Complex Method of Optimization of Magnet Levitation Transport Systems and Determinations of Spheres of their effective Applications

Dipl.-Ing. Arkadij LASCHER
Technische Universität Dresden, Institut für Elektrische Verkehrssysteme
Mommsenstr. 13, D-01062 Dresden, Germany
Phone: +49 (0)231 / 24 10 - 41, Fax: +49 (0)231 / 589 90 - 65
e-mail: a.lasher@gmx.de

Dr.-Ing. Mark UMANOV
Faculty Railway and Railway Economy, Dnepropetrovsk National University of Railway Transport
2, Academy Lazaran, 049700 Dnepropetrovsk, Ukraune
Phone: +38 0567 / 33 19 - 12, Fax: +38 0562 / 47 18 - 66
e-mail: diit2000@a-teleport.com

Dipl.-Ing. Helen PRISHEDKO
Institute of the Transport Systems and Technologies of the National Academy of Sciences of Ukraine "Transmag"
5, Pisarzhevsky St., 320005 Dnepropetrovsk, Ukraine
Phone: +38 0567 / 37 21 - 85, Fax: +38 0562 / 37 21 – 86
e-mail: ivan@npkista.dp.ua

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Abstract

Maglev-systems begin to take root in modern life. It illustrates China, where presently one of the Maglev-systems puts down its root. The question of decision making as to effective application of Maglev-systems, taking into account preliminary optimization of their parameters, is most essential one. The complex method of the Maglev-systems optimization and determination of spheres of their effective application depending on transport type (main, suburban, industrial) and basic parameters of the Maglev-system are advanced in the present paper.

1 Introduction

In the present work the complex technique of optimization transport Maglev-systems and definition of spheres of their effective application are proposed.

To begin, we propose to implement a modular approach as to design and to construct Maglev transport systems. Three basic types of Maglev transport systems may be considered:

- utilized electromagnetic suspension [1];
- utilized electrodynamic levitation with superconducting magnets [2];
- utilized persistent magnet levitation [3].

There are four basic magnetic propellers, which, in turn, may have next types of linear drivers

- synchronous with the long stator;
- synchronous with the short stator;
- asynchronous with the long stator;
- asynchronous with the short stator.

2 Mathematical model Magnetbahn$_{Regio}$ – systems

Model Magnetbahn$_{Regio}$ – systems is the multi-parameter and multipurpose mathematical model sharing all possible technical and organizational solutions, corresponding to demands of the regional communication. The proposed model functions as follows:

depending on value of initial operational parameters the multiple assemblage of optimum technical-constructional solutions of Magnetbahn$_{Regio}$ - systems is determined taking into account organization of transportation and development of a transport infrastructure technically relevant to initial conditions. Choosing of an optimum design from the assemblage is inferred while technical and economic optimization is being made.

Maglev systems as well as linear drivers may be systematized accordingly various types and principles of magnetic suspension, taking into account every possible variant of their design.

All technically possible allowable variants and their combinations are picked out. Each picked out combination one has to convert into the detailed block diagram of its design, which is to be described with regard to allowable sizes, and used materials.

Further, based on the developed detailed block diagram for the design of the picked out variant one has to present the given design in a modular implementation. Thus, each module carries out the certain function in interacting with other modules within the framework of the certain group, describing one of subsystems of an over-all design of transport system [4].

Depending on variety of allowable sizes and used materials, the same type of the module (within the framework of one picked out) can be implemented in several varieties. The essential in module(s) development has to be defined as interchangeability with each other, at manufacturing as well as at exploitation Magnetbahn$_{Regio}$ – systems. This interchangeability is based on a principle of "designer".

It enables interchangeable adopting of many developed modules and units of chosen Magnetbahn$_{Regio}$– system with others within picked out variants of its design referring to the given transport technology. This is because of design similarity for uniform modules based on same transport technology.

Choosing an optimum solution of the organization of transportation and development of Magnetbahn$_{Regio}$ – systems infrastructure [5], one has to strive for to accomplish the following conditions:

- organization of direct (or with a minimum number of changes) transportation;
- possibility to deliver passengers closer up to a place of their destination (as optimum there could be a „ door to door "solution);
- maintenance of conveyance comfort with maximum independence for passengers which should replace alternatively whenever possible freedom car trip;
- opportunity of maintenance of container and batch conveyances in the joint passenger-cargo communication [6].

The organization of conveyances and decoupling of transport Magnetbahn$_{Regio}$ – systems infrastructure are close as to choosing optimum maglev or linear driver in transport technology and variant of its design. So, an organization of conveyances and a decoupling of transport infrastructure essentially influence final design Magnetbahn$_{Regio}$ – systems being optimized [7].

All Magnetbahn$_{Regio}$ parameters presented above can be subdivided into:

- subdivision of initial parameters determined by external conditions of applying and maintaining Magnetbahn$_{Regio}$ – system. Parameters of the this subdivision once accepted could not be changed;
- subdivision of proceeding Magnetbahn$_{Regio}$ – systems parameters which depend on parameters of the first subdivision and thus, accept various values.

First subdivision of parameters includes such as: a type of transport (main, suburban, industrial), the instanced volume of passenger traffic (taking into account possible cargo and piggy-back freighting) or the instanced traffic density (in case of industrial transport), route length, supervising and average gradient.

All other operational parameters are to be included in second subdivision.

All functional relationships between modules also obey mathematical equations.

Non-uniform modules are functionally related to each other within the framework of that variant to which they belong.

Uniform modules have functional relationship with other uniform modules, and also with any non-uniform modules within the framework of $\text{Magnetbahn}_{\text{Regio}}$ – system or only within the framework of one of maglev or linear driver transport technology, depending on a level of their unification.

Based on above-stated, for each case of $\text{Magnetbahn}_{\text{Regio}}$ – system construction there are parameters of the first subdivision which determine demands of its exploitation. The values of these parameters, by means of special mathematical model, determine maglev and linear-driver transport technology and variants of their designs technically accepted of imposed demands.

Optimization of each of variant $\text{Magnetbahn}_{\text{Regio}}$ – system is to determine optimum aspect and amount of modules being used.

3 Evaluation of technical and economic parameters $\text{Magnetbahn}_{\text{Regio}}$ – systems

For each technically suitable variant from picked out maglev or linear driver $\text{Magnetbahn}_{\text{Regio}}$ – system transport technology, calculation of technical and economic parameters depending on conditions of its maintenance is being made.

3.1 Evaluation of capital investments

Capital investments went into construction of a system are determined from the sum of expenses for construction of a transport infrastructure and exploitation of a rolling stock. Evaluation of capital investments is made according to simulation models of evolution of $\text{Magnetbahn}_{\text{Regio}}$ – system route up to evaluated term of its exploitation. In this connection the transport infrastructure has to be planed matching varying service conditions for the specified evaluated term.

Because of constantly changing volume of conveyances proceeding development of $\text{Magnetbahn}_{\text{Regio}}$ – system route will increase the volume. Depending on volume of conveyances for final year of an evaluated exploitation life needed amount of a rolling stock and the schedules of its traffic in rush hours are determined.

$\text{Magnetbahn}_{\text{Regio}}$ – the system can actively be used in transportation of demanded quick delivery freight paying by raised transportation tariff. For example, perishable cargoes, urgent post-office, parcels post and so forth. Adapting combined passenger-and-freight conveyances will raise efficiency $\text{Magnetbahn}_{\text{Regio}}$ – system and will extend area of its application.

To begin, total amount of passenger-and-freight conveyances is determined as a passenger turnover. To calculate a volume of a traffic density in a term of passenger traffic magnitude of the instanced volume of passenger traffic (P_p^a) we use expression as next

$$P_p^a = G * K_G \text{, Passengers / year} \qquad (1)$$

where

G - total amount annual traffic density, tons / year;

$$K_G = n_p/m_g, \qquad (2)$$

where

n_p - amount of passengers which can be placed in one carriage, i.e. passengers capacity of the carriage;

m_g - carrying capacity of the carriage.

The given method is used for determination of conveyance volume for final year of evaluated $\text{Magnetbahn}_{\text{Regio}}$ – system life. Proceeding from this the volume of passenger traffic for evaluated year (P_p^m) is determined from expression:

$$P_p^m = P_{p_1} * (1+q_p)^{(m-1)} + P_{p_1}^a * (1+q_G)^{(m-1)}, \text{ Passengers / year} \quad (3)$$

where

m - last year of a evaluated life of $\text{Magnetbahn}_{\text{Regio}}$ – system route;

P_{p_1} - annual volume of passenger traffic in both directions for 1st year of exploitation of $\text{Magnetbahn}_{\text{Regio}}$ – system route, Passengers / year;

$P_{p_1}^a$ - annual instanced volume of passenger traffic in both directions for 1st year of exploitation of $\text{Magnetbahn}_{\text{Regio}}$ – the system route replacing over-all traffic density, Passengers / year;

q_p - average annual coefficient of volume of passenger traffic change;

q_G - average annual coefficient of traffic density change.

Depending on volume of conveyances and amount of the rolling stock simultaneously exploiting $\text{Magnetbahn}_{\text{Regio}}$ – system route, simulation of mathematical model is making to evaluate schedule for final year of an evaluated life of $\text{Magnetbahn}_{\text{Regio}}$ – system route.

Based on this calculation, a type of way structure (single-track, double- track, siding single- track), general extension, single-track and station tracks and total amount of all other devices and constructions of $\text{Magnetbahn}_{\text{Regio}}$ – system route infrastructure are evaluated.

Calculating capital investments in infrastructure construction one has to take into consideration a cost of modulus as well.

Amount of trains simultaneously exploiting route (N_Z) is defined from expression:

$$N_Z = \frac{Q_h}{q_Z}, \text{ Trains} \quad (4)$$

where

q_Z - maximum passengers capacity of a train, Passengers;

Q_h - volume of passenger per hour in rush hours, may be evaluated from:

$$Q_h = \frac{P_p^m * K_Q}{365}, \text{ Passengers / hour} \quad (5)$$

where

K_Q - coefficient of instanced ratio of conveyance volume per hour in rush hours to total amount of daily average conveyances (for example: $K_Q = 0{,}18$);

365 - number of days in one year.

A size of ordered capital investments in manufacturing a rolling stock depends on its number (M_Z) and may be evaluated from expression

$$M_Z = N_Z^m * k_r, \text{ Trains} \quad (6)$$

where

N_Z^m - number of trains simultaneously exploiting $\text{Magnetbahn}_{\text{Regio}}$ – system route in rush hours for evaluated year. In this case, it is 1st year exploiting;

k_r - unexploited rolling stock coefficient.

Because of annual growth of conveyance volume, it is required in each succeeded year to maintenance a route as well as to make capital investments in additional rolling stock manufacturing and, consequently, extension of basis of its maintenance.

Besides this, technology development requires annual capital investments in modernization of $\text{Magnetbahn}_{\text{Regio}}$ – system route.

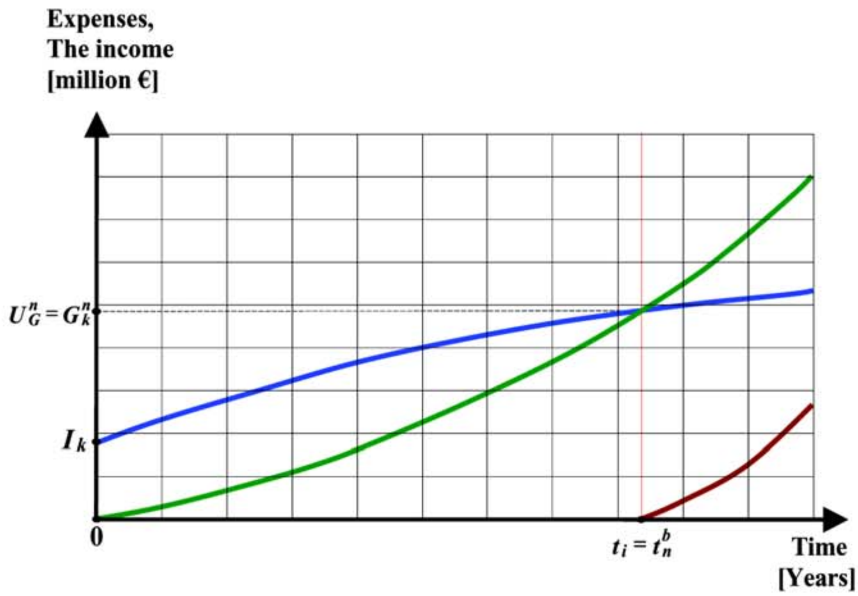
3.2 Evaluation of exploitation investments.

Exploitation investments sum cost of maintenance of $\text{Magnetbahn}_{\text{Regio}}$ –system route to keep it properly. Because annual conveyance volume is changing, exploitation investments for current year of evaluated life of $\text{Magnetbahn}_{\text{Regio}}$ –system route one has to calculate separately.

Exploitation expenditures directly depend on picked out transport technology $\text{Magnetbahn}_{\text{Regio}}$ – system and its variant.

3.3 Eure for construction of new $\text{Magnetbahn}_{\text{Regio}}$ – system routevaluation of total instanced expendit.

As one can see (**Fig. 1**), total instanced expenditures sum total capital outlays and total maintenance expense accumulated during exploitation of $\text{Magnetbahn}_{\text{Regio}}$ – system route.



- total instanced expenses;
- total instanced income;
- total profit;

G_k^n - total instanced expenses as to normative term of cost-outlay self-repayment;

U_G^n - total instanced income as to normative term of cost-outlay self-repayment;

I_k - capital investments in route construction;

t_n^b - normative term of cost-outlay self-repayment from beginning route exploitation;

t_i - term of cost-outlay self-repayment.

Fig. 1 Evaluation of the optimum transportation tariff for $\text{Magnetbahn}_{\text{Regio}}$ – system route

They may be evaluated as

$$G_k^m = \sum_0^m I_k^t * \eta_t + \sum_1^m B_k^t * \eta_t \text{, million €} \quad (7)$$

where

0 - time reference point (zero year). In this case, construction term of route is not taken into account because it is accepted approximately equal for all compared transport systems. Therefore all expenditure for $\text{Magnetbahn}_{\text{Regio}}$ – system route construction brought in zero year of putting route into exploitation;

1 - first year of route exploitation. In this case, exploitation expenses of $Magnetbahn_{Regio}$ - system route begin from first year of its exploitation, which is time reference point;

I_k^t - capital investments for current year, million €;

B_k^t - exploitation expenses for current year, million €;

η_t - coefficient taking into account a distance of expenses in a time, is evaluated from expression:

$$\eta_t = \frac{1}{(1+E_n^b)^t}, \tag{8}$$

where

t - current year of exploitation $Magnetbahn_{Regio}$ - system route, Years;

E_n^b - normative coefficient of reduction of occurring at different times expenses, is determined from expression:

$$E_n^b = \frac{1}{t_n^b} \tag{9}$$

where

t_n^b - normative term of cost-outlay self-repayment from beginning route exploitation is evaluated from expression:

$$t_n^b = t_n - t_b \text{, Years} \tag{10}$$

where

t_n - normative term of cost-outlay self-repayment, Years;

t_b - construction term of $Magnetbahn_{Regio}$– system route up to beginning its exploitation, Years.

3.4 Evaluation of total instanced expenses in case of $Magnetbahn_{Regio}$–system route construction instead of an acting route of a traditional transport system

In **Fig. 2** is shown that total instanced expenses, in case of $Magnetbahn_{Regio}$ – system route construction instead of acting route of a traditional type of transport, are defined from expression:

$$G_k^{mr} = \sum_{0}^{mr} I_k^t * \eta_t^r + \sum_{p+1}^{mr} B_k^t * \eta_t^r \text{, million €} \tag{11}$$

where

mr - last year of evaluated life of $Magnetbahn_{Regio}$ – systems route taking into account construction time, Years;

0 - zero year. In this case, beginning of $Magnetbahn_{Regio}$ – system route construction as zero year is accepted;

p - ending year of $Magnetbahn_{Regio}$ – system route construction and beginning of its exploitation;

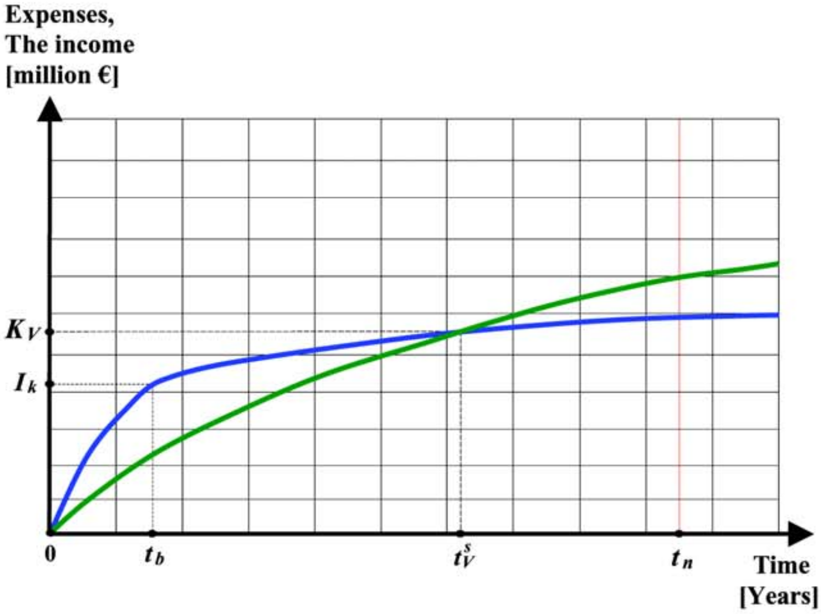
η_t^r - coefficient of in time distance accounting of expenses at replacement of the acting route with new one, is evaluated:

$$\eta_t^r = \frac{1}{(1+E_n)^t}, \tag{12}$$

where

E_n - the normative coefficient of reduction of occurring at different times expenses at replacement of acting route with new one, defined as:

$$E_n = \frac{1}{t_n}, \tag{13}$$



- total instanced expanses of $Magnetbahn_{Regio}$ - system route;
- total instanced expenses of acting traditional type of transport route from a moment of construction of $Magnetbahn_{Regio}$ - systems route;

K_V - value of total expenses intersection of $Magnetbahn_{Regio}$ – systems route and total expenses of acting traditional type of transport route;

t_b - construction term of $Magnetbahn_{Regio}$ – systems route up to moment of its putting into operation;

I_k - capital investments in construction of $Magnetbahn_{Regio}$ – Systems route, taking into account traditional type of transport acting route dismantling;

t_V^s - intersection time, total expenses of $Magnetbahn_{Regio}$ – systems route and the total expanses of acting traditional type of transport route;

t_n - normative term of cost-outlay self-repayment.

Fig. 2 Evaluation of effectiveness reconstruction of acting traditional type transport route by MagnetbahnRegio – systems route

3.5 Evaluation of total income of exploitation of $Magnetbahn_{Regio}$– system route

Total income of maintenance of exploitation of $Magnetbahn_{Regio}$ – system is defined as follow:

$$U_G^m = \frac{\sum_{1}^{m} P_p^t * T_p}{1*10^6}, \text{ million €} \quad (14)$$

where

1 - first year of exploitation of $Magnetbahn_{Regio}$ – system;

P_p^t - over-all annual volume of passenger traffic per current year of exploitation of $Magnetbahn_{Regio}$ – system, Passengers / year;

T_p - one way trip tariff per passenger $Magnetbahn_{Regio}$ – system route is evaluated:

$$T_p = T_p^s * L_S, \text{ € / Passenger*km} \quad (15)$$

4 Evaluation of optimum value of transportation tariff

In **Fig. 1** one could see, that optimum specific tariff of one passenger transportation per kilometer is defined from a condition of equality of self-repayment Magnetbahn$_{Regio}$ – system route term to normative term of cost-outlay self-repayment ($t_i = t_n^b$).

Proceeding from this condition, equality of the total instanced expenses with the total income as to normative term of cost-outlay self-repayment ($U_G^n = G_k^n$) should be carried out.

Minimally optimum value of the specific transportation tariff (T_p^s) may be evaluated from expression:

$$T_p^s = \frac{G_k^n}{\sum_1^n P_p^t * L_S}, \text{ € / Passenger*km} \tag{16}$$

where

- P_p^t - over-all volume of passenger traffic per current year being evaluated, Passengers / year;
- G_k^n - total expenses as to a normative evaluated Magnetbahn$_{Regio}$ – systems route life;
- 1 - first year of exploitation of Magnetbahn$_{Regio}$ – systems route;
- n - normative year of self-repayment of Magnetbahn$_{Regio}$ -system route.

5 Optimization Magnetbahn$_{Regio}$– systems

Optimum Magnetbahn$_{Regio}$ – systems technology as well as its design may be evaluated by a comparison of total expenses.

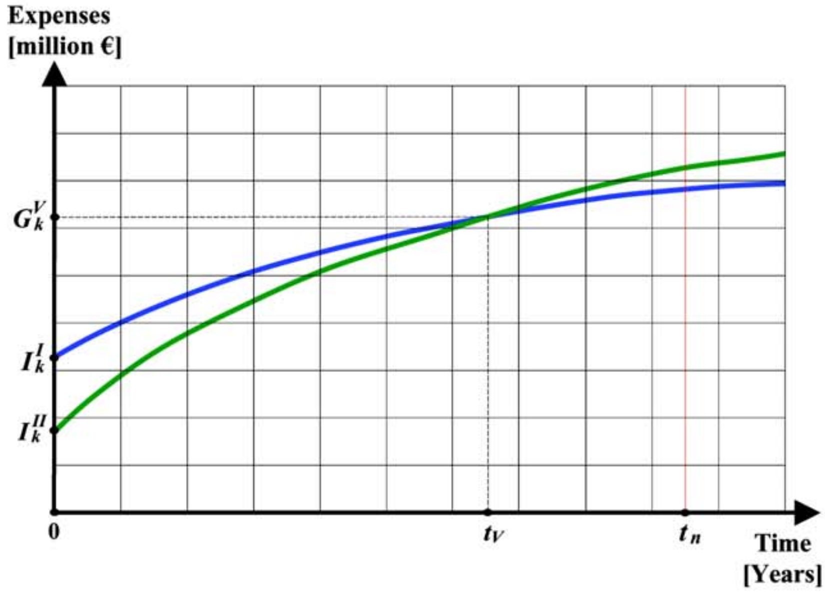
First, for concrete case of Magnetbahn$_{Regio}$ – systems route construction characterized by certain values of operational parameters, all technically suitable variants of maglev and linear- drivers transport technology of Magnetbahn$_{Regio}$ – systems would be evaluated. Then, for each of the picked out variants its total instanced expenses per evaluated life of Magnetbahn$_{Regio}$ – systems route one has to calculate.

At the following stage, comparison of total instanced expenses between two variants is made. Comparing total instanced expenses of two Magnetbahn$_{Regio}$ – systems variants one has to evaluate a term of equality of these expenses (t_V) .In case term of equality of the total instanced expenses (t_V) is not integer for current year, its exact value is evaluated as next:

$$t_V = \frac{(G_{k_1}^t - G_{k_2}^t) * \Delta t}{G_{k_2}^{t+\Delta t} - G_{k_2}^t - G_{k_1}^{t+\Delta t} + G_{k_1}^t} + t \text{, Years} \tag{17}$$

where

- t - current evaluated year, in which total expenses first of compared variants of construction of route Magnetbahn$_{Regio}$ – systems ($G_{k_1}^t$) still exceed the total instanced expenses of the second variant of its design ($G_{k_2}^t$), where $G_{k_1}^t > G_{k_2}^t$, Years;
- Δt - time interval with which calculation is carrying our, Years;
- $t + \Delta t$ - next year, after evaluated (t), in which total instanced expenses first of compared variants of Magnetbahn$_{Regio}$ – systems route construction ($G_{k_1}^t$) are already less than the total instanced expenses of second variant its) design ($G_{k_2}^t$), where $G_{k_1}^t < G_{k_2}^t$, Years.



- total instanced expenses of the first variant of Magnetbahn$_{Regio}$ - systems route construction;

- total instanced expenses of the second variant of Magnetbahn$_{Regio}$ - systems route construction;

G^V_k - value of equality of total instanced expenses of two compared variants of Magnetbahn$_{Regio}$ - systems route construction in a place of their intersection;

I^I_k - capital investments in the first variant of Magnetbahn$_{Regio}$ - systems route construction;

I^{II}_k - capital investments in the second variant of Magnetbahn$_{Regio}$ - systems route construction;

t_V - term of intersection of the total instanced expenses of two compared variants of Magnetbahn$_{Regio}$ - systems route construction;

t_n - normative term of cost-outlay self-repayment.

Fig. 3 Evaluation of an optimum variant of Magnetbahn$_{Regio}$ - systems route construction total instanced expenses comparing when term of equality of total instanced expenses of compared variants is *less* or *equal* to normative term of cost-outlay self-repayment

The given value (G^V_k) may be calculated from expression:

$$G^V_k = G^V_{k_1} = G^V_{k_2} = \frac{(G^{t+\Delta t}_{k_2} - G^t_{k_2})*(G^t_{k_1} - G^t_{k_2})}{G^{t+\Delta t}_{k_2} - G^t_{k_2} - G^{t+\Delta t}_{k_1} + G^t_{k_1}} + G^t_{k_2}, \text{ million €} \qquad (18)$$

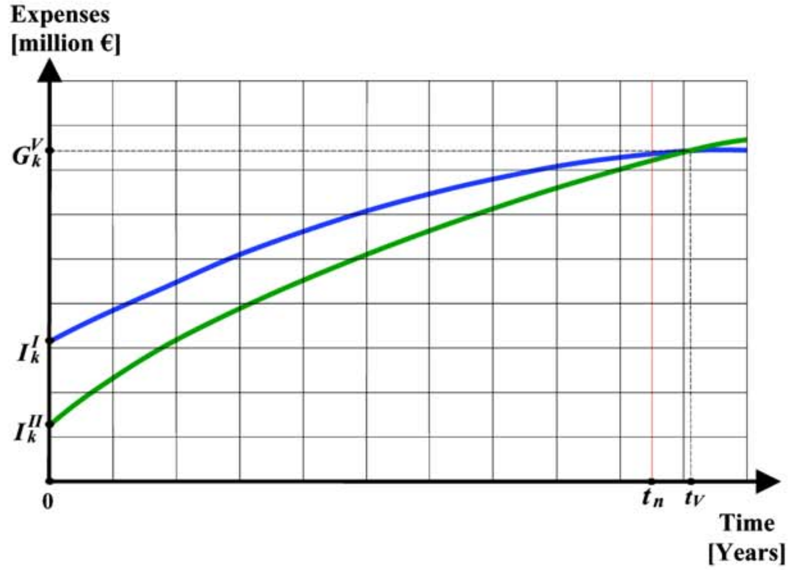
where

V - year of equality of total instanced expenses of two compared Magnetbahn$_{Regio}$ – systems route variants.

Evaluated term of equality of total instanced expenses of compared Magnetbahn$_{Regio}$ – systems route variants (t_V) have to be compared with normative term of cost-outlay self-repayment (t^b_n).

In case, term of equality of total instanced expenses of compared variants is less or equal to normative term of cost-outlay self-repayment ($t_V \leq t^b_n$) the variant of Magnetbahn$_{Regio}$ – systems route with greater value of capital investments in route construction (F**ig. 3**) is chosen.

In case, term of equality of total instanced expenses of compared variants is more than normative term ($t_V > t^b_n$) the variant of Magnetbahn$_{Regio}$ – systems route *with* smaller volume of capital investments in route construction is chosen. (F**ig. 4**).



- total instanced expenses of first variant of Magnetbahn$_{Regio}$ - systems route construction;

- total instanced expenses of second variant of Magnetbahn$_{Regio}$ - systems route construction;

G_k^V - value of equality of total instanced expenses of two compared variants of Magnetbahn$_{Regio}$ - systems route construction in a place of their intersection;

I_k^I - capital investments in Magnetbahn$_{Regio}$ - systems route construction in first variant;

I_k^{II} - capital investments in Magnetbahn$_{Regio}$ - systems route construction in second variant;

t_V - term of intersection of total instanced expenses of two compared variants Magnetbahn$_{Regio}$ - systems route construction;

t_n - normative term of cost-outlay self-repayment.

Fig. 4 Evaluation of an optimum variant of Magnetbahn$_{Regio}$ - systems route construction comparing total instanced expenses. In this case, term of equality of the total instanced expenses of compared variants is *more* than normative term of cost-outlay self-repayment

6 Evaluation of efficiency of application Magnetbahn$_{Regio}$ – systems in comparison with traditional types of transport

Comparison technical and economic parameters Magnetbahn$_{Regio}$ – systems with parameters of other types of transport purposing evaluation of efficiency of its application can be made for two cases:

- evaluation of efficiency of application Magnetbahn$_{Regio}$ – systems in comparison with other types of transport new route constructing;
- evaluation of efficiency of acting traditional type of transport route replacement by Magnetbahn$_{Regio}$ – systems route.

In first case, the comparison based on specific tariff of conveyance of one passenger per kilometer (T_p^s) is used.

As it was mentioned above, for picked out optimum variant of Magnetbahn$_{Regio}$ – systems route optimum value of its specific transportation tariff is evaluated.

Then derived value of specific transportation tariff Magnetbahn$_{Regio}$ – systems is compared with acting tariffs for conveyance by traditional and new types of transport. If value of specific transportation tariff is unknown (for example, novel types of transport), value of the unknown tariff is evaluated similarly through **expression (16)**.

In case, value of specific transportation Magnetbahn$_{Regio}$ – systems tariff is less than other transportation tariffs of other compared types of transport, one has to choose Magnetbahn$_{Regio}$ – the system as optimum type of transport for new route construction.

In second case, comparative analysis in two stages is made.

At first stage comparison of value of specific transportation tariff of Magnetbahn$_{Regio}$ – systems route and tariff of acting traditional type of transport route is carried out.

After comparison of transportation tariffs, if future Magnetbahn$_{Regio}$ – systems route appears to be more effective than acting route, second stage of the comparative analysis is made.

At second stage comparison of the total instanced expenses of Magnetbahn$_{Regio}$– system route with total exploitation expenses of acting traditional type transport route is carried out.

Even, if Magnetbahn$_{Regio}$ – systems route is more effective than acting traditional type transport route, one has to take into account significant capital investments in replacement required, with regard of dismantling of existing route expenses. Therefore, over-all cost-outlay as to normative evaluated life of Magnetbahn$_{Regio}$ – system route regarding construction term (t_n) should not exceed total operational expenses of acting route during the same time span (t_n). Otherwise, investments being made into replacement of acting traditional type of transport route by Magnetbahn$_{Regio}$ – system will be economically non-effective.

First of all, term of equality of the total instanced expenses of Magnetbahn$_{Regio}$– systems route as to total exploitation expenses of acting traditional type of transport route (t_V^s) is evaluated. Thus, total instanced expenses of Magnetbahn$_{Regio}$ – systems route (G_k^{mr}) through **expression (11)** are being made.

Total maintenance expenses of acting traditional type of transport route (B_{ks}^{mr}) are evaluated from expression:

$$B_{ks}^{mr} = \sum_{0}^{mr} B_{ks}^{t} * \eta_t \text{, million €} \tag{19}$$

where

B_{ks}^{mr} - maintenance charges of acting traditional type of transport route, million €;

η_t - coefficient of removal expenses which may be evaluated through **expression (12)**.

Term of equality of total instanced expenses of Magnetbahn$_{Regio}$ – systems route with total maintenance expenses of acting traditional type of transport route (t_V^s) follows from condition

$$B_{ks}^{V} = G_k^{V} \tag{20}$$

where

V - year of given expenses equality.

If term of equality of expenses (t_V^s) fall on integer, further calculation is not required. Otherwise, exact value of term of equality (t_V^s) may be determined as

$$t_V^s = \frac{(G_k^t - B_{ks}^t) * \Delta t}{B_{ks}^{t+\Delta t} - B_{ks}^t - G_k^{t+\Delta t} + G_k^t} + t \text{, Years} \tag{21}$$

where

t -current year when total instanced expenses of Magnetbahn$_{Regio}$ – systems route (G_k^t) are still *more* than total maintenance expenses of traditional type of transport route (B_{ks}^t), where $G_k^t > B_{ks}^t$, Years;

Δt - time interval of calculation carrying out, Years;

$t + \Delta t$ - next current year when total instanced expenses of Magnetbahn$_{Regio}$ – systems route ($G_k^{t+\Delta t}$) are already *less* than total maintenance expenses of traditional type of transport route ($B_{ks}^{t+\Delta t}$), where $G_k^{t+\Delta t} < B_{ks}^{t+\Delta t}$, Years.

Evaluated exact term of equality of compared expenses (t_V^s) has to be compared with normative term of cost-outlay self-repayment (t_n). If term of equality of expenses is less or equal to normative term ($t_V^s \le t_n$) then replacement acting traditional type of transport routes with Magnetbahn$_{Regio}$ – system will be economically effective and justified.

Value of equality of total instanced expenses of Magnetbahn$_{Regio}$ -system route and total operational expenses of acting traditional type of transport route can be also precisely calculated (K_V) through expression:

$$K_V = G_k^V = B_{ks}^V = \frac{(B_{ks}^{t+\Delta t} - B_{ks}^t) * (G_k^t - B_{ks}^t)}{B_{ks}^{t+\Delta t} - B_{ks}^t - G_k^{t+\Delta t} + G_k^t} + B_{ks}^t \text{, million €} \quad (22)$$

where

V - year when total instanced expenses of Magnetbahn$_{Regio}$ – systems is equal to total maintenance expenses of acting traditional type of transport route.

7 Conclusions

The area of effective application Magnetbahn$_{Regio}$ – systems in the regional communication [8] aggregates from effective application spheres (**Fig. 5**). The given spheres are computed in 3-D space characterized by the basic external operational parameters.

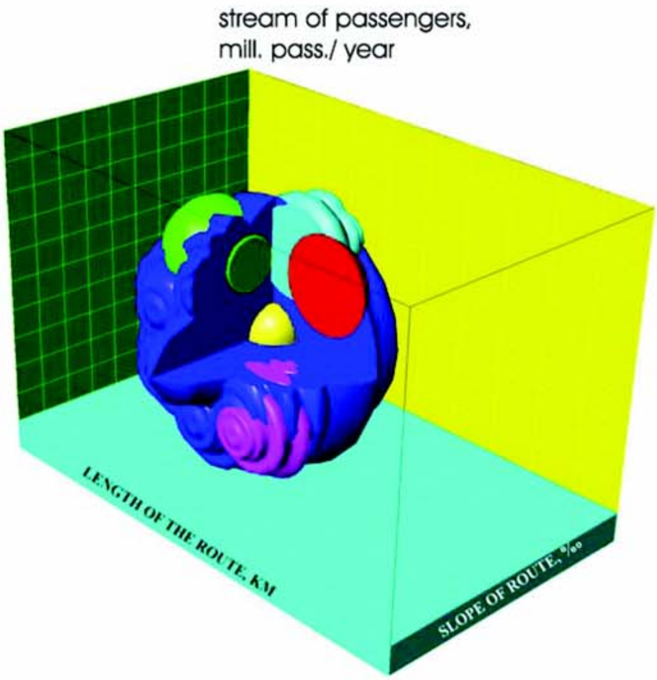


Fig. 5 Figure of effective Maglev-system application.

As basic external operational parameters a volume of annual conveyances, extension and leading route gradient are accepted.

For each of the specified parameters minimal and peak values as well as an interval of modification are evaluated.

Any point in 3-D axes of basic operational parameters is determined by concrete values. Besides, the same point is determined through still fixed additional operational parameters belonging to its specific accepted combination. Thus, any of points, within the framework of 3-D axes of the basic external operational parameters is determined specific values basic as well as additional external operational parameters.

Because, comparison of $Magnetbahn_{Regio}$ – systems efficiency with other types of transport would be made independently supposing construction of new route as well as independently supposing replacement of acting traditional type of transport route by $Magnetbahn_{Regio}$ – system then each combination additional operational parameters, sphere of effective $Magnetbahn_{Regio}$ – systems application should be evaluated independently too.

8 References

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