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## MIXING MAINLINE AND URBAN SYSTEMS: HOW TO COMBINE SYSTEM AND SUBSYSTEM APPROACHES FOR SAFETY DEMONSTRATION

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### SUMMARY

Combining mainline and urban systems in order to meet commuters' needs is currently developed. However, operational and technical requirements may be very different for mainline systems and urban systems (either metros or tramways).

On the one side, the will to pursue interoperability of the different national railway systems in the European Union for passengers and freight transportation implies to broke down the railway system into subsystems and make them compatible. On the other side, urban systems must meet specific requirements due to their environment and their level of service which are better handled with a systemic approach.

Combining mainline and urban systems requires a specific regulation to manage these two different approaches while making sure the mixed system meets the overall safety goals. The new French body of rules for these mixed systems is set on two main features: a common vehicle authorization application for urban and mainline, and a specific subsystem designed especially for these combined systems called the interlinking subsystem.

The common vehicle authorization application is intending to allow an assessment of the application by EPSF, the French rail safety authority, and STRMTG, the French urban guided transportation safety authority, within the same timeframe in order to make sure there is no contradictory safety requirement.

As for the interlinking subsystem, it is the pivotal part of this regulation. It embodies operational procedures and equipment that mitigate cross-risks, i.e. risks coming from the urban part of the system with consequences on the mainline part of the system and vice-versa. It allows to manage the two safety approaches as any other interface.



## INTRODUCTION

Combining mainline and urban systems in order to meet commuters' needs is currently developed due to three trends: i) urbanization is growing and more and more people are commuting daily; ii) in inner city, land is becoming scarce; iii) as well as financing for public services. The last two trends call for using existing infrastructure as much as possible.

However, operational and technical requirements may be very different for mainline systems and urban systems (either metros or tramways). These differences will remain and, therefore, combining mainline and urban systems requires a specific regulation to manage these two different approaches while making sure the combined system meets the overall safety goals. This paper will discuss the example of the new French framework for these mixed systems actually in force.

The first part of this paper will present the regulatory and institutional framework for urban guided transportation and mainline railway. Then specific issues related to mixed systems and the main features of the authorization process in order to address these issues will be discussed in the second part. The third part will handle the way this regulation about mixed systems was designed.

## FRENCH INSTITUTIONAL AND REGULATORY FRAMEWORK FOR URBAN GUIDED TRANSPORTATION AND MAINLINE RAILWAY

To put it in a word, the French institutional and regulatory framework for urban guided transportation and mainline railway is threefold: i) the same target for the level of risks (GAME principle), ii) two approaches to demonstrate the safety (system vs subsystem), iii) and two safety national authorities.

### The same target for the level of risks

For mainline as well as for urban systems, the maximum level of risks acceptable is set by the GAME principle ("globalement au moins equivalent") also called GAMAB principle ("globalement aussi bon"). The formulation of this principle is as follow: all new guided transport systems must offer a level of risks globally at least as good as the one offered by any equivalent existing system<sup>1</sup>. This principle is set for urban guided transportation in article 3 of decree n°2017-440 and for mainline in article 43 of decree n°2006-1279.

As the level of risks for existing mainline and urban systems designed for passengers' transportation are historically similar, thus, safety targets should be similar for the two kinds of new systems. This is an important point for mixed systems as one part of the system is not driving up the safety level of the whole system. Then, the safety demonstration must really deal with the safety targets of the urban part of the system and the mainline part.

### A subsystem approach for mainlines

If safety targets are similar for mainline and urban systems, some kinds of risks are specific to each type of system and the allocation process of mitigating measures are different.

On the mainline side, the will to pursue interoperability of the different national railway systems in the European Union for passengers and freight transportation implies to broke down the railway system into subsystems and make them compatible. For the EU, the structural subsystems are: infrastructure, energy, control-command and signaling (on-board and trackside), and rolling stock. Each of these subsystems must meet specific technical requirements in order to be compatible with one another.

<sup>1</sup> This is the formulation of the principle used in the standard NF EN 50126-1:2000. More on this principle can be find in annex D



With this subsystem approach, the allocation process of mitigating measures can only take place within each subsystem, without any change of these technical characteristics. In that way, interoperability is a constraint to design mitigating measures for specific risks not taken into account in interoperability requirements.

## A system approach for urban systems

On the urban side, urban systems have to meet specific requirements due to their environment (especially trams that are sharing infrastructure with cars and pedestrians or metros operated in tunnel with a specific gauge) and their level of service (high frequency and short distance journeys) which are better handled with a systemic approach.

For example, trams are generally operated with the line-of-sight driving principle. But in some cases, because the tram system is built in an already existing city, the line of sight may be very short and you can either choose to reduce the speed limit (allocation is on the driver), install a block system with trackside signals (allocation to the infrastructure) or a block system with continuous speed control (allocation to the infrastructure and the vehicle) depending on the level of risks.

Thus, the system approach allows more freedom in the allocation process of mitigating measures, and thus more innovative ways to meet a requirement, but implies to have one entity to manage both infrastructure and rolling stock. This approach is perfectly adapted to urban systems that are not linked the one with another and with only one company operating the system as a whole.

## Two safety national authorities, one for each approach

In France, two separate safety bodies are processing authorization demands: EPSF (the French rail safety authority) is in charge of mainline systems and STRMTG (the French ropeways and urban guided transportation department) is in charge of urban systems<sup>2</sup>.

STRMTG (service technique des remontées mécaniques et des transports guidés) is authorizing tramway lines and metro lines through a system approach. The authorization process is described in decree n°2017-440 (formerly decree n°2003-425). There are few mandatory technical rules but STRMTG publishes guides giving ways to comply with the rules set by decree n°2017-440.

EPSF (établissement public de sécurité ferroviaire) is the French national safety agency as defined in directive 2004/49/EC (until 16 June 2019 where the directive (UE) 2016/798 will enter into force). It is authorizing railway lines through a subsystem approach, especially authorizing independently fixed installations (infrastructure, energy and trackside control-command) and vehicle (rolling stock and on-board control-command). For each subsystem, mandatory technical requirements are set up in technical specifications for interoperability issued by the EU.

## AN INTERLINKING SUBSYSTEM AND A COMMON VEHICLE APPLICATION FILE TO ADDRESS SPECIFIC ISSUES REGARDING MIXED SYSTEMS

These two approaches will then remain and, therefore, combining mainline and urban systems requires a specific regulation to manage these two different approaches while making sure the combined system meets the overall safety goals.

<sup>2</sup> For the urban part, the local representative of the Government (called "préfet") is responsible for issuing the authorization based on the opinion issued by the STRMTG. For simplicity matter, this paper will refer to this two-step process as the authorization issued by the STRMTG.

## Specific issues regarding mixed systems

Specific issues are related on the one hand to vehicle (rolling stock and on-board control-command) and on the other hand to fixed installations (infrastructure, energy and trackside control-command).

For a mixed system, the vehicle has to meet urban requirements based on a system approach and mainlines requirements based on a subsystem approach. It has to be authorized twice, to be operated on the mainline part and on the urban part. Before the new rules set by decree n°2017-440, these two authorization processes were hold completely independently. That may lead to opposite requirements issued by the two safety bodies.

For example, for a light rail vehicle (as the French tram-train), the driving cab will have to be designed to meet high crashworthiness targets to comply with mainline requirements (trains must be C-I according to standard EN 15227:2008) and to offer an adequate outside visibility to comply with urban tramways requirements (line-of-sight principle – tramways requirements are set in a guide on visibility edited by the STRMTG<sup>3</sup>). These two objectives are competing as good crashworthiness implies strong pillars in the front end of the vehicle and as good visibility implies thin pillars. This is one case where the two safety national authorities have to agree on a balanced design that is acceptable regarding the two objectives.

Regarding infrastructure, the issue is different. The consequences of an accident may be on the urban part of the system and to prevent this accident or mitigate its consequences a specific equipment or rule may be set on the mainline part, and vice versa. In order to authorize the part of the infrastructure they have the responsibility of, each safety body may need to assess some equipment of the other part (as shown on figure 1).

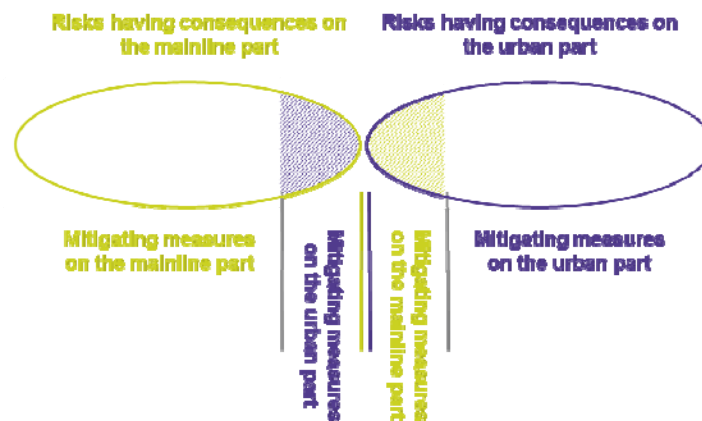


Figure 1 - Cross-risks and mitigating measures

For example, for a tram-train system with standard rails on the mainline part and grooved rails on the tramway part, tram-train vehicles have to be equipped with specific wheels adapted to both kind of rails. If a train equipped with standard wheels will run on the tramway part, it would derail and cause an accident with consequences on the tramway part. To prevent this to happen, a specific signaling device controlling the vehicle type (train or tram-train) will be set up, but on the mainline part.

To tackle these issues, the new regulation is set on two main features: a common vehicle authorization application file for urban and mainline, and a specific subsystem designed especially for these combined systems called the interlinking subsystem.

<sup>3</sup> This guidebook can be found on the STRMTG website [here](#) and an article on it in English can be found [here](#)

## Common vehicle authorization file

For the vehicle, the general principles used for the authorization procedure are as follows:

- a common and identical application file for the vehicle;
- a review of the application file by both EPSF and STRMTG in accordance with their respective set of rules;
- the issue of two authorizations.

The applicant has to submit two application files regarding the vehicle, one during the design stage and one during the manufacturing stage. EPSF and STRMTG will review these application files within the same timeframe and have to make sure there are not any opposite requirements in their decisions. In that way, the common file is a tool to make sure specific or innovative design proposed to meet one requirement on one part of the system is acceptable for the other part. The process at the manufacturing stage is shown on figure 2.

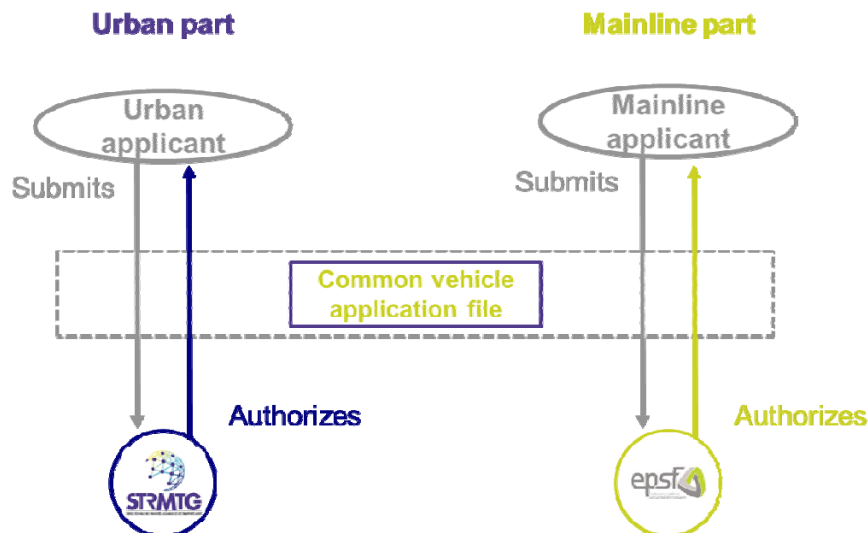


Figure 2 - Common vehicle application file - Manufacturing stage

To go back to the example of the light tram-train vehicle, the common vehicle authorization file will allow to share the same data to discuss the size of the pillar and the additional measures needed so the vehicle will be authorized on both the tramway part and the mainline part.

However, for the urban part, to keep in line with the system approach, the applicant for the urban part of the system will either submit the authorization file concerning the other subsystems at the same time of the vehicle authorization file or, at least, describe the hypothesis taken into account for the vehicle in the authorization file concerning the other subsystems. So, it adds a specific obligation to the applicant for the urban part.

## Interlinking subsystem

The interlinking subsystem encompasses all the structural and operational elements which make it possible to mitigate the risks arising from the mainline part and having consequences to the urban part and vice versa. On the basis of this definition, the main features of the interlinking subsystem are set out below:

- It includes:

- structural elements, that is to say equipment or groups of equipment, located on the mainline part and / or on the urban part or carried on board intended to mitigate a risk;
- operational elements, i.e. procedures or instructions to mitigate a risk.
- Risks mitigated by the interlinking subsystem, referred to as cross-risks, are:
  - the risks generated by the urban part of the system on the railway part;
  - the risks generated by the railway part of the system on the urban part.
- It is a functional subsystem without a continuous and homogeneous geographical perimeter. In particular, elements mitigating the risks generated on the mainline part may be located on the urban part, and vice versa.

Where appropriate, the structural elements of the transition subsystem include both trackside equipment and on-board equipment.

The applicant has to submit two application files regarding the interlinking subsystem, one during the design stage and one during the realization stage. For each stage, they are the first application files submitted. EPSF and STRMTG have to issue an opinion on these files that are binding for the two safety bodies. The process at the realization stage is shown on figure 3.

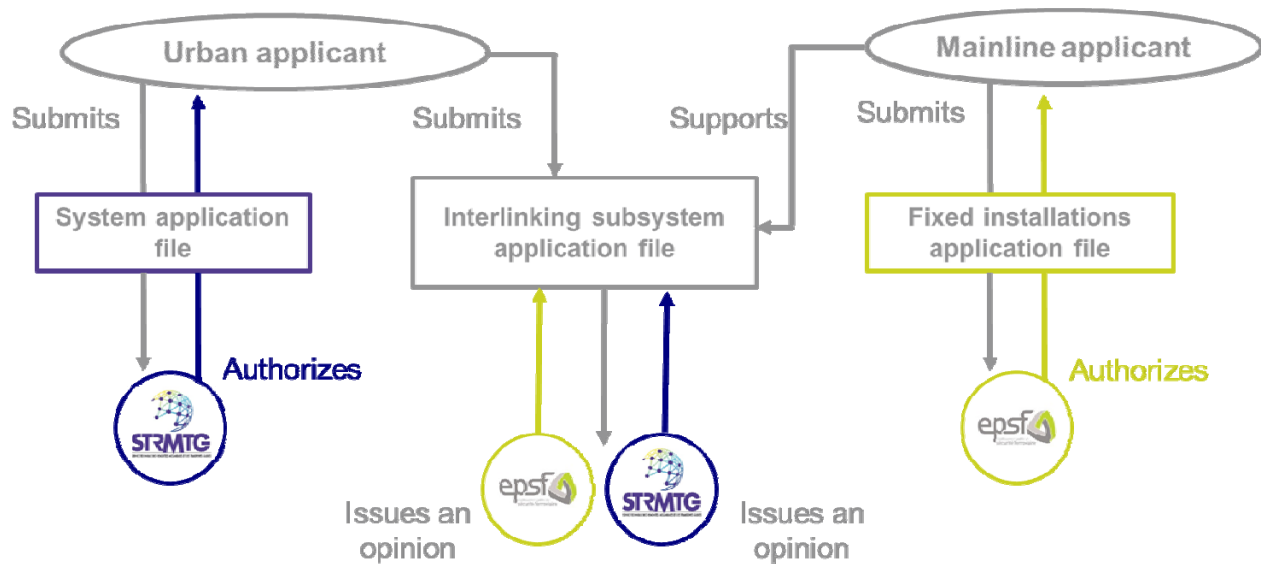


Figure 3 - Interlinking subsystem application file - Realization stage

To go back to the example of the tram-train system with standard and grooved rails, the files related to the interlinking subsystem will allow both the applicant for the urban part and the STRMTG to make sure the specific signaling device mitigates properly the risk of a train running on the grooved rails. In that example, if the STRMTG adds a condition for use or a restriction, EPSF will take it into account when issuing its authorization.

## A PROCESS TO DESIGN THE NEW BODY OF RULES INVOLVING ALL THE STAKEHOLDERS

A set of rules based on three texts

The regulatory body for mixed systems in France is based on three texts:



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- Decree n°2017-440 which sets the main rules and the main stages of the authorization process;
- An implementing act precisising the content of the various application files;
- A non-regulatory guide describing in detail what is expected to be sure to meet the requirements of the two texts mentioned above, especially regarding the content of the application files.

The decree and the implementing act were issued by the ministry for transport and are mandatory for any applicant. A concertation with the sector was done. The guide was produced by a joint urban / mainline working group coordinated by EPSF and STRMTG and isn't mandatory.

The process for modifying these texts is different for each kind of text. Changing a decree is a long process involving various state departments and administrative authorities. Modifying an implementing order is easier but still implies various state departments. Editing a guide may be done directly by EPSF and STRMTG but the content of a guide is not mandatory. Thus, how detailed is each text is critical to be able to get leeway to adapt the process to new situations.

These three texts had to be written and published on a constraint timeframe.

### Involving a responsive sector

Retrospectively, one of the key element in the process of writing these texts was to involve the sector in the working group very early. Initially, the working group was only for EPSF and STRMTG to write a joint guide. But it soon appears that, within the two safety bodies, we weren't able to answer all the questions that were arising to design an efficient and applicable text. That was really true to know what documents may be available at each stage of the making process. Thus, EPSF and STRMTG decided to involve the various stakeholders of the authorization process in the working group.

The other key element was that the sector was really responsive which allows to have all the stakeholders for the urban part and the mainline part represented in the working group. Moreover, as the working group was dedicated to the making of the guide, the representatives attending the working group were people acting daily in the authorization process and so having the knowledge to go into details. Thus, the working group became a place for deep and technical debate on the content of the guide but also on the rules set up by the decree and the implementing act as the three texts were written within the same timeframe.

### Designing details to be sure the general principles are working

Along the same lines, the meetings of the working group were held simultaneously with the process of writing the decree and the implementing act, allowing to go back and forth between the different texts. As the guide is the more detailed text, holding the process of writing the guide in parallel of the process of writing the decree and the implementing act allows to check that the general principles were understandable and applicable. It also allows to make sure that the understanding of urban stakeholders and mainline stakeholders was the same.

For example, the debate among the working group lead to major change in the content of the assessment report made by the independent body in charge of double-checking the safety demonstration. While writing the detailed content of the assessment report, it appeared that some parts were redundant and others weren't always conclusive. The working group proposed then a new frame with a conclusive assessment for the design stage and for the construction or manufacturing stage. This new frame was then accepted by the ministry for transport and the implementing order was modified.



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### CONCLUSION

Combining mainline and urban systems appears to be a cost-effective solution to meet transportation needs but raises specific issues as the safety approaches are different for the two kinds of systems. Safety for urban systems is based on a system approach adapted to urban specific conditions (environment and level of service) and safety for mainline systems is based on a subsystem approach suitable for interoperability.

The new French regulatory body deals with these specific issues setting up a common vehicle authorization application file for urban and mainline, and a specific subsystem designed especially for these mixed systems called the interlinking subsystem. To elaborate these new rules, EPSF and STRMTG, the national safety authorities respectively for mainline systems and for urban systems, set up a working group involving the sector to discuss the content of a guide detailing the general rules. This process allows to make sure the general rules were applicable and efficient.

With the entry into force of directives (UE) 2016-797 and (UE) 2016-798, a review of the rules will take place and will probably lead to some changes to comply with the new European rules, especially regarding the vehicle authorization process.