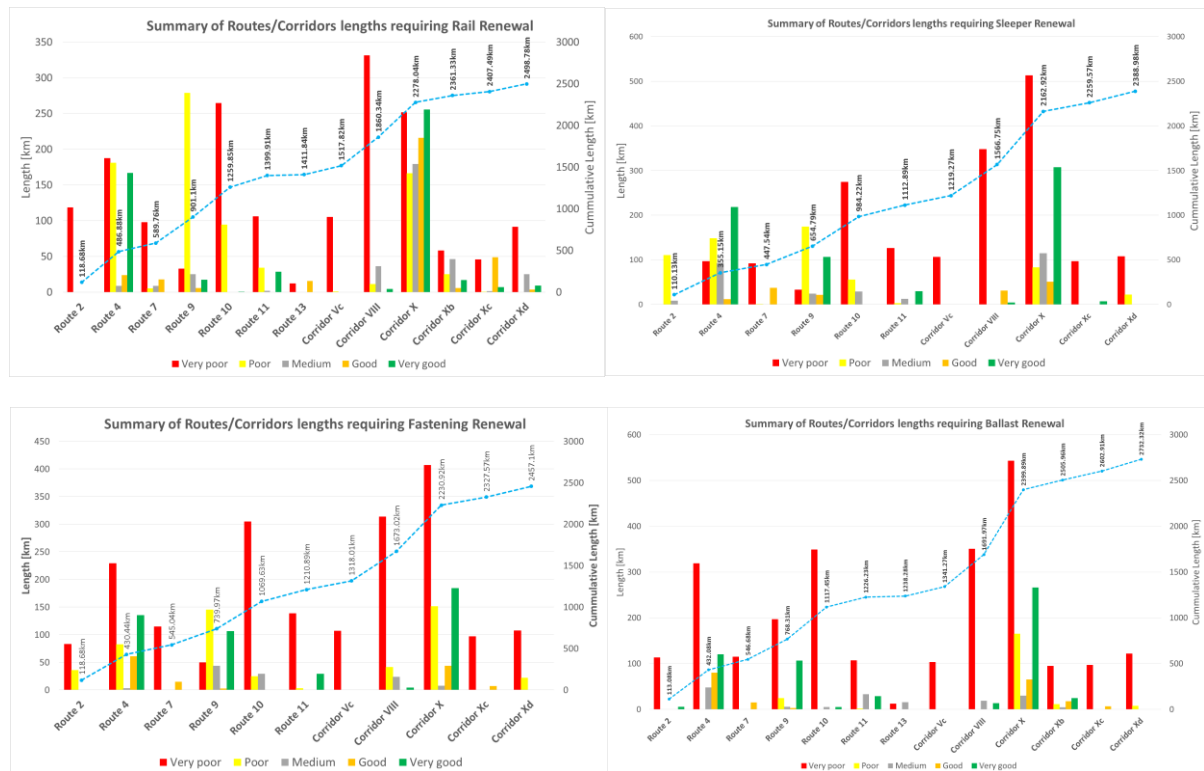
Figure 11: Summary of Rails, Sleepers, Fasteners and Ballast Residual Service Lives (RSL) per Corridors and Routes in WB6 (blue line showing cumulative RSL <= 20%)

As can be seen in Figure 11, out of approximately 3676.5 km for which data were obtained from WB6 RPs, 2499 km of rails, 2389 km of sleepers, 2457 km of fasteners and 2732 km of ballast have either exceeded their service lives (RSL <= 0) or have less than 20% RSL left (blue cumulative curve).

The reason why these two categories (RSL <= 0 and 0 < RSL <= 20%, i.e. effectively RSL <= 20%) were taken as important is that the aim of this project and this very processing was to define the M&R works that need to be performed in the 5-year period 2019-2023, and therefore, as usual service lives of RIA span between 25 and 50 years, if an RIA has more than 20% RSL, it will most certainly not fall within the period 2019-2023 as necessary to be replaced. Therefore, only RIA with RSL <= 20% represent "candidates for replacement" in the said period (this is just the first indication – in the renewal plan, further below, it is done more precisely).

4.2.6 Maintenance Needs Prioritisation Methodology

However, what is also obvious is that the volume of M&R is extremely large and therefore, a strategy had to be devised as to how to prioritise them, i.e. select from the "Ideal/Maximum" scenario the 50% of more important M&R to be performed in the "Medium" scenario and 20% of most important in the "Minimum scenario", as well as distribute them among the years in the 5-year target period 2019-2023. For this prioritisation, various strategies and criteria can be defined (and effectively, the best approach would be to apply those defined in chapter 4, e.g. the SEETO ones – but which could not be applied due to reasons explained in that chapter, primarily due to the lack of relevant information, though strongly suggested to be applied in closest-possible future), but all of them in order to be applied would require relevant data to be available in the first place. In that sense, the remaining possibilities for prioritisation were:

- Core vs. Comprehensive lines
- Line categories (national & UIC)

- Prioritisation indication in the requested file (*Route Priorities.xlsx*), of course, again, only for those RPs who populated and provided that file

- Overall Condition data (file: *OverallCondition.xlsx*), ranging from very poor (1) to good (4)), of course only for those RPs who populated and provided that file

However, the above parameters could afterwards be further expanded to the following parameters (once the required data get collected and become reliably available), representing traffic flows (current and forecasted (of course, objectively and a well-substantiated manner)):

- Number of trains per day,
- Annual tonnage.

The prioritisation methodology is intended to be applied in the simplest possible fashion, i.e. without any particular weighting method, and that is that, e.g. Core lines are to be addressed before Comprehensive lines. Among Core lines, however, firstly those having higher Line Categories (national & UIC) would be addressed first, and those having lower later. "Subjective Prioritisation" indication as per the requested file (*Route Priorities.xlsx*), would be applied after that, of course, only for those RPs who populated and provided that file. Finally, condition data, i.e. rating (1-poor to 4-good) would be used only if existent, in the sense that the lower categories (poorer track sections) would be addressed first.

Number of trains and annual tonnage are effectively often implicitly included in the line categorisation methodology (either national or UIC), but if wanted to be utilised in an explicit form, it could be added after the condition-data, in the sense that lines would be grouped into (usually) 3 classes according to the number of trains per day, in which case, the classes with larger number of trains per day would be addressed first. Similar approach should be taken concerning annual tonnage.

Furthermore, again, when necessary data become available, enhanced CBA and MCA analysis should be deployed to expand the prioritisation approach for the 5-years M&R Plans with the perspective of the development of the rail networks (but also road, as they interact mutually) of the WB6 region, relevant to the relative importance of corridors, routes and individual lines, thus at scanning and rendering the classification available according to their importance, as in this way, the main flagship axes would be selected for M&R, making a more effective allocation of funds.

Also, the prioritization process for rail projects should ideally include risk analyses and mitigation plans, using the multi-criteria methodology of the Analytical Hierarchy process (AHP) based on traffic volume, risks / impacts, shifting of cargo by road and passenger traffic for green transport, the impact of alternative routes and viable alternatives, multimodality, potential economic areas and eco-industrial zone, and so on. These approaches are thus strongly recommended for the subsequent projects within a similar domain, or indeed, for eventual extensions of this very Project.

4.2.7   Resulting M&R Plan & Budget Scenarios

Respecting the methodology explained in the December 2017 Report 2, where RIA with RSL <= 20% would be taken as requiring renewal, the volumes of BRSF renewal works were obtained, which were then accompanied by the M&R estimates for Switches & Crossings (S&C) units, Civil Works (i.e. objects or structures, such as Bridges, Tunnels, Culverts, Level-crossings and Stations), Electrification and Signalling Systems, Table 9-Table 11, whereas the respective methodologies for calculating M&R needs and related budgets for those other infrastructure assets were explained in the respective Chapters 6.2.6, 6.2.7, 6.2.8 and 6.2.9 of Report 5.

The reason why these two categories (RSL <= 0 and RSL <= 20%, i.e. effectively RSL <= 20%) were taken as important is that the aim of this project and this very processing was to define the M&R works that need to be performed in the 5-year period 2019-2023, and therefore, as usual service lives of RIA span between

25 and 50 years, if a RIA has more than 20% RSL, it will most certainly not fall within the period 2019-2023 as necessary to be replaced. Therefore, only RIA with RSL <= 20% represent candidates for replacement in the said period (this is just the first indication – in the renewal plan, further below, it is done more precisely).

Table 9: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Ideal/Maximum" scenario

Infrastructure Costs [EUR]		Track	S&C	Civil Works	Signalling	Electrification	TOTAL
ALB		177,802,372	3,075,000	?	0	?	**180,877,372**
BiH	BiH - ŽFBiH	?	?	?	?	?	**?**
	BiH - ŽRS	111,353,783	13,425,000	9,501,342	25,181,695	106,296,025	**265,757,845**
MKD		174,206,769	29,175,000	72,995,983	90,092,583	43,099,341	**409,569,676**
MNE		57,535,460	14,325,000	160,541,420	28,100,120	11,034,080	**271,536,080**
SRB		600,433,150	62,100,000	744,244,660	394,004,978	263,246,853	**2,064,029,641**
KOS		86,865,145	3,075,000	40,978,215	37,376,150	?	**168,294,510**
TOTAL WB6		**1,208,196,679**	**125,175,000**	**1,028,261,620**	**574,755,526**	**423,676,299**	**3,360,065,124**

Table 10: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Medium" scenario

Infrastructure Costs [EUR]		Track	S&C	Civil Works	Signalling	Electrification	TOTAL
ALB		111,675,257	1,537,500	?	0	0	**113,212,757**
BiH	BiH - ŽFBiH	?	?	?	?	?	**?**
	BiH - ŽRS	50,759,658	6,712,500	4,750,671	15,070,440	7,149,625	**84,442,894**
MKD		70,446,230	14,587,500	36,497,992	20,301,708	5,044,031	**146,877,461**
MNE		36,288,411	7,162,500	80,270,710	14,050,060	5,517,040	**143,288,721**
SRB		212,175,000	31,050,000	372,122,330	67,439,400	33,022,059	**715,808,789**
KOS		35,443,156	1,050,000	20,489,108	28,703,675	?	**85,685,939**
TOTAL WB6		**516,787,712**	**62,100,000**	**514,130,810**	**145,565,283**	**50,732,755**	**1,289,316,560**

Table 11: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Minimum" scenario

Infrastructure Costs [EUR]		Track	S&C	Civil Works	Signalling	Electrification	TOTAL
ALB		54,809,636	615,000	?	0	0	**55,424,636**
BiH	BiH - ŽFBiH	?	?	?	?	?	**?**
	BiH - ŽRS	15,269,161	2,685,000	1,900,268	15,070,440	7,149,625	**42,074,494**
MKD		33,435,641	5,835,000	14,599,197	20,301,708	5,044,031	**79,215,576**
MNE		20,122,638	2,865,000	32,108,284	5,620,024	2,206,816	**62,922,762**
SRB		91,917,857	12,420,000	148,848,932	67,439,400	33,022,059	**353,648,248**
KOS		17,302,134	675,000	8,195,643	0	0	**26,172,777**
TOTAL WB6		**232,857,067**	**25,095,000**	**205,652,324**	**108,431,572**	**47,422,531**	**619,458,494**

What also needs to be understood, and as explained in detail in the December 2017 Report 2, a "normal" or "standard" average RSL level of all RIA in Europe and also internationally, is considered to revolve around the figure of 40% (i.e. SL at the level of 60% of the maximum SL). In other words it means that the network, i.e. RIA, would neither be too young, nor too old, but would normally range between 100 and 0 RSL, slightly shifted towards 0, i.e. towards expiration (i.e. 50% average SRL would represent fully balanced RIA SRLs, but which is found, based on experience, to be "too good", i.e. unjustifiably good, so it is usually shifted by an additional 10% towards RSL of 40%, or SL at 60%). Whichever the case (i.e. either 40 or 50% SRL), no RIA should have negative SRL, i.e. for no RIA should the SL be expired.

An extremely important note, reflecting significantly on the mentioned budgets is that <u>no analysis of the substructure could be performed in this study, due to the fact that no data were found to exist on it</u> and no measurements at all (e.g. Ground Penetrating Radar) are being performed to check its quality. On the other hand, many track problems originate exactly from substructure, especially as the substructure is in most cases in its original form, from the times when the railway lines were

constructed, which often means many decades ago, and when the material for embankments was used indiscriminately, i.e. it was not tested for its suitability for embankments, but instead, whatever material was found in the nearby cuttings was used directly for embankments/fills. Moreover, the lines were constructed for much lower axle-loads and annual traffic loads, which were significantly increased over the years and for which the substructure was definitely not adequate, all causing its further and accelerated deterioration. For that reason, many embankments are of (very) inferior quality, incapable of holding the current axle-loads and annual traffic loads, which is causing the majority of track problems. Finally, as virtually no reconstructions of the substructure ever happened since the construction of the lines, the geometry of the substructure (primarily the width of the capping layer) is still as it was when the line was constructed, i.e. suitable for old-fashioned superstructure elements, primarily sleeper length. Thus, the modern superstructure elements cannot be even installed on top of such inferior substructure, as with the required length of sleepers, width of the ballast shoulder, ballast depth/height and ballast slope (usually required as 1:1.5), capping layers are too narrow to hold it – i.e. the base of such superstructure (i.e. the base of the ballast layer) is wider than the capping, or too wide for it (i.e. for the top of the substructure which is supposed to support it). In short, in most cases, modern superstructure cannot even be installed on top of the existing substructure. Thus, if modern superstructure is to be installed, firstly the substructure would have to be reconstructed, and that would require tremendous costs, a quick estimate of which could be that it could very well match the overall costs of superstructure (explained above in the previous paragraphs), if not even exceeding it. This would have to be taken into serious consideration when planning improvements of the railway infrastructure in the WB6 region.

Tables can also be represented graphically, Figure 14-Figure 16, and short summary in Figure 12-Figure 13.
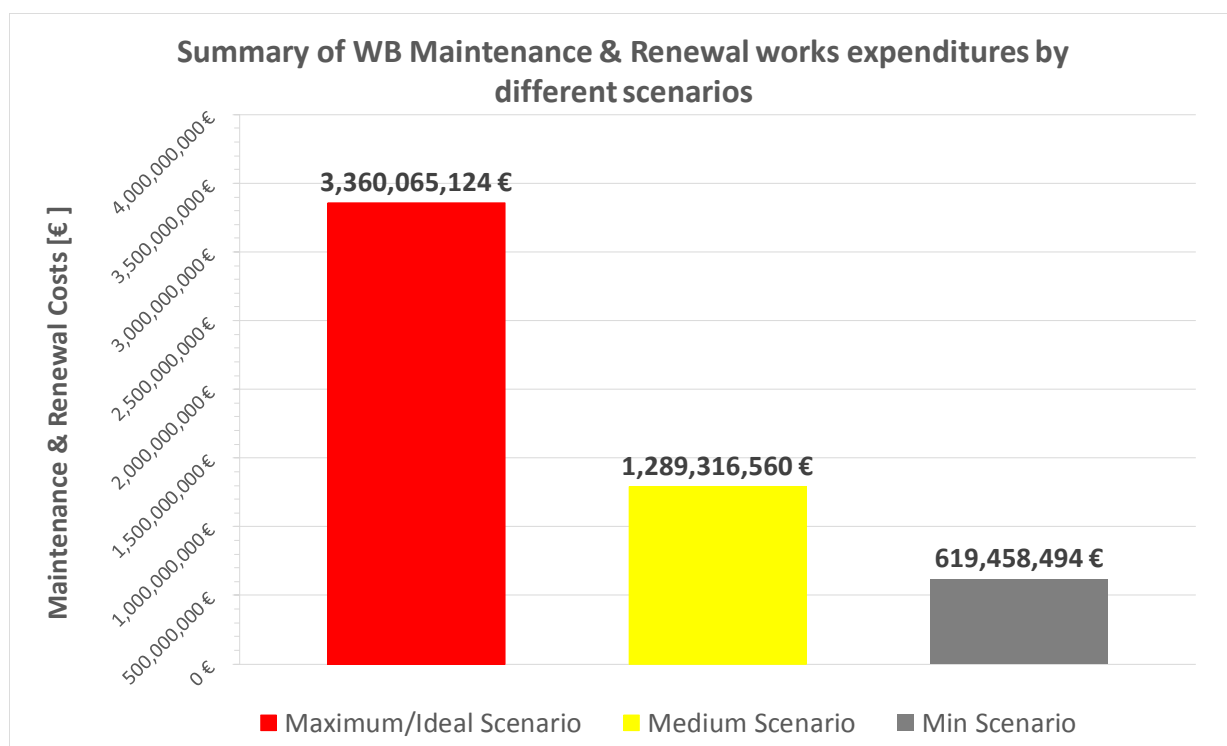

Figure 12: Rail Infrastructure 5-year (2019-2023) M&R Budgets for all 3 scenarios
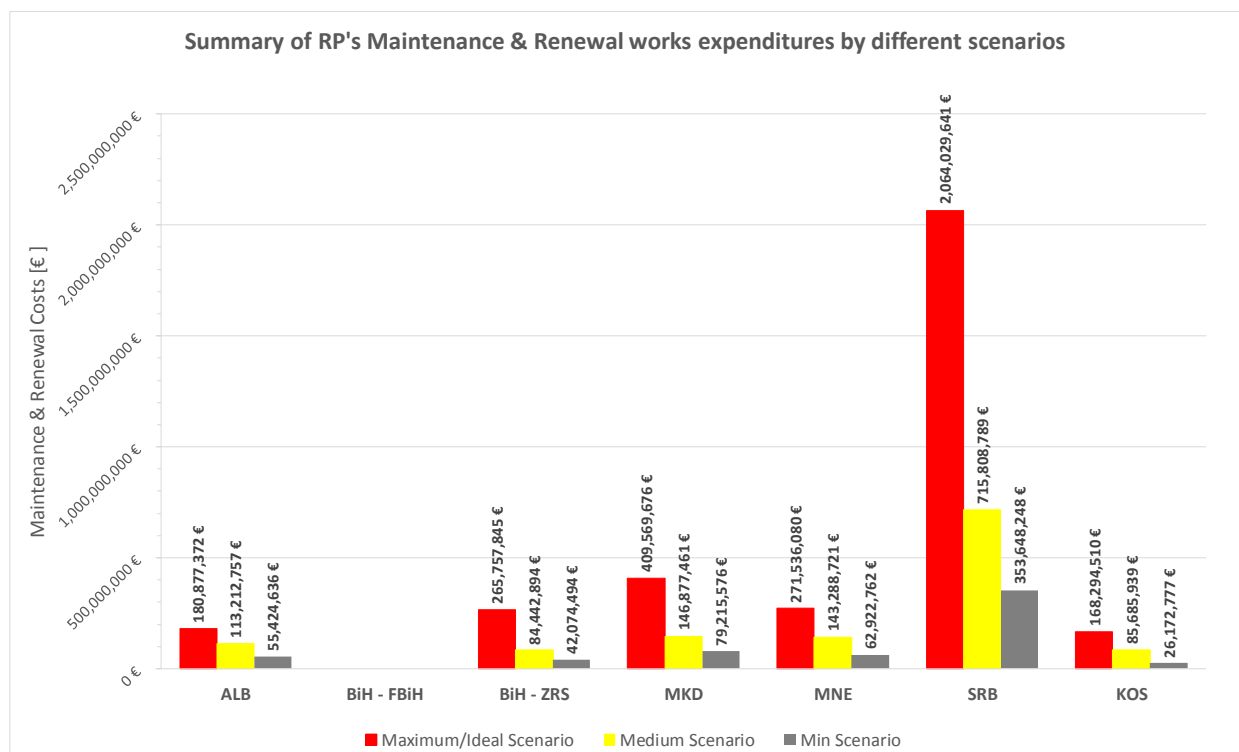
Figure 13: Rail Infrastructure 5-year (2019-2023) M&R Budgets for all 3 scenarios (per RP)
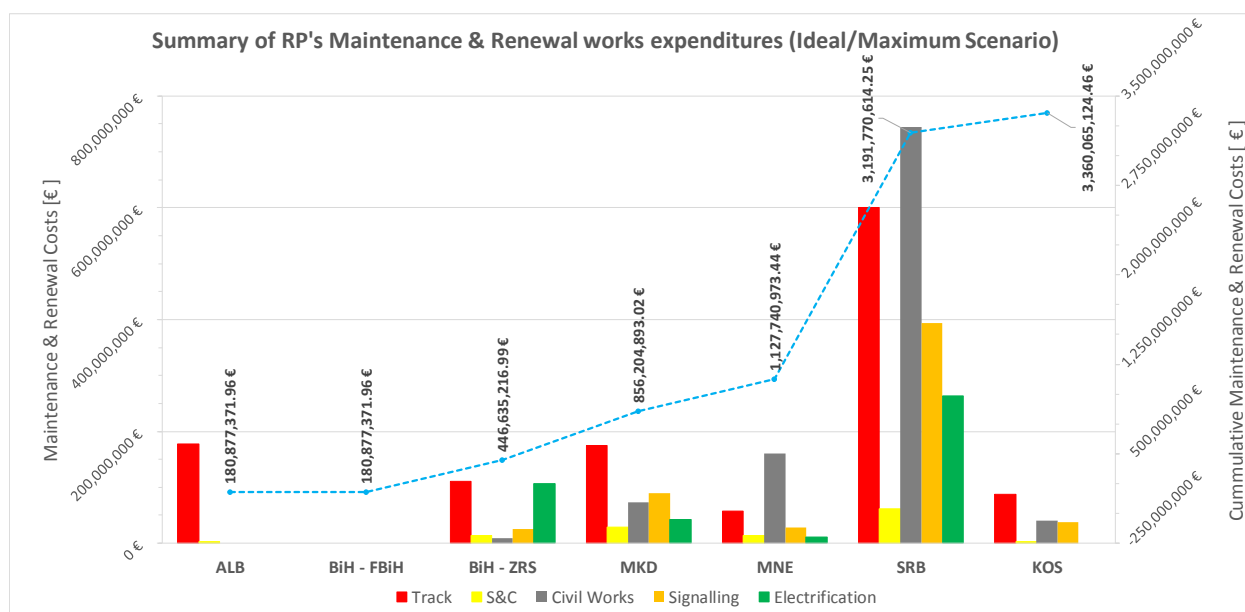

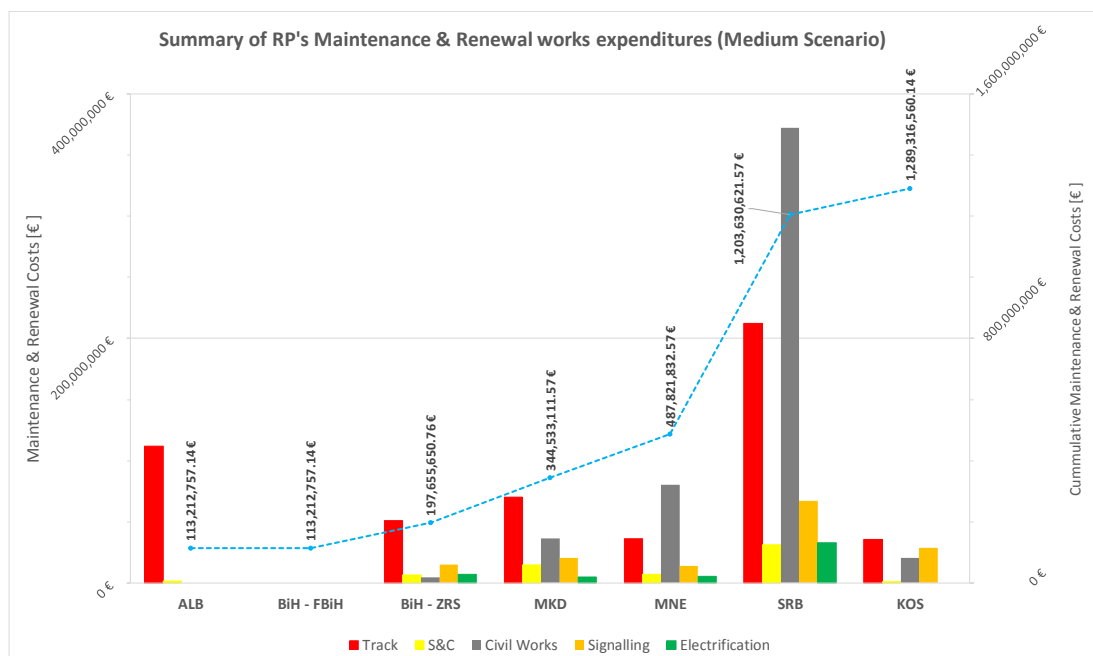*Figure 14: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Ideal/Maximum" scenario (per RP)*

Figure 15: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Medium" scenario (per RP)
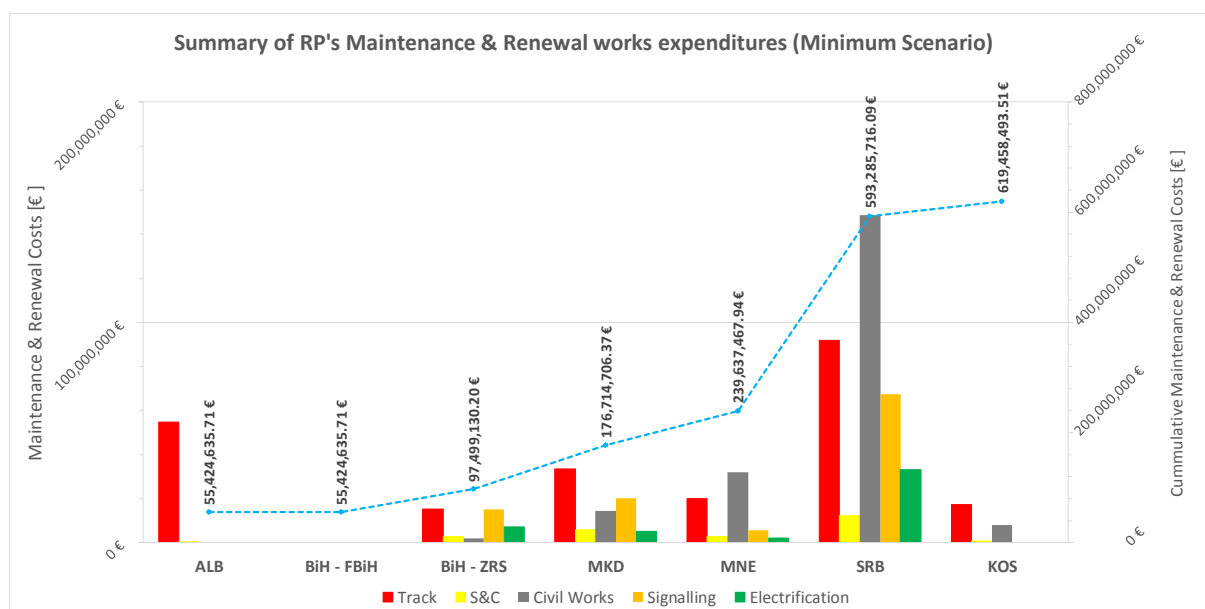

Figure 16: Rail Infrastructure 5-year (2019-2023) M&R Budget for "Minimum" scenario (per RP)

After infrastructure M&R requirements are defined and distributed among WB6 RPs, Corridors/Routes/Lines as well as throughout the 5-year period 2019-2023, considering that the required budgets were quite large, a detailed investigation of the possible sources of funding to be used for financing of these works as well as related procedures and rules for applying and securing those funds were described in chapter 8 of Report 5.

Finally, key recommendations were made concerning the RIA condition, ways in which they should be monitored, as well as how M&R works should be performed. Especially important here are the conclusions of Report 3, concerning the PBMC concept and the utilisation of Infrastructure Maintenance Contractors currently active in the region, e.g. ZGOP and RŽD-I (though both currently operating only in Serbia), as the volume of M&R works to be performed is indeed large and by far exceeds the current capabilities of WB6 RPs.

5 Key insights and recommendations for the future

5.1 Tentative Action Plan

Based on the key conclusions and recommendations from the entire project and all of its Activities and deliverables, elaborated in detail in the respective Reports, the following tentative Action Plan could be formulated, leading towards the achievement of the key Project goals under "ideal" circumstances.

Full and true *separation of railway infrastructure management from train operations* and *adoption of Railway Laws fully in accordance with EU directives* (*for those RPs who have not done it yet, or completely*)

Formulation of *multi-annual Business Plans* followed by corresponding multi-annual *contractual relationships* with the respective Government institutions

Formulation of a modern long-term concept concerning RIA M&R, preferably on *PBMC-basis*, utilising specialised IMCs and KPI-based controlling and pricing mechanisms

Updating of *Technical Regulations and Rulebooks* and their alignment with the European and international best practice

Implementation of a modern *RI-AMS system*

Enabling and ensuring regular comprehensive *RIA condition-monitoring* (*special focus on Civil Works, i.e. structures*)	Phased RI-AMS implementation: C. *Pilot/Trial Implementation* (*RI-AMS Feasibility Studies*), D. *Full-scale Implementation*,	Increased attention to improving the safety of road level-crossings

5.2 Individual key insights and recommendations

The key insights and recommendations for the future and improvement of the current, quite inferior condition of the rail infrastructure in the region were provided, stating:

1. ***Condition-monitoring*** (all RPs have suffered for decades from an inability to measure the condition of various railway infrastructure assets (RIA); some of them have been performing ad-hoc Track Geometry (TG) measurements, but very rarely, although the regulations of all RPs clearly stipulate a minimum of two TG measurements per year; in that sense, in the 5 years, only IŽS (SRB) have been measuring TG quite regularly, but with an outdated measuring car, so the measurements are quite questionable, whereas as for the others, MŽI (MKD) measured only twice, once in 2010 and in 2013,

ŽRS (BiH) also twice, the second one being a donation, the quality of which was reported as very low rendering it unusable, KOS is measuring with a system that is reported as inaccurate and unreliable, and the others are not measuring at all. The intention would be, as a minimum, to acquire a TG system and to measure twice a year for at least 2 years (i.e. a minimum of 4 measurement runs) in order to establish deterioration trends and be able to truly say something about TG behaviour and consequential ballast and substructure quality and M&R needs. Ideally, TG would be accompanied by: vehicle/track interaction monitoring, rail profile measurement system, rail corrugation measuring system and possibly Ground Penetrating Radar. An absolute ideal would be to add Overhead Line (OHL) geometry and wear measurements. However, TG is of paramount importance, so that would definitely constitute the minimum. The expected duration of such a project would be about 2 years. Direct benefits of the project would include:

a. Enabling the only manner for precise and objective determination of M&R works needs and prioritisation between them (determination of urgency levels)

b. Promoting contractual relationships between the responsible Ministries and Infrastructure Managers (IMs), as well as between Infrastructure Managers and Infrastructure maintenance Contractors (IMCs) (e.g. through PBMC concept), as **RIA condition-monitoring data are indispensable for the creation of infrastructure KPIs**, and which are of paramount importance for proper monitoring of the entire contracting process.

c. Precise and objective RIA condition-monitoring data forms indisputable grounds and arguments for the requests to International Financing Institutions (IFIs, e.g. banks) for funding of RIA M&R works as it promotes complete transparency and objectivity, rather than subjectivity and "rule of thumb", which is how IFIs mostly perceive the IMs estimates and requests nowadays

2. **Condition-analysis of Civil Works (structures)** (i.e. bridges, tunnels, culverts, etc., where bridges are arguably the most critical) (**Structural Health Monitoring - SHM**). The idea is to identify the most critical types of bridges, and based on that, the most critical single bridges, e.g. one bridge per RP, and to equip it with the necessary condition-monitoring systems, measure and follow the condition over a period of 2 years, analyse it and produce conclusions (about bridge behaviour and appropriate M&R works and their urgency) that would be valid and applicable to all other bridges of similar type. The expected duration of such a project would be about 2 years.

3. **Testing of a RI-AMS system** (i.e. **RI-AMS Feasibility Studies**); Considering the widely reported benefits of RI-AMS worldwide over the past couple of decades, stating M&R cost-reductions in the range of 5-15%, as well as significant improvements in overall RIA quality and consequential rail traffic safety, the idea is to use the asset register created in the current Project, bring in a suitable RI-AMS system (on the basis of Trial Licenses), and test the system on 30-50km long sections in each RP. The goal is for the RPs to understand what is needed to implement a RI-AMS, and the benefits RI-AMS can bring, how much it can improve the RIA M&R process, how much money it can save based on optimal M&R planning, how it can be used for M&R outsourcing (e.g. within PBMC), etc. Also, obviously, it should serve as the preparation for the subsequent full-scale RI-AMS implementation. The expected duration of such a project would be about 2 years.

4. **Updating of existing regulations and rule-books**; all RPs are utilising heavily outdated documents (normally from 1960-1970, and except for Albania, all others are still utilising old Yugoslav Railways (JŽ) documents). This is keeping them very far from modern best-practice, and thus incapable of catching up with modern European railways, especially in the domain of Condition-based M&R planning, and effectively incapable of adapting optimal M&R outsourcing and PBMC concepts. This is of paramount importance, as all WB6 RPs cannot even begin to expect to get closer to the European level, while adhering to decades old regulations. The project should first analyse all regulations, establish gaps and needs and perform prioritisation. This project could take up two different paths: (1)

update only the top priority documents (needing about 1 year), or (2) update all documents (needing up to 2 years).

5. ***Improving the safety of level-crossings*** (LCR) – there is still a tremendous number of LCRs present on the WB6 rail networks, including the SEETO Core & Comprehensive lines, the safety level of which is at best questionable, and in many cases very low. Clearly, an ideal solution would be a grade-separation between road and rail, but that is again, clearly, very expensive, time and effort-consuming. Nevertheless, the number and level of risk these LCRs demands urgent action in the following senses:

   a. Establish a database of LCRs, with all relevant characteristics and parameters, primarily pertaining to traffic safety, both road and rail

   b. Identify several of the most critical LCRs whose behaviour and events (primarily incidents, or close-incidents) would be monitored more closely (a couple per each RP)

   c. Investigate possible options for quick and cost-effective improvement of traffic safety (again both rail and road) on all LCRs (primarily those identified as most critical)

   d. Investigate possibilities of permanent remote safety-monitoring and condition-monitoring of LCRs, all with the aim of increasing road and rail safety

Estimated project duration: 2 years.

Finally, the key conclusions of the activities and analyses of the Report 5 were:

- Designed RIA data-structure was well accepted by the RPs yielding significant volumes of information that were provided

- The designed RIA data structure also proved suitable for the Infrastructure Database (ID) and the foundation of the Asset Register (AR)

- Preliminary rough estimates of the RIA M&R needs yielded the following figures:

   o For the assets in a "very poor" condition (which already exceeded Service Lives (SLs)):

   o For the "poor" assets with Residual Service Lives (Maximum SLs – current age) less than 20%:

   o For the "medium" quality assets with residual service lives less than 40%:

- ***Volumes of assets that already long exceeded their expected/maximum SLs, and which clearly represent worst locations, are so large that it is almost impossible to even consider any other condition category, before those locations are sorted out***

- On the other hand, ***volumes of assets that exceeded their SLs is so large that even if the funds to repair them were somehow miraculously found, those repairs would be physically impossible to be performed with the existing M&R capabilities of the regional IMs, even if reinforced by Infrastructure Maintenance Contractors (IMCs) active in the region (e.g. ZGOP and RŽD-I, though currently active only in Serbia, but having capabilities and a willingness to expand further in the region). For that reason, this M&R backlog will require a considerable amount of time to be cleared out, during which, unfortunately, also the assets which are currently not in such a critical situation, would also enter into this range.***

- Further analyses in this Project attempted to make use of whatever little information exists on the RIA condition-measurements (only Track Geometry (TG) and only for MKD (2 measurements, but quite outdated, dated 2010 and 2013 and SRB, 9 measurements in the period 2013-2017, which was the only one in line with the stipulations of valid M&R Regulations, and that is that TG measurements should be made twice a year), as well as more detailed elaboration of the non-track-related assets, such as Signalling Systems (SS) and Electro-Energy (EE) infrastructure components, by building upon the proposed concept of IoSR/IŽS (chapters 6.2.8 and 6.2.9). However, ***lack of RIA condition-data was so large, that very little could be done in this respect, which is seen as absolutely the greatest***

obstacle to creating accurate and reliable M&R Plans. Moreover, *without RIA condition-data no prioritisation between M&R works could be done nor determination of M&R work urgency levels to be used as a criterion for differentiation. This is an issue of paramount importance and thus represents the "number one priority" to be resolved, and as soon as possible.*

- Local M&R unit prices were elaborated to the maximum by extracting more information on this topic from the RPs, but unfortunately, most RPs were quite unresponsive in this respect, so most of the Catalogue information (containing very important pieces of information concerning RIA expected maximum SLs and unit prices) were not provided. For that reason, best possible workaround solutions had to be found to combine the most representative prices (and SLs) of all RIA with those regularly used in the modern international practice

Therefore, overall, the most important contributions and added value of this Project to the WB6 RPs were found to be:

- RIA data-structure was defined and most of the RIA data were successfully collected following the instructions and guidance from the Project Team (Table 6)

- ***Infrastructure Database and RIA Asset Register were defined, along with most appropriate data format and, created and populated by most of the RPs*** (except for ŽFBiH)

- ***Considering the large volumes of M&R works resulting from the many-decades of creating M&R backlog, it was clear that RPs would hardly be able to perform all those works themselves. For that reason, utilisation of Infrastructure Maintenance Contractors was found to be necessary.*** However, for their involvement, proper contractual relations needed to be defined and proposed, primarily considering **PBMC** (**Performance Based Maintenance Contracting** concept). For this reason, this concept was analysed in detail, including international best practices, and most suitable concept, including the structure of **KPIs** (**Key Performance Indicators**) was formulated and proposed. However, again here, the lack of RIA condition-data represented the largest obstacle, as they represent the key foundation for the creation of KPIs, thus without RIA condition-data, no objective KPIs can be created and used

- Considering that the only effective manner of keeping RIA in proper condition at all times, which guarantees safe rail traffic, was to deploy a ***comprehensive Railway Infrastructure Asset Management System (RI-AMS)***, this topic was analysed in detail, again including international best practices, and the most suitable concept together with ***list of RI-AMS functionalities was defined, as well as tentative Tender Requirements for the procurement of RI-AMS*** (except for MKD which is the only one in the WB6 region already possessing a modern RI-AMS). Again here, one of the key "levers" for RI-AMS to create most optimal M&R plans are the RIA condition-data, which are unfortunately greatly lacking.

- Finally, based on all the above, in this Report, final analysis of all RIA data was performed, including whatever RIA condition-data were provided (only TG, and only for MKD and SRB), and was used to assess the M&R needs in 3 distinct scenarios:

    a) "Ideal/Maximum", which would effectively encompass all necessary M&R works, and thus represents a form of "wish-list",

    b) "Medium", which was more feasible in financial terms, aiming at about 50% of the budget of the "Ideal/Maximum" scenario, and

    c) "Minimum", which encompasses only most urgent M&R works to be performed on most critical network sections, aiming at about 20% of the budget of the "Ideal/Maximum" scenario.

6 Overall Project Conclusions for the Rail domain

This Project has yielded several significant contributions to the overall railway infrastructure situation and M&R management in the region, primarily by:

A. ***Defining, creating and populating the Infrastructure Database (ID), i.e. the Asset Register (AR) for all RPs*** (except for ŽFBiH), which in itself is already a tremendous achievement, as no such database ever existed at any of the RPs, while they represent the first and key prerequisite for modern Railway Infrastructure Asset Management and M&R Planning (occurring throughout the project, from the very start, to the very end – sketched out in Report 2 and completed in the Report 5)

B. ***Analysis of Infrastructure Managers' (IMs') current M&R contracting strategies*** and recommendations including comparative analysis (PBMC), including the elaboration of the most suitable KPIs (*Key Performance Indicators*) (Report 3)

C. ***Analysis and Recommendations for setting up Railway Infrastructure Asset Management System (RI-AMS) in the region***, along with a detailed list of RI-AMS functionalities and tentative Tender Requirements for the procurement of RI-AMS (Report 4)

D. ***Support to RPs in preparing their own M&R plans for the period 2019-2023*** reflecting their specific characteristics, effectively containing a tentative M&R plan for all RPs, and for all infrastructure domains (Track, Civil Works, Signalling and Electrical facilities), with full assessment of Railway Infrastructure Assets (RIA) condition-analysis and consequential M&R Planning for the period 2019-2023 and related Budget (Report 5)

All the analyses and conclusions provided in this Project (and especially in Report 5), in terms of RIA quality and consequential M&R needs, are performed strictly on the technical basis. What this means is that the condition of RIA was analysed based on valid and widely adopted railway engineering practices, both in the region and internationally, and that in cases where this condition was assessed, according to these internationally accepted criteria, as no longer fit for safe traffic, or in other words, as causing too high a risk of negatively affecting rail traffic, their replacement, i.e. renewal, was foreseen. The reason why this is emphasised here is that ***the above approach is strictly technical, i.e. based on adopted railway engineering rules of practice, and does not take into account any geo-political, economic or other approaches, such as those related to the expected or desired increase in traffic volumes or other transportation strategies, either in the region, or in Europe as a whole***. The latter approach was to an extent included in the process, in the sense that all RPs were requested to provide their perspective with respect to the relative importance of certain corridors, routes and lines, i.e. to describe their "prioritisation" thereof. In that sense, the first, "Ideal" scenario, included all M&R works that were found to be necessary strictly on the basis of RIA condition and its implications for traffic safety, assuming all the financial funds (no matter how large) were already (or would certainly) made available. For this reason, this "ideal" scenario produced quite a high M&R budget needed for all RPs, as indeed, their infrastructure was in a very bad condition after lack of M&R going back decades. ***In fact, this "ideal" scenario reflects the M&R backlog that piled up after several decades of M&R negligence***. On the other hand, the "Medium" and "Minimum" scenario, were created using exactly the prioritisation the RP-s provided (for those RPs that did provide it), as well as Core vs. Comprehensive (where Core lines were given priority), line category and overall condition assessment, as also requested from RP-s (though not provided by all).

What is exceptionally important to be fully understood about the M&R plan for the period 2019-2023 produced in this Report is that this is most certainly NOT a MANDATORY M&R Plan, but the best possible plan that could be produced with the RIA data that were provided. *However, unlike RIA inventory, where most of the data was provided (except for ŽFBiH), since most of the RIA condition-data have still not been provided at all (except for Track Geometry in SRB and MKD),* ***in order for this plan to become a real, optimal and "workable" plan, i.e. a plan which could indeed be adopted and deployed in practice, all this RIA condition-data*** *(explained in detail in chapter 6.1 of Report 5)* ***must be acquired and used to refine the M&R plan provided in this Report***. *Without this refinement, the M&R plan*

provided in Report 5 of this Project is still quite rough (as it effectively uses only RIA ages, i.e. RIA age-based Residual Service Lives (RSLs) as the indication of RIA condition and consequential need of renewal, and not even the accumulated-tonnage-based RSLs, let alone RIA condition-data, which were not provided) and as such cannot be considered as final and certainly not as a plan that can be directly put into practice.

Thus, as explained in detail in the December 2017 Report 2 and confirmed in Report 5, the **RSL approach basically represents a strictly technical approach**, where it is long established in railway engineering practice that RIA towards their end of SL start exhibiting erratic and thus unreliable behaviour, prone to various kinds of failures, which may or may not cause traffic disturbances and/or accidents. This is exactly how the expected maximum SL is established, i.e. it is experience-based and it effectively represents the point after which a particular RIA starts exhibiting too frequent failures (or a risk thereof) and thus causes too high a risk for traffic safety and other disturbances, so that it can be considered that such RIA is no longer fit for usage and should be replaced. ***It clearly does not mean that on the particular anniversary of this particular RIA matching its SL such RIA would immediately completely collapse. Not at all***, and as most of the RPs in the WB6 region have already proven, RIA could indeed be retained in track for a number of years after the effective expiration of their SLs, but this is normally done with various kinds of "prices" and "consequences" mostly related to speed reductions, increased level of emergency maintenance, higher tolerance of traffic disturbances, reduction of line capacity and possible loss of customers to other traffic modes, etc. On the other hand, what the expiration of RIA SLs certainly means, is that such RIA cannot be considered to be of "satisfactory" quality according to well-established European and other international practices and as such suitable for "standard" traffic operating conditions normally required in Europe and on its main Corridors and Routes, e.g. for the tentative/indicative extension of TEN-T Core&Comprehensive network in the WB6 (C&CNWB).

Based on the above, the M&R works found to be necessary in this Report due to strictly technical reasons, i.e. RIA condition (RSLs), should be performed <u>***only if sound and credible reasons are found for the traffic volumes in this region to grow significantly in the near future or if the EU itself, for whatever (e.g. strategic) reasons, desires to raise the standard of rail infrastructure in the WB6 region and thus finance it accordingly itself***</u>***. Otherwise, if no sound grounds for traffic growth are found, or if the EU does not desire to finance the improvement of WB6 RIA on its own, regardless of whether the Routes/Corridors/Lines in this region will or will not be formally incorporated into the TEN-T network, the infrastructure in this region does not justify the (extremely) large budgets needed for these M&R works to be done.***

Respecting the fact that the volume of M&R found to be necessary for the "Ideal" scenario was extremely large, a strategy had to be devised as to how to prioritise them, i.e. select from the "Ideal/Maximum" scenario 50% of the more important M&R to be performed in the "Medium" scenario and 20% of the most important in the "Minimum scenario", as well as distribute them across the years in the 5-year target period 2019-2023. For this prioritisation, various strategies and criteria can be defined (***and effectively, the best approach would be to apply those defined in chapter 4 of Report 5, e.g. the SEETO ones*** – but which could not be applied due to reasons explained in that chapter, primarily due to the lack of relevant information), but all of them in order to be applied would require relevant data to be available in the first place. In that sense, the remaining possibilities for prioritisation were to use a ***"modified SEETO prioritisation strategy", which is highly recommended to be applied in the nearest possible future***, relying on the following parameters as prioritisation criteria:

- Core vs. Comprehensive lines

- Line categories (national & UIC)

- Overall Condition data (file: *OverallCondition.xlsx*), ranging from very poor (1) to good (4)), of course only for those RPs who populated and provided that file

- Prioritisation indication in the requested file (*Route Priorities.xlsx*), of course, again, only for those RPs who populated and provided that file.

Looking overall in retrospect on the entire Project and knowing exactly that M&R of the whole transport (and especially rail) infrastructure is still one of the major challenges in the region, primarily with regard to the institutional framework and budget allocation to infrastructure asset preservation, as well as with regard to the existence of structured processes, tools and skills for assets' condition-monitoring, analysis and consequential M&R planning (where previous assessments already concluded that 22.5% and 18.8% respectively of the indicative extension to TEN-T C&CNWB were found to be in need of maintenance and/or rehabilitation), *the above-listed deliverables directly represent the clear and objective confirmation of these previous assessments, as well as establishing a sound basis for the improvement of this situation*. Indeed, *this Project not only confirmed the previous assessments, but made much more precise and above all significantly more objective assessments of the RIA condition and consequential M&R needs and budget, which proved to be even graver than the original assessments*.

Also, as was already known before this Project, and which served as the initial motive for the performance of this Project, in order to ensure the sustainability of the rail network in the WB6 region, which plays an important role in the socio-economic development of the region, proper M&R is indispensable in order to maintain the required quality of service for its users, ensure economic and efficient rail transport system costs, as well as preserve all RIA. In that sense, *this Project directly served its purpose, as it provided not only the most accurate assessment of RIA condition and M&R needs and budget yet, but also assessment of related traffic safety, and provided direct solutions and proposals for the remediation of this situation, in the sense of strongly advocating far more frequent RIA condition monitoring, as well as concepts for M&R performance, under the PBMC concept with the involvement of Infrastructure Maintenance Contractors (IMCs)*. Also, this Project not only *provided examples of the best PBMC practice in Europe*, but also clearly elaborated and *proposed most optimal contractual relationships between the Infrastructure Managers (IMs) and IMCs, within the PBMC framework, based on most appropriate KPIs as controlling parameters, clearly elaborated and defined in the Project* (Report 3).

Moreover, in this sense, this Project undertook a detailed assessment of the institutional and budgetary framework for rail M&R, proposed best practice solutions, considering the situation in the WB6 region and prepared a detailed M&R plan for 2019-2023 for the indicative extension of the TEN-T Road/Rail Core/Comprehensive Networks in the WB6. Such an elaborate M&R Plan, as delivered in this Project, can thus serve as direct support to the WB6 ministries responsible for transport and infrastructure, railway IMs in further planning and programming infrastructure M&R, as well as the SEETO Secretariat in monitoring the implementation of relevant transport measures in the framework of the Connectivity Agenda.

Thus, this Project directly served and provided invaluable support to the soft measure "Establishment of functioning maintenance system ensuring no section in poor/very poor condition by 2020" defined through the agreement by the WB Prime Ministers in Vienna (August 2015), and provided a starting point and a cornerstone for improvement of the condition of the overall rail network in the WB6 region and laid down in detail the key related M&R systems that should be supporting and sustaining such improvement.

This way, this Project directly supported and enabled the efforts placed on the establishment of the Core Network and modification of the Comprehensive Network in the Western Balkans (WB) so that they truly provide a structure for more concentrated development of infrastructure in the entire WB6 region, with the final goal of enhancing connectivity and mobility and joining WB with the EU TEN-T network.

Tentative Action Plan

Based on the key conclusions and recommendations from the entire project and all of its Activities and deliverables, elaborated in detail in the respective Reports, the following tentative Action Plan could be formulated, leading towards the achievement of the key Project goals under "ideal" circumstances.

Full and true **separation of railway infrastructure management from train operations** and **adoption of Railway Laws fully in accordance with EU directives** (*for those RPs who have not done it yet, or completely*)

Formulation of **multi-annual Business Plans** followed by corresponding multi-annual **contractual relationships** with the respective Government institutions

Formulation of a modern long-term concept concerning RIA M&R, preferably on **PBMC-basis**, utilising specialised IMCs and KPI-based controlling and pricing mechanisms

Updating of **Technical Regulations and Rulebooks** and their alignment with the European and international best practice

Implementation of a modern **RI-AMS system**

Enabling and ensuring regular comprehensive **RIA condition-monitoring** (*special focus on Civil Works, i.e. structures*)	Phased RI-AMS implementation: E. **Pilot/Trial Implementation** (*RI-AMS Feasibility Studies*), F. **Full-scale Implementation**,	Increased attention to improving the safety of road level-crossings

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APPENDIX A: RELEVANT DOCUMENTATION

[1] Pace P., Jovanovic S. (2011), "Using measurement data for decision support", International Railway Journal, July 2011 issue, Volume 51, Issue 7, p. 37-39, ISSN 0744-5326

[2] Stanislav Jovanovic (2003), "Kostenreduktion bei der Oberbauninstandhaltung durch ECOTRACK", Der Eisenbahn Ingenieur (EI), Germany, May 2003 issue

[3] Stanislav Jovanovic (2003), "Condition-based decision making minimizes track costs", Railway Gazette

[4] International, UK, May 2003 issue, pp. 277 – 282.

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