INNOVATIVE WAY OF THE BELARUSIAN AUTOMOBILE ENGINEERING

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State programs

Further modernization, effectiveness and competitive increase of the economy on the basis of innovative methods are extremely important for the Republic of Belarus as a state with insufficient power and raw material resources of its own. Technical realization of received knowledge with the minimum material and power expenses in all spheres of human community is the most important task for innovative development. In the Republic of Belarus new knowledge is acquired and implemented with significant support from the government in research, development and technological works within state scientific programs of different levels (the fundamental and fundamental focused scientific researches, applied, scientific and technical, including branch and regional researches).

Mechanical engineering occupies the most important place in state economy with more than 40 branches of industry. The leading branch in domestic mechanical engineering is a complex one – automobile-tractor-agriculture machine building. This complex branch is mainly focused on foreign markets.

This orientation demands accelerated innovative development of the branch in order to preserve its' competitive ability on the world market. The revival and dynamic development of the domestic automobile-tractor-agriculture machine building industry are obliged to a scientifically provided possibility to produce new competitive machinery under the state scientific and technical program (SSTP) "Mechanical engineering" (first works of which have begun in 1996).Up until the year of 2005 more than 100 types of new base vehicles models had been developed and produced by domestic enterprises of mechanical engineering under the state program with the participation of 12 scientific organizations of the National Academy of Science of Belarus (NASB), 5 universities and leading design collectives from the Department of Industry. Now this machinery comprises the majority of all the production and stimulates the dynamic development of the largest domestic mechanical engineering enterprises.

A vivid example of consolidation in the innovative machinery cycle - «researches – design – technical realization» are large multilevel state research, design and development programs: the State complex program of scientific researches (SCPSR) "Mechanics" - SSTP "Mechanical engineering" - the State special-purpose program (SSPP) "Avtotraktorokombajnostroenie". This way, the implementation of innovative machinery issues up until 2010 had been provided by the state special-purpose development program in automobile, tractor and combine industry of the Republic of Belarus "Avtotraktrokombajnostroenie" (leading organization for this program is Joint institute of mechanical engineering NASB), and the informal parts of the innovations are renewed thanks to scientific researches under scientific and technical sections of the state complex scientific and technical program (SCSSTP) "Mechanical engineering".

SCSSTP "Mechanical engineering" (Fig. 1) unites SCPSR "Mechanics" and «Technical preliminary treatment», a state program of applied scientific researches (SPSR) "Metallurgy", SSTP "Mechanical engineering", «Technologies and the mechanical engineering equipment», «CALS technologies» and "Municipal economy". The state customers-coordinators SCSSTP of the "Mechanical engineering" program are the Ministry of industry and the National academy of Sciences. The head organization-coordinator for this program is confirmed to be the Joint institute of mechanical engineering of NASB. The state programs' ultimate purpose is to guarantee steady functioning and development of industrial complex of automobile and combine building and allied industries of the economy by constantly keeping up to date the machine model range and their design and production technologies.

SCPSR "Mechanics" and SSTP "Mechanical engineering" programs have a priority when it comes to innovative development of automobile engineering. These are the exact state programs aimed at the

decision of actual and big scientific and technical problems of developing export-oriented and import-substitutional mobile machines. SCPSR "Mechanics" concentrates on:

– Search and foundation of the most rational engineering solutions in the development of new machinery, their parts and components;

– Development of modern technology, methods and hardware-software complexes for machine design with the use of computers and IT achievements;

– System upgrading of live tests and research of designed machines, which includes development of methodological and technical base of the scientific and technical centers of the enterprises, and also development of the Republic proving ground.

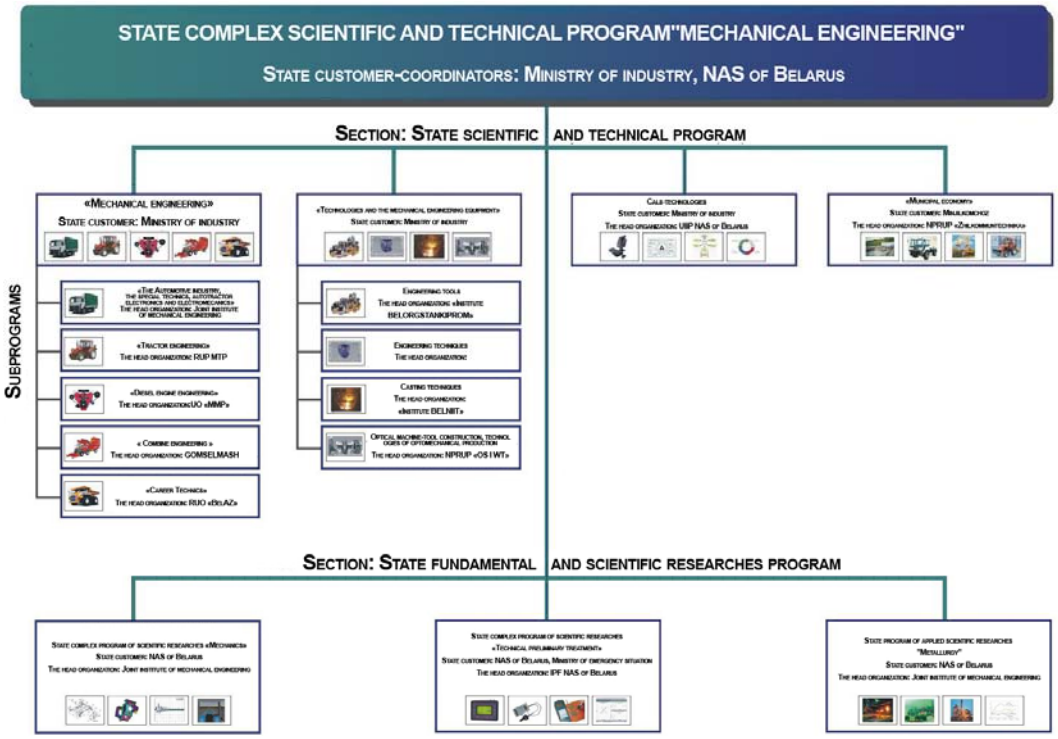

Figure 1: Structure of the SCPSR "Mechanics"
Main researches examples

According to the SSTP "Mechanical engineering", another job batch (the forth to be exact), all of which have been carried out from 2006 to 2010, is coming to an end. The program consists of five parts («The Automotive industry, the special technics, autotractor electronics and electromecanics»; «Tractor engineering»; «Diesel engine engineering»; « Combine engineering » and «the Career Technics») and includes more than 50 objectives.

Many machines developed under the SSTP "Mechanical engineering» are new for the domestic industry (Fig. 2, 3, 4): a model range of middle-tonnage machines and lorry convoys MAZ; saddle-type and towing MAZ haul trucks with body volume of up to 117 cubic meters, which correspond to Euro-4 emission standards; low-floor and ultra low-floor new generation MAZ buses for city and suburban transportation, which also correspond to Euro-4 emission standards.

It is necessary to point out the fact that the formation and development of a new branch such as bus engineering is closely tied with the SSTP "Mechanical engineering". This way the majority of “MAZ” buses has been developed under this program.

Figure 2: Examples of the Minsk automobile factory automobiles, which are developed under the State program "Mechanical engineering"

Under the SSTP "Mechanical engineering" the Minsk tractor factory has developed a wide model range of “Belarus” tractors. There are small-sized and powerful tractors with 250-300 h.p., and also new forestry and municipal vehicles.

Also a wide range of dump tracks and other mining vehicles were also developed in the Belarus automobile plant mainly under the SSTP "Mechanical engineering". Now there are career dump trucks with a load-carrying capacity of 360 tons.

All in all, the amount of machinery produced and mastered under the complete researches of the SSTP "Mechanical engineering" and SGP "Avtotraktorokombajnostroenie" up to the end of 2008 was equivalent to 1.9 billion USD, with a total budget expense of 21.24 million USD. The contribution to the budget was about 395 million USD and it exceeds the budget expenditure on new machine development by 20 times.

**Figure 3: Examples of the Minsk tractor factory tractors,
which are developed under the State program "Mechanical engineering"**

**Figure 4: Examples of Belarus automobile factory (BELAZ) career machines,
which are developed under the State program "Mechanical engineering"**

All the above listed examples of mastering and development of new machine production were implemented with a different extent of help from the Joint institute of mechanical engineering of the NASB, which performs the functions of an array of applied-research institutions in automobile, tractor and agricultural machine building in the Republic of Belarus.

Our institute carries out its' innovational, scientific and technical researches for domestic automobile engineering in compliance with worldwide tendencies.

These tendencies of modern automobile engineering include following directions.

1. Mass application of automatized and computerized technological equipment, assembled similarly to easily adjustable flexible manufacturing systems.

2. A large-scale switchover to a production of modular kitting with wide utilization of relatively cheap standard sized components (parts and assembly) of mass production. With the use of the modular principle in kitting and platform design, there is a possibility of creating a wide model range of cars by simply applying different combinations of modules (chassis, cab, engine, gearbox, live axle, suspension system)

3. Production of science intensive electronically equipped machinery. Nowadays, electrical kitting is one of the compulsory features for automotive machinery produced in the republic in order to compete on the foreign markets (especially European ones). And due to the rise in foreign machinery import rate, electrical kitting is becoming vital to compete on the home market too. There is about 30-40 first-priority types of electrical systems needed today in order to equip all the types of automotive machinery produced in the republic.

4. The use of modern constructive and instrumental materials and resource-saving technology in part fabrication.

One of the most important global processes involving machine building in the last few years, and automotive construction in particular, is globalization aimed at reducing production and retail costs (market conquering). As one of the reasons for this process, one can name the quick rise in the role of high technology in production and the costs of scientific research, empirical design and process development, which are becoming difficult and even impossible for one company alone. One of the results of this globalization is the deepening of world specialization and cooperation, which is revealed most of all in the field of components and is expressed, on one hand, in the amount of bought-in components in the end product, and on the other hand – in the consolidation and domination of a narrow circle of huge companies on the market of key components.

Components play the lead role in the revolutionary transformation of end products, technologies and manufacturing. High-technology science intensive components, having a high level of unification, provide a continuous functional expansion and growth of engineering-and-economical performance of new generations of machines and equipment. And these are the types of continuous and dynamic changes that take place in the fields of technically complicated and key automotive components, such as engines, safety systems, transmission, suspension systems, electronic control and diagnostic systems.

Multilink haul trucks

Belarus, as a transit country, must produce essentially new vehicles – modular multilink haul trucks for transcontinental cargo transportations through the corridor “West-East” from Brest to Beijing and Tokyo. Our institution, in collaboration with the Minsk automobile plant, leads this project within the state scientific and technical program “Mechanical engineering”, using the newest technology, materials and components of foreign and home production, which include a straddling hybrid engine unit, a built-in individual electric wheel drive, electronic systems for automatic coordinated control of the engine unit and link actuation, electronic systems for automated control of coordinated curvilinear motion of links, automatic hookup mechanism length regulation and others. (FIG. 5). In 2009 the truck underwent a series of tests on the Republic automobile proving ground and in May 2010 a series of tests aimed at evaluating the design rationality of multilink trucks, there infrastructural and operating conditions suitability where successfully conducted on a public road Brest-Moscow.

R = 35 м turn test

Experimental maneuver analysis

Moose test

Folding the truck into a triangle

Figure 5: Experimental tests of the truck

One of the most important constructional tasks consists in the design of electronic systems that will ensure safe functioning of this truck (FIG. 6). Among them there will be systems that have never before been seen on haul trucks:

– Link engine unit control system;

– Truck electrotransmission control system;

– Truck steering control system;

– Link coupling control system;

– Link control system when decoupled;

– Automatic truck drive control system.

The last system of the listed above will change the whole approach to the use of the energy in the engine unit of the truck. In order to provide maximum efficiency of the engine unit, it system will unite and coordinate the functions of all the other systems. This would give the possibility to lead the engines to economy mode and also cut down on emissions; improve vehicle dynamics thanks to the use of recuperated energy. Special attention will be drawn to systems that provide a high level of safety on the road and comfort for the driver, and also perform the diagnostics of the vehicle.

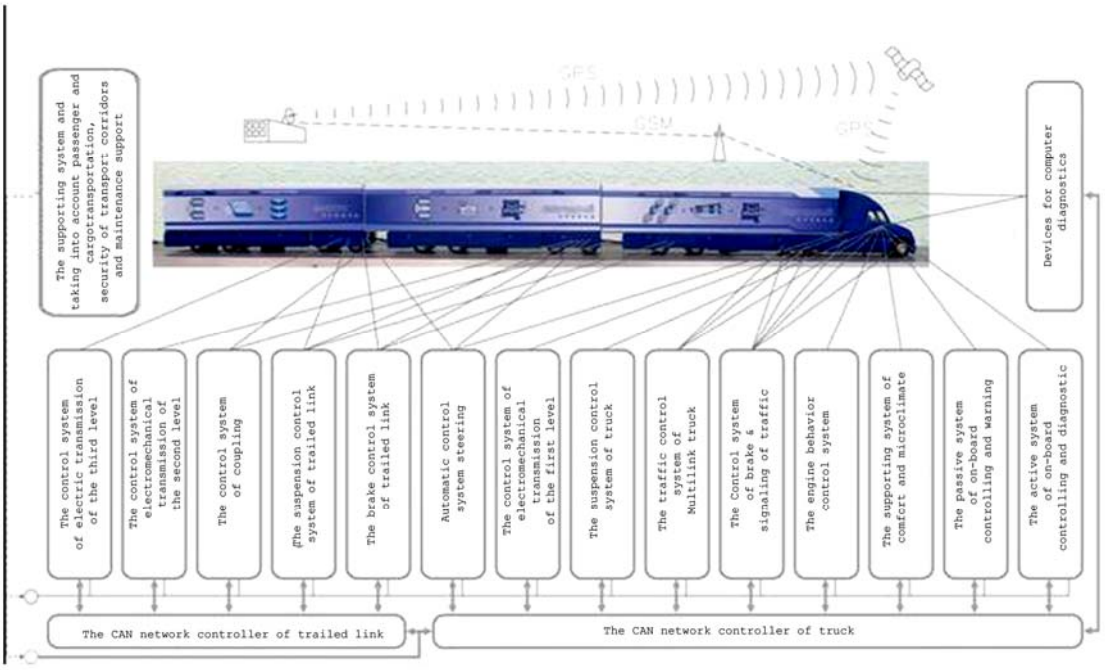

Figure 6: Multilink truck dataware and control

Internal combustion engines

One of the most topical problems of the republic today is for domestic manufacturers to uptake the production of high-power engines (in between 250-600 hp and more). These are the types of engines which are needed in automobile, tractor and combine plants most of all. We should point out the fact that the modern engine is the "heart" of any vehicle and at the same time its' most highly technological component. As a rule, integrated vehicle control systems are tightly bonded with electric engine control systems, so the last system defines the technological level of all the electronics in the vehicle. Unfortunately, we do not possess the scientific-based background for immediate liquidation of technological slippage from the world leaders. We are taking specific measures to activate common projects, but the existing inadequacy of the domestic engine building industry can be liquidated rapidly (and in accordance with the demands of today's market) only by creating a foreign or joint establishment with leaders in modern diesel engine construction on the territory of our country.

Electronics

Another important matter in domestic transport, tractor and agricultural machine building is the implementation of domestic onboard electronics. It's important to mention that the most modern and science intensive components of vehicles have electronic control systems for basis, without which there functioning is simply impossible. This is why onboard electronic systems are the most dynamically developing components in automobile industry. These systems comprise up to 10-15% of the vehicles cost and are predicted to reach 20-30% in the near future. An approach to the vehicle as to some sort of electronic platform, inside which onboard electronic systems form a flexible network system, is becoming dominant.

Our institution carries out work on creating an array of onboard electronic systems: information-management system of the vehicle and its' elements, which provide a wider informational exchange; a complex of instruments and design methods and intellectual active safety control system software support; electro-hydraulic control system of instruments mounted onto the "Minsk Tractor Works" (MTW) tractor, built on the basis of alternative, sensory and original algorithm support and others. Works on implementing these systems into mainstream production in the plants of the republic are also being carried out.

Different types of vehicles can be tested on the dynamometer road – from motorcycles to heavy dump trucks and special vehicles (Amcador, MZKT).

In the period from March 15th 2009 (the date of the proving grounds' validation) up to December 2009 a series of tests with different vehicle types have been conducted the Republic proving ground. Such vehicle types like L (motorcycles), N3 (heavy trucks), M3 (buses and trolleys) and special vehicles have been tested. Part of these vehicles where tested with the involvement of accredited testing centers "Minsk Wheel Tractor Plant", "Minsk Automobile Plant", "Belavtosertica" (BNTU). Test drives of Mercedes-Benz and Porshe cars have been conducted, which involved obstacle negotiation, stability evaluation and speed runs.

Republic proving ground

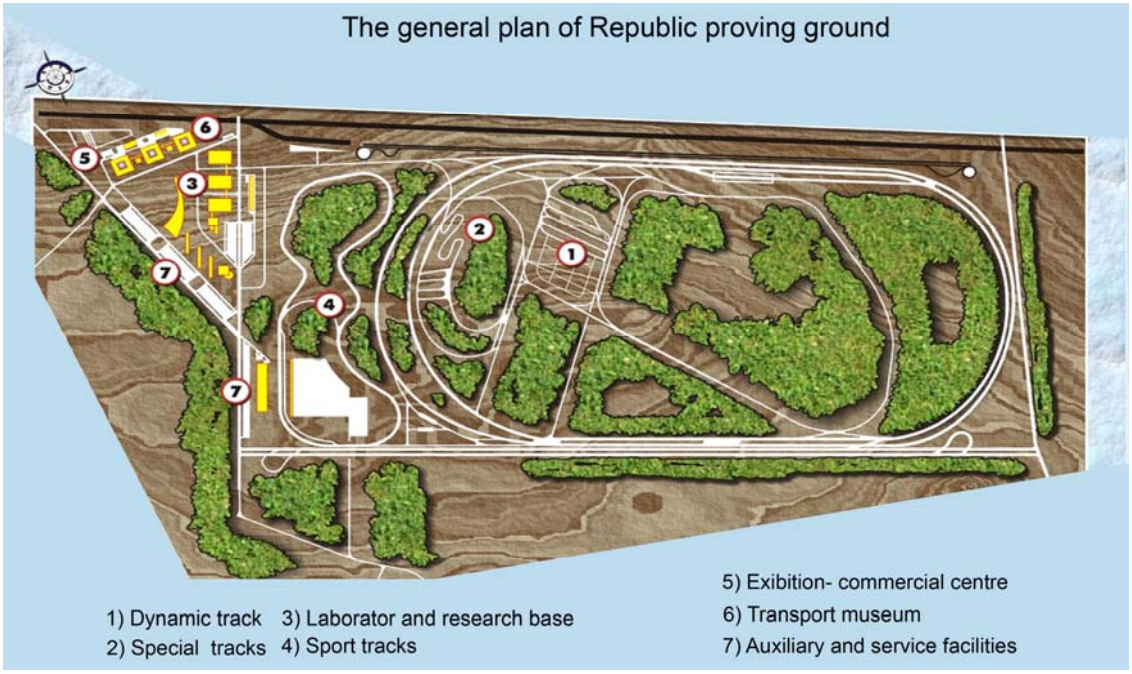

Figure 7: The general plan of Republic proving ground

On the basis of the Council of Ministers resolution № 1056 «On creation of the Republican proving ground for research, testing and certification of mobile machinery and total evaluation of their impact on road infrastructure», as well as the Order of the President of the Republic of Belarus № 175rp on financing the construction of social objects in 2008, the first stage of construction of the Republic proving ground for research, testing and certification of mobile machinery and total evaluator of their impact on road infrastructure (further on - Republic proving ground) has been carried out: - dynamometric road in Ozerische, Minsk district.

Main activities of Republic proving ground:

– Research and testing of prototypes and mass-production automotive machinery, systems, structural components of vehicles and development of recommendations to increase their running abilities in accordance with current and prospective requirements;

– Certification testing of vehicles.

– Formation and development of research and testing facilities.

– Upgrade of existing and the development of new testing methods of vehicles and requirements to them from the perspective of development work to improve vehicles design.

– Provision of services to increase driving skills and extreme-driving lessons.

– Presentation of new models of domestic and foreign production.

The length of the dynamometric road is 3382,8 meters, the width of the roadway is 10 meters. A one of its kind in the entire European part of the Eurasian continent asphalt concrete road surface allows to test vehicles with a load of 20 tons per axle, which is a unique feature for such structures. Just for comparison, the load-carrying capability of the dynamometric road of Federal State Unitary Enterprise «Central Scientific Research Automobile And Automotive Engine Institute» in Dmitrov, Moscow region (Russian Federation) amounts to 15 tons.

For acoustic tests there is a section of the road built from low-noise asphalt concrete with an optimal grain composition of its' mineral part situated in a very narrow range.

For brake efficiency tests an area with a base of reinforced uniform concrete plates coated with specialized basalt is built into the road structure. Its' length composes a total of 250 m.

To study the functionability of the vehicles' parking brake systems, the main road is provided with slopes of 8%, 12% and 18%.

Figure 8: General view of the dynamometric road (April 2009)

Besides the unique load-carrying capability, the dynamometer road is also a masterpiece when it comes to technical design and construction solutions to combine all the various test areas, and sites.

Figure 9: Formation of pavement (August 2007)

This allows to conduct the almost the whole range of vehicle test in search for their most significant parameters and indicators - braking, environmental (smoke, toxicity, noise), fuel efficiency, stability, controllability, etc., on a relatively small test area, while at other proving grounds special areas are needed for these purposes.

Figure 10: Test on bias

Conducted on a dynamometer road testing vehicles of various types - from motorcycles to heavy trucks, special vehicles (Amkodor, MWTP).

In the period from May 15, 2009 (date of certification dynamometric road with test sites of proving ground) on December 2009 at the Republican proving ground were tested vehicles of various categories, from L (motorcycles) to N3 (heavy trucks), M3 (buses, trolleybuses) and special equipment. Some of them were tested with the assistance of accredited testing centers JSC "MWTP", JSC "MAZ", "Belavtosertika" (BNTU). Were carried out test-drive cars of Mercedes-Benz and Porsche to obstacle negotiation, evaluation of stability and controllability, high-speed races.

From October 2009, in collaboration with the School of extreme driving, the construction of the 2nd stage of the Republic proving ground continues – a complex of buildings and structures which compose the laboratory, hangars for benchmark tests of the vehicles and there further preparation for road testing, and other buildings (FIG.11).

Figure 11: The test building of Republican proving ground

In the future we plan to design and construction of the third stage proving ground - high-speed ring road, sport routes, special sections for the endurance test vehicles.
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In the future there is a 3rd stage of building planned – speed ring road, sport tracks and a special purpose section (Fig. 12) for conducting vehicle endurance tests.

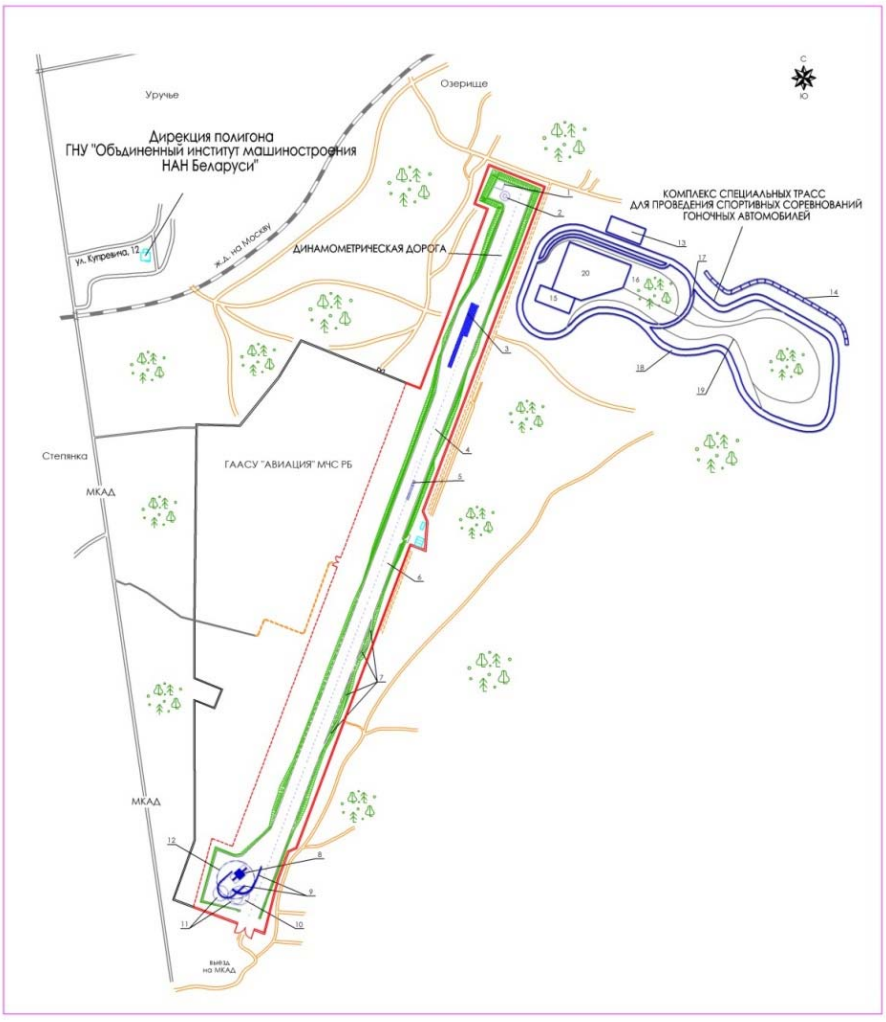

Figure 12: Speed ring road, sport tracks and a special purpose section of Republican proving ground

Conclusion

Taking in account all the above said, we should point out that the further innovational development of Belarusian automobile engineering shall be achieved with practical realization of scientific and technical projects and new knowledge, received during scientific researches, development work, experimental technological work on the basis of state science programs of different levels: fundamental, fundamentally oriented scientific research, applied, scientific and technical in competitive machines, equipment and technology.

The implementation of this task is possible only under the conditions of effective cooperation between science and industry. Cooperation with scientists of the joint institution of mechanical engineering is just as vital, due to the fact that it will from hereon play the role of the consolidating power in scientific support of the innovation chain in the domestic automobile building industry – starting from creating the novation (research and development) and up to the serial production. Only with the consolidation of scientific and technical potential of the industry, academic and higher educational sciences can the intensive innovative development of the domestic automobile building industry be provided in the 21st century.