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Implementation of new unit load carrier in the forest supply chain: Opportunities and challenges

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Content

1. Summary

This pre-study has been aimed at enhancing, analysing and appraising a new load carrier in the forest supply chain and creating understanding of how the load carrier, together with effective information management, can make an efficient and flexible supply chain possible. The background is that technical development in the shape of a new type of load carrier combined with partly existing technology in the shape of vehicles and information technology can create new conditions for improving the efficiency of material flows as well as resource utilisation in the forest industry – "from forest to use of product". The assumption has been that this can create opportunities for reduced tied-up of capital, better final quality of the product, reduced environmental impact and reduced waste. The overarching aim of the pre-study has been to continue development of a load carrier that can contribute to the creation of *more efficient* (resource-efficient) *supply chains*, resulting in less *environmental impact*. A number of sub-targets were identified to bring this about:

- Enhance the load carrier prototype.
- Demonstrate the technical design of the new load carrier concept.
- Identify potential for introduction of a new load carrier in a supply chain.
- Show how the developed technology can support process development via
    - efficiency improvement through new services based on the new load carrier,
    - improved traceability and exchange of information, and
    - quality improvement in the forest raw material.

Technical development has taken place in close interaction between the various industrial partners. Various technological development proposals have been discussed and appraised during a number of workshops. The load carrier has been developed in the following steps: (1) In order to analyse load volumes and load weights, data about wood weights in different geographical areas have been used as well as the information about weights for different types of assortments (2) The timber bunks have been developed to be foldable in a way that increases load capacity, (3) The load carrier has been provided with folding rollers to be compatible with hook lift equipment on trucks and forwarders, (4) The load-carrier towers have been modified in several ways and there are ideas concerning continued modification that solves problems relating to stacking of load carriers and the vision conditions of the operators, (5) A design for an end wall top section to be screwed onto the existing end wall to prevent the load carrier's end wall becoming too low, (6) To meet the need for a continuous hook lift truck, the present-day type of 4-axle hook lift trailer of the roller conveyor type can be taken as a basis, where shunting of the two timber frames can take place from both front and rear ends of the trailer, (7) The location of the box for the straps and its design were changed to the box being opened from the side instead of from above.

To investigate the potential role of the load carrier in the forest supply chain better, a number of studies and trials have been performed.

A field trial has been conducted in which the load carrier has been used in a real situation in felling in order to test technology concepts and identify possible improvements to the load carrier. The four load carriers that were available at the time but were built with a slightly varying construction were used in the trial. The practical trial covered all elements from when the timber is processed by the harvester and is lying on the ground to when the timber is unloaded at the receiving mill. Several opportunities for development were discovered during the trial, both technically and with regard to how load carriers should be managed and shunted in the forest and on the roads.

To create an understanding of the potential role of the load carrier in an existing industrial context, a study was also conducted on the basis of the supply chain of a specific company, Holmen Skog, Iggesund Region. By making a material flow mapping of both a supply chain where the load carrier is used and a conventional supply chain the use of resources could be compared. It was also of interest to try to investigate in further detail the opportunities and obstacles introduction of a new load carrier would mean in a particular context. Opportunities were identified in areas such as (1) Flow, (2) Handling, (3) Reduced waste and decrease in value. Challenges were identified in the following areas: (1) Coordination problems, (2) Assortment, (3) Technical aspects and costs, (4) Vehicles, (4) Handling and shunting of load carriers.

An analysis has also been done of the forest supply chain showing that the contractors in the forest industry are in a very strained situation.

A framework has been developed to enable the situations described above to the analysed. The framework is based on the new load carrier having potential to improve the efficiency of the forest supply chain. A hypothesis is that a new load carrier could be part of a complete solution that can address the heterogeneity and uncertainty that exist in the forest supply chain in an innovative and more effective way (with regard to both flow efficiency and resource efficiency). A holistic inter-organisational framework is needed to deal with this heterogeneity and complexity that can analyse the whole chain from forest to final product and the role of the load carrier in this.

Finally, in addition to the need for technical enhancement a great deal remains unclear regarding the opportunities and challenges related to an implementation of the load carrier in existing supply systems. This also needs to be analysed and appraised in a main study. In this there is a need for further concept development, development of business models and analysis of the interaction between load carriers and infrastructure. The load carrier needs to be analysed as new technology in a existing system.

2. Background

The background to this pre-study is that technological development in the shape of a new type of load carrier combined with partly existing technology, for example vehicles and information technology, can create new prospects for improving the efficiency of material flows as well as resource utilisation in the forest industry – "from forest to use of product". The assumption has been that this can create opportunities for reduced tied-up capital, better quality of the product, reduced environmental impact and reduced waste.

The pre-study together with a future main study contribute to a new load-carrier concept with the aim of improving efficiency in the supply chain in the forest industry. The pre-study creates an overview of the current situation and formulates questions that are relevant to various parties, which will be examined in greater depth in the main study.

2.1 Experience from other load carriers

Standardised load carriers have been shown to be important to minimise handling costs in efficient transport of goods. What is demanded and aimed for with regard to materials handling in the forest is load carriers that make efficient flows and good utilisation of resources possible and can be combined with already established technology. A number of developers have over time attempted to design various types of load carriers both for round wood and for other purposes, but none of these solutions has become a success in the market. Although this pre-study is focused on transporting of round wood, it is possible to benefit from the experience gained with regard to load carriers for other forest products, in particular chip scabbards, which are hook lift-based load carriers for the transporting of chips.. Similar concepts could be used for round wood, and these chip handling systems would then also be developed. There are a number of elements that limit efficiency in chip handling with hook lift systems and chip scabbards based on hook lift containers. Safety must be given high priority, which means among other things that there must be a sufficiently high end wall to eliminate the risk of the round wood flying forward over the cab and causing severe injury in the event of a sudden stop.

2.2 The Green Wood Logistics load carrier concept

The company Green Wood Logistics has developed a new load carrier concept (referred to below as the load carrier) based on a unit load carrier for round wood that is directly loaded at the time of felling. The system with the load carrier is intended to simplify reloading operations with expected lower energy consumption and lower tied-up capital, lower other costs, reduced loading damage caused by craning for the drivers and less damage to the timber.

Data on individual logs generated in the harvester unit in felling could be linked to the load carrier concerned, which becomes the carrier of both the raw material and relevant information. The generated information on the logs consequently would not be lost at the different reloading times. The concept is intended to make possible a coherent process and coherent quality follow-ups where a possibility is created of continuous improvements and increased efficiency.

Because of a shorter turnaround time, the quality of the raw material is preserved. The load carrier can be equipped with sealing, which provides a unique opportunity for chain of custody and other traceability.

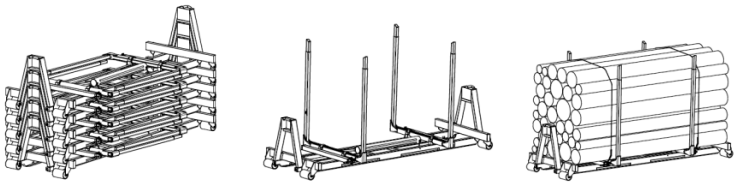

Figure 1: The stackability of the load carrier

The load carrier is stackable to make efficient transport of empty load carriers possible per vehicle transport (See Figure 1). This may reduce the risk of a shortages of empty load carriers at the clear-felled area. The load carrier is symmetrically reversible to enable handling from two directions and to make unloading possible from one short side and loading from the other short side. As a result, machines and vehicles do not need to drive around and turn to unload and load

The load carrier is expected to create better conditions for intermodal transport, which is particularly important in view of the fact that at least three different modes of transport are already used today. The large flows can take place with tractor unit, link and trailer for a light rig with the possibility of high load weight. Haulage companies with hook lift trucks can benefit from increased use of their trucks. Access to transport resources becomes more flexible and can be adapted to the needs of the forest industry.

3. Purpose

The purpose of the pre-study is to understand and identify opportunities to make supply chains more efficient by introducing a new load carrier of the type developed by Green Wood Logistics. The purpose of the pre-study is to:

1. analyse, appraise and technically enhance the load carrier
2. describe the present situation and create understanding of how the load carrier, together with efficient information management, can create the possibility of an efficient and flexible supply chain
3. identify and prioritise key areas and issues to continue to work on in a main study.

4. Enhancement of the new load carrier concept

4.1 Technical development of the load carrier

To make handling of a hook lift container more efficient in the forest, it is desirable that these can be handled from two directions. To ease handling of the load carrier, it has been designed symmetrically. The most significant differences for the interaction with other equipment are that the load carrier has foldable rollers and towers at both ends. The towers on the load carrier are designed in such a way that the hook lift container frames can be stacked one on top of the other. A risk that was discovered during the course of the study was that logs could be loaded into the open space in the tower and consequently obstruct unloading by truck at the mill. To prevent this the load carrier towers were equipped with skid plates. In the field trial, the operator noted that the skid plates obstructed the view somewhat in loading and wanted these to be designed as grilles instead.

The load carrier has been designed for stackability to make transporting back of a larger number of empty load carriers per run possible. Because load carriers can be stacked, the need for space to set up empty load carriers both at the logging area and at the mill is reduced. To enable the complete load carrier to be stacked, the stakes in the timber bunk must also be foldable. After development work a timber bunk developed in which the stakes were folded down alongside each other and the length of these was consequently increased by 5%, which also resulted in 5% higher average payload.

The location of the strap box and its design was changed so it is opened from the side instead of from above in order not to block it if the driver has forgotten to remove the straps before loading of timber. As transporting of round wood does not utilise the whole free transporting height of 4.5 m in Sweden, the end wall must also be equally high. The problem with the usually too low end wall can be solved with a end wall top section that is screwed onto the existing end wall.

The aim for hook lift container trailers is to develop a new function making shunting of the hook lift container possible from two directions. In order to be able to use present-day trailers, the aim is to make the load carrier, at least during a transition period, adaptable to the present-day standard. To meet the need for a continuous hook lift trailer it is possible to take as a basis the present-day type of 4-axle hook lift trailer of the roller conveyor type where it should be possible for shunting of both timber frames to take place at both the front and rear of the vehicle with the following modifications: The roller conveyors are provided with eight vertically mobile, hydraulically controlled pockets for rollers. This utilises the advantage of being able to utilise the existing rollers on the timber frames for shunting. In addition, good load locking is obtained when the rollers are in the pockets for rollers when the frames on the timber frames are resting against the roller conveyors and the locks are applied. A trailer according to the principle described above that can be shunted from two directions also matches the present-day hook lift system

where one unit is loaded from in front and one from behind, and in principle all platforms to Swedish standard can be used.

4.2 Testing of the functionality of the load carrier

A trial has been conducted in which the load carrier has been used in a real situation in felling in order to test technology concepts and identify possible improvements to the load carrier. The four load carriers that were available at the time but were built with a slightly varying construction were used in the trial. The practical trial covered all elements from when the timber is processed by the harvester and is lying on the ground to when the timber is unloaded at the receiving mill. This comprises the following groups of activities: (1) supply of load carrier from parking point to the logging area, (2) transfer of the load carrier to forwarder, (3) loading of the load carrier, (4) transfer of the load carrier to truck, (5) truck transport to parking point, (5) transfer of load carrier to trailer, (6) transfer to mill, and (7) unloading at receiving mill.

The trial was initiated by a truck transporting the first load carrier from a parking point (located a few kilometers away) to the clear-felled area. On arrival the truck backed in on a forest road and unloaded the load carrier (See Figure 2). On this first delivery it did not matter in what direction the load carrier was placed. .

Figure 2: Delivery of the load carrier

The forwarder then came to collect the first empty load carrier that stood on the forest road and transport it to the clear-felled area (See Figure 3).
The forwarder operator did not experience any problems in this element. A question that was discussed was whether there might have been problems in lifting over the stakes which are higher than on an equivalent conventional forwarder, but this was not considered to be a problem. The same applied to any instability due a high centre of gravity. It can be pointed out, however, that the clear-felled area was level and did not pose any terrain-related challenges.

Figure 3: The forwarder collects the first empty load carrier

The forwarder travelled back with the first loaded load carrier to the landing and unloaded this at the place to which the following load carriers are also delivered by the truck. This surface was level, which was something that had been wanted by the truck driver. At the time of unloading straps were thrown over the load and fastened in the hooks provided for this purpose. The truck then pulled up the load carrier and the driver checked the load and removed protruding parts such as branch wood and twigs. The truck then travelled to the parking point where the trailer was loaded. The truck then returned to the landing.

The process was repeated until the three load carriers were loaded with pulpwood and all were at the ground, two on the trailer and one on the truck (See Figure 4). They were then transported to a mill. The straps did not need to be re-tightened in this transport.

Figure 4: Loaded truck and trailer, with three load carriers, on the way to a mill

Unloading at the mill took place in the same way as with a traditional rig, and according to the truck driver took place without any problems occurring.

To ensure that stacking and transport of empty load carriers worked according to plan a special trial was performed regarding this. A truck transported empty stacked load carriers (three were available for the trial), which were deposited at the roadside. The stack with the three load carriers was unloaded at the clear-felled area as a package, and the forwarder operator lifted a load carrier from the stack with his crane without any problem. The forwarder pulled the stack up with loose load carriers with the hook without the stack shifting in any way and ran it out on the ground. No problems with instability in the stack with empty unsecured load carriers were noted.When the load carrier was to be lifted onto the stack again using the crane problems arose because high precision is required to stack the load carriers. Empty load carriers are normally not stacked in the forest but at the mill using fork-lift trucks, and it should not therefore pose any problem in reality.

4.2.1 Comments on the load carrier trials

It does not matter for the load carrier in what direction it is placed as the rollers are foldable, i.e. the forwarder can pull it up from any direction. This was illustrated to some extent in the test as the load carriers of earlier design needed more time and space to be positioned so that the forwarder could pull them up. The load carrier being symmetrical is an important part of the concept development so is the fact that the rollers can be folded. The folded-up stakes on an empty load carrier may fall down in lateral movements if they not properly locked. In the trial it was found, however, that this could be easily handled by the forwarder operator who could lift the stakes by control from the cab.

A matter discussed in the trial was how the load carrier is to be locked in vehicles with standard solutions existing at present. It may be of interest here to make some modifications if there are high lateral loads when the load carrier is driven on more difficult terrain than was the case in the trial. However, he did not experience any difference in stability in relation to his usual activity due to the shape of the load with a higher centre of gravity, which was not to be expected either as the height/width radio of the load carriers is the same as that of the chip scabbards, i.e. the load format is always in the present-day system.

It was also noted that when the forwarder driver loads timber on the load carriers which are then to go out to the landing, this must be done more carefully than usual. This takes more time, but it is not possible to say how much more time after this trial. This may have contributed to re-tightening of load securing not needing to be done. According to the interviews done with the forwarder operator it was found that if there are to be half-full load carriers due to sorting, the forwarder operator will load some other assortment to top up and unload this at some suitable location to reduce the number of runs. It is not possible at present to state how this will work in actual operation.

It was also indicated that depending on how the work is organised and who owns different resources, i.e. whether harvester and forwarder are owned by the same organisation or not, this has implications for the degree of productivity at a clear-felled

area. How this works differs, however, between different regions and there is no clear proof of the effects of this.

4.3 The role of the load carrier in a company's supply chain: opportunities and obstacles

To create an understanding of the potential role of the load carrier in an existing industrial context, a study was conducted on the basis of the supply chain of a specific company. It was also of interest to try to investigate in further detail the opportunities and obstacles introduction of a new load carrier would mean in a particular context. The study was carried in one of the four regions of Holmen Skog (referred to below as Holmen), Iggesund region. In the Region Holmen has a sawmill and an integrated pulp and paper mill, which are directly alongside each other.

4.3.1 Summing-up of experience: opportunities and obstacles to a new load carrier

To create an understanding of the potential role of the load carrier in an existing industrial context, a study was also conducted on the basis of the supply chain of a specific company, Holmen Skog, Iggesund Region. By making a material flow mapping of both a supply chain where the load carrier is used and a conventional supply chain the use of resources could be compared. It was also of interest to try to investigate in further detail the opportunities and obstacles introduction of a new load carrier would mean in a particular context. Opportunities were identified in areas such as (1) Flow, (2) Handling, (3) Reduced waste and decrease in value. Challenges were identified in the following areas: (1) Coordination problems, (2) Assortment, (3) Technical aspects and costs, (4) Vehicles, (4) Handling and shunting of load carriers.

Opportunities:

Flow:

- Shorter turnaround time from clear-felled area to mill is expected.
- Reduced inventories and buffers in the whole supply chain

Handling:

With the new load carrier the forwarder can unload the whole load in one lift

Reduced waste and value reduction:

- A reduction in waste and losses of value are expected due to reduced material handling and fewer storage points in the forest and at the roadside.

Challenges:

In order to take advantage of the opportunities that the implementation of the load carrier result in a number of challenges have to be addressed

Coordination problems:

- Trucks often run in different shifts compared with how the work is organised in the forest and this means potential coordination problems.
- When the roadside stocks are drastically reduced so is the the buffer between:
    - harvesting and forwarding (due to weather conditions in combination with other factors such as age of the forest, and orders, it is not always desirable for harvesting and forwarding to take place directly alongside each other).
    - forwarding and transport (due to road conditions, weather, distance to the mill etc it it is not always desirable for forwarding and transport to take place directly alongside each other

To handle these decouplings is expected to result in a great need for coordination of many load carriers. There is also a potential problem related to re-positioning of empty load carriers.

Assortment:

- The different assortments felled at a clear-felled area will go to different mills, due to swapping of round wood takes place between the forest companies. It is not clear what consequences this will result in.
- Only having assortment in each load carrier needs to be analysed further.
- The problems associated with having a mixed assortment in each load carrier needs to be analysed further. In the conventional system the different assortments are distinguished with strips or colour marking. Practically this may be possible also for the new load carrier, however it is not in line with the basic idea for the load carrier.
- If the load carrier is only used for one assortment is will result in a problem when it is used in combination with thinning because pure-assortment timber becomes too spread out in the forest. This needs to be observed since thinning accounts for 30-40% of Swedish forestry.
- There is a risk of tying up a load carrier with the wrong timber.

Technical aspects and costs:

- Very many load carriers will be needed. It is unclear at present how many.

- There may be problems if different suppliers who supply to a particular mill do not use the same load carrier. The mill thus needs to be able to receive both conventionally supplied material and material supplied in the load carrier.
- The load carrier is not suitable for all types of felling and it is necessary that the entire supply chain, from forest to mill, should be able to handle flows both with and without the load carrier.

Vehicles:

- Holmen regard the most promising technological development in the development of longer vehicles, e.g. the ETT project (the one-more-stack project, where four stacks instead of three is transported). It is important to examine how the load carrier works in this context.
- Present-day timber trucks may weigh up to 60 tons with load. There is thus a possible weight problem depending on the weight of the load carrier and the hook unit.
- It is important that the forwarder can be used both with and without the load carrier.
- When the load carriers is loaded on the forwarder it may lead to stability problems and a lower speed, due a higher centre of gravity.

Handling and shunting of load carriers:

- The new load carrier adds a new activity, loading of the carrier
- A challenge is the availability of space to place the load carriers on, when waiting to be loaded on the truck. There may possibly also be a need for new turning places.

4.4 Implications for the forest supply chain: an analysis of the Swedish forest supply chain

This part of the study aims to give an overview of the logistics challenges within the forest supply chain, with a special focus on the opportunities provided by the use of the load carrier.

The load carrier could contribute several positive effects for the supply chain such as shorter lead times and lower total stock levels. It is also noted that there are great opportunities to handle information, introduce traceability, reduce handling and therefore reduce the risk of damaging the timber, in use of the load carriers.

However, the advantages mentioned only affect the most immediate efficiency shortcomings in the system, which are actually merely symptoms of underlying problems in the supply chain. There are also many drawbacks of the load carriers such as empty returns to the forest and the cost of tied-up capital.

One conclusion from the analysis made of the forest supply chain is that the supply chain seems rather fragmented. Two key explanations were found. First, there seems to be a distorted balance of power in the supply chain. One reason for this is the difference in size and profitability between the few and large end-users and the many small forest owners as well as the many small individual contractors who carry out the felling and transport services. As this is a profitable business model for the end-users, they are not so keen to change this situation.

In addition, there is a lack of a holistic approach in the sector, which results in suboptimal solutions being introduced that lead to low integration between the various actors in the supply chain. This makes it difficult to avoid "bull-whip effects" in the supply chain. The deficiencies in the follow-up and communication systems between the various individual actors involved can only be offset by building large stocks throughout the supply system.

Finally, information management regarding timber has been identified as incomplete without an appropriate ability to trace and maintain the information that has been generated through the supply chain. This, in turn, has created high levels of discards in the supply chain when the products finally arrive at the mill and suboptimal use of the timber as all information on origin and characteristics of the individual timber has been lost. All these factors can be identified as barriers to increased efficiency in the Swedish forest supply chain.

Finally there is a risk that the basic cause of the inefficiency such as the imbalance between the different actors involved will partly prevent introduction of the load carrier system but also prevent it being used efficiently.

4.5 A framework for analysis of the role of the load carrier in an existing system

The framework that has been developed is based on the new load carrier having potential to improve the efficiency of the forest supply chain. The framework is based on some fundamental prerequisites. The present-day forest supply chain is characterised by heterogeneity and uncertainty on both the supply and demand sides. On the supply side there is heterogeneity with respect to raw material spread over large geographical areas which additionally varies greatly in quality (assortment). On the demand side the customers are spread out geographically and their area of application is also very heterogeneous (both manufacturing and process industries). The framework takes its point of departure in the new load carrier as the *focal resource.* This resource then needs to be combined with the established resources in the forest supply chain. This may be

various types of resources, for example wood raw material, harvester, forwarder, material handling equipment, measuring equipment, IT system, knowledge and expertise of various parties involved, business relations). Introducing a new resource into such a system can create great needs for adaptations of these various resources and new ways in which these resources are combined.

5. Key areas for a main study

In the following section key areas and issues to continue to work on in a future main study are identified and prioritised. Key questions to be touched on in the main study are:

- What activities are carried out in connection with utilisation of the load carrier, in what sequence, and how are these activities coordinated?
- Analysis of economic consequences of the introduction of a new resource and phase-out of existing resources, for example timber vehicle cranes.
- What other resources have an effect and is the load carrier affected by?
- What actors are involved in connection with utilisation of the load carrier, and how do these relate to each other, and how does exchange of information take place between them?
- How is the need for transport in the supply chain affected by the introduction of the load carrier?
- How is the utilisation of the vehicles in the transport systems affected by the introduction of the load carrier?
- What are the effects of it being possible for all forest products being handled and transported in a uniform system?
- How is the forest supply chain affected by the introduction of the load carrier?
    - How are the activities in the system carried out with respect to execution and coordination? Aspects concerning changed lead times and reloading times and stocking points enter here.
    - How can the parties involved improve control of the material and information flow in the supply chain through the load carrier?
- What opportunities are there to use the concept in an intermodal system?
- Description of the solution from a user perspective: What problem(s) does introduction of the load carrier solve for the user(s) – based on the perspective of different parties involved?
- Analyse the effects of traceability and therefore the possibility of coherent quality follow-ups for continuous improvements and increased efficiency with reduced assortment migration and possibility of chain of custody
- What are the effects of the introduction of a new load carrier on the information handling in the whole supply chain?
- Which existing load carriers, for example chip scabbards, could be adapted to a better standard?

- How does the structure of the forest industry affect the efficiency of the transport chain? How could the structure be developed for better function?
- What principal business model is used today on the basis of a load carrier perspective and what new business models are being developed?
- How is a business model developed that increases efficiency and bridges the identified imbalance in the power structure?
- Demonstration of the role of the load carrier in the whole supply chain.

6. Conclusions and continued research

As well as the need for technical enhancement a great deal remains unclear regarding the opportunities and obstacles that exist in an implementation of the load carrier in existing supply systems. This also needs to be analysed and appraised in detail.

The mapping of the supply chain performed in this pre-study has mainly focused on the part of the supply chain that is situated in the forest. In order to evaluate the consequences and opportunities of the use of the load carrier, studies of the whole supply chain, from forest to consumption, are needed.

How can planning and direction of material flows based on load carriers co-exist with conventional supply chains? How can the number of needed load carriers in the supply chain be calculated?

6.1 Continued technological development in the future main study

There is a need for continued development of rollers/the roller function to reduce handling time and develop a simpler function to fold up the rollers.

Another potential problem that needs to be analysed is in the guide plates that sit on the outside of the longitudinal members of the demountable body truck for certain models of demountable body trucks. This can be solved if necessary with narrower rollers and adapters in the cradles of the present-day trailer structure.

A calculation also needs to be made of the optimum height of the load carries to be able to carry empty load carriers within the permitted load height. Continued finite element calculations including choice of material to reduce weight with retained function/strength of the load carrier need to be carried out.

Continued development of the "accessories", such as skid plates and storage compartments, is also needed, according to the views expressed during the file test. Load

securing takes place at present with straps that are handled manually. It would be desirable for this handling to be dealt with using the crane so that the drivers avoid leaving machines and vehicles.

In the main project the project is to build/convert a trailer based on the above principles. Practical trials must be performed. There immediately appear to be significant benefits in being able to utilise the existing rollers of the timber frames for the actual shunting on the trailer.

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