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BERATEN PLANEN UMSETZEN

Study on unaccompanied combined transport of semitrailers through Switzerland

- Final report -

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1 Background and objectives

Switzerland is investing billions into the development of the two transalpine rail corridors, the Lötschberg and Gotthard routes. Both corridors are of exceptional importance for Unaccompanied Combined Transport (UCT) between Italy and Central, Northern and Western Europe, and the networking effect makes them equally crucial to the entire intermodal system in Europe. It is planned to open the NEAT, the New Railway Link through the Alps, in 2016 on completion of the Gotthard Base Tunnel. This will make substantial additional transport capacity available for traffic through Switzerland, including UCT in particular.

If, however, the feeder routes to the major CT terminals in the Milan area have not been upgraded appropriately by this time, it will not be possible to exploit the full capacity of the Gotthard line. This applies not only to route capacity as such, but also – and chiefly – to the loading gauge, which currently does not allow the transportation of semitrailers with a height of four meters, in contrast to the situation on the Lötschberg axis where limited line capacity is available.

Given the growing importance of semitrailers in European UCT (for which they are transported on "pocket wagons"), in transportation logistics generally and especially in transalpine transit traffic through Switzerland, the perpetuation of infrastructure-related restrictions would not merely limit the possibilities for transferring this traffic to UCT, but would largely prevent such a transfer. This is because except for road tankers and vehicles used to transport heavy-weight goods the overall height of the vast majority of all standard curtainsider or box-type semitrailers is four meters.

The costs of upgrading the southern feeder route to the Gotthard Base Tunnel, including widening of the loading gauge, are estimated at approximately CHF 940 million according to current studies of the Bundesamt für Verkehr (BAV), the Federal Office of Transport. Of these costs, Swiss experts estimate that about 30% will be due to measures aimed at improving passenger transportation by rail (see also section 5.).

Various potential solutions were tabled over recent months in order to solve the gauge problem. These involve new transhipment systems which focus on wagon technology in particular. They include the CargoBeamer system, which is currently operating on a test basis in Germany, and two variants of the Modalohr technology. In addition to its horizontal loading system for semitrailers which is already used commercially in France, the Lohr company has introduced what is known as a "UIC version" of its Modalohr technology. This should enable craneable semitrailers with a height of four meters to be transported in spite of gauge restrictions.

Given this background, the **objectives** of the study whose results are now published in this report were to analyse the system costs of the potential "CargoBeamer", "Modalohr Horizontal", "Modalohr UIC" and "UCT with pocket wagon" solutions, and ultimately to assess with which technology or technologies the modal shift objective stipulated by the Swiss constitution could be met in the most cost-effective manner.

2 Analysis of transalpine goods traffic in Switzerland

Transalpine goods traffic through the Swiss Alps grew by about 60% between 1994 and 2010. Over the same period, Unaccompanied Combined Transport by rail improved by 136.5%, thereby increasing the volume transported from 6.3 to 14.9 million net tonnes. This corresponds to an average annual growth rate of 5.5%. Due to this more than proportionate growth, UCT increased its share of transalpine goods traffic from 26.1% to 38.8% in the relevant period. This corresponds to a gain of almost 50% in market share (see figure 2-1).

The same is true of transalpine goods transport by road. With a volume of 6.2 million net tonnes in 1994, this transport category started out from almost the same position as UCT. Although its growth progressed differently, the volume transported by truck (14.3 million tonnes) was almost equal to the level for UCT again in 2010. On the other hand, wagon-loaded transport became less important in both relative and absolute terms. Within 16 years since 1994, its market share fell from 44% to only just over 19% in 2010.

Figure 2-1: Transalpine goods traffic in Switzerland by modes of transport: 1994, 2000-2010

Year	Road	WLT	ACT	UCT	Total	% share UCT
	(Million net tonnes)					
1994	6,2	10,6	1,0	6,3	24,1	26,1%
2000	8,9	10,5	1,0	9,0	29,4	30,6%
2001	10,8	10,7	1,0	9,1	31,6	28,8%
2002	10,7	8,8	1,1	9,4	30,0	31,3%
2003	11,4	8,8	1,5	10,2	31,9	32,0%
2004	12,5	8,9	1,8	12,2	35,4	34,5%
2005	12,8	8,5	1,9	13,3	36,5	36,4%
2006	12,8	8,5	1,9	14,8	38,0	38,9%
2007	14,0	8,3	1,9	15,1	39,3	38,4%
2008	14,4	8,8	1,8	14,8	39,8	37,2%
2009	13,4	6,4	1,8	12,7	34,3	37,0%
2010	14,3	7,4	1,8	14,9	38,4	38,8%

WLT = Wagonload traffic
ACT = Accompanied Combined Transport
UCT = Unaccompanied Combined Transport

Source: BAV: Verlagerungsbericht 2011. Dienst GVF: Alpinfo 1994. KombiConsult-Berechnungen

According to the BAV, the number of heavy trucks used for transalpine transportation rose by well over 70% from 732,000 journeys in 1990 to 1,257,000 journeys in 2010. The total number of vehicles recorded includes road trains and articulated vehicles as well as single trucks (lorries). The last category, whose volume has mostly fluctuated around a figure of about 200,000 journeys over the last two decades, can be disregarded in the following analysis because it will hardly be possible to transfer these vehicles and their movements to UCT, as is already the case at present. Specific Rolling Motorway (RoMo, RoLa) offerings might be suitable for this purpose under certain circumstances; alternatively, the number of journeys could be reduced with the help of appropriate incentive systems.

If we only consider road trains and articulated vehicles in the light of this information, it becomes apparent that their traffic volume more than doubled in the 1990-2010 period, with an increase from 0.52 to 1.06 million vehicles (+104%). The Gotthard route, with a share of about 80%, is the axis with the largest volume of transalpine traffic through Switzerland. Its growth was even stronger, with an increase of 109% (see figure 2-2).

Figure 2-2: Transalpine goods transport by road in Switzerland by vehicle categories, 1990-2010

Year	Gotthard corridor				Total transalpine traffic in Switzerland			
	Road trains	Articulated vehicles	Total	% articulated vehicles	Road trains	Articulated vehicles	Total	% articulated vehicles
1990	195.000	193.000	388.000	49,7%	265.000	254.000	519.000	48,9%
1995	252.000	398.000	650.000	61,2%	301.000	465.000	766.000	60,7%
2000	318.000	559.000	877.000	63,7%	366.000	664.000	1.030.000	64,5%
2005	259.000	547.000	806.000	67,9%	316.000	714.000	1.030.000	69,3%
2010	245.000	564.000	809.000	69,7%	303.000	758.000	1.061.000	71,4%

Source: BAV: Güterverkehr durch die Schweizer Alpen 2010. KombiConsult calculations

The volume of traffic of articulated vehicles and road trains was about the same until 1991. This was true of the Gotthard axis and of overall transalpine transport in Switzerland. Since 1992, the modal split between the two vehicle categories has changed abruptly in favour of articulated vehicles. According to our assessment, a combination of the following factors was key to this change:

- Changes in logistics processes following the liberalisation of goods transport by road in the EU since 1985.
- Substantial demand for transport capacity was created following the collapse of the Iron Curtain and the integration of the Eastern European countries into a European goods supply structure. This demand could be met most rapidly and efficiently by semitrailer combinations.

- Articulated vehicles have more favourable driving dynamics than road trains, and it is also considerably easier to manoeuvre them in reverse. This meant that even drivers with little practical experience were able to cope with these vehicles.

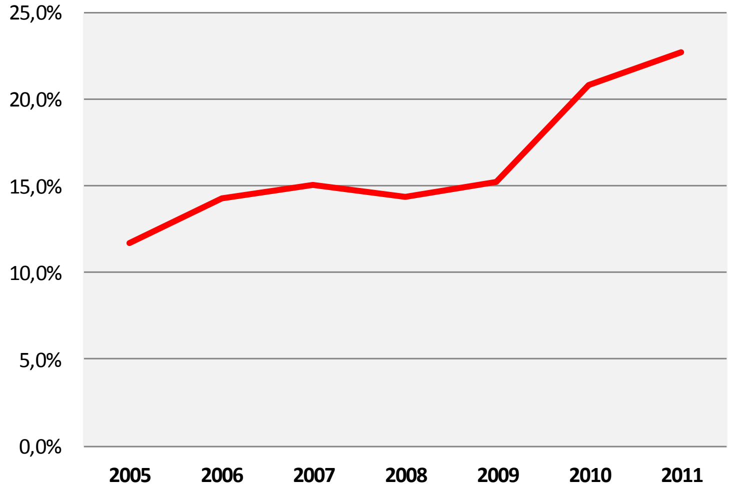
Over the last 20 years, further developments in goods traffic and logistics have contributed to this triumphant advance of the semitrailer throughout Europe (see section 4). Accordingly, the structure of transalpine goods transport by road in Switzerland, where the market share for articulated vehicles had increased to about 70% by 2010, clearly reflects the developments in Europe as a whole.

3 Analysis of Unaccompanied Combined Transport

At first sight, the share of semitrailers of the total UCT volume – both in Switzerland and as a proportion of the total volume of CT in Europe – is well below the percentage share of articulated vehicles in road transport. However, a comparison of this sort falls short of the mark, because one key advantage of UCT is specifically that a forwarder is able to tranship only the truck structure required for the relevant cargo onto the railway − in the form of a swap body or container – without needing to have the axle unit transported. During pre- and post-haulage by road, however, the majority of intermodal loading units are conveyed by articulated vehicles. Therefore this ratio provides the real basis for a comparison with the fleet structure in the road freight transportation sector.

Regardless of this, the number of craneable semitrailers that are transported in continental UCT in Europe has also been increasing for a good ten years now. This is confirmed by an analysis of UCT in Germany. The share of semitrailers in the volume of UCT in Germany was in continuous decline until the end of the 1990s, but a "renaissance" of the semitrailer has materialised over the last ten years or so, both in national and international transport. Between 2005 and 2011, the semitrailer's market share of continental UCT in Germany almost doubled, with an increase from 11.8% to 22.7%, and the volume grew by 186% from 137,000 to 392,000 semitrailers (see figure 3-1).

Figure 3-1: Percentage share of craneable semitrailers in continental UCT in Germany 2005-2011 (excluding transit traffic)



Source: KombiConsul, based on Destatis

This burst of growth is due not only to the aforementioned reasons related to logistics and vehicle technology but also, and mainly, to the improved possibilities for using craneable semitrailers in UCT which have the same capacity as a semitrailer that is only used on the road. Two factors were decisive here: the development of pocket wagons that can be used to transport megatrailers with an interior height of 3 meters, and the widening of the permitted loading gauge for major international rail routes to at least P 400. The last-mentioned improvement to the infrastructure definitely played the key part here, and the connection can be clearly demonstrated by reference to the example of the Brenner corridor.

In 1999, semitrailers accounted for about 17% of all shipments in transit through Austria from and to Italy but by 2008, their market share had risen to 28%. During the same period, the semitrailer volume grew by over 500%, whereas the total volume of UCT on this axis increased by "only" 300%. According to our market analyses, the percentage of semitrailers is likely to have soared to approximately 35-37% by 2011. The impetus for this more than proportionate growth was definitely the increase of the loading gauge from P45/P375 to P70/400 in 2000.

By comparison, the semitrailer currently plays a considerably smaller part in continental UCT through Switzerland:

- In the Gotthard corridor, on which P50/P380 is the maximum available loading gauge, semitrailers in UCT between Germany and Italy only accounted for some 14% of the total volume transported in 2010. However, the CT operators were able to increase the usable gauge to P56/P386 by developing modern pocket wagons, which have a loading platform for semitrailers that is 60 mm lower than the UIC gauge.
- On the other hand, the percentage of craneable semitrailers in the Lötschberg corridor − which offers gauge P 400 for a limited number of SIM (Simplon Inter-Modal) train paths – should be significantly higher, although no comprehensive statistics were available for this study. According to information from some CT operators who use SIM paths, semitrailers account for up to about 50% of their route-related transport volume.
- If the other traffic handled in transit through Switzerland between Italy and the Benelux countries and Northern Europe is also included in the consideration, the total market share of semitrailers in continental UCT in Switzerland is probably of the order of about 17-18%.

The above analysis shows that – despite comparable goods structures in transport to and from Italy through Switzerland and Austria – the CT customers in the Brenner corridor use semitrailers about twice as often as they do for transit through Switzerland. The causal link with the higher loading gauge, which can compete with road trucks, is obvious.

4 Comparison of the existing UCT technology with new transhipment systems

For the purposes of the following analysis key performance indicators (KPI) and system costs of new transport and transhipment technologies and of the existing UCT technology (UCT as-is state) were elaborated and compared. The investigation assumed identical overall and operational conditions or - if not applicable owing to specific features of the system in question - comparable conditions. In order to obtain the most comprehensive possible picture of alternative transhipment systems the following technologies were included in the study:

- Existing UCT technology for craneable semitrailers (short: UCT as-is state)
- CargoBeamer technology (CargoBeamer)
- Modalohr technology for horizontal transhipment (Modalohr horizontal)
- Modalohr technology for vertical transhipment (Modalohr UIC)

To make this comparison of systems more understandable, the newly developed technologies will first be presented in brief, with explanations of their main components. A description of the existing UCT technology is not required because it may be assumed that its system characteristics and modes of functioning are generally known.

4.1 Presentation of new technologies

The suppliers of the **CargoBeamer** technology state that the target market is the transport of non-craneable semitrailers.[1] Accordingly, this system is designed as a horizontal transhipment process with two main system components (see figure 4-1):

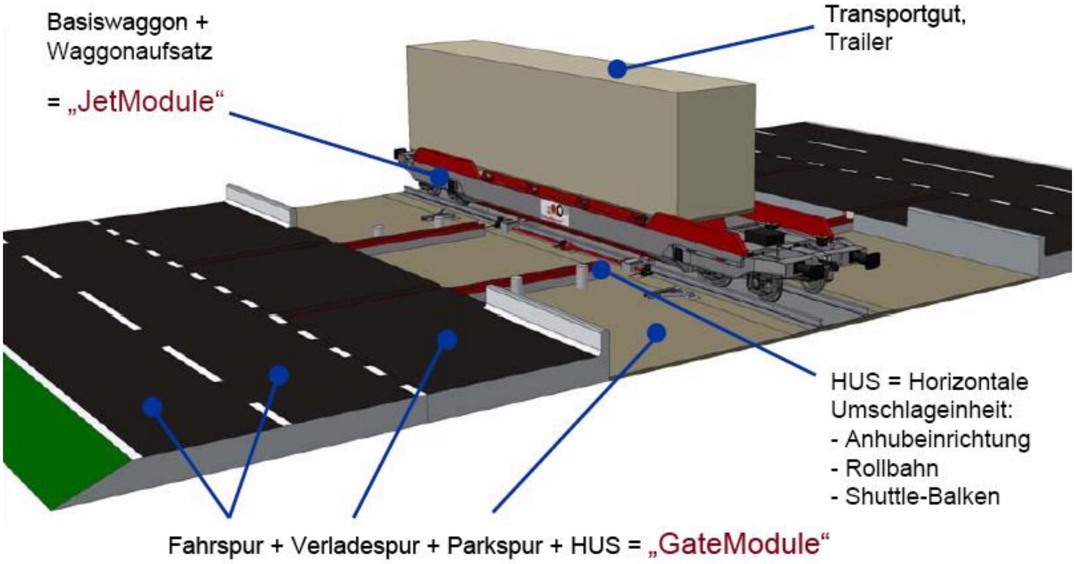
- The transhipment module comprises a centrally positioned transhipment track, two road lanes on both sides of the track as well as a loading and parking lane, and fixed-position horizontal transhipment units (HTU/HUS) with the following

[1] Of course, craneable semitrailers can also be transhipped.

components: wagon centering mechanism, lifting device, roller conveyor and shuttle bar to transport the wagon baskets.

- The rail transport unit consists of a special wagon and a wagon basket, known as the Jet module or CargoJet, onto which the semitrailers are loaded.

Figure 4-1: System components of the CargoBeamer technology



Source: CargoBeamer

Semitrailer transhipment is intended to be automated and centrally controlled. This means that for inbound trains, all the wagon baskets are lifted simultaneously and moved transversely towards both sides as far as the loading lanes. The semitrailers can then be moved out by tractors which advance from the front. For outbound trains, semitrailers are pulled onto the wagon basket by tractors and are parked there. Once all the semitrailers have been loaded, the wagon baskets are moved into the wagon enclosure. According to information from the manufacturer, this should take place within ten minutes. Due to this procedure, it is necessary to position loading and driving lanes on both sides of the transhipment track in order to ensure sufficient manoeuvring distance for the movements of the articulated vehicles (see Figure 4-2).

Figure 4-2: CargoBeamer testing transhipment facility

Source: CargoBeamer

We assume that for regular operation, an "indirect" operating organisation will be selected whereby the road-side delivery or collection of the semitrailers is separated from the loading or unloading operations. This means that a parking area close to the gate is set up for semitrailers, and that terminal tractors (Tugmasters) provide transport between the parking area and the transhipment module. Apart from the fact that this increases the facility's performance capacity, the placement of semitrailer on the narrow wagon baskets can be carried out with greater safety and speed by experienced terminal staff than by external truck drivers. This has also been proved by the Modalohr service of Lorry Rail (see below).

Like the CargoBeamer system, the **Modalohr technology for horizontal transhipment** focuses primarily on the transport of unaccompanied, non-craneable semitrailers. In addition, at least for the pilot route between Bettembourg and Le Boulou, the system is designed so that semitrailers with a height of four meters can be transported with a P375/P45 gauge. Three measures were implemented to achieve this:

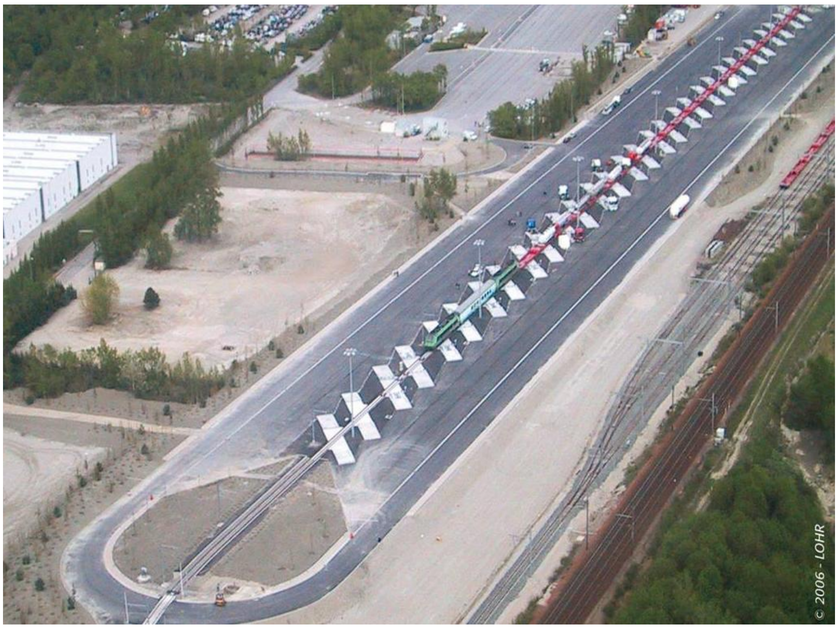
- Wagon technology: The loading platform for semitrailers is lowered to a height of approximately 205 mm above rail into the zone of the lower UIC gauge, which has otherwise to be kept clear.
- Infrastructure-related measures: To enable these wagons to operate in the first place, the lower UIC gauge was cleared on the pilot route, i.e. all operational or safety equipment installed in this zone had to be dismantled and moved away.
- Operational precautions (see details below).

The system approach and the components of the technology can be explained on the basis of the transhipment facilities built for the pilot route:

- The transhipment module consists of a centrally positioned transhipment track which is lowered in relation to the overall transhipment area; equipment to position the wagons and perform the transhipment; and parking areas for semitrailers (see figure 4-3).
- Six-axle articulated wagons of the type Modalohr NA are employed, which can carry two semitrailersTen of them are linked by fixed couplings to build a unit for one half of a complete train.
- The transhipment equipment comprises a lifting/swivelling system in the track bed to release the wagon pockets and to carry the vertical load. Each individual wagon-based transhipment unit is manually operated and controlled.

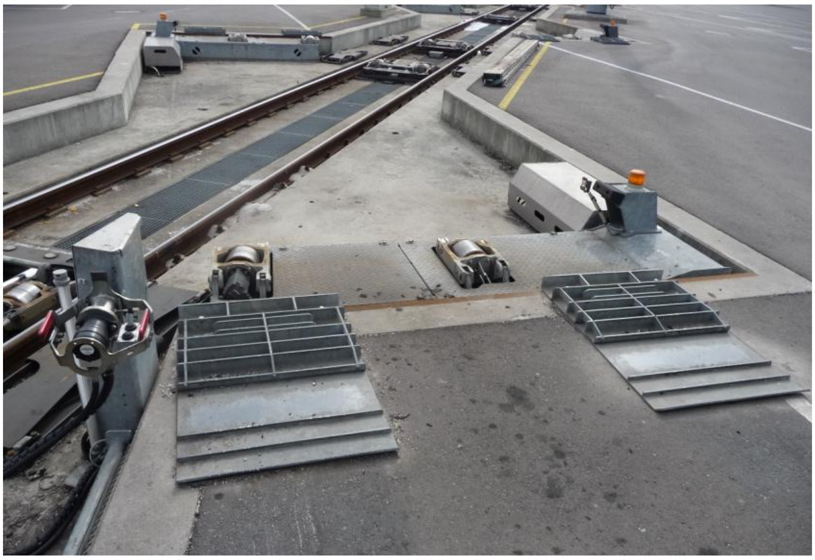
The wagons must be positioned precisely so that the wagon pocket can be lifted and rotated. Hydraulically powered support rollers rotate the wagon pocket into the end position, as far as the integrated limit stops. The wagon pocket is then positioned like a bridge between the two groups of support rollers (see figure 4-4). The loading and unloading of the semitrailers is carried out by Tugmasters (see figure 4-5). However, the customers place their semitrailers on a parking area in the transhipment module, or collect them from this area.

Figure 4-3: Transhipment facility for the Modalohr horizontal technology



Source: Lohr

Figure 4-4: Transhipment equipment for the Modalohr horizontal technology



Source: KombiConsult

Figure 4-5: Unloading a semitrailer with the Modalohr horizontal technology

Source: KombiConsult

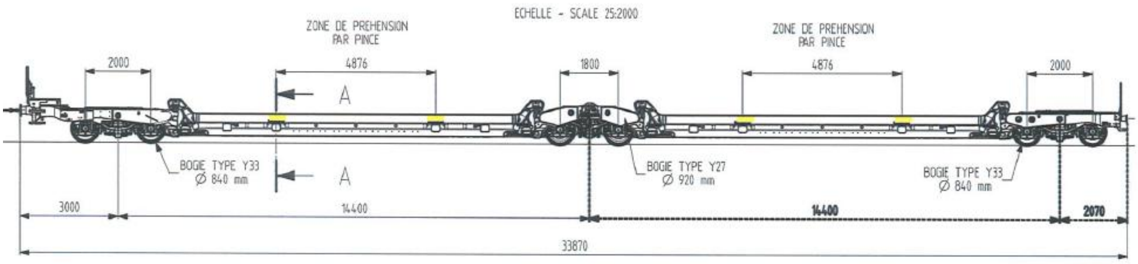
Figure 4-6: Securing the tarpaulin for the Modalohr horizontal technology

Source: KombiConsult

Since the Modalohr technology uses the loading gauge fully and leaving virtually any tolerances semitrailers – even if they are codified - have to be measured to ensure operational safety, even if they are codified. For the same reason, the tarpaulins of curtainsider-type semitrailers must be secured on the semitrailer with lashing straps (see figure 4-6). These two measures together take approximately 10-15 minutes.

So far, all that is known about the **Modalohr UIC technology** is the basic concept; it was presented in 2011 at the Transport Fair in Munich. With this technology, as with the current UCT, the vertical transhipment of craneable and codified semitrailers should be possible. The key component is a newly designed wagon of type Modalohr UIC (see figure 4-7), a development of the type Modalohr NA. Thanks to the new wagon technology and with the help of organisational measures in the terminal operation, the manufacturer states that a height gain of 160 mm is achieved as compared to the current pocket wagon. This (the manufacturer adds) ensures that semitrailers with a P400 coding can be transported through Switzerland and over the Gotthard feeder route via Chiasso, which has a P384 coding.

Figure 4-7: Double wagon of type Modalohr UIC



Source: Lohr

The key features of the type Modalohr UIC wagons are the ability to adjust the height of the pocket, the loading platform for semitrailers, and the supporting block, which receives the semitrailer's king pin. Depending on the weight of the semitrailer, the pocket can in fact be lowered or raised, and the supporting block can be adjusted accordingly so that the semitrailer rests firmly and in a fully horizontal position on the wagon. These measures are supposed to make sure that the available top loading gauge can be fully used without allowing for a tolerance as is the case with the pocket wagon.

In order to achieve this gain in height, provision must be made for the following processes in terminal operation - as far as is known at present - both for codified and non-codified semitrailers:

- All semitrailers must be weighed and measured accurately.
- If the pocket of a wagon has to be lowered or raised in order to comply with the bottom or top loading gauge, additional handlings are required. This action must be performed by the crane before the semitrailer can be accepted.
- Semitrailers must be loaded onto the wagons with extreme accuracy.
- Since the Modalohr UIC technology is intended to utilise the clearance gauge without any tolerance, we consider that measures will be required to ensure operational safety during rail transport. Tarpaulins on curtainsider semitrailers must be secured with lashing straps.
- As part of the technical inspection of wagons and trains, the contracted railway undertaking (RU) will also be obliged to repeat the measurement of wagons and semitrailers since responsibility for operational safety is transferred to the RU on handover of the train.

4.2 Comparison of technologies

In order to examine and compare all CT technologies it was assumed that each technology would be deployed in a **dedicated** system. This means that the relevant components, in particular the transhipment facility and rail transport, would be designed exclusively for the technology in question, and that there would be no "mixing" with other CT technologies. This requirement must be met in order to establish a uniform basis on which the CargoBeamer and Modalohr systems – which are designed exclusively for the transportation of semitrailers – can be compared with today's UCT technology.

Yet it must be pointed out that the logistics reality is actually more complex. Shippers' and forwarders' requirements for the type of transport equipment to be deployed are extremely varied; and, ultimately, this is also reflected in transalpine road freight and intermodal traffic through Switzerland. The existing UCT technology can match these requirements because of its open network and, thanks to the deployment of suitable rolling stock, it can handle and convey all types of swap bodies and containers − as well as semitrailers − using a standardised process.

Based on the assumption of dedicated systems the following key capacity and performance indicators were elaborated in order to arrive at a comparative assessment of the technologies:

- train capacity: the number of semitrailers which could be carried per train
- handling capacity of a transhipment facility
- space requirements and investment costs for a transhipment facility
- system costs for a terminal-to-terminal transport of a semitrailer

The basis for the analysis was provided by data from system manufacturers and/or operators, the KombiConsult database and knowledge base, and empirical values acquired during practice. Qualified assessments were undertaken in cases where no data or documentation was available in order to derive suitable performance indicators for certain new technologies.

4.2.1 Train capacity

In order to calculate the maximum possible loading capacity of a train for each technology, we began by making assumptions regarding the overall infra-structural conditions. According to information from SBB Infrastructure, it should be possible to operate CT trains with the following maximum parameters once the Gotthard Base Tunnel becomes operational: train weight of 2,000 t, and train length of 750 m. Assuming that one or two locomotives will be deployed, we derived the following parameters:

- Max. weight of wagon set: 1,800 t
- Max. length of wagon set: 700 m

We assume that the Italian feeder routes between CT terminals in the Milano area and the Gotthard Tunnel will also be upgraded to meet these train parameters by 2020. In principle, these parameters can already been realized on certain parts of the German rail network. In this regard, there should be no major restrictions on the north and south feeder lines to the Swiss rail network by 2020.

In addition, we referred to the following data, or made the following assumptions, in order to determine the system-specific train capacities:

- Load weight: a load weight of 20 tonnes was assumed as the average value across all freight groups and market segments. This is based on the following typical payloads for articulated vehicles and road trains respectively:
  - Groupage cargo and CEP (courier, express, parcel): 10 – 16 t
  - Packaged goods (automotive, chemicals, food): 18 – 22 t
  - Bulk, steel, paper, recycled materials and similar: 25 – 27 t
- Tare weight of semitrailers: manufacturers' data
- Tare weight of wagon: data from system providers and/or CT operators

The **capacity calculation** was carried out in three stages. The first step was to determine the maximum number of semitrailers, which could be moved in accordance with the above assumptions and in compliance with the maximum wagon set weight of 1,800 tonnes (see figure 4-8). The second step was to verify whether the capacities calculated hereby comply with the maximum wagon set length of 700 meters if the system-specific wagons were employed. It emerged that this is the case for all the technologies. This exercise provided the following **technical maximum train capacity** for the technologies involved (see figure 4-9):

- The existing UCT technology attains the largest transport capacity at 40 semitrailers per train.
- The two Modalohr technologies achieve a train capacity of 38 semitrailers each.
- The CargoBeamer system has the lowest capacity of 31 semitrailers. This is a direct consequence of the very high tare weight of the special wagons.

Figure 4-8: System-specific train capacities considering maximum train weight

Technology	Loading unit (LU)			Wagon tare	Σ (LU + wagon)	Max train weight	Max LU per train
	Payload	Tare	Total				
	(Tonnes)						(LE)
Existing UCT	20	7,5	**27,5**	17,3	**44,8**	1.800	**40,2**
Modalohr horizontal	20	7,2	**27,2**	20,3	**47,5**	1.800	**37,9**
Modalohr UIC	20	7,5	**27,5**	20,3	**47,8**	1.800	**37,7**
CargoBeamer	20	7,2	**27,2**	31,0	**58,2**	1.800	**31,0**

Source: KombiConsult

Figure 4-9: System-specific train capacities considering train weight, train length and rate of capacity utilisation

Technology	Max LU at 1,800t train weight	Train length ≤ 700m?		Train capacity		
		Length wagon	Train length	Max	Ø load factor	
	(LU)	(m)	(m)	(LU)	(%)	(LU)
Existing UCT	**40**	17,02	**681**	**40**	85%	**34**
Modalohr horizontal	**38**	16,95	**644**	**38**	85%	**32**
Modalohr UIC	**38**	16,95	**644**	**38**	85%	**32**
CargoBeamer	**31**	16,20	**502**	**31**	85%	**26**

Source: KombiConsult

Given the imbalances of logistics and fluctuations of transport volume in time the capacity of a CT train can't be fully used all the time. Therefore an average load capacity utilisation rate of 85%, which essentially ensures a viable service, was assumed in the third step. This resulted in the following **operational train capacity** for each technology (see figure 4-9):

- Existing UCT technology: 34 semitrailers.
- Modalohr horizontal and UIC: 32 semitrailers each.
- CargoBeamer: 26 semitrailers.

4.2.2 Capacity of transhipment facilities

As mentioned at the outset, this study assumes that each of the technologies under examination is deployed in a dedicated system. This also applies to the transhipment facility. A typical **layout and terminal configuration** was taken as the basis for calculating the transhipment capacities for each technology (see figure 4-10).

Figure 4-10: Components of system-specific transhipment facilities

Component	Existing UCT	Modalohr horizontal	Modalohr UIC	CargoBeamer
Handling tracks	4 x 700 m	1 x 700 m	4 x 700 m	1 x 700 m
Cranes	3	-	3	-
Operation scheme	indirect	indirect	indirect	indirect
∅ handling time per LU	3,0 min	4,0 min	4,5 min	10 min (train)
Daily operating hours	21 h	21 h	21 h	21 h

Source: KombiConsult

A "classical" transhipment module comprising four tracks with a craneable length of 700 m each and three portal cranes was assumed for the existing UCT and the Modalohr UIC technologies even though basically 2-3 tracks would be sufficient in respect of the optimised operating organisation described below. The layout explained in section 4.1 was adopted for the two horizontal transhipment systems Modalohr and CargoBeamer. It comprises a centrally positioned transhipment track so that the train can be loaded or unloaded from both sides. Generally speaking, it is also possible to install dual or multiple track systems. Those designs, however, are supposed to deliver only marginal economies of scale since doubling the capacity would require for all system components to be doubled and also entail a corresponding increase in the investment costs.

We assumed an **indirect terminal operating organisation** for all technologies. This provided a uniform basis for the comparison of systems, even though this procedure is not customary at present in UCT facilities serving continental CT. In the case of an indirect process organisation a pick-up and delivery truck after passing the check-in gate deposits an outbound semitrailer on a parking space. The semitrailer is picked up by a terminal tractor (tugmaster) and taken to the very transhipment area. In the case of both vertical handling technologies the tractor decouples the semitrailer, which subsequently is loaded on the train by a portal crane. In the case of horizontal transhipment systems, the tugmasters are supposed to perform the loading and/or unloading as well.

The **handling time** indicates the average period for loading and unloading of one semitrailer. It is therefore the average of the time required - for outbound units - to load a semitrailer safely onto the wagon after it has arrived in the transhipment area, and – for inbound units - to lift it with the crane and set it down on the road lane or, in case of horizontal systems, to remove it from the wagon.

The information regarding the current UCT technology is based on empirical values, and it also takes account of the indirect operating organisation, which should reduce the handling time from the current duration of about four minutes to three minutes. Measurements and data from operators are available for the Modalohr horizontal technology, resulting in an average duration of about four minutes. In this case, the loading procedure usually takes considerably longer than the time needed to unload a semitrailer.

An analysis of the times required for the processes indicated by the manufacturer was carried out for the Modalohr UIC technology. Since the unloading process is identical to the UCT procedure for semitrailers the handling time should also amount to approximately three minutes. In contrast to that we expect an average of six minutes for the loading process. Assuming equal volumes for dispatch and reception, this produces an average time requirement of 4.5 minutes. We determined the average transhipment period of six minutes for the loading process as follows: We assumed that in 50% of all cases it would not be required to adapt the loading platform of the wagons (see section 4.1 on this aspect). Under these conditions, the transhipment operation takes only three minutes. If, however, in another 50% of semitrailer movements such an adaptation were necessary for compensating for the weight of the semitrailers we expect a time requirement of about nine minutes for the entire loading process. This results in an average of six minutes for all loadings.

The CargoBeamer technology has a special feature. All outbound semitrailers are deposited on so-called "Cargojets" (baskets), which in one automated process then are pulled transversely into the wagons. According to the manufacturer, ten minutes are required for this purpose, although this does not take account of the time required to position the semitrailers in readiness on the Cargojets. Hence, the total time required for the loading operation is significantly more than ten minutes (see train sequence period below). For inbound semitrailers, the procedures are performed in reverse order but the time requirement will be about the same.

An actual **daily operating period** of 21 hours was assumed as the standard for the terminals. In this case, if the plant is open for 24 hours with three-shift operation, this would allow three hours for maintenance and repair work, as well as handover time when changing shifts.

These system configurations and input variables were taken as the basis for determining the transhipment capacity for each transhipment facility (see Figure 4-11). First of all, starting from the average operational utilisation of a train's capacity, the **time for unloading and reloading a train** under optimum conditions was calculated. What finally determines the handling capacity, however, is the **train sequence period (train headway)**. It indicates the period when the next train can be processed after completion of the loading and unloading of the preceding train. For this purpose, we also assume optimum operating conditions for all the technologies here. No restrictions are in place that would impede utilisation of the capacity of the facilities, either on the last mile rail section to the terminal or the long-haul line.

As concerns the four-track handling modules for the existing UCT and the Modalohr UIC technologies it is assumed that the next train is already positioned under the crane so that, in principle, the cranes after completing the unloading/loading of a train could continue to operate immediately. Nevertheless, we assumed a "transition period" of 10 minutes. With Modalohr UIC, the railway must repeat the measurement of wagons and semitrailers as part of the technical inspection of wagons and trains (see pp. 15f). We assumed that in the case of a four-track module, this work will not have a negative impact on the train headway and incur additional costs.

With a single-track system, on the other hand, the outgoing train has to be cleared from the track first, before the next incoming train can be placed in readiness. We assumed a time requirement of 60 minutes for this purpose in the case of the Modalohr horizontal transhipment technology. CargoBeamer itself indicates a train headway of about 180 minutes.

Based on an operating period of 21 hours, it is then possible to calculate the maximum number of train pairs that each system can process per traffic day (TD). Taking account of the average utilisation of train capacity, this produces the daily transhipment capacity and, assuming 250 traffic days, the **annual transhipment capacity** (see figure 4-11):[2]

- The terminal that is designed for the existing UCT vertical transhipment procedure for craneable semitrailers could handle 16 train pairs per day under the optimum operating conditions described above. Of all the technologies, therefore, the UCT system has the largest transhipment capacity amounting to 1,088 load units per traffic day or 272,000 load units per year.

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[2] 300 traffic days (for example) could also be taken as the basis. This would result in 20% more capacity, but would not change the ratios between the technologies under examination.

- A high transhipment capacity of 768 shipments per TD or 192,000 shipments p.a. is attained by Modalohr with the UIC vertical technology (12 train pairs per TD). Even so, this capacity is about 30% less than for the UCT system.
- By contrast, the two single-track horizontal transhipment systems deliver a comparatively low handling capacity due mainly to the significantly higher train headways. The CargoBeamer system would achieve 392 load units per TD or 91,000 load units per year, and Modalohr horizontal attains only 256 load units per TD or 64,000 load units per year. These systems therefore offer only 34% or 24% respectively of the handling capacity of the existing UCT technology.

Even if shorter transhipment times or train headways were assumed, the two horizontal transhipment procedures would not reach the capacity of the vertical systems. In this regard, it must be noted that the module width of the horizontal transhipment systems – and therefore the space required – is also more or less equivalent to the requirement for the vertical transhipment systems (on this aspect, see the following section 4.2.3).

Figure 4-11: System-specific handling capacities

Technology	Semitrailers per train (LU)	Loading & unloading (min)	Train headway (min)	Train pairs p.d.	Handling capacity (LU p.d.)	Handling capacity (LU p.a.)
Existing UCT	**34**	**68**	**78**	**16**	**1.088**	**272.000**
Modalohr horizontal	**32**	**256**	**316**	**4**	**256**	**64.000**
Modalohr UIC	**32**	**96**	**106**	**12**	**768**	**192.000**
CargoBeamer	**26**	**10**	**180**	**7**	**364**	**91.000**

Source: KombiConsult

4.2.3 Space requirements and investment costs for transhipment facilities

The results stated in section 4.2.2 are only meaningful to a limited extent if considered isolated. This is because they are based on different transhipment facility designs, on account of the system characteristics of the technologies under examination. For this reason, it is necessary to standardise the capabilities of the system-specific terminals and develop performance indicators allow to comparing the technologies. The following two measures are widely acknowledged as suitable key performance indicators. The specific space requirement is defined as follows: it indicates the average area required to create the capacity for the transhipment of one semitrailer per traffic day. Likewise, the specific investment costs are defined as the average amount required to create the capacity for handling one semitrailer per traffic day.

Know-how acquired by KombiConsult from numerous assignments and additional information from system providers or operators was taken as input in order to derive the system-specific key values. In addition, we made the following assumptions:

- The investments into the rail and road access infrastructure were not included in the calculations for any of the technologies.
- The costs of land were calculated at the uniform rate of €35 per m².
- For all technologies, the size of the parking area for semitrailers was determined as 50% of the average daily transhipment volume. In the case of the existent UCT technology, this figure is 544 spaces.
- Since the parking areas should be located outside of the transhipment module, the transhipment modules for the two vertical systems - UCT as-is state and Modalohr UIC - were calculated without the 3-4 storage lanes that would otherwise be usual. However, we assume a total of three instead of the usual two traffic and loading lanes under the crane.
- The requirements for the gate function, check-in/check-out and operational safety inspection of load units were set at the same level for all the technologies even though more handling positions are required for the existent UIC technology due to the higher throughput of loading units. But, on the other hand, the safety checks are significantly more extensive for the other three systems such

as weighing and gauge checking of the semitrailers, and securing the tarpaulins on curtainsider trailers. Ultimately, this is also likely to generate a higher staffing requirement at this point, but this was not allocated to the systems in this study.

The results of the study are now meaningful (see figure 4-12).

Figure 4-12: Specific space requirements and specific investment costs for the handling facilities of the technologies examined

Technology	Capacity	Space requirements		Investment costs	
	(LU/TD)	Total	per LU of capacity	Total	per LU of capacity
Existing UCT	**1.088**	**66.000 m²**	**61 m²**	**32.000.000 €**	**29.000 €**
Modalohr horizontal	**256**	**40.000 m²**	**156 m²**	**19.000.000 €**	**74.000 €**
Modalohr UIC	**768**	**57.000 m²**	**74 m²**	**30.500.000 €**	**40.000 €**
CargoBeamer	**364**	**42.500 m²**	**117 m²**	**24.500.000 €**	**67.000 €**

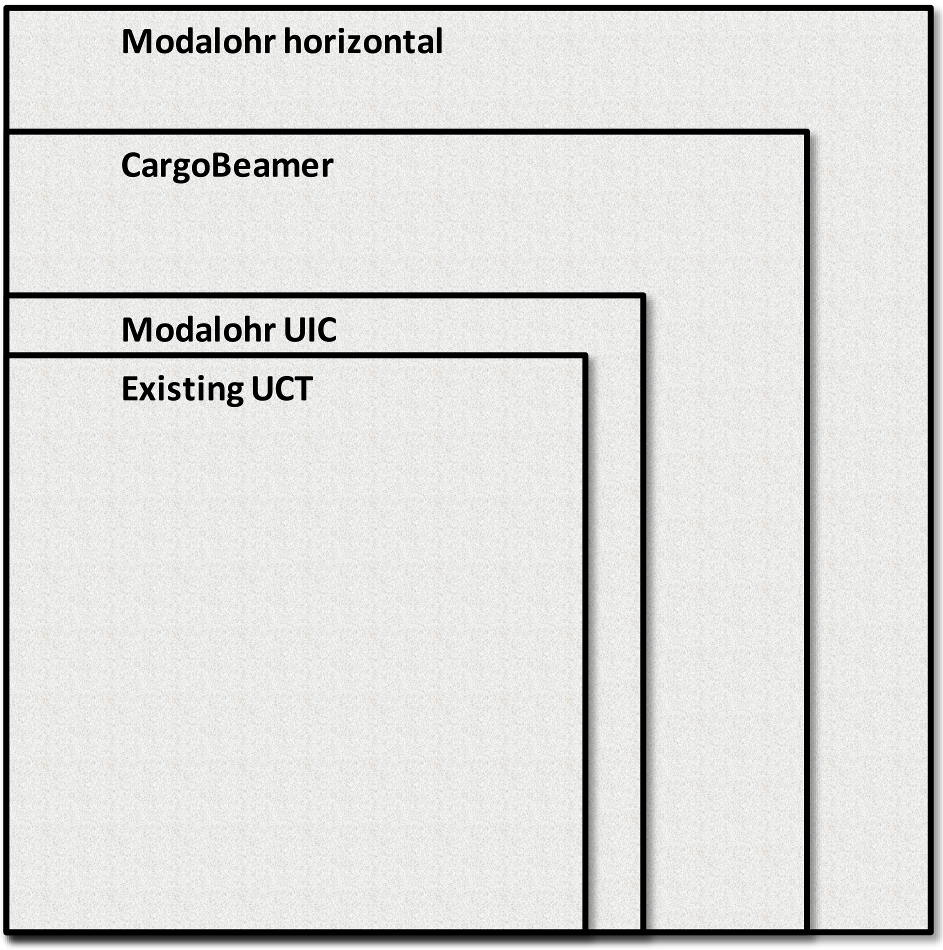
Source: KombiConsult

Although the existing UCT system requires for the largest terminal area this technology is nevertheless the most space-efficient. The **specific space requirement** is just 61 m² per unit (semitrailer) of capacity. The next most favourable technology, the Modalohr UIC system, requires 74 m² or about 20% more space. The horizontal transhipment processes are described by the system providers as "space-saving", but they actually perform very poorly on this key factor. The CargoBeamer requires 82% more space per unit of capacity and the Modalohr horizontal even 155% more compared with the existing UCT system for craneable semitrailers (also see Figure 4-13).

With regard to the **specific investment costs** the existing UIC technology again delivers the best result. The investment costs per unit of capacity and traffic day amount to about €29,000. On the other hand, the Modalohr UIC system on average requires 38%

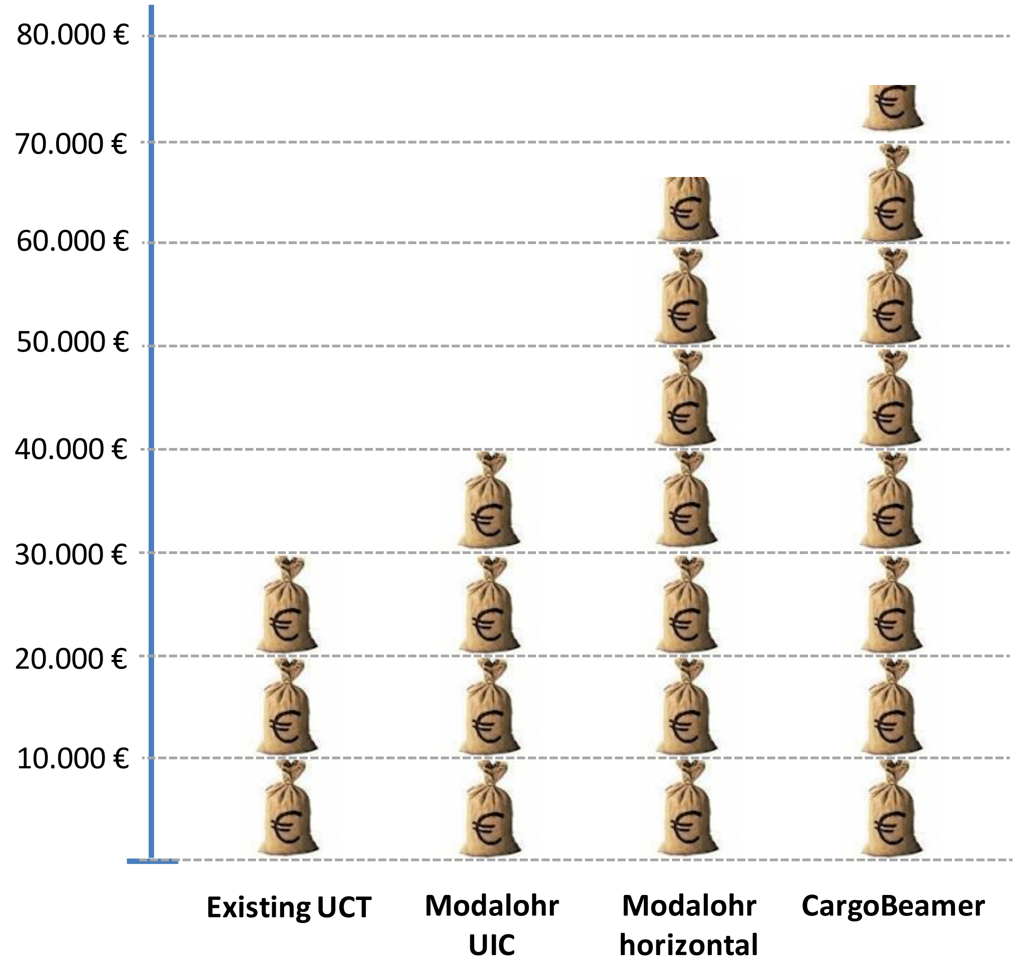
more investment costs per unit of capacity. The Modalohr horizontal and CargoBeamer systems show the lowest efficiency rates; the investments they require are twice as high as those for the existing UCT technology in order to install the same transhipment capacity (see figure 4-14).

Figure 4-13: Comparison of the specific space requirements per unit of capacity for the transhipment facilities of the technologies examined



Source: KombiConsult

Figure 4-14: Comparison of the specific investment requirements per unit of capacity for the transhipment facilities of the technologies examined



Source: KombiConsult , Nordkap

4.2.4 System costs of the technologies examined

We define **system costs** as the costs incurred during the transport of one semitrailer in combined transport between two terminals. System costs include the costs of transhipment at both ends of the transport chain, the costs of wagon employment, rail traction and deployment of the semitrailer. Since the costs of pre- and post-haulage would be identical for all technologies under the same conditions, they can be disregarded for the purpose of comparing the system costs. For the same reason, other cost components such as overheads, interest and costs of IT systems were not taken into account. Against this background the system costs calculated should not be confused with the costs or prices of resources currently used in UCT. For all systems examined it was assumed that the intermodal transport would be performed on the Köln-Milano service, with a rail transport distance of some 860 km. The following aspects were taken into account in order to determine the individual cost categories:

The **costs of the loading unit** include depreciation and maintenance costs; alternatively, rental or leasing rates can be applied. For the two vertical transhipment systems, use is made of craneable semitrailers. Their procurement costs are approximately €1,500 higher than for standard road trailers. With a depreciation period of five years and 250 operating days per year, this results in costs that are €2.0 higher per transport. An operating period of two days was assumed, which conforms to the real conditions of a goods transport on the trade lane in question.

The **transhipment costs** comprise financing and operating costs, and these were determined on the assumption that no government co-financing of the investment was obtained. For the financing costs, a depreciation period of 20 years on capital investments and a 3% interest rate were assumed. No valid data are available for the operating costs of the horizontal transhipment systems. Based on our analyses of the operating procedures (see section 4.1), we assume that the operating costs per semitrailer will be at least equal to those for the vertical transhipment systems. For this purpose, we calculated an average operating cost of €16 per semitrailer handled. This also includes the use of tugmasters.

As concerns the **wagons** the following investment costs per semitrailer space were applied; the source of information is given in brackets:

- Existing UCT, pocket wagon: €70,000 (operator information)
- Modalohr UIC: €200,000 (estimate)
- Modalohr horizontal: €175,000 (average of two sources)
- CargoBeamer €140,000 (system provider information)

The annual maintenance costs for the pocket wagon amount to 4.5% of the investment cost according to empirical data of wagon operating companies. Since the wagons for the other technologies provide for more complex mechanical, hydraulic or electrical devices their average annual maintenance costs were estimated at 8% of the investment. In the absence of adequate empirical values, we did not take account of the stricter safety requirements for wagon operators imposed in the aftermath of the Viareggio accident for any of the wagon types, although these are bound to result in higher costs.

Furthermore, we considered the average level of capacity utilisation of the train at a rate of 85%, as already explained in section 4.2.1. Based on the assumption that the trains always operate as shuttles with the same wagon configuration, an average of 15% of all wagons would therefore not be loaded. The relevant costs are allocated uniformly to the semitrailers carried.

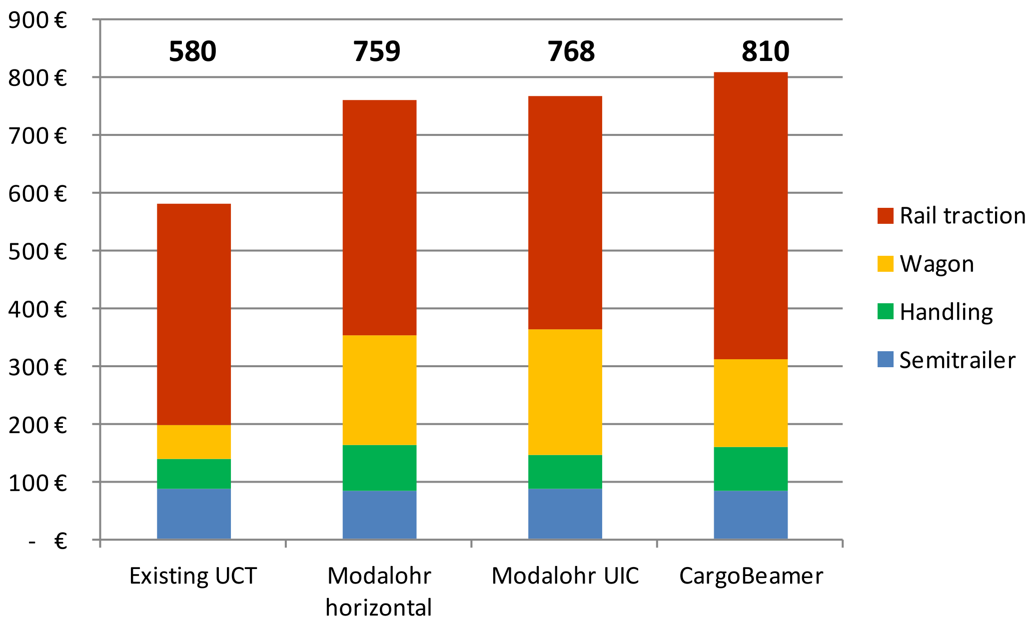
On the basis of these data, the **wagon costs per operating day** can be determined for each technology. Optimum operating conditions were assumed for this purpose: each wagon is deployed on 360 days per year, and there are no limbo days due to train cancellations or suspensions, delays or similar factors. In accordance with real conditions, however, two operating days were assumed for the Köln-Milano link selected.

For the **traction costs**, which also include infrastructure charges, we assumed a standard price of €14.5 per train-kilometre and a flat rate of €500 per train journey for technical train dispatch and clearance procedures.

The results of the analysis show that the transport of a craneable semitrailer between Köln and Milano in the existing UCT system offers the lowest **system costs** on a terminal-to-terminal basis of €580. Except for the costs of the deployment of the semitrailer, the UCT technology is also the most efficient in respect of all the individual cost categories. The cost advantage over all the new systems is considerable. With the two Modalohr technologies, the movement of one semitrailer costs €759 or €768 respectively. This is almost €200 or over 30% more than with the current UCT system. The CargoBeamer horizontal technology is in fact almost 40% more expensive than the UCT technology (see Figure 4-15).

Figure 4-15: System costs of the technologies examined for terminal-to-terminal transport of one semitrailer on Köln-Milano trade lane

Technology	Cost per semitrailer carried				
	Semitrailer	Handling	Wagon	Rail traction	Total
Existing UCT	88 €	51 €	60 €	381 €	**580 €**
Modalohr horizontal	84 €	80 €	190 €	405 €	**759 €**
Modalohr UIC	88 €	57 €	218 €	405 €	**768 €**
CargoBeamer	84 €	75 €	152 €	499 €	**810 €**



Source: KombiConsult

5 Analysis of costs for the transfer of semitrailer traffic through Switzerland

By 2018, two years after the scheduled opening of the Gotthard Base Tunnel, transalpine goods transport by road in Switzerland should have been reduced to a maximum of 650,000 trucks. This is the so-called "modal shift objective". The main burden of the shift of truck journeys to rail will have to be borne by articulated vehicles, which already account for 70% of the entire volume of transalpine long-haul road vehicles (see section 2). And their market share is likely to grow over the coming years.

According to our assessment, about two thirds of all articulated vehicles may have an overall height of about 4.0m. The only vehicles with significantly lower heights are those equipped with special structures, e.g. to transport liquids, bulk or materials for recycling. Likewise, semitrailers which carry heavy loads such as steel products or paper in one direction − so they do not require the permitted overall height of four meters – usually have height-adjustable superstructures so that they can carry volume-intensive goods on the return journey. The average specific weight of goods has been decreasing continuously for years so, in view of the ongoing effect of the changing goods structure, we expect a further strengthening of the trend towards procuring semitrailers which fully utilise the permitted overall height of 4.0m. This assessment is supported by the exceptional growth of so-called mega-trailers providing for an internal loading height of minimum 3.0m and an external height of – at least 4.0m. According to leading European manufacturers, they account for about 25-30% of all semitrailers sold within the last ten years.

To enable semitrailers with a height of four meters to be conveyed on UCT services the rail line must have a loading gauge of at minimum P400. As regards transalpine traffic through Switzerland from and to Italy only the Lötschberg corridor features this gauge at this time. However, almost all of the limited supply of train paths available for P400 has already been allocated to railway undertakings. Under no circumstances will it be possible to provide – even approximately – the large number of trains required in order to achieve the Swiss modal shift objective.

Providers of UCT services on the Gotthard corridor with terminals in the Milano area, including in particular the logistics hub at Busto Arsizio/Gallarate, are only able to ship semitrailers with a corner height of 3.80m at present. This would also remain the case after the Gotthard Base Tunnel goes into operation unless the existent gauge is enlarged. Therefore, about 65% of all semitrailers in transalpine transport could not be transferred to UCT and the modal shift objective not achieved.

In these circumstances, the Lohr company has offered to develop the UIC version of its Modalohr technology as appropriate because this would enable craneable semitrailers - and non-craneable semitrailers if the Modalohr UIC technology were also designed for horizontal transhipment purposes - with a corner height of four meters to be carried as far as the Milano area with no need to adapt the rail infrastructure on the feeder line to the Gotthard tunnel.

In the preceding section, it was possible to demonstrate that the existing UCT technology has significantly lower system costs for the transport of a semitrailer as compared to the Modalohr UIC technology. However, this still does not make it clear whether the employment of the UCT technology and an increase in the loading gauge, which requires for infrastructure investments, also represents a more favourable alternative in overall economic terms than the use of the Modalohr system in order to achieve the modal shift objective. The **purpose** of the following calculations is therefore to determine which overall investment and operating costs would be incurred for the two alternatives if the journeys of articulated vehicles required in order to achieve the modal shift objective were to be transferred from road to rail via CT.

This comparison will not include the other two technologies that were examined in section 4 since according to our assessment their deployment would not facilitate to solve the gauge problem. The CargoBeamer does not constitute an alternative because the loading platform for semitrailers is 330mm above rail thus even 60mm higher than the value for modern pocket wagons. This means that the CargoBeamer technology - like the existing UCT system - could not be deployed without investments in the infrastructure. This also applies to the horizontal technology offered by Modalohr, for which significant adaptations would be required to the lower UIC loading gauge throughout the

Germany-Italy corridor (see section 4.1); in our view, it cannot be expected that the necessary international consensus would be obtained or that the requisite investment funds would be provided.

5.1 Determination of the modal shift needs

As the first step, the modal shift needs had to be calculated. We use this term to denote the number of semitrailers that additionally would have to be transferred from road to CT services by a point in time "two years after the opening of the Gotthard Base Tunnel" so that the modal shift objective of 650,000 trucks could be met.

We have chosen the year 2020 as the relevant time horizon when according to the “Verlagerungsbericht 2011” the BAV expects a volume of 1.5 million truck journeys. This would mean an increase of 20% as compared to the volume of 1.26 million trucks in 2010 and would be equivalent to an annual average linear growth of 2%.

In order to determine the volume of semitrailers to be shifted the breakdown of the road transport volume by vehicle category in 2020 is required. As no forecasts are available we have developed an independent assessment of our own (see Figure 5-1):

- The analysis of the development of transalpine road transport in Switzerland showed that since 1980 the volume of lorries (single trucks) has being fluctuating around 200,000 journeys, despite the changes to economic and logistics structures. We assume that this volume will remain rather stable by 2020.
- The remaining volume of 1.3 million trucks (1.5 – 0.2) will be distributed among road trains and articulated vehicles. In order to determine the share of articulated vehicles we have drawn up three scenarios. Case (A) assumes that the market share will remain stable at about 70%, case (B) expects an increase to 80% reflecting a linear annual growth of one percentage point what would correspond to the development seen in the last 20 years. Scenario (C) is a medium evolution scenario with a share of semitrailers of 75% in 2020.
- Depending on the scenario the total volume of articulated vehicles would amount to between 0.91 and 1.04 million journeys in 2020.

Figure 5-1: Forecast for transalpine road transport in Switzerland, 2020

Year		Total transalpine traffic in Switzerland				% articulated of long-haul trucks
		Lorries	Road trains	Articulated vehicles	Total	
2010		196.000	303.000	758.000	1.257.000	71,4%
Forecast 2020	(A)	200.000	390.000	910.000	1.500.000	70,0%
	(B)	200.000	260.000	1.040.000	1.500.000	80,0%
	(C)	200.000	325.000	975.000	1.500.000	75,0%

Source: Bundesamt für Verkehr; KombiConsult(prognosis)

On the basis of the estimated total volume of articulated vehicles in 2020 we elaborated the modal shift needs that is the number of journeys required to be shifted on CT services. For this purpose we proceeded as follows (see also Figure 5-2):

- Despite its active modal shift policy Switzerland – as things stand at present – will continue to allow a volume of 650,000 truck journeys in the future. Basically, however, we assume that the 200,000 journeys by solo trucks cannot be transferred to CT for reasons related to logistics, technology and routing.
- Consequently, not more than 450,000 transalpine journeys of road trains and articulated vehicles would be allowed within the scope of the modal shift objective, and 850,000 trucks would have to be transferred to rail.
- Depending on the forecast scenario and the underlying proportion of articulated vehicles - 70%, 80% or 75% - the volume of semitrailers to be shifted amounts to 595,000, 680,000 or 639,000 journeys.

The European logistics sector expects that owing to its inherent benefits the employment of semitrailers will continue to increase not only in national but also – and in particular – in cross-border freight transport. It would therefore be perfectly conceivable that the market share of articulated vehicles might grow to 80% by 2020. In order to pre-empt a potential objection we would "exaggerate" the modal shift needs we decided to select the medium growth path as per scenario (C). Accordingly, the relevant **modal shift needs** amount to 639,000 semitrailers (see Figure 5-2).

Figure 5-2: Forecast modal shift needs for semitrailers, 2020

	Forecast scenario		
	(A)	**(B)**	**(C)**
Total truck journeys 2020	1.500.000	1.500.000	1.500.000
Modal shift objective	650.000	650.000	650.000
Thereof: "non-shiftable" lorries	*200.000*	*200.000*	*200.000*
max road trains& artic. vehicles	*450.000*	*450.000*	*450.000*
Modal shift needs road trains & artic. vehicles	850.000	850.000	850.000
Modal shift needs articulated vehicles	**595.000**	**680.000**	**639.000**

Source: Bundesamt für Verkehr; KombiConsult(prognosis)

5.2 Total costs of a modal shift policy of semitrailers applying existing UCT or Modalohr UIC technologies

To realize the modal shift needs elaborated above new transhipment capacities would have to be created. In principle, only locations to the north of Milano can be considered in Italy due to infrastructure-related reasons. According to its latest statements Modalohr prefers the region around Chiasso probably because the rail line here offers a somewhat higher loading gauge than the line via Luino into the Gallarate/Novara region. However, the latter location has higher priority for the operators of the existing UCT technology since they consider it more appropriately for bundling volumes. To simplify matters we designate the terminal location on the Italian side as Milano in the following.

North of the Alps, there are a large number of origins and destinations in Switzerland, Germany, France, the UK, the Benelux countries and Northern Europe. With the exception of France, the other relevant locations for transalpine goods traffic through Switzerland are integrated into a rail network, which offers a loading gauge of at least P400. For these locations, therefore, a policy to transfer the necessary number of semitrailers could be implemented with the existing UCT technology as well as with the Modalohr UIC system.

In order to determine the costs that the two systems would cause in implementing the modal shift needs we designed two scenarios:

- Scenario 1 – centralized modal shift
  Here we assume that Switzerland can only achieve the modal shift objective through its own efforts because the neighbouring countries are unable to meet the relevant requirements as concerns, for example, the transhipment capacities or train paths, or are unable to meet them promptly. The entire modal shift needs must therefore be covered centrally by two terminals in the Basel/Freiburg and Milano areas.

- Scenario 2 – decentralized modal shift
  This scenario is based on the expectation that, on the German side, the necessary requirements for a modal shift action are met so that the shift of truck journeys could be enabled decentralized by using several terminals. In this respect, we have selected three key economic and also intermodal centres Ludwigshafen, Köln and Duisburg although the results would not differ significantly if additional locations were included in the analysis. In addition, as is already the case at present, these three locations can also be used to "bundle" numerous other routes to destinations such as Rotterdam, the UK, Antwerpen or Northern Europe. The Milano area is retained in Italy.

For the purposes of the following comparisons we assumed that the total modal shift volume of 639,000 semitrailers, in scenario 1, will entirely be moved on the Basel/Freiburg-Milano service with a distance of some 450 km. In scenario 2, the total modal shift volume is uniformly distributed among three services: Ludwigshafen-Milano (650 km), Köln-Milano (860 km), and Duisburg-Milano (950 km).

The cost analysis relates to the system costs for the movement of a semitrailer between the aforementioned terminals, and it therefore takes account of the costs of the rail transport, the wagon, the transhipment at both ends of the CT service, and the employment of the semitrailer. For rail transport costs, which include traction costs and infrastructure charges, we assume – like in section 4 - €14.50 per train-kilometre and a flat charge of €500 per train for technical train dispatch and clearance procedures. The transhipment costs per semitrailer were also deduced in the preceding section.

The costs of the wagon and the semitrailer are primarily determined by the **system times**, the periods they are allocated to the journey in question. The system time relates to the total duration of a train journey from the start of loading of the train in the origin terminal until the unloading of the last unit in the destination terminal. The loading and unloading times were analysed in section 4. For the duration of transport, we did not apply the net rail travel times but instead we used the current timetables with reference to the end of loading and the start of unloading. Both at the origin and destination we have foreseen an additional hour of "transition time" in each case. This means that the calculation allows time buffers e.g. to replace damaged wagons or for delays. The system times were calculated for all four routes (see also figure 5-3).

By relating the entire system time for a train journey to a 24-hour day we obtain what we called the "time factor" for the route-related employment costs of a wagon and a semitrailer. As opposed to the usual procedure in today's commercial practice we did not calculate the costs of the use of wagons and semitrailers in complete days but as a precise number of hours. For example, if the system time is 18 hours the time factor is 0.75 and we applied 75% of the daily wagon costs (€30 x 0.75 = €22.50) or semitrailer costs (€44 x 0.75 = €33).

At this point, it must be emphasised that we assumed **optimum operating conditions** for both the scenarios and the technologies under examination. This means that we based the analysis on the assumption that, for example, sufficient train path would be available for the timetable required, a train can be immediately reloaded with semitrailers to travel in the opposite direction as soon as it has been unloaded in a terminal, sufficient semitrailers will have been delivered to the terminal by customers, and rolling stock would not be subject to any additional limbo time. These idealised conditions will certainly not be encountered in a real logistical situation but because this also would apply to each CT technology the cost parities, i.e. the ratio of system costs between the individual technologies, would not change significantly.

Figure 5-3: Modal shift scenarios: system times for the two technologies

Trade lane		System times one-way (min)					Total time (h)
		Loading	Last-mile	Traction	Last-mile	Unloading	
Milano - Basel/Freiburg	**UCT**	34	60	630	60	34	13,6
	Modalohr	49	60	630	60	49	14,1
Milano - Ludwigshafen	**UCT**	34	60	960	60	34	19,1
	Modalohr	49	60	960	60	49	19,6
Milano - Köln	**UCT**	34	60	1.140	60	34	22,1
	Modalohr	49	60	1.140	60	49	22,6
Milano - Duisburg	**UCT**	34	60	1.320	60	34	25,1
	Modalohr	49	60	1.320	60	49	25,6

Source: KombiConsult

The cost calculations for the two scenarios were carried out on this basis. For **scenario 1 "Centralized modal shift",** about 639,000 semitrailers would have to be transported over a comparatively short distance between Basel/Freiburg and Milano by 2020. The results of the study are as follows (see figures 5-4 and 5-5):

- With the existing UCT technology the terminal-to-terminal transport of one semitrailer incurs costs of €300, with the Modalohr UIC system €367 – disregarding costs that are supposed to be identical for both systems (overheads, pre- and onward carriage costs etc.). Modalohr would therefore be 22% more expensive than the existing UCT system.

- In order to realize the full modal shift needs of 639,000 semitrailers in the year 2020, the costs would amount to €191.5m for the existing UCT technology and €234.3m for the Modalohr UIC system.
- As compared to the Modalohr technology the current UCT system would be able to enable the same annual modal shift impact for €42.8m lower costs.

In **scenario 2 "Decentralized modal shift",** about 213,000 semitrailers should be transported on each of the three selected CT services in 2020. The results are as follows (see figure 5-6 and 5-7):

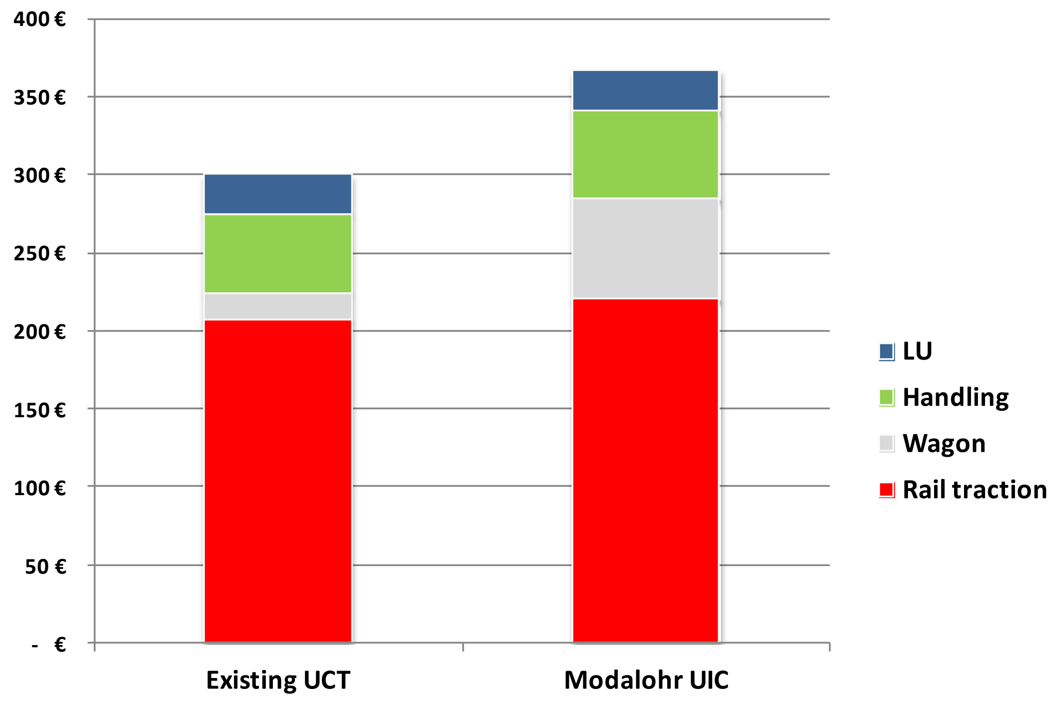
- On all trade lanes, the transport of a semitrailer with the existing UCT system is about €100 less costly than with the Modalohr UIC technology.
- In order to achieve the full modal shift needs of 639,000 semitrailers in the year 2020, the costs would amount to €309m for the existing UCT technology and €367m for the Modalohr UIC system.
- It is therefore evident that the existing UCT system would achieve the modal shift effect for almost €67m less than the Modalohr option (see also Figure 5-8).

Figure 5-4: Scenario 1: Total costs of the existing UCT and the Modalohr UIC technologies for achieving the 2020 modal shift needs

Trade lane	Technology	Time factor	Costs per semitrailer carried					Total costs 2020
			LU	Handling	Wagon	Rail traction	Total	
Milano - Basel/Freiburg	Existing UCT	0,57	25 €	51 €	17 €	207 €	**300 €**	**191.479.000 €**
	Modalohr UIC	0,59	26 €	57 €	64 €	220 €	**367 €**	**234.277.000 €**
Cost difference existing UCT vs Modalohr UIC								- 42.798.000 €

Source: KombiConsult

Figure 5-5: Scenario 1: Comparison of cost structures for the existing UCT and the Modalohr UIC technologies for the transport of one semitrailer



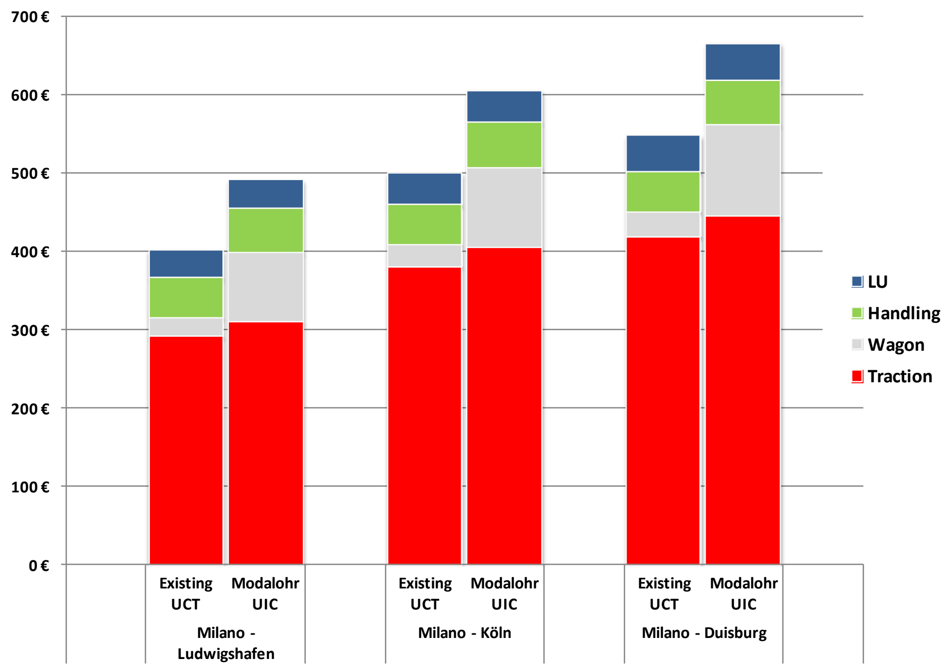
Source: KombiConsult

Figure 5-6: Scenario 2: Total costs of the existing UCT and the Modalohr UIC technologies for achieving the 2020 modal shift needs

Trade lane	Technology	Time factor	Costs per semitrailer carried					Total costs 2020
			LU	Handling	Wagon	Rail traction	Total	
Milano - Ludwigshafen	Existing UCT	0,80	35 €	51 €	24 €	292 €	**402 €**	**85.606.000 €**
	Modalohr UIC	0,82	36 €	57 €	89 €	310 €	**492 €**	**104.864.000 €**
Milano - Köln	Existing UCT	0,92	41 €	51 €	28 €	381 €	**501 €**	**106.652.000 €**
	Modalohr UIC	0,94	41 €	57 €	103 €	405 €	**607 €**	**129.206.000 €**
Milano - Duisburg	Existing UCT	1,05	46 €	51 €	31 €	420 €	**548 €**	**116.798.000 €**
	Modalohr UIC	1,07	47 €	57 €	116 €	446 €	**667 €**	**141.966.000 €**
Cost difference existing UCT vs Modalohr UIC							-	66.980.000 €

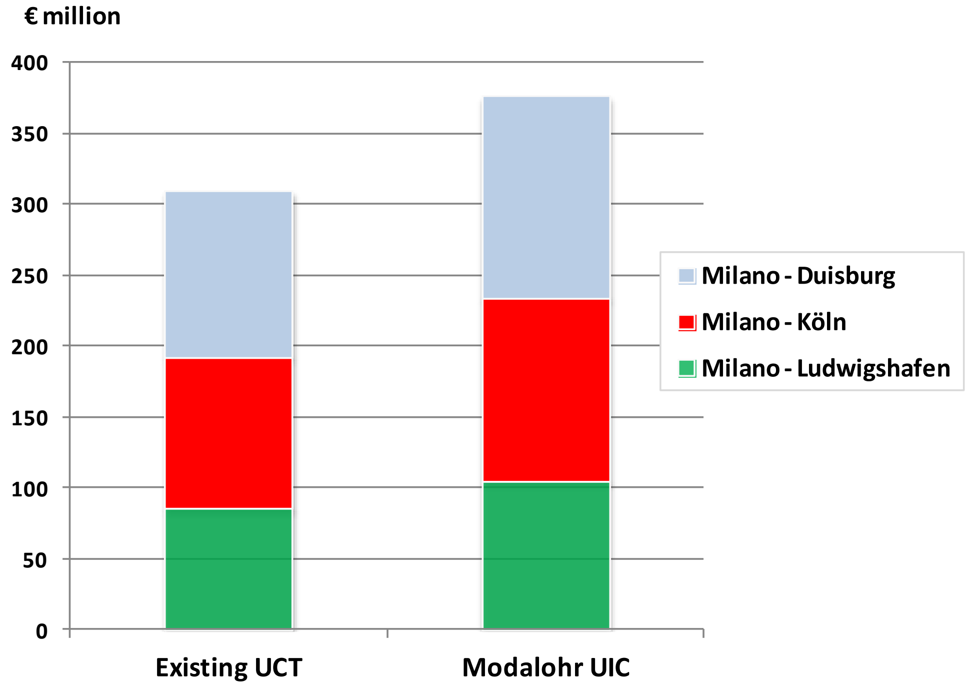
Source: KombiConsult

Figure 5-7: Scenario 2: Comparison of cost structures for the existing UCT and the Modalohr UIC technologies for the transport of one semitrailer per trade lane



Source: KombiConsult

Figure 5-8: Scenario 2: Total cost comparison for the existing UCT and the Modalohr UIC technologies for the 2020 modal shift needs



Source: KombiConsult

The analysis shows that in the case of semitrailer transport with the UCT technology, in scenario 1, the costs incurred are approximately 18.3% lower than with employing the Modalohr UIC system, and, in scenario 2, the costs are about 17.8% lower.

If only one single operating year is considered, it would be possible to fulfil the modal shift needs with the existing UCT technology at costs that are between €43m and €67m lower than with the Modalohr UIC technology. If we switch to a dynamic consideration and take the decentralized scenario 2 as basis the economic advantages of the existing UCT system are even more clearly apparent. Assuming a constantly high annual modal shift effect of 639,000 truck journeys in each case over a period of ten years, the exiting UCT technology would achieve a consolidated cost advantage of about €670m (10 years at €67m) as compared to the Modalohr UIC technology.

Considering that the volume of transalpine goods traffic in Switzerland is likely to continue growing the savings effect based on the existing UCT technology increases even further. For example, taking a linear growth rate for transalpine road freight transport of 1% per year as the basis over a 10-year period from 2020 to 2029 – the BAV anticipates an annual growth rate of 2% for the 2010-2020 period – the existing UCT system would achieve a cost advantage of about €700m as compared to the Modalohr UIC technology, or another €30m more than the figure obtained from a static consideration.

5.3 Comparison of total costs taking account of investment costs into rail infrastructure

The preceding section 5.2 showed that the existing UCT system would have a noticeable and sustainable cost advantage for the purposes of an active modal shift policy as compared to the Modalohr UIC system. However, this comparison of costs did not take account of the possible costs of measures to adapt the rail infrastructure.

According to information from the manufacturer, no investments of this sort are required for the **Modalohr UIC** option. On the other hand, if the current standard pocket wagon were to be used the **existing UCT technology** would be reliant on an enlargement of the loading gauge on the Gotthard corridor so that semitrailers could be transported with a P400 profile. However, it is beyond the scope of this study to clarify how far the UCT technology could - or could not - manage without an increased gauge if the same overall operating conditions were to apply to it as to the Modalohr UIC system (see section 4.1) and if the safety tolerances now regarded as necessary for railway operation were to be "exploited" in order to gain height for semitrailer transport.

In the following section, we nevertheless assume that an increase in the loading gauge would be required move semitrailers with a height of four meters using the existing UCT system. Current analyses indicate that the costs of infrastructure investments would amount to about CHF940m. According to estimates by Swiss experts, about

30% of these costs could be due to measures aimed at improving rail passenger transport, which could not be allocated to CT. In the following we assume that the existing UCT technology would have to bear the costs of the widening of the loading gauge and, for this purpose, we distinguish two cases to illustrate the bandwidth of potential consequences:

- "Case 100": the existing UCT technology must bear the entire costs of the infrastructure upgrade amounting to CHF940m (€783m).
- "Case 70": the existing UCT technology must just bear 70% of the costs of the infrastructure investment amounting to CHF658m (€548m).

Assuming a typical depreciation period of 50 years and annual financing costs of 6% we can calculate the nominal additional costs for the use of the rail infrastructure on the Gotthard route for the existing UCT option, disregarding compensation for inflation. Based on that the annual costs amount to €16.6m in "Case 100" and €11.6m in "Case 70" (see figure 5-9).

Figure 5-9: Additional costs of infrastructure use for the UCT (actual) option with semitrailers, if upgrade investment costs are charged

		Case 100	Case 70
Investment costs	(€ million)	783	548
Depreciation period	(years)	50	50
Depreciation p.a.	(€ million)	15,7	11,0
Capital cost (6% p.a.)	(€ million)	0,9	0,7
Total cost p.a.	**(€ million)**	**16,6**	**11,6**

Source: KombiConsult

In section 5.2, we established that the existing UCT technology achieves an annual cost advantage over Modalohr UIC of between €43m and €67m, depending on the scenario. Based on these results the UCT option could not only compensate for the annual rate of costs for the gauge increase of €16.6m in "Case 100" but there would even be a "surplus" left over in favour of the logistics sector amounting to some €26m for scenario 1 (centralized modal shift) and €50m for scenario 2 (decentralized modal shift). In the “Case 70”, which some experts regard as realistic, this "return on investment" for Switzerland would increase to €31m or €55m respectively.

These results enable to also evaluate the potential impacts of the infrastructure investment costs on the track access charging scheme for the existing UCT system. For this purpose, we took the following assumptions:

- Annual modal shift volume (see figure 5-2): 639,000 semitrailers
- Average capacity utilisation per train (see figure 4-2): 34 semitrailers
- Average transportation distance per train: 850 train-kilometers

Against this background we calculated a need for about 18,800 annual train journeys to enable the transfer of the relevant number of semitrailer transports from road to UCT. This results in an annual performance of approximately 16 million train-kilometres. If the additional costs of infrastructure use (as determined in figure 5-9) are apportioned to this total of train-kilometres the additional track access costs for the existing UCT system can be deduced. In "Case 100" they would amount to €1.04 per train-km and in "Case 70" to €0.73 per train-km (see figure 5-10).

Figure 5-10: Impact of the allocation of gauge improvement costs on track access charges for the existing UCT technology

		Case 100	Case 70
Total costs p.a.	(€ million)	16,6	11,6
Trains p.a.	(trains)	18.800	18.800
Train-kms p.a.	(km million)	16,0	16,0
Δ Track access charges/train-km	**(€)**	**1,04**	**0,73**

Source: KombiConsult

6 Management summary and conclusions

6.1 Management Summary

(1) This study, which has examined and evaluated the technical and economic feasibility of potential solutions that could enable a modal shift of transalpine road freight transports in Switzerland to rail, is based on two fundamental **starting points**.

The first aspect relates to the *modal shift objective*, as it is called, whereby – in accordance with the applicable legislation – transalpine road freight transport in Switzerland should be reduced to a maximum of 650,000 truck journeys by 2018. Even though the intermediate goal set for 2011 of limiting the volume of road transport to one million trucks was not achieved, thereby raising doubts as to whether the transfer objective for 2018 can be achieved, this study basically assumes that the objective continues to be valid. Only one minor adjustment was made with regard to the time horizon. In this report the volume forecasts, cost analyses, and therefore also the modal shift objective do relate to the year 2020.

Secondly, it should be assumed that the modal shift effect must take place predominantly in the *Gotthard corridor*. Following the opening of the Gotthard Base Tunnel and the NEAT scheduled for 2016, this is the only rail line where the additional transport capacities required for the transfer will basically be available.

(2) The study is based on the following main **premises**:

- The modal shift objective, i.e. the limitation of transalpine journeys through Switzerland to 650,000 trucks, will be achieved solely by the deployment of trains in Unaccompanied Combined Rail/Road Transport (UCT).
- Articulated vehicles offer the main point of approach for all transfer activities. Their market share of the volume of transalpine long-haul truck journeys in Switzerland is currently about 70%, disregarding single trucks which, according to our assessment, are virtually impossible to transfer to rail. Since semitrailers

are gaining more popularity among shippers as well as transport and forwarding companies due to their handling advantages, the proportion of articulated vehicles is likely to continue growing in the coming years, at the cost of road trains. By 2020, we expect articulated vehicles reaching a market share of 75%.

- The intermodal technology, which shall enable to match the modal shift objective, must be capable of carrying semitrailers with an external height of four meters. This is because their share of transalpine traffic through Switzerland is currently estimated at over 65%, and we expect it to carry on growing until 2020 in view of the ongoing effect of changes in the goods structure, with a more than proportionately high increase in volume-intensive goods.

(3) Several **potential solutions** are currently under discussion in Switzerland in order to achieve the transfer objective by means of Combined Transport (CT).

The first option is the existing UCT technology, which based on pan-European standards is now organised in the same way as an industrial production process. To enable semitrailers with a height of four meters to be moved by UCT services on pocket wagons, a rail line with a minimum clearance gauge of P400 is required, even though the full height is not utilised by every single vehicle. The Lötschberg corridor does have a limited number of lines for P 400, but almost all of these are already used. As mentioned at the outset, the envisaged modal shift effect can therefore be achieved only in the Gotthard corridor where – however – the loading gauges are currently only P380 (Luino line) and P384 (Chiasso). This situation would remain unchanged after the opening of the Gotthard Base Tunnel unless suitable upgrading measures were to be implemented. Their investment costs are estimated at approximately CHF925m.

Given this situation, additional potential solutions were brought into play in recent months. These involve new combined transhipment/transport systems which focus in particular on wagon technology. They include the CargoBeamer system designed for horizontal loading of semitrailers, which is currently operating on a test basis in Germany, and two versions of the Modalohr technology. In addition to the Modalohr horizontal system, which provides for horizontal loading of semitrailers and is already in commercial use in France, the Lohr company has introduced what is known as the Modalohr UIC technology. This should enable semitrailers with a height of four meters, to be transported in the Gotthard corridor via Chiasso as far as the region to the north of Milan despite the existing gauge restrictions, with no need to implement infrastructural measures on the feeder routes. According to manufacturer's information obtained at the time when this report was prepared the UIC technology should focus on the vertical transhipment of craneable semitrailers - as is the case with the existing UCT system.

(4) Against the above background the following **tasks** were established:

- As the first step, an analysis of the system costs of the existing UCT technology and the three new systems has been carried out. This work did not take into account yet whether the technologies are considered to contribute to the modal shift of 4m high semitrailers in transalpine transport through Switzerland.
- The latter aspect, in contrast to that, was key to the selection of technologies for the second step of the study. Here the modal shift needs with respect to semitrailers was elaborated and the comparative costs of the deployment of those technologies for achieving the Swiss modal shift objective calculated.

(5) For the purposes of the **system comparison**, it was assumed that all the technologies would be deployed in a dedicated system, i.e. that only semitrailers would be transported. This was the only approach that would deliver an uniform basis for comparing the CargoBeamer and the two Modalohr systems, which are solely designed to move semitrailers, with the current UCT system, which is able to handle all CT loading units in an open system. On this basis, relevant key performance indicators and ultimately the system costs were determined for all technologies. The results are explained below.

(6) Assuming that, after the implementation of the NEAT, intermodal trains can operate with a wagon set weight of 1,800t and a wagon set length of 700m on the Gotthard corridor the existing UCT option offers the highest **train loading capacity** of 40 semitrailers. The Modalohr technologies achieve a capacity of 38 semitrailers each, and the CargoBeamer system only attains 31 semitrailers due to the high wagon tare weight.

(7) To calculate the system-specific **terminal handling capacities** a representative system configuration was taken as the basis for each technology. Assuming optimised and restriction-free operating conditions, a daily terminal opening time of 21 hours and 250 traffic days per year the exiting UCT system reaches an annual transhipment capacity of 272,000 semitrailers. The Modalohr UIC technology system could handle 192,000 semitrailers per year or approximately 70% of the UCT capacity. The CargoBeamer and Modalohr horizontal systems only offer handling capacities, which account for 34% or 24% respectively of the performance of the existing UCT system.

(8) The absolute handling capacities are only meaningful to a limited extent because they are based on distinctive terminal designs resulting from the characteristics of the technologies under examination. For this reason it was necessary to find common, standardized performance indicators to compare the systems, as follows:

- The **specific space requirement** indicates the average area required to creating the capacity for the transhipment of one semitrailer per traffic day. The analysis showed that the existing UCT technology requires for 61 m^2 per unit of capacity and thus delivers the greatest space efficiency. The specific space requirement of the Modalohr UIC system is about 20% higher than the UCT option. The CargoBeamer technology needs 82% more area for creating one unit of capacity and the Modalohr horizontal system even 155% more.
- The **specific investment costs** are defined as the average financial amount required to creating the capacity for handling one semitrailer per traffic day. The specific investment costs for the existing UCT technology are the lowest, at €29,000. The Modalohr UIC technology requires 38% more investment costs (€40,000 per unit of capacity) than the UCT system and the horizontal systems need more than twice as much to install the same transhipment capacity.

(9) The above results show that the existing UCT technology delivers the best performance with respect to all key indicators. Finally, it also emerged as the most efficient technology when the **system costs** were analysed. We use this term to denote the costs incurred, for each technology examined, during the transport of one semitrailer

on a CT service between two terminals. System costs include the costs of transhipment at both ends of the transport chain, the wagon, the rail traction and the use of the semi-trailer. Since all other cost components such as pre- and onward haulage, overheads and interest would be identical for all the technologies under the same conditions they could be disregarded. The comparison of system costs was carried out on the basis of the Köln-Milano trade lane with a rail transport distance of about 860 km.

The results of the analysis show that the transport of a semitrailer between Köln and Milano in the existing UCT system offers the lowest system costs at €580. With the exception of the costs for the loading unit, the UCT technology is also the most efficient in all individual cost categories. With the two Modalohr technologies, the transport of one semitrailer costs about 30% more and the CargoBeamer horizontal technology is as much as 40% more costly than the existing UCT system (see the following figure).

System costs of the technologies examined for the terminal-to-terminal transport of one semitrailer on the Köln-Milano trade lane

Technology	Cost per semitrailer carried				
	Semitrailer	Handling	Wagon	Rail traction	Total
Existing UCT	88 €	51 €	60 €	381 €	**580 €**
Modalohr horizontal	84 €	80 €	190 €	405 €	**759 €**
Modalohr UIC	88 €	57 €	218 €	405 €	**768 €**
CargoBeamer	84 €	75 €	152 €	499 €	**810 €**

Source: KombiConsult

(10) In the second part of the study, we determined the costs incurred in order to attain the Swiss modal shift objective with the deployment of different technologies. Only the current UCT system and the Modalohr UIC technology were included in this **cost analysis**. There were two reasons for this. First, the existing UCT system delivers by far the lowest system costs of all the technologies examined. Second, both systems of-

fer definite prospects of enabling the transfer of 4m high semitrailers from road to CT in the Gotthard corridor.

Apart from the higher system costs of the two horizontal transhipment technologies, it is our assessment that they offer no such prospects. The CargoBeamer does not constitute a better alternative because the loading platform of the wagon for semitrailers is 330 mm above rail or 60 mm higher than in the case of modern pocket wagons. This means that the operation of this technology would not only necessitate higher system costs than for the existing UCT system but also infrastructure investments of at least the same level. The latter point also applies to the Modalohr horizontal technology. In this case, significant measures to adapt the lower UIC gauge would be required in the entire corridor between Germany and Italy. In our view, it cannot be expected that the necessary international consensus would be obtained or that the requisite investment funds would be provided.

(11) In order to carry out the cost analysis, it was first necessary to deduce the **modal shift needs**. We use this term to denote the number of semitrailers that would have to be carried in CT by the year 2020 in order to achieve the Swiss modal shift objective of 650,000 trucks. Based on a Bundesamt für Verkehr (BAV) analysis forecasting a total volume of 1.5 million truck journeys in transalpine road freight transport in Switzerland in the year 2020 if no additional modal shift actions had been taken, we calculated modal shift needs of 639,000 semitrailer journeys by this date.

(12) To enable the calculated modal shift needs to be implemented, additional transhipment capacities must be created at both ends of the Gotthard corridor. We examined two **scenarios** for this purpose in our study:

- In scenario 1 "Centralized modal shift" we assume that Switzerland can only achieve the modal shift objective through its own efforts and through cooperation with Italy. The entire transfer requirement must therefore be covered centrally by two terminals in the Basel/Freiburg and Milano areas.
- The scenario 2 "Decentralized modal shift” is based on the expectation that the necessary requirements are met at least on the German and Italian sides so

that a decentralized modal shift will be possible at several terminals. In order not to burden the study with a large number of variants, which would still not change the key results, we selected the economic centres of Ludwigshafen, Köln and Duisburg in Germany and the Milano area in Italy.

In scenario 1, the entire modal shift volume of 639,000 semitrailers is suggested to be moved on the Basel/Freiburg-Milano trade lane, whereas one third of this volume is allocated to each of the three routes for scenario 2.

(13) As the first step, the comparative cost analysis was carried out disregarding potential **infrastructure investment costs** for the upgrading of the Gotthard feeder lines and the increase of the loading gauge to at least P400. These costs were only allocated to the existing UCT system in the second step.

(14) Further the cost analysis assumes **optimum operating conditions** for both scenarios and each technology involved in the analysis. This means that we based the analysis on the assumption that, for example, sufficient train path would be available for the timetable required, a train can be immediately reloaded with semitrailers after unloading the incoming semitrailers, or sufficient semitrailers will have been delivered to the terminal by customers. These idealised conditions will certainly not be encountered in a real logistical situation but because this also would apply to each CT technology the ratio of system costs between the two technologies would not change.

(15) In order to achieve the full modal shift effect in 2020, in **scenario 1**, €191.5m of operational cost would be incurred for the terminal-to-terminal transport of 639,000 semitrailers if, subject to the given assumptions, the existing UCT technology were deployed. The Modalohr UIC system would achieve the same impact at 22.4% higher expenses of €234.3m. As a result the existing UCT technology provides for an annual savings potential of €42.8m in scenario 1.

Assuming stable annual modal shift needs of 639,000 truck journeys over a period of ten years the deployment of the existing UCT technology would ensure a nominal consolidated cost advantage of €428m, not adjusted for inflation, as compared to the Modalohr UIC technology.

(16) In **scenario 2,** the transport of one craneable semitrailer with the existing UCT technology would be about €100 more cost-efficient than with the Modalohr UIC system on all three routes. To ensure the full modal shift needs in 2020 total operational costs of about €309m would be incurred in the case of the existing UCT technology and €376m in the case of the Modalohr UIC technology. It is evident that the existing UCT system would achieve the envisaged modal shift effect for about €67m per year less than the Modalohr UIC system.

Assuming stable annual modal shift needs of 639,000 truck journeys the deployment of the existing UCT compared to the Modalohr UIC technology would ensure a consolidated nominal cost advantage of €428m over a period of ten years.

(17) In the final stage of our study, we assumed that the current UCT system would have to bear the costs for the upgrading of the rail infrastructure on the Gotthard line. Based on current analyses the investment costs would amount to about CHF940m, of which about 30% might be allocated to passenger transport, according to estimates by Swiss experts. We therefore analysed two alternatives for **allocating the investment costs**:

- "Case 100": the existing UCT technology must bear the entire costs of the infrastructure upgrade amounting to CHF940m (€783m).
- "Case 70": the existing UCT technology must just bear 70% of the costs of the infrastructure investment amounting to CHF658m (€548m).

Assuming a typical depreciation period of 50 years and annual financing costs of 6% the additional costs for the use of the rail infrastructure, which would be allocated to the existing UCT option, range from €11.6m in "Case 70" to €16.6m in "Case 100".

Since the existing UCT system achieves an annual cost advantage of between €43m and €67m against a deployment of the Modalohr UIC technology it would not only be able to bear these additional infrastructure access costs but, in "Case 100", even generate cost savings for the logistics sector amounting to some €27m for scenario 1 and €51m for scenario 2. In “Case 70”, which is regarded as more realistic, this "economic dividend" for Switzerland would account for between €31.5m and €55.5m respectively.

6.2 Conclusions

In order to attain the modal shift objective in Switzerland it is paramount that semitrailer journeys will be transferred from road to CT. The present study shows that this goal confronts Switzerland's modal shift policy with the challenge to prepare for the movement of 4m high semitrailers, which, according to our estimates, account for about two third of all semitrailers. Even after the completion of the NEAT, as plans stand at present, the Gotthard corridor will lack the necessary P400 clearance in order to convey craneable semitrailers using the existent UCT technology.

Given this background, the study analysed and evaluated two options: first, infrastructure investment and enlargement the loading gauge on the corridor to P400; second, doing without a gauge increase - at least in the immediate future - by deploying new transhipment and transport systems for semitrailers. Based on the results summarised in the preceding section, the following conclusions can be reached.

(1) At its present stage of development, the **CargoBeamer** horizontal technology cannot be regarded as an alternative to the existing UCT system for craneable semitrailers. First, the wagon loading platform for semitrailers has a height of 330 mm above rail so 60mm more than standard pocket wagons. Hence the CargoBeamer system would require an even greater enlargement of the loading gauge than the existing UCT technology. Second, the system costs of the CargoBeamer technology are about 40% higher than those for the current UCT option not to mention the enormous space requirement for transhipment facilities, which is almost twice as high per unit of capacity as the requirement for the UCT system.

(2) The **Modalohr horizontal** technology, which is operating on a pilot basis in France, is – in principle – available as an alternative solution because it could be employed to ship 4m high semitrailers without any improvement in the upper loading gauge. How-

ever, the special wagons are lowered so far that they protrude into the lower UIC gauge, so corresponding measures to adapt the rail infrastructure would be necessary. In our estimation, there is little likelihood that the investments for a special solution of this sort would be made available by the participating network operators or countries in the Germany-Italy corridor. Moreover, the system costs of this technology are about 30% higher than those for the existing UCT system, and the specific space requirement for terminals is about 150% higher as for the existing UCT option.

(3) Even though it currently appears that the two horizontal transhipment systems would not able to solving the gauge problem in CT services through Switzerland they might still be considered as potential instruments for contributing to the implementation of the modal shift policy. This is because the main target market of these systems − for which they were in fact developed − is the unaccompanied transport of non-craneable semitrailers. This aspect was not covered by the study but a preliminary assessment can be delivered based on the results of this study. They suggest that the feasibility of these horizontal transfer systems is facing the following fundamental obstacles:

- Only semitrailers with a restricted gauge can be moved on rail. Their market share, which is estimated at about 35% at present, is likely to continue declining.
- These technologies in fact are island systems for wagons and transhipment facilities. They are not compatible with the standardised existing UCT system or it would only be rendered compatible at significant additional costs for adapting devices and in operations.
- The system costs are so high that these technologies could only be operated with subsidies, which would be substantially above the rates of the current compensation schemes for transalpine UCT in Switzerland. Even more so we suggest that the horizontal systems would rely permanently on funding.
- Further it won't probably be easy to find appropriate areas for building transhipment facilities, which are large enough and provide for satisfactory rail and road access.

Against this background, the employment of another tried-and-tested technology − the Rolling Motorway – could lead to a solution that is at least equivalent in economic terms, all the more so as it is likely to be more space-efficient.

Ultimately, one question remains for all suppliers of horizontal transhipment systems targeting at non-craneable semitrailers. When road operators procure for non-craneable semitrailers they do so, first of all, because they intend to obtain revenues from operating them – accompanied - over the road only or, secondly, since they are not capable of forwarding them – unaccompanied – by rail. They do not switch to rail services in these cases for various reasons: road transport on shorter routes may be more cost-efficient than rail; the company does not have a transport organisation on both ends of a rail journey or does not provide for a sufficiently high and regular volume on a given trade lane ("critical mass"). For a company, which can systematically and regularly make use of unaccompanied CT services, on the other hand, the additional costs for a craneable semitrailer amounting to €1,500 to €2,000 will be amortised in a few journeys.

(4) The **Modalohr UIC** technology, which is currently under development, appears to be the only system that is able to overcome the gauge bottleneck without needing to adapt the rail infrastructure. The height-adjustable trough/pocket is an innovative solution – provided that it actually will meet expectations and be authorized for rail operation. Moreover, this technology could basically be run on an interoperable basis with the existing UCT system if it aims at the market for craneable semitrailers, as the system provider made clear in its original communication (although divergent press releases on this aspect have been appearing recently).

Subject to the feasibility of this technology the results of the present study throw up the following questions particularly in respect of Switzerland's modal shift policy:

- The success of combined transport and the strong growth in its volume during recent decades can mainly be attributed to the standardisation of the individual technological components, the reduction or elimination of operational interfaces (e.g. shuttle trains instead of shunting, multi-system locomotives) and the standardisation and simplification of processes. If technologies such as Modalohr were to be introduced special solutions would again make inroads into CT and the complexity of the workflow organisation would increase. This would be owing to, for example, the need to measure and weigh semitrailers, the adaptation of the wagons in height and additional safety inspections of wagons and loading units.

- If, however, the demand for "quick solutions" for the transfer of truck journeys through Switzerland is so strong that there is also a willingness to accept special structures such as those for the Modalohr UIC wagons, then the same conditions should also be granted to the existing UCT system. According to wagon technology experts, it would be possible to develop a pocket wagon that utilises the safety tolerances currently regarded as necessary for rail operation in order to gain height for the movement of 4m high semitrailers. In this case, the existing UCT technology would also manage without an extended gauge on the Gotthard rail line.
- In recent months, attempts have been made to suggest to the Swiss public an urgent need for an "interim solution" until the date when the loading gauge on the Gotthard corridor will be increased. Apart from the fact that certain auxiliary structures have a very long lifetime because they are linked to economic or political interests, there should be a detailed review of the economic fundamentals.
- This study shows that, in order to achieve the modal shift objective in 2020, 639,000 additional semitrailers would be required to be transferred from road to rail. The existing UCT technology would achieve this effect for €67m less costs than the Modalohr UIC system. Within twelve years of operation, the cost advantage of the existing UCT system would add up to over €800m assuming a stable volume of modal shift needs. Instead of spending this amount on an "interim solution" with non-standardised components, it could be better used for entirely financing the investment into the 4-meter-corridor on the Gotthard line, which is estimated at €783m.

(5) The **overall result** of the study demonstrates that the deployment and expansion of the exiting UCT technology, which is based on standards dating back many years, is clearly the more cost-effective option for Switzerland's modal shift policy as compared to a new Modalohr UIC system, parts of which have yet to be developed. This would also apply if the currently anticipated costs of widening the loading gauge on the Gotthard corridor would have to be borne in full by trains using the existing UCT technology. In this case, too, a comparison of the total costs shows that Switzerland can achieve the modal shift objective most efficiently and also, in view of the lasting economic benefits, with the greatest sustainability, by means of the existing UCT technology.