



## Wood supply chain optimization: Case studies of logging companies in Russia



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FORMEC'11

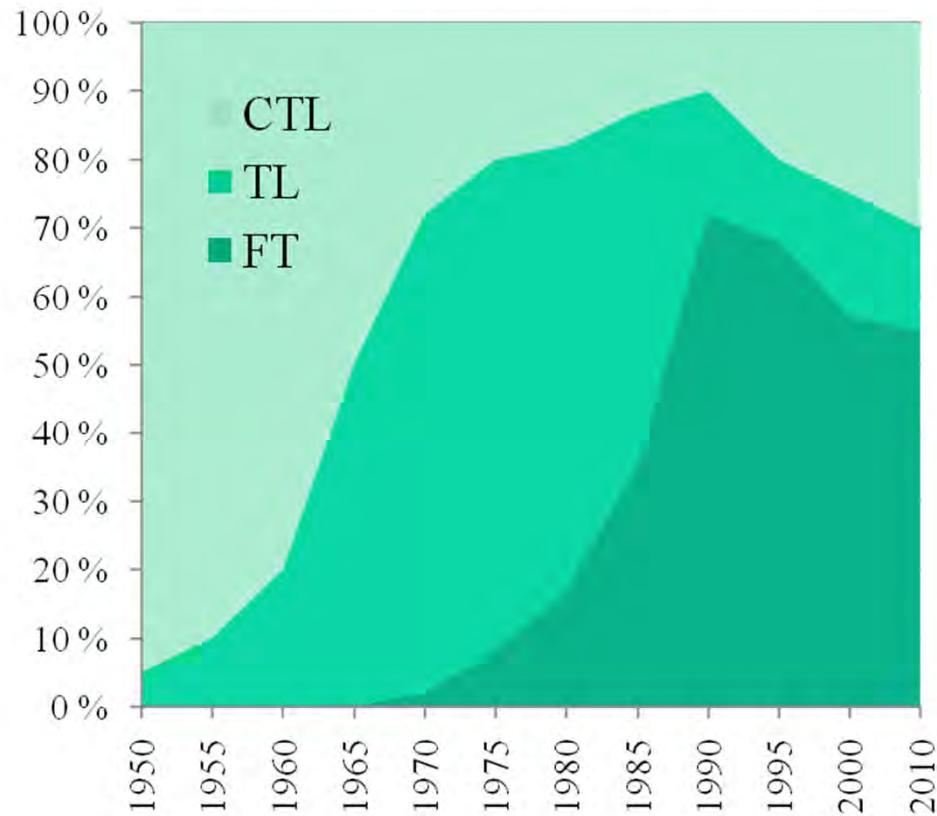
*October 9 – 12, 2011, Graz – Austria*

# Outline

- The operational-tactical-strategic context of wood supply in Russia
- Short description of the integrated DSS for logistics planning
- 3 test cases within operational, tactical and strategic transport planning
- Outputs
- Conclusion



# The operational context of wood supply in Russia



Region	CTL		
	Fully mechanized	Motor-manual	Total
Russia	18%	6%	24%
Karelia	75%	8%	93%

CTL machine	Import in 2008	Demand in 2015	Demand in 2020
Harvester	327	240-260	270-330
Forwarder	343	260-300	320-420

- Forest Development Project
- District Forestry Regulations
- Regional Forest Plan

# Decision making levels in wood supply chains

Planning level	Horizon	Harvesting decisions	Road decisions	Transport decisions
<b>Strategic</b>	1-10 yrs	Leasing area potentials Choice of harvesting method Equipment investments	Infrastructure investments Equipment investments	Choice of transport method Equipment investments
<b>Tactical</b>	3 months – 1 yrs	Annual harvesting volumes Harvest unit scheduling Equipment utilization Choice of equipment utilization level	Temporary truck access roads Upgrading and maintenance of permanent road	Transport delivery plan Choice of equipment utilization level
<b>Operational</b>	1 day – 3 months	Detailed harvesting plan		Truck routing

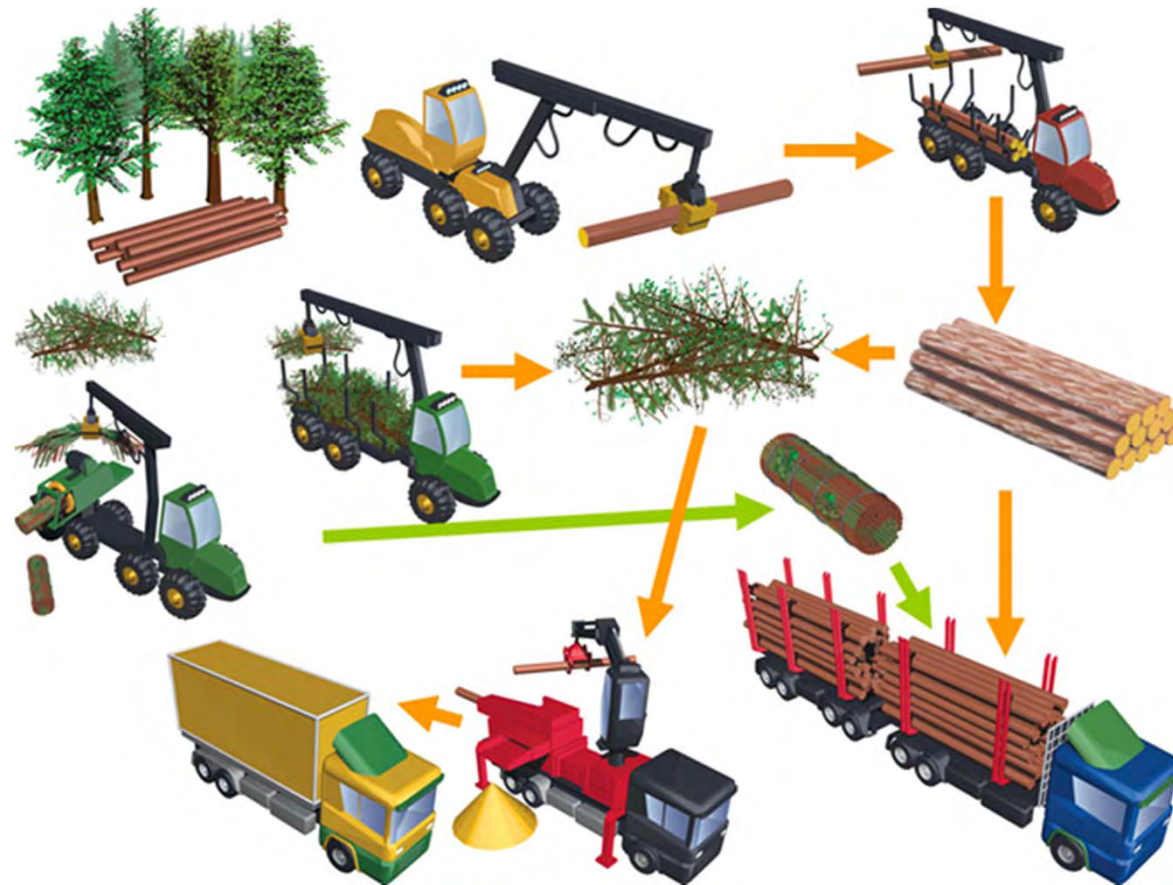
## Specific restrictions for wood supply operations

The following business rules present specific restrictions for wood supply operations in Russia:

- A logging company owns equipment for wood harvesting and transport and manages forest operations itself; outsourcing and entrepreneurship is not common practice
- The annual delivery plan should be fulfilled according to the annual contract, however the monthly delivery plans are flexible depending on many reasons such as seasonal conditions, market situation, infrastructure etc.
- Seasonal intermediate storages in the forest or at the central processing yard are common practice
- Limitations for the maximal truck axle loads on public roads and bridges; use of heavy trucks are restricted in many places
- The condition of roads, bridges and even parts of the same road may vary between periods.

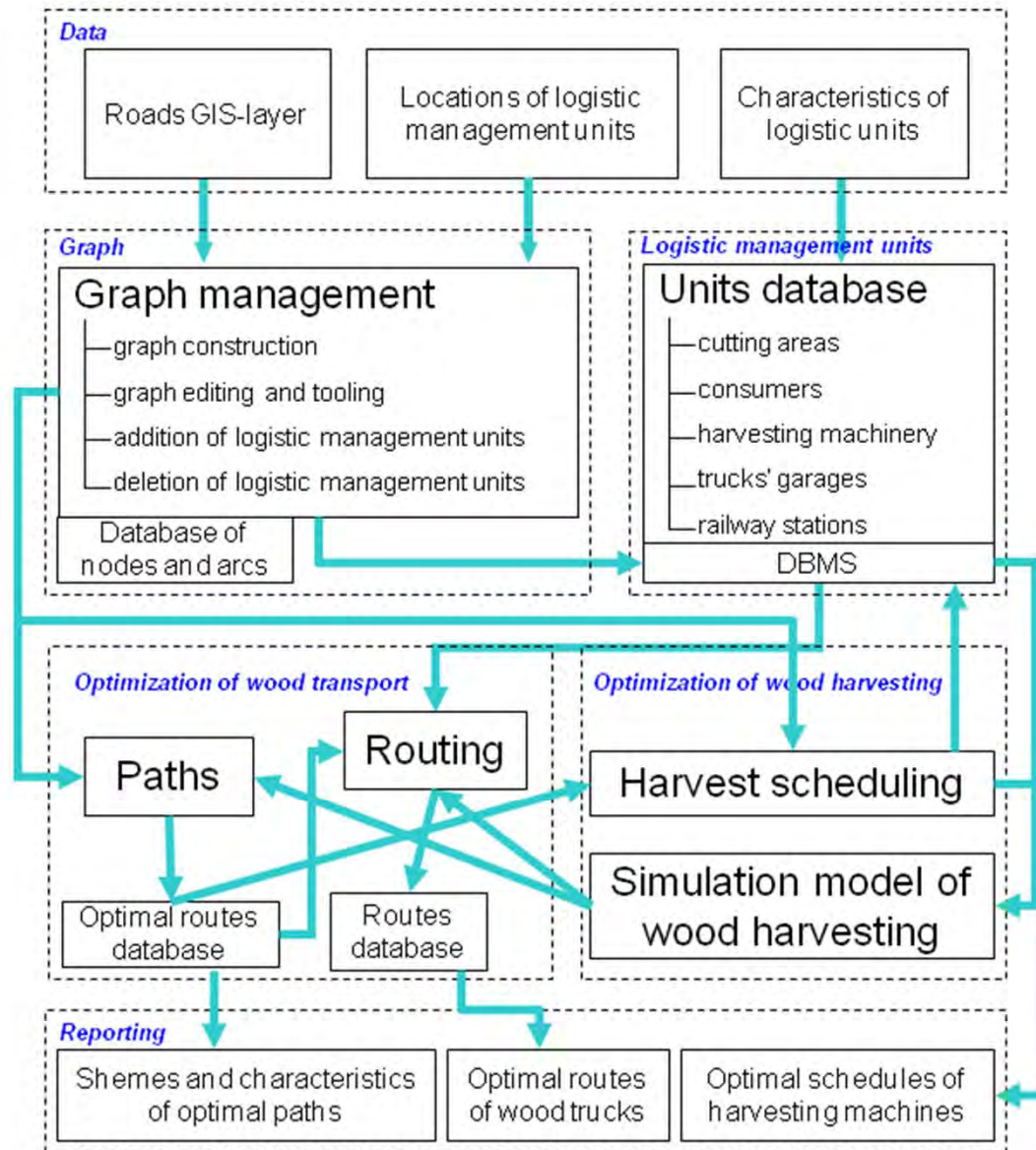


# Supply chain



Develop a decision support tool to support a wide range of planning decisions at on the company level including truck routing, choice of equipment utilization level, choice of transport method and infrastructure investments.

# Structure of the DSS



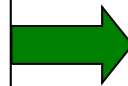
# Tools for the system constructing

## MapBasic

- Database management
- Interface

## MapInfo

- Objective database
- Internal database management system
- Spatial functions



## C++

- Simulation
- Search of optimal routes
- Search of optimal transtport plan
- Search of optimal harvesting schedules including energy wood
- Calculation of performance indexes

## MS Excel

- Reporting



# Interface - Road characteristics

The screenshot displays the MapInfo Professional interface with the 'Logistic' menu open and the 'Transporting Speeds and Costs' dialog box active. The dialog box is titled 'Transporting Speeds and Costs' and contains the following fields and options:

- Input the average speed for each type of road, km/h:
  - Type 1 (Highways): 100
  - Type 2 (Usual asphalt roads): 80
  - Type 3 (Earth roads): 35
  - Type 4 (Byroads): 15
  - Type 5 (Forest/field roads): 5
- Costs for transporting of 1 cubic meter of round wood at distance of 1 km:
  - Type 2 (Usual asphalt roads): 1
  - Railway roads: 0,2
- Set the reloading losses equal for each railway station?
  - Yes
  - No
  - Value: 25

Buttons for 'Cancel' and 'Ok' are located at the bottom of the dialog box. The background map shows a network of roads and a river, with a red truck icon on a road. The status bar at the bottom indicates 'Размер: 13,71 km', 'Изменяемый: НЕТ', and 'Выбранный: НЕТ'.

# Interface - Harvesting site

The screenshot displays the MapInfo Professional software interface. The main window shows a map titled "Forest transport logistic" with a network of roads and a river labeled "Svyatukha". A "Logistic" menu is open, listing various options such as "Graph", "Harvesting Sites", "Customers", "Garages", "Loggers", "Energy Wood production", "Railway stations", "Transporting Speeds and Costs", "Optimum Route", "Create Transporting Plan", and "Current state report". An "Outputs" dialog box is also open, showing a table of percentages for different wood products across four tree species: Pine, Spruce, Birch, and Aspen.

	Pine	Spruce	Birch	Aspen
Sawlogs, %	70	60	30	5
Pulpwood, %	20	30	60	10
Residues, %	16	17	22	18

The Windows taskbar at the bottom shows the system tray with the time 17:39 and the language set to EN. The taskbar includes icons for "ПУСК", "MapInfo Professional", "E:\", "C:\Мои документы\...", "Калькулятор", and "Paint Shop Pro".



# Interface - Harvest site characteristics

Harvesting site characteristics ✖

Name of Harvesting Site:  ID of Site: 4    Area, ha:     Stock, cub. m:     Stem volume, cub. m:

Species volumes, cub. m: Pine  Spruce  Birch  Aspen  Other

Name of Logger:  Logger ID: 2    Will be cut after:

Use of logging residues as energy wood:  Yes  No    Forwarding distance, m:     Secondary forwarding distance, m:

Long Vehicle:  Yes  No    Cutting may be started not earlier than: Day:  Month:  Year:

Daily output: Average output of logger, cub. m:   Calculated output, cub. m:   Corrected output, cub. m:

Sortiments

<input type="button" value="Recalculate"/>										
Species	Type	Min. Length, m	Max. Length, m	Min. Diameter, mm	Max. Diameter, mm	Standard	Sorted	Current volume, cub. m	Potential volume, cub. m	Customers
1. <input type="text" value="Birch"/>	<input type="text" value="Sawlogs"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="376"/>	<input type="button" value="..."/>
2. <input type="text" value="Birch"/>	<input type="text" value="Pulpwood"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="751"/>	<input type="button" value="..."/>
3. <input type="text" value="Aspen"/>	<input type="text" value="Sawlogs"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="16"/>	<input type="button" value="..."/>
4. <input type="text" value="Aspen"/>	<input type="text" value="Pulpwood"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="31"/>	<input type="button" value="..."/>
5. <input type="text" value="Any"/>	<input type="text" value="Firewood"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="391"/>	<input type="button" value="..."/>
6. <input type="text" value="Any"/>	<input type="text" value="Logging residue"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="button" value="..."/>
7. <input type="text" value="Any"/>	<input type="text" value="LR bunches"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="Domestic"/>	<input type="checkbox"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="button" value="..."/>

Customers ✖

Select supposed customer's factories

Unselected:		Selected:
Pitkyaranta Papermill	>	Impilakhty Sawmill Vyartsilya Export
	<	

# Interface - Input of customer's characteristics

**Customer's factory characteristics**

Name of customer's factory:  ID of customer: 1 Type of customer: Ordinary

Set the customer's factory active Railway distance to Remote Customer from indicated point, km:

	Species	Type	Min. Length, m	Max. Length, m	Min. Diameter, mm	Max. Diameter, mm	Standard	Sorted	Contract
1.	<input type="text" value="Spruce"/>	<input type="text" value="Sawlogs"/>	<input type="text" value="4"/>	<input type="text" value="4,15"/>	<input type="text" value="120"/>	<input type="text" value="250"/>	<input type="text" value="Domestic"/>	<input checked="" type="checkbox"/>	<input type="button" value="..."/>
2.	<input type="text" value="Spruce"/>	<input type="text" value="Sawlogs"/>	<input type="text" value="5,5"/>	<input type="text" value="5,7"/>	<input type="text" value="120"/>	<input type="text" value="250"/>	<input type="text" value="Domestic"/>	<input checked="" type="checkbox"/>	<input type="button" value="..."/>
3.	<input type="text" value="Spruce"/>	<input type="text" value="Sawlogs"/>	<input type="text" value="6"/>	<input type="text" value="6,2"/>	<input type="text" value="120"/>	<input type="text" value="250"/>	<input type="text" value="Domestic"/>	<input checked="" type="checkbox"/>	<input type="button" value="..."/>
4.	<input type="text" value="Any"/>	<input type="text" value="Firewood"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="checkbox"/>	<input type="button" value="..."/>
5.	<input type="text" value="Any"/>	<input type="text" value="Wood residues"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="checkbox"/>	<input type="button" value="..."/>
6.	<input type="text" value="Any"/>	<input type="text" value="Energy chips"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="checkbox"/>	<input type="button" value="..."/>
7.	<input type="text" value="Any"/>	<input type="text" value=""/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="checkbox"/>	<input type="button" value="..."/>
8.	<input type="text" value="Any"/>	<input type="text" value=""/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="checkbox"/>	<input type="button" value="..."/>

**Contract**

Input contract data

	Volumes, cubic meters by plane		Volumes, cubic meters by fact		
January	<input type="text" value="0"/>	<input type="text" value="0"/>	July	<input type="text" value="0"/>	<input type="text" value="0"/>
February	<input type="text" value="0"/>	<input type="text" value="0"/>	August	<input type="text" value="0"/>	<input type="text" value="0"/>
March	<input type="text" value="0"/>	<input type="text" value="0"/>	September	<input type="text" value="0"/>	<input type="text" value="0"/>
April	<input type="text" value="0"/>	<input type="text" value="0"/>	October	<input type="text" value="0"/>	<input type="text" value="0"/>
May	<input type="text" value="5 000"/>	<input type="text" value="200"/>	November	<input type="text" value="0"/>	<input type="text" value="0"/>
June	<input type="text" value="6 000"/>	<input type="text" value="0"/>	December	<input type="text" value="0"/>	<input type="text" value="0"/>



# Interface - Input of logger's characteristics

**Loggers characteristics**

Number of shifts per day:  Shift duration, h:

Average machine utilization rate:  Average logger transferring time, days:

List of loggers

ID	Name	Harvester	Forwarder	Daily Output, cub.m.	Activity
1	LG1	Harvester	Forwarder	125	Active
2	LG2	Harvester	Forwarder	215	Active
3	LG3	Harvester	Forwarder	233	Active
4	LG4	Harvester	Forwarder	243	Active
5	LG5	Harvester	Forwarder	243	Active
6	LG6	Harvester	Forwarder	243	Active
7	LG7	Harvester	Forwarder	184	Active
8	LG8	Harvester	Forwarder	146	Active
9	LG9	Harvester	Forwarder	247	Active

**Logger characteristics**

Logger ID: 3  Set the logger active

Logger name:

Harvester:

Forwarder:

Average daily output, cub.m.:

**Logging plan**

Select the order of harvesting sites for logger LG3 (ID of logger: 3)

Unselected:		Selected:
Prigorodnoye-116-1	>	Svirskoye-108-2
Prigorodnoye-116-2	>	Svirskoye-103-1
Prigorodnoye-116-3	>	Svirskoye-103-3
Prigorodnoye-117-1	>	Svirskoye-103-2
Prigorodnoye-118-1	>	Svirskoye-108-1
Prigorodnoye-118-2	>	Svirskoye-108-3
Prigorodnoye-168-1	>	Svirskoye-105-1
Prigorodnoye-169-1	>	Svirskoye-106-1
Oktyabrskoye-102-1	>	Tokovskoye-22-2



# Interface - Input of truck's characteristics

**Garage characteristics**

Name of garage: Pitkaranta ID of garage: 1

Set the garage active

Trucks in order of priority

Priority	ID	Type	Model	Trailer	Year	Number	Volume	Loading time	Activity
1	1	Timber Truck	MAZ-63171	Yes	2005	t232gf10	44	20	Active
2	4	Timber Truck	MAZ-6303	Yes	2004	f234kl10	43.8	22	Active
3	3	Timber Truck	MAZ-6303-26	Yes	2004	e897rt10	37.5	17	Active
4	5	Timber Truck	KAMAZ-44110	Yes	2006	s236nk10	31.6	21	Active
5	2	Timber Truck	KAMAZ-53212	Yes	2005	l551gh10	19.4	15	Active
6	7	Chips Truck	LT-170	Yes	2002	a641oo10	70	45	Active
7	6	Chips Truck	LT-7A	Yes	2003	m45tr10	37	40	Active

Move up

Add Properties Delete Cancel

**Add the truck**

Input truck characteristics

Name of garage Pitkaranta  Set the truck active

Garage ID: 1 Truck ID: 1  Trailer Type of truck: Timber Truck

Model: MAZ-63171 Number: t232gf10

Year: 2005 Volume cub.m.: 44 Average time for loading/unloading, min: 20

Cancel Ok

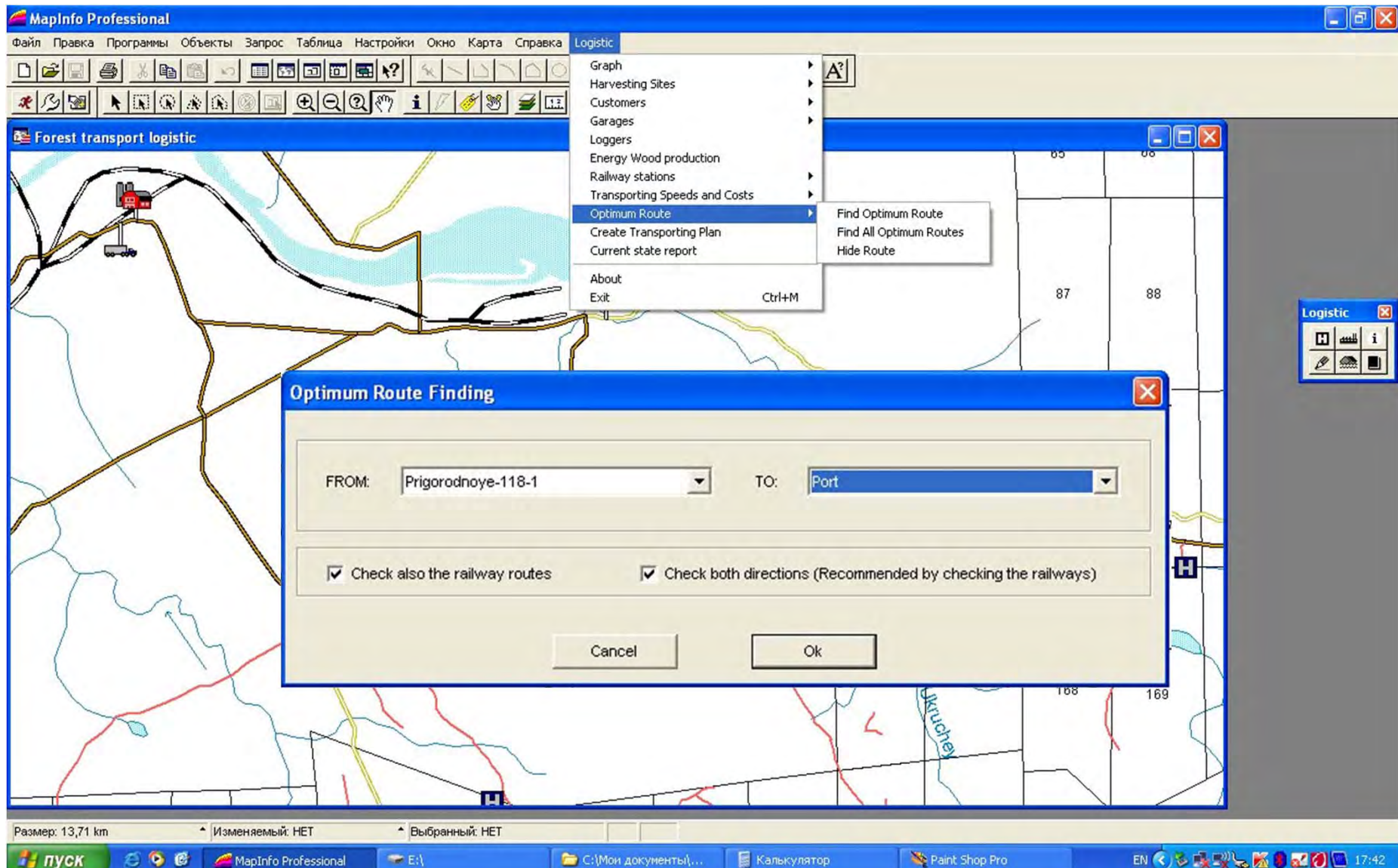
# Interface - Energy wood machinery characteristics

The image shows two overlapping software windows. The background window is titled "Energy wood production" and features a text input field for "Required wood fuel moisture in warm season no more than, %" with the value "47". Below this is a table of energy wood units with columns for Priority, ID, Method, Name, Main machine, Shifts per day, Shift duration, Utilization rate, and Activity. The table contains three rows of data. At the bottom of this window are "Add", "Properties", and "Delete" buttons.

The foreground window is titled "EW unit characteristics" and is for editing unit "EW4". It includes a "Method" dropdown set to "Chipping" and a checked "Set the unit active" option. The "Chipping" section contains a "Chipper" sub-section with "Model" set to "Kesla" and "Productivity, loose cub.m/h" set to "85". The "Chip truck" section has "Model" set to "SISU", "Volume, loose cub.m" set to "90", and "Average time for unloading, min" set to "15". The "Bundling" section has an empty "Bundling machine" field and "Productivity, loose cub.m/h" set to "0". At the bottom, "Number of shifts per day" is "1", "Shift duration, h" is "8", and "Average effective machine utilization rate" is "0,85". The "Current location" dropdown is set to "HS3". "Cancel" and "Ok" buttons are at the bottom.

Priority	ID	Method	Name	Main machine	Shifts per day	Shift duration, h	Utilization rate	Activity
1	4	Chipping	EW4	Kesla	1	8	0.85	Active
2	1	Bundling	EW1	John Deere	1	8	0.85	Active
3	3	Chipping	EW3	LHM	1	10	0.7	Inactive

# Interface - Search of optimal paths





# Interface - Search of optimal paths (results)

MapInfo Professional

Файл Правка Программы Объекты Запрос Таблица Настройки Окно Карта Справка Logistic

Forest transport logistic

HS3

Leppyasita

Impilakity Sawmill

Logistic

Сообщения

Route characteristics

Initial point: HS3  
Final point: Leppyasita  
Checking of railways: YES  
Checking the both directions: YES  
Distance: 40.0073 km  
Time: 0 h 56 min  
Transporting cost: 75

Размер: 41,81 km    Изменяемый: НЕТ    Выбранный: НЕТ

ПУСК    Погистика    Погистика    Статья.doc - Micro...    MapInfo Professional    Paint Shop Pro - [Ма...    EN    21:51

# Search of the optimal routes and schedules

**Transport Plan creating**

Date of start: Day: 21, Month: July, Year: 2007  
 Date of end: Day: 23, Month: July, Year: 2007

Number of shifts per day: 2  
 Check also the railway routes  
 Check both directions (Recommended by checking the railways)

The first shift: From 8:00 Till 18:00  
 Dinner Break From 13:00 Till 14:00

The second shift: From 20:00 Till 6:00  
 Dinner Break From 0:00 Till 1:00

The third shift: From 8:00 Till 18:00  
 Dinner Break From 13:00 Till 14:00

The fourth shift: From 30:00 Till 5:00  
 Dinner Break From 0:00 Till 1:00

Cancel Ok

Microsoft Excel - MOD3 Jan-Mar

File Edit View Insert Format Tools Data Window Help

95%

Arial Cyr 10

A4 TOTAL

**Transporting Plan Performance Indexes**

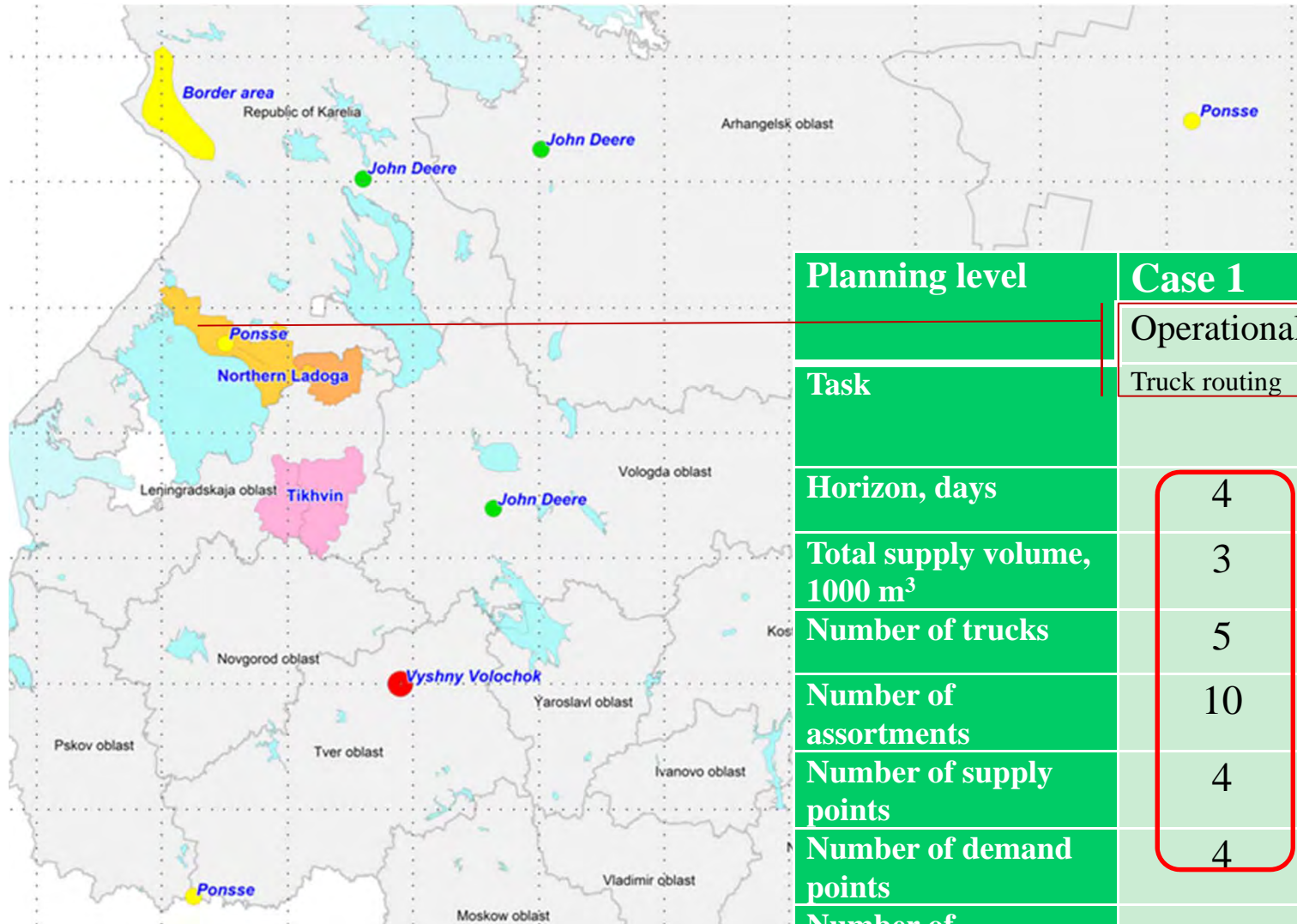
		Total number of shifts: 180		Total number of trucks: 9													
Date	Garage	Total working time, h	Delay of employed trucks, h	Total delay, h	Total run, km	Number of run	Total volume, cub.m	Total cargo, km	Required number of trucks	Fleet utilization rate	Index of loaded distance	Operation work, cub.m/km	Store, cub.m	Harvested volume, cub.m	Ratio removal to harvest	Comments	Contractor's transporting costs
3/21/2010	Podporozhye Garage	156.1	23.9	23.9	3197.2	39	1154	1198.9	9	0.867	0.375	0.361				Podporozhskoye-116-1 is done. Podporozhskoye-116-2 will be started.	184077.2
	<b>Total</b>	<b>156.1</b>	<b>23.9</b>	<b>23.9</b>	<b>3197.2</b>	<b>39</b>	<b>1154</b>	<b>1198.9</b>	<b>9</b>	<b>0.867</b>	<b>0.375</b>	<b>0.361</b>	<b>3493</b>	<b>1346</b>	<b>0.857</b>		<b>184077.2</b>
3/22/2010	Podporozhye Garage	158.9	21.1	21.1	3106.1	42	1232	1179.8	9	0.883	0.38	0.397				Vazhinskoye-49-2 is done. Vazhinskoye-49-1 will be started.	186689.4
	<b>Total</b>	<b>158.9</b>	<b>21.1</b>	<b>21.1</b>	<b>3106.1</b>	<b>42</b>	<b>1232</b>	<b>1179.8</b>	<b>9</b>	<b>0.883</b>	<b>0.38</b>	<b>0.397</b>	<b>3607</b>	<b>1143</b>	<b>1.078</b>		<b>186899.4</b>
3/23/2010	Podporozhye Garage	161	19	19	3402.8	41	1206	1436.6	9	0.896	0.422	0.354					193426.6
	<b>Total</b>	<b>161</b>	<b>19</b>	<b>19</b>	<b>3402.8</b>	<b>41</b>	<b>1206</b>	<b>1436.6</b>	<b>9</b>	<b>0.895</b>	<b>0.422</b>	<b>0.354</b>	<b>3544</b>	<b>1251</b>	<b>0.964</b>		<b>199426.6</b>
3/24/2010	Podporozhye Garage	155.6	24.4	24.4	3183.6	42	1232	1292.7	9	0.864	0.406	0.387				Vazhinskoye-46-1 is done. Vazhinskoye-46-2 will be started.	192730.9
	<b>Total</b>	<b>155.6</b>	<b>24.4</b>	<b>24.4</b>	<b>3183.6</b>	<b>42</b>	<b>1232</b>	<b>1292.7</b>	<b>9</b>	<b>0.864</b>	<b>0.406</b>	<b>0.387</b>	<b>3563</b>	<b>1346</b>	<b>0.915</b>		<b>192730.9</b>
3/25/2010	Podporozhye Garage	153.1	26.9	26.9	3079.5	42	1225	1341.6	9	0.851	0.436	0.398				Tokarskoye-27-3 is done. Tokarskoye-27-2 will be started.	194595.3
	<b>Total</b>	<b>153.1</b>	<b>26.9</b>	<b>26.9</b>	<b>3079.5</b>	<b>42</b>	<b>1225</b>	<b>1341.6</b>	<b>9</b>	<b>0.851</b>	<b>0.436</b>	<b>0.398</b>	<b>3684</b>	<b>1132</b>	<b>1.082</b>		<b>194595.3</b>
3/26/2010	Podporozhye Garage	147.8	32.2	32.2	2923.7	41	1199	1219.8	9	0.821	0.417	0.41					186956.8
	<b>Total</b>	<b>147.8</b>	<b>32.2</b>	<b>32.2</b>	<b>2923.7</b>	<b>41</b>	<b>1199</b>	<b>1219.8</b>	<b>9</b>	<b>0.821</b>	<b>0.417</b>	<b>0.41</b>	<b>3617</b>	<b>1279</b>	<b>0.937</b>		<b>186956.8</b>
3/27/2010	Podporozhye Garage	149.2	30.8	30.8	2923.9	42	1218	1295.4	9	0.829	0.443	0.417					192289.8
	<b>Total</b>	<b>149.2</b>	<b>30.8</b>	<b>30.8</b>	<b>2923.9</b>	<b>42</b>	<b>1218</b>	<b>1295.4</b>	<b>9</b>	<b>0.829</b>	<b>0.443</b>	<b>0.417</b>	<b>3678</b>	<b>1425</b>	<b>0.855</b>		<b>192289.8</b>
3/28/2010	Podporozhye Garage	149.1	30.9	30.9	2951.3	42	1232	1308.9	9	0.828	0.443	0.417					193554.6
	<b>Total</b>	<b>149.1</b>	<b>30.9</b>	<b>30.9</b>	<b>2951.3</b>	<b>42</b>	<b>1232</b>	<b>1308.9</b>	<b>9</b>	<b>0.828</b>	<b>0.443</b>	<b>0.417</b>	<b>3871</b>	<b>1121</b>	<b>1.099</b>		<b>193554.6</b>
3/29/2010	Podporozhye Garage	147.2	32.8	32.8	2957.2	40	1166	1182.5	9	0.818	0.4	0.394					177307
	<b>Total</b>	<b>147.2</b>	<b>32.8</b>	<b>32.8</b>	<b>2957.2</b>	<b>40</b>	<b>1166</b>	<b>1182.5</b>	<b>9</b>	<b>0.818</b>	<b>0.4</b>	<b>0.394</b>	<b>3826</b>	<b>1004</b>	<b>1.161</b>		<b>177307</b>
3/30/2010	Podporozhye Garage	136.8	43.2	43.2	2830.2	36	1041	1152.6	9	0.76	0.407	0.368					163199.7
	<b>Total</b>	<b>136.8</b>	<b>43.2</b>	<b>43.2</b>	<b>2830.2</b>	<b>36</b>	<b>1041</b>	<b>1152.6</b>	<b>9</b>	<b>0.76</b>	<b>0.407</b>	<b>0.368</b>	<b>3789</b>	<b>832</b>	<b>1.251</b>		<b>163199.7</b>
3/31/2010	Podporozhye Garage	134.9	45.1	45.1	2868	35	1008	1260.3	9	0.75	0.439	0.351					166159.4
	<b>Total</b>	<b>134.9</b>	<b>45.1</b>	<b>45.1</b>	<b>2868</b>	<b>35</b>	<b>1008</b>	<b>1260.3</b>	<b>9</b>	<b>0.75</b>	<b>0.439</b>	<b>0.351</b>	<b>3613</b>	<b>771</b>	<b>1.307</b>		<b>166159.4</b>
TOTAL	Podporozhye Garage	13734.9	2285.1	2465.1	245101.4	4294	125448	91314.1	9	0.848	0.373	0.512				Residues transfer med to firewood: 13953.0 cub.m	15992483
	<b>Total</b>	<b>13734.9</b>	<b>2285.1</b>	<b>2465.1</b>	<b>245101.4</b>	<b>4294</b>	<b>125448</b>	<b>91314.1</b>	<b>9</b>	<b>0.848</b>	<b>0.373</b>	<b>0.512</b>	<b>3613</b>	<b>129832</b>	<b>0.966</b>		<b>15992483</b>

## Performance indexes:

- Total working time and travel distance
- Total number of travels
- Total transported volume
- Total loaded distance
- Fleet utilization rate
- Index of loaded distance
- Transported volume per 1 km
- Transporting costs



# DSS test cases



Planning level	Case 1	Case 2	Case 3
	Operational	Tactical	Strategic
Task	Truck routing	Choice of utilization level	Choice of transport; investments
Horizon, days	4	90	365
Total supply volume, 1000 m <sup>3</sup>	3	80	272
Number of trucks	5	13	24
Number of assortments	10	9	8
Number of supply points	4	63	129
Number of demand points	4	5	5
Number of intermediate terminals	-	-	6

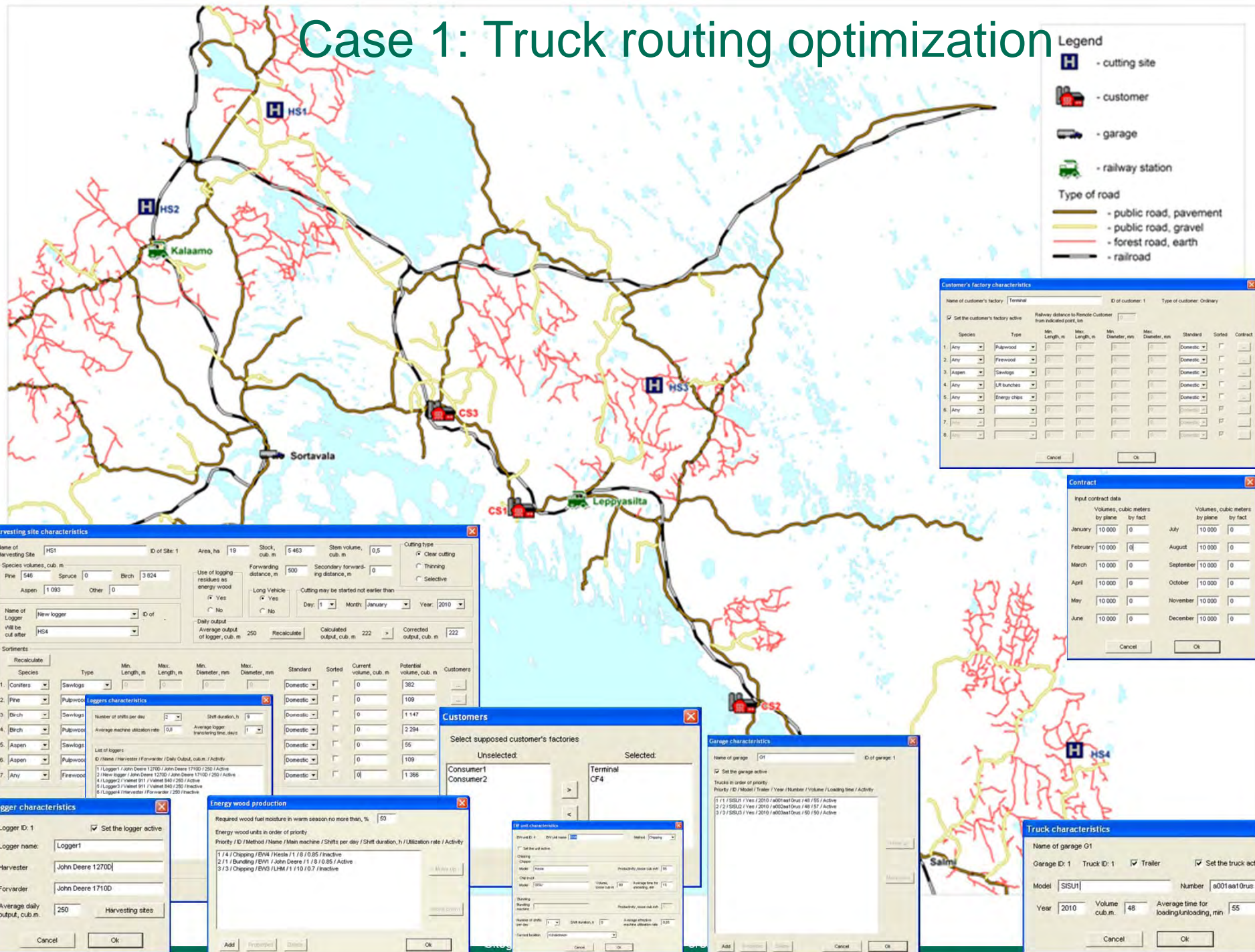
# Case 1: Truck routing optimization

**Legend**

- cutting site
- customer
- garage
- railway station

**Type of road**

- public road, pavement
- public road, gravel
- forest road, earth
- railroad



**Customer's factory characteristics**

Name of customer's factory: Terminal ID of customer: 1 Type of customer: Ordinary

Set the customer's factory active

Railway distance to the customer from indicated point, km: 0

Species	Type	Min. Length, m	Max. Length, m	Min. Diameter, mm	Max. Diameter, mm	Standard	Sorted	Contract
1. Any	Pulpwood					Domestic	<input type="checkbox"/>	<input type="checkbox"/>
2. Any	Firewood					Domestic	<input type="checkbox"/>	<input type="checkbox"/>
3. Aspen	Sawlogs					Domestic	<input type="checkbox"/>	<input type="checkbox"/>
4. Any	LP banches					Domestic	<input type="checkbox"/>	<input type="checkbox"/>
5. Any	Energy chips					Domestic	<input type="checkbox"/>	<input type="checkbox"/>
6. Any						Domestic	<input type="checkbox"/>	<input type="checkbox"/>
7. Any						Domestic	<input type="checkbox"/>	<input type="checkbox"/>
8. Any						Domestic	<input type="checkbox"/>	<input type="checkbox"/>

**Contract**

Input contract data

	Volumes, cubic meters by plane		Volumes, cubic meters by fact	
January	10 000	0	July	10 000
February	10 000	0	August	10 000
March	10 000	0	September	10 000
April	10 000	0	October	10 000
May	10 000	0	November	10 000
June	10 000	0	December	10 000

**Harvesting site characteristics**

Name of Harvesting Site: HS1 ID of Site: 1 Area, ha: 19 Stock, cub. m: 5 463 Stem volume, cub. m: 0.5 Cutting type:  Clear cutting

Species volumes, cub. m: Pine 548 Spruce 0 Birch 3 624 Aspen 1 093 Other 0

Use of logging residues as energy wood:  Yes  No

Forwarding distance, m: 500 Secondary forwarding distance, m: 0

Long Vehicle:  Yes  No

Cutting may be started not earlier than: Day: 1 Month: January Year: 2010

Daily output: Average output of logger, cub. m: 250 Recalculate: Calculated output, cub. m: 222 Corrected output, cub. m: 222

Species	Type	Min. Length, m	Max. Length, m	Min. Diameter, mm	Max. Diameter, mm	Standard	Sorted	Current volume, cub. m	Potential volume, cub. m	Customers
1. Conifers	Sawlogs					Domestic	<input type="checkbox"/>	0	382	
2. Pine	Pulpwood					Domestic	<input type="checkbox"/>	0	109	
3. Birch	Sawlogs					Domestic	<input type="checkbox"/>	0	1 147	
4. Birch	Pulpwood					Domestic	<input type="checkbox"/>	0	2 294	
5. Aspen	Sawlogs					Domestic	<input type="checkbox"/>	0	55	
6. Aspen	Pulpwood					Domestic	<input type="checkbox"/>	0	109	
7. Any	Firewood					Domestic	<input type="checkbox"/>	0	1 366	

**Loggers characteristics**

Number of units per day: 2 Shift duration, h: 9

Average machine utilization rate: 0.8 Average logger transferring time, days: 1

List of loggers:

- 1 / Logger1 / John Deere 1270D / John Deere 1710D / 250 / Active
- 2 / New logger / John Deere 1270D / John Deere 1710D / 250 / Active
- 3 / Logger2 / Valmet 911 / Valmet 840 / 250 / Active
- 4 / Logger3 / Valmet 911 / Valmet 840 / 250 / Inactive
- 5 / Logger4 / Invenstor / Forwarder / 250 / Inactive

**Customers**

Select supposed customer's factories

Unselected: Consumer1 Consumer2

Selected: Terminal CF4

**Logger characteristics**

Logger ID: 1  Set the logger active

Logger name: Logger1

Harvester: John Deere 1270D

Forwarder: John Deere 1710D

Average daily output, cub. m: 250 Harvesting sites

**Energy wood production**

Required wood fuel moisture in warm season no more than, %: 50

Energy wood units in order of priority:

- 1 / 4 / Chipping / BV4 / Kesla / 1 / 8 / 0.85 / Inactive
- 2 / 1 / Bundling / BV1 / John Deere / 1 / 8 / 0.85 / Active
- 3 / 3 / Chipping / BV3 / LHM / 1 / 10 / 0.7 / Inactive

**Truck characteristics**

Truck ID: 1  Set the truck active

Model: SISU1 Number: #001ast0rus

Year: 2010 Volume cub. m: 48 Average time for loading/unloading, min: 55

**Garage characteristics**

Name of garage: G1 ID of garage: 1

Set the garage active

Trucks in order of priority:

- 1 / 1 / SISU1 / Yes / 2010 / #001ast0rus / 48 / 55 / Active
- 2 / 2 / SISU2 / Yes / 2010 / #002ast0rus / 48 / 57 / Active
- 3 / 3 / SISU3 / Yes / 2010 / #003ast0rus / 40 / 50 / Active

**Truck characteristics**

Name of garage G1

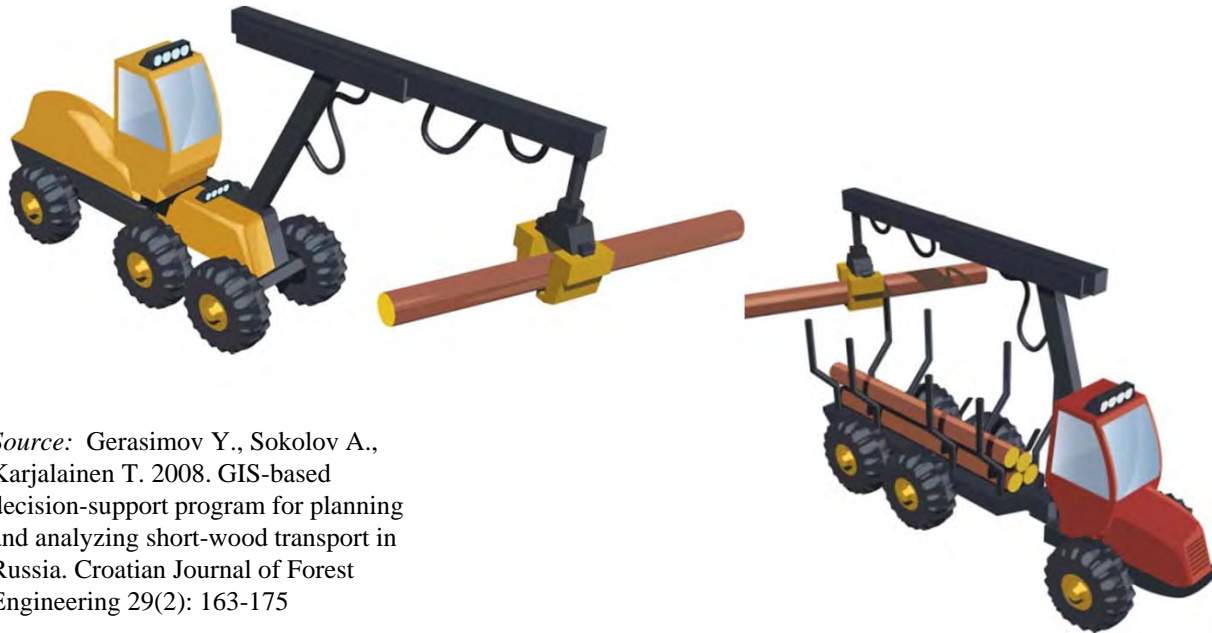
Garage ID: 1 Truck ID: 1  Trailer  Set the truck active

Model: SISU1 Number: #001ast0rus

Year: 2010 Volume cub. m: 48 Average time for loading/unloading, min: 55



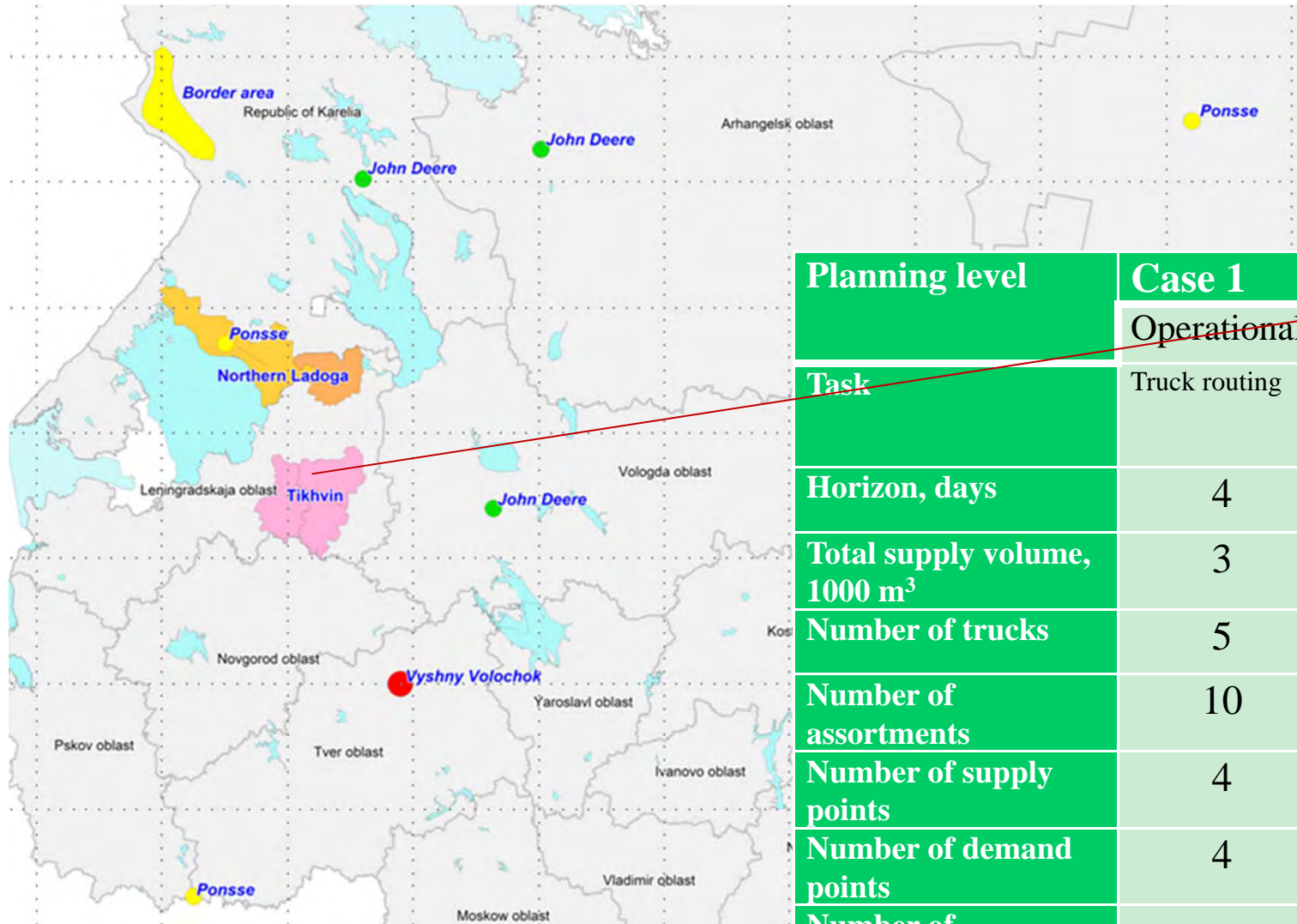
# Case 1: Truck routing optimization (results)



Source: Gerasimov Y., Sokolov A., Karjalainen T. 2008. GIS-based decision-support program for planning and analyzing short-wood transport in Russia. Croatian Journal of Forest Engineering 29(2): 163-175

Scenario	Required number of trucks	Total working time [h]	Total distance [km]	Number of trips	Total volume [m <sup>3</sup> ]	Total loaded distance [km]	Fleet utilization rate	Index of loaded distance	Operation work [m <sup>3</sup> /km]	Transportation cost [€/m <sup>3</sup> ]
Basic	5	307	7382	53	2740	2,212	0.754	0.300	0.371	5.6
Optimal 1	5	255	7382	58	2996	2,697	0.728	0.365	0.406	5.1
Optimal 2	4 (-20%)	239 (-22%)	5743 (-22%)	58 (+9%)	3000 (+10%)	2,872 (+30%)	0.895 (+19%)	0.499 (+66%)	0.526 (+42%)	4.0 (-29%)

# DSS test cases



Planning level	Case 1	Case 2	Case 3
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## Case 2: Choice of utilization level (results)

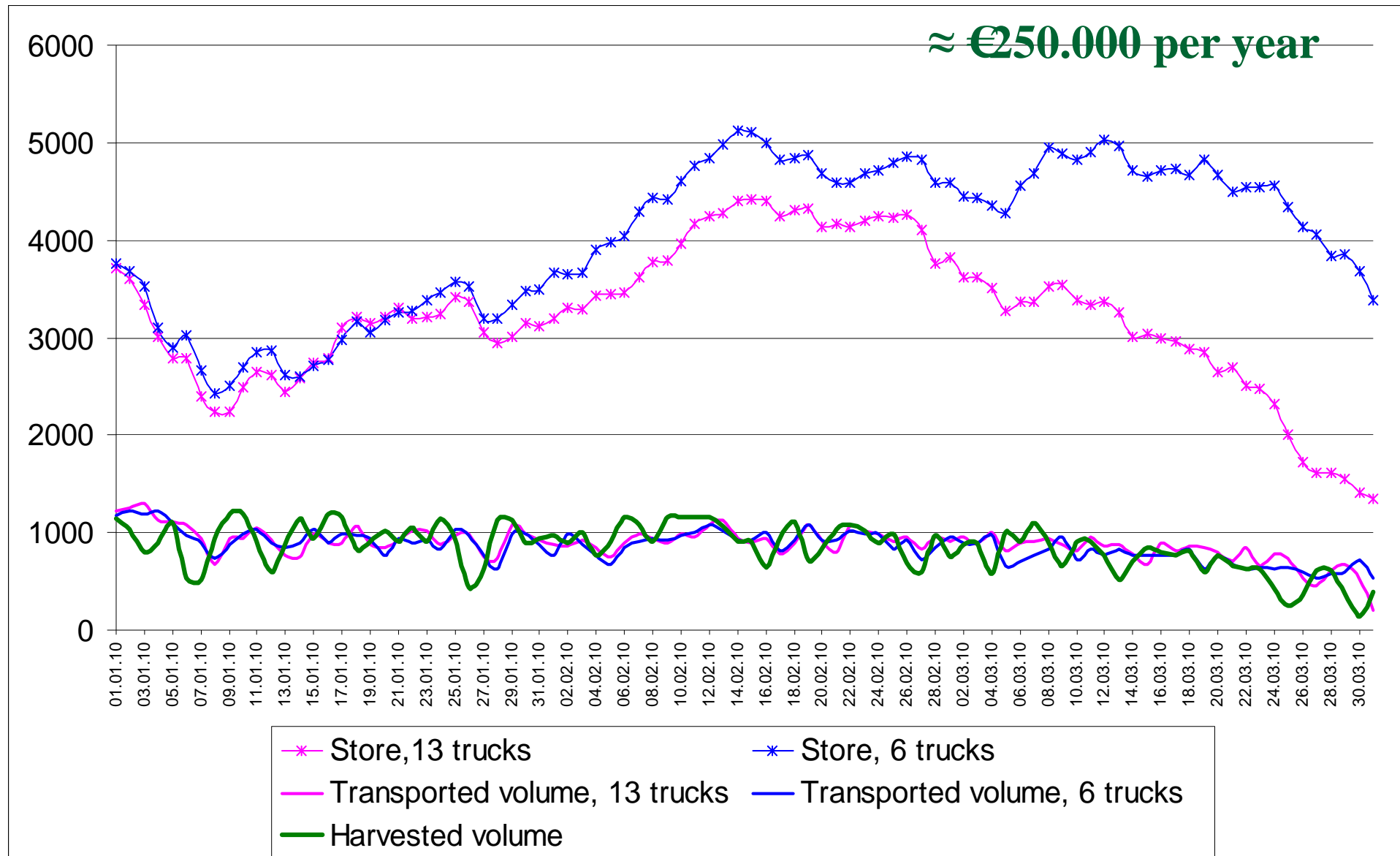


Source: Gerasimov Y., Sokolov A., Syuney V. 2011. Optimization of industrial and fuel wood supply chain associated with cut-to-length harvesting. *Systems. Methods. Technologies* 3(11): 118-124

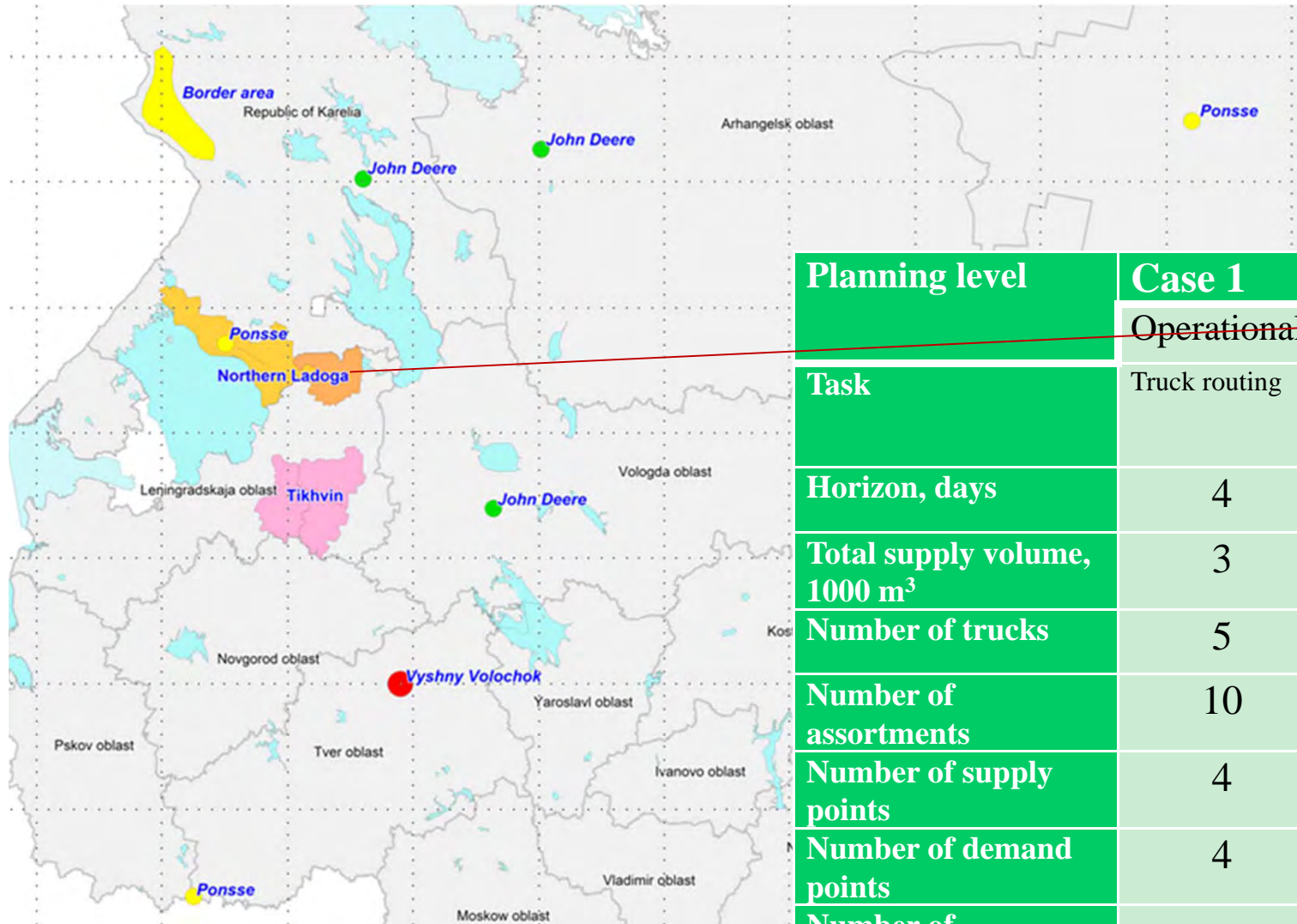
Scenario	Required number of trucks	Total working time	Total distance	Total volume	Total loaded distance	Fleet utilization rate	Index of loaded distance	Operation work	Transportation cost
		<i>h</i>	<i>km</i>	<i>m<sup>3</sup></i>	<i>km</i>			<i>m<sup>3</sup>/km</i>	<i>€/m<sup>3</sup></i>
<b>Basic</b>	13	13474	622453	80025	308211	0.858	0.495	0.129	7.3
<b>Optimal</b>	6	10349	449648	80325	223389	0.864	0.497	0.179	6.3
<b>%</b>	-54%	-23%	-28%	+0.4%	-28%	+1.5%	+0.4%	+39%	-14%



## Case 2: Choice of utilization level

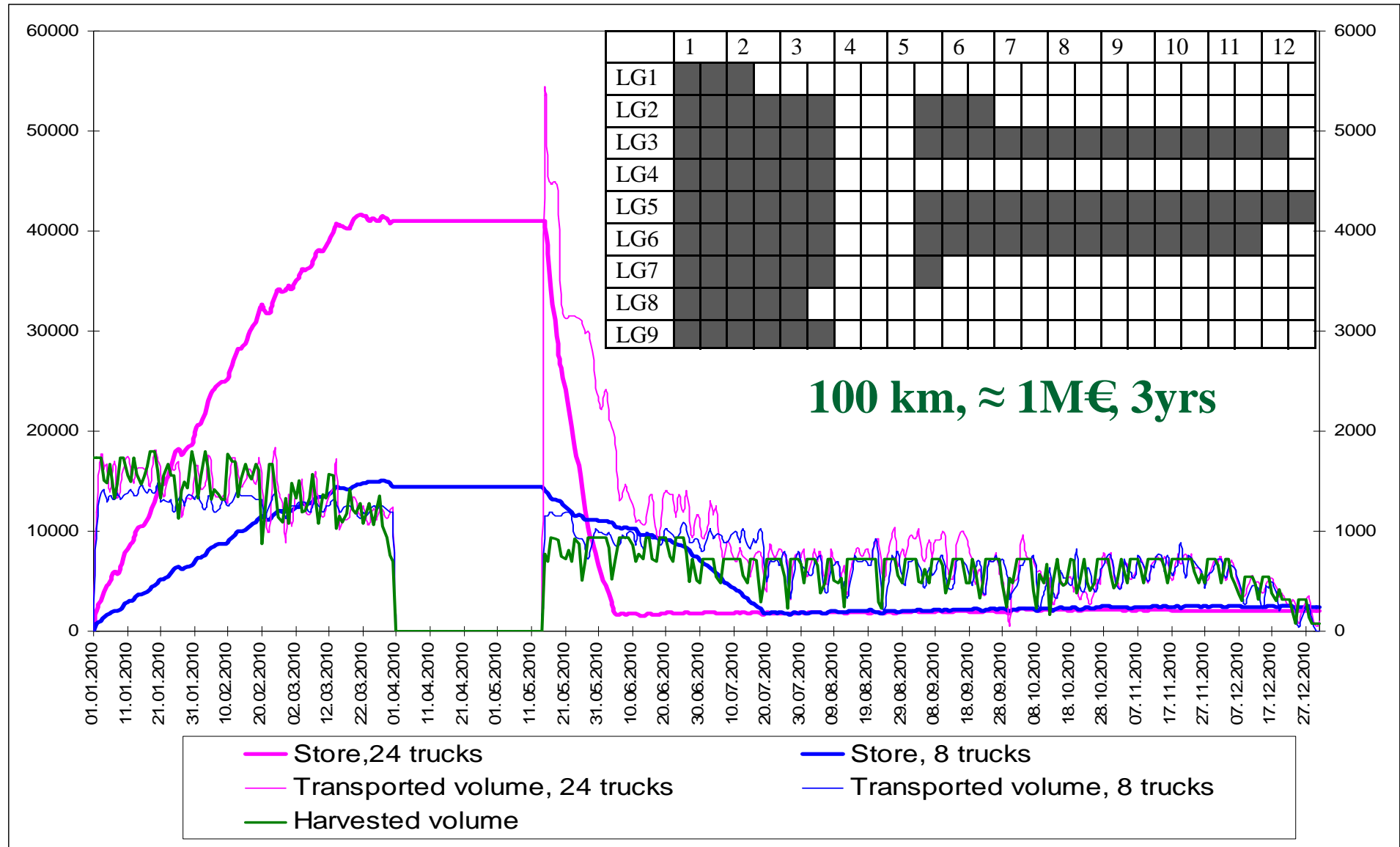


# The DSS test cases



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# Case 3: Transport method and road investments



# Case study 3: Transport method and road investments



Scenario	Required number of trucks	Total working time	Total distance	Total volume	Total loaded distance	Fleet utilization rate	Index of loaded distance	Operation work	Transporting cost
		h	km	$m^3$	km			$m^3/km$	$€/m^3$
Basic	24	37231	709898	314031	296217	0.477	0.417	0.442	6.0
Optimal	8	30222	584310	270072	252143	0.636	0.432	0.462	4.5
%	-67%	-19%	-18%	-14%	-15%	+33%	+3%	+5%	-25%

# Conclusion

The DSS can be used to support a wide range of planning decisions at on the company level including truck routing, choice of equipment utilization level, choice of transport method and infrastructure investments.

The potential cost savings calculated range from 14-29%.

Improvement of our knowledge on:

- Challenges CTL in Russia
- Current level of productivity/costs of CTL machines in local conditions

Know how about adaptation of FM CTL systems to specific conditions in Russia, in particular undeveloped infrastructure and service



# Thank you very much for your attention!

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