Best practice Guide

Measuring and upgrading the clearance gauges of railway lines

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1. INTRODUCTION

The efficient management of the railway clearance gauge is of major importance for rail freight transport, since clearance is a key determining factor in the development of new traffics. The railway lines that have a clearance gauge large enough to enable intermodal transport units to pass without any restrictions, for example between the Netherlands and Northern Italy (RFC 1), are already saturated. Moreover the market of combined transport in Europe is expected to keep growing in the next decades. Therefore there is a strong need from the railway undertakings for having access to a reliable and interoperable railway network. Although the collaboration between the various stakeholders of the rail freight has already made easier the access of operators to the infrastructure, efforts should still be made to improve the efficiency of the information distribution between the stakeholders. The demands from the railway undertakings can be structured in four items:

- Having access to more detailed information on clearance gauge and enabling an international traffic.
- Promoting the provision of a reliable and easily understandable information on clearance gauge, displayed in a standardized format.
- Defining a standardized, simple and quick process to have access to the infrastructure.
- Strengthening infrastructure development based on the clients' needs and on cost-benefits analysis.

From the IMs point of view, an important issue is to guarantee the quantity and the reliability of the gauge data. The methodology of the data processing is inherent to this issue, in order to produce reliable data. From this starting point, IMs are willing to collaborate with RUs in order to draw full benefit from the infrastructure. But the search for train paths often faces the lack of gauge data and the cost of upgrading the clearance gauge.

It is suspected that technical difficulties, communication deficiencies between infrastructure managers and their customers, unsuitable standards or inadequate practices about clearance gauge management contribute altogether to a current non-satisfactory situation that could be improved through the generalization of good practices. During the project "Measuring and upgrading the clearance gauge in railway lines", needs and good practices have been collected by questionnaires sent to IMs and RUs, as well as by bilateral discussions. Some recommendations and good practices have also been discussed during a one-day-long collaborative workshop, which gathered several stakeholders of the railway freight transport (RUs, IMs, RFCs, UIC, and ERA), enabling to build enhancement scenarios accepted by all the stakeholders. This Best Practice Guide makes the synthesis of the assessments and the recommendations expressed during the study. It suggests recommendations for the procedure of line codifications, outlining the role of different market actors.

2. ABSTRACT AND EXECUTIVE SUMMARY

2.1. Abstract

NB: The following abstract covers the whole study.

2.1.1. English

This study deals with the question of rail freight clearance gauges in several ways.

A feasibility study identifies the bottlenecks of the European network where an enhancement in the gauge would make it possible to develop combined transport in the medium term, by increasing the modal share of rail in traffics. The appropriateness of such work has been studied through economic and financial evaluations. An increase in the permissible gauge on the Rhone Valley and on Perpignan-Barcelona then seems to present a very interesting potential in terms of development of rail freight activity.

An assessment also presents the practices of the infrastructure managers concerning their management of the clearance gauge: knowledge of the actual gauge using measurements, procedures implemented in response to requests from railway undertakings, monitoring of the infrastructure information and communication of this information to customers, in particular via the Network Statements.

Finally, a Best Practice Guide presents recommendations in terms of regulations, based on these assessments, in order to smoothen interactions between the different stakeholders, to facilitate access to the rail network by customers and ultimately to develop rail freight business.

2.1.2. French

Cette étude sur la question des gabarits pour le fret ferroviaire aborde le sujet sous plusieurs aspects.

Une étude de faisabilité identifie les points du réseau européen où une amélioration du gabarit permettrait de développer le transport combiné à moyen terme, en augmentant la part du rail dans les trafics. L'opportunité de tels travaux a été étudiée au moyen d'évaluations socio-économique et financière. Une augmentation du gabarit admissible sur la Vallée du Rhône et sur Perpignan-Barcelone semble alors présenter un potentiel très intéressant en termes de développement du fret ferroviaire.

Un état des lieux présente également les pratiques des gestionnaires d'infrastructure à propos de leur gestion du gabarit sur leurs réseaux : la connaissance du gabarit via des mesures, les procédures mises en œuvre en cas de sollicitation par une entreprise ferroviaire, la conservation de l'information et la communication de cette information aux clients, notamment via les Documents de Référence du Réseau.

Enfin, un Guide des Bonnes Pratiques présente des préconisations en termes de règlementation, partant des observations réalisées, afin de fluidifier les interactions entre les différents acteurs, faciliter l'accès au réseau ferré par les clients, et à terme développer le transport de marchandises sur rail.

2.2. Executive summary

NB: The following executive summary only covers this document.

2.2.1. English

This best practice guide is the conclusion of the study "Measuring and Upgrading the Clearance Gauge of the Railway Lines", which aimed at improving the network accessibility for railway freight operators regarding the clearance gauge management and the compatibility between vehicles and infrastructure. The best practice guide gathers the good practices and the recommendations expressed in the study, drawing the main orientations for improving the roles of infrastructure managers (IMs) and railway undertakings (RUs), concerning the procedures for the revision of the line codification and for the network access. For each stakeholder, the recommendations take into account the acquisition of the gauge data, the management and the distribution of the gauge information, the procedures for the line codification and for the network access, and the gauge enlargement works. It appears that most of the recommendations are based on a better cooperation between IMs and RUs, and on a more appropriate allocation of responsibilities between both.

As owners of the railway network, the IMs remain responsible of the knowledge of the infrastructure. Therefore, they keep the responsibility of measuring frequently the railway gauge. In order to perform efficient and frequent measurements of the network, it is recommended to use laser-based devices mounted on railway vehicles. Nevertheless, for the measurement of some obstacles, measurement devices mounted on trolleys are still necessary to have a more accurate measurement. The measurement data should be stored in national databases, containing also the measurement date and a validity date for the data, giving an easy access to the updated data. The use of a standard format for the measurement data would make easier the storage and the exchange of the data. It is suggested to allow RUs to perform measurement of the clearance gauge if the information is not up to date or available. In this case, the quality of the measured data should be guaranteed by a quality certificate. Then, the measurements results should be made available to the relevant IM, to enhance or update the gauge database. Consequently, the measurements database would be more frequently updated and more reliable.

The distribution of the gauge information is the key point for a better collaboration between IMs and RUs. Indeed, having access to more information is a recurrent demand from the RUs. It is then suggested that the IMs provide to the RUs the relevant information needed to compute the line codification: the measured envelope of the track, the nominal speed of the line, the cant, and the track position. The information should be easy to find. For example, the gauge data could be stored on a web platform, for which the hyperlink is given in the Network Statement. The codification and other information concerning the lines could be given on Geographic Information Services (GIS), which seem to be the most convenient tool for all users. As P400 is the most wanted loading gauge for the RUs, it would be convenient also to provide catalogues containing the P400 lines. The needed information is not only about the gauge, but also about the condition of the infrastructure. Therefore, it seems interesting to share also the topology of the bottlenecks and the prevision of the enlargement works with the RUs, using web platforms linked to the Network Statements. Since the Networks Statement remain the main entry point to the gauge information for the RUs, it is suggested that one of the language giving the line characteristics should be English, and that the information is updated once a year. Loading gauges should also be indicated in the Network Statements, as well as contacts in the IMs department in charge of the line codification. When a request from a RU needs new measurements or further analysis, the IMs are responsible for the delay to provide

information, which should be less than two weeks.

It is suggested that the computation of the compatibility between vehicles and infrastructure, for exceptional transport, becomes under the responsibility of the RUs, provided that the IMs share the information needed for the computation. This recommendation requires to have a common methodology for the computation of the line codification between all stakeholders, which could be developed by a working group under the supervision of the UIC or of the ERA. A standard codification methodology would also enable to improve the interoperability throughout the European network. In this configuration, the RU would have to submit the results of its computation to the commission for exceptional transport of the relevant IM, who would have to check the conditions of the compatibility computation, and possibly the results if there is some disagreement on the conditions. Afterwards, the IM would share the new line codification with the other RUs. The availability of the information and the computation of the line codification by the RU should make the codification process faster and should improve the network accessibility for the RUs.

Infrastructure managers are responsible for the gauge maintenance, regarding the codification given in the Network Statements. A system of alert limit values should be used, so that no obstacle can go into the limit gauge before a maintenance operation is undertaken.

Enlargement works strategies could be set up by IMs and corridors, aiming at a P400 loading gauge for corridors core network. To take into account the needs from the RUs, it seems important to carry out market studies before the enlargement decisions. Indeed, it could be imagined that, in case of gauge incompatibility for a given route involved in a request for exceptional transport, a market study could be undertaken for this route, and a substitution route could be proposed to the demanding RU. The results of the market studies and of following feasibility studies shall be used to define priority axes. Then, it is necessary to identify the bottlenecks in the priority axes and to set up a range of solutions. The participation of the railway advisory groups in the corridors management boards would also improve the collaboration between RUs and IMs for the enlargement strategies. New ways of funding the enhancement works are proposed, such as involving the RUs through arrangement in future rail tolls.

The whole process of the line codification could be supervised by third parties, such as regulatory bodies. Their role could be to control the compliance of the stakeholders with the delays, and to supervise the agreements between IMs and RUs on the codification procedure and on the gauge data exchange.

At the end of the best practice guide, pilot applications are described to set up the recommendations on the enlargement links that have been identified by the market study performed during the Clearance gauge study. Scenarios are proposed to implement progressively the recommendations, using test phases and proposing to set up working groups for the standardization of the gauge data format and of the codification methodology.

2.2.2. French

Ce guide de bonnes pratiques marque la conclusion de l'étude « Measuring and upgrading the clearance gauge of railway lines », qui a pour objectif de faciliter l'accès au réseau pour les opérateurs de fret ferroviaire, en se concentrant sur la gestion du gabarit et la compatibilité entre les véhicules et l'infrastructure. Le guide de bonnes pratiques rassemble les bonnes pratiques et les recommandations exprimées pendant l'étude, esquissant les orientations principales pour améliorer le rôle des gestionnaires d'infrastructure (GI) et des entreprises ferroviaires (EF), dans le cadre des procédures de révision des codifications de

ligne et de l'accès au réseau. Pour chaque acteur, les recommandations proposées tiennent compte de l'acquisition des données de gabarit, de la gestion et de l'échange de l'information gabarit, des procédures de codification de ligne et d'accès au réseau, et des travaux d'élargissement du gabarit. Il ressort que la plupart des recommandations reposent une meilleure coopération entre les GI et les EF, et sur une meilleure répartition des responsabilités entre eux.

En tant que propriétaires du réseau ferré, les GI demeurent responsables de la connaissance de leur infrastructure. Ils conservent donc la responsabilité de mesurer fréquemment le contour de la voie. On recommande d'utiliser des moyens de mesure laser embarqués dans des véhicules. Cependant, pour mesurer certains obstacles, des lasers montés sur des trolleys sont toujours nécessaires, afin d'obtenir une mesure plus précise. Les données mesurées devraient être stockées dans des bases de données nationales, avec la date de la mesure et une date de validité des données, facilitant ainsi l'accès à des données à jour. L'utilisation d'un format standard pour les données de mesure faciliterait le stockage et l'échange des données. On suggère d'autoriser les EF à réaliser des mesures de gabarit lorsque l'information n'est pas donnée par le GI ou pas à jour. Dans ce cas, la qualité des données mesurées doit être garantie par un certificat de qualité. Ensuite, les résultats des mesures doivent être transmis au GI concerné, afin d'enrichir ou de mettre à jour la base de données. Il en résulterait une base de données puis fiable et mise à jour plus souvent.

L'échange d'informations est la clef d'une meilleure collaboration entre les GI et les EF. En effet, l'accès à davantage d'informations est une demande récurrente de la part des EF. On recommande donc que les GI fournissent aux EF toutes les informations nécessaires au calcul de la codification de ligne : l'enveloppe de la voie, la vitesse nominale de la ligne, le dévers, et la position de la voie. Ces informations doivent être faciles d'accès. Par exemple, l'information gabarit pourrait être mise sur une plateforme web, dont le lien serait donné dans le Document de Référence du Réseau. La codification ainsi que d'autres informations sur les lignes pourraient être données par des systèmes d'information géographique (SIG), qui semblent l'outil le plus pratique pour tous les utilisateurs. Puisque le P400 est le gabarit de chargement que les EF demandent le plus, il serait intéressant également de fournir des catalogues avec les lignes au P400. De plus, l'information nécessaire ne concerne pas seulement le gabarit, mais aussi l'état de l'infrastructure. Ainsi, il semble intéressant de partager la topologie des obstacles et la prévision des travaux d'élargissement avec les EF, en utilisant des plateformes web liées au Document de Référence du Réseau. Comme les Documents de Référence du Réseau restent le principal point d'entrée à l'information sur le gabarit pour les EF, il est suggéré qu'une des langues utilisées dans le document soit l'anglais, et que l'information soit mise à jour une fois par an. Les gabarits véhicules devraient être aussi indiqués dans le Document de Référence du Réseau, ainsi que les coordonnées du département du GI chargé de la codification des lignes. Lorsqu'une demande de la part d'un EF nécessite de nouvelles mesures ou des analyses plus approfondies, les GI sont responsables du délai de réponse, qui ne doit pas dépasser deux semaines.

On suggère que le calcul de la compatibilité entre le véhicule et l'infrastructure, pour les transports exceptionnels, passe sous la responsabilité des EF, dans la mesure où les GI fournissent l'information nécessaire au calcul. Cette recommandation nécessite d'avoir une méthode de calcul de codification de ligne qui soit commune aux différents acteurs, et qui serait élaborée par un groupe de travail supervisé par l'UIC ou par l'ERA. Une méthode standard de codification permettrait aussi d'améliorer l'interopérabilité des réseaux européens. Dans ce cas de figure, les EF devraient soumettre les résultats de leurs calculs à la commission des transports exceptionnels du GI concerné, qui devrait vérifier les conditions du calcul de compatibilité, et éventuellement les résultats en cas de désaccord sur ces conditions. Ensuite, le GI pourrait diffuser la nouvelle codification de ligne auprès

des autres EF. La disponibilité de l'information et le calcul de la codification de ligne par l'EF devraient rendre le processus de codification plus rapide et améliorer l'accès au réseau pour les EF.

Les GI sont responsables de la maintenance du gabarit, à partir de la codification donnée par le Document de Référence du Réseau. Un système de valeurs d'alerte doit être utilisé, afin qu'aucun obstacle ne pénètre à l'intérieur du gabarit limite avant une opération de maintenance.

Des stratégies d'élargissement pourraient être élaborées par les GI et les corridors, avec l'objectif d'un gabarit au P400 pour les cœurs de corridors. Afin de prendre en compte les besoins des EF, il semble important de réaliser des études de marché avant les décisions d'élargissement. En effet, on pourrait imaginer que, en cas d'incompatibilité pour un itinéraire faisant l'objet d'une demande de transport exceptionnel, une étude de marché soit réalisée pour cet itinéraire, et qu'un itinéraire de substitution soit proposé à l'EF demandeur. Les résultats des études de marchés et des études de faisabilité qui les suivent seraient utilisés pour déterminer des axes prioritaires. Puis il faudrait identifier les obstacles de ces axes prioritaires et mettre en place un éventail de solutions à ces obstacles. La participation des RAG (railway advisory groups) dans les comités de gestion des corridors permettrait aussi d'améliorer la collaboration entre GI et EF sur les stratégies d'élargissement. De nouvelles manières de financer les travaux d'élargissement sont proposées, comme par exemple l'implication des EF à travers des accords sur les futurs péages.

Le processus global de codification de ligne pourrait être supervisé par des tierces parties, comme les organismes de réglementation. Leur rôle pourrait consister à contrôler le respect des délais par les acteurs, et à superviser les accords entre les GI et les EF concernant la procédure de codification et l'échange de données.

A la fin du guide de bonnes pratiques, des applications pilotes décrivent la mise en place des recommandations sur des tronçons de lignes qui ont été identifiés par l'étude de marché réalisée pendant l'étude Gabarit. Des scénarios sont proposés pour implémenter progressivement les recommandations, en utilisant des phases de test et en proposant de mettre en place des groupes de travail pour la standardisation du format des données gabarit et de la méthode de codification.

3. GENERAL PRINCIPLE

This best practice guide aims at defining a distribution of the gauge information and a procedure for the revision of line codifications that allow the RUs to have an understandable information and an easy access to the network. The vision developed in this guide is that RUs should be able to perform the line codification on their own, under agreement of the IMs. This requires to set up a technical approach of the line codification understandable by both IMs and RUs. Especially, the development of a common methodology for the line codification should be supported.

First, the measurement of the clearance gauge could be improved to provide reliable and accurate data, and to feed updated databases (Chapter 4). These databases could be open on demand to RUs. Other information media, such as Network Statements, web services, profile catalogues and geographical information systems should be supported to give relevant information (bottlenecks, planning of enlargement works, loading gauge) to RUs (Chapter 5).

The improvement of the information distribution between stakeholders requires to set up a common methodology for the line codification. In that extent, interested RUs should be allowed to compute on their own the line codification. The line codification could still be performed, or at least checked by the IMs (Chapter 6). This process could be supervised by neutral organisations, such as regulatory bodies.

The rise of the demands for exceptional transport should lead to gauge enlargement works on railway lines. Market studies are an efficient help for deciding to carry out enlargement works, and for proposing way of funding the works (Chapter 7). Finally, the application of the suggested practices would contribute to improve the whole sector of intermodal railway freight (Chapter 8).

4. MEASUREMENT OF THE CLEARANCE GAUGE

4.1. Measurement techniques

The infrastructure managers, as owners of the railway networks, are responsible for the measurement of the clearance gauge. Some of them have chosen to perform the clearance gauge measurement on their own (for example Belgium or France), whereas some others have chosen to subcontract the gauge measurement and the processing of the measured data to external companies (for example in Spain or Sweden).

Mostly used measurement techniques are laser based. They are either vehicle-borne or mounted on trolleys. Vehicle-borne systems present the benefit of being able to be inserted into the commercial circulation. Both systems that are currently vehicle-borne are the laser telemeter and the 3-D laser scanner.

Figure 1: Hungarian IM Laser telemeter mounted on FMK004 track recording car (left) and hand-driven lorry (right)

Accuracy of clearance gauge measurement remains costly and capacity-consuming. High-output measurement techniques used for regular measurements are generally less accurate than local on-demand measurements, because the space resolution of the measuring system is relatively high (about 25cm) when the system is mounted on railway vehicles. Actually, the most accurate solution remains the use of hand-held trolley systems, which are still existing and are an efficient way to answer specific local needs. Therefore it is suggested to use both measurement systems (vehicle-borne and trolleys), in order to be able to measure with the most relevant accuracy level.

The balance between regular less accurate fast measurements and local on-demand measurement, is to a large extent a question of cost.

4.2. Measurement frequencies

Periodic measurement of the line clearance gauge is for all IMs a regular maintenance process that meets the mandatory mission of guaranteeing the safety of running trains.

The process is generally ruled by internal regulations, and funded on regular maintenance budget.

Depending on the IMs, the periodicity of periodic gauge measurement is characterized by a very large variability, ranging from every 6 months to 6 years. In most of the cases, the periodicity is reinforced in particular sensitive areas (tunnels, bridges) or when elements infringe the gauge or are likely to, up to an alert level.

Measurement after infrastructure works which impact the gauge are systematically carried out, either to check that the nominal gauge is not infringed (after track levelling, or construction in the vicinity of track, for example) or to control that the targeted gauge improvement has been achieved after infrastructure upgrading works.

Measurements carried out upon demand of RUs are very seldom. The only known cases are performed for the introduction of new rolling stocks (for example low wagons) by the RUs. Measurements requested by RUs in the case of exceptional consignments never happened so far. It is more likely that the IM launches a measurement campaign in the frame of a demand of exceptional consignment if the IM needs to know the gauge profile of the line.

4.3. Recommendations for improving the measurements

4.3.1. Measurement technology

A common approach of the measurement systems between IMs would support the accuracy and the reliability of the data. For example, it could be suggested that all European IMs use a laser based inspecting device mounted on railway vehicles. The frequency of the inspection should also be improved in order to increase the reliability of the data. Since it may be irrelevant to ask all IMs to have the same measurement frequency, it seems to be possible to promote the use of obstacle records which should be updated regularly. Particularly after infrastructure works, it seems non-negotiable to perform a gauge measurement and to update the database. Then, when acquiring an efficient measurement system, the railway lines should be measured in order of priority.

Accuracy is costly and capacity-consuming and might be opposed to a frequent measurement of the clearance gauge. Therefore it is suggested to use both measurement systems (vehicle-borne and trolleys), in order to be able to measure with the most relevant accuracy level.

4.3.2. Data management

Since the data of the gauge measurement should be available at a national scale, it seems necessary to store the data in a harmonized format (for example RailML) in a national database. In case of temporary gauge modifications (restoration or enlargement, infrastructure works), the modifications should be reported in the database before the infrastructure works, with the date of the gauge modification. Then, an alert could be sent, via the data management system, to the department of the IM in charge of the exceptional consignments, so that they are informed in real time of any modification of the clearance gauge.

It is suggested that IMs make freely available the measured data on demand for the RUs

or for the railway operators. In this case it would be necessary to indicate the date of the last measurement and when the next measurement is scheduled, to give an indication about the validity of the data. This solution would allow them to compute the line codification as well. Nevertheless, this solution could lead to different interpretations of the measurements data and of the line codifications, and could raise misunderstandings between IMs and RUs. Moreover, the absence of charge to have access to the data raise the issue of the value of the data.

4.3.3. Measurement stakeholders

It is suggested to allow RUs or other stakeholders (transport authorities, other IMs, etc.) to assist the IMs in their historical role of data management. For example, RUs could be allowed to measure the clearance gauge in order to enhance the measurement database, although the IMs remain responsible for the quality of the information. A quality procedure has to be proposed for the data acquisition and the database enhancement, in order to guarantee the quality of the data. For example, the enquirer should provide a quality assurance certificate delivered by an external controller, before being allowed to perform the measurements. The certificate could be based on an IRS from UIC or on a CEN norm. After the measurement, the data could be controlled by the IM before publishing it. To contribute to the quality of the provided data, the exchange format of the data should be standardized (for example based on RailML). The measurement operations should be funded by the enquirer. Nevertheless, it seems important that the data are gathered by a unique data manager, which is the IM.

4.4. Summary of the recommendations

- Common measurement technique in IMs, with a laser-based system.
- IMs should make available the clearance gauge data on demand, indicating the dates of the last measurement and of the next measurement.
- Allow other stakeholders to perform measurements, under the supervision of a unique data manager.
- Ensure the data reliability by setting up a quality certificate.
- Standardise the data exchange format.

5. INFORMATION MANAGEMENT

5.1. Information distribution

Having access to more information is a recurrent demand from the RUs. The needed information is not only about the loading gauge, but about the condition of the infrastructure. Hence, the diffusion of the obstacles leaflets, of the distance between track axes, and of the topology of tunnels and bottlenecks, could enable the RUs to have a first opinion about the line characteristics. Especially, a regularly updated list of bottlenecks is claimed by all RUs. RUs are also interested in the prevision of the enlargement works.

This information could be published in web platforms different from the Network Statements (NS), such that their publication is less constraining for the IMs than the NS publication. Other stakeholders, for example RUs, could contribute to these platforms by adding observations or measurements. In this case, the data reliability could be guarantee by a certificate, which would guarantee the methodology for acquiring the data, and/or by a validity date. Nevertheless, as owner of the network and of the data, the IMs remain responsible for the quality of the data and for the information distribution, by checking the reliability certificates.

The main recommendation is that the clearance gauge information, from the gauge measurement, should be published by the IMs on web databases. This information should contain all relevant information to enable RUs to compute the line codifications by themselves: the current state of the infrastructure gauge, the cant, the track position, the maximum speed. This recommendation could also contribute to make the codification process faster. The implementation of this recommendation requires nevertheless to build agreements between IMs and RUs on the methodology for the computation of the vehicle/infrastructure compatibility. In this case, the IMs may check the conditions of the compatibility computation by the RUs, and possibly the results if there is some disagreement on the conditions.

Another suggestion could consist in publishing the permissions granted for exceptional transport, with their validity date. This recommendation could nevertheless not be accepted by the stakeholders. The IMs underline that a permission for exceptional transport is given with operational conditions such as speed or loading and may not be renewed. The RUs don’t want to share market information, even anonymized, with rivals. Meanwhile, negative answers to demand for exceptional transport could be published.

It is suggested that the new information distribution strategy and the role of each stakeholder are supervised by neutral organisations, such as regulatory bodies. Practically, the regulatory body could enforce that IM makes available the data in the best possible quality and within a delay of 2 weeks from each request.

5.2. Network statements

Planned by the provisions of the directive 2012/34/UE of the European Parliament and of the Council of 21 November 2012 establishing the single European railway area, Network Statements (NS) are mandatory documents published by each Infrastructure Manager that describe the practical, technical, administrative, and price conditions and arrangements for a fair and non-discriminatory access to the railway network. They particularly give the useful contacts, describe the access conditions, describe the infrastructure, explain the process of capacity allocation for train paths and maintenance works, and present the provided services and their price.

5.2.1. The Network Statements Common Structure

The Network Statement Common Structure (NSCS) document[1] published by RailNetEurope (RNE) offers guidelines for the expected content, organization and other information useful for the production of the NS. This document states that information about "gauge" (including track gauge, loading gauges and access conditions referred to Exceptional Transports) should be stated in the Network Statement.

Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 and the Network Statement Common Structure document of RailNetEurope specify the Network Statement Requisites in terms of minimum content and format:

- The Network Statements shall be published in at least two official languages of the European Union. It is strongly recommended that at least one of these language shall be English.
- It is recommended that the Network Statements and its annexes are regularly updated.
- The Network Statements should be made available free of charge in electronic format on the web portal of the infrastructure manager or, in any case, should be easily available.
- Complementary contents to the Network Statements should be identified in the main document, specifying how to reach them and the department or contact person responsible of the content. It is recommended that these additional content are easily accessible and are updated.

In the Network Statements, the IMs are invited to provide available documents including detailed infrastructure data and give contact details for further information. Where relevant, maps or lists should be produced, or reference should be made to documents containing the required information, ideally by means of Geographical Information Systems (GIS) allowing the customers to quickly access infrastructure information on the specific line. The NS shall also contain information setting out the conditions for access to service facilities connected to the network. Besides, the IMs should state how the information on the Network Statement is consistent with the rail infrastructure register, including how the register can be accessed.

Concerning the Rail Freight Corridors, they have to produce a Corridor Information Document (CID), which should contain all the information in relation with the RFC contained in the national Network Statements. Especially, this document should compile the information concerning the loading gauge and the infrastructure gauge of the corridor lines, and refer to the NS with a hyperlink. In a similar way that with the networks statements, RailNetEurope issued a "Corridor Information Document Common Structure"**.** The objective of this specification is to offer guidelines for the expected content, organisation and other information useful for the production of the Corridor Information Document. Rail Freight Corridors are also asked to display the lines characteristics for the corridors in a GIS application.

5.2.2. Recommendations concerning the Network Statements

In general, the IMs follow the recommendations of the NSCS. Nevertheless, the directives concerning the content of the Network Statements are not always fulfilled and thus some important information lack in the NS of several IMs. Therefore, additional requirements regarding the content of the NS could be needed to better specify the necessary information that should be delivered in the Network Statements. Especially, giving line

[1] *Network Statement Common Structure*, RailNetEurope, 2015

characteristics in English and regularly updated information is of the primary importance. Then, it seems also a priority to indicate the loading gauges and the possibilities for exceptional consignments.

It is also recommended that NS should contain a URL to the other online media that give detailed information about gauge (GIS, profile catalogues, database).

5.3. Vectors for the information distribution

Three scenarios can be recommended for the information distribution.

5.3.1. Catalogue of the P400 lines

The first solution consists in giving a catalogue of the lines with a P400 loading gauge, because this is the most interesting gauge for the RUs. The information should be published by the IMs as pdf files, which could be gathered by the corridors, in order to have one catalogue per corridor. The catalogue should be updated once a year. The catalogue could also contain the prevision of gauge enhancements.

5.3.2. Digital platforms

This solution consists in sharing the information on a digital platform, for example as a web service. Actually, this solution could give rise to the apparition of new stakeholders: engineering third parties could emerge and provide services to RUs, in order to analyse the published information which remains under the responsibility of the IMs. The information should be updated as frequently as possible using a database linked to the platform and updated after interventions on the infrastructure. The database can be enhanced by data collected by the RUs.

5.3.3. Geographical information systems

This tool is definitely the most wanted and most convenient tool for all users. It promotes the collaboration between IMs and RUs. It should display on an interactive map the lines for a given loading gauge, taking into account the data provided by the IMs. This tools could additionally allow the user to identify the best route to go from one point to another by introducing the characteristics and parameters of a train. It relies therefore on a consistent database.

Actually, according to the different actors consulted, GIS tools are recognized as the most efficient and user-friendly ways of displaying the information, as long as it does not impose duplication and multiple updating of the data by the IMs.

The RINF will provide a GIS in 2017, which should be considered as the final objective regarding the information format and its content. Meanwhile, intermediate tools such as GIS provided by IMs and corridors remain relevant, since they are closer to the national databases and likely to feed the RINF.

5.4. European harmonization

The development of European standards has two major goals. First, it makes easier the information distribution and increases the user-friendliness of the information, by making the information understandable by each stakeholder. Then, it reduces the opportunities of having wrong or obsolete information, because it avoids to have multiple channels and multiple ways for the information distribution. Therefore, the use of European standards makes the system more efficient thanks to a more reliable information. Three topics could be addressed by a European harmonization:

- The first harmonization is related to the format of the shared information. For example, RailTopoModel could be used for the format of the shared gauge information.
- The development of a standardized information tool offering a common interface would make easier the access to the information.
- Finally, the harmonization of the methodology for the line codification represents a real enhancement for the stakeholders. Actually, few experts are able to compute the line codification, and the codification methods are different depending on the country and the stakeholders (IM/RU). A common methodology would enable to have a codification information understandable by each stakeholder, and later on to have the revision of line codifications performed by other stakeholders than IMs.

Working groups made up of experts from all stakeholders are needed to develop the new standards. UIC already started to gather experts from several stakeholders to define RailTopoModel and a codification methodology (UIC 502 working group), and seems therefore to be indicated to coordinate the harmonization groups.

5.5. Summary of the recommendations

- Support a harmonization of the content of the NS.
- Develop a common methodology for the line codification.
- IMs should set up a web platform with infrastructure information, such as bottlenecks, upgrading works previsions, etc.
- IMs should publish catalogues with lines compatibles with main loading gauges, with P400 as a priority.
- IMs should set up an open data web platform to share the information about gauge and measurement, guaranteed by a quality certificate.
- Promote the publication of the information with GIS tools.
- Promote the harmonization of the data exchange format, for example based on RailTopoModel.

6. LINE CODIFICATION

6.1. Codification methodology

The analysis of the current situation shows that the various infrastructure managers throughout Europe do not have the same methodology for computing the line codification, neither the same terminology for referring to the various gauges. Nevertheless, most of them use the gauge system GA-GB-GC for the reference profile, and the associated method, recommended by norm EN 15273. On the rolling stock side, the intermodal codification system expresses the ability of the line to be ran by certain categories of intermodal trains. This loading codification system is described in the UIC leaflet 596-6: the P codification is used for semi-trailers, and the C codification is used for containers and swap bodies. One major problem is that both codifications systems are not compatible one with each other: an intermodal codification does not correspond to a clearance gauge, and vice-versa. However, practically, some correspondence can be assumed (GA ≈ C22; GB ≈ C45).

It is therefore not surprising that it is a common claim from many interviewed RUs that IMs should deliver the information in terms of a codification of train profiles that can go through the infrastructure clearance, in a language that every stakeholder does understand.

The need for a common codification methodology is expressed by all the stakeholders, so that they are able to understand each other. Therefore, it is suggested to gather technical experts from all European IMs in order to find a common codification methodology. This working group should also include representatives from RUs, for example via the UIRR (International Union for Road-Rail combined transport). The working group could be funded by the European Union, via the European comity for normalization, supervised by the ERA and led by UIC. Actually, UIC has already proposed a codification system that extends the principles of defining standard loading profiles to all loading configurations, in the frame of the UIC 502 group[2]. Knowing the weight, width and height requirements, 45 profiles have thus been determined to fit the needs of the RUs.

6.2. Procedure for the revision of line codification

6.2.1. Current practices

UIC leaflet 502-1 provides the reference procedures regarding the study, authorization and operation of exceptional transportations. It defines the concept of exceptional consignment, indicates the respective roles of the client, of the main operator and of the infrastructure manager, sets up their responsibilities and proposes templates of data forms allowing an accurate and complete examination of the request, setting a maximum delay of 15 days to answer a request. It stipulates the conditions for transportation allowance, sets the time framework for its validity (3 months), specifies the conditions for loading and preparation to carriage, as well as the needed marking.

The recommendations of UIC leaflet 502-1 are followed by most of IMs, apart from some variable interpretations points. A large variability is observed in terms of delays indicated

[2] UIC leaflet 502-2, *Exceptional consignments – outline procedure.* 1st edition, Nov. 2009.

by the responding IMs, reaching up to several weeks for highly complex requests. Moreover, the IMs have to indicate in their Network Statement which body is in charge of the rules for exceptional transports and give their contact names and address.

In most cases, the RU undertakes a preliminary study from the client's demand, and requests for an exceptional consignment to the department for exceptional consignments of the Infrastructure Manager. Usually, this department gathers experts from the Safety Department, the Infrastructure department, the Logistics services department, and from the national safety agency.

The department of exceptional consignment reviews the preliminary study and the past exceptional consignments, conducts the studies needed to determine whether the consignment is feasible and, where appropriate, the transport conditions and traffic requirements that must be taken into account. When agreed, the department of exceptional consignments sets the possible transport restrictions and releases the transport authorization to the RU who reports to the client and asks for a running plan to the traffic department.

6.2.2. Recommendations

The RUs want to know quasi-instantaneously whether their train can use a specific route, or which other route will be adapted to the train. All the recommendations rely on the need for a better cooperation between IMs and RUs. This better cooperation starts with a better communication between IMs, RUs, and the corridors, in order to take into account the demands of each stakeholder, and can go until the participation of a member of a Railway advisory group (RAG) in the department for exceptional consignments. Moreover, the RU has usually only a contact in the commercial department and in the commission for exceptional consignments. It would be useful that they can communicate with technical departments too, so that they can discuss about the loading or the calculation of the gauge.

When supplementary analysis are needed before granting the exceptional transport, the RU should be informed of the time needed for these analysis.

When the exceptional consignment cannot be granted on the requested route, alternative routes can be proposed to avoid the identified bottlenecks (certain tunnels or bridges), or operational restrictions can be set up (use a specific track or speed restriction).

A solution might be to allow the RUs to compute the line codification on their own, using the measurement data made available by the IMs in a web service. If the codification methodology is common to all stakeholders, this could make the procedure faster. If this is not the case, the IMs should check the compatibility with the infrastructure, which could slow the procedure and create misunderstandings with the RUs.

6.3. Summary of the recommendations

- The codification method needs to be harmonized, to have the same codification method for all stakeholders. This harmonization could be done by gathering a group of expert from all stakeholders.
- Improve the cooperation between IMs and RUs, in order to improve the understanding between both and to make the procedure faster.

7. GAUGE ENLARGEMENT WORKS

7.1. Enlargement strategies

7.1.1. The big diversity of the enlargement strategies

No case of enlargement works upon the demand of RUs has been reported in the study. The dialog between RFCs and IMs often instigates the decision of gauge enlargements, in order to carry out engineering works on lines identified as a priority by the RFCs.

Nevertheless, there is a wide variability in the clearance gauge enhancement strategy in the European Union, depending on the IMs. Some of them develop a long term strategy to enhance whole lines for which a need has been identified. For example, SNCF Réseau, in cooperation with RFCs and RUs, has decided to enlarge 14 tunnels on the Calais-Basel route, in order to open a new route in RFC 2, rebalancing RFC1 and RFC 2 to unblock RFC1, and to capture road traffic. In Sweden, Trafikverket's strategy relies on market studies, in order to assess the potential benefits of gauge enlargements on modal shift.

For some other IMs, the strategy consists in enlarging bottlenecks with a located-based point of view, punctually, and taking advantage of improvement works in certain infrastructure (such as tunnels or bridges) or the renewal of track at the end of the useful life of the superstructure.

In Romania and Switzerland, the enlargement works are partly funded by public stakeholders (state, federal state, European Union), which are committed by laws to enhance the network capacity.

Even if there is no formal procedure through which an operator would request a gauge enlargement to an IM, a large number of active exchanges between IMs and their clients are existing to make the IMs aware of the needs of the RUs. Especially, the Railway advisory groups (RAGs) bring the point of view of the RUs in discussions with RFCs and IMs.

7.1.2. Recommendations for involving the RUs in the enlargement processes

First, it seems important to take into account the RUs needs when deciding an enhancement of the clearance gauge. Several solutions exists, such as:

- Carry out market studies before the enlargement decisions. If the market studies are performed and funded by RUs, they could be used as an argument to ask for enhancement works on the selected line.
- Have a systematic representation of the RAGs in RFCs management boards.

Particularly, it is recommended that the IMs or the corridors should perform a market study for a gauge enlargement when they know that some RUs could be interested in the enlargement. It could be suggested that, after a request from a RU leading to a negative answer, a market study could be conducted, if no market study has been performed in the past two years.

It appears from the RUs questionnaires and the discussions that RUs are mainly interested in enhancements to P400 codification. Moreover, RUs claim that the first action should be to identify the bottlenecks in each corridor. Then, the IMs, in collaboration with the RAGs

and the corridors, should propose a strategy for resolving these bottlenecks.

RUs also need to be informed of the enlargement works that are planned by the IMs in order to organize their traffic plan consequently. It would be appreciated that the IMs provide diversion routes when a route is closed during the engineering works.

7.2. Ways of funding the engineering works

When only market considerations are involved, the infrastructure managers are facing a more problematic question, as the economical profitability of the enlargement is often insufficient for them to finance on their own. As explained in the previous section, the enlargement works are most often funded by IMs, with sometimes a contribution of the state or European Union. Three non-exclusive solutions can then be considered:

- A call for public funding, that generally needs the support of an in-depth business case study,
- A call for the contribution of the railway undertakings which are operating (or likely to operate) on the considered route, requesting transparency and good will from all parties,
- Recourse to low-cost but long-term technical solutions, taking benefit of regular maintenance or investment operations on tracks to progressively tackle at the same time the gauge issue.

Establishing an adequate funding requires conducting detailed market analysis that need to be systematised, standardised and extended to all potentially interested RUs.

In any case, it is reported that financing from the only IM is rarely possible, as the expected incomes hardly cover the costs induced by the traffic growth, and financing from individual RUs is neither possible since the benefit that results from the enlargement is collective. A partial funding by potentially interested RUs would be appreciated. A solution could be to set up a public-private partnership to gather IMs, RUs and public actors in a common entity. In that case, the participation of RUs could be supported by compensation, for example discounts in future path rates. This procedure has nevertheless to be framed such that it answers specific needs from the IMs, for example engineering works which leads to a higher freight traffic, or which improves the commercial service.

Otherwise, some financial packages could be set up in order to involve indirectly the RUs on the funding of the enhancement works. For example, if the RUs commit themselves to a certain traffic level and a certain rail toll after the gauge enhancement, they could guarantee a return on investment to the financing IM.

Finally, another idea to involve the public stakeholders in the financing process would be to set up a tax on the road transport whose revenue could finance the enlargement works. This would also support the modal shift.

7.3. Maintenance of the clearance gauge

Maintenance of the clearance gauge is a crucial condition for the efficiency of the management process and for the reliability of the data. There exists a variety of situations regarding the existence of alert limit values or intervention limit values systems or procedures when a discrepancy is observed. Most IMs report applying alert system, based on TSI limits or ruled by specific national regulations. Since no obstacle can go into the limit gauge, the alert gauge larger than the limit gauge is defined such that a maintenance

operation has to be undertaken when the alert gauge is exceeded by an obstacle.

Depending on the situation (nature of the problem, speed of evolution) a speed restriction and possibly traffic restrictions can be imposed until the correction is completed. Consequently, the RUs operating on the concerned line should be informed as soon as possible. For each IM, the maximum delay before the maintenance operation depends on the line category and of the speed of evolution of the obstacle.

7.4. Summary of the recommendations

- RUs could be more involved in the decisions of enlargement works, for example by conducting systematically market studies, or by guaranteeing the representation of the RAGs in the Corridors Management Boards.
- Enhancement works should start with the identification of the bottlenecks in the priority axes and the implementation of solutions.
- The upgrading works could be funded by several stakeholders, among which the potentially interested RUs could participate.
- Inform the RUs about the planning of line upgrading works, and of maintenance works, providing when relevant diversion routes.

8. PILOT APPLICATIONS

8.1. Market study for the identification of pilot lines

In the frame of the project, a deep market study has been performed in order to identify gauge enlargement links, on which a feasibility study has been conducted. This market study took into account the current traffic of RUs, as well as the previsions for future traffic, due to route diversions and to modal shift. It was based on questionnaires sent to IMs and RUs, and on bilateral discussions with the partners of the study. Then, a measurement campaign has been carried out on the identified lines, leading to a feasibility study for the gauge enlargement. The feasibility study relies on a cost/benefits analysis, from the economic and the financial points of view.

It appears that the most interesting strategy is to identify small bottlenecks which, once suppressed, could open large track sections by homogenizing the gauge on a whole line. Five track sections have been identified as particularly interesting to work on:

- The tunnels of the Vosges seems to be the most interesting one, by opening the east-west link both for the Atlantic corridor and for the North Sea-Mediterranean corridor.
- Enlarging the tunnels of the Rhone Valley also enables to enhance the Mediterranean and the North Sea-Mediterranean corridors.
- The track section Meaux-Epernay allows to open the Atlantic corridor towards the East.
- The track section Bayonne-Hendaye allows to open the Atlantic corridor too, in the frame of the French Atlantic Rail Motorway.
- The enlargement of the section between Barcelona and Perpignan would enhance the Mediterranean corridor and the link between Spain and France.

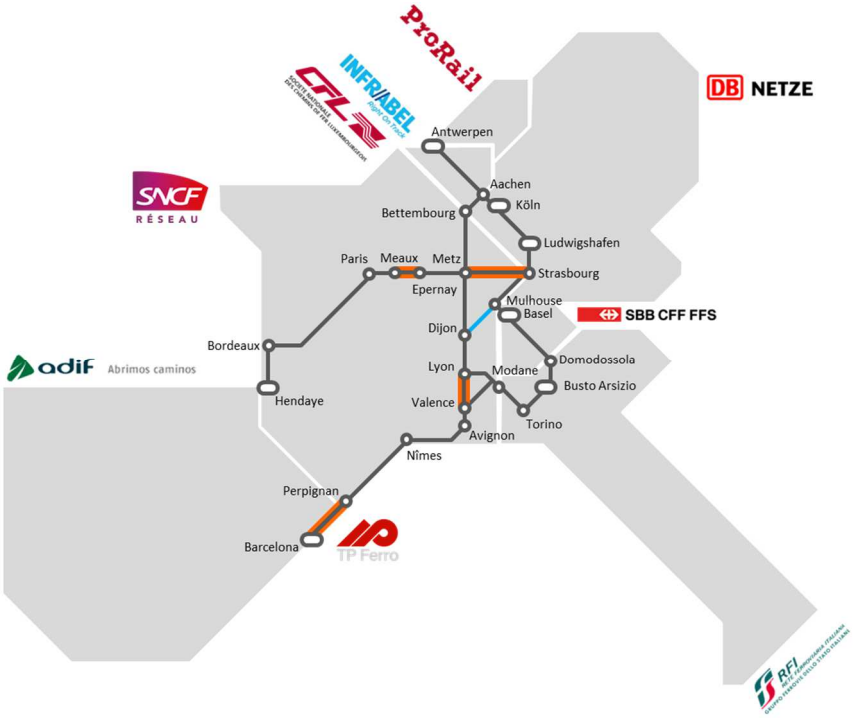

Figure 2: Identification of five gauge enlargement links

The identification of enlargement links needs a strong international cooperation, so that the suppression of bottlenecks benefits to all corridors. For example, in the present study, the enhancement of RFC2 enables to relieve RFC1. The section between Barcelona and Perpignan also needs a more evident cooperation between SNCF and ADIF.

For future enlargement cases, the market study shall be performed by stakeholders which are more involved in the enhancement process. Especially, it is suggested that RUs make their traffic information and traffic prevision available, and that the RAGs mutualize the data given by RUs and make the link with the RFC Management Boards. Then, supported by the RAGs, each RFC Management Board is required to undertake a transport market study, which analyses the demand for international traffic using the RFC, covering the different types of traffic. It should also include a socio-economic cost-benefit analysis, and plays a central role in the implementation of that RFC, in that it:

- Determines short and long term planning, particularly for investment and path allocation
- Allows bottlenecks to be identified, and the location and level of amelioration required
- Will be taken into account for the construction of the Pre-arranged Paths (PaP) and the definition of reserve capacity, and
- Should identify where there are suitable alternative routes to avoid "irrational" transport routes and possible bottlenecks.

The cost and benefit analysis performed in the frame of the present Study showed that it was relevant to focus on two loading gauges: P400 and P394. Actually, P400 allows to carry 4m trailers on standard pocket wagons (33cm), and thus offers a modal shift opportunity for a large market. Besides, P400 has been adopted on most lines of the TEN-T because it does not present any restriction for the operators in terms of rolling stock and thus allows the continuity of operating conditions. On the other hand, P394 allows to carry 4m trailers on lower pocket wagons (27cm). Despite it requires a particular type of pocket wagon (in fact these wagons are increasingly used now), the need for gauge enlargement is smaller than with P400 and thus the investment costs are lower.

8.2. Scenarios for implementing solutions

8.2.1. Information distribution

IMs should make available their measurement data to the RUs, such that RUs are able to compute the line codification. The availability of the data could be controlled by the regulatory bodies.

RUs do not see the need to prescribe the harmonisation of the way of displaying data and of the technical standards by law. For every stakeholders, corridors seem to be the most relevant level for sharing the information, because they are in close relationship with the IMs while promoting an international and interoperable transport area. The harmonisation should thus be consolidated at the RFC level, which allows moving faster and being closer to specific market requirements. Therefore, this recommendation highlights the role of the Corridor Information Documents, in order to manage the information distribution at the corridor level.

Nevertheless, the exchange format of the data should be standard, because the standard is useful to guarantee the quality of the data. The harmonization at the European level could then be monitored by ERA or UIC, which could if necessary mandate CEN of ETSI to create a norm or a TSI.

The data provider should justify the quality of the data provided, using a quality certificate. A unique data manager is needed in every country, associated to a standardized industrial

measurement mean, in order to have a unique database for a whole national network. The need for a common codification methodology throughout Europe is also underlined, for which UIC leaflet 502-2 could be used as a starting point.

The main scenario displaying a recommendation for the information distribution gathers the three supports of information presented in Section 5.35.3.1: a catalogue with the P400 lines, a digital platform for sharing information, and a geographical information system (GIS). The GIS provided by the RINF will be functional in 2017 and should be considered as the final objective for the distribution of the standard information. The data should be provided by IMs and collected by the corridors and the RINF, in order to enrich their own databases. The following process could be set up:

- 2017: benchmark of existing databases and catalogues, harmonization of the exchange format.
- 2018: creation of open databases by the IMs. External engineering companies can access to these databases to analyse the data.
- 2019: All stakeholders can provide data to enhance the databases: IMs, RUs, transport authorities, etc.
- 2020: Display of all lines that can be travelled by P400 vehicles and the projection of line codification enhancement for P400.

A particular attention should be paid to supporting the IMs in this transformation process. Compensations, such as European funds or working groups, could be imagined. This process could be supported and monitored by European stakeholders, such as ERA, the regulatory bodies, RNE or UIC. Some compensation could also be offered to RUs who take part in the distribution of the information, which could be lower charges for using the line.

8.2.2. Enlargement works

The cost of the enlargement works are often an obstacle for carrying out the works. For example, depending on the technical option chosen for the works (arch raising or platform lowering), a minimal amount of 60 M€ should be necessary to finance the upgrading works for the line sections identified in Section 8.1. SNCF is not in position to finance these works, since the expected incomes from infrastructure access charges will not make the upgrading economically profitable. Actually, the construction of consortiums gathering IMs and RUs could be imagined to finance this kind of upgrading works, since both IMs and RUs could be interested in the results.

For minimising the impact on the traffic and the costs, it is advised to mutualize the upgrading works with heavy maintenance works on the track, as far as it possible.

When implementing the suggested solutions for measuring and upgrading the railway gauge, a test phase can be operated first, relying on voluntary IMs, and allowing other stakeholders to carry out measurements or engineering works. A financial support could be brought by the European Union. After an evaluation phase, and when all IMs have efficient measurement means, the procedure can be widen to all European countries and become mandatory.

This process relies on the elaboration of a common methodology for the line codification, which could be available within five years. The process also relies on standards regarding the data format, which have to be set up to ensure the quality of the information.

8.2.3. Procedure for the line codification

Since the selected lines have been measured with a laser-scanner, reliable data are available for the whole lines and their profiles are known. Therefore it is possible to store

the data on a national database. Provided that RUs and IMs agree on the codification methodology, the database could have an open access, such that the RUs have a free access to the measurement data. Besides, the IM should publish information about the identified bottlenecks of the selected lines, as well as the planned enlargement works if relevant.

Afterwards, the IM computes the line codification and adds it to the Profile catalogue. The information is provided to the RINF, in the infrastructure gauge system as well as in the loading codification system. The corresponding corridor takes the information to enhance its geographical information system too. With that tool the RUs can have a first estimation about the possibility for its trains to run through.

The RU that wants to use one of the selected lines for an exceptional transport carries out a preliminary study using all the information provided by the IM, and submits its demand to the commission for exceptional consignments of the IM. The commission for exceptional consignments reviews the preliminary study, and, if necessary, performs deeper studies. The IM should give an answer to the RU within two weeks. During the delay, the IM should inform the RU of the main steps of the study (acceptance of the preliminary study, deeper analysis) and give the contact of the person responsible for the study performed. When agreed, the commission for exceptional consignments releases the transport authorization to the RU. In case of negative answer, an alternative route could be proposed to the RU.

9. CONCLUSION

While a modal shift and an increase of rail freight traffic are highly expected on European railway networks, the good management of the railway clearance gauge is of major importance, as clearance is a key determining factor in the development of new traffics.

In particular, when infrastructure works are to be decided, efficient decision-making procedures for the provision of adequate loading gauge and clearance have to ensure that not only immediate needs are taken into account, but also that longer term market perspectives are anticipated.

Moreover, the reliability of the data, its availability and completeness as well as fluid and transparent communication between Infrastructure Managers and their clients on the railway lines clearance gauge are of essential importance to capture new markets and traffics with a short reaction time.

The propositions presented in this guide aim at giving solutions for a better management of the clearance gauge. They are structured in four items: measurement of the clearance gauge, line codification, information distribution and gauge enlargement works. Most of the proposed solutions are based on a better involvement of all stakeholders (especially the railway undertakings) in the different processes, a European harmonization of the codification method, and a more business-oriented data management. Their application now relies on the good will of all of the stakeholders to work together at their implementation.