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EUROPSKI STRUKTURNI
I INVESTICIJSKI FONDovi



Operativni program
KONKURENTNOST
I KOHEZIJA



Measurement method of energy consumption of skidder



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RESEARCH AIM

The main goal of the research is to develop methods for measuring the energy consumption of skidders

ie. determination of the energy consumption of the skidder at different operating tasks and under different field conditions.

It is necessary to perform field measurements on existing vehicles, then conduct an adequate analysis of the collected data which, after processing, are used as a basis for the development of hybrid drives.





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SKIDDER TYPE AND MEASURING DEVICES

Skidder Ecotrac 140V skidder was equipped by new measurement device – WIGO-E (Telematic Data collector) gateway fuel flow meter.

Devices provided precise data collecting of technical characteristics during timber skidding at different operating tasks and under different field conditions.

RESEARCH AREA

Bjelovar-bilogora County – timber skidding from final fellings on hilly terrains

Lika –Senj County – timber skidding selective fellings on mountainous terrains





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MEASUREMENTS

Mobilisis – measuring equipment (installation)

WIGO-E (Telematic Data collector) gateway

- collecting and storing data from sensors and motor computer via CANBUS
- integrated GPS system
- data transfer of WLAN, LAN and GSM communication to Web platforms (Cloud).



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MEASUREMENTS

Differential fuel flow meters– DFM 100 D

Model	Minimum flow rate in each measuring camera, L/h	Maximum flow rate in each measuring camera, L/h	Measurement inaccuracy, ± %
DFM 100D	10	100	3

Nominal / Max fuel pressure, MPa	0,2 / 2,5
Min / Max kinematic viscosity, mm ² /s	1,5 / 6.0
Infiltrations size in the liquid, mm	0,08
Min / Max supply voltage, V	10 / 45
Max current consumption, mA, dor Unom = 12/24 V	50 / 25
Operating temperature, °C	-40 ... +85 / -20 ... +60
Ingress protection rating (IP Code)	54

Measurement precision = 0,001 L



MEASUREMENTS

Remote measurements

- Fuel consumption (mL)
- position (travelling route) of skidder (lat, lon)
- Detection of winch work (0, 1)
- Engine rpm (min^{-1})
- Engine torque (% od max)
- Throttle position (%)
- Engine temperature
- sampling frequency – 3-5 s

Terrain measurements

- skidder load volumes per cycles
- slopes of skid trails (GNSS)





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DATA COLLECTION

- Web platform
- Mobilisis interface
- Vehicle operation reports (graphic and tabular display, .xlsx, .pdf)

The screenshot displays the Mobilisis web platform interface. The main map shows a purple route with several 'stop' markers. The left sidebar contains a list of vehicles, including 'Skider EcoTrack' (734574) and 'Bjelovar' (EcoTrack 140). The right sidebar shows vehicle status information, such as 'Rad motora vrtlo desno Vito', 'Napon: 27.8 V', and 'Brojač km: 4 km'. The top navigation bar includes various icons for different functions like 'Praćenje', 'Izveštaji', and 'Statistika'.

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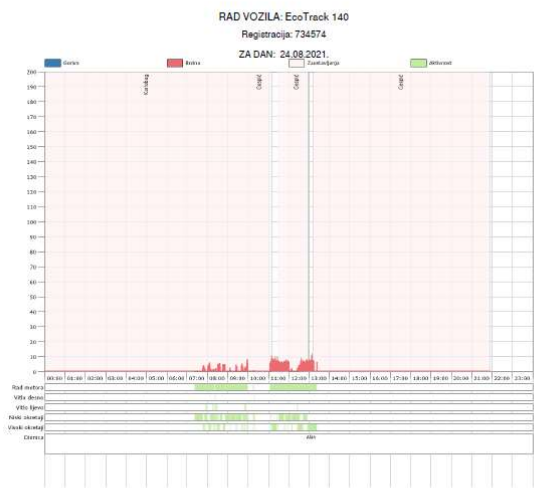
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DATA COLLECTION

- Web platform
- Mobilisis interface
- Vehicle operation reports (graphic and tabular display, .xlsx, .pdf)

MOBILISIS®



Rad

	Početnik	Kraj	Radni sati	Apsolutna vrijednost	Udaljenost
Vožnja	08:57	13:13	05:37	03:16	8 km
Radni interval	07:22	13:23	06:00	08:01	8 km
Vrsto dnevno	08:22	10:17	02:00	01:55	0 km
Vrsto dnevno	07:52	12:26	05:09	04:32	0 km
Niški okretaji	07:22	12:54	05:29	06:32	0 km
Viški okretaji	07:47	13:23	01:38	05:36	4 km

24.8.2021. 21:53:32

1.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
	D	Lat (m)	Visina (m)	Brzina (km/h)	Kurs (deg)	Brz. sat.	Ekv.	DOP	Kalibracija - prijenosni (m)	Baterija	IO Status	Kontakt								
1	24.08.2021.13:23:25	44.67007.15.091	1221	7	95	32	2	1	64	27.88	0000010001	-								
2	24.08.2021.13:22:43	44.67629.15.090	1218	7	117	32	2	1	6	27.88	0000010001	-								
3	24.08.2021.13:13:22	44.67082.15.089	1211	7	20	33	1	1	647	27.88	0000010001	-								
4	24.08.2021.13:13:12	44.67055.15.089	1211	8	35	33	1	1	657	27.88	0000010001	-								
5	24.08.2021.13:13:00	44.67047.15.089	1214	7	47	33	1	1	669	27.88	0000010001	-								
6	24.08.2021.13:12:56	44.67042.15.089	1217	7	35	33	1	1	675	27.88	0000010001	-								
7	24.08.2021.13:12:46	44.67024.15.088	1220	6	21	33	1	1	683	27.88	0000010001	-								
8	24.08.2021.13:12:42	44.67017.15.088	1219	8	8	33	1	1	687	27.88	0000010001	-								
9	24.08.2021.13:12:34	44.67000.15.088	1219	7	21	33	1	1	695	27.88	0000010001	-								
10	24.08.2021.13:12:09	44.66992.15.088	1221	8	6	33	1	1	720	27.88	0000010001	-								
11	24.08.2021.13:12:00	44.66994.15.088	1222	7	355	33	1	1	729	27.88	0000010001	-								
12	24.08.2021.13:11:42	44.66902.15.088	1223	7	341	33	1	1	747	27.88	0000010001	-								
13	24.08.2021.13:11:28	44.66876.15.089	1226	7	354	33	1	1	760	27.88	0000010001	-								
14	24.08.2021.13:11:17	44.66855.15.089	1228	7	7	33	1	1	771	27.88	0000010001	-								
15	24.08.2021.13:11:01	44.66825.15.088	1231	8	22	33	1	1	787	27.88	0000010001	-								
16	24.08.2021.13:10:51	44.66806.15.088	1233	8	8	33	1	1	797	27.88	0000010001	-								
17	24.08.2021.13:10:35	44.66774.15.088	1232	7	354	33	1	1	813	27.88	0000010001	-								
18	24.08.2021.13:10:30	44.66766.15.088	1233	7	342	33	1	1	818	27.88	0000010001	-								
19	24.08.2021.13:10:11	44.66733.15.089	1234	8	329	33	1	1	837	27.88	0000010001	-								
20	24.08.2021.13:10:02	44.66717.15.089	1237	8	345	33	1	1	846	27.88	0000010001	-								

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DATA PROCESSING

- merging all data into a database

Mjerač protoka goriva Bjelovar (EcoTrack 140) 10.02.2022														FMS podaci Bjelovar (EcoTrack 140) 10.02.2022 00:00 - 23:59														
MOBILISIS®														MOBILISIS®														
Mobilisis d.o.o. Varaždinska ul. 8, 42000, Jalkovec 042 311 777 www.mobilisis.hr														Mobilisis d.o.o. Varaždinska ul. 8, 42000, Jalkovec 042 311 777 www.mobilisis.hr														
Datum	Temperatura goriva	Mod mjer.	Trenutna potrošnja goriva (l/h)	Ukupno izmjerena potrošnja goriva (l)	Potrošnja goriva u radu na mjestu (l/h)	Potrošnja goriva u vožnji (l/h)	Potrošnja goriva u maksimalnom protoku (l/h)	Potrošnja goriva u radu s maksimalnim protokom (l/h)	Vrijeme rada motora prema zabilježenoj potrošnji goriva (h:mn)	Vrijeme rada motora u optimalnom protoku (h:mn)	Vrijeme rada motora prema maksimalnom protoku (h:mn)	Vrijeme rada motora s optimalnim protokom (h:mn)	Vrijeme rada motora u najgorim uvjetima (h:mn)	Vrijeme	Stanje brojčanika (l)	Brzina (km/h)	Ukupna potrošnja goriva	Količina goriva u spremniku	Razina goriva	Radnih sati	Broj okretaja motora (Rf)	Okretni moment (% od maksimalnog)	Pozicija papučiće gasa	Temperatura motora	Stajanje s upaljenim motorom (h:mn)	Broj pritiska kočnice	Broj pritiska kočnice	
10.02.2022 6:56	47	0	0,02	510,758	67,978	430,585	12,195	4,015	56:04	32:16	23:35	00:00	00:02	00:08	10.02.2022 14:44:58			7.651,0			785,30	748	14			00:00		
10.02.2022 6:56	-2	1	0,03	510,838	68,028	430,615	12,195	4,015	56:05	32:17	23:35	00:00	00:02	00:08	10.02.2022 14:44:48			7.651,0			785,30	1.800	15	58		00:00		
10.02.2022 6:56	-2	0	0,04	510,858	68,043	430,62	12,195	4,015	56:06	32:18	23:35	00:00	00:02	00:08	10.02.2022 14:44:43			7.651,0			785,30	1.285	71	48		00:00		
10.02.2022 6:56	-1	1	0,16	510,908	68,078	430,635	12,195	4,015	56:06	32:18	23:35	00:00	00:02	00:08	10.02.2022 14:44:39			7.651,0			785,30	1.127	0	4		00:00		

broj	visina	x	y	razmak po x osi	razmak po y osi	horizontalan razmak	stacionaža, m	Stvaran razmak n	visine	nagib u	nagib kretanja u stupnjem	prazan	ovara, r	vremena
15	154,336		526881,818	5040010,643	225,18	276,46	22,40	0,00	22,52	154,34	-10,51%	-6,00	pun	4,96 8:03:33
14	151,982		526896,824	5040027,270	37,03	115,69	12,36	22,40	12,49	151,98	-14,68%	-8,35	pun	4,96 8:03:44
13	150,168		526902,909	5040038,026	176,31	559,28	27,12	34,76	27,22	150,17	-8,41%	-4,81	pun	4,96 8:03:51
12	147,888		526916,187	5040061,675	361,91	1329,33	41,12	61,88	41,42	147,89	-11,96%	-6,82	pun	4,96 8:04:04
11	142,970		526935,211	5040098,135	66,39	489,34	23,57	103,00	23,84	142,97	-14,97%	-8,52	pun	4,96 8:04:33
10	139,440		526943,359	5040120,256	11,53	669,83	26,10	126,58	26,40	139,44	-15,14%	-8,61	pun	4,96 8:04:45
9	135,487		526946,755	5040146,137	48,16	1560,25	40,11	152,68	40,16	135,49	-5,14%	-2,94	pun	4,96 8:05:00
8	133,427		526953,695	5040185,637	223,53	867,07	33,02	192,78	33,05	133,43	-4,09%	-2,34	pun	4,96 8:05:26
7	132,076		526968,646	5040215,083	35,25	534,63	23,87	225,81	23,88	132,08	-2,30%	-1,32	pun	4,96 8:05:50
6	131,528		526974,583	5040238,205	0,03	258,82	16,09	249,68	16,09	131,53	-2,64%	-1,51	pun	4,96 8:06:00
5	131,104		526974,755	5040254,293	22,94	848,62	29,52	265,77	29,55	131,10	-4,38%	-2,51	pun	4,96 8:06:11
4	129,810		526969,965	5040283,424	60,23	477,42	23,19	295,29	23,20	129,81	-3,79%	-2,17	pun	4,96 8:06:29
3	128,932		526962,204	5040305,274	4,61	212,90	14,75	318,48	14,76	128,93	-4,45%	-2,55	pun	4,96 8:06:56
2	128,275		526960,058	5040319,865	9,71	335,37	18,58	333,23	18,60	128,28	-4,60%	-2,63	pun	4,96 8:07:06
1	127,421		526963,174	5040338,178				351,80		127,42			4,96	8:07:22 kraj

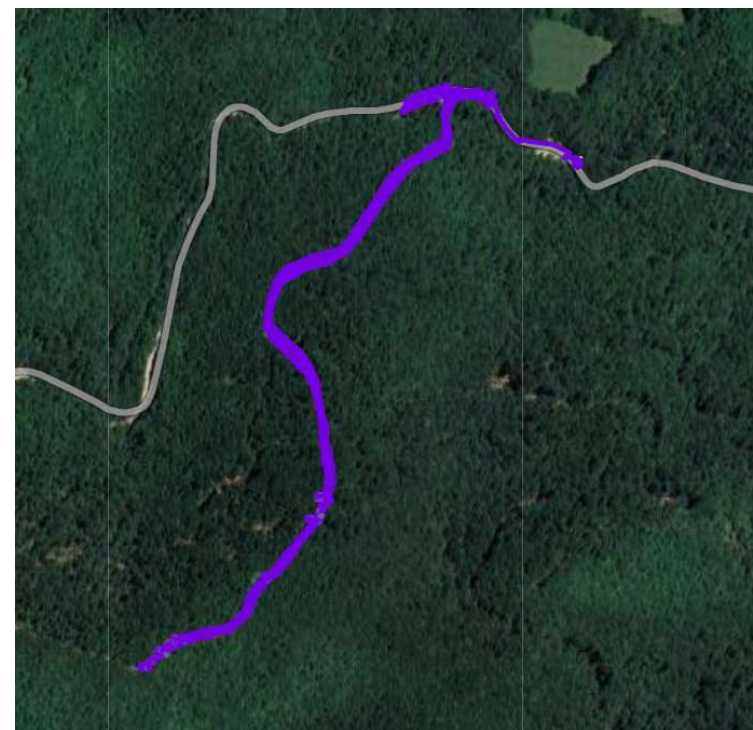
Radilište	Datum	Vrijeme turnusa	Broj turnusa	Broj komada u tovaru	Vrsta drveta	Promjer (cm)	Duljina (m)	Obujam (m³)
Dišnica - Zobikovac - Petkovača 10c	10.2.2022	7:00	1		Bukva	50	6	1,1775
Dišnica - Zobikovac - Petkovača 10c	10.2.2022		1		Bukva	52	7	1,485848
Dišnica - Zobikovac - Petkovača 10c	10.2.2022		1		Bukva	44	6,4	0,972646
Dišnica - Zobikovac - Petkovača 10c	10.2.2022		1		Bukva	45	5,4	0,858398
Dišnica - Zobikovac - Petkovača 10c	10.2.2022	8:10	1	5	Bukva	43	3,2	0,464469

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- merging all data into a database

Datum	Turnus	Radni zahvat	Potrošnja goriva, L	Potrošnja energije, kWh	Potrošnja goriva po turnusu, L	Potrošnja energije po turnusu, kWh	Privučeni tovar, m ³
28.4.2022	1	Prazan	2,66	29,15	5,94	65,048	1,82
28.4.2022	1	Privitlavanje	0,83	9,10			
28.4.2022	1	Pun	1,87	20,50			
28.4.2022	1	Stovarište	0,575	6,30			
28.4.2022	2	Prazan	2,87	31,46	5,85	64,171	3,91
28.4.2022	2	Privitlavanje	1,275	13,97			
28.4.2022	2	Pun	1,005	11,01			
28.4.2022	2	Stovarište	0,705	7,73			
28.4.2022	3	Prazan	2,915	31,95	5,85	64,116	2,28
28.4.2022	3	Privitlavanje	1,43	15,67			
28.4.2022	3	Pun	0,95	10,41			
28.4.2022	3	Stovarište	0,555	6,08			
28.4.2022	4	Prazan	2,74	30,03	6,32	69,322	2,46
28.4.2022	4	Privitlavanje	0,995	10,91			
28.4.2022	4	Pun	1,545	16,93			
28.4.2022	4	Stovarište	1,045	11,45			
28.4.2022	5	Prazan	3,195	35,02	5,11	56,006	1,98
28.4.2022	5	Privitlavanje	0,565	6,19			
28.4.2022	5	Pun	0,445	4,88			
28.4.2022	5	Stovarište	0,905	9,92			
28.4.2022	6	Prazan	2,075	22,74	4,19	45,977	2,57
28.4.2022	6	Privitlavanje	0,72	7,89			
28.4.2022	6	Pun	0,98	10,74			
28.4.2022	6	Stovarište	0,42	4,60			
28.4.2022	7	Prazan	2,17	23,78	5,19	56,937	2,5
28.4.2022	7	Privitlavanje	1,22	13,37			
28.4.2022	7	Pun	0,92	10,08			
28.4.2022	7	Stovarište	0,885	9,70			



Skid trail length: 896 m

Skid trail average slope: + 8 %



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CONCLUSIONS

The development of methods for the determination of the energy consumption of different types of forest vehicles performing different work tasks under different terrain conditions is a very important topic of scientific research in the field of forestry engineering. These data could be used as a basis for the development of hybrid and electric forest vehicles.

The new measurement method indicates the high accuracy of measuring data and could be considered a favorable tool for remote monitoring of operational characteristics of skidder in uncontrolled conditions for scientific research.



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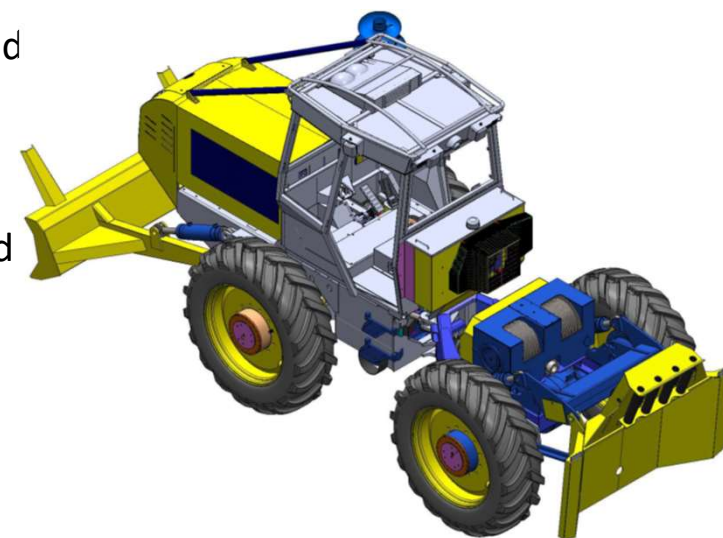
HiSkid

ACKNOWLEDGMENTS

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The project is implemented in partnership between the Faculty of Forestry and Wood Technology and the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

The final outcome of the project is the conceptual design of a hybrid skidder that will be the basis for the prototype.





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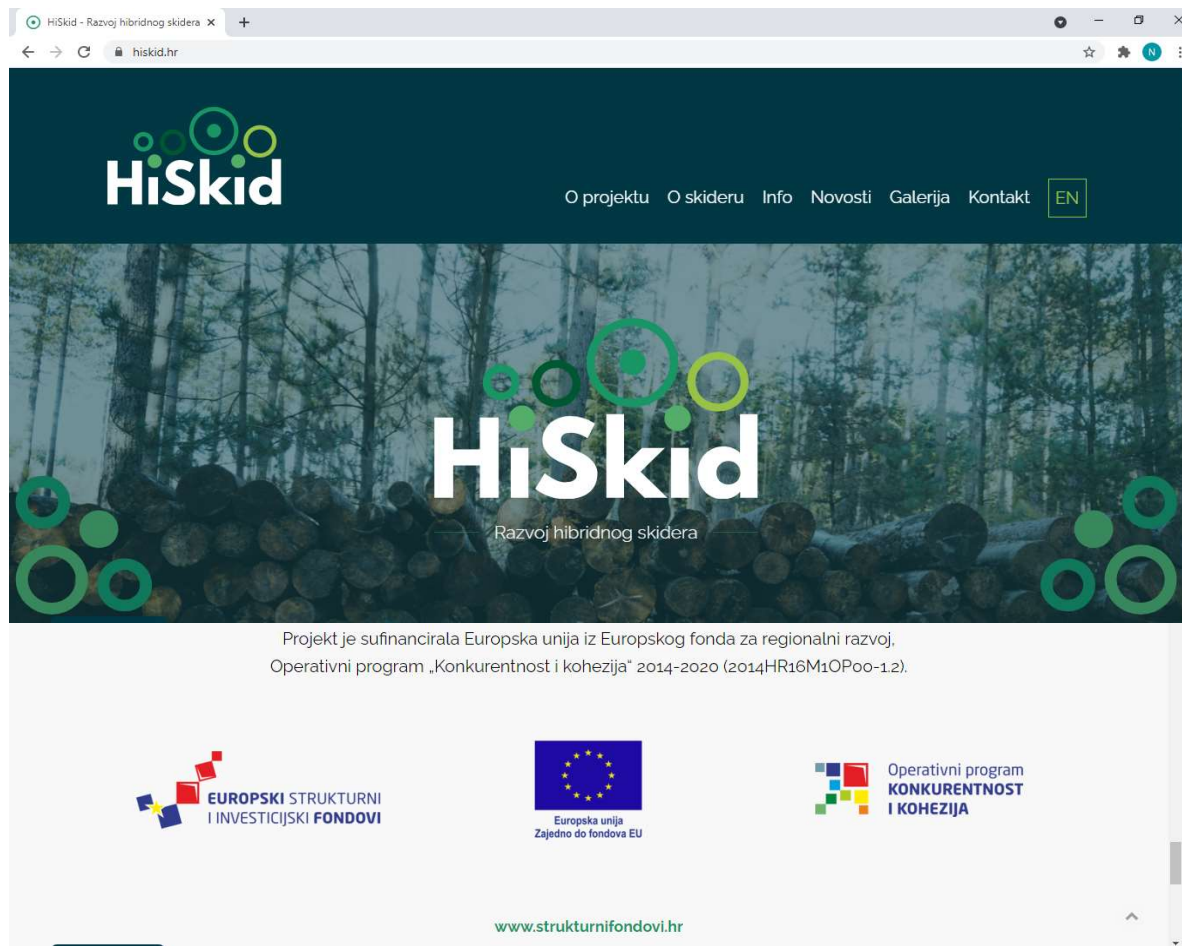


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