Table Of Contents
### Background

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Research</td>
<td>4</td>
</tr>
<tr>
<td>Milles Akeri Umea</td>
<td>22</td>
</tr>
<tr>
<td>DB Schenker &amp; Milles Akeri Gothenborg</td>
<td>24</td>
</tr>
<tr>
<td>Posten Umea</td>
<td>34</td>
</tr>
<tr>
<td>Road Trip</td>
<td>36</td>
</tr>
<tr>
<td>Stena Line Gothenborg</td>
<td>40</td>
</tr>
<tr>
<td>Volvo Demonstration Center</td>
<td>46</td>
</tr>
<tr>
<td>Volvo Design</td>
<td>50</td>
</tr>
<tr>
<td>Internet &amp; Literature Research</td>
<td>56</td>
</tr>
<tr>
<td>Flow of Goods</td>
<td>60</td>
</tr>
<tr>
<td>Loading Units</td>
<td>62</td>
</tr>
<tr>
<td>Concept &amp; Examples</td>
<td>66</td>
</tr>
</tbody>
</table>

### Goals & Wishes

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideation</td>
<td>94</td>
</tr>
<tr>
<td>Evaluation of Ideation</td>
<td>96</td>
</tr>
<tr>
<td>Addressing The Problem Area</td>
<td>152</td>
</tr>
<tr>
<td>Coupling Method</td>
<td>154</td>
</tr>
<tr>
<td>Decisions</td>
<td>156</td>
</tr>
<tr>
<td>New Brief &gt; New Truck Modularity</td>
<td>159</td>
</tr>
<tr>
<td>Truck (Tractive Unit)</td>
<td>160</td>
</tr>
<tr>
<td>Loading &amp; Load Carrying Units</td>
<td>162</td>
</tr>
<tr>
<td>Number of Axles</td>
<td>164</td>
</tr>
<tr>
<td>Storing Load Carrying Units</td>
<td>166</td>
</tr>
<tr>
<td>Project Focus</td>
<td>168</td>
</tr>
<tr>
<td>Load Carrying Unit</td>
<td>170</td>
</tr>
<tr>
<td>Articulation &amp; Connectivity</td>
<td>172</td>
</tr>
<tr>
<td>Design Proposal</td>
<td>178</td>
</tr>
</tbody>
</table>

### Research Mapping

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route Network</td>
<td>80</td>
</tr>
<tr>
<td>Possibilities</td>
<td>82</td>
</tr>
<tr>
<td>Design Direction</td>
<td>84</td>
</tr>
<tr>
<td>Problem Areas</td>
<td>86</td>
</tr>
</tbody>
</table>

### Problem Areas

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Proposal</td>
<td>90</td>
</tr>
</tbody>
</table>

### Sources

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals &amp; Wishes</td>
<td>94</td>
</tr>
<tr>
<td>Ideation</td>
<td>96</td>
</tr>
<tr>
<td>Evaluation of Ideation</td>
<td>152</td>
</tr>
<tr>
<td>Addressing The Problem Area</td>
<td>154</td>
</tr>
<tr>
<td>Coupling Method</td>
<td>156</td>
</tr>
<tr>
<td>Decisions</td>
<td>159</td>
</tr>
<tr>
<td>New Brief &gt; New Truck Modularity</td>
<td>160</td>
</tr>
<tr>
<td>Truck (Tractive Unit)</td>
<td>162</td>
</tr>
<tr>
<td>Loading &amp; Load Carrying Units</td>
<td>164</td>
</tr>
<tr>
<td>Number of Axles</td>
<td>166</td>
</tr>
<tr>
<td>Storing Load Carrying Units</td>
<td>168</td>
</tr>
<tr>
<td>Project Focus</td>
<td>170</td>
</tr>
<tr>
<td>Load Carrying Unit</td>
<td>172</td>
</tr>
<tr>
<td>Articulation &amp; Connectivity</td>
<td>178</td>
</tr>
<tr>
<td>Design Proposal</td>
<td>180</td>
</tr>
<tr>
<td>Sources</td>
<td>236</td>
</tr>
</tbody>
</table>
Background
Exam Work with Volvo Trucks AB
“Long Vehicle Combinations”

Initial brief from Volvo Trucks was specific for loading-unloading situations of long vehicle combinations. There were 2 safety issues reported regarding reversing and coupling-uncoupling processes of semi-trailer trucks. However I conducted the research in a wide perspective because I wasn’t very familiar to the topic. Also, not only other types of trucks, other means of transportation are related to semi-trailer trucks in some cases. Gathered information is also used for inspiration and checking the consistency of the final concept.
Initial Problems

Look into the loading/unloading situation from the safety point of view
When the driver comes to the terminal he/she needs to maneuver the truck with perfect control and in a safe way for people close to the vehicle.
The driver might need to disconnect the link or the trailer which is a complicated and unsafe situation. How could it be improved?
Initial Questions
What is a long vehicle combination?

Long vehicle combination is a truck or tractor combination with two or more trailers or semi trailers to cover the increasing need of transportation of goods.
How “long” are we exactly talking about?

Length and weight of vehicles are regulated by laws and different countries have different maximum limits. Average number of loading compartments is 2 or 3. Longest combination is with 6 loading compartments and operating only in Australia, called “Powertrain” or “Body and six”.

However, since it is kind of a matter of honor, there is a competition about driving the longest combination. 70 years old John Atkinson from Australia used a single prime mover to pull 112 trailers for 100 metres. Length of the vehicle itself was 1,474.3 metres.
**Truck**

A truck is a motor vehicle designed to transport cargo. Trucks vary greatly in size, power, and configuration, with the smallest being mechanically similar to an automobile. Commercial trucks can be very large and powerful, and may be configured to mount specialized equipment, such as in the case of fire trucks and concrete mixers and suction excavators. Modern trucks are powered by either gasoline or diesel engines, with diesel dominant in commercial applications. In the European Union vehicles with a gross combination mass of less than 3,500 kilograms (7,716 lb) are known as Light commercial vehicles and those over as Large goods vehicles.

The first motor truck was built in 1896 by the German automotive pioneer Gottlieb Daimler. Daimler’s truck had a four-horsepower engine and a belt drive with two forward speeds and one reverse. It was the first pickup truck.

1898 Daimler is the world’s oldest truck to survive in original condition.


**Truck Types**

The three main classifications for road truck by weight are light trucks, medium trucks, and heavy trucks. Above this there are specialised very heavy trucks and transporters such as heavy haulers for moving oversized loads, and off-road heavy trucks used in construction and mining which are too large for highway use without escorts and special permits.

**Light trucks**
- Minivan
- Sport utility vehicle
- Canopy express
- Pickup truck
- Panel truck
- Cab-forward
- Tow truck (may also be a medium or heavy truck)
- Panel van
- Sedan delivery

**Medium trucks**
Some of the truck types listed under heavy trucks may also come in medium sizes. In North America, a medium duty truck is larger than a heavy-duty pickup truck or full-size van.

- Box truck
- Van
- Cutaway van chassis
- Medium Duty Truck such as Ford F-650 in North America
- Medium Standard Truck
- Platform truck
- Flatbed truck (may also be light duty trucks)
- Firetruck (may also be a heavy truck)
- Recreational Vehicle or Motorhome

**Heavy trucks**

Except for semi-trailer trucks and, generally, mobile cranes, the following types may also come in medium sizes.

- Ballast tractor
- Concrete transport truck (cement mixer)
- Crane truck or mobile crane or truck-mounted crane
- Dump truck
- Garbage truck
- Log carrier
- Refrigerator truck
- Semi-trailer truck also known in British English as “Artic” for ‘articulated lorry’
- Tank truck or tanker or tanker lorry in British English (can also be a Medium truck)

**Very heavy trucks and transporters**

Vehicles in this category are too large for highway use without escorts and special permits.

- Ballast tractor
- Construction equipment
- Self Propelled Modular Transporter
- Toter

The following are not types of trucks but types of use of the trucks listed above:

Delivery truck, Multi-Stop truck, Bottler.
Anatomy of a truck

Almost all trucks share a common construction: they are made of a chassis, a cab, an area for placing cargo or equipment, axles, suspension and roadwheels, an engine and a drivetrain. Pneumatic, hydraulic, water, and electrical systems may also be identified. Many also tow one or more trailers or semi-trailers.

Cab

The cab is an enclosed space where the driver is seated. A sleeper is a compartment attached to the cab where the driver can rest while not driving, sometimes seen in semi-trailer trucks.

There are several possible cab configurations:

- Cab over engine (COE) or flat nose; where the driver is seated above the front axle and the engine. This design is almost ubiquitous in Europe, where overall truck lengths are strictly regulated, but also widely used in the rest of the world as well. They were common in North America, but lost prominence when permitted length was extended in the early 1980s. To access the engine, the whole cab tilts forward, earning this design the name of tilt-cab. This type of cab is especially suited to the delivery conditions in Europe where many roads follow the layout of much more ancient path, and trackways which require the additional turning capability of the cab over engine type. The COE design was invented by Viktor Schreckengost.[11]

- Conventional cabs are the most common in North America and Australia, and are known in the UK as American cabs and in the Netherlands as “torpedo cabs”. The driver is seated behind the engine, as in most passenger cars or pickup trucks. Conventional are further divided into large car and aerodynamic designs. A “large car” or “long nose” is a conventional truck with a long (6-to-8-foot or 1.8-to-2.4 m or more) hood. Aerodynamic cabs are very streamlined, with a sloped hood and other features to lower drag.

- Cab beside engine designs also exist, but are rather rare and are mainly used inside shipping yards, or other specialist uses such as aircraft baggage loading.
Engine

Most small trucks such as sport utility vehicles (SUVs) or pickups, and even light medium-duty trucks in North America and Russia will use petrol engines (gasoline engines), but many diesel engined models are now being produced.

Drivetrain

Small trucks use the same type of transmissions as almost all cars, having either an automatic transmission or a manual transmission with synchronesh (synchronizers). Bigger trucks often use manual transmissions without synchronisers, saving bulk and weight, although synchronesh transmissions are used in larger trucks as well.

Frame

A truck frame consists of two parallel boxed (tubular) or C-shaped rails, or beams, held together by crossmembers. These frames are referred to as ladder frames due to their resemblance to a ladder if tipped on end. The rails consist of a tall vertical section (two if boxed) and two shorter horizontal flanges. The height of the vertical section provides opposition to vertical flex when weight is applied to the top of the frame (beam resistance). Though typically flat the whole length on heavy duty trucks, the rails may sometimes be tapered or arched for clearance around the engine or over the axles. The holes in rails are used either for mounting vehicle components and running wires and hoses, or measuring and adjusting the orientation of the rails at the factory or repair shop.

The frame is almost always made of steel, but can be made (whole or in part) of aluminium for a lighter weight. A tow bar may be found attached at one or both ends, but heavy trucks almost always make use of a fifth wheel hitch.
Volvo Trucks Product Range

- Tractor + Semi Trailer
- Van Body / Box Body / Curtain Sider
- Swap Body Carrier
- Concrete Mixer
- Hook Lift
- Dump Body
- Tipper
- Refuse Body
- Liquid / Gas / Dry Bulk Tanker
- Timber Body
- Car Transporter

Trucks used for freight transport
Rates to register a truck or farm vehicle are determined on the basis of the number of axles on the vehicle. If this vehicle is part of a combination of road vehicles, however, the number of axles of the trailer (or semi-trailer) it is pulling must be included. For example, a 3-axle truck pulling a trailer with 2 axles will pay the rate that corresponds to 5 axles.
A semi-trailer truck is an articulated vehicle consisting of a towing engine and a semi-trailer (plus possible additional trailers) that carries the freight. This arrangement requires both tractor and semi-trailer to be distinct in design from a rigid truck and trailer.
Semi-Trailer

A semi-trailer is a trailer without a front axle. A large proportion of its weight is supported by a road tractor.

A road tractor coupled to a semi-trailer is often called a semi-trailer truck.
Field Research

At the beginning of the process, I conducted qualitative field research including:

In-depth interviews with truck drivers, other operational and logistical staff, engineers, road and sea transportation companies in combination with rail transportation, test drive of a 16.5 meters semi trailer truck at Volvo Demonstration Center for experiencing maneuver behavior of the vehicle, 36 hours delivery trip in subarctic conditions (limited daylight, frozen roads, as cold as -37 °C observed) involving different loading unloading scenarios, switching trailers, sleeping in the cab of the truck, maintenance of frozen equipment on the go.
Milles Åkeri AB
Umea

Milles is a private company, with around 180 employees, working as a part of DB Schenker transportation and logistics and has one of the largest fleets among Schenker. Traffic goes between West Coast and Norrland in Sweden. International flow mainly includes Finland and Norway with semi trailer trucks. 35 % of the total freight is transported via rail which is equal to 17 000 Twenty-foot equivalent unit (TEU) per year for environmental and cost concerns.

I visited Umea and Gothenburg offices of Milles. Observations include interviews with drivers, equipment demonstrations, general transportation flow of Milles, and a short trip between Milles terminal to rail station for observing intermodal transportation process.
Vehicle and Equipment Demonstrations

Truck-trailer connections on semi trailer

Truck-trailer connections on truck

Drawbar trailer coupling receiver

Semi trailer-dolly connection

Connections on dolly

Rear door lock on truck
Heavy duty drawbar system

Sliding axle on B-train semi trailer
Vehicle and Equipment Demonstrations

- Loading-unloading docks at terminal
- Clearance between semi-trailer & b-double while parking
- Loading dock ramp
- 5th wheel lock handle while semi trailer is coupled with the truck
- Snow pile on flatbed semi trailer and semi trailer connections
Extreme frost on various parts

Loading dock curtains for isolation (weather & animals)

Inside of loading dock while unloading a semitrailer
Vehicle and Equipment Demonstrations

Rigid flatbed truck carrying 20 foot ISO container

Gap between truck and container since this truck is not produced specifically for ISO container transport. Rear end of the truck also protrudes for this reason.

Mercedes truck coupled with curtain sided semi-trailer

Platform steps on Mercedes semi-trailer truck

Unused Swap Body Container and semi-
Door of one truck hits another’s mirror because of tight terminal docks. This makes it hard to climb to the cab because of the placement of steps.

Trailer coupled with a dolly in the parking lot of the terminal.

Truck combination with cooling function.
Terminal-Rail Station Ring Delivery Scenario

Moving container from truck to train

Aligning truck to main terminal dock

Opening rear doors before reversing

Reversing to dock

Transfer of received cargo from semi trailer to 20 foot ISO container on a rigid flatbed truck

Adjusting 8 parts for compensating the size difference between ISO container and swap body container
Light guided docks at Schenker terminals

Entering warehouse for handing in the papers

Unloading cargo for further distribution

Registration at train station

Approaching departure lane to drop the ISO container

Unlocking container twist locks at 4 corners

Turning to arrival lane to pick swap body container

Aligning truck roughly to crane

Locking container twist locks at 4 corners
DB Schenker stands for the transportation and logistics activities of Deutsche Bahn. The Logistics sector of DB is the world’s second largest transportation and logistics services provider based on revenues and performance.

DB has Europe’s densest land transport network and the rail expertise of Europe’s largest rail freight company.” (From DB Schenker website)

Some excerpts from Schenker and Milles staff interviews are as follows:

Schenker plan the entire transport of the cargo and delegate the work to private companies depending on the destination and weight-size of the cargo. For example if the cargo is more than 1 tonne Milles pick the cargo from customer and if it’s less than 1 tonne, Schenker delegate another company which have smaller trucks.

Operation area of Milles is limited to some parts of Sweden including Umea, Gothenburg and Sundsvall and they don’t transport goods to Stockholm. For example if a customer in Umea wants to send a semi-trailer to another country, Milles only transport the semi-trailer from Umea to Gothenburg harbor and leave the semi-trailer there.

Sometimes goods are manipulated in Schenker’s terminals. For example cargo picked from different customers which is going to same destination is combined and loaded to same truck.

Sometimes semi-trailers and containers are transported with train or ferry. The shortest distance Milles use the train is 300 km. If the destination is closer than this, they use truck.

Milles have customers which prefer train transportation because of environmental concerns, despite the fact that it takes more time.

Road trains are used for long distance domestic road transport in Sweden which is 25,25 meters long. It’s the longest combination allowed in Sweden and some other European Countries. 18,75 m is the limit for the rest so Milles send semi-trailer trucks if final destination of the cargo is another country.

Comman type of road train in Sweden is a combination of a rigid truck (sometimes flat bed that carries a swap body box) and a trailer. Nowadays instead of full trailers, semi-trailer coupled with a dolly is used more often since this way of combination can be converted to semi-trailer truck combination for the cargo that will be sent another countries.

Manipulation of goods at the terminals of forwarder companies and using semi-trailers for truck combinations are reported to be comparingly new in logistics-trucking industries and improve the efficiency of freight transportation. C-train combination with semi-trailer seems like a good solution for their flexibility to switch between Swedish and other European length limits for now. However it doesn’t offer solutions for possible future longer vehicle combinations and ISO container transport.
Posten,  
Umea

“Posten AB is a part of PostNord AB that was founded through the merger of Post Danmark A/S and Posten AB in 2009. The group offers communication and logistics solutions to, from and within the Nordic region.

The parent company PostNord AB is a Swedish public company owned 40% by the Danish state and 60% by the Swedish state. The group’s headquarter is located in Solna, Sweden.”
(from Posten website)
Posten offices pick the packages and palettes from customers with minivans and bigger trucks, bringing them in their terminals, sorting them in different directions. Then they load the cargo in their longer route trucks. These trucks consist of a swap body box attached to a swap body carrier and a semi trailer attached to a dolly.

They prefer swap body boxes because of their flexibility. They can be lifted off the truck and left at the terminal for loading-unloading while the trucks pick ready ones for transportation. These boxes can be carried by trains as well as trucks. Posten also have entrepreneurs transporting Posten's cargo and they don't use each other's trucks because of insurance issues. So trucks meet at terminals and drivers switch the boxes.

Kaj Bareklev
Small goods are collected and delivered with minivans. For palette goods bigger rigid trucks are used. After collecting, goods are sorted out depending on the route. "Long John"s and other loading lines are connected to automatic sorting machines which distribute the goods depending on the distribution labels on packages.
Road Trip

I was lucky to observe a delivery trip with Tom Berle, a semi trailer truck driver of Milles Umea. Milles is the biggest private company working for Schenker. Trip started from Umea, some goods were unloaded at Skellefteå. Then we drove to Haparanda, a Swedish City at the Finland border. Here we met with the other truck which also works for Schenker, took the trailer coming from Finland and give our trailer coming from Umea. This is done for time efficiency since Tom Berle was about to fill his weekly driving hours. Then some goods were unloadad at Svartliden Mine, rest were taken to Umea.

The whole trip took nearly 36 hours and frozen equipment because of subarctic conditions was the toughest part of the journey.
Umeå - Skellefteå - Haparanda - Svartliden (Pauträsk, Storuman)- Lycksele-Umea

11:41 - 13:11 Driving to Martinsons Kroksjon 14 Skellefteå
13:11 - 13:41 Obligatory break
13:41 - 14:12 Driving to Martinsons Kroksjon 14 Skellefteå
14:12 -14:19 Unloading goods to customer
14:19 -14:29 Driving to gas station
14:29 -14:38 Filling Fuel
14:38 - 18:00 Driving to Haparanda
18:00 - 03:20 Obligatory 9 hours break (Dinner & Switching Semi-Trailers & Sleep)
03:20 - 07:50 Driving to Svartliden Gold Mine
07:50 - 08:35 Obligatory break
08:35 - 11:15 Driving to Svartliden Gold Mine
11:15 - 12:35 Unloading goods to customer
12:35 - 14:15 Driving back to Umeå
14:15 - 15:00 Obligatory break (Lunch)
15:00 - 16:00 Driving back to Umeå

Tachograph Symbols
- Driving
- Break
- Other Work (Loading&Unloading)
Driver Tom Berle, struggling with frozen and stucked connections and side curtain of the trailer.

Frozen 5th wheel prevents uncoupling. Another driver trying to pull 5th wheel handle while Tom drives forward to release king pin from 5th wheel.
Notes:

- Frozen 5th wheel lock and landing gear took time and effort to uncouple trailer with truck. Driver needed to find another person to help him out, which is not always an available option. Low light conditions also made it hard to uncouple.

- It is even harder for female drivers to handle some tasks like unconnecting air and electricity connections, pulling 5th wheel handle, changing tires, opening side curtains of trailer since these tasks require greater effort especially if the equipment is frozen or stuck with dirt and the driver is alone. It is reported that stuck situations are not rare.

- When driving behind a truck with a trailer, only the number plate of trailer is visible, and the number plate of the truck is not visible, which somehow can cause security issues if the trailer is stolen.

- Driving hours is an important part of the trip and planning the trip was not always an easy task for driver to handle, some breaks were taken at remote places where even no toilettes exists.
Stena Line
Gothenburg

Stena Line Group is an international transport and travel service company and is one of the world’s largest ferry operators.

Stena Line has a route-based organisation with business areas made up of three geographical markets: Scandinavia, Irish Sea and North Sea. The head office is in Gothenburg, where the management team and staff functions are based.

Stena Line is owned by Stena AB, a company in the Stena Sphere. The Stena Sphere includes, among other things, activities within shipping, offshore drilling, property, and waste management and recycling.

The Stena Sphere comprises three family-owned parent companies: Stena AB, Stena Sessan AB and Stena Metall AB. There is also the majority-owned, listed company Concordia Maritime AB.

(From Stena Line AB website)
Tugmaster and apparatuses that are used for moving ISO containers and semi trailers inside the facility.
Notes:

• Stena line has different types of ferries and ro-ro ships. Some only carry ISO containers, some carry a mix of semi-trailers, ISO containers and passengers.

• They have special apparatuses for carrying ISO containers and semi-trailers. For ISO containers they use a plastic platform with wheels for moving them from parking area to the ferry and for semi-trailers they use extra legs since landing gear of semi trailers are not strong enough for sea shipping. They rarely carry semitrailers with the truck part.

• They are both carried by special trucks called tugmasters into the ferry. Cab interior of these trucks can be reversed so drivers don’t need to drive reverse. This type also allows drivers to reach air and electricity connections without leaving truck which is both safer and more efficient comparing to semi-trailer trucks.
Volvo Demonstration Centre, Gothenburg

Meeting with Engineers at Volvo Demonstraition Center was a good opportunity to observe coupling sequences and truck-semi trailer maneuvering behaviour. In addition to observations, I was lucky to drive an 18,75 m. semi-trailer truck configuration inside the traffic free area.

This experience was very helpful for me to understand the maneuver behaviour of the vehicle. For example on a narrow road if you want to turn left, first you need to turn right a little bit, then turn left. It was harder for me since I’m not experienced but this kind of maneuvers happens frequently and may result in interference when there are obstacles around the vehicle.
Coupling

Aligning and reversing truck

Climbing platform steps

Making air & electricity connections

Gap between truck and trailer after 5th wheel is locked to king pin

Readjusting height of the truck with the trailer

Winding the landing gear up

Ayca Kinik / MA Advanced Product Design / Umea Institute of Design / Degree Project 2012 Sponsored by Volvo Trucks
Making air & electricity connections
Adjusting the height of the truck
Reversing more for connecting 5th wheel & king pin
Walk around for checking lights
Releasing trailer brakes
Vehicle and Equipment Demonstrations

Right mirror view while taking a left turn. Trailer overhangs almost half width of the trailer.

Jackknife (placing the trailer at a very sharp angle to the tractor) and the effect on connection cables.
Risk of interference with the obstacles when the trailer overhangs because of turning maneuver
Volvo Design,
Gothenburg

We had a meeting at Volvo Trucks facilities in Gothenburg with Chief Exterior Designer Asok George, Chief Interior Designer Carina Byström and Designer Ismail Ovacik. Until this part, all field research was about understanding the current situation of freight transport and the trucks. During this meeting we talked about what future might bring and meeting raised questions about the future of containerisation, road and rail transport. Some of the excerpts are on the next pages.
Q: Is there a better way to transport goods?

A1: Trucking as a whole is optimized to reduce the cost of the transportation. The entire setup is like that, so it’s a modular system and is basically built up on trying to increase efficiency at one end and that is optimized cost, and I think that will have to change. It has to be optimized for another type of efficiency. And that is to be environmental, more sustainable. So therefore I think optimization is still the key but with a very different focus.

The standard today is container, that is a very efficient standart. But i think we need to find a new standart. That is more efficient for not just for the cost, not just the monetary cost, but the environmental cost.

There are different kinds of containers, but in general it is very optimized, it’s a very efficient system to ship things around the world, so i think it is a good system, at least was a good system. I don’t think it is any more. It’s cheaper to get rid of a container, than to ship it back. In us right now they have a huge problem because there are tons of containers coming in everyday which they don’t know what to do with it. Right now some architects are designing buildings with these containers.

So then you need something to export really to send them back or you need to find a new way of transportation or new way of living. So i think trucks is just one element of this big question. The question is much bigger that trucks. But yes, i think that we will definitely need to change trucks as well.

Q: I was talking to Schenker and they say for only 25% of their workload, they use road transportation. They mainly send goods with trains. If trains are used, why trucks are so common? For me transportation seem like it has to be more compatible with rails.

A1: It’s difficult, because the railway don’t really offer the flexibility that trucks offer. And in Europe we have a huge problem which is not the same as other bigger countries. Because in Europe every country more or less has its own railway system and it’s different on purpose from the other country. This is because of security reasons. They don’t want what happened during the 30s to happen again. Then in Europe we are a little more handicapped compared to the US or to other bigger countries like China and India where there is much more opportunities for railway. So therefore I don’t think that railways will necessarily be able to solve the all problem, especially in Europe.

A2: And railway system is not covering all the places, so even if you have a main part of it(transport) via rail you must be able to take from the train to wherever you want the goods.

Q: But still that may be for shorter distances. A person I talked today was optimistic about railways, for long distances, to china for example. What dou you think about this, How this will going to evolve? Obviously future of transportation is not only railways because of time pressure also...

A1: if you look historically railways is a very heavy investment, it’s a huge investment and the reason why you had the actual railway on the ground is because you needed something to guide the vehicle right? Today it doesn’t make sense anymore we don’t need physical objects to guide the vehicles. You can guide from satellites, you can send any vehicle anywhere on earth using satellites. So you don’t really need rails anymore. So I don’t think railways is the right way, we probably maybe have to come up with some new solutions as long as you clear the way. People are still not used to that concept; it leads to looking backwards, the traditional ways and see how we can improve it, but at some point we need to ask a bigger question and see is there a new way of transporting, and it’s not necessarily railways or trucks or something, it has to be something new.

Q: What interests me about this whole thing is that at some point we disassociate ourselves from these thing. For example this phone; at some point it was made by someone in china, some human being actually touched this, and it was put into a box, and then it became a “thing” that needs to be transported, but at some other point here in Sweden Karin is waiting for her new phone, someone eventually gets it, it’s back to a human touch again. At some point between the place where pause and they put in the box and you’re getting it, it’s a “big problem”, whereas actually is not, is it?

It’s basically two human beings doing something that the other end of the cycles, if you break it down to that sort of question, you’re going to have completely different kind of perspective of the problem. I think we are always trying to find extremely big solutions to extremely complicated things, then actually it really that complicated.
Q: Does that require an economical change, I mean I cannot _as a designer_ say, this problem cannot be solved in this economic system?

A1: That’s what the important thing is because the role of the designer, the new role of the designers is not to find answer, is to ask the right questions. We have a very complicated world, very complicated life. We have become very fast in the last 55 years, I think it started in the 50’s, so in 55 years we have come more than humans have ever come, we’re maybe not capable of this, we have acceded our own limit. Now we have created problems that we cannot fix, so we need to question ourselves. I don’t think one group of people can find solution, it’s not possible, but someone has to ask questions and uncomplicated the complicatedness, because everyone is just trying to fix things and make things even more complex.

A2: There are things also really changing, nowadays we talk about transportation and that we’re building thing for transportation. 20 years ago it was more about trucks, there is a change, it’s shifting. If you talk about trucks than you mean trucks, but if you talk about transportation it doesn’t have to be trucks. Transportation is not only trucks, so it’s really shifting out to something else.

A1: It’s very cheap to transport things around the world, still financially… but it’s not cheap, there are other aspects that people do not account for that, that cost is not accounted. Now if, every single part of this phone is charged per whatever, CO2 gram percent, if there is a tax on that levied by the governments of each different countries, than there is a new cost, then people are forced to think differently. But until that happens, it’s still cheap to transport.

Q: But that’s a forced way of changing, it doesn’t feel like it’s going to work.

A1: The other option is like, some say the other day, if you look back in history, there has always been ups and downs, there has been great empires, great civilizations, which collapsed. So that’s what’s going to happen. So either we try different experiments see if something succeeds or just accept that fact and “let’s party until it collapses”

We are also forced; we are forced so hard that some of the truck companies may not survive. After 2014 we will have a new emission standard for trucks, which actually means, if you literally take it, it is almost like the air going into the truck is dirtier than the air coming out from exhaust. So our truck will become giant air cleaners. It’s extremely tight.

I look it in that way, we reached this sort of a situation because we were unlimited, we used our imagination, our human skills unlimited and we reached a certain point, now we can either use the same creativity to solve that problem, but I don’t think we will because there is not so much money in that. Then you have to start restrict. Free market fantasy has to change. Therefore it’s either you have to start controlling or restricting, OR some people who are creative, they have to ask the right questions, and start to make the right noises.

Q: One of the most important points about trucking is the safety of drivers. I’m mostly standing in drivers’ side, how their work sequences can be improved. I’m not sure what’s going to come out of future concepts and maybe we won’t need drivers, but I can’t just underestimate the possibility of having some sort of operators...

A1: There will always be some operators even if we don’t have them in the trucks or whatever who is transporting but someone has to always control, where thing are or to make sure that it goes from a to b. So even if you don’t have driver, you’ll have someone in an office or somewhere making sure that trucks are on track.

A2: I think it’s important to reclaim. Because at the end of the day we still need jobs, and even if we have the technology we still need to reclaim it because otherwise we’re going in the wrong direction again.

A1: But why should we reclaim those jobs? There so many other jobs that aren’t done by people anymore like warehouses or some kind of operators that used to be in factories mounting things, they are not reclaimed...

A2: No but maybe we should.
Internet & Literature Research

On this phase, I investigated 2 other master thesises that I received from Volvo Trucks. One was about the work sequences of semi-trailer trucks which explains the problems of coupling process in detail, the other one was about low speed maneuvering of long vehicle combinations. Along with my own observations, these documents supplied very detailed information about semi-trailer trucks, and it’s safe to say that coupling process and low speed maneuvering topics have many safety gaps.

In addition to semi-trailer truck research, I wanted to see the context that semi-trailer trucks operate in and searched for information about fundamental transportation concepts, examples of future of semi-trailer trucks and examples from other fields that can offer solutions to some of the problems of current semi-trailer trucks.
Flow of Goods
Cargo (or freight) is goods or produce transported, generally for commercial gain, by ship, aircraft, train, van or truck. In modern times, containers are used in most intermodal long-haul cargo transport.

Transport modality is a term used to distinguish substantially different ways to perform transport. The most dominant modes of transport are aviation, land transport, which includes rail, road and off-road transport, and ship transport.

Each mode of transport has a fundamentally different technological solution, and some require a separate environment. Each mode has its own infrastructure, vehicles, and operations, and often has unique regulations. Each mode also has separate subsystems. A subsystem is a group of many parts that make up one part. All modes of transportation have 6 subsystems. They are:

**Propulsion**
The propulsion system provides the force that moves the vehicle toward the destination. Example: Engine and Transmission

**Suspension**
The suspension system supports the weight of a vehicle as it moves down a pathway. Example: Shocks, Wings, and Tires

**Control**
Control systems control speed and direction of a vehicle’s path. Examples: Steering Wheel and Brakes

**Guidance**
Guidance systems provide information concerning the control of the vehicle. Examples: Maps and GPS

**Structural**
Structural systems accommodate a vehicle’s cargo and form the basic framework of the vehicle. Examples: Chassis and Body

**Support**
Support systems are used to maintain vehicles. Example: Garages and Gas Stations

A transport mode is a combination of the following:
- Transportation infrastructure: thoroughfares, networks, hubs (stations, bus terminals, airport terminals), etc.
- Vehicles and containers: automobiles, motorcycles, trucks, wagons, trains, ships, and aircraft
- A stationary or mobile workforce
- Propulsion system and power supply (traction)
- Operations: driving, management, traffic signals, railway signalling, air traffic control, etc.

The most widely used modes for freight transport are Sea (40,000 bn ton km), followed by Road (7,000), Railways (6,500), Oil pipelines (2,000) and Inland Navigation (1,500)
Goods Flow Concepts

Logistical processes can be illustrated in a network made of nodes and links. Two basic concepts illustrate goods flow in the logistical process:

Single-step System is an uninterrupted flow of goods from supply point to the reception point. During this action, there is no need for additional storage or movement (only a means of transport is in use).

Multi-step System is a concept where the goods flow is interrupted at least at one place. At these points, good manipulation (warehousing, deconsolidation,…) takes place. In a multi-step transport chain the change of transport means takes place between supply and reception point.

Some specific circumstances as great distances or volume of goods generate Combined System of goods flow. In a combined system simultaneous direct and indirect goods flows are possible. With great distances, there can appear delays in distribution of goods. In case of avoiding this problems, regional deconsolidation and warehousing centers are located between the supply and reception points where necessary.

Transport Process

Transport process refers to overcoming distances between supplier and receiver. The main criteria for the choice of transport mode are:

- Geographical characteristics of transport route,
- Amount of goods to be transported,
- Transport cost,
- Transport time,
- Safety of transported goods

Approach to the problem leads through the freight transport chain analyses. Sequences of technical and organizational interconnected events, by which goods are moved from supplier to reception point, represent the whole transport chain.

Transport chain is a part of a goods flow and refers only to the logistical function of transport.

Organizational structure of transport chain can be built up in the following way:
International multimodal transport is logistical concept, which covers the movements of goods from supplier to receiver under the responsibility of a single transport operator. It represents the flow of goods, where at least on one part of the transport chain, two different modern means of transport are involved at the same time.

Multimodal transport operates on the global market and variety of cultures, languages and commercial practices at both ends of a trade are involved. Because of that, it is reasonable that one qualified and skilled operator (MTO – Multimodal Transport Operator) organize and be responsible for the whole transport chain on the base of one multimodal contract.

Theoretically this concept can represent multi-step or combined system of goods flow. It is executed without a change of transport units (containers, trucks...).

Intermodal and Multimodal Transport

Intermodal transport covers combined transport on the international level. It represents the flow of goods where the means of transport (road, rail, air, water) change at least one time on the existing transport route. Separate mode of transport is responsible for its part of the route in the transport chain. There is not necessary to containerize the goods, while modern manipulation facilities are settled on the separate nods.

Intermodal transport chain can be built up in the following way:

International multimodal transport is logistical concept, which covers the movements of goods from supplier to receiver under the responsibility of a single transport operator. It represents the flow of goods, where at least on one part of the transport chain, two different modern means of transport are involved at the same time.
Loading Units
Observations showed that there are 3 types of loading units used for freight transport for different purposes.

1. **Semi-trailers:** A semi-trailer is a trailer without a front axle. A large proportion of its weight is supported by a road tractor, a detachable front axle assembly known as a dolly, or the tail of another trailer. A semi-trailer is normally equipped with landing gear (legs which can be lowered) to support it when it is uncoupled.

A road tractor coupled to a semi-trailer is often called a semi-trailer truck or semi, or in the UK an articulated lorry. The fifth wheel on a truck connects to a semi trailer Kingpin. Kingpins come in many guises, however the most common within the UK market is the 2.0” (50.8mm) EEC approved type. This Kingpin is fully interchangeable and, given a strict maintenance schedule, it should last the life of a trailer.

2. **Swap body containers:** A swap body (or swop body) is a standard freight container for road and rail transport. “Swap body” containers are frequently used for land transport in Europe along with European domestic containers. They are a mix between a highway trailer and a sea container. Swap bodies do not travel overseas; they are only used for regional road/rail transport within Europe. Swap bodies are quasi-containers; they typically have ISO corner castings on the bottom, but they are optional on the top. As a result, some swap bodies can be stacked but most cannot. The sizes typically follow the same dimensions as European domestic containers: lengths of 7.15m, 7.45m, 7.82m, and 13.6m are used. Most are 2.5m or 2.55m wide to accommodate European pallet widths. (http://www.matts-place.com/intermodal/part4/europe_swap.htm)

Since most swap bodies do not have top lifting castings, they are lifted from the sides using castings along the bottom as shown.

Many swap bodies are fitted with four up-folding legs under their frame, to make it possible to change or “swap” their body from one carriage to another, or to leave the swap body at a destination, without using a crane or hoist.

3. **ISO containers:** Freight containers are a reusable transport and storage unit for moving products and raw materials between locations or countries. There are approximately seventeen million intermodal containers in the world; a large proportion of the world’s long-distance freight generated by international trade is transported in shipping containers.

A typical container has doors fitted at one end, and is constructed of corrugated weathering steel. Containers were originally 8 feet (2.44 m) wide by 8 feet (2.44 m) high, and either a nominal 20 feet (6.1 m) or 40 feet (12.19 m) long. They could be stacked up to seven units high. At each of the eight corners are castings with openings for twistlock fasteners.
Logistical unit

Up-to-date logistics follows the principles of unification and standardization in “unit-load-concept” or “unitization”. The point is that different goods are formed in standardized and unified transport units, which enable economical and safe transport, reloading, warehousing and other logistical operations. Basic idea is that whole goods flow from producer to the customer is executed in unified content and form. In this way we can simplify physical operations, measuring, counting, weighing, controlling and other operations.

That concept also leads to the standardization of transport holders, vehicles, reloading mechanization, warehouses, etc...

International trade had always aspired for some solutions until ISO (International Organization for Standardization) was established in the 1950’s. Vital role in global business represent ISO standards, which are leading global standards for palettes, containers, transport vehicles and all elements of logistical process.

The concept of logistical unit is represented in the scheme below:

Various business partners manage with logistical units on the whole supply chain, that’s why all the manipulation points must follow “unit-load-concept” standards to provide efficient service.

The biggest logistical unit is container, which is standardized for multimodal transport operations:
20 feet container is basic measure for ship capacity. One TEU (Twenty Equivalent Unit) fits the volume of one standardized 20 feet container.

Logistical unit fulfils following demands:
- Unitization of goods in bigger units,
- Standardization of units regarding form and dimensions,
- Mechanization of logistical process,
- Safety of goods and easy manipulation,
- Enables uninterrupted logistical chain from supplier to demander.
Palette (basic logistical unit)

Standardized palette for frequent use is one of the basic principles in logistics. The idea for palettization of goods appeared because of practical reasons which are:

- Keeping goods together through the whole transport route,
- Easily and faster manipulation of packed units,
- Clear and rational warehousing.

ISO standardized Euro wooden palette (1200mm x 800mm x 144mm); max weight= 1.5 metric ton:

Standardized palettes must follow all the regulations and must be marked properly to get into the logistical cycle. European Palette Association (EPAL) is coordinated and regulated palette flow in Europe. The price of one Euro standardized flatten pale is 5-7€ and it is depreciated in 5-7 turns (cost 1€/ turn).

Beside flatten palettes we also know box-palettes, which consist of flatten part and side protection.

Various standardized palettes for frequent use are in use in everyday logistic business around the world.

<table>
<thead>
<tr>
<th>Palette standards</th>
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<tbody>
<tr>
<td>1200 mm x 800 mm</td>
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<tr>
<td>1100 mm x 1100 mm</td>
</tr>
<tr>
<td>1165 mm x 1165 mm</td>
</tr>
<tr>
<td>48” x 40”</td>
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<tr>
<td>1219 mm x 1016 mm</td>
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Ayca Kink / MA Advanced Product Design / Umea Institute of Design / Degree Project 2012 Sponsored by Volvo Trucks
Concepts and Examples
There are some concepts and examples that though different needs of freight transportation on road. Aerodynamics is the most addressed problem of especially long distance semi-trailer trucks.

Truck producers have some concepts regarding aerodynamics of both truck and the trailer and therefore fuel efficiency.
Few concepts address the coupling and articulation of the truck. Two semi trailer truck concepts from Man and Renault have automatic coupling feature which requires additional apparatus on trailers, hence does work with only that type of trailers. Freightliner concept with fifth wheel coupling and has a rear door for accessing trailer-truck connections easily instead of walking down the cab and climbing up the steps of the platform to reach the connections.
Jost is a 5th wheel manufacturer and has various solutions for:

- Semi-automatic coupling (picture 1): pull button for ejecting 5th wheel handle, so 5th wheel handle doesn’t need to be pulled manually (video reference:

- Automatic coupling (picture 2): retrofit apparatus both for truck and the trailer to facilitate coupling of bot 5th wheel and air-electricity connections (video reference:

- Sliding 5th wheel (picture 3): smart gap system that adjusts the gap between truck and the trailer in order to have better aerodynamics (video reference:
Traffic congestion and increased collaboration between different modes of transport are addressed by Volvo with green corridor and 2020 truck concepts. The aim of the Green Corridor is to make freight traffic efficient through concentrating transport routes specially adapted for heavy transports between major centers on efficient motorways, sea routes and railways that complement each other. The trucks are equipped with IT systems that aid drivers to drive in a fuel-efficient manner and to communicate with each other and the road system. (http://www3.volvo.com/investors/finrep/ar11/eng/challengeits/green-corridors-saf.html)
An example of steerable trailer axles by VSE Advanced Steering and Suspension solutions shows improved maneuverability. The steering of axles provides a saving in fuel and tyres. (Video reference: RTS-E BY VSE; THE INTELLIGENT REVERSE STEERING SYSTEM FOR A CASTER AXLE)

Other example is from ETF Mining Trucks. All wheels are steered at low to medium speeds reducing tyre wear, while at higher speeds the last two axle lines gradually change to nearly rigid resulting in better stability. (Video reference: ETF Mining Trucks MT-240 full turning circle)
The need of specific solutions for ISO container transport shows itself with tailor made examples those fit current semi-trailer trucks. Both carry more than 1 containers and steerable axles for better maneuverability since the vehicles become longer.
CargoBeamer - As a part of Marco Polo Project

Cargo Beamer project is supported by European Commission with the funds from Marco Polo 2 programme. It is a programme for projects which shift freight transport from the road to sea rail and inland waterways. This project is an indication of the importance of intermodality.

Project declares: “Over 60 percent of all HGVs on Europe’s motorways are comprised of semi-trailers, but 98 percent of these semi-trailers cannot be loaded onto the environmentally friendly railways purely for technical reasons. Goal of the project is to create “profitable, efficient and worldwide effective transportation system for unmodified semi-trailers to relieve the long distance roads.”

Market
Intermodal transport of standard semi-trailer

- Only 15% of road transport volume can be craned and takes part in intermodal transport

- CargoBeamer
  - addresses conventional, unmodified semi-trailer
  - quadruples the share of semi-trailer for intermodal transport

100% = total road transport 2009 in
Germany: 425 bn km
source: BASL, RBA
Truck arrives to rail station and Cargo Beamer rail cars slides out for the coming truck.

After driving the semi-trailer on the Cargo Beamer rail car, driver uncouples the truck with the semi-trailer.

Loading and unloading of semi-trailers happens at the same time for time efficiency.
MANEUVERING
VISIBILITY

ALLOW DRIVERS TO
HAVE SUFFICIENT
VISIBILITY IN MIRRORS
IMP. POTENTIAL
8 OUT OF 12

HEATERS IN ALL
MIRRORS SHOULD
BE EFFICIENT
ENOUGH TO PREVENT
IMP. POTENTIAL
6 OUT OF 12

TO AVOID THAT THE
DRIVER HAS TO GET OUT
OF THE DOCK AND TO
AVOID ACCIDENTS. ALSO
"NIGHT VISION" IMPLEMENT
FOR FACILITATING REVERSING
IMP. POTENTIAL
6 OUT OF 12

TO ENSURE THAT THE
DRIVER HAS SIGNIFICANT
VISIBILITY WHEN
REVERSING IN DARKNESS.

IMPROVEMENT POTENTIAL
6 OUT OF 12

TWO LIGHTS ON
THE BACK OF THE
CAB, AIMED SLIGHTLY
OUTWARDS, THUS
ILLUMINATING THE
AREA LEFT & RIGHT OF
THE TRAILER WHEN
REVERSING

IMP. POTENTIAL
6 OUT OF 12

TRACTION & HANDLING
OF TRUCK SHOULD
ALLOW DRIVER TO
SAFELY POSITION
TRUCK AT A DOCK ON A
SLIPPERY SURFACE
A_decline_of
WITH A
.Speed

IMP. POTENTIAL
8 OUT OF 12
Extensive field, literature and internet research revealed project opportunities in various freight transportation areas as well as the problems of current semi-trailer trucks. First I mapped these opportunities, then concentrated on the problem areas of semi-trailer truck in low speed maneuvering, loading-unloading and coupling-uncoupling situations. This way of mapping gave me the opportunity to see the core of the problems and to explore short term and long term solutions. Semi-trailer trucks require immediate solutions for coupling safety and efficiency problems, while on the other hand there is an emerging need for looking into the core problems of road freight transportation in order to be able to handle obvious congestion and environmental concerns.
Route Network

From interviews and road trip observations, route network and some problems can be figured as follows:

1. There is a non-stop ring tour between main hubs of the forwarder company (For example between Umea-Gothenburg for Milles). Rigid truck-semi-trailer combination is used for this ring tour. Each driver drives for 4,5 hours, change the truck and drive back to point of departure. For example driver takes one truck from Umea and drives for 4,5 hours, then meets the other truck coming from Gothenburg, takes that truck and turns back to Umea. By this way each driver drives for 9 hours a day and the ring never stops. Rigid truck and semi-trailer combination is used for this ring.

2. Semi-trailer truck combination is used for international road delivery if the destination country only allows 18,75 m. This time drivers either take the cargo to destination or switch semi-trailers at some place on road. These places sometimes happen to be remote places and uncoupling and coupling process becomes problematic under harsh weather conditions.

3. For road-train intermodal transport, forwarder company moves semi-trailer, swap body box or ISO container from terminal to nearest train station. Company uses same rigid flat bed truck for transporting swap body boxes and ISO containers since they both have the same castings at ISO centers. However their lengths are different and this creates problems during loading unloading. Trucks carrying ISO containers can not be reversed to terminal docks since there is a distance between the rear end of the truck and the rear end of ISO container. Trucks also become less stable while carrying an ISO container comparing to carrying a swap body box since container sits on a higher platform.

4. For road-train-ferry intermodal transport, forwarder company moves semi-trailer or ISO container (Swap body boxes are not carried on ferry) from terminal or nearest train station to harbor. In this case ferry company attaches additional apparatus to semi-trailers since their landing gear is not strong enough. So ferry carries the dead weight of this apparatus and the wheels of semi-trailers. In some rare cases the whole truck with semi trailer is carried by ferry.
Even though the project started for semi-trailer trucks, research revealed more possibilities that require improvements about other transportation areas that are connected to semi trailer trucks. I didn’t want to exclude these from the start since I may need to reshape the brief and to consider these complicated relations later in the project process.
Observations and research findings showed there are several problems with the current truck/semi trailer configuration. Looking ahead at future concepts exposes the current issues even more. Most of the future concepts do not mention how to handle loading units (semi trailers & trailers). Other couple of examples are far away from the current reality, which makes it hard to change and shift the way how we’re transporting goods with trucks, since the whole transportation system is connected to each other and there are hundred years old standards which are not considered as safe or efficient. Solutions for this possibility area need to cover some of the standards of the industry. Research shows there is big opportunity of improvement in this almost untouched area. Also, research findings and sponsor company expectations can meet in here.

Considering the rising traffic volumes, congestion, pollution and extra costs, new possibilities for shifting road transport to other transport modalities is a rising value. For a while, many different countries have been mentioning the importance of improving intermodal transportation and reducing the load on road transportation. Recently, European Commission funds the projects that stresses this topic. Transfering the semi-trailers between different modes of transport is identified as a design opportunity.

Intermodal policies and the reasons behind them have a high potential for transforming the way of road transportation. This pressure may effect the way we are transporting goods on road in various ways. Not only the amount of road transportation, the whole layout of road transportation vehicles and the way we load and unload the goods on them need reconsideration. Design of a new type of towing system for road transportation is identified as a design opportunity.

Whole shift in logistics and road transportation will surely effect the logistical units. Current unplanned variety of logistical units effects efficiency and compatibility. In addition, we are experiencing the side effects of containerization, which used to be an efficient way of transportation. There is a rising problem of handling unused containers. Design of a new type of logistical unit for road transportation which is compatible with other means of transportation is identified as a design opportunity.
Due to the complicated nature of the topic in general and considering the time given, information about the first three areas will be used as inspiration. Truck/Semi-Trailer configuration and current safety issues will be the initial focus.

**Design Direction**

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Design Direction

Focus

There are variety of safety areas regarding the work sequence of a truck. As a result, scope is narrowed to mainly “Connecting/Disconnecting” area. However, “Loading/Unloading”, “Low Speed Maneuvering” and “Reversing into Position” areas are also closely related to each other and problems of these areas will be addressed as the “Wishes” of the project.
Transportation: The most time consuming part of a transport was usually the road transport itself. The effectiveness of road trains was most prominent for long distance transports where high volumes were transported. Three hours driving could be considered a minimum time, but it could vary to as much as several days of driving.

Loading/Unloading: Loading and unloading the trailers was usually the second most time consuming part of a transport. Containers with goods not stacked on pallets were by far the most time consuming to unload while timber was the fastest. For example, during a co-riding to a freight terminal in Nässjö, unloading of the two containers took almost four hours. However the driver stated that it usually took 2-3 hours, but longer times were not unusual. If the goods were stacked on pallets the time would be more in the range it took to load or unload general goods, which was about 15-40 minutes for a full trailer. Since the semitrailer and lead trailer were supposed to be fully laden when the driver of the tractor came to pick them up, the time spent loading them could not be counted in the same way as for the other transports.

Connecting/Disconnecting: The third most time consuming part was the connecting and disconnecting of the trailers (not including the maneuvering into position for coupling). The driver has to exit the cab numerous times to attach connections and to perform other operations. It was observed during co-ridings that the connecting and disconnection time varied considerably between drivers. Some drivers were observing all safety precautions, while others worked as fast as possible and only adhered to the most rudimentary safety precautions. Typical time spent on these operations during a freight terminal visit (on those visits where disconnecting was needed) varied from 10 to 30 minutes.

Low speed maneuvering: The fourth and least time consuming part of the transport was the maneuvering (including the reversing) on the freight terminal. The timekeeping studies showed that the average time to maneuver a B-train into position at a loading dock was 179 seconds (based on 25 different maneuvers by 17 different drivers at the five different places mentioned above). The design of the freight terminal had a major influence on the time spent where the streamlined and efficient design in the Skandia harbor in Gothenburg averaged 116 seconds while the same maneuver in more traditional freight terminals averaged 209 seconds. Even though the statistical material was mainly based on container transports, 3 minutes (rounded up from 179 seconds) could be considered an average for the whole market, since container transports had the largest market share for B-trains in Sweden. An average maneuvering time around 3 minutes was also confirmed during interviews, but the time was only valid for an experienced B-train driver while a less experienced driver could require considerable longer time. This was also observed with a driver that had only a few months experience of driving a B-train where the same maneuver took in excess of 15 minutes.

Low speed maneuvering aids for long vehicle combinations, KRISTOFFER BORRE & RICHARD LARSSON, 2012
### Problem Areas

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Communication</th>
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<tbody>
<tr>
<td><strong>A. Steps to platform</strong>&lt;br&gt;1. Risk of getting hit by other drivers while climbing up/down from platform&lt;br&gt;2. Climbing up/down is physically stressful in long term&lt;br&gt;3. Poor placement &amp; design of step</td>
<td><strong>A. Communication with unprotected road users</strong>&lt;br&gt;1. Cyclists and pedestrians aren’t aware of the maneuvering behaviour of trucks and stand too close (dangerous especially for right turns)</td>
</tr>
<tr>
<td><strong>B. Platform</strong>&lt;br&gt;1. Driver feels unsafe while working on the platform when not using trailer parking break&lt;br&gt;2. Gets dirty between cab &amp; trailer&lt;br&gt;3. Space between cab &amp; trailer is not enough for working with connections</td>
<td><strong>B. Communication with other road users</strong>&lt;br&gt;1. Cars and other shorter vehicle drivers are not aware of the maneuvering behaviour of trucks and stay / drive too close</td>
</tr>
<tr>
<td><strong>C. Connections</strong>&lt;br&gt;1. Connections get tangled up and dirty</td>
<td></td>
</tr>
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<td>1. Hard to judge distance by looking at mirrors while reversing</td>
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</tbody>
</table>

D. Planning stops & routes

1. Drivers don’t always know the place and route they are heading. As a result they are not always able to plan the stops in a favourable way and have to take their mandatory breaks at at lonely places, sometimes even without toilets.
2. Drivers call main station, use GPS device, log breaks in tachometer and keep a logbook. Using all these methods for one purpose becomes confusing.
Problem Areas

Hardware  Communication  Visibility  Maneuverability  Security & Planning
<table>
<thead>
<tr>
<th>Road Transportation</th>
<th>Loading/Unloading</th>
<th>Connecting / Disconnecting</th>
<th>Low speed Maneuvering</th>
<th>Reversing into Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Steps to platform Platform</td>
<td>Wear &amp; Tear</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fifth wheel lock Connections Controls / Checks</td>
<td></td>
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<td></td>
<td></td>
<td>Security of driver Security of cargo</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Determine accessibility Planning stops &amp; routes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Goals & Wishes
Goals

• Improve safety of connecting/ disconnecting semi trailer
• Reduce time spent on connecting/disconnecting semi-trailer
• Maneuverability aid for connecting/ disconnecting semi-trailer
• Improve communication with other drivers while connecting/ disconnecting semi-trailer
• Minimize the walk around the vehicle while connecting/ disconnecting semi-trailer
• Improve air and electricity connections between truck and semi-trailer

Wishes

• Improve security and sense of security for the driver and the trailer while parking remote places
• Communication aid for driver to plan the trip, stops and the accessibility situation of the terminals which he/she is not familiar with
• Vision & maneuverability aid for reversing into position at terminals & ports
• Improve communication with URU’s and other road users while low speed maneuvering

Check Points

• Reduce wear & tear
• Reduce time spent
Ideation

Group and individual ideation happened in two phases

Phase 1:

This first part of ideation is for semi-trailer truck problems. Results of this phase are organised in order to refer to the detailed problem mapping of semi trailer trucks. For this, I started ideating on each problem and sort the solutions.
Problem: Risk of getting hit by other drivers while climbing up/down from platform.

Problem Direction: Hardware >>> Steps To Platform
Suggestion
- Wind deflectors folding out
- Light warning on wind deflectors

Improvement
- Creates clearance at the side of the truck for driver for stepping up/down
- Warning for other drivers
Problem: Poor placement & design of step

Comfort
Safety
Efficiency
Suggestions

- Folding Steps for better access

Improvements

- Creates clearance at the side of the truck for driver for stepping up/down
- Warning for other drivers
Driver activates the maintenance / coupling mode

Wind deflectors and the lift opens

Driver steps on

Problem

- Climbing up/down is physically stressful in long term

Problem Direction

- Comfort
- Safety
- Efficiency

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- Wind deflectors folding out
- Light warning on wind deflectors
- Lift instead of steps for platform access

Improvement
- Creates clearance at the side of the truck for driver for stepping up/down
- Warning for other drivers

Driver steps on lift platform
Lift platform carries driver to catwalk
Driver steps on catwalk for maintenance / coupling
Problem: Climbing up/down is physically stressful in long term

Problem Direction:
- Comfort
- Safety
- Efficiency

Hardware >>> Steps To Platform

Ayca Kinik / MA Advanced Product Design / Umea Institute of Design / Degree Project 2012 Sponsored by Volvo Trucks
Suggestion
- Wind deflectors folding in
- Extra platform slides out
- Light warning on wind deflectors

Improvement
- Creates clearance at the side of the truck for driver for stepping up/down
- Warning for other drivers
Problem

- Gets dirty between cab & trailer

Problem Direction

- Comfort
- Safety
- Efficiency

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- Suggestion
  - Covering roof of platform

- Improvement
  - Clean platform
Problem

- Gets dirty between cab & trailer
- Connections get tangled up and dirty

Problem Direction

- Comfort
- Safety
- Efficiency
Suggestion
• Cable management

Improvement
• Clean and accessible cables
Problem:
- Gets dirty between cab & trailer
- Connections get tangled up and dirty

Problem Direction:
- Comfort
- Safety
- Efficiency
Suggestion

- Cable management

Improvement

- Clean and accessible cables
Jost Smart Gap System

Problem

- Space between cab & trailer is not enough for working with connections

Problem Direction

- Comfort
- Safety
- Efficiency
Suggestion
- Sliding 5th wheel

Improvement
- Adjustable platform width
Problem

- Driver feels unsafe while working on the platform when not using trailer parking break
Suggestion

- Moving parking brake to the front of the trailer

Improvement

- Make parking brakes more accessible
- Encourage drivers to use parking brakes

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Problem

- Driver feels unsafe while working on the platform when not using trailer parking break

Problem Direction

- Comfort
- Safety
- Efficiency
Suggestion

- Connections slide from middle to driver’s side when needed

Improvement

- No need to climb on platform
• Fifth wheel lock handle is hard to reach
• Driver has to walk around the vehicle to raise/lower the chasis when fifth wheel lock is stuck
Suggestion:
- Replace fifth wheel lock handle to driver’s side or
- Wireless control unit for elevation and other feedback

Improvement:
- Less walk around during coupling/uncoupling
- Reduces the risk of ignoring safety precautions

Wireless elevation remote
Jost Flashtronic

- There is no proper confirmation that the trailer is properly coupled with the truck
- Fifth wheel lock handle sensor

- Lock handle feedback light or indication can be placed in the cab or on elevation remote control
Problem

- Lack of vision in blind spots while reversing

Problem Direction

- Comfort
- Safety
- Efficiency

Visibility >>> Vision in Blind Spots

• Lack of vision in blind spots while reversing

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Suggestion

- Extending arm carrying camera for seeing blindspots

Improvement

- Not working
Problem

• Hard to see when reversing in the dark

Problem Direction

Visibility >>> Vision in Bad Light Conditions
Suggestion

- Light guide for aligning trailer

Improvement

- Increase visibility for alignment of the truck and trailer in bad light conditions
Articulation issue

Problem:
- Hard to approach loading docks where slots are narrow & when ground not levelled (especially in winter time)
Suggestion

• Double articulation point

Improvement

• Lower risk of collusion with people and obstacles
• Easier to maneuver
• Smaller turning radius
Maneuverability >>> Maneuverability in Tight Places

Problem
- Hard to approach loading docks where slots are narrow & when ground not levelled (especially in winter time)
Articulation Points

- Double articulation point
  - Lower risk of collusion with people and obstacles
  - Easier to maneuver
  - Smaller turning radius
• Hard to approach loading docks where slots are narrow & when ground not levelled (especially in winter time)
Suggestion

• Double articulation point

Improvement

• Lower risk of collusion with people and obstacles
• Easier to maneuver
• Smaller turning radius
Driving Mode:

Cab gets closer to trailer and gets lower. Adjustable wind deflectors on top and front moves in a way that create less air drag.

Coupling Mode:

Cab slides forward to create sufficient gap for driver while handling connections. Top wind deflector becomes the roof of platform in order to protect driver from rain and snow.
Low Speed Mode:

Cab gets higher. Top wind deflector flattens and lightens around the cab

Rest Mode:

Cab lowers for better accessibility. It also slides back and locks to the trailer. Top wind deflector flattens and can be used for lighting the environment when needed
Phase 2:

Second phase was free ideation. On this phase I didn’t consider the current structure of semi-trailer truck and tried to reconstruct the truck in order to address more problems. On this phase I conducted a group brainstorming session with toys and mock-ups and tried to come up with different coupling scenarios.
**SPLITABLE ENGINE**

Engine splits from the main truck body for coupling in tight areas. Landing gear of the trailer is folded when engine couples with the trailer.
Double Side Coupling

Cab can turn 180 degrees while aligning cab and the trailer
Cab can couple on both sides of the trailer
Smart Connectors

Two wheelsets are attached to the back of the truck.
Wheelsets split from the truck and grabs the container on the ground.
Container together with the wheelsets couple with the truck.
Extending Chasis

1. Truck reverses to the terminal dock

2. Terminal dock ejects the container

4. Truck starts moving forward, pulling the container on the truck, while rear wheelset is locked to its position
3
Truck grabs the container

5
When the container is completely on the truck, rear wheelset gets unlocked
Sorting Ideation Results Depending on the Current Stakeholders

There are 3 stakeholders which involve semi-trailer truck coupling. First is the truck producer, second is the 5th wheel producer and the third is the trailer-container producer. Since loading-unloading is also an important part of the project, I took terminals as 4th stakeholder to keep in mind. Some ideation results effects some or all 3 stakeholders and last one effects the terminals. Because of these dynamics I needed to divide ideation results into 3 areas depending on the level of change in order to find core problems of current trucking.

Area 1: Keeping manual coupling and modifying truck (involves truck producer)
Area 2: Keeping manual coupling and modifying trailer involves trailer or other 3rd party producers)
Area 3: Changing to automatic coupling which results in changing truck and the trailer (involves truck, 5th wheel and trailer producers, as well as terminals)
Foldable steps for better ergonomics

Direct access from the cab to the platform

Covering the roof of the platform

Hanging the connections on cab

Laser guide for truck-trailer alignment

Moving 5th wheel handle on driver side

Retractable connections on cab

Sliding 5th wheel

5th wheel lock indicator inside the cab
Solution ideas on tractor for manual coupling

- Bigger space on platform ("Shape Shifting" tractor or sliding fifth wheel)
- Improved access to platform (improved steps, lift instead of steps, side platform under the cab or "Shape Shifting" tractor for direct access to back platform)
- Lights (to communicate the coupling process to other drivers and to make coupling and connecting in bad light conditions easier for the driver)
- Wind deflectors covering the gap between tractor & trailer (Easier for driver to work in bad weather conditions, covering connections from weather conditions and dirt)
- Simple sensored fifth wheel (Jost Flashtronic) for coupling feedback on dashboard or on elevation remote
- Fifth wheel handle sticking out for easy access
- Embedded and covered connections
- Wireless elevation remote or fifth wheel lock handle on the driver’s side for reducing travel
Moving trailer brakes closer to air & electricity connections

Adding retrofit moveable connections on trailer
Solution ideas on trailer for manual coupling

• Light warnings to inform other drivers about coupling process and to make coupling, connecting and reversing easier for the driver

• Sensors and/or cameras for blind spots

• Connector slots and parking brakes at the drivers side between cab and trailer (1. To be able to make the connections when the driver is on the ground, without climbing the platform 2. To make the parking brakes used also at ports by both drivers and tugmasters)

• Replace the landing gear crank on driver’s side to reduce the walking around vehicle
• Truck can be coupled on both sides of trailer
• Cab can be turned 180 degrees for ease of alignment

• Wheel sets grab the container on the ground and connects to the truck

• Engine splits and moves alone for coupling

• Rollers on terminal docks
• Truck ejects container on terminal dock
Solution ideas for automatic coupling with or without 5th wheel

• Automatic coupling eliminates most of the safety issues since leaving the cab is limited to checking the lights or cargo after coupling.

• For that reason automatic coupling has a high potential to be the next safety measure for handling trailers and semi trailers.

• May require structural changes on both trailer, tractive unit and terminals. May also eliminate 5th wheel
Evaluation of Ideation

After sorting ideation results and meeting with Volvo Advanced Technology & Research Department, ideas are evaluated depending on coupling method instead of stakeholders. I started to see that if I try to keep the stakeholders same (as truck producer, coupling apparatus producer and trailer producer) I may fall away from the other core problems of road transportation that needs to be considered for mid-term to long term projects. Then I realised automatic coupling is the way to solve the safety and efficiency problems of trucks and it can be solved with or without 5th wheel thus, stakeholders may change depending on the project.
## Adressing the Problem Areas

Ideation results adress highlighted problem areas. Communication and Security topics were not addressed, I kept them in mind for further steps of the project.

### Communication

<table>
<thead>
<tr>
<th>A. Communication with unprotected road users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cyclists and pedestrians aren’t aware of the maneuvering behaviour of trucks and stand too close (dangerous especially for right turns)</td>
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### Hardware

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### Visibility

**A. Lack of vision in blind spots**
1. Lack of vision in blind spots when driving forward
2. Lack of vision in blind spots while reversing

**B. Vision in bad light conditions**
1. Hard to see when reversing in the dark

**C. Judging distance**
1. Hard to judge distance by looking at mirrors while reversing

### Maneuverability

**A. Maneuverability in tight places**
1. Hard to approach loading docks where slots are narrow & when ground not levelled (especially in winter time)

### Security & Planning

**A. Security of driver**
1. Drivers worry about theft of belongings in the cab
2. Drivers feel insecure outside the cab in remote places

**B. Security of trailer**
1. Drivers worry about theft of goods in lonely places or some truck stops

**C. Determine accessibility**
1. Drivers don’t always know the terminal they are heading and don’t have communication about accessibility situation

**D. Planning stops & routes**
1. Drivers don’t always know the place and route they are heading. As a result they are not always able to plan the stops in a favourable way and have to take their mandatory breaks at at lonely places, sometimes even without toilets.
2. Drivers call main station, use GPS device, log breaks in tachometer and keep a logbook. Using all these methods for one purpose becomes confusing
**Coupling Method**

**A. Manuel Coupling**

<table>
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<th>Mechanical Connection</th>
<th>Mechanical Connectivity</th>
<th>Air&amp;Electricity Connections</th>
<th>Air&amp;Electricity Connectivity</th>
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</thead>
<tbody>
<tr>
<td><img src="image1" alt="Mechanical" /></td>
<td><img src="image2" alt="Mechanical" /></td>
<td><img src="image3" alt="Air&amp;Electricity" /></td>
<td><img src="image4" alt="Air&amp;Electricity" /></td>
</tr>
</tbody>
</table>

**Pros**

- Safety improvement by warning environment about driver working outside the cab
- Improving ergonomics with better platform area and access, better cable management, better feedback for coupling for better safety, comfort and efficiency
- Possibility to implement comparatively in short term

**Cons**

- Driver still leaves the cab and solutions relies on attention of environment, passive way of improving safety
B. Automatic Coupling

### Pros

- Driver doesn’t need to leave the cab and step on platform for connecting the cables. This eliminates most of the safety issues which are directly related to trailer handling process.
- Requires limited modification on trailers.

### Cons

- Do not offer solution for parking brake and wheel shock use.
- Requires to keep both types of cable connection in order to facilitate trailers that are not modified.
- Adds extra cost and weight on trailers, which is not efficient considering intermodal transportation.
- Does not offer answer to the question of how to add smart components for future safety solutions.
C. Automatic Coupling without 5th wheel

**Pros**

- Driver doesn’t need to leave the cab and step on platform for connecting the cables. Eliminates safety issues which are directly related to trailer handling process
- No need for lot trestles (plastic support for the landing gear of semi-trailer) during ferry transport since loading unit becomes a box
- Since wheels are removed from the trailer, and there won’t be any lot trestles, train and ferry will only carry the container weight
- Since rear axles becomes a part of the tractive unit and not the trailer, it’s possible to add sensors or cameras and have a better control on the vehicle
- Possibility to have more organised and flexible modularity

**Cons**

- Requires change of trailers and modification of main terminals
- Longer term solution proposal
Decision

Problem areas can be addressed in 3 levels regarding coupling method:

- *Keeping current manual 5th wheel and kingpin coupling and improving the ergonomics of the tractive unit, which is a truck (tractor) design project*

- *Keeping current 5th wheel and kingpin coupling and adding retrofit solutions for air and electricity connections to make it automatic, which is a retrofit apparatus design project which Jost, a fifth wheel producer developed*

- *Exploring alternative coupling methods which addresses more safety and efficiency problems, which is a future truck modularity project*

Problem areas can partially be addressed by focusing only on tractive unit or the fifth wheel. In addition, current 5th wheel coupling method effects the maneuverability of the truck which causes safety problems. For this reasons I decided work on new type of coupling method which changes the structure and the modularity of the truck.

C. Automatic coupling without 5th wheel

<table>
<thead>
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<th>Mechanical Connections</th>
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<th>Air&amp;Electricity Connections</th>
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<td>Other</td>
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</table>
The structure of current semi-trailer truck is built around the 5th wheel coupling. Process showed me the need of new automatic coupling method for the sake of safety, efficiency and maneuverability considering mid-term to long term period. As I started evaluating each element of the current truck, decisions on each element formed the structure of new concept.
Truck (Tractive Unit)
I started with evaluation of the tractive unit. Currently trucks have rear extension because of 5th wheel coupling.

First idea was to combine the load carrying unit and the tractive unit and make the rear axles foldable. Rear axles can be extended for different sizes of loading units. With this type of solution, loading terminals need to change in order to be able to eject the loading unit on truck and this makes the coupling process automatic. By this way, driver stays in the truck and safety problems of coupling process are eliminated. However this solution is suitable when the truck is carrying only one trailer which is an important drawback of this idea. In addition trailer still overhangs when the vehicle turns right or left because articulation center remains same as semi-trailer truck. This inspired me to cut out the extension and consider a short back tractive unit.

When the tractive unit is short back, overhanging problem of the truck can be solved depending on the design of the connection & articulation area. This makes it possible to maneuver better in tight places.

In addition maximum permissible length of trucks varies depending on the region or the country. Currently legal length of truck combinations is around 18 meters for most of Europe, however in some countries including Sweden, this is 25,25 meters. In the future this may become longer in order to reduce the engines on roads because of environmental and cost concerns. New truck structure, without a rear extension and with extendable load carrying units can fit different regulations of different countries and will offer more flexibility for future longer vehicle combinations. For these reasons I decided to develop the concept on short back tractive unit.
Loading & Load Carrying Units
The components of the new truck structure are tractive unit, loading unit and load carrying unit. In this case taking ISO containers as loading unit was the most convenient way to start since ISO container is the basic intermodal loading unit and container transportation has a big share in the transportation industry. In addition there is a lack of specific solutions for road transportation of containers which eliminates the coupling safety problems and increases the efficiency.

ISO containers have corner castings and the measurements of these castings are specified with ISO standards so any other type of containers those are produced with corner castings can be carried with this new truck. This type of structure adds greater flexibility to road transportation.

Wheels of the load carrying unit can be smaller with this structure. By this way center of mass can be closer to ground which makes the vehicle more stable. I took the height of current short distance cab (around 3,3 meters) as reference so container and load carrying unit together won’t be heigher than the cab, which gives enough space for drivers in the cab and good for aerodynamics without extra wind deflectors. In addition, it’s easier to store unused units with small wheels. For these reasons I set the diameter of the wheels to 600 mm instead of 1043 mm which is the diameter current trailer wheels.
Number of Axles for Load Carrying Unit
“The axle load of a wheeled vehicle is the total weight felt by the roadway for all wheels connected to a given axle. Viewed another way, it is the fraction of total vehicle weight resting on a given axle. Axle load is an important design consideration in the engineering of roadways and railways, as both are designed to tolerate a maximum weight-per-axle (axle load); exceeding the maximum rated axle load will cause damage to the roadway or rail tracks.”

(http://en.wikipedia.org/wiki/Axle_load)

Since it’s an important design consideration for trucks, I searched for the regulations about the number of axles and axle distances for the semi-trailers. Semi-trailer truck weight distribution is very different then this concept, for semi-trailer truck, driving and non driving axles of the tractive unit also carries some amount of weight but in this case only the wheels under trailer carry the weight. So I took the following numbers just to stay among the reasonable limits.

“Allowed weight for tandem axles of trailers is 16-20 t, depending on axle distance. The maximum gross-combination weight was in this directive set to 40 t for a vehicle combination with five axles. 44 t gross combination weight was allowed for transports of 40-foot ISO containers in a combined transport operation. The tractor must then have at least three axles, and the whole combination shall have at least five axles.” (Vehicle combinations based on the modular concept document http://www.nvfnorden.org/lisalib/getfile.aspx?itemid=1589)

From this information, in order to carry a gross combination weight of 44 tonnes, there needs to be at least 2 tandem axles (4 axles in total) under each container. 1020 mm distance between centers of the axles and super single tires (2 single wide tires instead of 4 regular tires on 1 axle) makes it believable to drive the vehicle on current European roads.

At this point I had two options about the number of axles. One is to stay at the minimum limit and continue with 2 axles on each unit which makes 4 axles in total under the container. The other was to put 3 axles on each unit and 6 axles in total in order to decrease the weight per axle. These options are created for upper weight limit and for 40-foot ISO containers but it will also carry 20-foot containers. In this case there are too many wheels those create more friction and more fuel consumption and for this reason I continued with 2 axles on each unit.
Storing Load Carrying Units
Initially, I was trying to find a way to drive load carrying units with the tractive unit after the container is left at train station or at the harbour. One option was to fold the units after leaving the container. This makes the product complicated and storing problem of the unused units remains. It is also not efficient considering fuel consumption. Mikael Soderman, from Volvo Advanced Technology & Research Department suggested to share these units among trucks and store them near terminals, stations and ports. By this way usage scenario became more convenient and environmentally friendly.
Project Focus

At this point, overall concept is composed of 4 design opportunities; tractive unit, loading unit, coupling mechanism and share terminal. Considering the limited time of the project I needed to pick some parts of these opportunities. I focused on the load carrying unit and the coupling mechanism design for my thesis.

Coupling method sits in the center of this modularity concept since it mainly defines the whole usage scenario and the geometry of tractive and load carrying units. Having a believable coupling concept will show whether overall concept will work or not. So if the coupling method and transport scenario that the project offers won’t work, there won’t be any need to design a tractive unit and share terminals. Share terminal design also depends on the design of loading units.
Load Carrying Unit
Since this unit will be used with current ISO containers and the length of the unit is adjustable for different sizes of containers, geometry of it partially depends on container and restrained by some criteria. First of all it should have twist locks at ISO centers to fit the container. Maximum length needs to be as long as 40 foot container which is 12.19 meters. It should also be as small as possible when retracted for ease of storage. Each module length is defined by the axle distance, size of the wheels and the clearance that is required for steering of wheels. There should be enough space on each unit to hold coupling mechanism and to store the long electricity and air cables. Geometry should protect components from damage, dust and freezing. The height at the rear end of the unit should not exceed 350 mm for legal rear underrun protection. These requirements, especially the design of coupling mechanism led the form of the project.

<table>
<thead>
<tr>
<th>Without container</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
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<table>
<thead>
<tr>
<th>20 foot container</th>
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<td><img src="image2.png" alt="Diagram" /></td>
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<table>
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<th>40 foot container</th>
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<tr>
<td><img src="image3.png" alt="Diagram" /></td>
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3 cables together

Sliding lock
Articulation & Connectivity
Initially I considered a double arm option to prevent the overhang problem of the trailer. It functions good for turning right or left (yaw rotation) but it started to become complicated when uphill-downhill movement (pitch rotation) functions are added. In addition scissor movement of the arms can damage the cables if the air and electricity cables are placed in the arms.

Second option is to use cross pistons for articulation. This also works fine in yaw rotation and becomes complicated when pitch rotation is added. In addition pressurized air in pistons holds the tractive unit and the container together during the entire journey which is not very reliable considering potential air leakage.

After making paper and Lego mock-ups for other two options, finally a tiny Lego part inspired me for articulation of the vehicle. This part is used for power transmission and freely turns in 2 axis (yaw and pitch). I needed a restricted turn for my project in order to prevent interference of the tractive unit and the trailers, which can be easily applied on this type of connector.
Design Proposal
Volvo Hauling Modularity Concept
Volvo Hauling Modularity (VHM) is concept for articulated trucks (trucks coupled with trailers) that improves freight transportation & logistics by changing the structure of truck. There are 2 modules on each VHM.

Concept offers;

- Safer and faster automatic coupling while drivers stay in the cab
- Controlled articulation & maneuver of the truck
- Sensors and warning lights for safer maneuvers
- Greater flexibility with electric powered uniform extendable modules. These modules are compatible with different sizes of trailers-containers & allow the vehicle to match different length regulations of different countries
- Low center of mass for stability & higher load capacity within height limits.
- Optimization of road transportation for intermodal transportation

*Intermodal freight transport involves the transportation of freight in an intermodal container or vehicle, using multiple modes of transportation (rail, ship, and truck), without any handling of the freight itself when changing modes. Reduced costs over road trucking is the key benefit for intracontinental use, as well as reduced greenhouse gas emissions.* (Wikipedia)
Current flatbed trailers are built to carry certain size of containers. They are left in terminal areas and occupy unnecessary space when they are not in use. VHM can be extended to fit different container sizes and can be retracted when not in use. When retracted, VHM become 5 m long. This and 600 mm diameter small wheels allow retracted modules to be stored in a lot smaller storage areas.
Intermodal scenario happens between the terminal of a forwarder company and train station or harbor. After loading the container at the terminal, truck arrives to these places to leave the container. Container is picked from truck with cranes.

At the train station or harbor, truck sometimes leaves one container to departure lane and picks one from arrival lane in the same tour, but sometimes there is no arriving container. In this case truck leaves the unloaded and retracted VHM modules to the Share Terminals which are placed inside or close to these places.
- All wheels are locked
- Container is unlocked

- Wheels of rear module are locked
- Wheels of front module are released
• Truck reverses and pushes front module backwards
• Front and rear modules are locked into each other

• Truck pulls VHM to Share Terminal
Rear End
There are 2 Connection Heads on VHM. Mechanical, air and electricity connections between truck and trailers are made with this heads. Truck end head has female and rear end head has male mechanical connections.
FEATURES

- Vertical alignment vanes
- Extension Rails
- Horizontal alignment vane
- Cable inlets
Horizontal and vertical rotation vanes on connection head are locked when it is ejected for coupling so it slides out parallel to ground and straight. Then vanes are released and head makes free turns within the 40 degrees yaw and pitch limits after coupling.
Connection Head replaces the 5th wheel-king pin coupling and connection cables altogether. By this way there are no tangling cables like on semi-trailer trucks. Connections are made by pressing button inside the cab so driver doesn’t leave the cab.

When the vehicle is driving on a level road, whether driving straight or turning right-left, there is no roll angle between truck and trailer except the tolerances. However when truck makes a combined maneuver of turning and for example beginning to climb a hill there is a need of roll angle in order to facilitate the maneuver safely without moving the center of mass of the trailer.

On a standard fifth wheel this occurs as a result of clearance in the fifth wheel to bracket fit, compression of the rubber bushes and also vertical movement between the king pin and locks may allow some lift of the trailer one side which can result in moving the center of mass depending on the hill or turning degree.

VHM connection heads on the other hand, creates this roll angle only during combined yaw and pitch rotations. This feature, independent suspensions on wheels, steerable wheels (only on low speed <30 km/h), low center of mass and adjustable truck-trailer gap (by sliding connection heads) indicates safe roll stability and better maneuverability both on high and low speeds.

On the current semi-trailer trucks, rotation about the longitudinal axis of up to 3° of movement between the tractor and trailer is permitted. (From SAF Holland, Fifth Wheel Handbook document)
VHM connection heads create roll angle only during combined yaw and pitch rotations which makes turning and uphill-downhill combined maneuvers possible without lifting trailer up on one side.
Connection heads can slide in and out by moving inside the extension rails and the gap between truck and trailer or other trailers is adjusted by this feature. Each connection head is 400 mm long so the maximum distance becomes around 800 mm which allows approximately 40 degrees angle between truck and trailer or other trailers during right and left turns.
Position 1:
The gap between truck and trailer becomes around 800 mm when the vehicle is on low speed < 30 km/h. In addition all wheels of VHM becomes steerable. These features allow the vehicle to maneuver in smaller areas without jacknifing or dragging trailers.

Position 2:
When the vehicle is more than 30 km/h and less than 45 km/h connection head on trailer slides in so the gap between truck and the trailer becomes around 400 mm. This is to achieve better aerodynamics. In addition, wheels become rigid and not steerable when the speed exceeds 30 km/h. This is to achieve better stability on high speeds.

Position 3:
When the vehicle is more than 45 km/h connection head on both on trailer and truck slides in and the gap closes. This is to achieve better aerodynamics.
Connection Head stays retracted and uncovered at the truck end. However, mechanical connection and air-electricity connection areas are covered with spring loaded caps in order to keep it unaffected from dust, rain, and snow.
FEATURES

- Signal & Warning Lights
- Spring Loaded Mechanical Connection Caps
- Spring Loaded Air & Electricity Connection Cap
- Alignment Sensors
During coupling process, driver presses eject button and male connection head on truck or rear connection head on last trailer extends. When it hits the female connection head on the trailer, mechanical connections lock into each other. At the same time spring loaded air & electricity caps press on each other and opens the mechanical iris on each head. This enables air & electricity connection to be made and turns VHM on.
Each mechanical irises on connection heads start opening when they press on each other during coupling in order to make air and electricity connections.
Connection Head at the rear end is covered with electronic license plate. Currently, semi trailers have their own license plate and the plate of the towing truck is not visible from behind. With this, the license plate of the truck is projected on rear.
 Licence Plate flips and retracts when the vehicle is going to be coupled with additional trailer. Then the male connection head slides out for coupling.
There are 8 wide tire wheels on each VHM that are steerable under 30 km/h speed. Tire width is same as super single tires which is 445 mm. Wheels are connected to the main body and there are no through axles between 2 wheels in order to increase the ground clearance. Each wheel has an electric motor that creates additional traction to the prime mover (truck part).
FEATURES

- Electric Motor & Brakes
- Steering Mechanism
- InWheel Independent Suspensions
There are 4 side locks and container supports which fit container geometry. Side locks aligns VHM with container and prevent container to be separated from VHM after passing the bumps on road.
FEATURES

Retractable Locks

Container Support
There are 2 air (one for emergency) and 1 electricity cables between two VHM modules. Bracing wires and cable holder holds the cables straight so that there is no stretching force on air and electricity cables.
FEATURES

- Adjustable Bracing Wire
- Steel Pins
- Air & Electricity Cables
- Cable Holder
Adjustable bracing wires are connected to each other with steel pins and can rotate around them. Wires are stretched when VHM is extended and pins carry the stretching force of bracing wires. Cable holder is also connected to these pins and only carry the weight of the air and electricity cables.
When VHM is not in use, bracing wires and cables are stored inside VHM with spring loaded rollers. This function also enables adjusting the length of VHM to desired container dimension.
FEATURES

Spring Loaded Cable Rollers

Spring Loaded Bracing Rollers
Air and electricity cables are color coded with standard semi-trailer cable colors in the inlet area for maintenance purposes. There are two housing areas here to keep the bracing wire and cable holder thickness inside when the VHM is not in use and the modules are locked together.
FEATURES

- Cable Indicators
- Cable Holder Housing
- Steel Wire Housing
Each VHM holds one male and one female locks facing together which keep the units together when the VHM is not in use and retracted. There are also rotating guides for steel bracing wires close to locks which reduces the friction between wire and VHM module and makes rolling in or out easier.
FEATURES

Rotating Guide for Steel Bracing Wire
Male Lock
There are lights and sensor areas on the four corners. Lights are used for warning other road users about the maneuvers of the truck and sensors supply information about the environment to the driver. By this way driver has the control about the whole truck without putting extra equipment on trailers.
Corner lights and sensors are important advantages of VHM over semi-trailer or trailer truck combinations. Today, semi-trailers, trailers and containers are the loading units which drivers have no control over. However, since VHM divides the loading unit into cargo box which travels around and wheel-sets that are not carried around, and turn wheelsets into intelligent products, drivers or other operators have full control over the whole truck. This means safer truck combinations both for driver and other road users. At the same time VHM offers a platform for future applications like Intelligent Vehicle Highway Systems.
LOW SPEED TURNING

Connection Heads fully extend and set to position 1 to facilitate smaller turning radius.

When the truck starts steering, corner lights indicate the turning area and warn other vehicles and pedestrians about the turning area.

Wheels of the front module turn in the same direction with the truck and the wheels of the rear module turn to the opposite direction to enhance turning.

Sensors on the corners warn driver about the obstacles, other vehicles and pedestrians in the turning area.
When the truck is on high speed, connection head position is 3 and gaps are closed but when truck brakes or starts steering, connection head on truck slides out and switches to position 2.

Wheels are not steered on high speed over 30 km/h so combination moves like current combinations.

Corner lights warn other vehicles about lane change of truck.

Sensors check the lane lines and other vehicles.
Coupling the truck with a trailer is a fully automatic process that is sensor guided. Driver follow the warnings and the steps in the cab. Mechanical, air and electricity connections are made all at once. The process is explained on the following pages. Cab image is taken from Volvo 2020 concept truck for illustrative purposes to show what kind of feedback is supplied to truck driver.
Step 1

When driver is reversing to couple with a loading unit:

1. Orange square indicates the position of truck and the blue dots indicates the receivers on the loading unit.
2. Arrow on the steering wheel show the required rotation of the steering wheel which is clockwise for the situation on picture.
Step 2

When the sensors are aligned and the truck is close enough to the loading unit, which is around 400 mm, the length of the connection head on truck:

1. Green dots and green square show the alignment of the truck and the loading unit is completed
2. Pause icon on the steering wheel warns driver to stop steering and to brake
3. Eject icon appears after driver stops steering and brake
Step 3

When driver hits eject icon, connection head on truck slides out and connects to the connection head on the loading unit.
Step 4

When the connection head on truck is locked into the connection head on the loading unit:

1. An OK icon appears inside the green square to indicate the successful coupling.
2. A forward arrow icon appears on the steering wheel to warn the driver to drive straight. Connection head on the loading unit slides out as the truck moves ahead.
Step 5

When the connection head on the loading unit slides fully out:

1. The gap between truck and loading unit is in position 1 which is around 800 mm and fully open for better maneuverability since the truck is on low speed.
2. Wheels of VHM are steerable now for enhanced maneuverability since the truck is on low speed.
3. An OK icon appears also on steering wheel to indicate that the driver now can turn the steering wheel freely for desired maneuvers.
**Side Underrun Protection**

VHM’s small wheels and geometry offers rear underrun protection for the truck, however side underrun protection was not considered on the original concept.

Feedback from the final presentation to Volvo showed that there is a need for also side underrun protection.

Side underrun protection is for preventing cyclists and pedestrians to fall under the truck and doesn’t need to be as strong as rear and front underrun protection.

According to international underrun standards, side underrun protection needs to resist 1kN force whereas front needs to 80 kN and rear to 50 kN. (From www.monash.edu.au Review of truck safety: Stage1: Frontal, side and rear underrun protection document)

This makes it possible to use stretched steel wires as side underrun protection. These steel wires can as well be rolled and stored inside VHM modules like the other cables and wires.
Share Terminals

VHMs are considered to be shared between trucks. By this way when trucks don’t have any containers to pick up, they don’t have to drive VHMs around and this increases fuel efficiency. This requires Share Terminals close to train stations, harbors and company terminals. Share terminal design is excluded from the project because of time considerations. However since VHMs have small package size when retracted, they can possibly be stacked on top of each other in the storing terminals with elevator function.
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