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## **Innovative concept of a forwarding system for considerate treatment of forest soil and improved efficiency**

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### Abstract:

The shortwood handling Forwarder is deemed to be the economic standard in flat to average mountaineous terrain in Central Europe. On sensitive forest stands the loaded forwarder raises the dimension of soil damages with every pass. The sum of technical adaptions to avoid the loose of the trafficability of the forwarder itself raises its deadweight and will compound the grade of the damages in the soil more and more. The use of alternative soil-conserving systems for transporting shortwood is mostly inadmissible expensive. Although, the forwarder has the disadvantage to stand by with all transportation equipment while loading and to carry all the heavy loading equipment over and over again.

With an innovative approach we present a forwarding system that will use a light forwarder that retains in the stands and a slim drone with a new kind of carriage that will show low impact of shear forces on forest soil. The forwarder has just to positioning itself. Although the slip regulation realising electrical wheel hub engine is possible to be light and underpowered. The drone will work self-sufficient and is capable to receive and deliver a bundle of shortwood automatically to a possible second drone, when the skidding distance will be too far for one drone at all.

The innovative conceptual design of the forwarding system is aimed to optimise the economical power of the established forwarder while upgrading the protection of the driven forest soil with a new kind of carriage, minimising the moving masses and shows the potential and limitations of a future development.

**Keywords:** forwarding system, sensitive forest soil, new kind of carriage, economical optimisation

### Introduction

Harvester and forwarder are deemed to be the standard in Central Europe forestry machines during the last two decades. Reasons of that technical and procedural revolution were the improved technical reliability, the enhanced efficiency und not least the revised ergonomic operation of the machine or rather the handling of the logs. With that, by and by the Scandinavian developments established in Central Europe and displaced the long wood method by the short wood method. Inside of that method the forwarder shows high haulage capacity because of a well proportion of dead weight and payload. Furthermore the short wood method does need only two elements (chain links), so the forwarding of the short wood to the next forest road could be easily extend to a medium range transport to the storage site.

But the up to 50 tons heavy machines cause with every pass exstensive and long-during damages on the forest high sensitive forest soil. In extreme, the depression will lower or will preclude the trafficability of the machines itself. With these damages, the in Germany by law

fixed principle of sustainability (soil protection law) will be injured. But with the missing of any technical or procedural alternatives and the ecological demand of a gainful forestry, this contradiction is generally silent tolerated.

To solve the problem of the nonconformity of the Scandinavian forestry technology on Central Europe forest soil conditions, the original forwarder was adapted with a lot of additional fittings. To date, all of these technical innovations only aimed at the risk of losing trafficability with maximising the power and the grip of the machine, not to protect the driven soil intensive. At the end, the "improvements" show a disproportional increase of the deadweight of the machines with the result that the driven soil is more and more affected and the bettering will be annulled. Curiously, often the light and not log-transporting harvester is the only devise, for that innovations of the carriage are made for. Although the fully loaded forwarder, as the real matter of soil destruction is overrunning the sensitive forest soil several times. With the background of increasingly heavy machines causing increasingly disastrous skid roads, the destructive dealing of the forestry with the forest itself effects a straight public discourse. More and more in that it is asked for care about the natural and social capacities of forests as intensive as about the economical relevance in logging.

To date there is no solution known, that will be able to adapt the Scandinavian machines to Central Europes conditions to ensure for an economical gainful, an ecological sustainable and social agreeable forestry. Either gentle machines are less powerful or powerful machines are less gentle to fulfil interdisciplinary requirements.

We as the Institute of Forest Utilization and Forest Engineering at the Technical University of Dresden developed the Portalharvester (presented at the Formec 2008 in Schmallenberg and at the Formec 2012 in Dubrovnik) and a convenient cable way system for lowland stands (presented at the Formec 2011 in Graz). This pair of machines is well performed for logging on impassable wet and sensitive forest stands.

Figure 1 shows the small operational area for harvester and forwarder in a stands-matrix, displaying the actual soil moisture as the trafficability on x-axis and the soil value as the derived distance for skid roads on y-axis.

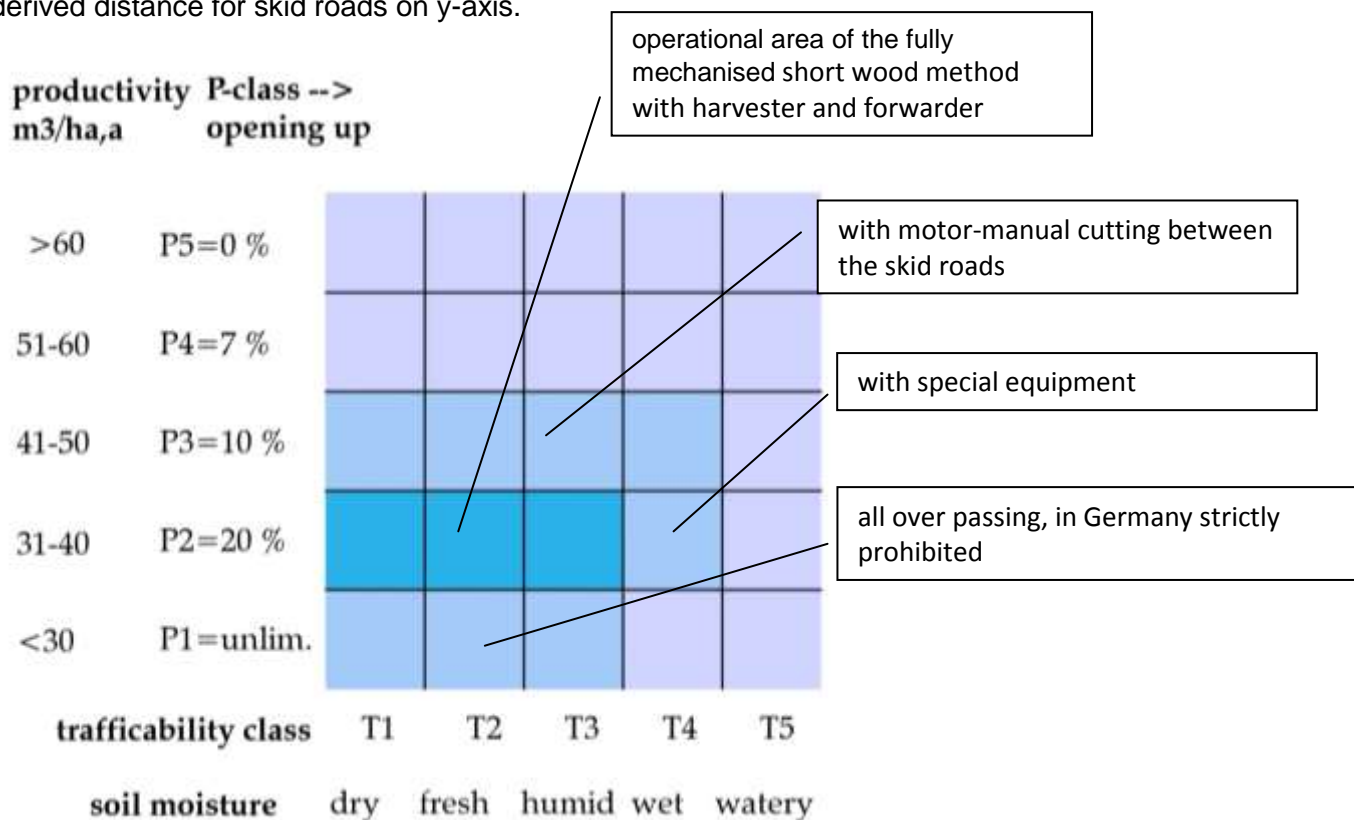
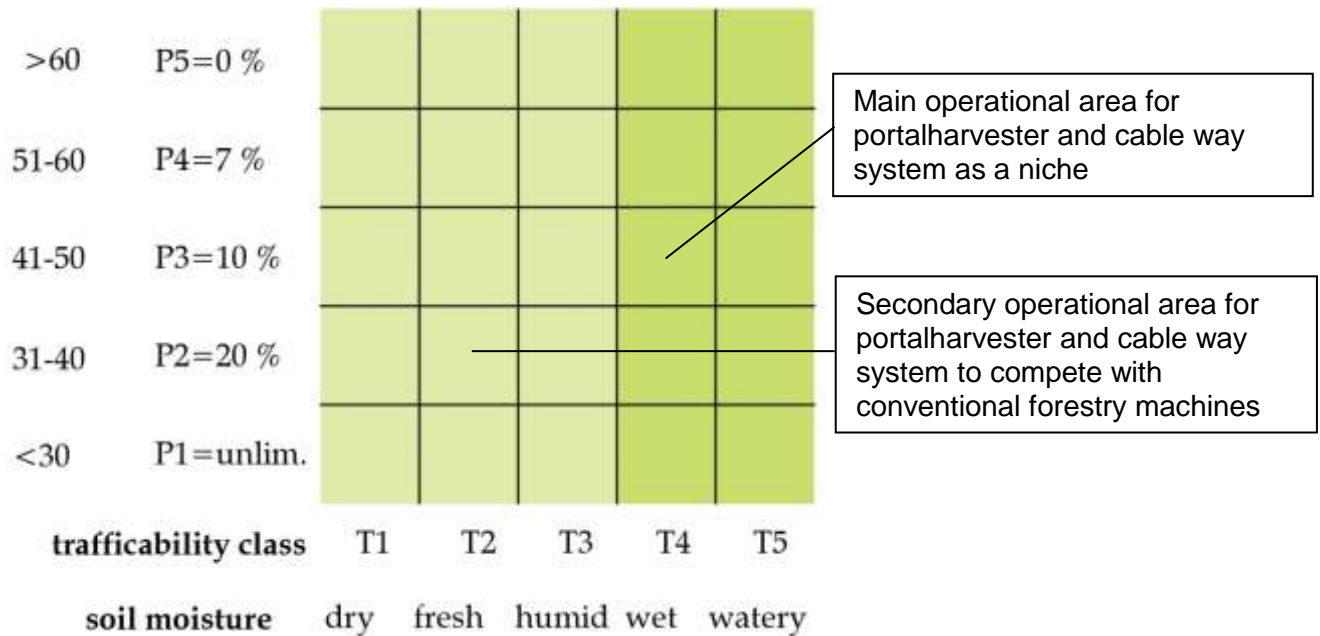


Figure 2 shows the operational area for portalharvester and cable way system for lowland stands, which are classified as impassable for wheel or track based forestry machines

productivity P-class -->  
m<sup>3</sup>/ha,a opening up



### The challenge

Nevertheless, additional to the niche covering forestry methods using the special machines portaltharvester and cable way system for lowland stands, the professorship of Forest Engineering at the Technical University of Dresden looked up for any ecological und economical successful operating solution of forwarding on sensitive forest stands nor in a niche than on a wide spectrum of forest stands.

The approach to solve the problem is to improve the forwarders prejudice of performing the processes of loading and forwarding only one after another and that the forwarder has to carry the sum of lifting equipment during every transport operation on the sensitive forest soil.

### Solution

The innovative concept shows a new kind of forwarder, consisting of a light master unit (deadweight 12 tons, payload 11 tons) and an unstaffed slave vehicle (deadweight 7 tons, payload 11 tons).

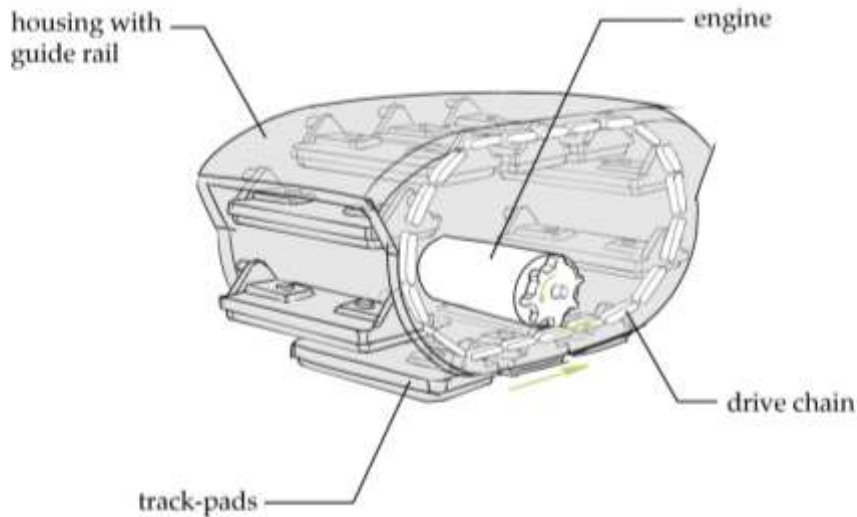
The master unit looks like a conventional forwarder and consists of the articulated carriage, the cabin for the operator, the lifting crane and a special load basket. The master unit only loads the short wood in its special load basket, but doesn't transport the logs. For this purpose, the forwarder can get under-powered and light weighted. And while this master unit passes the sensitive forest stand just empty to and from the lifting area, a standard wheel based carriage is a good solution. Moreover, the forwarder can be motorised by electrical power with fully integrated slope controlled wheel hub drives by which the soil destruction will be minimised. The logs will be lifted in the load basket and will lay on some conveyor belts, from where they will be moved over to the slave vehicle.



The slave vehicle consists of a load basket, which is identical with that on the master unit and a new kind of carriage. It is moving unmanned inside the skid trail, orientates itself on the driven tracks and on mounted positioning mirrors. If the slave vehicle is docked onto the master forwarder, it will be possible to move over the shortwood bundle. Afterwards the master forwarder will be ready to continue the collecting process and the slave vehicle starts to transport the bundle directly to the forest road or rather to the fixed landing area. If the way is too long, so that the master forwarder has to wait, a second slave vehicle can increase the productivity. At the landing area, the whole textile fibre fixed bundle will be dumped quickly. With that kind of divisioning labour it will be possible to transport and load logs at the same time.



The slave vehicle shows a new kind of a Track-Pad-Carriage that will realise a movement on sensitive forest soils showing a huge area of contact or rather a low contact pressure and at the same point a minimum of acting shear forces. The carriage consists of several slewing track-pads that are fixed on a chain conveyer, moving in that way, that the track-pads are lowered and lifted in a vertical way, while three to four track-pads will touch the forest soil at the same time. Four tiltable track-pad-units with crab steering realises a small turn radius and a minimum of track offset.



Because of adding the filled load basket just with a minimum of necessary transport equipment, the rate of deadweight and payload keeps the soil loading to a minimum. The tiltable track-pad-units adjust floor unevenness and will be necessary for unload the logs. Then, the slave unit will lean to ground and the conveyor belts will effect the controlled dumping of the whole bundle. The time-consuming unloading log for log will not longer appropriate.

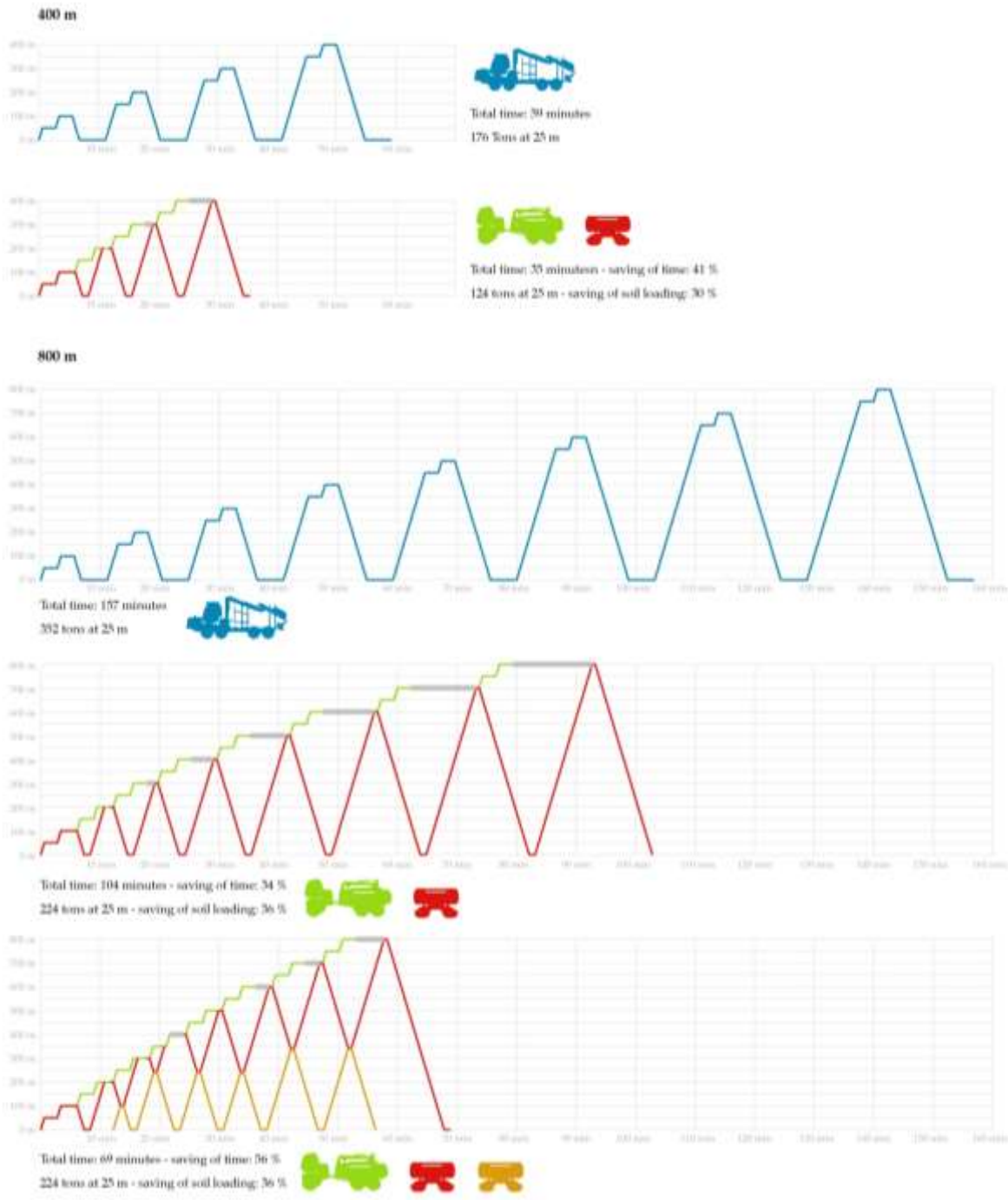


#### Productivity forecast

Figure 3 shows path-time-diagrams at a skidding distance of 400 m and 800 m, comparing the method of operation of a conventional forwarder (John Deere 1010E) and the imagined concept assuming equal driving speed of 5 kph, loading capacity of 11 tons and loading rate. Therein it is possible to analyse the current total time of forwarding logs and to count the total mass, which is loaded on the skid road.

At a skidding distance of 400 m the conventional forwarder will need 41 % longer (59 minutes) in time than the pair of master and slave unit (35 minutes) and the conventional forwarder will load 30 % more tons than the imagined concept (176 tons against 124 tons). But the longer the skidding distance the longer the master unit has to wait for the slave unit load the logs onto it. At a skidding distance of 800 m the conventional forwarder will need 157 minutes meanwhile the pair will still save 34 % of forwarding time (104 minutes). The sum of waiting time of the master forwarder are about 44 minutes, therefor it will be

interesting to take two slave units, that will lower the waiting time of the master forwarder down to 10 minutes. Then the saving of time will be about 56 % compared to the forwarding process of the conventional forwarder. When forwarding on a 800 m long skidding road, the conventional forwarder will load the forest soil with 352 tons, meanwhile the pair as the trio will load just 224 tons, a saving in soil loading of 36 %. Thus it appears that the concept will help lower the load on the forest soil while lowering the forwarding time on the other hand. But one has to ask, if the saving of time and of mass will legitimate the more in machines, that will rise the machine costs per hour.





**Result:**

The presented paper describes an innovative concept of forwarding logs based on the Scandinavian standard forestry method using harvester and forwarder. Especially the heavy loaded forwarder showed up to now, that the Scandinavian technology is not perfect adjusted on Central Europe's forest soil conditions. The caused extensive and long-lasting soil damages reasoned a conflict with opposite uses of the forest.

For the first time, the imagined concept will realise a lower load on forest soil meanwhile the efficiency of forwarding will increase at the same time. Therefore, the concept will show the maximum potential of a future development, that will advance the economical successful Scandinavian forestry technology on Central Europe's condition. At the end the concept will also interesting for the use in Scandinavia or elsewhere in the world.



