Experimental evaluation of the operational properties of snowmobile motor vehicles

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Abstract. The article demonstrates the results of the experimental estimate of the speed and load modes as well as operational properties of the oversnow equipment during which a large number of parameters and indicators allowing for their use during designing of new generation of oversnow vehicles have been determined. This work demonstrates the results of the tests in determining speed and brake properties, as well as stability and controllability of the Russkaya Mekhanika's oversnow vehicles, models RM Buran Leader, RM Tayga Varyag 550, RM Tayga Patrul 800 SWT, RM Vector 551i and over companies' oversnow vehicles, models BRP Lynx Xtrim Commander 800 E-TEC, Arctic Cat Pantera 7000 XT LTD, Polaris 800 Titan Adventure 155.

The experimental estimate procedure has combined tests conducted to estimate speed and brake properties, as well as stability and controllability of the oversnow vehicles in critical movement modes.

The speed properties include the following indicators: maximum speed; acceleration to maximum speed, to speed of 60 km/h and to speed of 30 km/h. The ride was conducted on an even snow-covered area, a tester accelerated to a maximum speed using 100 % of power. The tests for each oversnow vehicle consisted of four rides over the same track with variable directions of movement in twins [1]. The maximum speed of the oversnow vehicle was determined as an arithmetic average of the conducted measurements.

The barking length of the oversnow vehicles was determined by results of four measurements (rides) conducted in two mutually opposite directions. The movement speed at the braking start moment was established against a standard speed meter. Additional monitoring of the measurement results was done with use of the third-generation GPS-based data recording system VBOX 3i [2].

The tests were conducted in critical movement modes to determine indicators which characterize controllability and stability of the oversnow vehicles [3]. Test of "Turn over set radius Rп = 25 m" are intended to determine maximum speed of maneuver when entering a turn. "Elk tests Sп = 16 m" are intended to determine maximum speed of maneuver when changing movement trajectory within a limited path. The oversnow vehicle's maximum speed during maneuver was determined as an arithmetical average of speeds during three rides with a maximum speed at which the ground marking was not overrun. The marking of

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the sites for Tests of turn over set radius Rп = 25 m and Elk tests Sп = 16 m was done in accordance with the diagrams given in the article [4].

The items under test included the Russkaya Mekhanika's oversnow vehicles, models RM Buran Leader, RM Tayga Varyag 550, RM Tayga Patrul 800 SWT, RM Vector 551i and over companies' oversnow vehicles, models BRP Lynx Xtrim Commander 800 E-TEC, Arctic Cat Pantera 7000 XT LTD, Polaris 800 Titan Adventure 155 which characteristics are given in Table 1.

Table 1. Oversnow vehicle main characteristics

	RM Tayga Patrul 800 SWT	RM Buran Leader	RM Tayga Varyag 550	RM Vector 551i	BRP Lynx Xtrim Commander 800 E-TEC	Arctic Cat Pantera 7000 XT LTD	Polaris 800 Titan Adventure 155
Engine							
Engine cc /Cylinders	800 / 2	635 / 2	553 / 2	553 / 2	799.5 / 2	1049 / 3	795 / 2
Power, h.p.	60	34	55	67	164	127	154
Chassis							
Transmission	CVT	CVT	CVT	CVT	CVT	CVT	CVT
Brake gear	Hydraulic, disc	Mechanical, disc	Hydraulic, disc	Hydraulic, disc	Hydraulic, disc	Hydraulic, disc	Hydraulic, disc
Suspension							
Type of front suspension	telescopic	elliptic spring	telescopic	levered	A-LFS with A-levers	Arctic Race with gas shock absorbers	AXYS® Front Suspension
Type of rear suspension	slide	independent, spring-balance	slide	slide	PPS-5900-A	XTRA-ACTION with torsion springs	Titan with hinged extension
Track, L×W×H, mm	3968x 600x 30	2x 2878x 380x 17.5	3968x 508x 35	3968x 500x 30	3923x 500x 44	3912x 508x 35	3937x 508x 45.7
Dimensions							
Oversnow vehicle dimensions, L×W×H, mm	2990x 1130x 1400	2700x 910x 1335	2990x 1050x 1380	3250x 1270x 1425	3230x 996x 1230	3378x 1270x 1473	3280x 1220x 1450
Dry* weight, kg	350	285	285	320	318	285	298

Brought to the tests were samples of the weight including weight of a sample ready for normal operation, filled with fuel and other service fluids, with tools, test-driver's weight of 80 kg and a weight of measurement equipment.

Purpose of the tests:

-experimentally determine speed and brake properties as well as indicators which characterize stability and controllability of the oversnow equipment.

The comparability tests were conducted in Rybinsk, Yaroslavl oblast, Russia at the horizontal terrain sections with the maximum slope of 1%. The terrain was covered with

loose snow 12-15 cm deep, the snow was uniform along the entire depth, with a temperature of minus 6 °C [5].

The tests were conducted in dry windless weather at an ambient temperature of minus 6 ºC, atmospheric pressure of 748 mm Hg and air relative humidity of 86 %.

A measurement system Racelogic with software VBOXTools was used during the comparability tests. This system with software makes it possible to record and store data on oversnow vehicle' 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.

The results of tractional dynamic measurements for the oversnow vehicles, models RM Buran Leader, RM Tayga Varyag 550, RM Tayga Patrul 800 SWT, RM Vector 551i and oversnow vehicles BRP Lynx Xtrim Commander 800 E-TEC, Arctic Cat Pantera 7000 XT LTD, Polaris 800 Titan Adventure 155 are given in Table 2.

Table 2. Oversnow vehicle tractional dynamic measurement results

Oversnow vehicle model	**Parameters**						
	Maximum speed, km/h	**Time of acceleration to, s**			**Path of acceleration from rest to speed building-up, m**		
		30 km/h	**60 km/h**	**Max. speed**	**30 km/h**	**60 km/h**	**Max. speed**
RM Buran Leader	61.42	2.59	11.74	14.27	10.53	139.5	182.92
RM Tayga Varyag 550	81.45	1.95	4.86	12	8.66	53.7	206.5
RM Tayga Patrul 800 SWT	82.08	2.07	5.66	14.01	8.84	55.87	226.62
RM Vector 551i	81.48	1.93	4.79	12.46	6.92	43.04	195.28
BRP Lynx Xtrim Commander 800 E-TEC	104.04	1.52	3.49	8.6	6.08	31.81	155.05
Arctic Cat Pantera 7000 XT LTD	102.43	1.61	3.74	11.11	6.62	34.04	215.11
Polaris 800 Titan Adventure 155	106.42	1.84	4.3	10.63	6.9	36.8	191.4

The results of braking dynamic measurements for the oversnow vehicles, models RM Buran Leader, RM Tayga Varyag 550, RM Tayga Patrul 800 SWT, RM Vector 551i and oversnow vehicles BRP Lynx Xtrim Commander 800 E-TEC, Arctic Cat Pantera 7000 XT LTD, Polaris 800 Titan Adventure 155 are given in Table 3.

Table 3. Oversnow vehicle braking dynamic measurement results

Oversnow vehicle model	**Parameters**					
	Time of braking from speed, s			**Braking path at braking from speed, m**		
	30 km/h	**60 km/h**	**Max. speed**	**30 km/h**	**60 km/h**	**Max. speed**
RM Buran Leader	2.1	3.94	4.02	8.36	30.92	33.49
RM Tayga Varyag 550	2.2	4.61	6.18	8.93	38.4	68.44
RM Tayga Patrul 800 SWT	2.68	5.05	6.58	11.37	40.98	71.15
RM Vector 551i	2.54	4.52	5.72	10.52	34.99	58.22
BRP Lynx Xtrim Commander 800 E-TEC	1.96	3.77	5.75	8.24	30.72	74.97
Arctic Cat Pantera 7000 XT LTD	2.38	4.18	6.21	9.52	31.52	76.78
Polaris 800 Titan Adventure 155	2.03	3.66	5.86	8.64	28.4	76.41

Two maneuvers, namely a test of turn over set radius Rп = 25 m and an Elk test were conducted to determine indicators characterizing controllability and stability of the oversnow vehicles. The maximum speed of the oversnow vehicles at entry into, recovery from and during the maneuver was measured while conducting the test of turn over set radius Rп = 25 m.

The results of the oversnow vehicle speed measurement during the "test of turn over set radius" maneuver are presented in Table 4.

Table 4. Results of the oversnow vehicle speed measurement during the "test of turn over set radius Rп = 25 m" maneuver

Oversnow vehicle model	**Maximum speed at sections of the Turn maneuver, km/h**		
	At entry	**In mid-maneuver**	**At recovery**
RM Buran Leader	41.76	29.52	36.53
RM Tayga Varyag 550	41	31.4	41.17
RM Tayga Patrul 800 SWT	36.7	35.4	30.14
RM Vector 551i	40	29.2	32.3
BRP Lynx Xtrim Commander 800 E-TEC	42.9	23.8	34.8
Arctic Cat Pantera 7000 XT LTD	40	25.4	34
Polaris 800 Titan Adventure 155	41.8	29.5	34.6

Maximum speed of the oversnow vehicles at entry into and recovery from the maneuver during the Elk test maneuver.

Results of speed measurements for the domestic and foreign oversnow vehicles during the Elk test maneuver are presented in Table 5.

Table 5. Results of speed measurements for the domestic and foreign oversnow vehicles during the Elk test maneuver

Oversnow vehicle model	**Maximum speed at sections of the Elk test maneuver, km/h**	
	At entry	**At recovery**
RM Buran Leader	53.4	48.7
RM Tayga Varyag 550	68.1	64.65
RM Tayga Patrul 800 SWT	68.16	68.03
RM Vector 551i	69.9	67.3
BRP Lynx Xtrim Commander 800 E-TEC	66.1	64.8
Arctic Cat Pantera 7000 XT LTD	80.1	76.2
Polaris 800 Titan Adventure 155	76.3	73

Outcome

Acceleration of RM Buran Leader vehicle to speed of 30 km/h was 2.59 s, distance covered - 10.53 m. Acceleration of RM Tayga Varyag 550 vehicle to speed of 30 km/h was 1.95 s, covered distance - 8.66 m. Acceleration of RM Tayga Patrul 800 SWT vehicle to speed of 30 km/h was 2.07 s, distance covered - 8.84 m. Acceleration of RM Vector 551i vehicle to speed of 30 km/h was 1.93 s, distance covered - 6.92 m. Acceleration of BRP Lynx Xtrim Commander 800 E-TEC vehicle to speed of 30 km/h was 1.52 s, distance covered - 6.08 m. Acceleration of Arctic Cat Pantera 7000 XT LTD vehicle to speed of 30 km/h was 1.61 s, distance covered - 6.62 m. Acceleration of Polaris 800 Titan Adventure 155 vehicle to speed of 30 km/h was 1.84 s, distance covered - 6.9 m.

Acceleration of RM Buran Leader vehicle to speed of 60 km/h was 11.74 s, distance covered - 139.5 m. Acceleration of RM Tayga Varyag 550 vehicle to speed of 60 km/h was 4.86 s, covered distance - 53.7 m. Acceleration of RM Tayga Patrul 800 SWT vehicle to speed of 60 km/h was 5.66 s, distance covered - 55.87 m. Acceleration of RM Vector 551i vehicle to speed of 60 km/h was 4.79 s, distance covered - 43.04 m. Acceleration of BRP Lynx Xtrim Commander 800 E-TEC vehicle to speed of 60 km/h was 3.49 s, distance covered - 31.81 m. Acceleration of Arctic Cat Pantera 7000 XT LTD vehicle to speed of 60 km/h was 3.74 s, distance covered - 34.04 m. Acceleration of Polaris 800 Titan Adventure 155 vehicle to speed of 60 km/h was 4.3 s, distance covered - 36.8 m.

Acceleration of RM Buran Leader vehicle to a maximum speed of 61.42 km/h was 14.27 s, distance covered - 182.92 m. Acceleration of RM Tayga Varyag 550 vehicle to a maximum speed of 81.45 km/h was 12 s, covered distance - 206.5 m. Acceleration of RM Tayga Patrul 800 SWT vehicle to a maximum speed of 82.08 km/h was 14.01 s, distance covered - 226.62 m. Acceleration of RM Vector 551i vehicle to a maximum speed of 81.48 km/h was 12.46 s, distance covered - 195.28 m. Acceleration of BRP Lynx Xtrim Commander 800 E-TEC vehicle to a maximum speed of 104.04 km/h was 8.6 s, distance covered - 155.05 m. Acceleration of Arctic Cat Pantera 7000 XT LTD vehicle to a maximum speed of 102.43 km/h was 11.11 s, distance covered - 215.11 m. Acceleration of Polaris 800 Titan Adventure 155 vehicle to a maximum speed of 106.42 km/h was 10.63 s, distance covered - 191.4 m.

Braking of RM Buran Leader vehicle from initial speed of 30 km/h to a full stop was 2.1 s, braking path - 8.36 m. Braking of RM Tayga Varyag 550 vehicle from initial speed of 30 km/h to a full stop was 2.2 s, braking path - 8.93 m. Braking of RM Tayga Patrul 800 SWT vehicle from initial speed of 30 km/h to a full stop was 2.68 s, braking path - 11.37 m. Braking of RM Vector 551i vehicle from initial speed of 30 km/h to a full stop was 2.54 s, braking path - 10.52 m. Braking of BRP Lynx Xtrim Commander 800 E-TEC vehicle from initial speed of 30 km/h to a full stop was 1.96 s, braking path - 8.24 m. Braking of Arctic Cat Pantera 7000 XT LTD vehicle from initial speed of 30 km/h to a full stop was 2.38 s, braking path - 9.52 m. Braking of Polaris 800 Titan Adventure 155 vehicle from initial speed of 30 km/h to a full stop was 2.03 s, braking path - 8.64 m.

Braking of RM Buran Leader vehicle from initial speed of 60 km/h to a full stop was 3.94 s, braking path - 30.92 m. Braking of RM Tayga Varyag 550 vehicle from initial speed of 60 km/h to a full stop was 4.61 s, braking path - 38.4 m. Braking of RM Tayga Patrul 800 SWT vehicle from initial speed of 60 km/h to a full stop was 5.05 s, braking path - 40.98 m. Braking of RM Vector 551i vehicle from initial speed of 60 km/h to a full stop was 4.52 s, braking path - 34.99 m. Braking of BRP Lynx Xtrim Commander 800 E-TEC vehicle from initial speed of 60 km/h to a full stop was 3.77 s, braking path - 30.72 m. Braking of Arctic Cat Pantera 7000 XT LTD vehicle from initial speed of 60 km/h to a full stop was 4.18 s, braking path - 31.52 m. Braking of Polaris 800 Titan Adventure 155 vehicle from initial speed of 60 km/h to a full stop was 3.66 s, braking path - 28.4 m.

Braking of RM Buran Leader vehicle from maximum initial speed of 61.42 km/h to a full stop was 4.02 s, braking path - 33.49 m. Braking of RM Tayga Varyag 550 vehicle from maximum initial speed of 81.45 km/h to a full stop was 6.18 s, braking path - 68.44 m. Braking of RM Tayga Patrul 800 SWT vehicle from maximum initial speed of 82.08 km/h to a full stop was 6.58 s, braking path - 71.15 m. Braking of RM Vector 551i vehicle from maximum initial speed of 81.48 km/h to a full stop was 5.72 s, braking path - 58.22 m. Braking of BRP Lynx Xtrim Commander 800 E-TEC vehicle from maximum initial speed of 104.04 km/h to a full stop was 5.75 s, braking path - 74.97 m. Braking of Arctic Cat Pantera 7000 XT LTD vehicle from maximum initial speed of 102.43 km/h to a full stop was 6.21 s, braking path - 76.78 m. Braking of Polaris 800 Titan Adventure 155

vehicle from maximum initial speed of 106.42 km/h to a full stop was 5.86 s, braking path - 76.41 m.

Maximum speed of the RM Buran Leader vehicle during the turn over set radius (R=25 m) maneuver was 41.76 km/h at entry, 36.53 km/h at recovery, 29.52 km/h in mid-maneuver. Maximum speed of the RM Tayga Varyag 550 vehicle during the turn over set radius (R=25 m) maneuver was 41 km/h at entry, 41.17 km/h at recovery, 31.4 km/h in mid-maneuver. Maximum speed of the RM Tayga Patrul 800 SWT vehicle during the turn over set radius (R=25 m) maneuver was 36.7 km/h at entry, 35.4 km/h at recovery, 30.14 km/h in mid-maneuver. Maximum speed of the RM Vector 551i vehicle during the turn over set radius (R=25 m) maneuver was 40 km/h at entry, 29.2 km/h at recovery, 32.3 km/h in mid-maneuver. Maximum speed of the BRP Lynx Xtrim Commander 800 E-TEC vehicle during the turn over set radius (R=25 m) maneuver was 42.9 km/h at entry, 23.8 km/h at recovery, 34.8 km/h in mid-maneuver. Maximum speed of the Arctic Cat Pantera 7000 XT LTD vehicle during the turn over set radius (R=25 m) maneuver was 40 km/h at entry, 25.4 km/h at recovery, 34 km/h in mid-maneuver. Maximum speed of the Polaris 800 Titan Adventure 155 vehicle during the turn over set radius (R=25 m) maneuver was 41.8 km/h at entry, 29.5 km/h at recovery, 34.6 km/h in mid-maneuver.

Maximum speed of the RM Buran Leader vehicle during the Elk test maneuver was 53.4 km/h at entry into the maneuver, 48.7 km/h at recovery from the maneuver. Maximum speed of the RM Tayga Varyag 550 vehicle during the Elk test maneuver was 68.1 km/h at entry into the maneuver, 64.65 km/h at recovery from the maneuver. Maximum speed of the RM Tayga Patrul 800 SWT vehicle during the Elk test maneuver was 68.16 km/h at entry into the maneuver, 68.03 km/h at recovery from the maneuver. Maximum speed of the RM Vector 551i vehicle during the Elk test maneuver was 69.9 km/h at entry into the maneuver, 67.3 km/h at recovery from the maneuver. Maximum speed of the BRP Lynx Xtrim Commander 800 E-TEC vehicle during the Elk test maneuver was 66.1 km/h at entry into the maneuver, 64.8 km/h at recovery from the maneuver. Maximum speed of the Arctic Cat Pantera 7000 XT LTD vehicle during the Elk test maneuver was 80.1 km/h at entry into the maneuver, 76.2 km/h at recovery from the maneuver. Maximum speed of the Polaris 800 Titan Adventure 155 vehicle during the Elk test maneuver was 76.3 km/h at entry into the maneuver, 73 km/h at recovery from the maneuver.

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