The UNICHANGER Project: A unique approach to eliminate rail frontiers due to the variable gauge

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Summary: As it is well known Spanish conventional network has a track gauge (1668 mm or Iberian gauge) wider than the European one (1435 mm or UIC gauge). The high speed lines (starting in 1992 with the Madrid-Seville line) have been built with the UIC gauge and therefore from that time we share in Spain two different gauge networks. The strong deployment of HSL from that date up to now- at the time being we have more than 2000 kms of HSL with UIC gauge- has created an internal problem of interoperability that has been mainly solved by using variable gauge train technologies which are in a very mature status. Talgo (from 1969) and Caf (from 2000) are currently operating these trains in our country at speeds up to 250 km/h. This paper explains first the current situation of these technologies in Spain, as well as the different steps we have followed to reach the current level of reliability in the gauge changer facilities in commercial operation. The final step in this process has been the development of a new gauge changer platform (TCSR3) able to allow the pass of trains from TALGO and CAF. This new development have been promoted and managed by Adif, the Spanish Railways Infrastructure Manager in the frame of a cooperation research project called Unichanger with a more ambitious objective which is to integrate in a unique platform not only the Spanish technologies, but the rest of them existing in Europe, i.e. Rafil DB (German) and SUW 2000 (Polish). This new platform, called TRCS3, has been already built, installed and tested in an Adif's changeover facility close to Tarragona (Spain). The paper will first explain the problem of connecting different gauge networks and later it will detail the first tests as well as the main characteristics of this new platform.

Index Terms: Variable gauge technologies, gauge changers.

1.- INTRODUCTION

Variable gauge is a worldwide problem; the most common gauge in the world is the "so called" UIC gauge of 1435 mm. However two other main gauge coexist around the world: the Russian gauge (1520 mm) in all the soviet area plus Finland (1524 mm) and the Iberian gauge (1668 mm) in Spain, Portugal and also in India and Pakistan. Therefore in some emergent countries border as Russia with Europe and China and India and Pakistan with Russia and China, this issue will be very relevant in the near future.

In Spain the problem of having a gauge different than the European one has been one of the reasons of the Iberian isolation in the last decades. Furthermore the decision adopted in 1992 of implementing high speed lines with the UIC gauge has created an internal barrier between the conventional network-11.755 Kms- and the new high speed lines-, 2080 Km at the end of 2010 a plus 2500 under construction now-.

Due to this reason Spain has developed different solutions to solve its internal problem: the first approach has been the third rail track consisting on a track with UIC and Iberian gauges, this solution has been only applied in some very specific places because the most extended solution has been the use of variable gauge trains able to run over both networks. This solution started with Talgo variable gauge trains in 1969, and up to now more than 260.000 trains and 325 millions of passengers have used these trains.

In 2000 a second Spanish variable gauge system developed by CAF started to be in commercial exploitation. The two trains operated by Renfe implementing those variable gauge systems (S-130 of Talgo and S-120 of CAF) are running every day in both networks over the 14 changeover facilities connecting them-plus 2 connecting Spain and France. During 2009, 24.036 trains ghanged their gauge in these facilities.

Additionally to the two Spanish systems there are a Polish (PKP SUW 2000) and a German (Rafil-DB) variable gauge systems developed in those countries to connect Europe with Russia. By this reason ADIF started developing the UNICHANGER project presented in this paper with the main objective of designing, developing and testing an universal platform able to perform the gauge change of all the existing systems. This universal platform will be the solution for interconnecting those countries with different gauge by means of facilitating the rail operators the selection of the rolling stock variable gauge system most appropriate for their interest in terms of cost, performances or any other selected by the operator. In this sense, the Unichanger project is one more step in the process of achieving real interoperability among countries with different gauge, following the Spanish experience that variable gauge trains are the best solution to overcome this problem.

2.- DIFFERENT GAUGE NETWORKS: AN SPANISH AND WORLWIDE PROBLEM

As it is well known, Spanish conventional network has a different gauge than the rest of Europe. Our conventional network has a track gauge of 1668 mm while the European one is the so called “standard gauge” of 1435 mm. This different gauge has been a traditional barrier between Spain and the rest of Europe through the Pirineés (not Portugal because their gauge of 1676 mm is compatible with the Spanish one). This problem was internalized in 1992 when it was decided to build the new Madrid-Sevilla high speed line with the 1435mm standard gauge. From those days up to now Spain has built a high speed network of more than 2,000 km (including the new Madrid-Valencia line to be open Dec 18 2010) which is currently coexisting with more than 12,000 km of conventional lines. The interoperability between these two networks has been a challenge for Spanish railways from 1992 and this paper explains how this problem has been solved in Spain.
Due to this situation Spain has developed some technologies to be able to operate jointly both networks in order to allow new high speed trains to arrive to cities where the high speed network still does not arrive. Two different solutions have been adopted. The first one is the three-rails track, which is a track incorporating three rails for both the Spanish and the standard gauges. This three rails track (Figure 1) is being used in some specific places where it is the best solution, but due to its cost, complexity, absence of track circuits, etc., is a costly solution to be applied just in places where no other solutions are possible.

The second solution, which is the more extended one, is the use of variable gauge trains able to modify the distance between wheels in a fast and reliable way. These variable gauge trains are the best way to connect both networks and, as it is explained in section 2, they are in operation in Spain from the beginning of the standard gauge high speed lines operation.

Figure 1. Three rails track (1668mmm and 1435 mm)

Talgo, from 1969, and Caf from 2000 are the two Spanish manufacturers of these technologies. Figure 2 shows a picture of Talgo S-130 and Caf S-120 trains which are running over high speed and conventional networks at 250 km/h and 200 km/h respectively.

a) b)

Figure 2. a) Talgo S-130 and b) Caf S-120 variable gauge trains.

From the rail infrastructure manager point of view the use of variable gauge trains technology has to be complemented by means of installing gauge changers installations to allow trains to change the gauge. This is the role of Adif and it is the main objective of the work presented in this paper. These changeover facilities allow the trains to change the gauge without stopping at a speed between 15 and 20 km/h. Therefore locating these facilities close to stations or places where the train has to stop neither generate any impact in the operation nor causes any additional delay.

Due to this, Spain is, at the time being, the world country with a highest experience in variable gauge trains and gauge changer facilities technologies. However we would like to highlight here that different gauge between rail networks is not only an Iberian problem, but it is a worldwide issue as it is shown in figure 3 in which different gauges along worldwide are shown. Therefore the Spanish experience in this issue, and more specifically the work of developing universal gauge changers facilities for variable gauge trains explained in this paper, could be a solution to this worldwide problem of reaching real interoperability among different gauges networks which means a fast pass between them. This will avoid the still existing procedures of changing train bogies or translating goods between trains which enormously increases the time and cost of both passengers and freight international rail traffic.

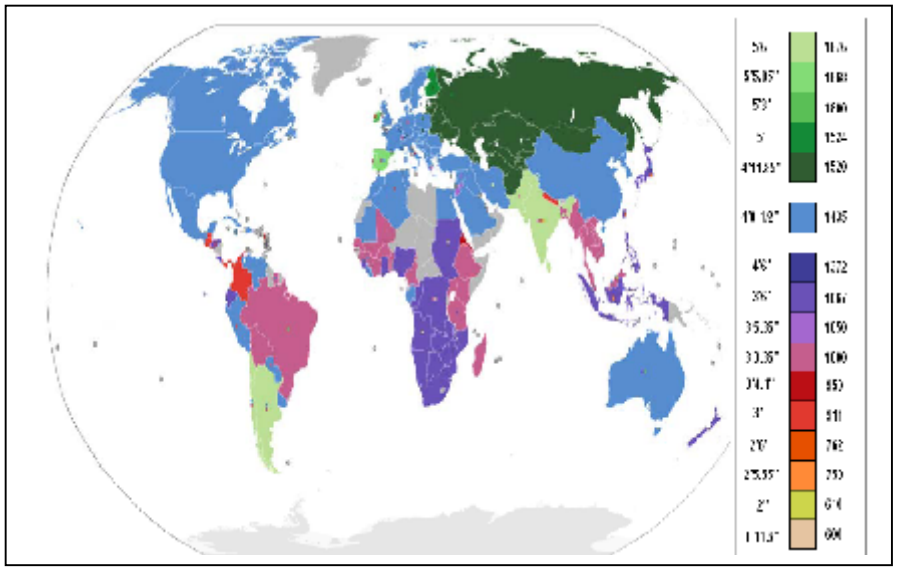


Figure 3. Rail track gauges worldwide.

3.- CURRENT SITUATION OF VARIABLE GAUGE TECHNOLOGIES IN SPAIN

The automatic track gauge changing technology has been a remarkable success in Spain. In fact the old Spanish problem of having two different gauge networks not connected between them has been overcome by using these systems.

In Spain since 1969, more than 300.000 trains carrying around 70 million passengers have changed gauge in the automatic gauge changer facilities. At the time being this technology is being used in Spain connecting high speed and conventional networks. Table 1 shows the number of gauge change operations among the three high speed corridors and the conventional lines connected to them. These figures mean that every day around 74 trains change gauge in the 13 installations in service.

H.S.L. Madrid- Barcelona	7.280 Operations
H.S.L. Madrid -Valladolid	9.308 Operations
H.S.L. Madrid – Sevilla / Málaga	7.280 Operations

Table 1 :Gauge changer operations in
High Speed Lines during 2010

In the early years of this technology it allowed the swift interconnection between the Spanish network and the French network.

The new high-speed lines, built in the 1.435 mm gauge, started in 1992 with the Madrid-Seville line and continued from that date with an ambitious high speed program based on which more that 2.600 kms of double track HSL are in operation at the end of 2010. For this development, the automatic gauge

changing technology has been very relevant. It has allowed ADIF to extend the benefits of the high-speed infrastructure to the rest of the more of 12.000 kms existing conventional network in 1668 mm.

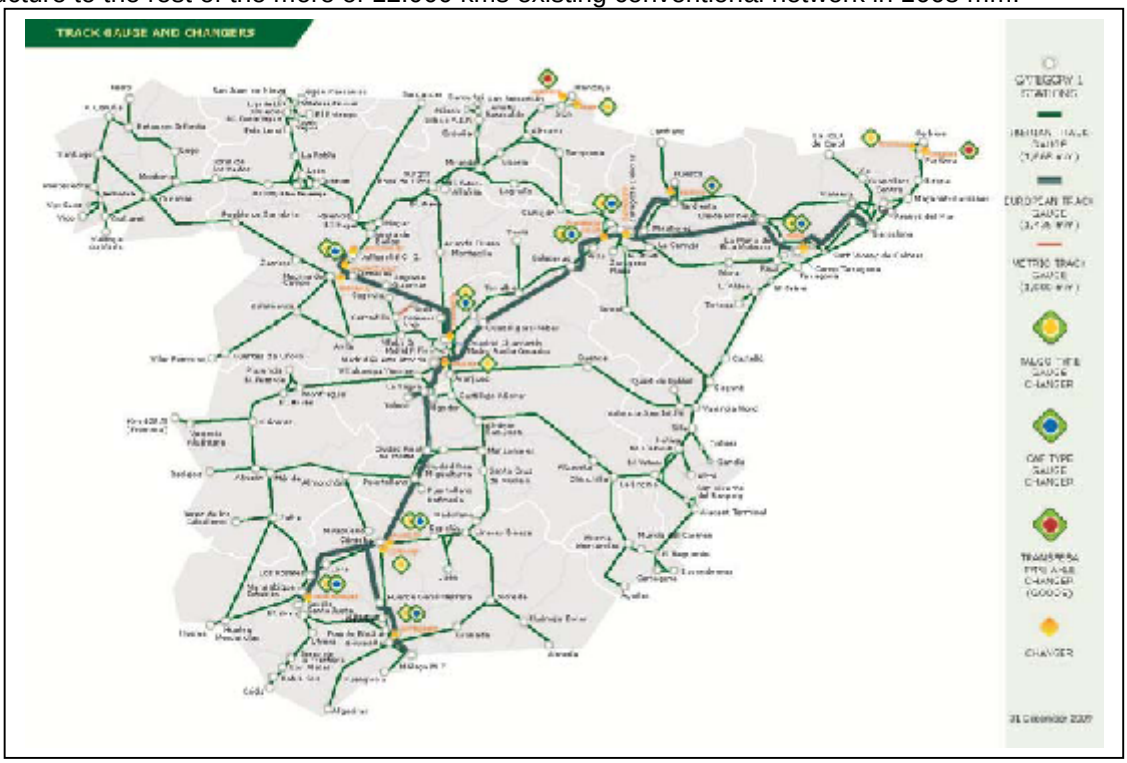


Figure 4 Gauge changer facilities for passenger traffic. 2009

Based on the success of variable gauge systems, nowadays, the Spanish high speed and conventional networks, constitute a joined infrastructure which is operated in an integrated way. Figure 4 shows a map of the Spanish rail network including both the conventional and the high speed lines and showing the situation of the 13 gauge changers facilities in commercial exploitation. Both Talgo and Caf variable gauge trains use these changeover facilities tacking advantage of running over the new high speed lines to reach destinations still located outside the high-speed grid.

ADIF has been working for years, improving and optimizing the infrastructure for the better operation of the track gauge changing trains. At the beginning as the only technology was Talgo, the changers were only valid for these trains. Starting in 2000 and once Caf developed its first variable gauge trains, Adif incorporated in a single installation the platforms for both trains.

The evolution of gauge changer has been performed in the following way: initially two different platforms were installed in two separate facilities to allow the pass of both trains, but later on the integration of both technologies has been done gradually as it is shown in figures 5 and 6.

Figure 5 shows the so called TCSR1 installation where platforms for Talgo and Caf are integrated in a single facility and they are reclining platforms which are located in their corresponding position before passing the Talgo or Caf train.

Figure 5. TCSR1 Reclining dual changer

The second generation of dual gauge changer facilities is shown in figure 6 and it is based in two horizontally moving platforms that are located in their position before passing each kind of train.

Figure 6. TCSR2 Horizontal dual changer

The gauge changers in operation today are therefore based in integrating in a single facility the two different platforms from Talgo and Caf. For this reason Adif started a research project to integrate in a single platform the mechanisms needed to perform the change of gauge of these two types of trains. This

was the origin of the new platform which is the main subject of this paper. The development of this new platform is one more step in integrating the existing technologies to walk through a higher interoperability between the two networks. It is also important to mention that both manufacturers, Talgo and Caf, are currently developing a new generation of variable gauge trains able to run at up to 300 Km/h in the high speed lines.

4.- TALGO-CAF GAUGE CHANGER (TCRS3)

As mentioned before, the latest research program sponsored by ADIF in this area is the "TALGO-CAF GAUGE CHANGER (TCSR3)". It is a gauge changer facility that drastically optimizes the infrastructure, allowing TALGO and CAF trains to change the gauge in a unique platform. Until now both technologies needed a different platform. The first generations of ADIF's gauge changers had to change the platform before the arrival of each train.

Incorporating both systems in a single platform is a first step of a more ambitious target which is to incorporate in this single platform also the other two technologies existing in Europe, the German Rafil/DB and the Polish SUW2000. These four technologies will be the future TCSR4 which is the final target of the Unichanger project. Adif experts have already analyzed the possibility of integrating all the systems and the result of this analysis is positive. This platform is foreseen to be developed by mid 2011.

The new system implemented in the so called "TALGO-CAF GAUGE CHANGER" platform incorporates both systems in a single platform with the following features:

- Reduced time to change between TALGO and CAF configuration.
- Reduced width, which allows the infrastructure planners to place the gauge changer facilities almost anywhere.
- Reduced cost.
- Improved operation with new guides, artificial vision and wifi transmission of changing parameters to the train cabin.
- Offers the infrastructure manager the possibility to use two different proven train technologies.

The main characteristics of this installation are summarized in table 2:

Dimensions	Length 15 meters. Width 4 meters. Height 1,5 meters.
Lay out	Maximum slope of 5 mills. 50 meters of straight track at each side.
Structure	Concrete pit with steel structure anchored in slab.
Moving parts	Mechanized guides made of different materials, actuated by an automated hydraulic system with 64 actuators to perform movements and locking of elements.
Configuration time	30 seconds to change from TALGO configuration to CAF configuration and vice versa.
Train speed	Trains do the gauge change running at 15 km/h.
Maximum load	22,5 ton per axis.
Trains	TALGO series 6 and 7. TALGO 130. CAF 120. CAF 121. CAF TRD.

Table 2: Main TCSR3 dual changer characteristics

The TCSR3 platform has been already constructed, installed and tested in a gauge changer placed near Tarragona. In that place it was previously installed a gauge changer when the high speed line from Madrid to Barcelona arrived only to Tarragona. Now that the full line is in operation from February 2008, this installation is an ideal place to perform these tests.

Tests were performed during September 2010 year by means of passing a train with CAF technology (train S-121 from Renfe) and a train with TALGO Technology (ADIF's train laboratory BT). Figures 7 and 8 show the pictures of the first passes of both trains over this new TCSR3 platform.

Figure 7. Talgo train passing over the new TCSR3 platform

Figure 8. CAF train passing over the new TCSR3 platform

The performed tests have been a full success showing the viability of the TCSR3 platform, as a unique solution for the trains running in the Spanish network. According to the first results of the tests, only small modifications are needed in the platform and they will be completed very soon.

TCSR3 platform will be therefore the next generation of Spanish gauge changer facilities, providing a compact solution with the advantages of space, cost, time of change and robustness listed before, which

will increase the interoperability among different gauge networks based on the solid and contrasted Spanish long time experience.

4.1.- TCRS3 movement process

The TCSR3 is a platform with mobile parts and each of them are located in the proper position for both the Talgo and Caf positions. Figure 9 shows the main parts of TCSR3 which are the following: a) Unblocking guides: these guides unblock the wheels locking system, allowing free movement of the wheels, b) Supporting guides which supports the wagon weight while the gauge is being changed. It is important to highlight that when Talgo and Caf systems vary the gauge, the wheels are not supporting the wagon weight which is supported by these guides. In this sense they are different to Rafil and SUW2000 systems because these systems do not unload the wagon weight while changing the gauge. and c) The guides moving the wheels once they have been unblocked.

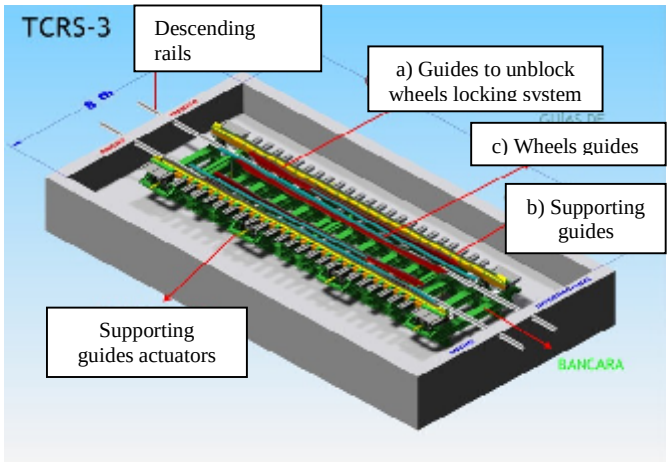


Figure 9. Main TCSR3 elements

The elements a)unblocking guides and b)supporting guides, are moved between Talgo and Caf positions. This movement is performed according to figures 10 to 13. Figure 10 shows the dual changer in Talgo position. In the next paragraphs we will describe the process of changing between this position and Caf position.

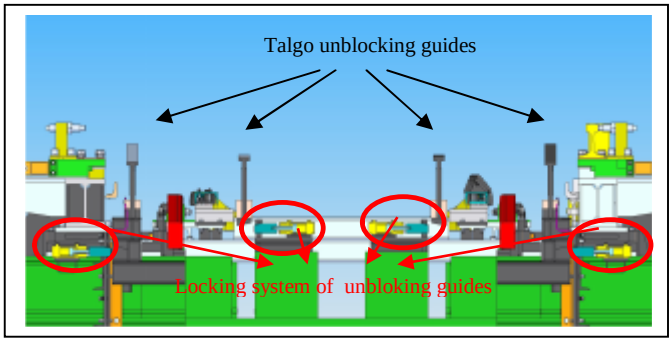


Figure 10. TCSR3 in Talgo position

The first action is to pull out the locking system in order to allow moving the Talgo unblocking guides (Figure 10). These elements have to be hided to allow a CAF train entering into the gauge changer.

Secondly as it is shown in figure 11 we lower these guides by means of a set of hydraulic cylinders.

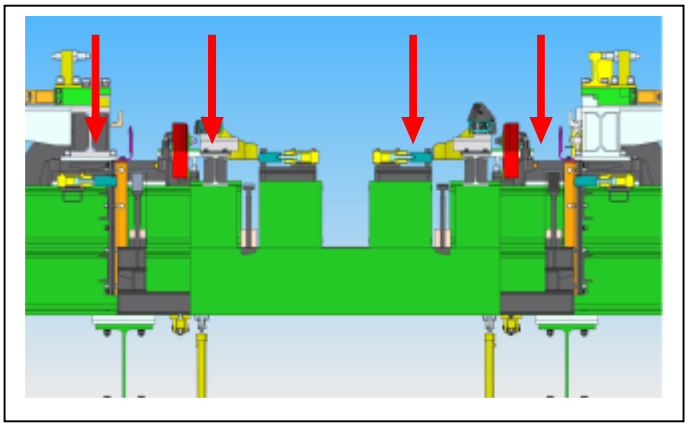


Figure 11. Movement of Talgo unblocking guides

The next operation consists in positioning the supporting guides for CAF. To do this, first there are a set of locking elements that are pulled out (figure 12).

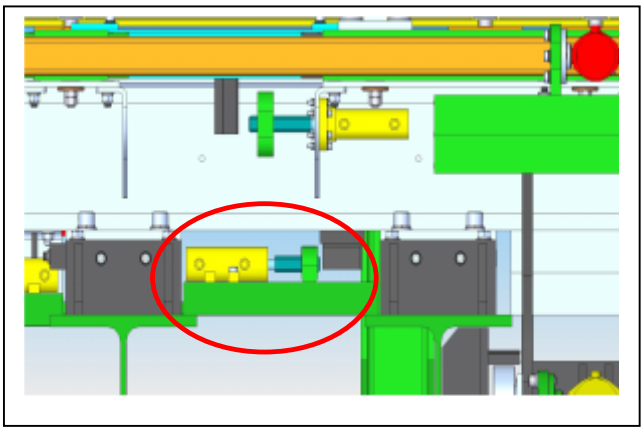


Figure 12.Supporting guides unlocking.

Once they have been unlocked TALGO and CAF supporting guides are slided in a horizontal plane. The TALGO guides are moved to the outside while the CAF guides that are underneath are moved to the interior. This operation is shown in figure 13.

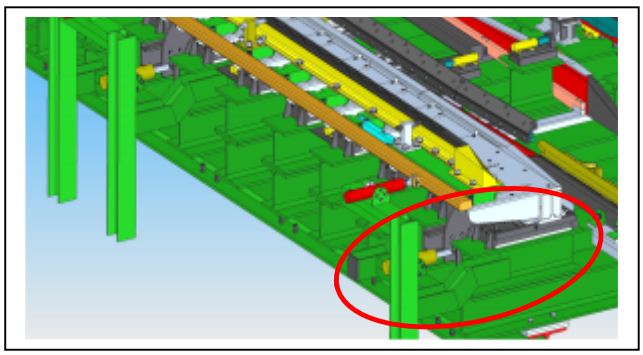
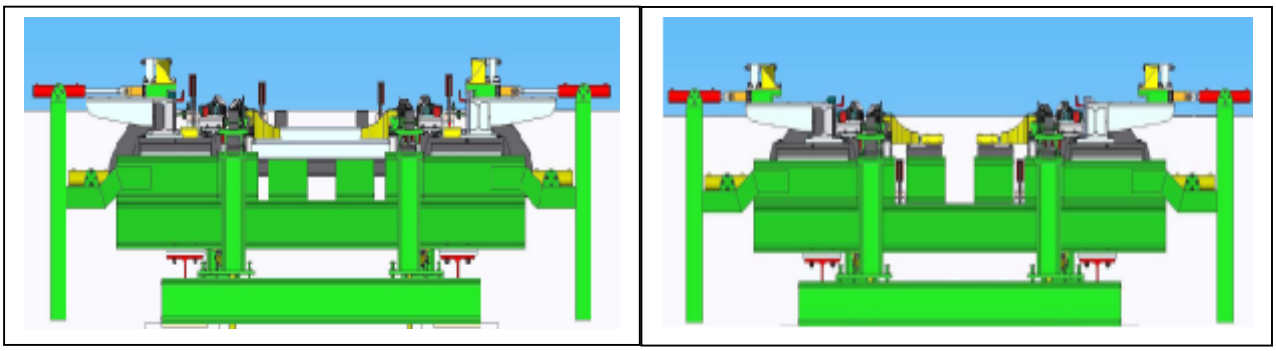


Figure 13. Supporting guides movement Talgo outside and Caf inside.

Finally the supporting guides are locked and the TCSR3 is in Caf position as it is shown in figure 14 b). In this figures are represented both initial Talgo position (a) and final Caf position (b).



a) b)

Figure 14. TCSR3 dual gauge changer in a) Talgo position and b) Caf position.

5.- CONCLUSIONS AND NEXT CHALLENGES

This paper has shown how the new dual Talgo-Caf gauge changer (TCSR3) has been designed, built and successfully tested. This new system integrates in a unique platform both technologies and allows increasing the interoperability between different gauge rail networks.

Next challenges in the way of improving gauge changers could be summarized in the following:

1. Gauge changers explained in this paper are related with Spanish gauge changes between 1,435 mm and 1,668 mm. However almost the same technology could allow the change between 1,520 mm (Russian gauge) and 1,435 mm.

2. The Unichanger research project team is currently working on incorporating Rafil/DB and SUW 2000 technologies in addition to the Talgo and CAF in the same platform.

3. According to our studies, for double track lines, it is preferable to install two multipurpose changers instead of converging two tracks into one, offering greater capacity as well as reducing the total cost by removing the other elements of the superstructure.

4. Conceptually gauge changers are suitable for passenger and freight trains. Up to now they have been used for the passage of self-propelled trains, but they could admit operations for settings with locomotives and towed wagons.

5. In Spain, the gauge change also involves the change in voltage (1,435 mm = 25 kV ac and 1,668 mm = 3 kV dc), regulation and signaling system. This change is currently performed in the own changer but it should be analyzed the possibility of performing these changes before or after the changer to improve the process reliability.

Acknowledgements

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