Relational Effect of Preservation of the Wagon Fleet

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Keywords: Damage to the wagon, preservation of the wagon fleet, gravity hump, slid flat, JSC "VNIIZHT", relational strategy, complementary effect.

Abstract: The analysis is carried out and the causes of damage to wagons during freight operations are considered. It is proposed to consider the relations between the rail traffic participants as relational. A system of ranking indicators of profitability of enterprises from participation in the relational process has been developed. A relational model of the process of organizing the work on the preservation of the wagon fleet in Russian Railways JSC has been developed, it has been proved that the maximum effect for the preservation of the wagon fleet can be achieved only from joint projects to organize the processes of the preservation of the wagon fleet by financing infrastructure projects of Russian Railways JSC by private investors with further profit due to the implementation of investment projects.

1 INTRODUCTION

The structure of the organization of work to ensure the preservation of the wagon fleet was created in the Ministry of Transport of the USSR by conducting long-term research and accumulating experience in preventing damage to wagons en route. The limiting factor was the ownership of the wagons by one owner – the state. The emergence of wagon owners in parallel with the development of the market for the provision of railway transport services has led to a redistribution of functions and differentiation of interests of participants in the railway transportation market.

The leaders among the owners of rolling stock are First Freight Company PJSC, Federal Freight Company JSC and a number of others (Table 1).

During the post-war years, with the development of railway transport in the USSR, a system was built to ensure the preservation of wagons, aimed at improving the technical maintenance of the wagon fleet. An inspection for the preservation of the wagon fleet was established and actively operated in the Ministry of Railways. The tasks of the inspection included the development and implementation of measures to prevent damage to wagons. At the Department of Wagon Economy (in the Ministry of Internal Affairs - the main department of wagon economy), an apparatus of auditors for the preservation of the wagon fleet has been created.

In parallel with the creation of the structure for monitoring the preservation of the wagon fleet in the USSR, research, design and project work was launched to ensure the durability and survivability of the wagon fleet, both when creating new wagons and from the development of the rules for the operation

Table 1: The largest wagon owners and operators of rolling stock.

Ser. No.	Company name	Fleet of wagons	Date of establishment
1	PGK PJSC (First Freight Company PJSC)	110000	2007
2	FGK JSC (Federal Freight Company JSC)	134200	2010
3	Transcontainer PJSC	122000	2006
4	Neftetranservice JSC	70200	2006
5	Modum-Trans LLC	69000	2010
6	Globaltrans	68190	2008
7	GC RTC	68000	2008
8	SUEK	55000	2001
9	RailGo	31500	1997
10	Gazpromtrans LLC	30000	2002

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of the wagon fleet.

Advanced designs of wagons with metal sheathing, metal floor and sides appeared at that time, and the direction for the development and application of anticorrosive materials began to develop.

2 ORGANIZATION OF SCIENTIFIC RESEARCH IN THE FIELD OF WAGON FLEET PRESERVATION

In order to solve the issue of preventing damage to wagons at the end of the 60s of the last century, the All-Russian Research Institute of Railway Transport of the Central Research Institute of the Ministry of Railways (now VNIIZHT JSC) began work on creating a standard for ensuring the preservation of the wagon fleet during shunting and loading and unloading operations. This standard was called GOST 22235-1976 "Freight cars for 1520 mm gauge main line railways. General requirements for preservation during loading and unloading and shunting operations" (GOST 22235-1976, 2000). This GOST established the basic terms and definitions characterizing the damage to the wagon during its operation. A group of railway scientists under the leadership of the head of the laboratory of wagons of the Ural Branch of the Central Research Institute of the Ministry of Railways, Candidate of Technical Sciences Senderov, G.K., developed the basic principles of ensuring the preservation of wagons. For these purposes, studies, calculations, tests were carried out, since each figure included in the standard required confirmation. Thus, the works of S.A. Drugal are devoted to the development of systems for unloading frozen cargo and requirements for them, the works of V.V. Zubarev - to the rules of cargo transportation, the works of M.Yu. Pashkevich - to the reliability of wagon designs, the works of A.P. Stupin, M.L. Kamenomost, V.S. Usov, V.V. Kolomiichenko, S.G. Ivanov and other scientists - to maintenance issues (Drugal, 1974; Zubarev, 1968; Kolomiychenko, 1980).

The above-mentioned studies cover a wide range of issues related to the organization and management of the preservation of the wagon fleet for a period of almost 40 years, i.e. up to the moment when the division of the railway transportation market took place.

Already after the beginning of the reform of railway transport, in order to streamline the relationship between the owners (operators) of rolling stock, the owner of infrastructure, stevedores (owners of non-public tracks), as well as the wagon repair complex, attempts were made to process the regulatory documents in force at Russian Railways JSC. In 2010, under the guidance of the authors of this study, the standard for the preservation GOST 22235-2010 was revised (GOST 22235-2010, 2011), and later, in 2019, VNIIZHT JSC developed a standard for the organization of a non-profit partnership "Association of Manufacturers of Railway Equipment" (OPZHT NP) (STO OPZHT 00.000-2018), aimed at streamlining relationships within the organization.

To date, there is a situation in the industry when the requirements for the manufacture of new wagons, the operation of railway rolling stock are regulated by technical regulations (Technical regulations of the Vehicle, 2011) and Railway Operating Rules (Rules of technical operation of railways of the Russian Federation, 2019), and the requirements for preservation are voluntary.

There is a need to analyze statistical information, control the production activities of enterprises, and develop effective solutions for organizing the continuous process of preserving the wagon fleet.

3 ANALYSIS OF THE DAMAGE OF FREIGHT CARS ON THE RAILWAY NETWORK OF RUSSIAN RAILWAYS JSC

The losses of participants in the railway transportation market from damage to wagons on non-public tracks and during shunting work are enormous. And although in recent years there has been a tendency to reduce the number of damaged wagons, the overall dynamics of the growth of damaged wagons in the conditions of structural reform of railway transport remains at the level of 80 - 100 thousand damaged wagons annually. Thus, according to the management of the carriage economy of Russian Railways JSC, if in 2005 - 17,155 wagons were damaged on the railway network, 2007 - 43,500, 2010 - 57,806, then in 2013 - 118,380 cases were recorded. Currently, the situation has stabilized (Table 2), remaining at the level of 70-80 thousand wagons (Sverdlov, 2021).

Table 2: Damage on public and non-public tracks.

Indicator	Damaged wagons, total					
	2016	2017	2018	2019	2020	2021
Damaged wagons on the Sverdlovsk Railway have been identified	1071	1054	1058	1127	1004	1074
Damaged roads on the network have been identified	126715	117382	99976	95970	85950	70718

The main reason for the large number of damaged wagons is the result of their interaction with technical means of loading and unloading: rope grab buckets, car dumpers, vibrating rippers, unfreezing facilities, and other devices (Klavdienko, 2013; Lapshin, 2017). On railways serving sea and river ports, this is the use of clamshell technology for unloading coal from gondola cars (Lapshin, 2012), and the current technical and technological level of organization and conduct of cargo operations at industrial enterprises cannot guarantee the exclusion of risks of damage to freight cars. Figure 1 shows a graph diagram of the causes of damage to wagons on public and non-public tracks. The checks carried out on the roads to ensure the SVP, mechanisms interacting with the car, compliance with the requirements of GOST 22235-2010, technical conditions of loading and unloading mostly depend on the consent and "goodwill" of the owners of industrial enterprises and non-public tracks (Ministry of Internal Affairs of the Russian Federation, 1999; JSC Russian Railways, 2020; NZ1 Sverdlovsk railway, 2021). In addition, in the last two decades, the losses of wagon owners from the theft of components and parts of rolling stock have increased significantly (Table 3) (Korsakov, 2011).

There are about 180 gravity humps on the roads of the Russian Federation, including more than 20 fully automated humps, about 50 fully mechanized humps and 40 partially mechanized humps, which use car retarders of various designs (Savitsky, 2000).

On low-power humps, of which there are up to 70 units, gravity brake shoes are used for braking, which are placed under the moving uncouples with the help of special forks by the speed controllers of the wagons. On the Sverdlovsk road there are four non-mechanized gravity humps and six more humps where there are manual braking positions. Gravity brake shoes have a limited service life, as well as such a dangerous effect as "welding" the skid to the

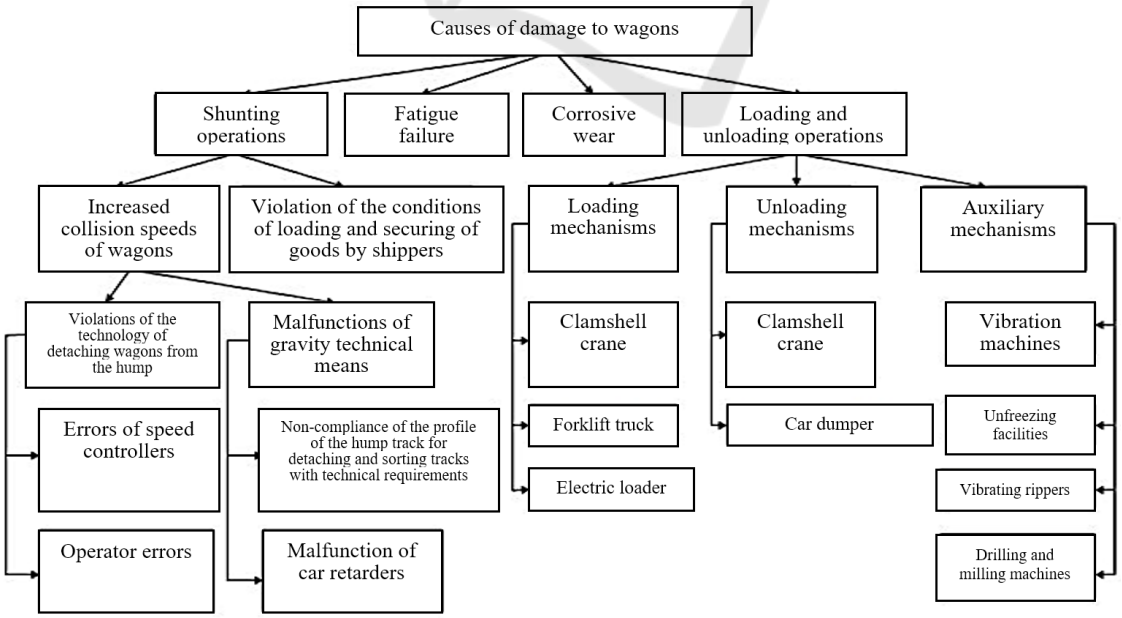

Figure 1: Causes of damage to wagons during shunting and cargo work.

Table 3. Identification of stripped down wagons on the Sverdlovsk Railway in 2020 and in 2021.

Year	Number of identified wagons with stripped down assemblies and parts	Number of missing brake equipment parts								Number of identified wagons with stripped down unbraked assemblies and parts	Auto-mode bearer bar
		Nipple	Fitting	Coupling	Supply tube	Auto Mode	Parking brake				
							Steering wheel	Thrust	Other		
2020	12285	477	102	3	232	1507	670	4598	329	307	4060
2021	39570	65	32	54	1270	4540	4140	9656	1570	1843	16400

rail during braking. The main disadvantage of using shoe braking is the formation of slid flats - thermal damage as a result of heat generation when the wheel rubs against the rail (Table 4). On the slid flats, as a result of heating and subsequent mechanical action, microcracks are formed, during further operation leading to discoloration of the metal and the formation of dents, which, in turn, lead to the formation of fatigue cracks in the disk or in the rim of the wheel (Tankeev, 2021).

Financial losses of Russian Railways JSC from the need to reimburse the owners of wagons for the repair of wheel sets caused by damage from slid flats and shelled treads account for a significant share of non-production costs. In 2021, Russian Railways JSC was sued by the owners of wagons for more than 660 million rubles in cases of wheel damage such as slid flats and shelled treads, most of which were satisfied by the courts (Puzanov, 2022) (Table 5).

In total, for the whole of 2021, the court recovered 481,194.9 thousand rubles on claims from wagon owners from the formation of slid flats and shelled treads from Russian Railways JSC.

Table 4: Identification of one-sided slid flats on gravity humps Sverdlovsk railway and the network of Russian Railways JSC.

Year		Type of gravity hump											
		M			PM			NM			Total		
		up to 0.5 mm	from 0.5 mm to 1 mm	more than 1 mm	up to 0.5 mm	from 0.5 mm to 1 mm	more than 1 mm	up to 0.5 mm	from 0.5 mm to 1 mm	more than 1 mm	up to 0.5 mm	from 0.5 mm to 1 mm	more than 1 mm
2021	Sv railway	0	0	0	268	6	1	253	18	0	521	24	1
	Railway network	152	9	0	3326	1198	5	9609	5913	130	13087	6120	106
2020	Sv railway	0	0	0	117	13	0	75	10	0	192	23	0
	Railway network	0	0	F	3261	1007	0	12004	5682	29	15265	6689	29
2019	Sv railway	13	10	0	8	6	0	4	0	0	25	16	0
	Railway network	70	31	0	2071	730	0	6212	3470	41	8353	4231	41
2018	Sv railway	18	13	0	15	12	1	0	0	0	33	25	1
	Railway network	870	48	0	256	326	1	5723	2155	65	6849	2529	66

Table 5. Amounts presented by recoverers for 11 months of 2021 on one-sided slid flats and shelled treads.

Recoverer (10 main wagon owners)	TOTAL		Slid flats, shelled treads		In favor of Russian Railways JSC	Against Russian Railways JSC
	cases	Amount of claims	cases	Amount of claims		
PGK PJSC (First Freight Company PJSC)	801	819877909.24	574	368198657.04	7554465.64	229673573.89
Locotrans CJSC	263	171561186.93	259	171244456.46	5513002.72	132910128.62
HC Novotrans	60	45434560.27	60	45434560.27	12150232.57	11653049.30
SGK LLC	60	23061080.09	59	23046886.47	11190447.82	3839606.38
Archbum LLC	46	18773552.33	40	18485063.62	1456114.10	13904165.09
Neftetranservice JSC	33	304501029.27	1	2959829.03	522114.87	2437704.16
SG-trans JSC	38	5552481.7	2	570850.81	0	570850.81
RK Novotrans LLC	14	18213746	2	1513883.00	0	1513883.00
TEK-NNE LLC	7	2350533.82	5	2282649.64	884276.38	1398373.26
TPK "Vostok-Resource" LLC	13	8922876.28	13	8922876.28	0	6366332.32
TOTAL	1683	1583505176.32	1096	664495429.59	42 410 932.9	405 600 718.52

4 DEVELOPMENT OF A RELATIONAL STRATEGY IN THE FIELD OF PRESERVATION OF THE WAGON FLEET

Considering the issues of the preservation of the wagon fleet, it is necessary to take into account the formation of a complementary effect for all rail traffic participants *(hereinafter referred to as RTP).* Historically, the concept of complementarity was introduced for the market when, with a decrease in the cost of one product, the consumer's interest in another product arises.

By participating in a complementary business, each rail traffic participant, acting as an investor, should receive a profit and additional remuneration to his main activity.

Changes that enhance the effect of each other are called complementary (Zimin, 2013). That is, the task of searching for complementary relationships in relation to the preservation of the wagon fleet is to search for such indirect effects that would ultimately surpass direct effects. As an example, we can cite the solution of the problem of preventing the formation of one-sided slid flats when braking cars on non-mechanized gravity humps and the formation of slid flats and shelled treads on the wheels of freight cars).

The term complementarity was first introduced in (Milgrom, 1990) and consists in the following formulation:

Several types of activities are considered complementary if an increase in the volume of any of them increases (or at least does not decrease) the marginal profitability of each of all other activities of this group.

As a result, the solution to the problem of ensuring the preservation of the wagon fleet, there is a need to create complementary assets, which consists in reducing the losses of Russian Railways JSC, owners of wagons and enterprises-owners of non-public tracks. Complementary assets are assets that complement each other in such a way that increasing one of them increases the efficiency of investing in the other, which ultimately creates a positive relationship between them.

Ensuring the complementarity of certain assets of all RTP leads to stimulating relations with companies that increase innovation activity by coordinating their activities with business partners (Salkina, 2015), transforming complementary activities into a relational strategy.

A relational strategy is a strategy aimed at forming the relational space of a specific RTP, as a set of bilateral ties between RTP and other participants in the railway transportation market, which create partnership advantages in order to make a profit (Krymov, 2013).

The relational effect Er is a complementary effect from the activities of a particular RTP in the technical, technological and socio-economic fields,

obtained by comparison with the complex effect of *Ec* from the activities of this RTP as an independent market entity without the use of concessional forms of management and private investments for a certain period of time t (t=0, 1, ... ζ) (Sirina, 2020):

$$E_{r_t} = \frac{\sum_{i=1}^{n} a_{i_t} q_{i_t}}{\sum_{i=1}^{n} q_{i_t}}, E_{r_t} \in R^t \quad (1)$$

where *a it is* an estimate of the output according to the i-th indicator of the off-project activity of the RTP; n is the number of indicators of off-project activity of the RTP; *q it is* the weight of the i-th off-project activity of the RTP

$$q_i = \frac{\frac{100}{\sum a_i}}{\sum_{i=1}^{n} \frac{1}{\sum a_i}} \quad (2)$$

The relational effect calculated according to the formula (GOST 22235-1976, 2000) means the maximum amount of additional income that each RTP can potentially count on, taking into account the impact of the external environment and a set of indicators of an out-of-project agreement on the object of the agreement.

The ranking of profitability indicators is carried out according to the following indicators:

- unsatisfactory,E *r* = 1 - there is practically no potential for cash income;
- satisfactory, E *r*=2 – there is a slight economic effect;
- good,E *r*=3 – provides a significant effect from additional activities on the part of a private partner on the object of the preservation of the wagon fleet;
- excellent, E *r*=4 – a high level of net discounted income, low financial risks, or their absence (striving for 0).

If we consider public-private partnership in the railway transportation market, then in general, the economic efficiency of investments by the state E *g* and the private concessionaire E *in* differs by the discount rate. For a private partner, the allowable interval is 3-10 years, for the state – up to 50 years, up to the non-return of the invested funds.

The peculiarity of the onset of the complementary effect in order to achieve acceptable indicators for ensuring the preservation of the wagon fleet is an identical payback period for all project participants, which should achieve the necessary effect over a period of 3-5 years.

Net discounted income is considered as a function of investments I and discount rates *E g* for Russian Railways JSC and *E in* for private partners.

$$NPVg=f(Ig+\Delta K; E\,g)$$

$$NPV\,in= f\Sigma(I\,in-\Delta K; E\,in), \quad (3)$$

where *NPV g is* the net discounted income of Russian Railways JSC, *Ig is* the investment of Russian Railways JSC at *E g, NPV* in *is* the net discounted income of the *i-th* private partner*, I in is the investment of the i-th private partner participating in the project,* n is the number of private partners participating in the project, the *ΔK – difference in investments of the i-th partner.*

The effect of the implementation of joint RTP projects can be represented as:

$$E=Ek+Er, \quad (4)$$

The relational effect of the private partner E *rin* can be defined as the weighted average value of the indicator E *r* for each participant of the relational strategy side for all indicators for the period t+1:

$$Erin(t+1)=B(Erin1 * y1)=(Er1/Ki)qk1, \quad (5)$$

where Kt is the number of participants of the PPP agreement party.

The relational effect is a compensating element in the business investment project and allows you to guarantee the replenishment of financial risks and receive additional profit from ancillary activities. For the public partner - Russian Railways JSC, this will be a reduction in losses from payments on claims of wagon owners for damage to wagons during shunting work and the passage of damaged wagons to the infrastructure when they are admitted, for owners of access roads - a reduction in losses from loading bad-order wagons, fines for repairing damaged wagons, the maintenance of a large number of wagon repair depots and those involved specialists. For the owners of rolling stock, the relational effect includes a reduction in the cost of maintaining wagons, especially for the organization of current uncoupling repairs, an increase in the service life of wagons to physical wear, a reduction in the staff of specialists servicing auxiliary non-production activities of concessionaire enterprises.

Figure 2 shows a relational model of the process of organizing work on the preservation of the wagon fleet.

5 CONCLUSIONS

In the conditions of changing external environment, the division of the wagon fleet and the appearance of many owners of rolling stock, the maximum effect for ensuring the preservation of wagons can be achieved from joint projects to organize the

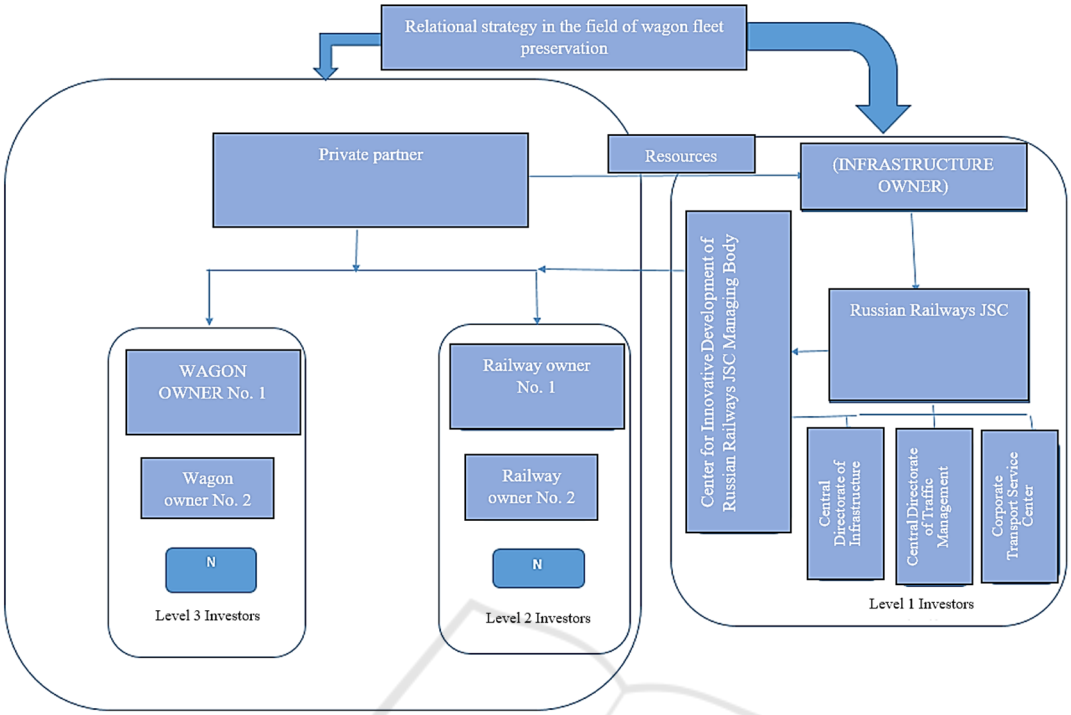

Figure 2: Relational model of the organization of the preservation of the wagon fleet.

processes of ensuring the preservation of the wagon fleet by financing infrastructure projects of Russian Railways JSC by private investors with further profit due to the implementation of investment projects.

The implementation of the proposed directions for the development of relations between rail traffic participants in the field of the preservation of the wagon fleet allows you to set targets for achieving the effects of the preservation of the wagon fleet, increase the attractiveness of investing money in safety as an object of investment, ensure compliance with regulatory legal acts concerning the preservation of the wagon fleet.

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