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Locomotives in Service of Space[1]

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Научная статья

Локомотивы на службе космоса[1]

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On June 2, 1955, based on the directive of the General Staff of the Armed Forces of the USSR, the organisational and staff structure of the Research Test Site No. 5 was approved and its headquarters, military unit 11 284, was established. This date is considered the day of foundation of the first Baikonur Cosmodrome in the history of mankind.

At present Russia has such cosmodromes as Baikonur (Russia, Kazakhstan), Kapustin Yar, Plesetsk, and Svobodny. By the Russian Federation Presidential Decree dated November 6, 2007, the construction of another Russian cosmodrome, Vostochny in Amur region, began and was completed in April 2016 [1]. The structure of each cosmodrome includes facilities, utilities, and special equipment necessary for launching boost rockets. They are called sites or positions. There are launch and technical sites, a fueling and neutralisation station, a command and control post, a landing complex, a landing range, a range measuring complex, a material and technical base, and a living area.

The construction of the first Soviet cosmodrome was a competition with nature, an experience that later allowed preserving and multiplying Russia's space glory. The harsh climatic conditions significantly affected the pace of construction. In winter, the sandy soil froze to one and a half meters, so the sand had to be blasted. In summer, the wind in the region became parching: the temperature rose to 50°. The construction was carried out from scratch, in a bleak steppe, the only infrastructure element that existed at that time was the railway. A week after the first builders of the future cosmodrome got off the Orenburg – Tashkent line, echelons with machinery and workforce from all

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Fig. 1. Railway schedule at Baikonur cosmodrome[2,3]

corners of the Soviet Union began arriving at Tyura – Tam station. Later, the railway started delivering rockets for satellite launches and the spacecraft themselves.

Each site of the test ground began with extending a railway line built by railway troops to it. The first line went from Tyura – Tam station in the northern direction, where the construction of the famous launch site No. 1 began. However, it did not become famous at once, but six years later, on April 12, 1961, when Yuri Alekseevich Gagarin went into space from it. Although this launch pad had the title first number, rocket launches did not begin there. The first launch of the R-7 ballistic missile was carried out from another launch pad on May 6, 1957. By that time, the launch complex, assembly and testing and integration buildings, a concrete road and railway access roads had been built here.

Throughout the history of the cosmodrome until the 2010ies, all movement of cargo, materials and personnel was by railway, and relatively recently bus routes were allowed and organised for Baikonur workers (*Fig. 1*).

Motor locomotives, as Baikonur workers called the trains, consisted of compartment and interregional cars manufactured by Ammendorf (GDR). The trip to work took 1–3 hours depending on the remoteness of the site.

The total length of Baikonur railway is about 470 km. All railway tracks here are not electrified. The choice of the locomotives to provide the traffic is not accidental, because the transported structures are heavy cargo: the platform on which the booster lies, the rocket itself, the spacecraft.

The first locomotives sent to Baikonur were Э^{у} series steam locomotives manufactured by Lugansk Plant (*Fig. 2*). They were used during construction of the cosmodrome and for provision of the first launches.

It should be noted that steam locomotives were not involved in towing the rockets to the launch. They built roads and provided auxiliary traffic. They were replaced with diesel locomotives of ТЭ2 series operating in one and two sections, but their capacity did not prove sufficient (*Fig. 3*).

Fig. 2. Э^{у} series steam locomotives manufactured by Lugansk Plant

[2] Al photos are from: Locomotives in Service of Space. URL: https://opzt.ru/news/lokomotivy-na-sluzhbe-kosmosa
[3] Text of the inscription: TRAIN No.102. Gorodskaya st. – Severnaya st., departure at 5:54. TRAIN No. 101. Severnaya st. Gorodskaya st., arrival at 16:23.

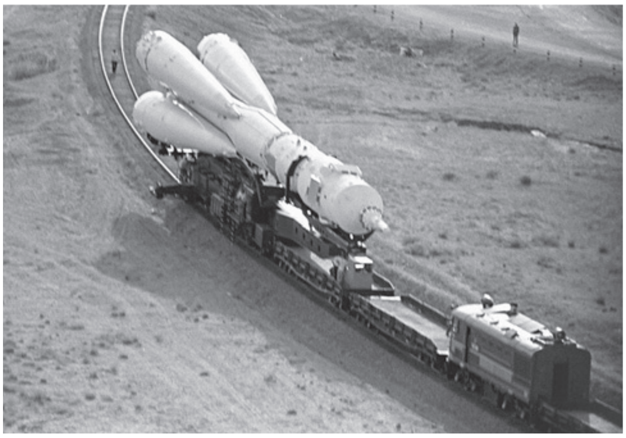

Fig. 3. ТЭ2 diesel locomotive

Fig. 4. Assembled full-scale mock-up of RN (rus. PH) Energy booster: 4M item in the process of transportation with ПТЭ3 diesel locomotives

In 1953, Lugansk plant produced a new locomotive: a ТЭ3 series two-section diesel locomotive with the engine power of 2 × 2000 hp. Mastering of the production of ТЭ3 diesel locomotives with 2Д100 diesel engines ensured the governments planned conversion of railway transport from steam power to diesel operation, and in 1956 the production of steam locomotives in the USSR stopped. From the early 1960ies to the mid-1980ies, ТЭ3 was the main locomotive on non-electrified railways of the USSR [2]. In 1966, the Baikonur management requested Lugansk plant to create a special locomotive for the cosmodrome. In the same year, ПТЭ3 (*Fig. 4*) appeared. Externally, they practically did not differ from their civil counterparts, but inside they had fundamental differences. In the same year a batch of three two-section ПТЭ3 (Nos. 2511, 2512, 2521) diesel locomotives was produced. Structurally, these were serial ТЭ3 which had automatic speed control at 10 km/h and the possibility of synchronous movement of two diesel locomotives on parallel tracks using the multiple unit system (MUS).

Subsequently, the complexes were transported to the tester stations and launch site by two parallel tracks with a center distance of 18 m using two specially converted 2М62 diesel locomotives (*Fig. 5*).

Later on, cosmodromes started using ТЭМ2УМ-201 shunting diesel locomotives produced by Bryansk Mechanical Engineering Plant. This was a consistent modification of ТЭМ2, the most widespread diesel locomotive in the USSR, with a diesel-driven generator capacity of 1,350 hp instead of the standard 1,200 hp due to the use of 1ПД-4А generators (*Fig. 6*).

It is also necessary to recall such an exclusive development as a battery-driven electric locomotive designed for transportation of inflammable and explosive cargoes. Druzhkovka Mechanical Engineering Plant produced three modifications of the electric locomotive for the cosmodrome: 11Т125 — for transportation of Cyclone booster, 11Т756 — for transportation of Zenit booster, 11Т186 — for transportation of Zenit-2 booster (*Fig. 7*, *8*) [3].

In the early 2000ies, the locomotive fleet of the cosmodrome gradually began renewing, and new diesel locomotives of ТЭМ2У and ТЭМ2УМ series were delivered (*Fig. 9*). They have been produced by Bryansk Me-

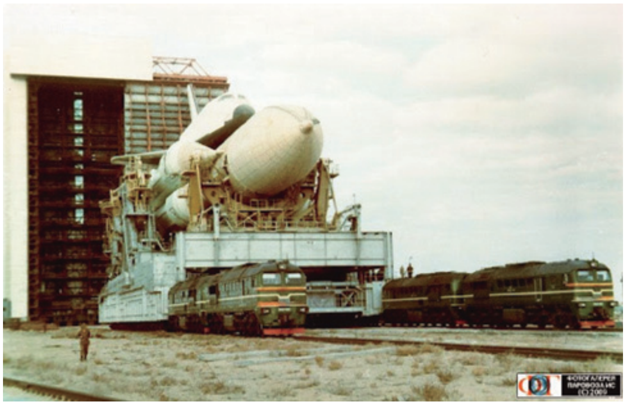

Fig. 5. 2М62 diesel locomotives

Fig. 6. ТЭМ2У diesel locomotive

Fig. 7. 11T125 electric locomotive produced in 1976 with a single-structure body for 11T125 units and T30 electric locomotives in the assembly and testing facility

chanical Engineering Plant. These locomotives started arriving both at Baikonur and Plesetsk cosmodrome. However, the diesel locomotives of this series are no longer used by twos, as ПТЭ3 and 3М62П, but by fours, with one from each corner of the platform.

Vostochny cosmodrome, the youngest of the domestic ones, uses the most powerful shunting diesel locomotives on its railway network: ТЭМ14 (*Fig. 10*). Their capacity is twice as high as that of ТЭМ2 — 2,400 hp [4].

Apart from ТЭМ14, diesel locomotives of ТЭМ7/ТЭМ7А series manufactured by Lyudinovo Diesel Locomotive Plant are also used (*Fig. 11*). Although their capacity is somewhat lower — 2000 hp, the "seventh" has proven itself to be good at large marshalling yards, in specific conditions of open-pit mines and coal pits. The latest video surveillance and pre-start heating systems have been introduced into the diesel locomotive design, which greatly facilitates the work of locomotive crews at the cosmodrome.

Railway transport has played a major role in the formation and development of the Russian space program. However, the role of domestic cosmonautics is also invaluable in the development of railway transportation.

Since 2008, Russian Railway OJSC has been implementing the Strategy for the Development of Railway Transport in Russia until 2030 [5]. This document

Fig. 8. 11T186 electric locomotive in the assembly and testing facility

Fig. 9. Transportation of Soyuz TMA-02M by ТЭМ2У diesel locomotive

Fig. 10. ТЭМ14 shunting diesel locomotive

Fig. 11. ТЭМ7А diesel locomotive

has established the priority areas, including the use of innovations in the industry. In the 2010ies, as part of the implementation of this strategy, the cooperation between railways and space has significantly expanded. One of the areas that is being successfully implemented at present is the implementation of the project for the development of fast and high-speed transportation.

The development of fast traffic necessitates the search for optimal solutions for infrastructure modernization. One of the ways to increase speeds is to increase the unbalanced acceleration in curves with their minimal change. It is in this area that Russian Railways OJSC and Yu. A. Gagarin Research & Test Cosmonaut Training Centre FSBI have been cooperating for several years. Space experience has provided the necessary data to ensure the safety of transportation at high speeds.

To determine the permissible travel speeds with regard to human exposure to unbalanced acceleration and vibrations, Russian Railways OJSC, in cooperation with the Cosmonaut Training Centre, conducted studies that determined the relevant regulatory requirements both for locomotive drivers and passengers (*Fig. 12*).

The result of the set of studies conducted by Yu. A. Gagarin Research & Test Cosmonaut Training Centre FSBI, VNIIZhT JSC, and VNIIZhG Rospotrebnadzor FSUE was the new regulatory requirements that ensure increased permissible passenger train speeds without negative consequences for passenger comfort and locomotive crew performance, while unconditionally ensuring traffic safety. The tests were successfully conducted in the 2010ies using ЭП20 locomotives and TALGO passenger cars (*Fig. 13*). The train ran along the Moscow – Nizhny Novgorod route.

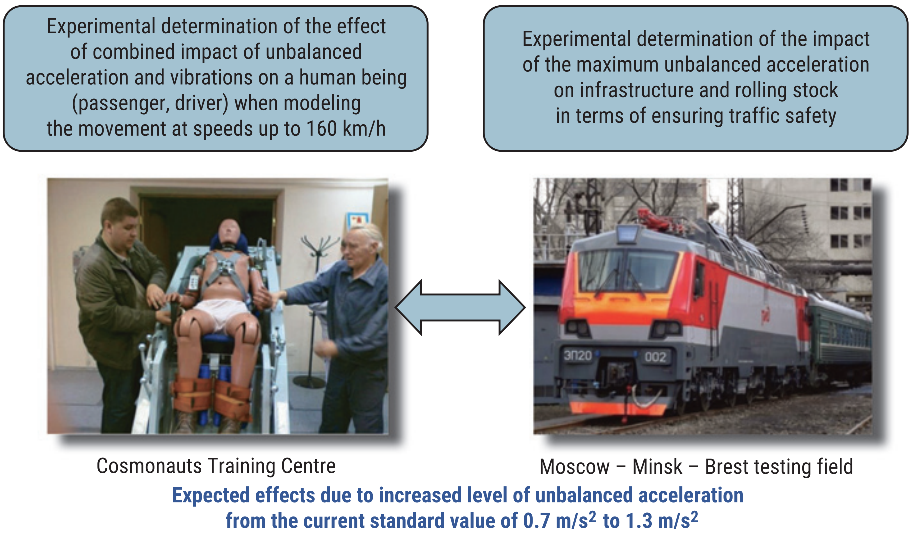

Fig. 12. Development of a regulatory framework for interaction between rolling stock and railway infrastructure

Fig. 13. ЭП20 locomotive

Similar studies of the complex effect of unbalanced acceleration on the human body were previously conducted more than 50 years ago by specialists of Leningrad Institute of Railway Transport Engineers and S.M. Kirov Military Medical Academy.

In 2024, on the eve of the Cosmonautics Day at 12:00:00 Moscow time, the first launch of the Angara-A5 booster with the Orion upper stage and test payload was carried out from 1A site of the newest Vostochny cosmodrome. This was the sixth launch of a Russian booster in 2024, including the second from Vostochny. For Angara-A5, this flight was the fourth in history and the first from Vostochny.

The booster was delivered to the launch complex by ТЭМ series diesel locomotives. In addition, many industrial enterprises of the railway industry contributed to the development flight tests of the Amur space rocket complex with Angara heavy-lift booster at Vostochny cosmodrome. The technological systems for the Angara space rocket complex were designed and manufactured by Uralkriomash JSC (part of Uralvagonzavod Concern JSC).

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