Experimental evaluation of speed and brake properties of domestic and foreign made utility terrain vehicles

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Abstract. Experimental evaluation of operational properties of the transport equipment allows to determine its technical level in real operational conditions. The test results can lay ground for developing initial data to design future equipment of this class. Results of the tests conducted to determine speed and braking properties of the Russian-made utility terrain vehicles (UTV), models RM 650-2, RM 800 (by SC Russkaya Mekhanika), Stels 800 Guepard (by Group of Companies Velomotors), as well as foreign-made UTV, models Yamaha Grizzly, BRP Outlander Max XT, BRP Outlander 6x6, Polaris Sportsman 1000, Polaris Ranger EV4x4 are described in the article.

1. Introduction
According to the Russian Federation standard GOST R 52008-2003, UTV is a motorized four-wheel all-terrain transport vehicle that travels on tires with inner pressure not more than 69 KPa (0.7 kgf/cm²), has a motorcycle-type seat and a motorcycle-type steering control handlebar [1, 9]. It is designed to transport one (two) men and travel off the public roads. The equipment of this class is mainly featured by traveling in the non-determined conditions [6]. The experimental evaluations were conducted for main properties which determine dynamic quality of the UTV. The main dynamic properties will include speed and brake properties of the UTV.

2. Test conditions
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 experimental runs were performed over an even asphalt platform. A test driver accelerated the vehicle to a maximum speed using 100% of power. The test of each UTV included four runs over the same track with different directions of movement in coupled runs [2, 3, 7]. The UTV maximum speed was determined as an arithmetic average of the measurements carried out.

The UTV braking distance was determined by the results of four measurements (runs) carried out in two mutually-opposite directions. The movement speed at the braking moment was determined by a standard speedometer. The measurement results were additionally checked in each run with use of third generation VBOX 3i GPS data logger [4, 5, 8].

The speed and brake tests were carried out using the models ready for standard operation, filled with fuel and other service fluids with due consideration for the test driver weight of 80 kg and weight of test equipment. In addition, two UTV models BRP Outlander 6x6 and Polaris Ranger EV4x4 were
subjected to tests under maximum load. The maximum load of UTV BRP Outlander 6x6 included a
driver of 80 kg + cargo of 279.75 kg. The maximum load of UTV Polaris Ranger EV4x4 included a
driver of 80 kg + a passenger of 105 kg + cargo of 271.75 kg.

The tests involved Russian-made UTVs RM 650-2, RM 800 (by SC Russkaya Mekhanika), Stels
800 Guepard (by Group of Companies Velomotors), as well as foreign-made UAVs Yamaha Grizzly,
BRP Outlander Max XT, BRP Outlander 6x6, Polaris Sportsman 1000, Polaris Ranger EV4x4.

The test objectives are the following:
- to experimentally determine speed and brake properties of the domestic and foreign-made UTVs;
- to make a comparative evaluation of the speed and brake properties of the domestic and foreign-
made UTVs.

Main specifications of the tested domestic UTVs are given in Table 1, those of the foreign-made
UTVs are given in Table 2.

| Table 1. Main specifications of domestic UTVs |
|---------------------------------------------|
| **ENGINE**                                   |
| Engine type                               | Four-stroke | Four-stroke | Four-stroke |
| Cubic capacity, cm³                        | 800         | 622         | 800         |
| Maximum power, h.p.                        | 60          | 42.5        | 67          |
| Fuel                                      | Gasoline with minimum octane number of 92 |
| Fuel tank capacity, l                    | 24.5        | 24          | 30          |
| **CHASSIS**                                |
| Transmission                              | CVT         | CVT         | CVT         |
| Drive                                     | 2/4WD + EDL | 2/4WD + EDL | 2/4WD + EDL |
| Braking system: front/rear                | Hydraulic disk / Hydraulic disk |
| SUSPENSION                                |
| Chassis type/drive wheels                 | 4x4         | 4x4         | 4x4         |
| Suspension, front/rear                    | Double wishbone cross suspension with hydraulic shock-absorbers |
| Suspension travel, front/rear, mm         | 190/200     | 170/195     | 185/180     |
| Minimum rad clearance, mm                | 295         | 290         | 310         |
| **OVERALL DIMENSIONS**                    |
| Number of seats                           | 2           | 2           | 2           |
| Overall dimensions: L/W/H, mm            | 2340/1210/1480 | 2320/1245/1255 | 2344/1228/1420 |
| Dry* mass, kg                            | 408         | 375         | 382         |
| Tire size, front/rear                     | 26x9-14/26x11-14 | 26x8-14/26x10-14 | 28x9-12/28x10-12 |
Table 2. Main specifications of foreign-made UTVs

| Engine | Yamaha Grizzly | BRP Outlander Max XT | BRP Outlander 6x6 | Polaris Sportsman 1000 |
|--------|----------------|----------------------|-------------------|------------------------|
| Engine type | Four-stroke | Four-stroke | Four-stroke | Four-stroke |
| Cubic capacity, cm³ | 708 | 570 | 650 | 952 |
| Maximum power, h.p. | 49 | 48 | 62 | 85 |
| Fuel System/Battery | Gasoline with minimum octane number of 92 | Gasoline with minimum octane number of 92 | Gasoline with minimum octane number of 92 | Gasoline with minimum octane number of 92 |
| Fuel tank capacity, l | 18 | 20.5 | 20.5 | 19.9 |

| Chassis | Yamaha Grizzly | BRP Outlander Max XT | BRP Outlander 6x6 | Polaris Sportsman 1000 |
|---------|----------------|----------------------|-------------------|------------------------|
| Transmission/Final Drive | CVT | CVT | CVT | CVT |
| Drive | 2WD/4WD | 2/4WD + EDL | 6-wheel full drive / 2-axis rear drive. Front axis with automatic differential lock | AWD/2WD |
| Braking system: front/rear | Two ventilated disk brakes / one ventilated disk brake | Two ventilated disk brakes / one ventilated disk brake | Two ventilated disk brakes / one ventilated disk brake | All-wheel hydraulic brakes |
| Chassis type/drive wheels | 4x4 | 4x4 | 6x6 | 4x4 |
| Suspension, front/rear | Double wishbone cross TTI | 2-wishbone/ independent TTI | 2-wishbone/ independent TTI | Dual A-arm |
| Suspension travel, front/rear, mm | 193/232 | 229/236 | 230/236 | 188/170 |
| Minimum radial clearance, mm | 288 | 270 | 305 | 343 |

The comparative tests to determine traction and brake dynamic of the domestic and foreign-made UTVs were carried out at the Bronnitsy testing area over asphalt roads with a maximum slope of 1%. The tests were run in dry calm weather at an ambient temperature of plus 24 ºC, atmospheric pressure of 752 mm Hg and relative humidity of 65 %.

The RaceLogic measuring system with VBOXTools software was used as a test equipment. The system software allows recording UTV speed, acceleration, distance covered, motion path, etc. The
VBOXTools software is based around the ReportGenerator data-processing engine with links to Graphing tools, Mapping tools and VBOX Setup tools.

3. Test results
The runs were conducted to determine the following speed characteristics: acceleration to 30 km/h; acceleration to 60 km/h; acceleration to maximum speed.

The results are shown in Table 3.

**Table 3. UTV traction dynamic measurement results**

| UTV model            | Maximum speed, km/h | Acceleration time to speed of, s | Acceleration distance from rest to desired speed of, m |
|----------------------|---------------------|---------------------------------|-------------------------------------------------------|
|                      | 30 km/h             | 60 km/h                         | Max. speed                                            |
|                      | 30 km/h             | 60 km/h                         | Max. speed                                            |
| RM 650-2             | 83.41               | 1.78 6.2                        | 20.17 7.73 66.18 360.93                               |
| RM 800               | 111.58              | 1.22 3.39                       | 24.08 5.29 33.74 597.79                               |
| Stels 800 Guepard    | 106.2               | 1.34 3.67                       | 21.3 5.3 36.05 487.53                                |
| Yamaha Grizzly       | 105.37              | 1.54 3.45                       | 14.39 6.55 31.74 306.34                               |
| BRP Outlander Max XT | 103.97              | 1.65 3.69                       | 14.5 7.06 33.42 300.5                                |
| BRP Outlander 6x6    | 84.64               | 1.66 4.43                       | 9.7 6.93 42.86 152.82                                |
| BRP Outlander 6x6 (max. load) | 83.12 | 2.23 6.28                       | 13.4 9.4 61.93 208.07                                |
| Polaris Sportsman 1000 (limited) | 76.33 | 1.38 3.4                        | 6.5 5.84 32.13 93.36                                 |
| Polaris Ranger EV4x4 | 37.3                | 8.05 -                           | 18.29 46.47 - 143.59                                 |
| Polaris Ranger EV4x4 (max. load) | 37.3 | 9.67 -                           | 28.68 56.02 - 239.55                                 |

The runs were conducted to determine the following brake characteristics: braking from initial speed of 30 km/h; braking from initial speed of 60 km/h; braking from maximum initial speed.

The test results are shown in Table 4.

**Table 4. UTV brake dynamic measurement results**

| UTV model            | Braking time from speed of, s | Braking distance from speed of, m |
|----------------------|-------------------------------|---------------------------------|
|                      | 30 km/h 60 km/h Max. speed   | 30 km/h 60 km/h Max. speed      |
| RM 650-2             | 1.49 3.1 4.5 5.95 23.63 52.2  |
| RM 800               | 1.39 3.29 6.9 5.96 25.93 120.09 |
| Stels 800 Guepard    | 1.89 3.59 6.49 7.51 29 98.59   |
| Yamaha Grizzly       | 1.39 2.81 5.21 5.92 23.02 79.93 |
| BRP Outlander Max XT | 1.49 2.4 4.2 5.67 19.23 61.35  |
| BRP Outlander 6x6    | 1.19 2.29 3.09 4.77 18.43 37.12 |
| BRP Outlander 6x6 (max. load) | 1.5 | 3.09 4.7 6.03 22.8 49.68 |
| Polaris Sportsman 1000 | 1.39 2.69 3.9 5.24 21.77 45.61 |
| Polaris Ranger EV4x4 | 1.79 - 2.5 7.67 - 14.28      |
| Polaris Ranger EV4x4 (max. load) | 2 | - 3.1 8.51 - 18.22 |

4. Conclusion
UTV RM 650-2 accelerates to 30 km/h in 1.78 s over travelled distance of 7.73 m. UTV RM 800 accelerates to 30 km/h in 1.22 s over travelled distance of 5.29 m. UTV Stels 800 Guepard accelerates to 30 km/h in 1.34 s over travelled distance of 5.3 m. UTV Yamaha Grizzly accelerates to 30 km/h in 1.54 s over travelled distance of 6.55 m. UTV BRP Outlander Max XT accelerates to 30 km/h in 1.65
UTV BRP Outlander 6x6 accelerates to 30 km/h in 1.66 s over travelled distance of 6.93 m. UTV BRP Outlander 6x6 (max load) accelerates to 30 km/h in 2.23 s over travelled distance of 9.4 m. UTV Polaris Sportsman 1000 accelerates to 30 km/h in 1.38 s over travelled distance of 18.29 m. UTV Polaris Ranger EV4x4 accelerates to 30 km/h in 9.67 s over travelled distance of 28.68 m.

UTV RM 650-2 accelerates to 60 km/h in 6.2 s over travelled distance of 66.18 m. UTV RM 800 accelerates to 60 km/h in 3.39 s over travelled distance of 33.74 m. UTV Stels 800 Guepard accelerates to 60 km/h in 3.67 s over travelled distance of 36.05 m. UTV Yamaha Grizzly accelerates to 60 km/h in over travelled distance of 31.74 m. UTV BRP Outlander Max XT accelerates to 60 km/h in 3.39 s over travelled distance of 33.42 m. UTV BRP Outlander 6x6 accelerates to 60 km/h in over travelled distance of 4.43 s over travelled distance of 42.86 m. UTV BRP Outlander 6x6 (max load) accelerates to 60 km/h in 6.28 s over travelled distance of 61.93 m. UTV Polaris Sportsman 1000 accelerates to 60 km/h in 3.4 s over travelled distance of 32.13 m.

UTV RM 650-2 accelerates to maximum speed of 83.41 km/h in 20.17 s over travelled distance of 360.93 m. UTV RM 800 accelerates to maximum speed of 111.58 km/h in 24.08 s over travelled distance of 597.79 m. UTV Stels 800 Guepard accelerates to maximum speed of 106.2 km/h in 21.3 s over travelled distance of 487.53 m. UTV Yamaha Grizzly accelerates to maximum speed of 105.37 km/h in 14.39 s over travelled distance of 306.34 m. UTV BRP Outlander Max XT accelerates to maximum speed of 103.97 km/h in 14.5 s over travelled distance of 300.5 m. UTV BRP Outlander 6x6 accelerates to maximum speed of 84.64 km/h in 9.7 s over travelled distance of 152.82 m. UTV BRP Outlander 6x6 (max load) accelerates to maximum speed of 83.12 km/h in 13.4 s over travelled distance of 208.07 m. UTV Polaris Sportsman 1000 accelerates to maximum speed of 76.33 km/h (limited) in 6.5 s over travelled distance of 93.36 m. UTV Polaris Ranger EV4x4 accelerates to maximum speed of 37.3 km/h in 18.29 s over travelled distance of 143.59 m. UTV Polaris Ranger EV4x4 (max load) accelerates to maximum speed of 37.3 km/h in 28.68 s over travelled distance of 239.55 m.

UTV RM 650-2 slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.49 s over braking distance of 5.95 m. UTV RM 800 slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.39 s over braking distance of 5.96 m. UTV Stels 800 Guepard slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.89 s over braking distance of 7.51 m. UTV Yamaha Grizzly slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.39 s over braking distance of 5.92 m. UTV BRP Outlander Max XT slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.49 s over braking distance of 5.67 m. UTV BRP Outlander 6x6 (with an 80-kg driver) slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.19 s over braking distance of 4.77 m. UTV BRP Outlander 6x6 (max load is an 80-kg driver + 279.75-kg cargo) slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.5 s over braking distance of 6.03 m. UTV Polaris Sportsman 1000 slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.39 s over braking distance of 5.24 m. UTV Polaris Ranger EV4x4 (with an 80-kg driver) slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 1.79 s over braking distance of 7.67 m. UTV Polaris Ranger EV4x4 (max load is an 80-kg driver + 105-kg passenger + 271.75-kg cargo) slows down after the brakes have been applied from initial speed of 30 km/h to a full stop in 2 s over braking distance of 8.51 m.

UTV RM 650-2 slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 3.1 s over braking distance of 23.63 m. UTV RM 800 slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 3.29 s over braking distance of 25.93 m. UTV Stels 800 Guepard slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 3.59 s over braking distance of 29 m. UTV Yamaha Grizzly slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 2.81 s over braking distance of 23.02 m. UTV BRP Outlander Max XT slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 2.4 s over braking distance of 19.23 m. UTV BRP Outlander 6x6...
(with an 80-kg driver) slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 2.29 s over braking distance of 18.43 m. UTV BRP Outlander 6x6 (max load is an 80-kg driver + 279.75-kg cargo) slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 3.09 s over braking distance of 22.8 m. UTV Polaris Sportsman 1000 slows down after the brakes have been applied from initial speed of 60 km/h to a full stop in 2.69 s over braking distance of 21.77 m.

UTV RM 650-2 slows down after the brakes have been applied from maximum initial speed of 83.41 km/h to a full stop in 4.5 s over braking distance of 52.2 m. UTV RM 800 slows down after the brakes have been applied from maximum initial speed of 111.58 km/h to a full stop in 6.9 s over braking distance of 120.09 m. UTV Stels 800 Guepard slows down after the brakes have been applied from maximum initial speed of 106.2 km/h to a full stop in 6.49 s over braking distance of 98.59 m. UTV Yamaha Grizzly slows down after the brakes have been applied from maximum initial speed of 105.37 km/h to a full stop in 5.21 s over braking distance of 79.93 m. UTV BRP Outlander Max XT slows down after the brakes have been applied from maximum initial speed of 103.97 km/h to a full stop in 4.2 s over braking distance of 61.35 m. UTV BRP Outlander 6x6 (with an 80-kg driver) slows down after the brakes have been applied from maximum initial speed of 84.64 km/h to a full stop in 3.09 s over braking distance of 37.12 m. UTV BRP Outlander 6x6 (max load) slows down after the brakes have been applied from maximum initial speed of 83.12 km/h to a full stop in 4.7 s over braking distance of 49.68 m. UTV Polaris Sportsman 1000 slows down after the brakes have been applied from maximum initial speed of 76.33 km/h to a full stop in 3.9 s over braking distance of 45.61 m. UTV Polaris Ranger EV4x4 (with an 80-kg driver) slows down after the brakes have been applied from maximum initial speed of 37.3 km/h to a full stop in 2.5 s over braking distance of 14.28 m. UTV Polaris Ranger EV4x4 (max load) slows down after the brakes have been applied from maximum initial speed of 37.3 km/h in 8.51 s over braking distance of 18.22 m.

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