# Report on a new last-mile production method separating train movements and shunting processes

| | |
|---|---|
| Grant Agreement N°: | SCP2-GA-2012-314255 |
| Project acronym: | **ViWaS** |
| Project title: | **Vi**able **Wa**gonload Production **S**chemes |
| Funding scheme: | Collaborative project |
| Project start: | 1 September 2012 |
| Project duration: | 3 years |
| Work package N°: | WP 6 |
| Deliverable N°: | D6.2 |
| Status/ date of Document: | Final, 31/07/2015 |
| Due date of document: | 31/07/2015 |
| Lead contractor for this document: | Fret SNCF<br>Paris, France |
| Project Website: | www.viwas.eu |


| **Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)** | | |
|---|---|---|
| **Dissemination Level** | | |
| **PU** | Public | **X** |
| **PP** | Restricted to other programme participants (including the Commission Services) | |
| **RE** | Restricted to a group specified by the consortium (including the Commission Services) | |
| **CO** | Confidential, only for members of the consortium (including the Commission Services) | |

# Involved partners

Following project partners have been involved in the elaboration of this document:

| Partner N° | Organisation short name | Involved experts |
|---|---|---|
| 1 | HaCon | Niklas Galonske, Frederic Falke, Sascha Nerger, Eckhard Riebe, Sebastian Weismantel |
| 5 | Fret SNCF | Denis Levy, Luc Débant |
| 7 | NEWOPERA | Franco Castagnetti, Giuseppe Rizzi, Armand Toubol |

# Table of contents

# Table of figures



# Table of tables

# List of Abbreviations

| | |
|---|---|
| EPSF | Autorité francaise de sécurité ferroviaire<br>EN: French Railway Safety Agency |
| ICT | Information and Communication Technologies |
| IM | Infrastructure Manager |
| RR | Road/Rail |
| RU | Railway Undertaking |
| SWL | Single wagonload |

# 1 Introduction

**The ViWaS project**

Single wagonload (SWL) transport is still a major component in numerous European states' transport systems and in the logistics of different economic sectors such as steel, chemical industry and automotive. However, changing framework conditions and increasingly demanding market requirements have led to dramatic market losses, important financial losses and even to complete shutdown of SWL business in some countries. As this business segment has been evaluated as important for specific transports in a European co-modal transport system also for the future, significant improvements are needed.

The ViWaS partners believe that for the success of SWL the following two issues might be crucial:

(1) A viable SWL system is highly dependent on the critical mass. Thereby all options have to be considered to secure a high utilisation of the trains operated on the trunk lines, including a combined production with intermodal loads.

(2) Only comprehensive and complementary measures are able to sustainably improve and preserve the European SWL systems in accordance with increasingly demanding market requirements.

The ViWaS project will follow such a comprehensive approach; therefore aiming at the development of

- Market driven business models and production systems to secure the critical mass needed for viable SWL operations,
- New ways for "Last-mile" infrastructure design and organisation to raise cost efficiency,
- Adapted SWL technologies to improve flexibility and equipment utilisation,
- Advanced SWL management procedures & ICT to raise quality, reliability and cost efficiency

The applicability of these solutions and their effects will be proved on the basis of pilot business cases (by demonstrations). Thereby important findings will be gained for a European wide implementation of developed solutions.

ViWaS stands for Viable Wagonload Production Schemes.

The ViWaS consortium includes railway operators (SBB Cargo, Fret SNCF, and Bentheimer Eisenbahn), infrastructure providers (Interporto Bologna / IB Innovation) technology partners (Eureka, Wascosa) and consulting/ scientific partners (ETH Zürich, TU Berlin, HaCon, and NEWOPERA).

**Work Package 6** examines possibilities to optimise last-mile rail operations which are considered as crucial to reduce the overall SWL production costs. Deliverable D6.1 – submitted to the European Commission in February 2015 – focussed on possibilities for containerised SWL traffic (task 6.1) and SWL traction schemes with hybrid locomotives (task 6.2).

**Deliverable D6.2** describes the new last-mile production method that is based on the idea of separating distribution train movements and shunting processes in sidings by deployment of bi-modal Road/Rail tractors (task 6.3). The report also contains documentations of the search for suitable business case and related test sites as well as of other related project activities within WP9 (”Training”) and WP10 (“Demonstration”).

# 2 Executive Summary

**The concept**

In the last mile operation of SWL traffics there are two phases:

- One on the National Railway Network from the last marshalling yard to the entrance of the private siding.
- One for conveying the wagons from the entrance of the private siding to the tracks where the cargo will be handled. Quite often the wagons have to be moved inside the private siding for logistics reasons.

These two operations imply the use of a team for the outside running of the distribution train which is sometimes delivered directly inside the private siding when the logistics operations do not need to move the wagons for instance, and one inside to place the wagons to perform the handling operations. The idea developed was to separate these two operations and/or reduce as much as possible the work load of the distribution train avoiding, when efficient, the penetration in the private siding. Moreover the introduction of a bimodal Road/Rail tractor avoids doubling the tracks to withdraw the locomotive from the siding with the switches associated. On top of that if the Road/Rail Tractor is allowed to run on the National Railway Network it can proceed with the exchange of wagons coming from the siding /going to the siding in the most favourable place where the distribution train may avoid any backing movements. The Road/Rail tractor with its capacity to get in and out of an embedded rail tracks easily offers the possibility to avoid backing movements requiring an enlarged team of two people. Finally if the distribution train may serve another siding in the vicinity the adequate Rail Road tractor may serve both sidings as it is capable to run on the road as a classical vehicle.

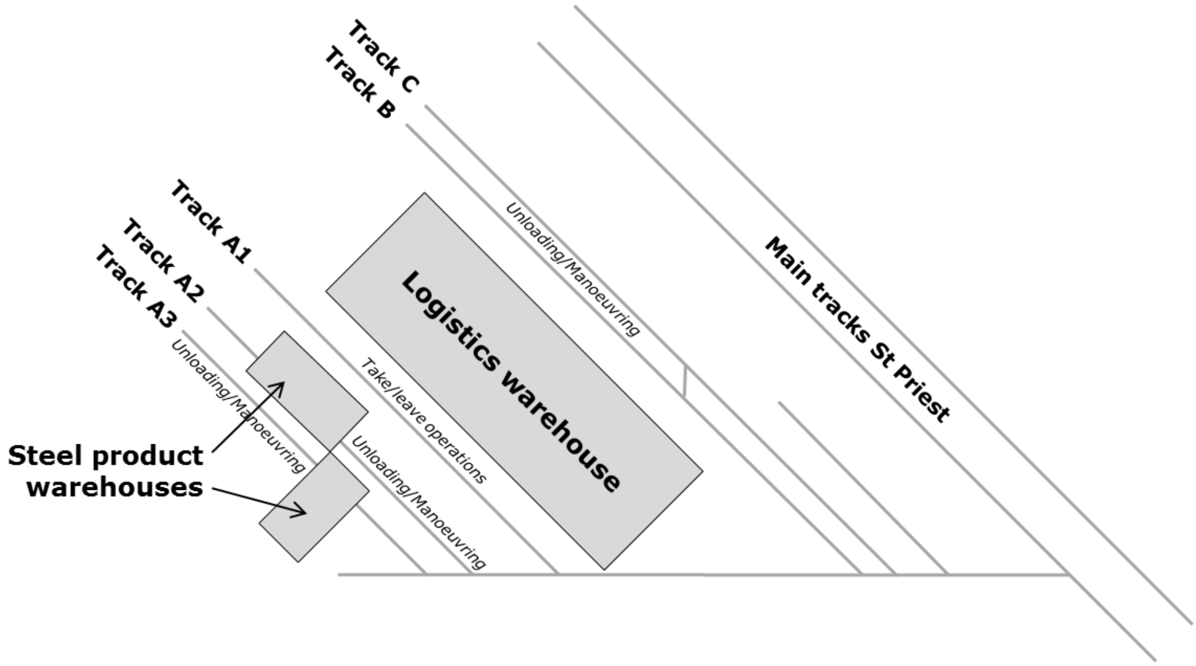
**The development of the project**

The development of the project has implied the research of adequate sites for the tests. After a long search, because private sidings owners having already optimised their internal operations taking into account the present way of the collection and delivery, have been reluctant to change their operations for a short period. Moreover the penetration of the Road/Rail Tractor on the National Railway Network could not be obtained immediately as there is no legal frame for such situations.

The test was finally organized inside a private siding which layout allows demonstrating most of the possibilities of the new solution.

It is in St. Priest (Figure 1) private siding of Fret SNCF serving two main users: AIR Liquide discharging $CO_2$ from heavy trains and Steel operators for Logistics operations in Sheds.

**Figure 1: Logistics site of St. Priest**




*Source: HaCon based on SNCF*

Presently SNCF runs the distribution train to the inside of the private siding by long backing movements. Then the movement of the wagons between the various tracks is performed by a light rail Diesel Motor tractor Y8000.

The search of an adequate Road/Rail tractor led to the rental of a MOL 2444 which power is largely sufficient to ensure a full reliability of the operations.

**Figure 2: Road/rail tractor MOL RR 2444**

*Source: NEWOPERA, SNCF*

The role of the Road/Rail tractor was to pick the wagons left by SNCF at the entrance of the private siding and then to proceed with all necessary movements inside for putting the wagons in place but also for moving them when the logistics operations needed it. The Y8000 was not at all used during the test period.

## The Demonstration

The demonstration lasted 3 months after training the staff to the new vehicle. The precise operations were:

- To place the half train of $CO_2$ on the unloading track and exchange it with other half when the operation was over and to bring them globally back to the entrance of the private siding where SNCF took them in charge with their diesel locomotive.
- To serve the two sheds where the steel coils were to be handled by several sets of few wagons placed under the Gantry crane of the shed.

Compared to the Y8000 service the complexity of the operation has been largely reduced as the Road/Rail Tractor could leave the embedded track anywhere. Moreover the Road/Rail tractor is equipped with a remote control which could enable any operation to be made by a single operator. Even backing movements could be made by a single operator as soon as the radio remote command could be used with one hand only.

The demonstration has shown significant gain of time for the steel operations (30%) and a marginal gain for the CO2 operation.

The demonstration has shown that the ability to drive and operate the Road/Rail tractor is obtained in one day, that the safety is at a high level with convenient footboard, with a vigilance system in case of a fall down of the operator, with a slewing seat enabling to have the best driving position, with a very precise positioning when touching the buffers of the wagons and with many other devices like cameras. The time to get the right pressure in the brake pipe of the wagons to move them is 20% shorter than with the Y8000 enhancing the efficiency. The team operating was very favourably impressed.

## The economic analysis and the KPIs

The theoretical economic analysis has to take into account the various elements impacting the efficiency: distance on which the distribution train is doing backing movements, the frequency of deliveries, the volume of traffic, the layout of the private siding and the nature of the logistics operations on the private siding as well as the existence of other sidings for a joint use of the Road/Rail Tractor. Of course the use of the Road/Rail Tractor reduces the number of tracks, switches necessary and their maintenance. It has to be noted that for existing sidings only the economies of maintenance have to be taken into account while investments economies should also be considered for new sidings.

However taking into account the main possibilities a methodology of analysis has been proposed to see where the solution could be effective. It appears that if the authorisation to go out for a simple exchange of wagons on the National Railway Network is granted and if the use with one hand of the remote control is done the global economies (for the distribution train service and the private siding operation) could be at the level of 10% for a single simple delivery to 22% for a double delivery. In the case of St. Priest the economic analysis benefits from the efficiency in the inside operations leading to a global economy of 35%.

**Results, Further developments and implementation**

In the case of St. Priest there is even a scope for a further improvement as another adjacent private siding receives car carrier trains which are only placed on tracks in two parts and withdrawn in the same way. This is an operation that can be easily bundled with the actual operation as the use of the Road/Rail tractor leaves time to do this very short operation in an efficient way at a distance of a few meters.

Following this economic analysis KPIs characterising the efficiency of the operations have been elaborated as the cost of investment and maintenance per meter of usable track of the siding, the cost of delivery for a given number of wagons and the time gained of hauling the wagons. The results were positive on all the KPIs for the St. Priest test.

The tests effectively performed have not allowed to operate on the National Railway Network and to fully use the remote control. But there are already some derogations granted to access to National Railway Network for a simple exchange of wagons and ideas are being developed for a single hand remote control command. For the Road/Rail tractor checking the way to ensure an efficient connection of the track circuits will have to be done. None of these developments should take a very long time.

The implementation of the new solution will need to select adequate sites on the basis of a methodology helping to proceed with a rigorous analysis to detect the favourable situations. Then convincing the private siding owner and the Railway Undertaking responsible for the distribution train to share the benefits will have to be done. Disseminating the results of the test in workshop with interested stakeholders to analyse their precise problem could speed up the market uptake.

# 3 Development of a new last-mile production method separating distribution train movements and shunting processes

## 3.1 Concept

When analysing the collection and delivery processes of SWL traffics it becomes clear that related costs represent an important share of the overall transport costs of around 40%. In such rail operations a team of two people is mobilized from the concentration point (= marshalling yard) until the delivery point. It has first to proceed through the main tracks of the National Railway Network and then through secondary lines to reach the entrance(s) of the private siding(s). During that part of rail service generally a diesel locomotive is used in order to be able to serve directly the private siding by a backing movement if necessary. Then the wagons are left on the siding for the private owner to move them by himself.

The first part of the development idea researched within ViWaS was to optimize the use of the diesel engine to serve several sidings in one work period by avoiding the backing movements to enter the private siding while introducing a Road/Rail tractor to pick them on the main distribution track and drag them into the private siding in a direct movement.

The second part of the idea was to mutualise the use of a Road/Rail tractor between two or three private siding owners in the vicinity because of its capacity of quick transfer by road to the next location and because of the improved efficiency of the main distribution train. At the same time the capacity of the Road/Rail tractor to get out of the rail track from an embedded track zone should avoid an extra siding track and two switches in investment and maintenance.

## 3.2 Layout principles and clusters of sidings (variants)

An efficient application of the new last mile solution is supported by certain factors:

- Clustered sidings connected to a secondary distribution line enables to envisage a mutualised use of the RR tractor;
- Possible bundled operation of collection and deliveries creates a possibility of more cost reduction;
- Effective logistics operations in the private siding implying wagon movements is a favourable factor for the use of all possibilities of the RR tractor

Of course the fully ideal situation might not be frequent and the flexibility of the solution is a favourable factor for its application. It can even find its justification only in internal siding operation or combining simple collection/delivery in one siding with full logistics operation in a nearby siding.

## 3.3 Administrative framework conditions and necessary amendments

Today, RR tractors are not allowed on the French National Railway Network. There are no standards directly applicable to such RR tractors. The standard of the French Railway Safety Agency (EPSF) for main line locomotives is not applicable to such vehicle as the level of the requirements is in line with the performances of a locomotive running on a main line and thus is too high. For EPSF a new standard cannot be elaborated rapidly for such vehicles. At the same time, authorisations granted to civil work RR tractors by the infrastructure manager are not applicable to RR tractors.

However, certain operators of private sidings have been authorised to access the National Railway Network under certain conditions to perform only an exchange of wagons. The standards applicable for this kind of situations are not applicable to RR tractors in the frame of operations more complex than the simple exchange of wagons.

Two major technical obstacles exist but can be overcome:

- A bad connection of the track circuits by the RR tractor;
- A risk of deterioration of safety device controlling the switches because of a failure of respecting the lower clearance profile by the RR tractor.

For France, the EPSF and the infrastructure manager (SNCF Réseau) must define the terms of reference of a new standard applicable to RR tractors. WP11 "Evaluation of ViWaS project developments" will provide a deeper look into the operation experiences of bimodal RR tractors and related administrative framework conditions in other European countries.

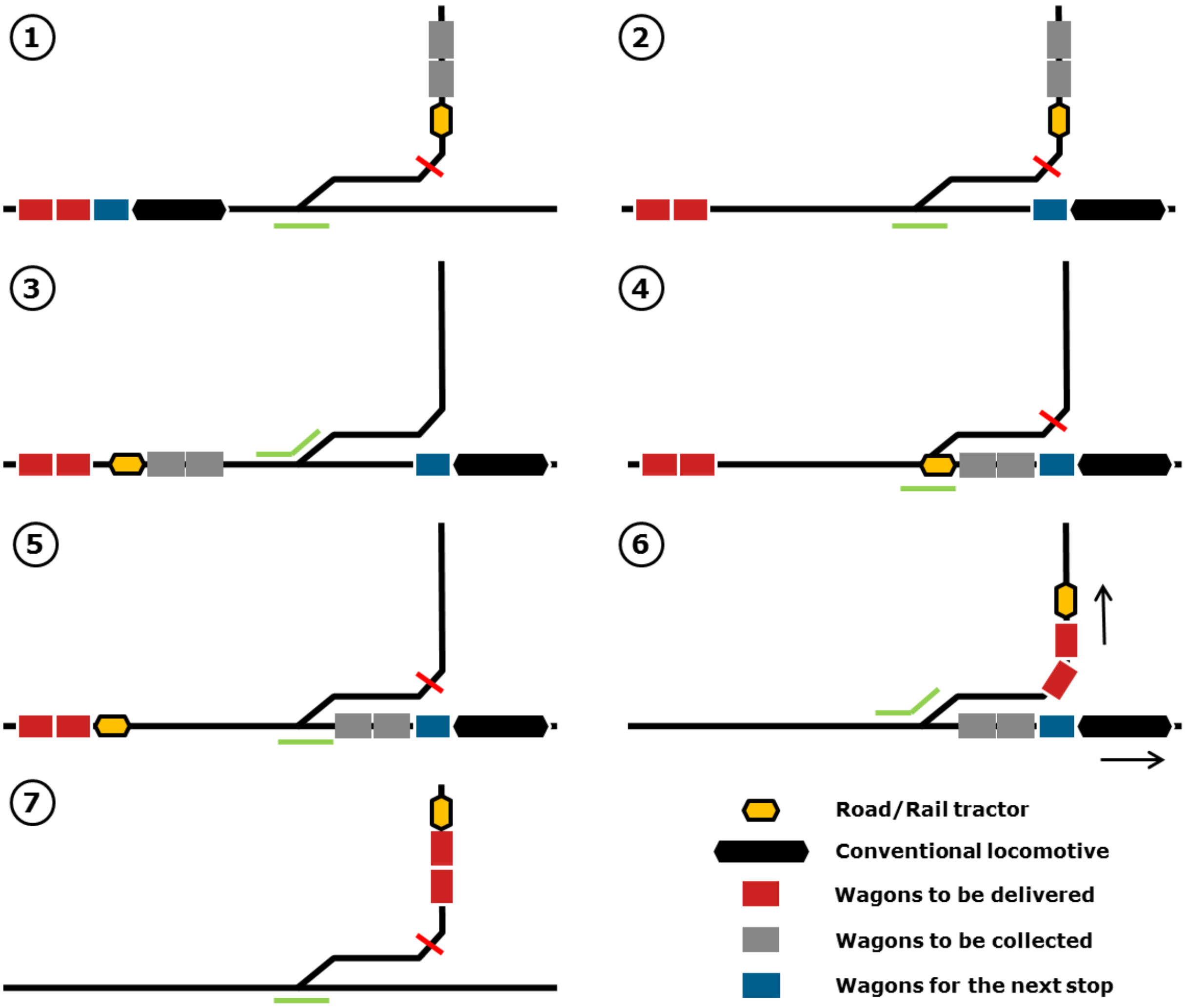
## 3.4 Operational schemes

Operational schemes are numerous according to the commercial need (take and leave) to link the private siding and the main distribution line which may be a single track line or a double track line (a main line or a secondary line). It happens very often that the siding entrance is only in one direction even if it is on a double track line. Moreover, the signalling system may be very different on the distribution line according to the level of traffic using that line (axel counter, manual block signalling, automatic block signalling).

The proposed procedures to be applied which preserve the safety will be described in a specific sub-point of this paragraph.

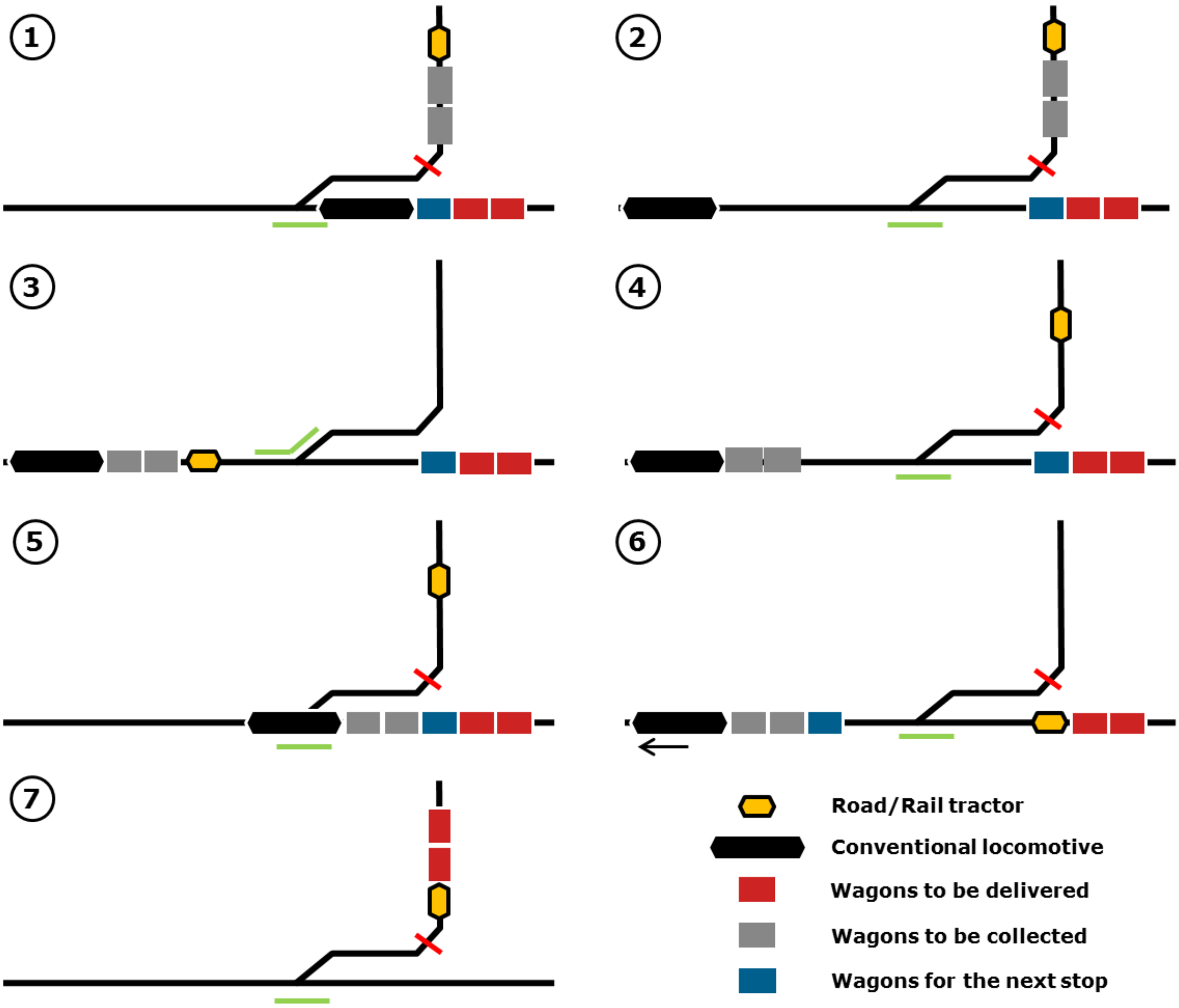
In order to show how we have proceeded, the schemes here under explain the most complex process when you have to leave and take wagons on a single track line. The two possible situations are shown in the following (Figure 3 and Figure 4):

**Figure 3: Take and leave operations with direct entrance (Case 1)**




*Source: ViWaS project*

**Figure 4: Take and leave operations with backward movements (Case 2)**




*Source: ViWaS project*

**Technical conditions**

The conditions to make these scenarios technically possible are the following:

- The power of the Road/Rail tractor must be sufficient to draw the wagons inside the private siding taking into account the maximum weight of the wagons and the profile of the line.
- The Road/Rail tractor must not deteriorate the safety devices ensuring the safety of the point switches.
- The radio communication between the driver of the distribution train and the RR tractor driver must be effective.
- The radio communication with the traffic control centre must also be effective.
- The driver of the Road/Rail tractor must be trained to the opening and the closure of the switches giving access to the private siding.
- The driver of the RR tractor must be trained to decoupling and coupling operations of wagons.
- The solution is only applicable when there is no risk of wagons sliding when they are decoupled.

**Safety procedures**

The operation needs very clear and stringent safety procedures:

- The evolution zone of the distribution train and of the RR tractor alone or with wagons is able to be totally protected during the operation to ensure that no other train than the distribution train and the RR tractor will be allowed to move in that area.
- The RR tractor is equipped with a specific device that automatically stops the operations if the driver does no acts at all during a given time (a few seconds).
- The RR tractor must have a slewing driving seat with a double command panel to be always in the best driving position.
- The access switch to the private siding must always be in a position that authorises only safe movement:
    - For that reason the switch giving access to the private siding must clearly indicate its position.
    - A device must prevent the train to penetrate on the main line and opening this access is interlocked with the right position of the switch to avoid bursting the points open.
- The radio connection with the local train control centre and with the distribution train driver must be checked before the operation.

- The RR tractors driver must be advised by a sound and a visual signal to be validated to authorise any operation and to avoid automatic immobilisation.
- When the RR tractor penetrates on the distribution line its driver gets the lead of the operation and the distribution train driver must act in agreement with him.
  - For a <u>simple operation to pick up wagons</u> from a distribution train the procedure is the following:

    The distribution train has stopped, uncoupled the wagons to be delivered and moves to the end of the operational protected zone to free the access switch.

    The RR tractor penetrates on the main line following the safety prescriptions described here above.

    The entrance switch must remain in the access position if the RR tractor and the delivered wagons are on the same side of the switch of the main line

    The RR tractors driver couples the wagons to be picked up and return on the private siding; he stops and put the access switch in the closed access position and checks that the device which is interlocked with the switch effectively closes the private siding entrance.
  - For <u>complex "take and leave" operations</u> the procedure is the following:

    The entering procedure is the same as before but after entering on the distribution line the access switch must close the private siding access and allow free movements on the distribution line.

    But the distribution train driver must have decoupled the wagons to be delivered previously and moved on the other side of the access switch.

    When entering the distribution line the RR tractor pushes forward the wagons to be taken away by the distribution train and couples them to the distribution train with the help of the distribution train driver moving backward or with its remote control of the RR tractor.

    Then the RR tractor moves back, escapes from the main line and the RR driver puts the switch in the position closing the access.

    The main distribution train moves backward to couple to the wagons to be delivered at the next siding with the help of the RR tractor driver for the safety. The RR tractor driver decouples the wagons to be left and couples the wagons for the next siding if any. Then the main line train moves forward beyond the switch leaving enough space for the RR tractor to operate.

    The RR tractor driver puts again the access switch in the position allowing the RR tractor to enter on the main line and closes the access of the private siding to move backward and couple to the wagons left.

    The RR tractor picks the wagons to be delivered and moves beyond the access switch with its remote control command, opens the switch to access to the private siding, moves its RR tractor and its wagons backward in the private siding and closes the private siding access putting the switch in the position allowing free movements on the main line and informs the distribution train driver who acknowledges this information.

Afterwards, operations are over and the distribution train may move to the next delivery zone, while the train control centre is advised by him that the free movements can resume on the distribution line. This information must be acknowledged by the train control centre.

- These scenarios should be adapted according to the direction of the entrance on the distribution line and to the volumes of wagons to be delivered. For instance the remote control if properly adapted to be operated with one hand only should allow the backward movements in a totally safe way, leaving the other hand to secure the operator position on the wagon during this process.

## 3.5 Available Road/Rail tractors and necessary amendments

Several types of RR tractors exist with different traction power and different authorised speed on the road. Some of them totally respect the standards to run on road without specific protections. However, certain specificities to access the National Railway Network are to be checked and implemented if necessary:

- Efficient shunting of the track circuits;
- A radio remote control command operable with only one hand.

## 3.6 Economic analysis

The economic analysis is quite complex as many different situations have to be considered. However, certain factors are key points to create progress of efficiency.

**(1)Target of the project**

The idea of the research was to separate the main distribution train movements from the last penetration in the private sidings and to use a RR tractor to ease those penetrations and movements. The target was also to use only one RR tractor on several sidings close to each other.

**(2)The main efficiencies expected**

Gaining time in the siding to move the wagons, reducing the staff necessary to move the distribution train by the help of the RR tractor driver for the limited backward movements, reducing the maintenance costs on the private siding as the RR tractor can easily exit from an embedded track and the possibility to avoid spare time of the RR tractor in advantage of other sidings or at least to operate the link with the distribution train are inter alia main efficiency improvements expected. Moreover, the investments for the private sidings would be reduced by saving one track (used for the locomotive movements) and the two switches associated which generates a maintenance cost reduction as already mentioned above.

Extra costs arise due to the renting of the RR tractor and the embedding of the track at limited places.

**(3)The main cases to be explored are linked to the distribution service scheme**

<u>Single distribution per working period</u>

In that case the list of efficiencies involves one staff reduction on the distribution side, no extra staff cost for the private siding as the RR tractor already used for internal movements and its driver can marginally operate the take and leave operation in collaboration with the distribution train driver, the investment and maintenance cost reductions while adding a share of the renting of the RR tractor representing the cost of the small vehicle usually used to move the wagons inside the siding.

<u>Double distribution per working period</u>

In that case the list of efficiencies is to be slightly revised. It is assumed that the RR tractor can be used on both sites but then there is a part of the staff used for running a small vehicle to move the wagons while the RR tractor is away which is to be added. The cost of the distribution train is to be divided by two to appreciate the gain for each private siding delivery while economies of maintenance and investments are fully applicable to each siding.

<u>Internal efficiency gains</u>

These gains are highly linked to the type of operations performed in the private siding. If these operations require multiple use of switches to place wagons on a handling area with forward and backward moves the economies may become very substantial. If all wagons are placed once, economies may be seriously reduced. For that reason we considered an average operational level for the economic analysis.

<u>Reference costs</u>

All economies have been calculated on the area where the tests have taken place with the costs incurred by the incumbent company and applying the rules of the French National Network in terms of safety. Adaptations should be made for other sites operated differently. No allowances of economies have been made for improved quality of service.

All calculations have been made on the basis of 20 days of effective service per month.

- Investment costs: track 400€/m; switch (simple) 50K€; amortisation period 20 years (rate of interest: 3%).
- Maintenance costs: 5% of investment costs.

It has been considered that the costs of a very simple vehicle to move the wagons on the private siding would be 25% of the cost of the RR tractor.

**(4)Results**

The economies produced by the solution compared to the standard solution are influenced by the following positive or negative factors:

<u>In the case of one delivery per day:</u>

- The economy of the assistant of the distribution train driver necessary during the whole work period for the back movements.
- Extra costs for the rental of the RR tractor while saving the engine used to move the wagons on the siding but without adding a new driver. A specific analysis will be conducted if there are no movements of the wagons on the private siding.
- The economies resulting from not building an extra track of 200m and two switches including their maintenance.

This analysis shows that the economies are around 16% of the current costs without taking into account the internal economies on the logistic operations which might be substantial.

**Table 1: Theoretical Analysis of the first concept (one delivery per day)**

| | Standard solution | New solution |
|---|---|---|
| Mainline diesel locomotive | X | X |
| RU driver | X | X |
| RU assistant for manoeuvre | X | |
| Private driver | X | X |
| Small engine ("pusher") | X | |
| Road/Rail tractor | | X |
| Infrastructure elements (switch/track maintenance, etc.) | X | Reduced |
| **Total costs per day** | **3,100.00 €** | **2,600.00 €** |
| | | → **16 % less** |

*Source: ViWaS project*

<u>In the case of two deliveries per day:</u>

- The economy of the assistant of the distribution train driver during the work period for the back movements.
- The extra cost of the RR tractor while partially saving the private driver of the small engine and its cost.
- The economies resulting from not building an extra track of 200m and two switches including their maintenance.
- This analysis show that the economies are around 22% of the actual cost without taking into account the internal economies on the logistic operations which might be substantial.

**Table 2: Theoretical Analysis of the first concept (two deliveries per day)**

| | Standard solution | New solution |
|---|---|---|
| Mainline diesel locomotive | **X** | **X** |
| RU driver | **X** | **X** |
| RU assistant for manoeuvre | **X** | |
| Private driver | **X** | **X** |
| Small engine ("pusher") | **X** | |
| Road/Rail tractor | | **X** |
| Infrastructure elements (switch/track maintenance, etc.) | **X** | **Reduced** |
| **Total costs per day** | **1,800.00 €** | **1,400.00 €** |
| | | **→ 22 % less** |

*Source: ViWaS project*

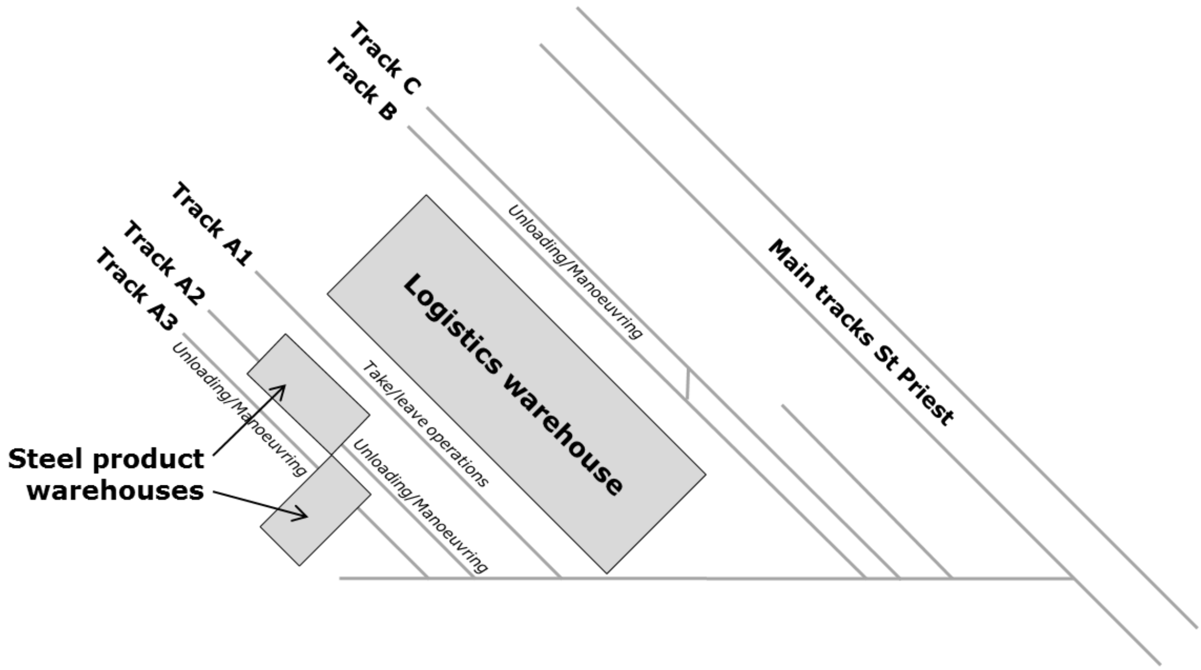
### (5)Analysis of St. Priest test

As explained in the first Periodic Report it has not been possible to find a site satisfying in short term all conditions to test the full concept: few sites were sufficiently near from each other, sometimes the distribution line was a major line and not a secondary line implying a full homologation of the RR tractor on the National Railway Network and sometimes the private siding owners had already optimised internally their operations and they were reluctant to jeopardize these organisations for a temporary test.

However, to ensure the feasibility of the full concept, which competitiveness was highly probable in line with the theoretical analysis, a private logistics site operated by SNCF for different customers was selected in St. Priest.

The plan of this logistics site is shown below (Figure 5):

**Figure 5: Logistics site of St. Priest**



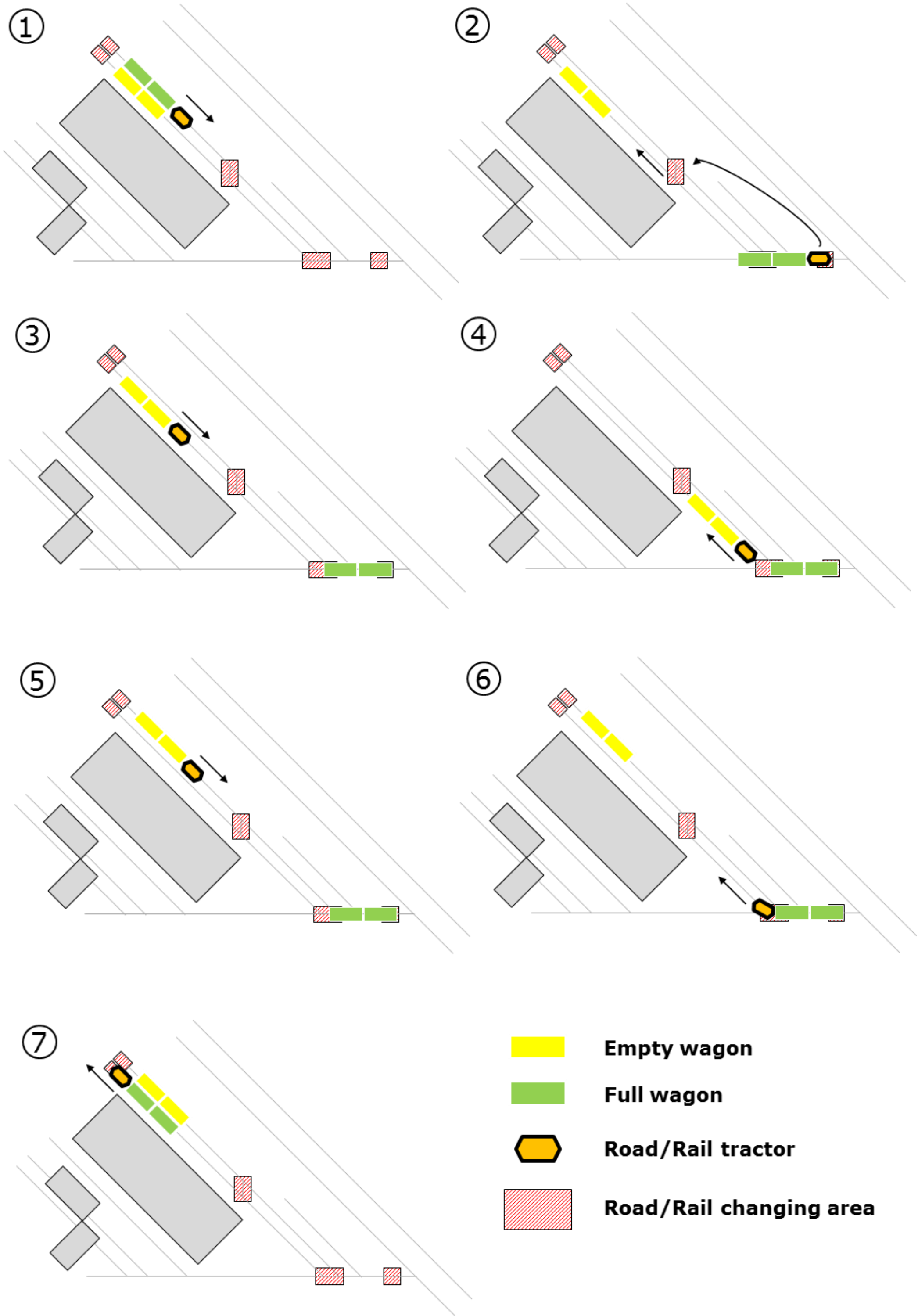

*Source: HaCon based on SNCF*

On this site, many operations are performed by a classical diesel locomotive of SNCF (Y8000) on various tracks implying many movements forward and backward.

The different traffics involve movements of trains with chemicals to be discharged, steel wagons carrying coils to be handled in a special shed and mechanical spare parts in another shed.

The sequence of operations for the chemical traffics ($CO_2$ gas for Air Liquide) is shown in Figure 6:

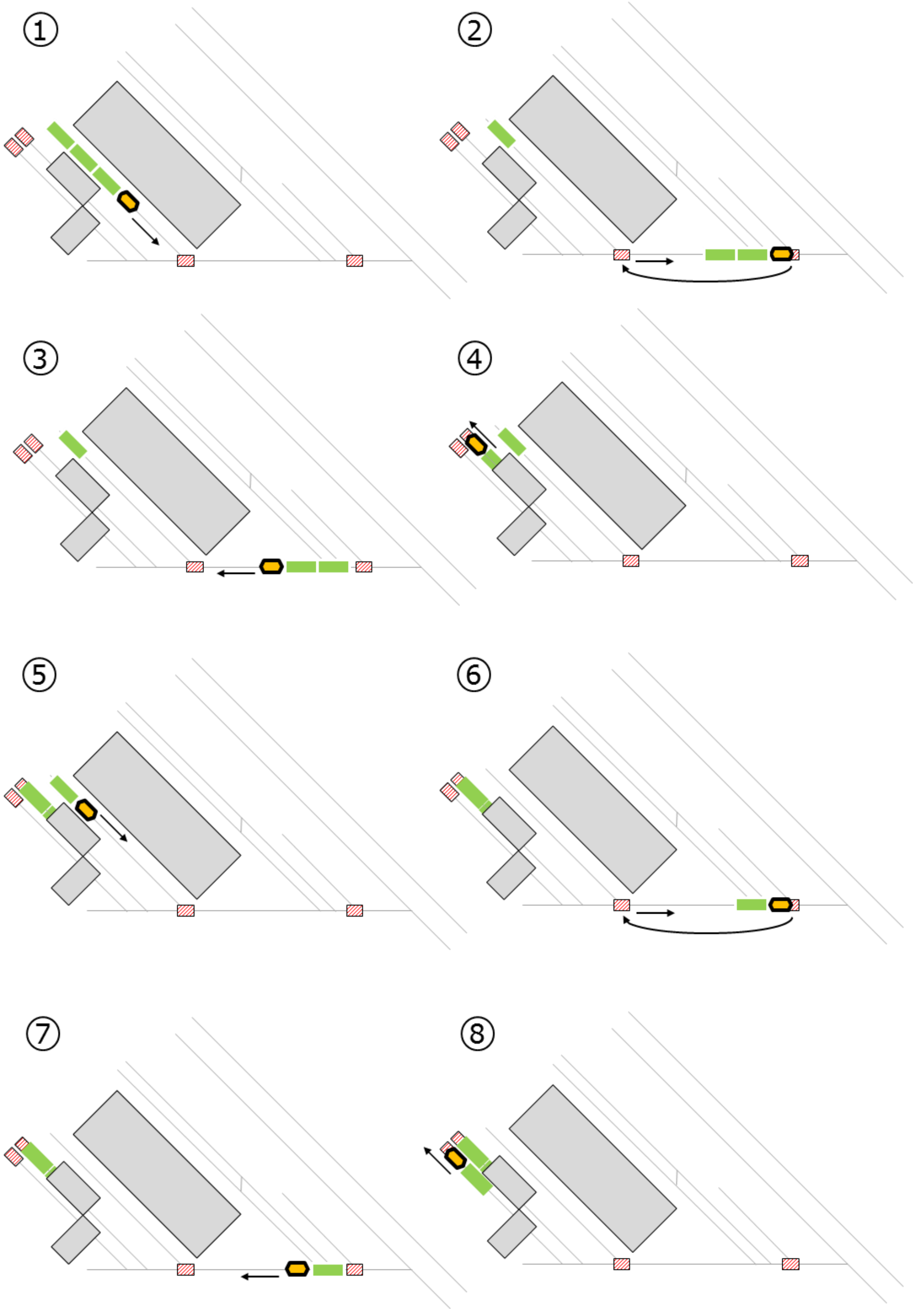
**Figure 6: Chemical traffic operations in St. Priest**




*Source: ViWaS project*

The sequence of operations for the steel traffics is shown in Figure 7.

**Figure 7: Steel traffic operations in St. Priest**




*Source: ViWaS project*

Globally, the results of the demonstration show a significant reduction of time and staff in the logistic operations performed. However, the choice of RR tractor type was extremely conservative choosing a high capacity RR tractor to be absolutely sure that the service to the customers could not suffer from any disruption.

The costs of the RR tractor chosen was 7,000€/month for a full service.

The experience has shown interesting results to be taken into account for a sound evaluation of the cost/benefit analysis:

- Chemical traffic operation: Y8000 Locomotive = 2 staff x 50’; RR tractor = 1 x 50’
- Steel traffic operation: Y8000 Locomotive = 2 staff x 90’; RR tractor = 1 x 60’

These results should be even improved with the full use of the remote control of the RR tractor with the driver being at the head of the first wagon in a backward movement.

The results of the tests are included in the economic analysis:

- At this stage, partially saving of the distribution line locomotive a driver to bring the train in the position to be picked up by the RR tractor.
- The extra cost of the rental of the RR tractor.
- The saving of the diesel locomotive used on site.
- No economies have been taken for the investment and maintenance.
- One staff on the logistics side has been taken into account.
- The final result of the analysis is around 34% of savings despite using a more powerful RR tractor than strictly necessary for a total reliability of the solution.

**Table 3: Global St. Priest Analysis operations**

| | Standard solution | New solution |
|---|---|---|
| Mainline diesel locomotive | 100% | 75% |
| RU driver | 100% | 75% |
| RU assistant for manoeuvre | X | |
| Private driver | | X |
| RR tractor | | X |
| Shunting locomotive | X | |
| Driver for shunting locomotive | X | |
| Staff of private siding | 3 | 2 |
| Fuel consumption | 80l | 52l |
| **Total costs per day** | **5,000.00 €** | **3,400.00 €** |
| | | **→ 34 % less** |

To fully achieve such benefits - which do not incorporate the extra capacity gained by the terminal - a certain number of actions have to be undertaken:

- Obtain the authorisation for the RR tractor to run on the French national railway network without being obliged to fulfil all general railway vehicle requirements in case it is in a protected zone and on limited distance. This was not achievable in the time frame of the project but the subject is progressing and it is expected that some authorisation, based on derogation, could be granted by the end of the year. Meanwhile, there is also an attempt to define a general frame to homologate these types of RR tractors on the national railway network; but this will take a much longer time.
- Develop with the RR tractor manufacturer a remote control that can be operated with only one hand in order to fulfil general safety requirements for rail workers which implies to have 3 points of support when the agent is on the footboard of a slow moving wagon. This should be feasible to be achieved in the next year (2016). The impact would be very significant as all backing movements, switch manipulations and couplings could be done in an extremely efficient way.
- Define with the infrastructure manager the rules to set up and maintain safe communications between the RR tractor driver and the control centre during the operations, similar to how it is done with the distribution train driver.
- Analyse the problems regarding the protection of infrastructure safety devices that might be touched by the tyres of the RR tractor when the grove in the tyre becomes too deep. As the movements of the RR tractor on rail is slow reloading the grove with rubber of the adequate quality could be an idea of solution to be checked with the tyre suppliers.

All these problems do not seem too difficult to resolve; therefore a short-medium term market uptake is expected.

The most important action to be undertaken is to check the private sidings where such solution may provide a significant efficiency improvement because of their vicinity with other private sidings, on today's type of service operated there and on the nature of the tracks serving these sidings. This analysis should be done with the full collaboration of the infrastructure manager before developing larger contacts with the owners of relevant private sidings.

**(6)Further potential application cases**

From the study two further potential application cases are being examined by various authorities:

- One in the region of Le Boulou;
- One in the Port of Sete.

A description of these cases and results from the studies will be included in the WP11 report.

# 4 Business case ”Last-mile service on French secondary lines”

## 4.1 Business cases supporting project developments

The ViWaS approach foresees a close link of project developments to specific business cases that are used for testing and demonstration purposes. The business cases are foreseen to be implemented in different European regions (mainly Switzerland, Germany, France, Italy and the Netherlands). All of them tackle specific challenges to improve single wagonload operations in the current and future freight market.

The ViWaS business case ”Last-mile service on French secondary lines” shall be used to test the new concept for the streamlining of “last-mile” and shunting operations based on active collaboration between RU and shippers. The RU distribution train stops in front of each siding and collaborates with a RR tractor driver in the shunting operations, (coupling, decoupling, switch...) which are performed by the shipper with its own traction unit. The neighbouring shippers organise themselves with a shared bimodal Road/Rail tractor which replaces totally or partially all shunting vehicle of each partner.

The subsequent sections describe the selection process, the selected testing framework as well as details on specific economic and technical situations.

## 4.2 Selection methodology of test locations

The methodology to identify favourable sites for the new “last-mile” solution will take into account several parameters: e.g. the distance from the main line, the existing layout of the private siding tracks, the need for the siding’s owner to move wagons with an engine, the frequency of incoming/outgoing wagons, the number of wagons handled, the existence of other sidings nearby for a potential shared usage of the RR tractor.

Ports that own and operate their port rail network and that have some industrial plants and rail sidings located in the port area should be examined.

On-site visits will have to be made to talk to the involved actors and to finalise the choice of sidings for the in-depth analyses and potential field tests.

Finally, administrative issues have to be clarified and necessary permissions need to be coordinated.

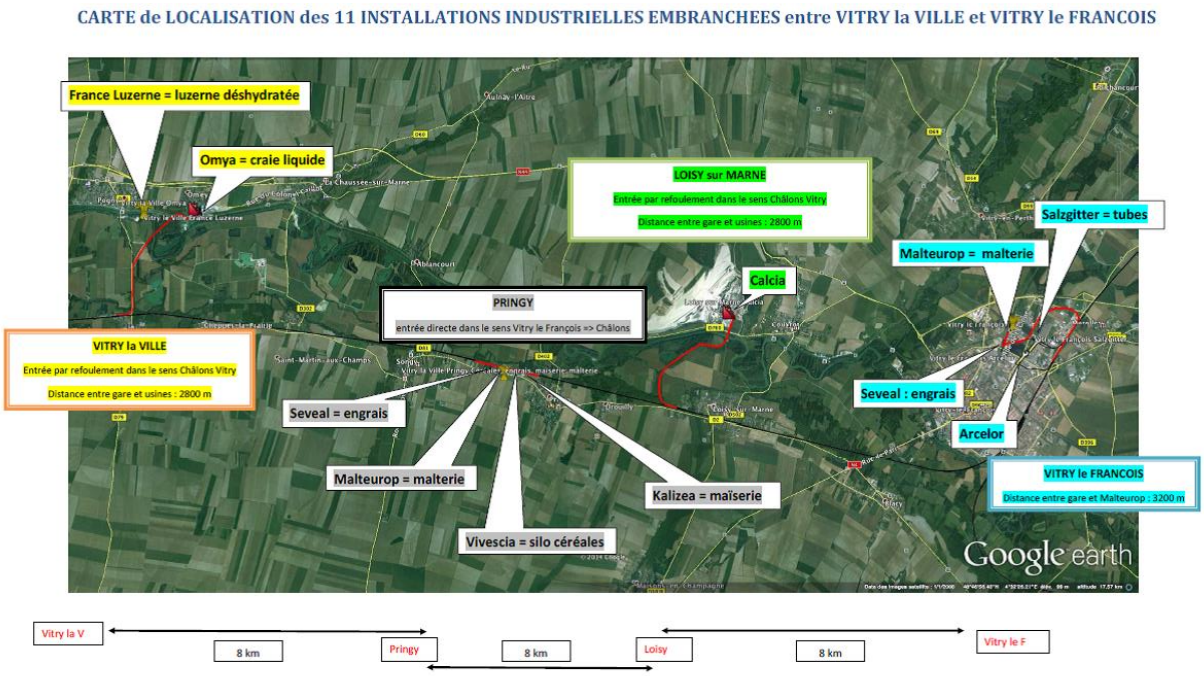
## 4.3 Documentation of location search

**Initial idea:** The initial idea was to test the method in a region with several cereals silos largely distributed in the country side. A more detailed check of the site and framework conditions showed that the site was not suitable for tests as the road context was not very favourable.

**First search:** The search for suitable test locations for the new "last-mile" production method has started at the beginning of 2013. The place envisaged was near Le Boulou to serve certain terminals in the area. The social sensitivity in that region would have implied extremely delicate discussions.

**Second search:** A second search of more favourable sites has been launched in 2014 by SNCF. As a result, sites in the area of Vitry la Ville, Pringy, Loisy and Vitry le François (e.g. Vénissieux, Bruyères sur Oise) have been identified (Figure 8). In preparation to the planned tests a cost-benefit analysis for the specific sites has been conducted. This showed that the sites are already optimised internally. However, benefits from the new method can be generated with 2 / better 3 deliveries per day.

**Figure 8: Favourable sites in the Vitry la Ville / Vitry le François area**




*Source: NEWOPERA*

Even for relative short movements on public tracks, the Infrastructure Manager is demanding a specific agreement for the RR tractor. Numerous meetings were conducted with the IM to get an exceptional permission for the tests. Unfortunately, no agreement could be reached. The application process for the demanded specific agreement on changed operation rules would have taken significant additional time efforts.

**Third search:** To avoid further delays and to assure the feasibility of the concept within the project lifetime, SNCF Fret decided in autumn 2014 to shift the tests to an area that does not require the usage of public tracks, but is at the same time identical in the operating conditions compared to the initially selected test case. This specific configuration could only be found in a private siding which is operated under the responsibility of SNCF Fret at the Lyon St. Priest Terminal ("fall-back solution").

## 4.4 Economic and technical evaluation of the selected business case

The business case of St. Priest shows some interesting characteristics and findings:

(1) It is a business case which has demonstrated its efficiency on the operations inside. The full efficiency could have been reached with the full use of a remote control. But to reach this first target some steps have to be taken:

- The impact is a clear reduction of one employee on the internal organisation with the possibility of handling more traffic. This needed a preparation with the teams which have been very helpful during the test phase showing possible new developments with this solution and finally a possible efficient staff increase. At the same time, the staff has appreciated the safety, quality and comfort progresses brought by the RR tractor in their operations.
- A development outside the space of their usual activity could also help to overcome the social obstacles. This implies further discussions with the IM (SNCF Réseau) and the RU (Fret SNCF).

(2) It is a business case where the possible gain for the chemical products would be valuable as it is roughly a full train that is delivered with a backing movement while there is a storage possibility of 500m before crossing a public road. In order to progress further it is necessary to analyse the traffic on the main railway distribution line which is shared between two users. The gain could be in such a case by reducing the backward movement time of the Main distribution train for the benefit of all users and to let the RR tractor serve the two users very efficiently as it would be done in the forward direction. The delivery of the wagons would also be largely simplified when the remote control will be fully operational.

(3) To make a sound evaluation of that business case we have taken into account the basic volumes handled on the logistic area and the way they are served:

- Every week the team of the railway undertaking serves the private siding 5 times in a backing movement with 2 agents.
- Every week 2 x 16 chemical wagons are delivered needing 50’ each for positioning with agents of the local staff.
- Every week 3 X 21 steel wagons are delivered needing 90’ each for positioning with 2 agents of the local staff.
- Based on the assumption of a gain of one hour for the railway undertaking team if the train was left near the marshalling yard but already on the track dedicated to the two users.
- With direct movements operated by the RR tractor the operations would take a marginal time of the operations on site.
- In summary, every day the railway undertaking would be able to serve one more customer generating a potential benefit of 625€. For the local operator the costs which are marginal would not increase the global costs. The main gain inside

would be manoeuvring the trains with only one agent instead of two. This is equivalent to 500€ every day. With a full service cost of an adequate RR tractor at 225€ per day the direct benefit is around 275€ every day

- If there could be an agreement with the neighbour company operating light wagons carrying cars then the cost- benefit analysis becomes extremely profitable as SNCF will save a full delivery that is not profitable for them and two users would share the RR tractor cost. This appears to be possible as the car carrier trains operating on the next private sidings do not move inside after positioning leaving total freedom to the RR tractor to operate the logistics movements on the site of its normal operation. It would be a very good demonstration of a collaborative approach.

# 5 Training

## 5.1 Training needs/plan

The training has been conducted in two phases:

**Phase 1: Training on RR tractor**

The training to get used to the RR tractor has been performed by the supplier and contains the following main issues:

- Giving permission to the individuals to operate the RR tractor
- Functionalities of the RR tractor
- Getting hold of the RR tractor
- Achieving operation to get on rail from road and out of rail to road
- Performing simple manoeuvers

The training session has been followed by a phase of total mastering of simple manoeuvers and with increased complexity progressively.

**Phase 2: Training on remote control command**

The training to the use of the remote control command has been done by the supplier and followed by an assessment of the mastering of the radio remote control command.

## 5.2 Documentation of training activities

In the following some photos of the trainings are provided:

**Figure 9: Training - Getting on rail**


*Source: NEWOPERA, SNCF*

**Figure 10: Training - Nearing and coupling operations**


*Source: NEWOPERA, SNCF*

**Figure 11: Training - Final contact for the coupling**

*Source: NEWOPERA, SNCF*

**Figure 12: Training – Manoeuver**


*Source: NEWOPERA, SNCF*

By the end of February the training measures for this business case have been concluded. Supported by the trainings, involved employees have "accepted" the new technologies and processes as an important pre-condition for successful field-tests.

# 6 Demonstration

## 6.1 Documentation of conducted field tests

The logistics terminal of St. Priest conducts transhipments of cargo between railway and road modalities. These operations imply the utilisation of gantry cranes to handle the cargo and frequent positioning of some group of wagons. The limited capacity of the installation does not allow handling large train pieces, making the operation with a classical diesel locomotive complex with low efficiency.

As separated from the national network (though connected to it), the terminal does not require any authorisation for the use of a Road/Rail tractor on site. With regard to the specifications of St. Priest potential operational improvements through the use of a RR tractor seemed to be possible. The field test was carried out to study actual effects of the deployment on the current production in real business situations.

## 6.2 Activities on site

In 2014, St. Priest terminal received 1,600 wagons (block trains or semi block trains). Nearly 70% of the activity produced by the logistics centre implied rail movements. 1,100 wagons have requested railway manoeuvres under the transhipment gantry cranes. However, the terminal offers only marginal progress for the activity as the main installations are not working to capacity. The wagon handling concerning the operation time might be optimised.

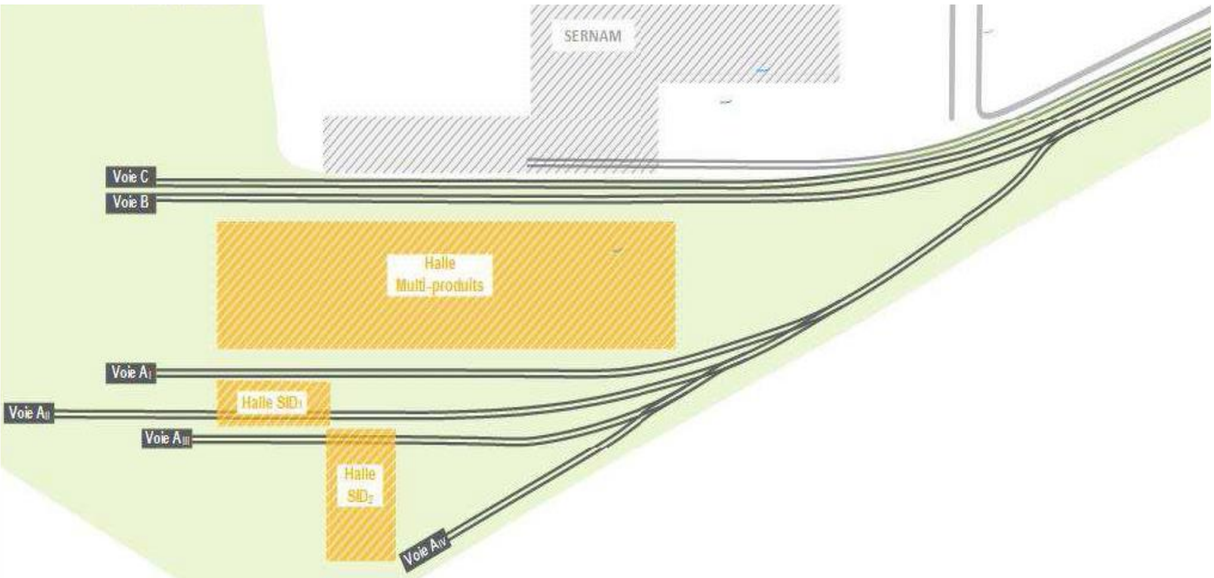
### 6.2.1 Railway facilities

The site of St. Priest is equipped with 6 tracks:

- 1 track of 390m serving the unloading position for the $CO_2$ traffic (track C);
- 1 track of 370m is designed for the reception of palletized products (track B);
- 2 tracks of 230m and 163m serving the transhipment zone (tracks A2 and A3);
- 2 tracks of 270m and 46m (A1 and A4).

The plan below (Figure 13) shows the site in its operating configuration for logistics and railway operations.

**Figure 13: Operation configuration at St. Priest logistics centre**




The relatively short length of the tracks and the absence of the forced drawer production lead to complex manoeuvres.

### 6.2.2 Tested bimodal engine

The Road/Rail tractor to be tested is of the type MOL RR 2444 (equivalent to Zwiehoff ROTRAC RR 2444; cp. Figure 14 and Figure 15).

**Figure 14: Road/rail tractor MOL RR 2444**

*Source: NEWOPERA, SNCF*

**Figure 15: Road/rail tractor MOL RR 2444 – technical specifications**

| | |
|---|---|
| **Weight** | 24 tonnes |
| **Traction capacity** | 2,400 tonnes |
| **Turning circle** | 7,575 mm |
| **Dimensions** | Length: 7.430 m<br>Width: 2,500 m<br>Height : 3,491 m |
| **Maximum speed** | 27 km/h |
| **Engine output** | 245 HP (181 KW) at 2,300 rpm |
| **Engine displacement** | 7,150 $cm^3$ |
| **Transmission** | Road axles (tires on rail) |
| **Towing capacity** | =/- 12.5 kN |
| **Tank capacity** | 450 litre |
| **Compressor** | Flow 2,300 litre / min at 10 bar |
| **Axle control** | Camera on each axle, installed colour monitor |
| **Coupler** | UIC hook type, front and rear |
| **Buffer** | Type UIC |
| **Cabin equipment** | 360° visibility, air conditioning, second cockpit |
| **Security** | Backlit in reverse mode, four emergency stop buttons |

*Source: MOL*

### 6.2.3 Conducted field test

The test plan has been designed according to the following points:

**(1)Training**

- Training preparations for staff by the provider
- Quality evaluation of the training, the timing and the level of understanding by the operators
- Training of the agents with the radio remote control by the provider

**(2)Appropriation of the RR tractor**

- Operation to set the RR tractor on rail and to exit rail
- Performing simple manoeuvres with one or several wagons (progressive complexity increase)
- First series of measures

**(3)Reaction of RR tractor when manoeuvred**

- Checking the reaction and performance of the Road/Rail tractor
- Comparable analysis with the conventional diesel locomotive

**(4)Production**

- Monitor the diesel consumption
- Checking the indicator of the level of consumption
- Check of reaction in manoeuvres
- Recording the time when the RR tractor is in use
- Test of traction with wagons loaded in curves and in places with the highest constraints
- Time measurement of the manoeuvre to change from track to track (enter and exit from the rail) and evolution of the Road/Rail tractor between the tracks
- Brake test and time measurement to reach the right level of pressure in the brake pipe
- Test of new possible manoeuvres
- Reliability measurement of the RR tractor
- Operational test with the radio remote control
- Comparable analysis with the standard diesel locomotive

### 6.2.4 Railway operation

Currently, in St. Priest the following weekly rail traffic occurs:

- 1 or 2 convoys of 16 wagons positioned in two times on track C (loading on the bulk place for AIR LIQUIDE)
- 1 or 2 convoys of 21 wagons positioned in three times on track A2 and A3 (handling of coils by a mobile rail gantry crane serving two to three wagons each time)
- Additional spot traffic which is operated on the tracks under the mobile rail gantry cranes (A2 and A3) or on track B.

For both types of traffic - when the operation inside the private siding is done by the Road/Rail tractor - the sharing of railway operations between the team of the RU conveying the train from Venissieux marshalling yard and the local team remains unchanged as the Road/Rail tractor is not allowed on the national railway network yet. The types of manoeuvres have not changed yet. However, they will be partly simplified with the withdrawal of the long backing movement to be performed by the Road/Rail tractor in direct traction as soon as it will receive permission to go on the National Rail Network for the simple exchange of wagons.

There is no major time reduction for the internal operations of the chemical traffics, but these operations can be performed with one agent only.

For the steel traffics, the flexibility of the RR Tractor has demonstrated its efficiency when putting in place three parts of the steel wagons because of its capacity to change easily from track A2 to track A3 to position the wagons in the precise area where the rolling gantry cranes can operate. These operations are achievable by one agent in only 60 minutes.

In summary following time needs have been documented:

- **Chemical traffics:**
  Standard locomotive: 2 x 50 minutes
  Road/Rail tractor: 1 x 50 minutes
- **Steel traffics:**
  Standard locomotive: 2 x 90 minutes
  Road/Rail tractor: 1 x 60 minutes

By using the radio remote control smoother operation including necessary manoeuvres are achieved in the steel warehouse. However, the remote control command needs to be controlled two-handed with the existing equipment. This circumstance made it impossible for the operator to control the shunting process from the first wagon footboard.

## 6.3 Operational experiences and proposed adjustments

Several functional characteristics have been measured. These have been gathered within the necessary operational framework of the St. Priest logistics platform.

Are detailed and comparative analysis of 52 items (Y 8000 vs MOL 2444) is attached in the annex.

Most of the characteristics are equivalent or better for the RR Tractor, especially the lower fuel consumption, the more comfortable access and the easiness to get hold of the driving.

### 6.3.1 Performed measurements

The following detailed process times for the Road/Rail tractor have been measured during the field tests:

- **Time to set on rail:**
  2 to 3 minutes
- **Time to exit from rail to road:**
  less than 30 seconds
- **Time for coupling:**
  identical with shunting locomotive
- **Time to put the brake pipe at the right pressure:**
  20% compared to the diesel locomotive

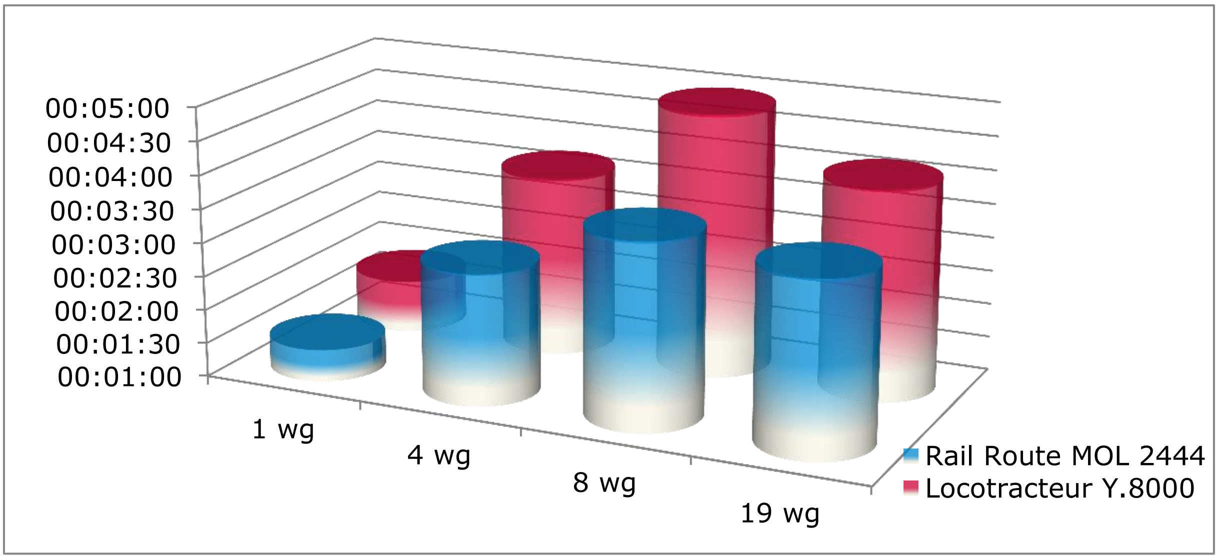
40 separate measurements have been performed with up to 19 wagons. The comparison between Y8000 and MOL RR 2444 shows significant time savings for the RR tractor (cp. Figure 16 and Figure 17).

**Figure 16: Comparison of manoeuvre times between Y8000 and MOL RR 2444 (table)**

| Mesures | | Locotracteur Y.8000 | | | Rail Route MOL 2444 | | | Analyse Comparée | |
|---|---|---|---|---|---|---|---|---|---|
| Format (en n.wagons) | N.mesures | Temps Mini (Y.8000) | Temps Maxi (Y.8000) | Moyenne (Y.8000) | Temps Mini (MOL.2444) | Temps Maxi (MOL.2444) | Moyenne (MOL.2444) | Gain du MOL.2444 | Performance du MOL.2444 |
| 1 wg | 5 | 00:01:37 | 00:01:57 | 00:01:47 | 00:01:18 | 00:01:39 | 00:01:29 | 00:00:18 | 17,3% |
| 4 wg | 5 | 00:03:11 | 00:04:10 | 00:03:41 | 00:02:46 | 00:03:07 | 00:02:57 | 00:00:44 | 20,0% |
| 8 wg | 5 | 00:04:52 | 00:04:57 | 00:04:55 | 00:03:30 | 00:03:58 | 00:03:44 | 00:01:11 | 23,9% |
| 19 wg | 5 | 00:03:51 | 00:04:22 | 00:04:06 | 00:02:57 | 00:04:09 | 00:03:33 | 00:00:33 | 13,6% |

*Source: NEWOPERA*

**Figure 17: Comparison of manoeuvre times between Y8000 and MOL RR 2444 (diagram)**




*Source: NEWOPERA*

### 6.3.2 Functionalities

In rail operations mode, the RR tractor is characterised by its great flexibility, linked to its dynamic flexibility and its ability to be operated on both rail and road.

**Dynamic flexibility:**

Compared to the diesel locomotive the coupling operations are performed smoother and getting the buffers touching each other is done with no bumps.

**"Bimodal" rail and road:**

This characteristic is particularly efficient on a site like the logistic platform of St. Priest which is characterised by:

- A layout of tracks with constraints (short tracks and no special siding to free the locomotive)
- A high proportion of embedded track which enables the operation of the RR tractor easily when it is necessary to go on rail or to leave rail.

**Manoeuvrability of the RR tractor**

All-wheel steering enables a very high mobility of the RR tractor despite its size. The steering with all four wheels allows small turning circles.

**Operations in radio remote mode**

The principal characteristics of the remote control are the following:

- Commissioning: Remote functioning after beep and LED signal; remote in braking position.

- There is an immediate automatic safety procedure in case the operator falls down
- There is an emergency stop button on the remote control.
- There is a vigilance function.
- There is indirect or direct braking (depending on the manufacturer's operating instructions)
- Operator trainings provided by manufacturer (duration: 1 day). It is suggested to operate the radio remote with two hands.

The appropriation of the remote control by the operators has been done in a very short time. During transhipment or positioning of wagons under the gantry cranes, the use of the radio remote control eliminates the necessity to go in the cabin. Consequently, the risk associated with descending from the diesel locomotives are reduced, too.

During the test period two agents have been operating the RR tractor. The target is to operate it with only one agent.

It has to be noted that the suggestion to operate the radio remote control with two hands are incompatible with the backing movement from a wagon which, for safety reasons, must provide three points to be hold by the operator.

Globally, and considering the needs of the logistic platform of St. Priest, the use of the RR tractor has been assessed as more efficient due to improved performance.

### 6.3.3 Safety

In terms of safety, the use of the Road/Rail tractor MOL 2444 provides similar safety conditions like the Y 8000 diesel locomotive. The following security-related aspects have been improved:

- The existence of four emergency stop buttons very near from the four buffers;
- The automatic engine stop in case of an abnormal rise in water temperature or drop in oil pressure;
- The signalling by a rotating light.

### 6.3.4 Ergonomics

The ergonomics of the Road/Rail tractor MOL 2444 have been improved compared with the Y8000 shunting locomotive. The following points contribute to the safety and the comfort of the user:

- Easy access to the cabin via steps from the walkable front frame;
- Air-conditioned driver cabin;
- Driver seat features an adjustable suspension and is rotatable according to the direction of the movement;
- 360° all-round vision;

- Soundproofed driver cabin (noise protection);
- Rear view camera that projects the area behind the vehicle on a colour screen within the cabin (when moving backwards);
- Control screen indicating all information connected to the operation of the Road/Rail tractor;
- Three-speed windscreen wiper.

Generally, the MOL 2444 engine has been highly appreciated by the users due to the facts mentioned above.

### 6.3.5 Acquiring competences

The agents which were involved in the training had already the certifications and competences called "P1/P2/P3" (these certifications characterise the ability to assist the drivers for the manoeuvres of the trains and to utilise gantry cranes or elevator chariots for handling).

The user's feedback indicates that the Road/Rail tractor MOL 2444 is very accessible, intuitive to use and very easy to drive. The RR tractor's rail mode is identical to a diesel locomotive. The road mode is similar to driving of a classical private car and thus easy to adapt to. According to the staff's feedback, it takes roughly a one day training to get used to the RR tractor.

### 6.3.6 Remaining questions

Beyond the positive characteristics described previously, it is also necessary to point out certain aspects which need improvements:

**Use of Road/Rail tractor on the national railway network**

While some actions have started to obtain homologation, it is likely that they will not be achievable rapidly. However, certain technical characteristics of the engine that has been tested (transmission by tyre and the rail contact):

- do not allow setting the Road/Rail tractor as a wagon in a railway train;
- have a risk of bursting the switches open;
- must have a reliable track circuit contact (29:32).

The lower gauge of the Road/Rail engine and specifically its tyres may also request improvements to avoid any deterioration of switches, the safety device of switches and the signalling boxes.

**Reliability of Road/Rail tractor**

The duration of the test has not been long enough to ascertain the real reliability of the Road/Rail tractor and of the rapid intervening in case of a breakdown.

The estimates of the wear and tear of the equipment - which has to be paid by the renting organisation (like the wear of the tyres) - have not been checked effectively for the same reason.

**Use of radio remote control**

The process to use the radio remote control has not been tested in its totality, specifically in the phase of backing movement with the operator on the footboard of the front wagon.

This phase requires the option of manoeuvring one-handed with the radio remote control to have 3 points of support for the agent. This has not been tested yet.

## 6.4 Selected KPIs of business case

Suitable success criteria (KPIs) have been already defined within Deliverable D4.1, submitted to the European Commission in November 2013. The KPIs related to the considered business case "Last-mile service on French secondary lines" are described as follows:

The last-mile operations method proposed in ViWaS is based on the separation of the movement of the distribution train on the secondary line from the operation of cutting the required number of wagons from the distribution train, couple them to a bimodal small hauling truck and drag them to the private siding. The cost reduction and the capacity increase may allow serving certain new areas with scattered traffics at acceptable costs. Thus, the following KPIs have been selected:

- Investment costs on the private siding for the delivery of less than ten wagons. The KPI will be the basic investment cost.
- Operational costs of a delivery of a given number of sidings served today by one distribution train. The KPI will be the delivery costs per siding.
- The percentage of time gained on one round trip of the train (giving an idea of the reserve of capacity to possibly serve a larger area).

Because of this methodology, potential advantages contain the following:

- Simplify the private siding's plan as it needs one track and one switch less than with a pure rail locomotive which significantly reduces the investment cost.
- The number of staff necessary to operate the distribution is also reduced
- The bi-modal hauling machine may be shared by several users.
- The delivery capacity of the line is increased as the operations are simplified which enables the distribution train to serve more customers.

| | Criteria | KPI | | Description | Unit of measurement |
|---|---|---|---|---|---|
| Operational KPIs | Cost efficiency | 1 | Infrastructure costs | Costs for investment and maintenance | Costs per siding (€/m) |
| | | 2 | Operational costs | Delivery of a given number of wagons | Costs per delivery |
| | Service quality | 3 | Time benefit | Time gained per roundtrip of train | Hours per delivery haul |

**Table 4: Selection of operational KPIs for business case "Last-mile service on French secondary lines"**

*Source: HaCon based on NEWOPERA / Fret SNCF*

## 6.5 Measurement and results of selected KPIs

The KPIs described are very simple but representing effectively the efficiency of the solution.

**Infrastructure costs**

Regarding the infrastructure costs two situations have to be considered:

- On an existing siding no investments will be made to withdraw a switch and one track. In that case we must only take into account the economies of maintenance. For a saving of 200M of tracks costing 400€/m to be built the saving would be 4,000€/year. The saving on the switch maintenance would also represent 5% of their value 80,000€ for the two amounting to 4,000€. If the length of the tracks are 200m the economies amount to **40€/m**.
- In case of a new investment the saving would amount to 160,000€ (80,000€ for the switches and 80,000€ for the track) resulting in a yearly costs reduction of 13,000€ with an interest rate of 3% and an amortisation period of 20 years. The maintenance economies would be the same as in the first case evaluated to 8,000€ per year. The global economy would amount to 21,000€ per year equivalent to 105€/m for a private siding of a single 200m track long. If the layout is different with a longer track length as for instance 500m the economy would be **72€/m**.

**Operational costs**

Regarding operational costs the calculation of the economies must only consider the delivery and positioning of the wagons on the siding. However the use of the RR tractor to move the wagons in the sidings should be taken into consideration if the operations need such a movement inside the private siding. So we should analyse two very different situations:

- The <u>wagons placed on the siding are not moving</u> at all after their positioning until their removal.

  In that case the use of the RR tractor is not marginal and the new solution should be compared only to the delivery with a classical diesel locomotive of the RU. The only difference would lie on the necessary backward push of the wagons in the private siding by the RU locomotive and the necessary staff to operate in such a situation.

  The result depends on the distance of the private siding from the main line; if that distance is short it is possible that the economies would be marginal and that the solution would not be appropriate; if the distance is long then the fact that the RR tractor would allow to operate forward enabling to operate with a single agent the economy of one agent for a working period is significant:

  600€ per delivery compared to a cost of 225€ of renting the RR tractor, 500€ for its driver while the economy on the diesel locomotive of the RU would amount to 200€ at least if the RU has enough of traffic to fully use its equipment. The solution is marginally profitable: **75€/delivery**.

  Of course it is necessary to take into account the volume of traffic of the private siding or of the group of private sidings that could be served. If the economies created in the accounts of the RU are fully passed on to the customer the limit is to have a traffic justifying at least one delivery every day. If the private siding must have empty wagons permanently to prepare the next departure the situation is again very different and the need of a second track for the empty wagons arriving is necessary with one switch to link the two tracks towards the exit /entrance.

  To optimize the solution the transfer from the RU locomotive and the RR tractor must take place near a level crossing enabling the RR tractor to escape during the coupling with the locomotive of the RU. Then the solution is optimised for the RU locomotive or the RR tractor. In these cases the infrastructure economies would impact favourably the result of the solution.

- The <u>wagons placed on the sidings are to be moved</u> for the internal operations

  In such cases the RR tractor replaces a necessary vehicle to move the wagons which can be an Y8000 diesel locomotive like in St. Priest which cost is 265€/day. In this case the replacement by a RR tractor of an adequate power is directly profitable by its flexibility, the operating time saved and the economies of fuel. The economies presented in the theoretical calculations are applicable and the results should be at the level of **10% (at least 500€ per delivery)** minimum to which internal operations economies should be added as well as the infrastructure economies.

**Time benefits**

On that matter the layout of the network is essential. If we take into account the operations economies in time when done with the RR tractor compared to the Y8000 there is already half an hour gained. If we take the train much further as soon as the train has been placed in a safe position to be recuperated by the RR tractor an hour more should be gained. The estimated time benefits amount to **1.5 hours per delivery**.

# 7 Conclusions

In general, the conclusions of the tests performed with the RR MOL2444 are positive despite the fact that they have not been able to experiment all the functionalities. Compared to the Y8000 light rail motor tractor the functionalities are improved as well as the conditions of use by the agents in terms of comfort and safety.

It is to be noted that it has not been possible to fully explore all the options and functionalities during the 3 months test period. However, the flexibility of use and the possibility to operate with a single agent are not only a simple improvement of the manoeuvres or the capacities to cope with high or low level of activity. It also opens up the opportunity to reorganize completely the logistics operations and thereby generating significant efficiencies.

Besides that, the more the penetration distance on the national railway network will increase the more possible changes in the system will appear. Today, the fact that the RR tractor is not yet authorised on the French national railway network yet is still a weak point.

The economic analysis developed here above shows very clearly the interest of developing the solution. The implementation will become very easy when the present evolutions on the secondary network in France will be achieved with an extended possibility for “short liners” to operate on the secondary network with alleviated rules. In other European countries it is already possible to use the remote control on the National Network like in Switzerland.

The daily application appears possible in certain sites and a methodology to select them is proposed in the table hereunder:

**Figure 18: Methodology to select RR tractor for daily application**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Operation | Take and Leave only | | | | | | | |
| Volume | Volume high | | | | Volume low | | | |
| Frequency of Delivery | High | | Low | | High | | Low | |
| Back move distance | Long distance back move on single track | Short distance back move on single track | Long distance back move on single track | Short distance back move on single track | Long distance back move on single track | Short distance back move on single track | Long distance back move on single track | Short distance back move on single track |
| | | | | | | | | |
| Operation | Take and Leave and operations with wagon movements | | | | | | | |
| Volume | Volume high | | | | Volume low | | | |
| Frequency of Delivery | High | | Low | | High | | Low | |
| Back move distance | Long distance back move on single track | Short distance back move on single track | Long distance back move on single track | Short distance back move on single track | Long distance back move on single track | Short distance back move on single track | Long distance back move on single track | Short distance back move on single track |
| | | | | | | | | |
| If bundling is possible with an only take and leave near siding. | If timing fits | If timing fits | | | If timing fits | | | |

| Favourable | | To be studied | | No suitable solution |
|---|---|---|---|---|

Author: A. Toubol - Newopera

*Source/Author: NEWOPERA / Armand Toubol*

To develop this solution across Europe it is expected to organise workshops with users and with experts separately in the last project phase in the scope of WP11 "Evaluation of ViWaS project developments".

# Annex:

**Comparison between RR tractor and Diesel Locomotive (French)**

# Annexe 9.3

| PROJET | EXPERIMENTATION ENGIN RAIL ROUTE<br>Plateforme Logistique de Saint-Priest | COMPARATIF Y.8294 VS RR MOL.2444 (52 items) |
|---|---|---|
| | | Gain en faveur du RR MOL,2444 |
| | | Equilibre Y.8294 / RR MOL.2444 |
| | | Nonc concerné par une appréciation |
| | | Gain en faveur du Y.8294 |

| | n° | Items | Locotracteur Y.8294 | RR MOL.2444 | Observations | Appréciations |
|---|---|---|---|---|---|---|
| DONNEES GENERALES | 1 | Diplômes ou certifications pour conduite sur rail | Formation P1 / P2 / P3 | Formation P1 / P2 / P4 | Formations RR intervenues après la formation locotracteur, les agents étaient donc déjà tous formés P3 ce qui facilité l'acquisition des données | RAS |
| | 2 | Carburant | GNR | GNR | Normes euro stage 1 | RAS |
| | 3 | Rayon de courbure minimum franchissable | 100 mètres | 100 mètres | FR 196 et données Lemonnier | RAS |
| | 4 | Diplômes ou certifications pour conduite route | (Non concerné) | P3 et/ou Caces | Accessibilité assez simple au vue des différents domaines de conduite proposé par le RR | RAS |
| | 5 | Dimensions | Longueur 10m / largeur 2m87 / hauteur 3m83. Empattement : 5m50 | Longueur 7m43 / largeur 2m50 / hauteur 3m37. Empattement : 3m60 route et 5m40 rail | FR 196 et données Lemonnier | RR plus compacte sur toutes les mesures (intéressant pour le transport et la sécurité en terme d'engagement de gabarit sur lignes spécifiques par exemple) |
| | 6 | Poids | 35 T | 24 T | Nous parlons de masse en service | RR plus léger de 11 tonnes |
| | 7 | Capacités du réservoir | 700 litres (350 x 2) | 450 litres | FR 196 et données Lemonnier | Capacité du Loco plus grande de 250 litres |
| | 8 | Année de construction | de 1977 à 1989 suivant numéro | 2012 | FR 196 et données Lemonnier | RR plus récent |
| SECURITE | 9 | Ceinture de sécurité | Dépourvu | Ceintures de sécurité conducteur et chef de manœuvre | attache l'opérateur par le bas du ventre | Présence de la ceinture de sécurité uniquement sur le RR |
| | 10 | VACMA | Non | Oui | La VA n'est pas d'un confort total pour l'utilisateur du fait de la concentration et des manipulations supplémentaires qu'elle requière, cependant elle est un atout certain en terme de sécurité | Présence de la VA uniquement sur le RR |
| | 11 | Rétroviseurs | Non équipé | Equipé et plutôt efficace | Utilisables uniquement en conduite normale (impossible en conduite poste inversé) | Présence des rétros uniquement sur le RR |
| | 12 | Klaxon | Deux tons, deux commandes, contrôle parfait et indépendant sur chaque ton. Son puissant | Deux tons, deux commandes (une par sens de circulation), contrôle impossible en intensité car activation par bouton électrique on/off. Pas de contrôle indépendant sur chaque ton. Son puissant | | Klaxon plus facile à utiliser, commande plus précise et possibilité de klaxonner à la demande et avec contrôle en terme d'intensité sur le loco contrairement à celui du RR |
| | 13 | Marches pieds : dimensions de passage du corps | 2 ouvertures à 84 cm à l'avant, 2 ouvertures à 85 cm à l'arrière / 3 marches de 34 cm | 3 ouvertures à 67 cm, une quatrième plus étroite (avant droit) à 54 cm / 4 marches de 30 cm | hauteur, largeur, nombre de marches sont mesurés ici | Ouverture du passage du corps plus large sur le Loco, nombre de marche inférieur, hauteur de plancher plus basse |
| | 14 | Marches pieds : éclairage | Non | Oui | | Eclairage des marches pieds présent uniquement sur le RR |
| | 15 | Bouton d'urgence | Présent uniquement dans la cabine au nombre de 1 mais très accessible en plein milieu de la console centrale | 6 possibilités de taper l'urgence, sur la manipulateur de freinage conducteur, sur le milieu du pupitre (chef de manœuvre) et aux 4 coins de l'engin à l'extérieur | | 6 boutons de mise à 0 de la CG positionnés dedans et en dehors de l'engin |
| | 16 | Action de refoulement | Très confortable et très claire du fait de l'espace intérieur et de la possibilité de déplacement du conducteur dans la cabine, notamment vers les fenêtres | Bonne conception de l'engin du fait du possible retournement complet du poste de pilotage dans le sens de la marche demandé (manœuvre dans espace assez exigüe), mais attention certaines fonctionnalités ne sont plus accessibles (neutre, camera, écran digitale d'info etc…) | dépend également du sens et donc du poste d'accostage car la cabine sur les deux appareils n'est pas au centre. Plus la cabine est prêt de la rame et moins la visibilité est bonne. | Seul le RR est équipé de rétroviseurs, cependant, et ceci faisant l'unanimité, il semblerait que l'action de refoulement soit un peu plus pratique sur le loco du fait du déplacement possible dans le cabine et donc du rapprochement des ouvertures afin de pouvoir regarder de partout |
| | 17 | Visibilité | Excellente, la liberté de mouvement et de déplacement du conducteur à l'intérieur de la cabine est un gage de visibilité. Facilité de regarder par les ouverture pour contrôle. | Correcte, mais la position assise impliquant l'impossibilité de se déplacer et péjore la visibilité, notamment en courbe. Très inconfortable de regarder par les ouvertures pour contrôle. | | La liberté de mouvement et de déplacement du conducteur à l'intérieur de la cabine rend la visibilité meilleure sur le loco |
| CONFORT ERGONOMIE QVT | 18 | Gestion de la température intérieure du poste de pilotage | Chauffage | Climatisation possible | Climatisation possible en option (non dispo sur le 2444) | Gestion du chaud et du froid uniquement présent sur RR (en option, non disponible sur notre engin d'essai) |
| | 18 | Volume sonore extérieur | 82 dB | 80db | Mesures effectuées avec un sonomètre homologué Trotec BS15 à 1m50 du point le plus bruyant de l'engin | Léger avantage minime pour le RR |
| | 20 | Volume sonore intérieur | 67 dB au ralenti / 75 dB en accélération pour décollage de l'engin | 62 dB au ralenti / 77 dB en accélération pour décollage de l'engin | Mesures effectuées avec un sonomètre homologué Trotec BS15 au centre du poste de pilotage | Très semblable d'un engin a l'autre, RR légèrement moins fort au ralenti |
| | 21 | Prise en main | assez facile | très facile | | RR un peu plus facile à prendre en main du fait de la position assise et du frein direct à pied. Les commandes sont à plat (frein direct sur le côté par exemple pour le loco) |
| | 22 | Accès aux contrôles divers lors de la PS | Assez facile. Portes d'ouvertures du compartiment moteur un peu lourde à manipuler | Assez facile, à l'exception de bouchon de remplissage de GNR sous une trappe résistante avec clef de berne. Portes d'ouvertures des capots moteurs sur vérins hydrauliques très pratiques | | Plus pratique sur le RR |
| | 23 | Evolution du conducteur à l'intérieur de la cabine | Excellente, permet d'appréhender l'espace intérieur et les distances extérieures | Impossible ou presque (quelques dizaines de cm) | | Excellente dans le loco, impossible dans le RR |
| | 24 | Confort fauteuils | 2 sièges mais confort passable, petite assise et petit dossier | Plutôt confortable, dos bien maintenu, réglable. Fauteuil du chef de manœuvre confortable et assez large, rabattable | | Meilleur confort sur le RR |

| | | | | | | |
|---|---|---|---|---|---|---|
| INSTRUMENTATION | 25 | Tableau de bord : visibilité et facilité de compréhension | Plutôt clair et aéré, mais vieillissant | Un peu trop compacte et ramassé, mais très complet, avec notamment deux écrans de contrôle très précis | | Plus de précision et de quantité d'informations sur le fonctionnement et l'état de l'appareil sur le RR. Présence de camera et d'écran digital |
| | 26 | Caméra | Non équipé | Vue sur l'arrière de la machine et les deux loris | | Cameras uniquement présentes sur le RR |
| | 27 | Ecran de contrôle | Non équipé | De taille limite mais très complet | Voir annexe des informations disponibles sur les écrans digitaux de contrôle | Ecran de contrôle uniquement sur RR |
| | 28 | Manomètres | Grandes tailles, très lisibles, très précis. | Petites tailles, peu lisibles, oblige à baisser la tête. L'aiguille de pression de la CG sur notre appareil est erronée, elle indique la pression demandée et non la pression réelle dans la rame. | L'aiguille de pression de la CG sur les engins avant 2014 est erronée, elle indique la pression demandée et non la pression réelle dans la rame. Problème très handicapant en production car oblige à passer en neutre pour contrôler le desserrage. Problème résolu sur les | Manos très performants et très lisibles sur le loco. Mano CG du RR à revoir d'urgence sur les modèles avant 2015 |
| PERFORMANCES | 29 | Temps de gonflage des rames | (Voir annexe gonflage) | (Voir annexe gonflage) | Mesures reprises sur tableau annexe | RR gonfle plus vite d'environ 20% |
| | 30 | Roues directrices | (non concerné) | 4 roues directrices sur le MOL : trois possibilités : roues arrières bloquées avec roues avants directrices, roues avants et arrières directrices ou 4 roues tournant dans la même direction pour déplacement en diagonale | | Roues directrices uniquement sur le RR, très efficace |
| | 31 | Puissance | 219 KW | 181 KW | FR 196 et données Lemonnier | Loco plus puissant de 38 KW |
| | 32 | Consommation GNR | en conditions SPR : environ 20 litres / heure | en conditions SPR : environ 13 litres / heure | plutôt variable en fonction des conditions d'utilisation, notamment fréquence de démarrage, tonnage transporté etc… | Consommation moins élevée avec le RR : environ 35% |
| | 33 | Autonomie en heures d'utilisation | en condition SPR : environ 30 heures | en condition SPR : environ 35 heures | plutôt variable en fonction des conditions d'utilisation, notamment fréquence de démarrage, tonnage transporté etc… | Meilleure autonomie avec le RR |
| | 34 | Effort de traction | 129 KN | 135 KN | FR 196 et données Lemonnier | Effort de traction au démarrage meilleure sur le RR de 6 KN |
| | 35 | Débit d'air du compresseur | 1850 l/min à 1500 t/min | 2300 l/min à 1000 t/min | FR 196 et données Lemonnier | Meilleur débit d'air sur le RR avec 450 l/min de plus |
| | 36 | Nombre de personnes admises en cabine | 5 | 2 | FR264 et données Lemonnier | Plus de personnel possible dans le loco |
| | 37 | Vitesse limite | 60 km/h en GR / 30 km/h en PR | 23 km/h (paramétrable à souhait) | FR 196 et données Lemonnier | Loco plus rapide mais RR paramétrable en fonction du site utilisateur et des contraintes terrain |
| | 38 | Analyse des performances de freinage en charge | Le frein wagons est à main, il est plutôt précis et n'a pas trop d'inertie. Freinage puissant (dépend aussi de la rame) | Le frein wagons est une commande électropneumatique main droite. Son contrôle est excellent et très précis. Le freinage est puissant, (dépend aussi de la rame) même en charge moyenne (charge | Pas de dispositif de mesure de freinage de disponible sur site, le résultat annoncé découle du ressenti des agents | Le frein wagons est une commande électropneumatique au contrôle excellent et précis. L'aide du frein direct à pied lors des très faibles vitesse en manœuvre rend cette dernière un peu plus précise |
| | 39 | Analyse des performances de freinage HLP | Le frein direct est à main, il est pratique (deux côtés de la cabine) puissant et facilement dosable | Le frein direct est à pied. Son contrôle est excellent et très précis, notamment en ce qui concerne l'accostage. Le freinage est puissant | Pas de dispositif de mesure de freinage de disponible sur site, le résultat annoncé découle du ressenti des agents | Le frein direct est plus précis sur le RR, notamment en ce qui concerne l'accostage. |
| | 40 | Capacité de traction | FR196 : voir annexe 9 de la FR 196 | Données constructeur : 2700 T | Les tonnages annoncés seront évidemment valables dans des conditions optimales de traction : temps sec, hors courbure, hors pente. | Meilleure capacité de traction pour le RR |
| | 41 | Analyse du comportement sur rail | Machine assez réactive mais un peu d'inertie sur les enchainements des différentes manipulations. Talonnage des aiguilles possible | Très peu d'inertie, accélération franche et freinage facile, attention talonnage des aiguilles interdit. Nous noterons des a-coups de traction lors du passage des trois vitesses automatiques | Le talonnage des aiguilles n'est pas un geste métier autorisé à SPR, cependant en cas d'erreur de l'agent, il n'y a pas de conséquence avec le loco. Le risque de déraillement avec le RR est quand a lui a ne pas négliger | Le RR se déplace avec plus de précision et de confort (matière des roues) les commandes sont précises. A noter un mouvement de caisse légèrement supérieur par rapport au loco du fait d'une masse moins élevée. |
| | 42 | Analyse du comportement sur route | (Non concerné) | Appréhension du gabarit très simple notamment a l'aide des rétroviseurs et de la camera de recul. Très maniable grâce a ses 4 roues directrices. Commandes douces. Seul défaut les à-coups de traction lors du passage des trois vitesse automatiques | La conduite sur route n'est possible qu'en poste de pilotage normal (cabine inversée impossible) | Très intuitive grâce au volant. Le système hydraulique donne une sensation de direction assistée très agréable. Les rétroviseurs aide à la conduite, le gabarit est facile à appréhender du fait de la hauteur de l'engin |
| | 43 | Conditions de ravitaillement GNR | Sur rail uniquement, mais très facile sur notre site | Sur rail ainsi que sur route très facile sur notre site | | Plus pratique avec le RR car deux possibilités d'approche du point de ravitaillement, rail et route |
| | 44 | Conditions de ravitaillement GNR en dehors du site sur route | (Non concerné) | Non testé | | Attention en ce qui concerne le RR aux risques liés à la sécurité routière et à l'engagement éventuel du gabarit sur le site de livraison GNR |
| | 45 | Durée de mise sur rail de l'engin | (Non concerné) | Dépend de la dextérité du conducteur notamment pendant le placement sur les rails. Variable en fonction de la présence d'une courbe ou non, mais aussi de la distance planchéiée à disposition (6 mètres mini) : entre 2 et 3 minutes en moyenne (mini 1m50 / maxi 4m) | Placement d'approche très important. Enraillement en marche arrière uniquement. 4 phases à enchainer. | Facilité de cette action correcte, le temps d'enraillement dépend en partie de l'agent et de ses compétences ainsi que des conditions de voie (courbure éventuelle) |
| | 46 | Durée de sortie des rails de l'engin | (Non concerné) | Automatique donc presque parfaite : 24 secondes | A noter toutefois quelques bugs avec nécessité de bouger légèrement l'engin (traction avant ou arrière) avant le passage définitif en mode route pure | Action très simple et rapide : moins de 30 secondes |
| | 47 | Conduite par radio commande | RC à partir de la serie 8400, 8294 non concerné | opérationnelle (fréquence : 429,770 mh) | Réduction des fonctions significative (mano, caméra, neutre etc…) | Certaines fonctions ou indicateurs disparaissent mais le MOL est comptatible à la conduite avec RC. |
| | 48 | Définition du protocole d'utilisation de la RC | (Non concerné) | En cours | Aux yeux des experts loco SNCF la formation RC du RR ne serait pas assez approfondie. En cours d'expertise par les instances légitimes | Formations achevées le 21/04 mais protocole non réalisé |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| SUIVIS SPECIFIQUES | 49 | Suivi du taux d'usure des pneus et roues | Mesurable uniquement par le matériel | Pas d'observation d'usure anormale en environ 45 heures d'utilisation (arrêté au 21 avril) | L'usure dépend également du tonnage des charges remorquées. Sur le site de SPR la masse des rames tirées est plutôt faible du fait des coupes effectuées en raison des longueurs maxi de voie | A priori usure moins rapide sur le loco du fait de la matière concernée. Toutefois le RR propose la solution de tourner les pneus et d'ainsi de x2 le temps avant usure totale | |
| | 50 | Suivi des temps d'intervention en cas d'incidents | Inertie plutôt importante et enlèvement du loco par le matériel souvent inévitable notamment pour les interventions importantes | Sauf incident grave la maintenance s'exécute sur le site détenteur | Attention retour a modéré du fait d'un utilisation moyennement intensive sur notre site. A revaloriser en cas d'activité forte notamment sur un grand triage | Maintenance sur site direct dans la plupart des cas curatifs et des interventions programmées (y compris le changement des pneus) | |
| | 51 | Suivi de la maintenance (contenu, périodicité) | Voir Matériel | Voir constructeur | Temps de test trop court pour réellement effectuer des mesures | Rien ne sera effectué à priori au cours de notre test car amplitude courte (quelques mois). Voir données constructeur et matériel. | |
| | 52 | Suivi de l'appropriation technique et fonctionnelle | Assez facile d'accès, la formation de 3 jours comprenant accrocheur et chef de manœuvre est suffisante | Après concertation avec toute l'équipe il apparait que d'une manière générale le RR est facile d'accès et plutôt instinctif, toutefois la formation d'une demie journée semble trop courte, notamment en ce qui concerne le test en production réelle | Passage d'une demie journée à une journée complète préconisée par la SNCF | RR plutôt facile d'accès | |
| | | | | | | | |