LOW-DENSITY LINES: STATE AND OPTIMIZATION OPTIONS

Vakulenko, Sergey P., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*
Kolin, Alexey V., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*
Evreenova, Nadezhda Yu., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

ABSTRACT

The methodology and methods of the conducted research are based on the system analysis and scientific generalization of domestic and foreign experience in operation and maintenance of low-density railway lines. At the same time, not only the current state in this sphere of transportation is evaluated, but also suggestions are made with regard to optimizing processes using technical re-equipment strategies, changing technologies, stimulating demand through organization of new types of service, and use of forms of public-private partnership.

Keywords: management strategy, low-density railway lines, cost-effective operation, freight and passenger transportation, optimization, methodology, differentiation of destination.

Background. *The solution of the problem of the efficiency of using low-density railway lines (LDRL) in a market economy is one of the priority tasks, which the transport industry is facing.*

Objective. *The objective of the authors is to consider main issues concerning operation and optimization of low-density railway lines.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, scientific description.*

Results. *The length of LDRL is 15 353 km, which is about 18 % of the entire network of railways. These are single-track lines, most of them are not electrified. General information on LDRL is presented in Table 1.*

On the network of JSC Russian Railways, low-density lines are located mainly in the European part of Russia, where the railway network has the greatest density. Moreover, the topology of LDRL does not coincide with the main vectors of cargo flows, which usually move in latitudinal directions. After all, LDRL are often lateral roads that connect latitudinal directions, or are their dead ends.

At the same time, LDRL provide connectivity and maneuverability of the network, increasing reliability of its operation in the event of possible technological failures, natural disasters, when there is a shortage of capacity during the periods of reconstruction, modernization of the main lines, etc.

Despite the fact that LDRL are low-loaded (an average of 3,5 pairs of trains per line per day) and, therefore, unprofitable, almost the same requirements are imposed on their maintenance as to the main lines.

Until 2015, there were no uniform criteria for classifying railway lines as low-density. The current criteria are presented in Table 2.

The distribution of signaling and communication facilities on LDRL as a percentage is illustrated in Pic. 1.

As the means of interval regulation, signaling and communication, the simplest means are used: semi-automatic blocking (66 % of the total length), electric-token system (12 %), telephone communication (7 %). Only on 11 % of the length of the lines automatic blocking and on another 7 % centralized traffic control are used. This indicates that most of the existing low-density lines were the same in the past (20–30 years ago).

Analysis of foreign experience allowed to identify the main trends in the operation of rail lines with low-intensity traffic [1–7]:

Table 1

General information about LDRL

№	Parameters	Indicators
1	Length	15353 km
2	Share of LDRL from the whole rail network	18,2 %
3	Share of electrified	14 %
4	Share of non-electrified	86 %
5	Share of single-track	100 %
6	Average length	55 km
7	Average number of «threads» of trains (of all categories) Including freight	3,5 pairs 2,1 pairs

Table 2

Criteria for classifying railway lines as low-density

№	Document	Criterion
1	«Charter of Railway Transport», Operation rules of the Russian Federation	Low freight traffic and poor performance
2	Order of JSC Russian Railways «On approving the methodology of classification and specialization of railway lines» No. 3048r dated December 23, 2015.	Total volume of movement of passenger and freight trains no more than 8 pairs per day
		Reduced load intensity 5,0 million t • km gross / km per year and less

Table 3

Ways to improve the efficiency of sections of low-density railway lines

№	Criterion	Ways to improve efficiency of LDRL	Country
1	Legal status	Closing of LDRL and transition of transportation to other types	Germany
		Transfer to the private sector on a competitive basis with a focus on intermodal companies that perform road and rail transportation	Netherlands
		State programs for transportation reorganization	USA
		Delivery of a part of the lines for rent, sale to third parties, change in the form of ownership; in some cases – closure	USA
		Rearrangement of LDRL into motor roads	Sweden
		Use of LDRL for organization of tourism services	Great Britain, Sweden
2	Traffic organization	Reduction of staff, number of positions	Finland, Sweden, Estonia
		Simplification of centralized traffic control	Germany
		Use of satellite navigation to control train movement	USA, Romania
3	Infrastructure	Automation and telecontrol, application of modern control technologies (for example, replacement of post and floor equipment with microprocessor centralization)	Switzerland
		Improvement of track state and electrification of sections	Sweden
4	Rolling stock	Use of special light-weight rolling stock	Germany, Sweden, Finland
5	Tariffs	Differentiated approach to formation of tariffs	Germany, Sweden

– use of satellite navigation to control the movement of trains, which leads to abandonment of a significant part of the outdoor equipment of the signalling and blocking division, which requires expensive cable networks (rail chains and axle counters, traffic lights, point and continuous ALS sensors);

– automation and telecontrol of centralization systems;

– prevalence of modern technologies (for example, replacement of post and floor equipment with microprocessor centralization), which allows reducing the staff and in the conditions of a high level of European wages to achieve a significant economic effect.

Methods of increasing the effectiveness of LDRL, implemented in foreign countries, are presented in Table 3.

The operation of LDRL in Europe is expensive, due to a large number of manual operations and the need for staff to receive and send trains at stations. Cost reductions can be achieved by reducing the need for staff, reducing the number of floor signals and determining the level of technical equipping LDRL that would be sufficient to ensure safety.

The introduction of foreign experience on the network of JSC Russian Railways, in our opinion, is advisable in the part of:

– organization of tourist service;

– staff reduction;

– use of a specialized rolling stock of a lightweight type.

When optimizing the work of LDRL, the following strategies can be applied:

1) technical re-equipment and changes in technologies that increase efficiency by reducing the loss ratio of the lines as a whole or their individual sections;

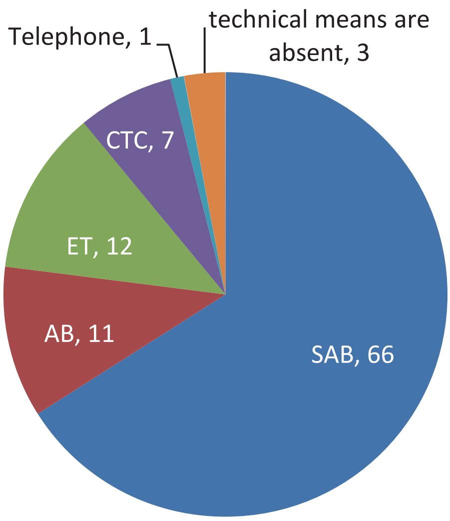
2) stimulation of demand for transportation through the organization of new types of services (tourism, etc.);

3) subsidies of federal or regional budgets, other legal entities and individuals;

4) transfer of LDRL or their individual sections to private ownership or lease to the balance of the party concerned, as well as the use of other forms of public-private partnership;

5) in the exceptional case, if no other measures are capable of increasing the efficiency of the work, with the appropriate justification, the closure of LDRL or their individual sections.

In accordance with the proposed strategies, LDRL can be divided into several types according to functions:



Legend: AB – automatic blocking;
SAB – semi-automatic blocking;
ET – an electric token system;
CTC – centralized traffic control.

Pic. 1. Equipment with means of signaling and communication, in % of the total length of LDRL.

Table 4

Options for optimizing the functioning of LDRL (sections)

Parameter under consideration	Types of LDRL (sections) by the functions performed			
	for social needs	for commercial needs	for federal state needs (defense function)	non exploited
Possible interested person/source of funding	Federal executive bodies, executive bodies of the subjects of the Russian Federation, municipal authorities	JSC Russian Railways, commercial organizations (industrial enterprises)	Federal executive bodies	JSC Russian Railways
Example	Novgorod–Novolisino, Ledmozero 1–Yushkozero (October Railway)	Kanzyba–halt 557 (Krasnoyarsk Railway)	Iliyno–Frolischi (Gorky Railway)	Soshno–Valutino (Moscow Railway)
Possible options of functioning optimization strategy	1, 2, 3, 4	1, 2, 3	1, 2, 3, 4, 5	1, 2, 3, 5

– for commercial purposes – profitable or potentially profitable, as well as those in which cargo owners are interested, willing to consciously go to increase their own costs (in connection with the transfer of LDRL to their balance) in order to preserve the markets for supply and/or sale;

– to meet social needs – with a view to supporting the vital activities of population centers gravitating towards LDRL;

– having a defensive significance;

– not exploited.

The options for optimizing the functioning of LDRL are presented in Table 4.

The most logical form of supporting lines for social needs is the justification of subsidies from the regional or federal budgets.

The analysis of the existing technology of the work of LDRL has made it possible to identify the main directions for increasing the efficiency of their work.

In the field of cost reduction:

- *rolling stock – transfer of LDRL for maintenance by rail buses, incl. on the combined run, and transition to low power locomotives;*
- *organization of traffic – combination of professions and positions, introduction of a mobile crew service system, application of the «single locomotive» technology (one train on a section);*
- *maintenance of infrastructure – combination of professions and positions, reduction of types and frequency of inspections, performance of works according to the actual state.*

In the field of increasing incomes:

- *organization of tourist services, including allocation of individual LDRL for its organization while preserving the social functions of the line for human settlements service. As a pilot project, Bologoe–Velikie Luki line (with a branch to Torzhok), which has a favorable location, is close to Moscow and St. Petersburg, in the zone of attraction of which are located popular tourist sites (Lake Seliger and others);*
- *increase in traffic intensity of suburban trains using buses on a combined run.*

Conclusions. *The analysis of domestic and foreign experience of operation of railway lines with low-intensity traffic has been carried out, offers have been made for optimizing maintenance and current maintenance of low-density sections.*

Taking into account the strategies used, emphasis is placed on differentiation of the functional designation of the lines, the efficiency of the traffic organization, the rolling stock and the maintenance of the infrastructure.

REFERENCES

1. Barbu, G. SATLOC – a system for train traffic control based on satellite navigation for low-density lines [*SATLOC – sistema upravlenija dvizheniem poezdov na baze sputnikovoj navigacii dlja malodejatel'nyh linij*]. *Zheleznye dorogi mira*, 2014, Iss. 6, pp. 63–67.
2. Train traffic control on low-density lines in Finland [*Upravlenie dvizheniem poezdov na malodejatel'nyh linijah v Finljandii*]. *Zheleznye dorogi mira*, 2004, Iss. 7, pp. 54–58.
3. Automation of low-density railway line Bern–Lucerne (Switzerland) [*Avtomatizacija malodejatel'noj zheleznodorozhnoj linii Bern–Ljucern (Shvejcarija)*]. *Zheleznye dorogi mira*, 2004, Iss. 10, pp. 76–77.
4. Grant, S. The 2007 Beeching Report – a preview. *Modern Railways*, 2006, Vol. 63, № 694, pp. 36–39.
5. Ingels, P.-E. Cost-effective train control on low-density lines. *Railway Gazette International*, 2010, № 6, pp. 40–44.
6. Westerfield, M. Le fret de proximité débarque outre-Manch. *Le Rail*, 2010, № 168, pp. 16–19.
7. Gärtner, E. US Railways: Features of Freight and Passenger Transportation [*Zheleznye dorogi SShA: osobennosti gruzovyh i passazhirskih perevozok*]. *Zheleznye dorogi mira*, 2007, Iss. 4, pp. 9–32.

Information about the authors:

Vakulenko, Sergey P. – Ph.D. (Eng), professor of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, k-gdsu@mail.ru.

Kolin, Alexey V. – head of the scientific center of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, alex5959@yandex.ru.

Evreenova, Nadezhda Yu. – Ph.D. (Eng), associate professor of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, nevreenova@mail.ru.

Article received 20.01.2017, accepted 14.04.2017.