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Experimental evaluation of profile passability of terrain vehicles

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Experimental evaluation of profile passability of terrain vehicles

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Abstract. The article presents the results of experimental evaluation of profile passability of the Russian- and foreign-made utility terrain vehicles (UTV). Russian-made UTVs RM 650-2, RM 800 (by JSC Russkaya Mekhanika), Stels 800 Guepard (by GC Velomotors). Foreign-made UTVs Yamaha Grizzly, BRP Outlander Max XT, BRP Outlander 6x6, Polaris Sportsman 1000. The tests to determine profile passability of the Russian and foreign UTVs were conducted for the following cases: 1) UTV climbing; 2) UTV downhill movement; 3) UTV aslope movement; 4) Trench crossing of an UTV; 5) Hole crossing of an UTV; 6) UTV crossing of a single irregularity in the form of a log.

1. Tested item and place of test

The items under test included Russian and foreign UTVs. Russian made UTVs RM 650-2, RM 800 (by JSC Russkaya Mekhanika), Stels 800 Guepard (by GC Velomotors). Foreign-made UTVS Yamaha Grizzly, BRP Outlander Max XT, BRP Outlander 6x6, Polaris Sportsman 1000.

The comparative tests to evaluate UTV profile passability were conducted close to Rybinsk at the horizontal terrain sections and sections with slope up to 32º. The tests were conducted in cloudy dry windless weather at an ambient temperature of plus 2 ºC, atmospheric pressure of 767 mm Hg and air relative humidity of 88% [1, 2, 3].

The soil of the test range was mainly heavy and medium-textured sandy clay as well as loam. Sandy clay contained wood and needle of the dominating forest trees in some places.

In autumn snow cover was 2 cm deep in places.

Climate conditions of the test range featured moderate summer when most annual precipitations fell and moderate winter.

2. Measuring equipment

Measurement system Racelogic with software VBOXTools was used during the comparative tests to evaluate profile passability and flotation of the Russian and foreign UTVs. This system makes it possible to record and store data on UTV speeds, accelerations, travel, movement trajectory, etc. Software VBOXTools is based on data processing core ReportGenerator with references to the graphic imaging tools, mapping tools and VBOX setting tools.

GPS-sensor Racelogic and video-recording cameras Racelogic were installed on the UTV in addition to measuring unit Racelogic.

3 pcs of video-recording cameras were used.

Video-recording camera No.1 recorded parameters from the UTV instrument panel.

Video-recording camera No. 2 recorded position of the UTV gas trigger.

Video-recording camera No. 3 was installed in front of the UTV to record the path it travels on.

A professional laser range finder UT395A was used to measure geometrical parameters of the obstacles, including length, height, elevation, etc.

Actual geometrical parameters affecting passability of the tested UTVs were measured with tape measure.

3. Measuring actual geometrical parameters affecting passability of the tested UTVs

Dimensions of the UTVs were determined in accordance with the certified method "Determining main external dimensions of motor vehicles. Measuring method".

The following values were measured to determine actual geometrical parameters affecting passability of the tested UTVs: 1) UTV height; 2) UTV length; 3) UTV width; 4) UTV clearance; 5) Front and rear overhang; 6) Angles of approach and departure; 7) Passability longitudinal radius; 8) Passability lateral radius [4, 5, 6].

Tables 1 and 2 contain the results of tests of the dimensional parameters influencing Russian and foreign UTVs.

Loaded UTVs were subjected to tests.

Table 1. Dimensional parameters influencing passability of the Russian UTVs RM 650-2, RM 800, Stels 800 Guepard

Parameter	Value		
	RM 650-2	RM 800	Stels 800 Guepard
Length, mm:	2,320	2,340	2,344
Width, mm:	1,245	1,210	1,228
Height from ground contacting area, mm:			
– to steering handle:	1,180	1,190	1,270
– to front footrest:	340	320	385
– to driver's saddle:	940	950	980
Wheel-base, mm	1,490	1,480	1,505
Clearance, mm	290	280	315
Gauge, mm	950	980	1,030
Wheel width, mm:	200	220	250
Wheel grouser height, mm	20	20	30
Front overhang, mm	105	40	100
Rear overhang, mm	65	55	0
Angle of approach, o	82	87	82
Angle of departure, o	85	86	90
Passability longitudinal radius, mm	730	795	543
Passability lateral radius, mm	390	412	416

IOP Conf. Series: Materials Science and Engineering **709** (2020) 033086 doi:10.1088/1757-899X/709/3/033086

Table 2. Dimensional parameters influencing passability of the foreign-made UTVs Yamaha Grizzly, BRP Outlander Max XT, BRP Outlander 6x6, Polaris Sportsman 1000

Parameter	Value			
	Yamaha Grizzly	BRP Outlander Max XT	BRP Outlander 6x6	Polaris Sportsman 1000
Length, mm:	2,070	2,310	3,030	2,230
Width, mm:	1,230	1,168	1,170	1,240
Height from ground contacting area, mm:				
– to steering handle:	1,210	1,180	1,220	1,250
– to front footrest:	370	360	370	400
– to driver's saddle:	950	880	950	970
Wheel-base, mm	1,253	1,499	2,081	1,346
Clearance, mm	320	265	260	330
Gauge, mm	950	950	950	1,100
Wheel width, mm:	200	220	200	200
Wheel grouser height, mm	15	20	15	40
Front overhang, mm	50	135	80	80
Rear overhang, mm	35	60	105	50
Angle of approach, o	86	80	83	83
Angle of departure, o	87	85	81	85
Passability longitudinal radius, mm	444	840	457	468
Passability lateral radius, mm	435	387	398	463

Analysis of tables 1 and 2 demonstrates that the main geometrical dimensions of the Russian UTVs, which influence their profile passability, fall within the same limits as the modern foreign analogues. Russian model Stels 800 Guepard exceeds its analogues by wheel width (by 30 mm above the range upper limit) and by rear overhang (0 for the Russian model) that gives this model additional advantages by profile passability over its analogues.

4. Determining profile passability of terrain vehicles

The tests to determine profile passability of the Russian and foreign UTVs were conducted for the following cases: 1) UTV climbing; 2) UTV downhill movement; 3) UTV aslope movement; 4) UTV crossing of a trench; 5) UTV crossing of a hole; 6) UTV crossing of a single irregularity in the form of a log [7, 8].

4.1. UTV climbing

UTV climbed as per the diagram presented in Fig. 1a.

Climb geometrical parameters were determined with use of professional laser range finder UT395A and recorded in Table 3.

Table 3. Climb geometrical parameters

Parameter	Unit	Value
X_3	m	11
α	°	20

where X_3 – climb length; α – climb angle.

Table 4 shows values of maximum speed and time of climb by tested UTVs.

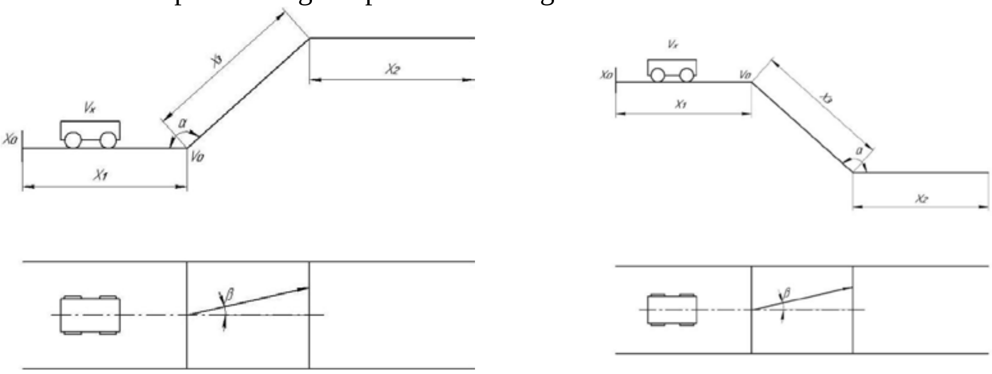
Table 4. Maximum speed and time of climb

UTV model	Max. speed, km/h	Time of climb till full stop, s
RM 650-2	24.02	3.6
RM 800	23.9	3.9
Stels 800 Guepard	25.86	4.7
Yamaha Grizzly	27.06	3.8
BRP Outlander Max XT	25.56	4.4
BRP Outlander 6x6	17.65	5.3
Polaris Sportsman 1000	26.87	3.8

Analysis of data given in Table 4 demonstrates that maximum speed and time of climb of the Russian-made UTVs fall within the same values demonstrated by the foreign analogues.

4.2. UTV downhill movement

UTV moved downhill as per the diagram presented in Fig. 1b.



a) b)

Figure 1. UTV movement diagram: a) climbing; b) downhill movement

Geometrical parameters of downhill movement are presented in Table 5.

Table 5. Geometrical parameters of downhill movement

Parameter	Unit	Value
X_3	m	11
α	°	20

where: X_3 – downhill length; α – angle of decent.

Table 6 shows values of maximum speed and time of downhill movement by tested UTVs.

Table 6. Maximum speed and time of downhill movement

UTV model	Max. speed, km/h	Time of downhill movement till full stop, s
RM 650-2	32.53	3.4
RM 800	30.83	4
Stels 800 Guepard	33.35	3.3
Yamaha Grizzly	32.74	3.4
BRP Outlander Max XT	30.46	3.6
BRP Outlander 6x6	23.66	5.1
Polaris Sportsman 1000	32.98	3.4

IOP Conf. Series: Materials Science and Engineering **709** (2020) 033086 doi:10.1088/1757-899X/709/3/033086

Data given in Table 6 demonstrates that maximum speed and time of downhill movement of the Russian-made UTVs fall within the same values demonstrated by the foreign analogues.

4.3. UTV aslope movement

An UTV safely moved aslope at a maximum possible speed in accordance with the diagram presented in Fig. 2.

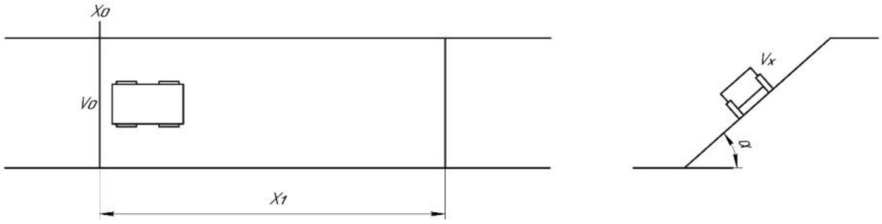


Figure 2. UTV aslope movement diagram

Geometrical parameters of the slope are presented in Table 7.

Table 7. Geometrical parameters of slope

Parameter	Unit	Value
α	°	20
X_1	m	40

where: α – slope angle; X_1 – vehicle's path on a slope.

Table 8 presents values of UTV maximum speed on a slope of 20° over a distance from 0 to 40 m.

Table 8. UTV maximum speed on a slope of 20° over a distance from 0 to 40 m.

UTV model	Max. speed over a distance from 0 to 40 m, km/h	To max. speed	
		Time, s	Distance, m
RM 650-2	40.21	3.89	24.32
RM 800	43.16	3.3	22.02
Stels 800 Guepard	40.81	3	20.77
Yamaha Grizzly	45.53	2.99	19.95
BRP Outlander Max XT	37.20	2.9	17.82
BRP Outlander 6x6	40.45	3.54	23.61
Polaris Sportsman 1000	45.54	2.59	19.23

Maximum safe in the perception of a driver (tester) speed of aslope movement of the Russian UTVs meets same indicators of the foreign analogues.

4.4. Trench crossing of UTVs

UTV crossed a trench as per the diagram presented in Fig. 3.

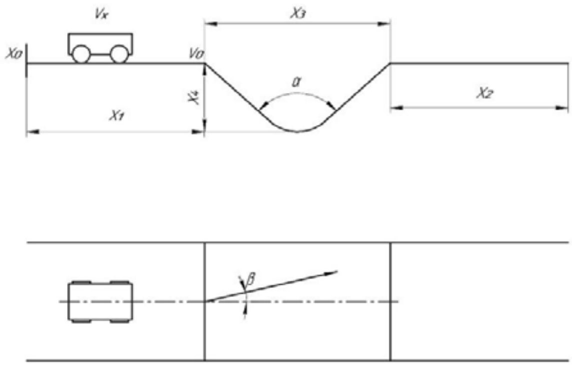


Figure 3. Diagram of trench crossing by an UTV

Geometrical parameters of a trench are presented in Table 9.

Table 9. Trench geometrical parameters

Parameter	Unit	Value
X_3	m	5.47
X_4	m	1.7
α	°	118

where: X_3 – trench length; X_4 – trench depth; α – trench elevation.

Table 10 presents values of maximum speed and time of movement in the mid trench, as well as time of trench crossing till UTV full stop.

Table 10. Maximum speed and time of trench crossing

UTV model	Speed in the mid trench, km/h	Max. speed, km/h	Time of crossing till full stop, s
RM 650-2	8.72	11.8	5.8
RM 800	4.34	11.2	5.3
Stels 800 Guepard	8.89	10.1	6.3
Yamaha Grizzly	7.8	10.1	5.0
BRP Outlander Max XT	6.6	13.3	5.4
BRP Outlander 6x6	8.2	8.2	5.3
Polaris Sportsman 1000	10.04	14.8	5.7

All UTV models crossed a trench without any difficulties.

4.5. Hole crossing of UTVs

UTV crossed a hole as per the diagram presented in Fig. 4.

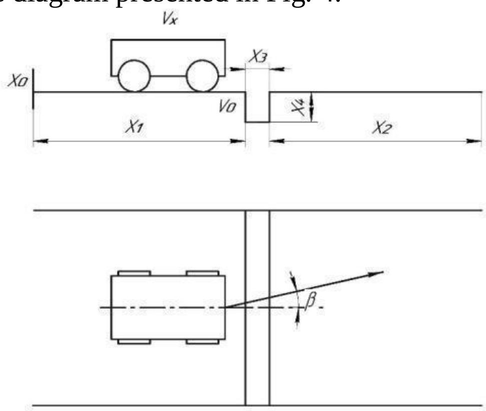


Figure 4. Diagram of hole crossing by an UTV

Geometrical parameters of a hole are presented in Table 11.

Table 11. Hole geometrical parameters

Parameter	Unit	Value
X_3	m	1.4
X_4	m	0.573

where: X_3 – hole width; X_4 – hole depth.

The analysis of the photos, video materials and data obtained from the Racelogic system suggests that a hole 1.4 m wide and 0.573 m deep is successfully crossed by all UTVs. With that some parts of UTVs touched a ground:

IOP Conf. Series: Materials Science and Engineering **709** (2020) 033086 doi:10.1088/1757-899X/709/3/033086

No contact – BRP Outlander 6x6, Yamaha Grizzly, Polaris Sportsman 1000;
Slight bottom contact – RM 800, Stels 800 Guepard;
Bottom contact – RM 650-2;
Strong bottom and nose contact followed by fracture of soil upper layer – BRP Outlander MaxXT.

4.6. UTV crossing of a single irregularity in the form of a log

UTV crossed a single irregularity in the form of a log per the diagram presented in Fig. 5.

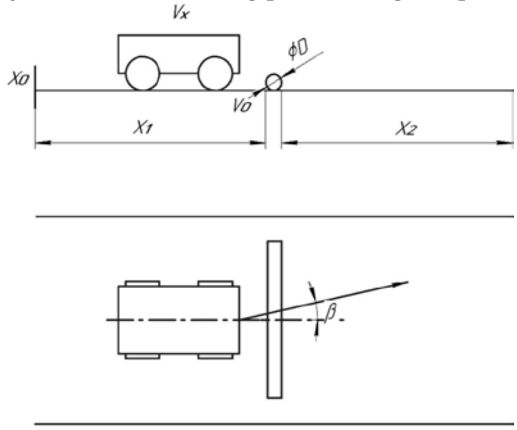


Figure 5. Diagram of log crossing by an UTV

Geometrical parameters of an obstacle (log) are presented in Table 12.

Table 12. Geometrical parameters of an obstacle (log)

Parameter	Unit	Value
D	m	0.33

where: D – log diameter.

The analysis of the photos, video materials and data obtained from the Racelogic system suggests that a log 0.33 m in diameter is successfully crossed by all UTVs. With that UTVs Yamaha Grizzly and Polaris Sportsman 1000 crossed an obstacle with no bottom contact with an obstacle. During obstacle crossing UTVs RM 800, BRP Outlander MaxXT, BRP Outlander 6x6, Stels 800 Guepard touched a log with their bottom. UTV RM 650-2 touched a log with its front mudguards and plastic parts.

Obstacle touching by Russian UTVs RM 800 and Stels 800 Guepard can be mainly explained by clearance which 1.5 – 15% less than of the foreign models Yamaha Grizzly and Polaris Sportsman 1000.

5. Conclusions

Following the climbing and downhill movement tests basing on the analysis of the photos, video materials and data obtained from the Racelogic system it may be concluded that all UTVs have succeeded in climbing and downhill movement over a distance of 11 m at an elevation of 20°.

It may also me concluded that all UTVs have succeeded in aslope movement (elevation of 20°) and covered distance of 40 m.

All UTVs have crossed a trench 5.47 m wide, 1.7 m deep and elevation of 118°.

All UTVs have successfully crossed a hole 1.4 m wide and 0.573 m deep.

All UTVs have negotiated a log 0.33 m in diameter.

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