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Development of Functional Requirements for Sustainable and Attractive European Rail Freight

D5.5 – CBA for Automatic Couplers

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Dr. Gerhard Troche (KTH Railway Group)

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EXECUTIVE SUMMARY

For the purpose of assessing business cases for Automatic Couplers a cost-benefit model has been developed, quantifying costs and benefits of Automatic Couplers in concrete transport chains. The model allows to calculate the cost effects of Automatic Couplers with different automation levels (Type-1 to Type-5 couplers) in relation to the use of screw couplers. Transport chains in different production systems can be modeled and different market environments (in terms of labor costs) can be taken into account.

The results indicate that there is in most cases a positive business case for Automatic Couplers, if even indirect cost effects (such as effects made possible through an automation of brake tests and creation of train composition list) are taken into account. In this case a positive business case can be achieved even in market environments with low labor costs.

If only cost effects related to the coupling and de-coupling processes are taken into account, the business case is weaker, but in most cases still positive.

The business case (cost-benefit-ratio) improves strongly when going from Type-3 to Type-4 couplers (or higher), jumping from a cost-benefit ratio of 2,0-2,5 for Type-1 to Type-3 couplers to 3,0-4,0 for Type-4 and Type-5 couplers (in wagonload traffic even >4,0). This calls for aiming at a high automation level, allowing even data transmission between the wagons in a “train-bus” (i.e. Type-4 or higher); data transmission is an enabler or facilitator of more far-reaching digitalization and automation in the rail freight system.

The report discusses further the nature of benefits of Automatic Couplers (even such benefits which are more difficult to quantify and which are not included in the model) and challenges for the migration to Automatic Couplers.

At the end of the report several measures are suggested to improve the business case for Automatic Couplers, through technical measures, but primarily through the creation and use of financial instruments. Key design features for a possible support program are also suggested.

1. INTRODUCTION

1.1 Background

With screw couplers as the standard system for coupling of railway vehicles the European railway system is – among all major railway systems in the world – today rather an exception than the rule. The disadvantages of the legacy screw-coupler system are becoming ever more apparent. The lack of an automatic coupling solution is slowing down and decreasing the efficiency in train formation processes and hinders European rail freight from participating fully in and reaping the benefits from digitalization, automation and in prolongation potentially partially of fully autonomous operations. European rail freight is in risk of becoming detached from these trends and the important development potentials inherent to the railway system, if not successful paths can be found for the migration to Automatic Coupling, which is an enabler for many other innovations for the digitalization of the rail freight system.

With the fast advances taking place in the above fields in other transport modes, in particular road transport, a continued reliance on the manual screw-coupling system might become a blocking factor for maintaining and strengthening railways' competitiveness on the European freight transport market.

Rail freight operators and other stakeholders in European rail freight have recognized this and therefore included Automatic Coupling as a key aspect in the freight pillar (Innovation Program 5) of the EU-wide research & development-initiative Shift2Rail.

An important aspect for the migration to Automatic Couplers is the ability to assess the business case of their introduction. Therefore this report studies the economics of Automatic Couplers in different use-cases (transport chains). It closely relates to and should be read in conjunction with the report D5.6 "Migration Plan for Automatic Couplers", elaborated under the same project.

1.2 Objectives

1.2.1 Objectives of the introduction of Automatic Couplers

The main objectives of introducing Automatic Coupling in the European rail-freight system can be summarized as follows:

- Increasing railways cost competitiveness by reducing costs in production processes in the rail freight system
- Improving railways service competitiveness, allowing rail to enter into new or re-enter into lost market segments, by improving service features in rail freight, such as transit times and enabling rail to offer added-value services, e.g. in form of provision of electric power on freight wagons
- Further improving railways already high safety performance and increasing working comfort in order to ensure a high attractiveness of jobs in rail freight in an increasingly competitive labor market

- Enabling and facilitating a larger-scale automation in rail freight in order fully reap the benefits of digitalization, e.g. through automatic brake tests, automatic generation of wagon-lists and predictive, condition-based maintenance

1.2.2 Objectives of this report

The objective of this report is to quantify in monetary terms, as far as possible, the benefits of Automatic Couplers in concrete use-cases (transport chains) and to weigh them against costs in order to assess potential business cases for Automatic Couplers and to facilitate decisions of commercial and policy stakeholders related to Automatic Couplers. The knowledge and understanding of the economics of Automatic Couplers is crucial in order to build confidence in the sector for a future European Automatic Coupling System.

It is important to note that this report cannot and shall not replace (often internal) in-depth analyses of Automatic Couplers by individual market actors, taking into account the specificities of their assets and operations. The approach in this report is therefore also a different one, looking at transport chains rather than entire fleets or traffic systems. The cost model on which this report is based allows to analyse transport chains in a wide variety of different production systems (e.g. trainload, wagonload, etc.). It is therefore particularly suited to help market actors to identify and to select concrete flows in which the introduction of Automatic Couplers should be prioritized. Thus, this report must be seen as a complement to further analyses to be carried (or already carried out) by the individual market actors, which likely will focus rather on entire fleets or traffic systems.

1.3 Methodology

The methodological approach to quantify the costs and benefits of Automatic Couplers in concrete transport chains consisted in:

a) *Developing a cost and benefit model*, which allows to depict transport chains in different production systems or combinations of such production systems; the model discerns the production processes which are directly or indirectly affected by the introduction of Automatic Couplers. The processes directly affected are the train composition and de-composition (i.e. the coupling and uncoupling processes as such); among the processes indirectly affected are e.g. the brake test, the train and wagon data collection, but also for example the train movement insofar as Automatic Couplers may allow trains to operate at a higher speed. By discerning these different processes the model allows to depict different levels of automation of the Automatic Coupler. The model includes as a base scenario a transport chain with the use of screw couplers and as development scenarios the use of Automatic Couplers from Type 1 to Type 5, with one development scenario for each type.

b) *Filling the model with input data*. The input data are gathered from previous studies and from expert interviews. In order to fill gaps in the input data in certain cases qualified assessments have been made; this concerns in particular data for the time consumption of certain processes. When it comes to the investment costs for Automatic Couplers these have been obtained from project partner CAF, which is developing the Automatic Coupler in Shift2Rail. This means that the results of the cost-benefit analyses presented in this report are based on the use of those couplers. The cost-benefit-model would, of course, in principle allow to insert cost data even for other Automatic Couplers. When it comes to staff costs, the values used are approximate values based on expert interviews; the model allows to select three different levels of staff costs ("low cost", "medium cost", "high cost") in order to depict different market environments in Europe.

c) Defining transport chains, for which the calculations are made. Presented in this report are results for a wagonload transport chain and for an intermodal transport chain. The model can of course be used to analyse further transport chains. For technical reasons the chains are limited to a maximum of five "transport segments", which however should be sufficient to cover most transport chains in Europe.

The cost-benefit-model is in further details described in chapter 4.

At the end of the report includes a chapter discussing various possibilities to improve the business case for Automatic Couplers, looking at certain technical measures but primarily considering the creation or use of financial instruments.

2. POTENTIAL BENEFITS OF AUTOMATIC COUPLERS

2.1 GENERAL REMARKS

The benefits actually or potentially arising from the use of Automatic Couplers can be assigned to three groups:

1) Benefits relating to the transmission of tractive and compressive forces in the train consist
2) Benefits relating to the coupling and de-coupling process
3) Benefits relating to the enabler-/facilitator-role of Automatic Coupler for other innovative solutions

In this chapter the benefits are presented in further detail, and their practical relevance in European rail freight is discussed in qualitative terms. It is not the purpose of this report to provide full-fledged technical analyses of these aspects, since such analyses have in many cases already been carried out in earlier studies. The main aim of this chapter is to assess to which extent the benefits concerned are relevant in a broader perspective to support a business case for Automatic Couplers in Europe.

2.2 BENEFITS RELATING TO THE TRANSMISSION OF TRACTIVE AND COMPRESSIVE FORCES

When it comes to the first group of benefits, relating to the transmission of tractive and compressive forces, these can arise from the capability of Automatic Couplers to transfer higher longitudinal forces than screw couplers, at least when it comes to tractive forces.

It would be in principle possible to design even screw couplers with similar capabilities, however, the limiting factor here is the need to keep the weight of movable parts of the screw coupler, which have to be lifted manually, on a reasonable level. Therefore the dimensions of these parts cannot be increased beyond a certain limit. A general trend to tighten work safety and work comfort rules might in the future even have an effect in the opposite direction, i.e. reducing the possibility to design screw couplers for high longitudinal forces.

The ability to allow higher tractive and compressive forces with Automatic Couplers in the longitudinal central axis of the wagon / train, can generate a number of benefits:

1. Possibility to operated heavier trains (this often means also longer trains)
2. Higher running safety, in particular reduced risk for derailments
3. Possibility to raise train speeds by allowing higher brake forces
4. Simpler and lighter design of the wagon frame, since both tractive and compressive forces are transferred in the center of a wagon (today compressive forces are taken up on the sides of a wagon)

While all these benefits certainly arise in theory, their practical relevance in European rail freight is nonetheless somewhat more limited:

Train weights and train lengths in Europe are – with exception of very few isolated traffic operations - usually not such, that the use of screw couplers would constitute a limitation for the train weight. In

Europe trains with up to ca. 4.000 gross tons have already been in the past operated with screw couplers. Even with a general trend towards higher axle-loads and longer trains it is rather unlikely that a significant number of traffic operations would reach this weight. To give an example: An intermodal train in Europe has a typical meter-weight of ca. 2,2 - 2,5 t/meter. Even with a train length of 1.000 meters and head traction only the train would not reach a weight where longitudinal forces would reach a level, which could not be transferred by screw couplers. For unit trains with bulk commodities meter-weights are certainly higher and there might be some few traffic operations where train weights will reach levels which cannot be transferred safely with screw couplers. However, often these are isolated traffic operations, where Automatic Couplers could be introduced without requiring a European- and fleet-wide migration to Automatic Couplers.

The higher running safety (reduced risk for derailments) is partly stemming from the fact that with Automatic Couplers both the compressive and tractive forces are transferred along the longitudal central axis of the wagon/train. A further improvement can arise from the possibility to easier introduce ep-braking in freight trains with the use of Automatic Couplers (from type 4). In this latter case this benefit sorts rather under group ‘3’ listed in chapter 2.2, since it also requires introduction of further innovations (ep-brake for freight). It is difficult to assess today the practical relevance of this improvement, since rail transport is relatively safe and only few derailments occur. It would require a deeper analysis of freight train derailments in order to assess this benefit properly.

Regarding the possibility to run trains at higher speeds due to the possibility to allow higher longitudinal forces with Automatic Couplers the practical benefits will vary in Europe, due to the fact that braking rules till vary quite considerably in different countries. This means that at least in some countries major improvements of freight train speeds could also be achieved still with the current screw coupler system, by amending braking rules to a more “ambitious” (but still safe) practice in Europe.

Concerning the advantage stemming from the possibility to make use of simpler and lighter designs for the wagon frame of freight wagons, this advantage naturally only is relevant for new-built wagons, not for wagons subject to retrofitting. For new-built single-frame container bogie wagons the weight net advantage could be in the magnitude of 0,5-1,2 tons, in combination with other improvements of the wagon design even higher. However, it should also be noted that the weight benefit depends on the type of wagon; for certain wagon types there may even be no advantage or a very low one, e.g. for intermodal pocket wagons, where longitudinal forces are taken up by side beams. In this case it is therefore no advantage to transfer compressive forces at the ends of the wagon centrally.

Further advantages of Automatic Couplers relating to the transmission of tractive and compressive forces are:

5. Reduced wear on wheels and rails through reduced lateral forces at the rail/wheel interfact
6. Elimination of buffer wear and need for buffer lubrication

Regarding the reduced wear on wheels and rails there have been indeed reported substantial reductions in specifc traffic operations where Automatic Couplers todays are used in isolated operations. For the “lignite shuttle” reductions of up to 30% have been reported. However, these results are strongly due to the very specific infrastructure and operational conditions in this specific traffic, such as:

- Relatively high actual train weights and axle-loads

- Very small radii on some rail sections
- Train is pushed over certain sections with tight curves

Thus, the results from these operations cannot be generalized. For the majority of the rail network and for the majority of traffic operations the reduction of wheel and rail wear through Automatic Couplers is likely to be very low and probably almost neglectable. Significant effects can be expected, if at all, on sections and in networks with frequent tight curves in combination with heavy trains (high axle-loads). However, to assess the potential effect more precisely further research would be needed.

Buffer wear and the need for buffer lubrication is for natural reasons eliminated with Automatic Couplers, since buffers are not part of the system any longer. At the same time certain wear and need for component service is also connected to Automatic Couplers. However, the design of the draft gear (taking over the role of the buffers in a system with Automatic Couplers) will likely lead to a lower wear, especially since lateral glide movements are largely reduced.

2.3 Benefits relating to the coupling and de-coupling process

Turning to the second group of benefits (compare chapter 2.1), the following benefits related to the coupling and de-coupling process can be expected to arise from the use of Automatic Coupers:

1. Reduced staff need / improved labor productivity
2. Improved working comfort and working safety
3. Faster coupling and uncoupling
4. Reduced infrastructure occupation / higher throughput
5. Higher rolling stock utilization due to reduced yard dwell times
6. Shorter transport times

With the reduction of manual actions required in connection with the coupling and de-coupling process staff needs are going to be reduced, i.e. overall labor productivity in the train formation process is going to increase.

To which extent the staff needs will decrease depends strongly on the automation level chosen of the Automatic Coupler, i.e. is dependent of the Coupler Type. With Type-1 couplers the staff reduction will be relatively limited, since the air pipe still well need to be coupled manually. The need of manual involvement in the coupling process at the wagon itself will disappear first with Type-2-couplers and higher. When it comes to the uncoupling process automation requirements are higher in order to eliminate the need for manual action at the wagon. First with Type-5 couplers and remote-controlled uncoupling any need for manual action at the wagon will entirely disappear. However, the time consumption for manual action at the wagon in connection with uncoupling will be reduced even with lower coupler types.

It is one of the purposes of the cost-benefit-model to calculate more precisely how much staff needs (labor time consumption) is reduced through Automatic Couplers (see chapters 5 and 6).

Improved working comfort and safety (especially the first) are more difficult to measure, however the possibility to reduce and ultimately eliminate heavy work under open sky, i.e. unprotected from climatic conditions and even during night-time, will likely be of major importance to attract people to choose jobs in rail freight production.

The faster coupling and un-coupling processes may also have a number of other positive effects, e.g. reduced occupation times for (especially in highly mechanized marshalling yards relatively expensive) track infrastructure in yards, opening for a higher throughput with existing infrastructure and/or reduced infrastructure needs. The latter advantage will become effective only when new infrastructure is to be built or when there is need for re-investments, i.e. it is highly dependent on the investments cycles of concrete facilities, when this advantage can be reaped.

On the operational side faster coupling and un-coupling may also translate into shorter yard dwell times and ultimately shorter transport times.

However, to which extent track occupation times can be reduced, how much this will translate into shorter yard dwell times and shorter transit times depends to a very high degree on how related processes in the yard (see also chapter 2.4) but also in timetabling and traffic management are adapted. The possibilities here are in their turn again dependent on the automation level of the Automatic Coupler and a major impacts can only be expected with higher automation levels (Type 4 or higher).

2.4 Automatic Couplers as facilitator and enabler of other innovative solutions

The third group of benefits (compare chapter 2.1) are those not directly stemming from the Automatic Couplers as such, but from innovative solutions for which Automatic Couplers are a pre-condition (enabler) or a facilitator. Automatic Couplers indeed open up for the implementation of technologies and solutions, which allow a much more far-reaching automation in the rail freight system.

Yard processes, which can be automatedare for example:

1. Full or simplified brake test
2. Generation of train composition list

Processes, which can be improved and services, which can be provided during the train movement thanks to the use of Automatic Couplers are for example

3. Electric on-board power supply
4. On-board train integrity control, eliminating the need for track-side control of train integrity
5. Real-time monitoring of the wagon condition

Again, the possibility for Automatic Couplers to provide such an enabler- and/or facilitator-role is highly dependent on the automation level. In case of point 3 above at least a Type-3 coupler is required, in case of points 1, 2, 4 and 5 at least a Type-4 coupler. However, potentially these indirect benefits of Automatic Couplers are at least as important, if not more important than their direct benefits. This is also reflected in the results of the cost-benefit-analyses, see chapter 6.

The on-board train integrity control can eliminate the need for track-side control of train integrity, potentially reducing the need for track-side equipment substantially. It can also help to increase line capacity by allowing the introduction of moving block operations.

The real-time monitoring of the wagon condition (through sensors monitoring various wagon components) can facilitate the introduction of condition-based maintenance, reducing maintenance costs and stopping failures and increasing the availability of the wagon.

Regarding benefits 3, 4 and 5 above, these are however difficult to quantify without deeper research in these areas and it is particularly difficult to allocate the benefits to specific transport chains. For this reason the cost-benefit model used for this report focuses on the benefits under point 1 and 2 above.

2.5 Benefits in different production systems

Table 1 shows an attempt to assess the importance in practice of benefits potentially stemming from the use of Automatic Couplers in different production systems. It should be considered as indicative and huge differences certainly do exist between different traffic operations within each of the production systems. Also, a concrete traffic operation may very well be a combination of different production systems. Though the assessment, for the reasons above, only can give a very general and rough picture, the table nonetheless shows a certain tendency that in particular wagonload traffic may benefit more than average from especially from the introduction of Automatic Couplers. This is true especially when it comes to the rationalization of the coupling process and, possibly even more, the indirect effects stemming from other (process) improvements made possible through the introduction of Automatic Couplers.

It should nonetheless be underlined that the benefits are by far not limited to the wagonload system, but that huge and important benefits can be expected in trainload and intermodal traffic as well. Thus, the table also allows the conclusion that practically no production system in rail freight will be without considerable benefits stemming from the introduction of Automatic Couplers.

To be emphasized here again is, that the emergence of benefits from Automatic Couplers and the magnitude of these benefits to a high degree depends on the automation level of the couplers. Especially the indirect effects can only be realized with Type-4 couplers or higher (this finding is further supported by the results of the cost-benefit-analyses presented in chapter 6).

	Trainload	Wagonload	Intermodal
Transmission of higher longitudinal forces			
Higher safety / reduced risk for derailment	Low	Low	Low
Possibility to run heavier trains	High	Medium	Medium
Possibility to run faster trains through increased use of breake regime 'P'	Low-Medium	Medium	High
Reducing wear on wheels and rails	Medium	Low	Low
Rationalisation of coupling process			
Increased labor productivity	Medium	Very high	Medium
Increased rolling stock utilization	Medium	Medium	Medium
Reduced infrastructure occupation / yard dwell time	Low	High	Low-Medium
Reduced transport times	Low	Medium	Low
Improved working comforts and safety	Medium	Very high	Medium
Indirect benefits (synergy effects in combination with other innovations)			
Electric on-board power supply	Medium	Medium	High
Automated brake test	Medium-High	Very high	Medium-High
Generation of train composition list	Medium-High	Very high	Medium
On-board train integrity control	High	High	HIgh
Real-time monitoring of wagon condition	Medium-High	High	High

Table 1: General assessment of importance of benefits of Automatic Couplers in different production systems.

3. CHALLENGES FOR A MIGRATION

There have been in the past repeatedly a number of attempts to introduce Automatic Couplers in the European rail freight system. So far, all of these attempts failed and Automatic Coupler are today used only in a number of geographically and operationally isolated traffic operations in various countries, with practically no traffic exchange with the general freight transport system. Only in the Finland and the Baltic States Automatic Couplers are the general coupling system in freight, due to their close linkage to the Russian and ex-Soviet railway systems. No couplers with higher levels of automation are in use today.

There are a number challenges for a migration to automatic coupling in Europe, which are partly inter-related and of which many have a direct or indirect impact on the business case for Automatic Couplers:

1) A very wide range of market environments in Europe

There are huge differences in the market environments in terms of the cost situation of rail freight operators. Staff costs are hugely varying between different parts of Europe (here EU/EEA-countries), with a factor 17(!) between the country with the lowest and the highest labor costs (Bulgaria resp. Switzerland). Between the country with the biggest rail freight market and the second-biggest rail freight market in Europe, Germany respectively Poland, there is still a factor 5 in the labor costs. At the same time it can be assumed that the costs for buying Automatic Couplers will be largely the same in entire Europe.

Thus, the economic benefits of an automation of currently manual processes in the rail freight system will vary strongly geographically between different parts of Europe. In other industries such a situation is resulting in a varying intensity in the use of automation in different countries. The European Automatic Coupler System proposed in the FR8RAIL-project responds to this situation by providing versions of the coupler with different automation levels – and different cost levels. This will help to balance at least to some extent the differences in market environments for different traffics, however, it will still be a challenge to ensure a positive business case for if not all, then at least a vast majority of rail freight operations in Europe.

One further measure to improve the chances to generate a positive business case is to allow for some flexibility in the timing of the migration. However, in this context even the aspects of interoperability and mixed operations of screw couplers and Automatic Couplers need to be addressed (see even report D5.6 "Migration Plan of Automatic Couplers", chapter 3.5).

2) Many benefits appear and/or deliver economic savings only under specific operational conditions

As already pointed out in chapter 2.5 rail freight is characterized by a wide range of different production systems with characteristic "mixes" of operational processes affected by a potential change of the coupling system. These different production systems are – with the exception of relatively few completely or at least highly isolated traffic operations – to some and often to a high extent interlaced. Most obvious is this in the wagonload system, which is practically European-wide interconnected, with wagons circulating more or less freely in the network, even internationally. However, even in other production systems, such as intermodal and trainload services, the allocation of wagons is – at least seen over a longer period of time – shifting between different traffic lanes and services, partly in order to respond to changing transport demand and transport flow patterns, partly as a consequence of changes of contracts with either shippers or wagon suppliers.

3) Certain benefits appear and/or deliver economic savings only with a high deployment rate

The European freight wagon fleet counts about 600.000 freight wagons. Therefore the question when benefits arise from the use of Automatic Couplers becomes important for their business case. Figure 1 illustrates possible relations between the grade of automation respective the deployment rate and the benefits generated by them.

In many cases the relation between the deployment rate and the benefits is not linear. The situation that huge benefits arise already with low deployment rates – which would be favorable for the business case – can be found in rather few cases. One example would be the possibility to operate heaver trains and/or run trains at higher speeds. This effect can be realized already with relatively low fleet-wide deployment rates (however, even here full deployment is necessary within the train consist, thus in certain production systems like wagonload this can be difficult to achieve at an early stage of deployment). The reduction of wear on wheels and rails is likely to grow rather linear to the deployment rate. Many benefits, however, will most likely appear first with a high or (almost) full deployment of Automatic Couplers. This is in particular true for benefits indirectly related to Automatic Coupling, i.e. benefits from the automation of processes for which Automatic Coupling has an important enabler-function, such as the possibility to remove line-side equipment for the train integrity control (track circuits or axle-counters); these benefits require a practically full deployment at least within parts of the rail network.

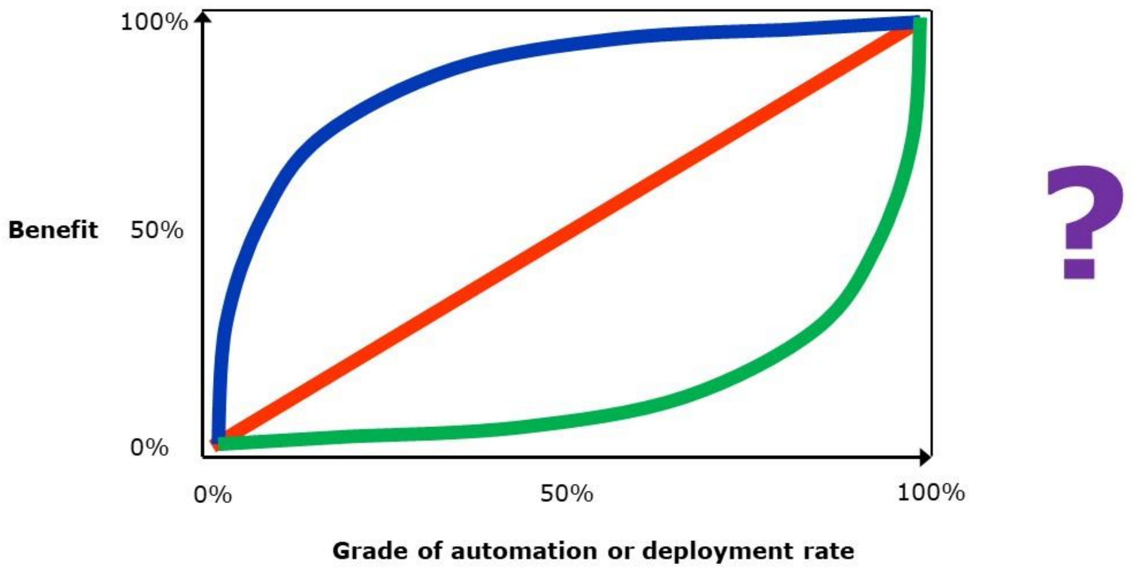

Figure 1: How much automation do we need respectively when is automation profitable? The figure illustrates different situations of the relation between the grade of automation respectively the deployment rate and the benefits generated by it (own figure).

The question of when benefits arise is also relevant in the context of the automation level. Certain benefits require a relatively high level of automation; they may not be possible to achieve without an electric power line and data transfer through the train for example. This aspect becomes triggers the question of whether a minimum entry level for Automatic Couplers should be defined (see also report D5.6 "Migration Plan for Automatic Couplers", chapter 3.5). An ambition to reap as huge benefits as possible from the introduction of Automatic Couplers would call for a rather high minimum entry level – however, the objective to ensure positive business cases under a wide range of different market environments (see point 1 above) would call for a rather low minimum entry level. Thus, there are target conflicts to be handled in this context.

4) Certain benefits of Automatic Couplers only appear in combination with the implementation of other technical innovations

As has been mentioned already earlier (see i.a chapter 2.4), Automatic Couplers play an important role as enablers or facilitators of other technical innovations in the rail freight system, which allow the automation of other processes than only coupling and de-coupling. Mentioned here have been the automation of the brake test, the automatic generation of the train composition list, the on-board train integrity control and the automatic monitoring of the wagon condition.

While this is on the one side an advantage, it also means that certain benefits only arise if these other innovations actually are implemented. Since the enabler- and facilitator-role of Automatic Couplers is often linked to a high automation level of the coupler (Type 4 and higher), it comes with an additional cost (for the coupler). This calls for a coordination of timelines for deployment of innovative technology – of wich Automatic Couplers are only one element – in order to avoid or at least as much as possible reduce the time-lag between the point of time of expenditure and the phase when the benefits can be reaped.

In Shift2Rail this aspect is addressed in the FR8HUB-project, Work Package 1, which looks at the migration to innovative solutions for rail freight in a broader perspective with the aim to coordinate migration timelines for different solutions in an optimized way.

In parallel to this, also the regulatory environment needs to be adapted with a view on facilitating digitalization and automation in rail freight in a broad perspective.

5) A high number of market actors with different business models and limited investment abilities

The European railway sector is since the beginning of the 1990-ies characterized by fundamental legal and structural changes, strongly linked to the liberalization of the European rail markets. This is in particular true for rail freight. The result has been on one side a certain “fragmentisation” of the sector and on the other side the emergence of new business models and new actors entering the market. While this has on the positive side led to a stimulation of the rail freight market and that the several decade-long downward trend for rail on the freight market (in terms of market share) could at least be stopped, it has also led to an increased number of actors, many of them covering only specific market segments. This in combination with generally rather limited investment abilities of the sector due to a continued high competitive (price) pressure from competing modes, in particular road transport, provides a challenge for large-scale capital-intensive system changes, as the migration to Automatic Couplers is.

In this context it should be kept in mind that the inability to find (and maintain) consensus among European market had already been in the past a hindering factor for the introduction of Automatic Couplers in Europe (though the number of actors at that time still was lower). However, it should also be underlined, that a full consensus among all market actors certainly is not necessary, but it should be sufficient that a “critical mass” of actors can agree, which will allow them to set a de-facto standard when it comes to coupling. However, it must also be ensured that this standard does not hamper the proper functioning of a Single European Railway Market.

At the same time the introduction of Automatic Coupling also generates benefits for society, not least in form of strengthened long-term competitiveness of the most energy-efficient and environmentally-friendly transport mode, paving the way for modal shift. This can deliver an important and probably necessary contribution to achieve national, European and global key policy objectives in the field of climate and environmental policy. This calls for an active role by the public in facilitating the migration to Automatic Couplers by taking a pro-active role in the coordination and adaptation of the regulatory environment and could justify public intervention through incentives and possibly use of financial instruments to support the migration to Automatic Couplers.

6) Difficulties to ensure a reasonable and quick return on investment for those bearing the cost for equipment/retrofitting of wagons with Automatic Couplers

Partly linked to the aforementioned point, a major challenge lies in the fact, that it is relatively easy to identify the market actors directly bearing the expense for migrating to Automatic Couplers. However, the benefits are often widely spread among different market actors and appear often only with a certain time-lag and the point of time when the investment pays off may even be difficult to predict.

This calls partly for the setting up of cost-benefit sharing models among market actors, partly could justify public intervention. Part of solution could for example be incentivisation schemes, such as a differentiation of track access charges or facility charges.

While a life-cycle-cost approach can facilitate investment decisions, it should nonetheless be taken into account that there are further factors influencing such decisions and that there are also certain challenges linked to a life-cycle-cost approach. Here should be mentioned in particular the fact that freight wagons have a relatively long life-time, which can cause uncertainties in the assumptions concerning the use of the wagon. This means, that also the absolute investment cost to be covered will in many cases in reality have an impact on investment decisions.

7) Some uncertainty about the performance/reliability of Automatic Couplers under real-world operating conditions

While there are a number of Automatic Coupler designs with different automation levels – including high-automated couplers of Type-4/5 – currently under development in Europe, it deserves be mentioned that currently at least all higher-automated versions still remain to prove their long-term performance and reliability under real-world conditions. For the time being, no proven designs are “ready-to-deploy”.

This situation calls on the one side for:

a) an extensive and ambitious testing program with longer field tests

b) the provision of resources for “finetuning” and if necessary re-designing of couplers and sub-sequent repeated tests

An idea to consider in this context would be harmonized test-cycles to compare different coupler designs, covering all relevant operational and climatic conditions and including enduring tests.

On the other side a migration to Automatic Couplers can be facilitated by deploying easily upgradable couplers. This would allow to start the migration relatively early with lower-automated versions (e.g. Type-3 or Type-2-couplers) and to upgrade these couplers at a later point of time – when proven solutions are available – to Type-4/5-couplers by installing the required additional devices. A pre-condition for this approach is, of course, that the basic coupler is a proven design and does not incur any technical risks.

8) A "bad reputation" of Automatic Couplers among some market actors in Europe (though this attitude is gradually changing)

There have been several attempts in the past to introduce Automatic Couplers in the European rail freight system, however, all these failed, though partly substantial preparatory works (and investments) had been carried out.

This has led to a certain "bad reputation" of Automatic Couplers among European market actors and that the "belief" in Automatic Coupling – at least for a while – more or less disappeared. The strongest and maybe most severe consequence of this "fatalistic" attitude towards Automatic Coupling has been that the requirement to design freight wagons in such a way that they could be retrofitted with Automatic Couplers at a later stage was dropped and that therefore new freight wagons are not any longer necessarily prepared for retrofitting with Automatic Couplers.

However, one can also note that the attitude in the past years has changed (again) and that the sector generally shows an increased interest in and openness for Automatic Coupling. As the main reason behind this change of attitude can be seen a general trend towards digitalization and automation in the economy, permeating practically all industrial branches. The railway community has realized that it needs to participate in this trend, also in the area of rail freight, in order to maintain its competitiveness and its ability to be part of advanced logistical supply chains. As a consequence it has realized that Automatic Coupling is a facilitator – if not a pre-requisite – for digitalization and automation of rail freight on a much broader scale. Thus, the focus has shifted from the role of Automatic Couplers for the automation of the coupling and de-coupling processes to their role in a digitalized and automated rail freight system.

The prices for couplers in the cost-and-benefit analysis are based previous studies (in particular the Sünderhauf-study), interviews with sector experts, price offers by suppliers and for the European Automatic Coupler System – being the proposed target system of Automatic Couplers for Europe – on estimations by CAF as the partner being in charge of the technical development of the coupler. Whenever possible, price estimations were checked against several sources (literature, experts, internet research) in order to get them confirmed. Thus, it can be assumed that the estimations made in this study are reasonably secure.

In order to ensure comparability of the different coupling solutions the devices for the absorption of compressive and tractive forces have always been included, which in the case of the legacy screw couplers means that two side-buffers are included, while for the Automatic Couplers the draw gears are included.

Prices for screw couplers + side-buffers

For the legacy screw-coupler system prices collected in the project varied strongly, mostly depending on the type of side-buffers used (rather than on the coupling device itself). For a screw-coupler with two “basic” side-buffers a price of ca. 1.500 EUR could be confirmed; however, the price could increase with the use of more advanced buffers: For a screw-coupler together with two “crash”-buffers – as they are often used on new tank wagons – the “system price” could go up to 3.500 – 4.000 EUR. In figure 2 both price levels are indicated. However, in the cost-benefit-analysis only the lower price is used, which means that the cost comparisons tend to favour screw-couplers; or with other words: The results indicated for the Automatic Couplers are rather on the safe side.

World market prices for Automatic Couplers (Type 1)

In order to obtain a price reference for a future system of Automatic Couplers for the European rail freight system even prices for Automatic Couplers as they are in use in other parts of the world were gathered. The most common Automatic Coupler systems world-wide are the North-American AAR-couplers (also in use in i.a. Japan, China, Taiwan, New Zealand, South Africa, Saudi Arabia, Brazil and Chile) and the Russian SA-3 couplers (also in use in the CIS-countries, Mongolia, Iran, Turkey, Finland and Northern Sweden/Norway).

The prices collected for these couplers (including draw gears) range from (less than) 1.000 EUR to ca. 1.300 EUR, with the AAR-couplers tending to have a slightly higher price, though differences are not huge. Thus, one can note the interesting fact that it probably would be cheaper to equip European freight wagons with Automatic AAR- or SA-3 couplers than with screw couplers and side-buffers! Even in the hypothetic case that this would not generate any operational benefits, there could be a positive business case for these Automatic Couplers only stemming from lower price compared to screw couplers and side-buffers.

However, with a view on the European Automatic Coupler System proposed in the FR8RAIL-project it must be emphasized that the standard AAR- and SA-3 couplers correspond in their functionalities to the Type-1 coupler (see below), i.e. they do not provide the possibility of automatic coupling of the air pipes, electric power and data lines and neither allow automatic uncoupling. Further, the current models are neither upgradable to higher levels of automation (with exception of a version of the SA-3 coupler providing the possibility to integrate an automatic connection of the air pipe, i.e. to upgrade in best case to Type-2). Thus, since a requirement set for a future European Autoamatic Coupling

System is to allow higher levels of automation in the European rail freight system the AAR- and SA-3 couplers available on the world market are not of relevance. The prices indicated here for them are therefore only taken up as a reference; these couplers are not included in the cost-best-analyses and the CBA-model.

Prices for couplers of a future European Automatic Coupling System (EACS)

The European Automatic Coupling System developed and proposed in the FR8RAIL-project includes coupler versions with different automation levels with all versions being interoperable with each other. The following automation levels are included in the different coupler "types" of the system:

Coupler type	Description (automated functions)
Type 1	Only mechanical coupling (tractive and compressive forces)
Type 2	Type 1 + automatic coupling of air pipe
Type 3	Type 2 + power line
Type 4	Type 3 + train data bus
Type 5	Type 4 + automatic de-coupling

Table 2: Coupler types defined in the project with different levels of automation

Project partner CAF carried out a careful estimation of prices based on cost estimations for each component of the different coupler types and the necessary manufacturing processes. As can be seen from figure 2 the estimated prices range from ca. 3.200 EUR for the Type-1 couplers, i.e. the lowest automation level, to slightly above 5.100 EUR for a fully automated Type-5 coupler.

While the prices for the EACS-couplers are higher than those for the standard SA3- and AAR-couplers they are lower than prices often indicated for other Automatic Coupler designs with similar automation levels, for example those types of couplers currently tested by some European railway undertakings in various test trains and pilot operations. The main reason for this is that the EACS-couplers developed under the FR8RAIL-project are based on a simpler basic coupler design, the SA-3 coupler (with which it is also fully interoperable). The SA-3 coupler comprises fewer parts, which need to be joined and fewer surfaces, which need to be treated during the manufacturing process. This has a cost(-reducing) effect on all coupler types of the European Automatic Coupling System (i.e. from Type 1 to Type 5). More information about the reasoning behind the choice of the coupler design for the European Automatic Coupler System can be found in chapter 2.4 of the FR8RAIL-report D5.6 "Migration Plan for Automatic Couplers".

Figure 2: Indicative prices for different types of couplers. Prices for Automatic Couplers are including the draft gear in order to ensure comparability with the prices for screw-couplers with side-buffers. EACS = European Automatic Coupling System – i.e. the target system defined within the FR8RAIL-project, based on a further developed SA3-coupler. For further explanations, please see text. (Source: Supplier offers, quotes by sector experts, CAF, own estimations).

We can discern two types of costs in the context of Automatic Couplers. There are investment costs, operational, maintenance and service costs.

When looking at the nature of the impact which these costs have on the business case for Automatic Couplers, the latter three can be considered together: They are largely dependent on the labor costs – the operational costs fully, and the maintenance and service costs mostly (in the maintenance and service costs even expenses for spare parts and consumables are included which are not labor-cost dependent).

Investments costs are one-time or repetetive at rather large time intervals – the life cycle of a coupler can be shorter than the life time of a wagon; in this case re-investment costs occur.

Thus, the business case for Automatic Couplers is strongly affected by investment costs for the couplers and labor costs. The investment costs can be expected to be rather homogenous across entire Europe – since the Automatic Coupler will be standardized there is a European-wide market and for certain versions of the Automatic Coupler even sourcing on a global market will likely become possible.

In contrast to the investment costs, labor costs strongly vary within Europe. This has a major impact on:

a) The one-time retrofitting costs of wagon from the existing wagon fleet

b) The operational benefits stemming from the use of Automatic Couplers instead of screw couplers; e.g. will the rationalization of the train formation process be of very different value in different parts of Europe

In order to tackle this situation in the cost-benefit model three different levels for labor costs have been defined:

- LOW labor-cost (15 EUR / hour)
- MEDIUM labor-cost (30 EUR / hour)
- HIGH labor-cost (50 EUR / hour)

These are approximative costs applied to all personell categories directly involved in rail freight production processes.

To put the costs for Automatic Couplers in relation to total wagon costs, it can be calculated how much the leasing costs of a freight wagon would increase if they are equipped with Automatic Couplers instead of screw couplers. Assuming a writing-off period of five years, an interest rate of 2,5% and the investment costs above and an effective utilization rate (operational days/calender days) of 65% the daily leasing costs of a wagon would increase by 3,10 EUR for a Type-1 coupler and 6,36 EUR for a Type-5 coupler compared to ta wagon equipped with screw couplers (this means the benefits of using Automatic Couplers must exceed these levels in order to reach a positive business case for Automatic Couplers). Put in relation to a leasing cost of e.g. 25 EUR / wagonday for a freight wagon the increase would be between ca. 12% and 25%.

5. CBA-MODEL

In order to carry out cost-benefit-analyses of Automatic Couplers an excel-based model has been developed. The model calculates the cost impact of the use of Automatic Couplers in concrete transport chains.

The model takes into account the (direct or indirect) cost effects (benefits) of Automatic Couplers on the following processes:

- Shunting
- Marshalling (humping)
- Coupling process
- Uncoupling process
- Full brake test
- Simplified brake test
- Generation of train composition list
- Train movement (speed)

The selection of the above processes was made with a view on the availability of data and the possibility to allocate the benefits to specific transport chains.

As has been pointed out in chapter 2 already, there may be further – especially indirect – benefits of Automatic Couplers, such as for example the possibility to remove trackside-equipment for the control of train integrity or the possibility to introduce condition-based maintenance of freight wagons through real-time monitoring of the wagon condition. While these effect may be important they are also connected to a high level of uncertainty regarding the assumption to be made, to certain difficulties to obtain input data and there are also certain methodological challenges to allocate such benefits to specific transport chains. It should be mentioned that in Shift2Rail research projects are ongoing to tackle these areas. When the results of these projects are available, it might be worth to include these effects in the CBA-model. However, with the above selection of processes on which the use of Automatic Couplers has a direct or indirect effect, already a substantial part of the benefits of Automatic Couplers is supposed to be covered. Further, when analyzing the results of the calculations it became clear that already with the inclusion of the above effects a positive business case for Automatic Couplers could be demonstrated. This was a further reason to refrain from the inclusion of additional cost effects with high uncertainties and a weaker basis for quantification.

The model allows the design of transport chains involving up to six nodes and linked with up to five transport “segments”. Each node is a terminal, marshalling yard, loading site or similar location, where stationary processes take place. Each segment is a (train) movement between two nodes. Each node can be of different character, i.e. one node can represent a terminal, the next a marshalling yard and the next one an industrial spur with a loading/unloading site.

The cost effects are calculated for a transport of a wagon or group of wagons in the transport chain. The trains are for each segment individually described by their length and the number of wagons (i.e. the wagon or wagon group for which the calculation is made can be conveyed in trains of different size in each segment).

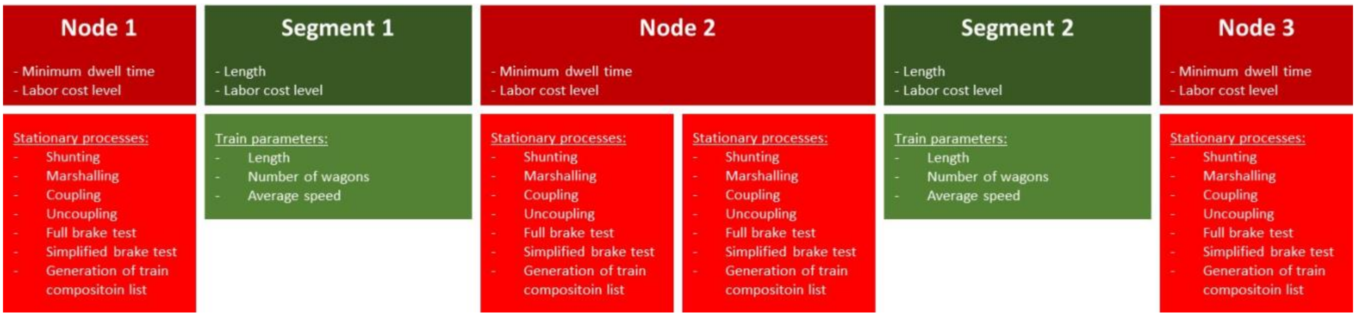

Figure 3: Example of a transport chain as it can be build in the CBA-model. This transport chain involves three nodes and two segments; the model allows to build transport chains with up to six nodes (i.e. up to five segments).

Each calculation involves by default six scenarios:

1) Base scenario – use of screw couplers
2) Development scenario – use of Automatic Couplers Type-1
3) Development scenario – use of Automatic Couplers Type-2
4) Development scenario – use of Automatic Couplers Type-3
5) Development scenario – use of Automatic Couplers Type-4
6) Development scenario – use of Automatic Couplers Type-5

The model calculates for each development scenario the difference in costs and benefits in relation to the base scenario. This means, the model is not a full-fledged transport cost model but allows to to calculate whether the use of Automatic Couplers – and of which type of Automatic Coupler – leads to an improvement of the business case or not compared to the use of screw couplers. If the benefits, i.e. cost savings are higher than the costs, then the business case for Automatic Couplers is positive.

Some assumption had to be made to allocate the costs for Automatic Couplers to concrete transports. This is done by breaking down the annuities of a wagon in a first step to wagon days (assuming a certain number of total "productive" wagon days per year) and calculating for each transport chain the number of wagon days "consumed" in that transport chain. The annuities have been calculated based on the investment costs indicated in chapter 4, a writing-off period of five years and an interest rate of 2,5%.

6. RESULTS

6.1 TRANSPORT CHAINS

This chapter show the results of the cost-benefit-analyses for two transport chains, one transport chain in the wagonload system and one transport chain in an intermodal shuttle system.

The wagonload transport chain looks as follows:

- Number of nodes: 6
- Number of transport segments 5
- Number of nodes with shunting: 4
- Number of nodes with humping (marshalling yards): 2
- Total length of transport chain: 1.200 km
- Train size:
    - Main runs: 35 wagons
    - Local trains: 15 wagons
    - Last-mile runs: 5 wagons
- Total transport duration: 3 days
- Labor cost levels: HIGH + LOW (two scenarios)

The intermodal transport chain (rail part) looks as follows:

- Number of nodes: 2 x 2 (out & return)
- Number of transport segments 2 x 1 (out & return)
- Number of nodes with shunting: 2 x 2 (out & return)
- Number of nodes with humping (marshalling yards): 0
- Total length of transport chain: 2 x 750 km = 1.200 km (out & return)
- Train size:
    - Main runs: 32 wagons
- Total transport duration: 2 x 1 day (out & return)
- Labor cost levels: HIGH + LOW (two scenarios)

6.2 RESULTS FOR A TRANSPORT CHAIN IN WAGONLOAD TRAFFIC

The below diagrams show the results for the transport chain in wagonload traffic.

For each of the Automatic Coupler types (1-5) the additional cost per transport is shown with a red bar, the cost savings with a green bar and the net cost effect with a blue bar. The black line shows the ratio between costs and benefits. If the ratio is above 1 the net effect is positive, i.e. it indicates a positive business case, otherwise it is negative.

The first two diagrams, figures 4 and 5, show the results for high labor-cost levels. The first of these diagrams shows all cost effects included (i.e. those listed in chapter 5). As can be seen all coupler types show a positive business case, however, it is clearly visible that the cost-benefit ratio is remarkably better with Types 4 and 5!

This is due to the fact, that first an automation level from Type 4 upwards allow a data transmission along the train, paving the way for automation of further processes beyond coupling and uncoupling. The diagram also shows that the net cost effect increases (i.e. cost savings increase) from Type 4 to Type 5, the latter allowing even automatic uncoupling. The cost-benefit ratio, however, remains on the same (high) level, since also the costs for this automation level are higher.

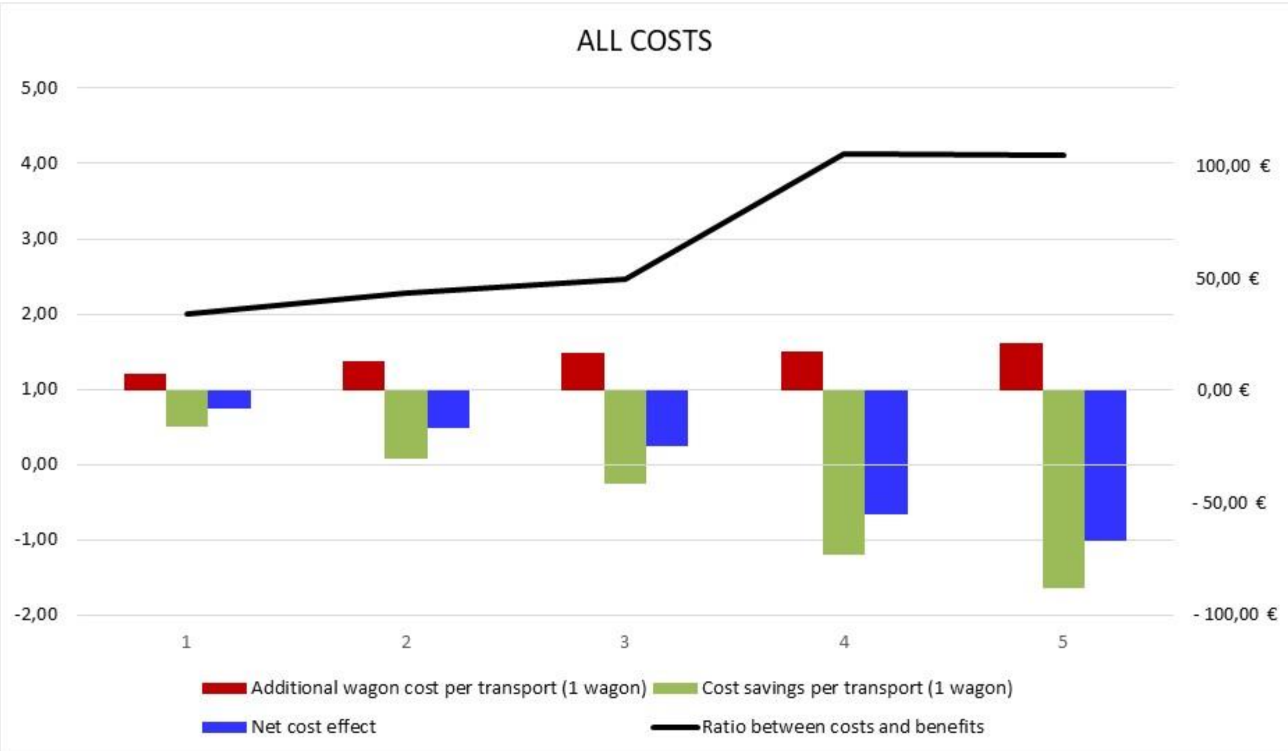

Figure 4: Results for a transport chain in the wagonload system with high labor-cost levels, all cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

Figure 5 shows the results for the same transport chain as above, but with low labor cost levels. As can be seen are the cost effects here much lower, especially for the Type-4 and Type-5 couplers, compared to the high-cost scenario. However, even here Type-4 and Type-5-couplers show a better cost-benefit-ratio than the lower automated couplers! For the Type-1 to Type-3 couplers the cost-benefit-ratio is neutral or even very slightly below 1.

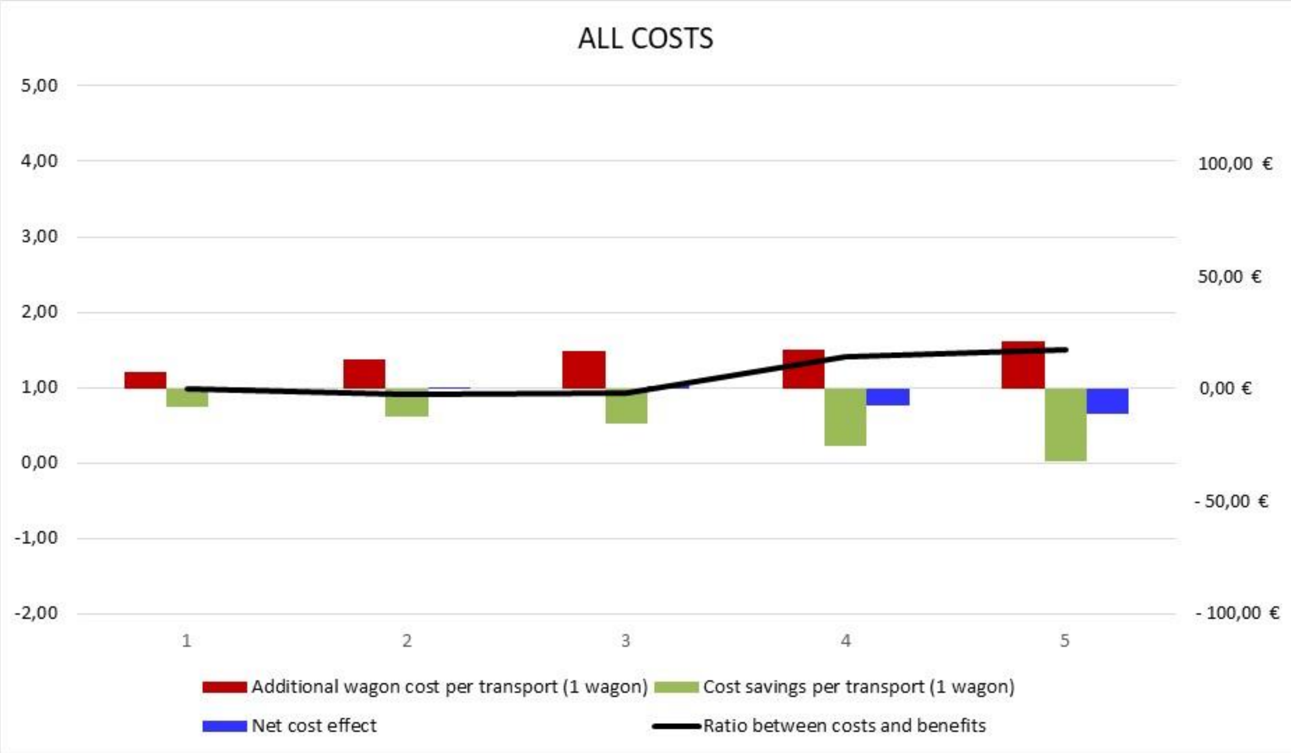

Figure 5: Results for a transport chain in the wagonload system with low labor-cost levels, all cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

The importance of the indirect cost effects of Automatic Couplers is also confirmed, when looking only at the cost effects for coupling and uncoupling, i.e. disregarding all other effects (figures 6 and 7).

Even when only looking at the effects on coupling and uncoupling costs the benefits and also the net effect grows with an increased automation level, however, the cost-benefit ratio remains rather unchanged and is on a similar level for highly automated couplers as for low-automated couplers. Nonetheless, it deserves attention that the cost-benefit ratio is still positive for all coupler types, at least in a market environment with high labor-cost levels.

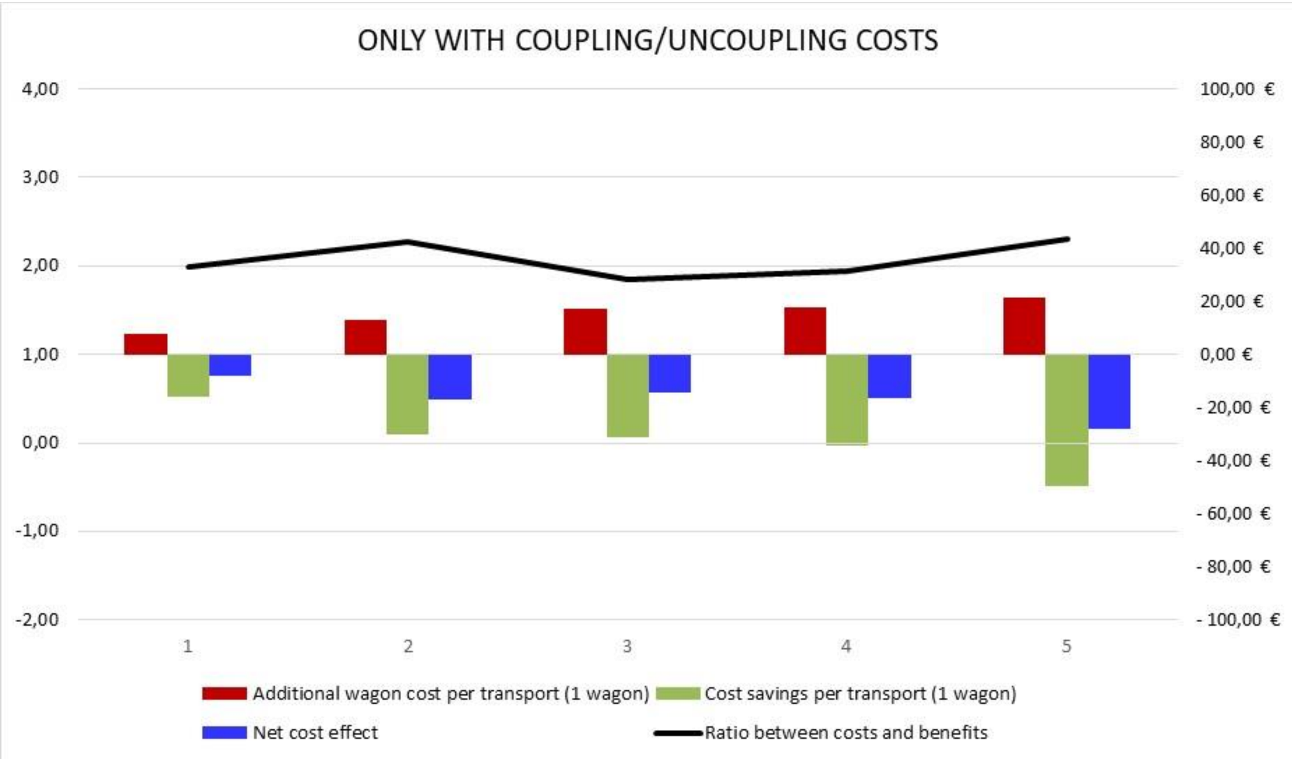

Figure 6: Results for a transport chain in the wagonload system with high labor-cost levels, only coupling and uncoupling cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

When looking at the business case for Automatic Couplers, only taking into account the effects on coupling and uncoupling costs, in a market environment with low labor-costs, however, it appears to be difficult to achieve a positive business case. This is true for all coupler types. As figure 7 shows, the cost-benefit ratio is in best case neutral, or even slightly below 1.

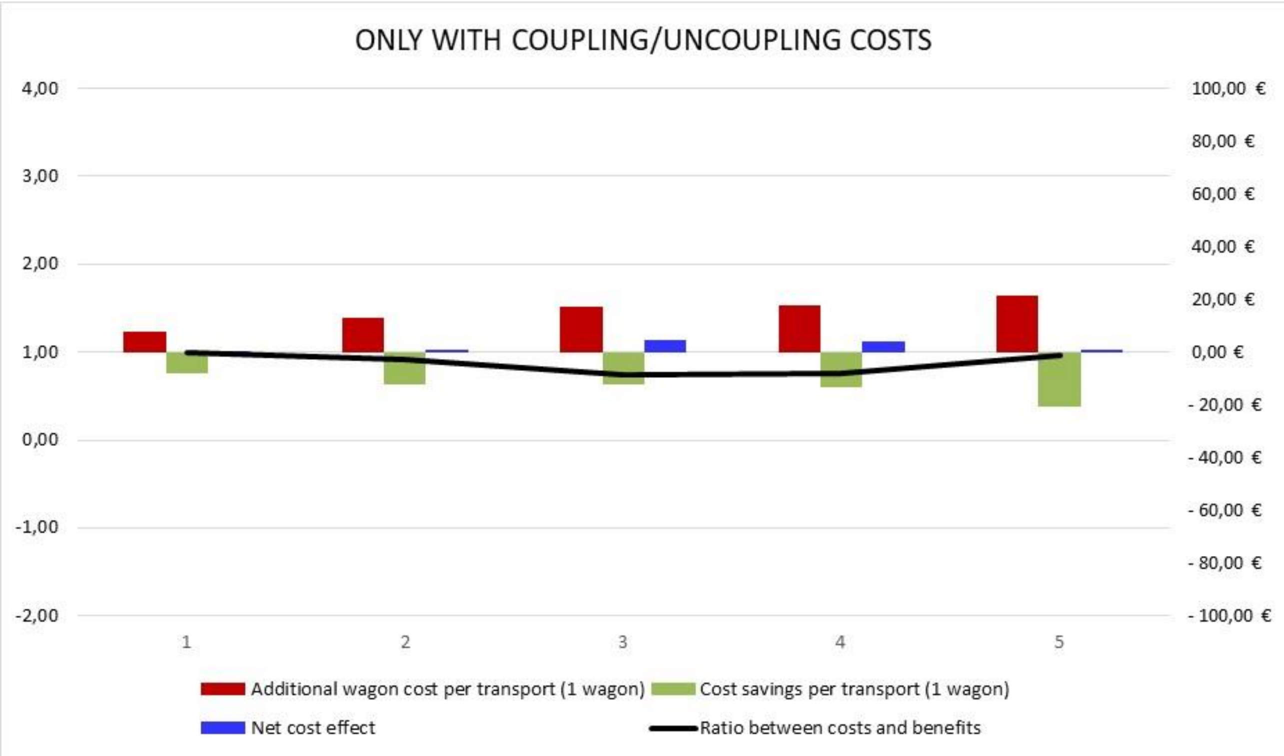

Figure 7: Results for a transport chain in the wagonload system with low labor-cost levels, only coupling and uncoupling cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

6.3 Results for a transport chain in Intermodal Traffic

The below diagrams show the results for the transport chain in intermodal traffic, as described in chapter 6.1.

The first two diagrams show even here the results taking into account all cost effects (as listed in chapter 5). Though the transport chain is of very different character, the results actually show a similar pattern as for the wagonload transport chain. The benefits and net cost effects increase with higher automation levels, with a clear "jump" between Type-3 and Type-4-couplers. The cost-benefit-ratio for Type-4 and Type-5 couplers is certainly (in the high-cost scenario) not fully as high as in the wagonload transport chain, however, achieves still very good values.

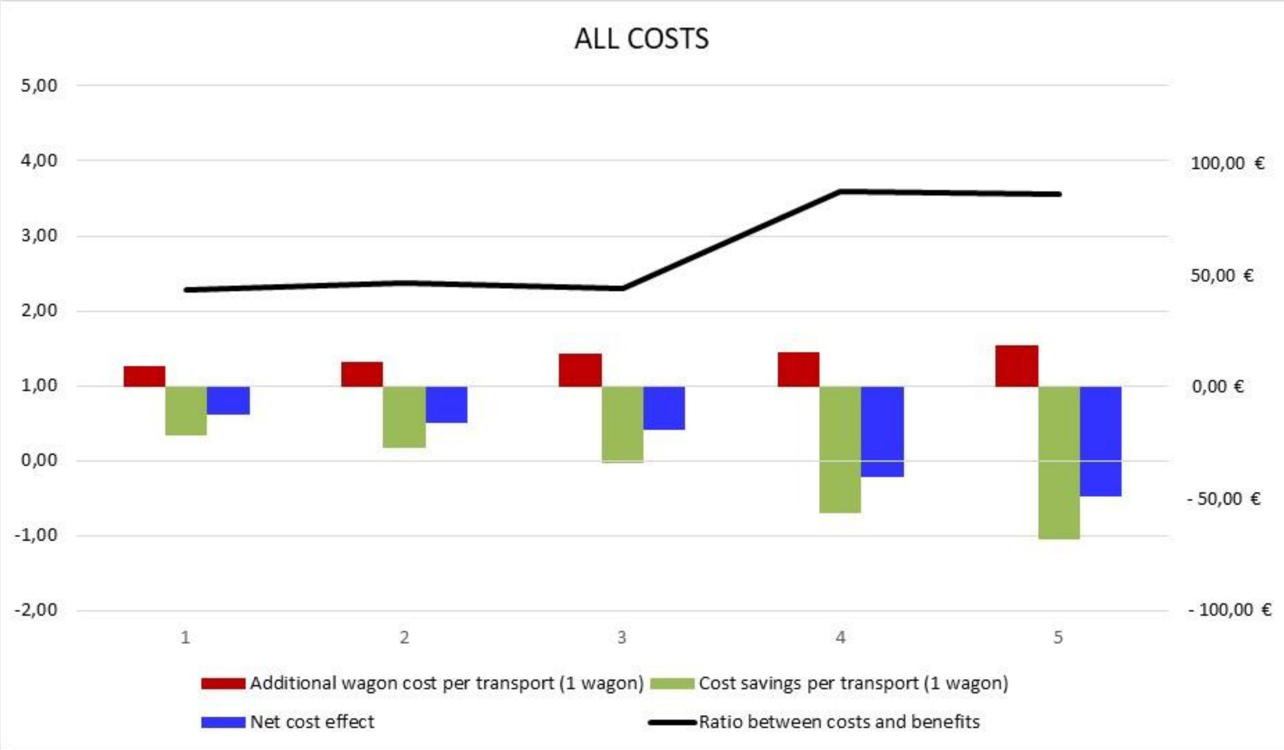

Figure 8: Results for a transport chain in intermodal traffic with <u>high</u> labor-cost levels, all cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

When looking at the same transport chain in a market environment with low labor-costs the patterns look even here quite similar to those seen in the wagonload transport chain. However, to note here is that the cost-benefit ratio still is slightly positive (while it has been neutral or slightly negative in the wagonload transport chain). This can be explained by the fact that the turnround-time of the wagons in intermodal traffic is shorter, i.e. though the transport chain as such involves fewer processes, the number of processes in a given time period is not necessarily lower.

Figure 9: Results for a transport chain in intermodal traffic with low labor-cost levels, all cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

When looking at the same intermodal transport chain and only looking at the effects on coupling and uncoupling costs, the results show, that all coupler-types still show a positive cost-benefit ratio in a market environment with high labor-costs (figure 10), but in a market environment with low labor costs the cost-benefit ratio is slightly positive only for the lower automation levels and neutral for the higher automation levels (figure 11).

Here one can see a slight difference to the situation in wagonload traffic, where the cost-benefit-ratio of higher automated couplers was rather equal or slightly higher for higher automated couplers, while in this intermodal transport chain the higher-automated couplers tend to show a slightly lower cost-benefit ratio.

However, it is worth to mention that the ratio is still neutral, i.e. the additional costs for (even higher-automated) couplers are compensated by the reduction of costs in the coupling and uncoupling process alone already, even in a market environment with low labor cost. But it should be emphasized that this business case is very cost-sensitive, i.e. with higher costs for the Automatic Couplers the cost-benefit-ratio would be below 1, i.e. there would likely be no positive business case for Automatic Couplers any longer.

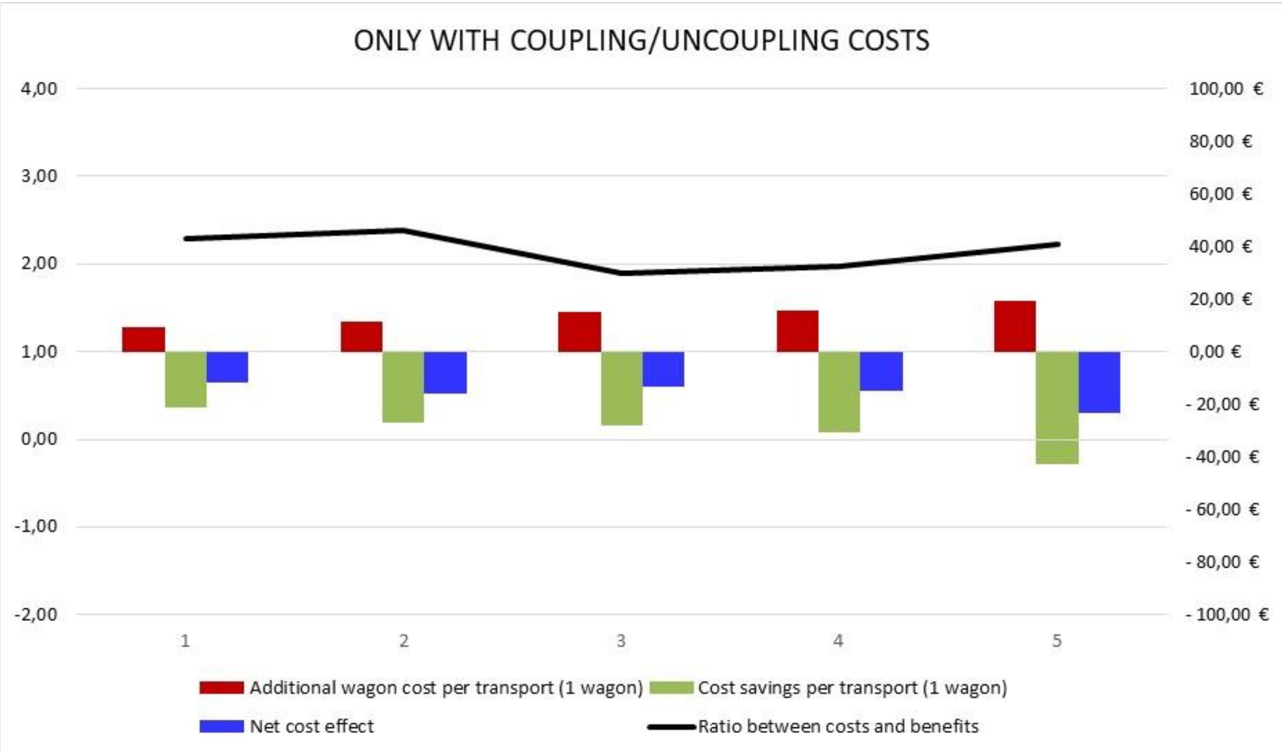

Figure 10: Results for a transport chain in intermodal traffic with <u>*high*</u> *labor-cost levels, only coupling and uncoupling cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.*

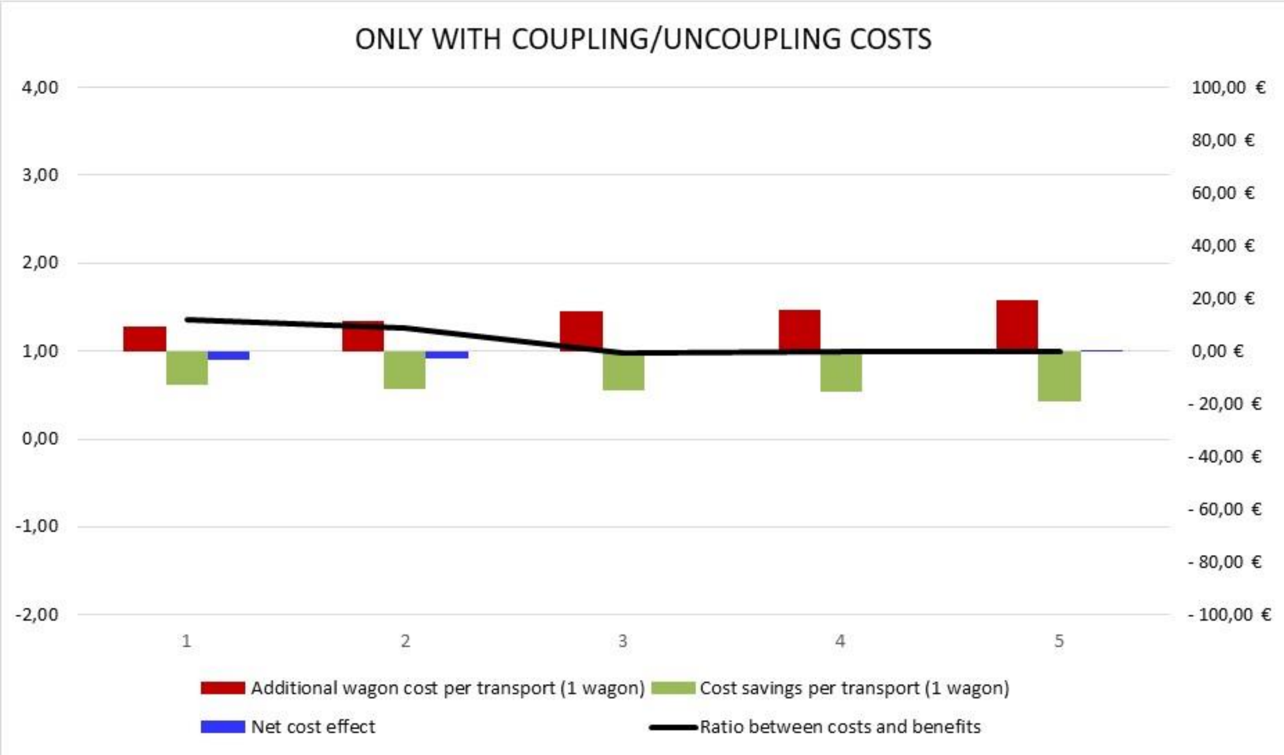

Figure 11: Results for a transport chain in intermodal traffic with low labor-cost levels, only coupling and uncoupling cost effects included. The red bars indicate additional costs, green bars cost savings, blue bars the net cost effect and the black line the cost-benefit ratio.

7. POSSIBILITIES TO STRENGTHEN THE BUSINESS CASE FOR AUTOMATIC COUPELRS

The cost-benefit model used for the analyses in this report does not take into account a number of possibilities to strengthen the business case for Automatic Couplers.

There are a number of measures which could be taken to do so, both technical measures as well as policy measures, such as:

- “Short-coupling” of wagon-groups, e.g. of 2-5 wagons, with Automatic Couplers only at the ends and (cheaper) draw-bars connecting the wagons within the group.
- Setting up of cost-benefit sharing models, to create incentives for those market actors directly bearing the cost for retrofitting or equipping wagons with Automatic Couplers. One element to be considered in this context could be differentiated track access charges, which would allow infrastructure managers to encourage train operators to deploy Automatic Couplers. The infrastructure managers will in the long term benefit from increased line capacity and reduced infrastructure needs (e.g. equipment for lineside control of train integrity).
- Co-funding migration to Automatic Couplers with help of various financial instruments, such as
    - Grants (e.g. from the CEF)
    - Low-interest loans (e.g. from the EIB)

  Such financial contribution could be justified by the (indirect, but potentially important) benefits Automatic Couplers can give for society, by facilitating modal shift to rail and thus helping to achieve key objectives in climate and environmental policy.

The European Commission has already in the past recognized the importance of Automatic Couplers and included e.g. in the CEF Transport Annual Call 2014 under the priority “Freight Transport Services” the possibility to co-fund (i.a.) Automatic Couplers:

“The following types of proposed Actions will be funded under this Priority:
(…)
Small-scale technical improvements increasing the efficiency of the transport operations and use of infrastructure capacity: use of technical solutions already available on the market leading to reducing emissions, energy use and fuel consumption of vehicles/vessels (e.g. vehicle traction control systems, such as equipment for remote control of locomotives in freight trains with distributed power, IT support tools, calibration of vehicle routing and scheduling, aerodynamic tools, speed management systems, automatic couplings in wagons).”

The table below presents suggestions for key principles for a possible design of future European or national support programs for the introduction of Automatic Couplers. It would be highly recommended that any such programs are co-ordinated between European and Member State level respectively between Member States.

Retrofitting of legacy fleet	New wagons
• High co-funding rate, e.g. 90% (material & work costs) • Long-term program – e.g. two EU Financial Periods (=8 years)	No permanent support for AC deployment ! But: Funding for 'early deployers' : • High co-funding rate, e.g. 80%, for first 10.000 wagons • Medium co-funding rate, e.g. 55%, for next 30.000 wagons • Low co-funding rate, e.g. 30%, for final 60.000 wagons

Table 3: Design principles of possible support programs for the introduction of Automatic Couplers.

8. CONCLUSIONS AND RECOMMENDATIONS

This report shows cost-benefit-analyses for Automatic Couplers with different automation levels, from Type-1 couplers to Type-5 couplers, in two different transport chains with very different characteristics (wagonload and intermodal) and for market environments with high as well as low labor-cost levels.

The results indicate:

1) that there is a very positive (and at least neutral) business case for Automatic Couplers in most cases

2) that the business case (cost-benefit-ratio) improves strongly when going from Type-3 to Type-4 couplers (or higher), jumping from a cost-benefit ratio of 2,0-2,5 for Type-1 to Type-3 couplers to 3,0-4,0 for Type-4 and Type-5 couplers (in wagonload traffic even >4,0)

3) that the indirect benefits of Automatic Couplers (i.e. their enabler- and facilitator-role for process improvements beyond the coupling and de-coupling process) are important

4) that at least neutral and sometimes slightly positive business case can be achieved for Automatic Couplers – even for the higher-automated coupler types – even in a market environment with low labor costs.

5) that Automatic Couplers in none of the cases show a strongly negative business case

At the same time it must be highlighted that the cost-benefit ratio in market environments with low labor-costs is relatively sensitive to the cost of couplers. The results indicate that it is still possible to achieve a slightly positive business case for Automatic Couplers even under these conditions (even of higher-automated versions) with the cost levels of the couplers used in the calculations, however the results will likely be different if the cost for the couplers would be significantly higher.

For the future it should be considered to evaluate more transport chains, but also to improve the model and include effects currently not yet covered by the model. This may become possible with the results of other Shift2Rail-projects becoming available. However, there will be a substantial need to collect input data in order to allow these effects to be calculated with a reasonable level of accuracy.

Regarding the deployment of Automatic Couplers it would be recommendable to aim at an automation level realized with the Type-4 couplers and higher, since it is first the data transmission capability of the couplers which strongly facilitates a larger-scale automation in rail freight. For that reason it must be a priority to make sure that a coupler with this automation level and with a satisfying long-term performance and reliability can be provided.