On the way to virtual certification: An NSA's point of view

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1. Introduction

The issue of tests to be performed for rolling stock and infrastructure for safety demonstrations - with a view to obtaining authorization or certification - has been the subject of much debate in the rail sector. The costs, safety constraints, organizational challenges (particularly finding available train access to the network) and sometimes the limitations (the difficulties encountered in trying to conduct physical tests for certain extreme conditions such as overspeed, real infrastructure configurations, atmospheric conditions, degraded modes, safety risks, etc.) of these tests have led stakeholders to find alternative ways (lab testing, dedicated test plants, numerical simulation etc.) in order to keep field tests to a minimum wherever possible.

Already widely used in the design and pre-validation of sub-systems, numerical simulation is still relatively rare in the validation phase (certification and authorization), where trials are still generally used to provide sufficient results for compliance assessments.

More specifically, the technical specifications for interoperability (TSI) set result targets which must be reached but do not specify the means used to achieve them, other than to explicitly reference the standards or parts of standards which apply to each technical domain (braking, dynamic behavior, current collection etc.). The norms vary in terms of the means which they deem acceptable for demonstrating compliance with the applicable standards: the regulations may stipulate compulsory testing, or else leave significant room for simulation, or else decline to specify.

Anticipating the trend for more widespread use of alternatives to field tests for compliance demonstrations, the French National Safety Authority has launched in 2017 a "think tank" (composed of manufacturers, certification bodies, laboratories, railway undertakings and infrastructure managers) to define the conditions for accepting evidence based on virtual certification.

2. Use of simulation

Appearing in the 80s, numerical simulation has since evolved continuously, along with the increasing power of computer tools, software development tools, and measurement tools to acquire data from real tests.

In the field of finite elements, the numerical models have thus gone from a few tens of elements making it possible to simulate simple load cases, to hundreds of thousands of elements that allow to deal with particularly complex multi-physical cases.

This leads to an increased use of this type of tool, the objective of manufacturers is to reduce the cost inherent to online testing. To date, simulation is widely used during design phases, pre-validation before industrialization, but the field of certification is still mainly supported by tests, which remain the norm. In addition to a strong "cultural" part among operators and manufacturers, the reasons are many: firstly, tests conducted in real conditions constitute a real "justice of the peace" and bring results and findings difficult to discuss if they have been made in the state of the art. In addition, the

confidence of evaluation bodies is all the stronger as the evidence provided comes from the field. However, the realization of online tests also has limitations: without developing the difficulties to obtain specific train paths and the associated costs, the fact of making circulations within other commercial ones, to run in overspeed, or with some disabled safety equipment creates significant risks that must be covered by an organization and heavy but essential processes. Moreover, the obvious limited duration of these tests on the rail network can limit the number of configurations to be tested, and the chosen time slot does not always make it possible to control the climatic conditions.

The use of numerical simulation makes it possible to overcome some of these constraints. Indeed, the simulation allows to free oneself from the constraints of the field and, by means of sufficient data, to have a reliable model and correlated to real tests, grants an infinite number of investigations, including for degraded modes difficult to test in reality. While simulation minimizes risks compared to actual tests, the level of confidence of the assessors in the results provided remains low. Several reasons explain this observation: the lack of knowledge of the field and the possibilities that it offers, the absence of accreditation of the staff in charge of the realization of the models (where the test body are), the difficulty of appreciating the models and assumptions to judge their representativeness, and consequently confidence in the results obtained compared to those that a real test would bring.

Looking towards other transportation sectors, simulation is widely used in aerospace and automotive design, and its share in safety demonstrations continues to grow. Passive safety and command-control are the technical fields where the simulation is most commonly used for certification purposes. Overall, simulation accounts for 80% of certification activities. But in all cases, the simulations used are correlated and validated on the basis of representative tests of the structure to be certified. Justification by test alone is paradoxically marginal and concerns mainly the dynamic aspects: landing gear, seat tests in crash conditions (decelerations), fuel tank tested in dynamic (drop test), determination of the characteristics of the structures and their eigenfrequencies. But even these dynamic tests are usually followed by a simulation to assess the sensitivity to different parameters.

In aeronautics, there is no other method for the use of tools. It is the correlation of experience that is used for tool recognition. In automotive industry, stakeholders have developed their own method of validating numerical tests, judging the European standard insufficient.

In summary, simulation is widely used before the certification step, and to prepare it, but there is always one or more tests to achieve to obtain the final validation. Simulation can therefore be said to be a tool that helps to minimize the uncertainty of failure of a final test, but that the reflection on virtual certification must still progress to be accepted by the assessors.

3. Prospective approach put in place by EPSF

The previous finding should not prevent assessors, and in particular safety authorities, from reflecting on the criteria for accepting evidence that would be transmitted through a safety file to obtain an authorization. The growing desire of the sector to switch to virtual certification requires at least to establish a doctrine in this area. The advent of innovation increasingly using digital equipments should accentuate this trend. An example of this is road vehicle crash tests, for which the manikin has so far been positioned as the lambda driver, facing the road and hands on the steering wheel, with a limited number of test cases. The autonomous vehicle calls into question test cases, since passengers can now be positioned in multiple ways in the vehicle. The test cases become too numerous to be all tested, and the use of the simulation then becomes indispensable.

In 2017, EPSF took the initiative to set up a think-tank with actors from the railway sector in France: manufacturers, operators, research organizations, testing organizations and certification bodies took part in a in-depth analysis of the subject.

This work, carried out in a co-construction approach with the actors, consisted of:

- listing all the available simulation tools used by industry players sorted per technical field.

- establishing a complete map of the technical specifications for interoperability (TSI), which are the European regulations in force in Europe which set out the requirements to be respected by any actor wishing to obtain an authorization. This mapping allowed, for each requirement, to identify the standards called by the requirement, and if these standards allow or not the use of numerical simulation, and under what conditions.

- drafting a position paper, published by EPSF in February 2019, and laying the groundwork for the criteria by which the national safety authority would assess any evidence using numerical simulation.

This high level position note specifies the elements that may be requested for this case of use. It lays down, in particular, general principles of acceptance relating to the simulation tool used, the skills of the user of the tool, the validity of the models of the object under study and the models of its environment, and the content of the dossier.

The document received a particularly favorable response in the railway community, and led to the setting up of a working group within the CEN/CENELEC (European Committee for Electrotechnical standards) in order to extend the discussions to the European scale. On the basis of the document published by EPSF, the working group aims to establish a set of recommendations for technical standard managers that would introduce the use of numerical simulation in future documents.

In addition, within the framework of Shift2Rail, (which is a public-private partnership to provide a platform for coordinating research activities with a view to driving innovation in the rail sector in the years to come), several projects are part of a similar approach, such as the "PLASA2" project concerning Smart Planning and Virtual Certification.

4. Concrete case

Regardless of the work carried out, but in line with the results already obtained, SNCF has indicated its desire to use numerical simulation in part to demonstrate the safety of two of its new projects, the French new generation suburban train “RER NG” and the new generation of high speed train “TGV2020”.

The "RER NG" project is intended for the Ile-de-France Region (Paris Region) and should be authorized by 2023. The rolling stock must therefore be the subject of a safety file providing the evidence in terms of compliance and safety.

For this project, SNCF has chosen to use numerical simulation to reduce the number of tests to validate the train at low temperature current collection (0 ° C), and the evacuation of the train.

SNCF is also developing models to validate the dynamic behavior of the train using numerical simulation. These approaches are discussed in advance between the applicant and the safety authority, in order to properly frame the area of acceptability of the evidence that will result.

These uses are concrete first steps in the exclusive use of numerical simulation to validate technical fileds usually intended to be demonstrated by tests. This reinforces the need for safety authorities to anticipate these new practices that tend to develop in the future.

5. Conclusion

If this is no longer a novelty, the use of numerical simulation to develop virtual certification is increasingly desired by industry, which is part of a logic of reducing costs and delays in commissioning new rolling stocks and infrastructures.

The two sides of the process must be considered synchronously: on the industrial side, the process leading to minimize the number of attempts to obtain evidence necessary for obtaining authorizations, on the side of the assessors the acceptance process of these proofs which free themselves in all or part of the field tests, whose "reassuring" side is facilitator of the assessment.

If the total substitution of the tests by simulation is not for tomorrow, the current rationalization should not be hampered by a misunderstanding of the assessors or a poor framing of these new uses in the safety demonstrations.