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CUSTOMER-ORIENTED SERVICE DEVELOPMENT METHODS IN SUBURBAN RAILWAY TRAFFIC, FOCUSED ON THE BUDAPEST SUBURBAN RAILWAY DEVELOPMENT PROJECT

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Abstract

This paper introduces suburban railway passenger development from a customer-oriented point of view. It focuses on the development of timetable, through which the requirements of railway commuters can easily be met. This document introduces a regular interval timetable development by means of value analysis in the frame of a Budapest Suburban Railway Development Project, emphasizing the assessment possibilities of timetables. Finally this paper determines the conditions which are necessary for further developments of suburban timetables, and introduces a recommendation for the process of development.

Keywords: timetable development, regular interval timetable, suburban railway traffic, value analysis.

1. Introduction

One of the efficient solutions for reducing traffic problems caused by suburbanization is to emphasize public transportation, railway passenger transport in principle. In order to create the competitiveness of suburban railway traffic, there is a need to realize a long-term system approach development programme focusing on the demands of the passengers. Priority should be granted to those of efficient development tools, which could support retaining or slightly expanding the market position in a short run while using a fairly low investment.

2. Characteristics of Suburban Traffic

2.1. Commuting as a Lifestyle

Deterioration of life quality indicated by economic development, rising living standards and economic damage has led to suburbanization in the Western European cities. However, 10–15% of the citizens have moved to the agglomeration to enjoy a more sustainable environment. On the other hand they had to face the uncomfortable fact that due to the lack of administrative and infrastructural services it is a must to travel back to the city every day. It is a significant characteristic that the commuters not only go to school and to their workplaces but to satisfy their entertainment needs as well. It must be taken into consideration that commuting habits are changing. The beginning of the work in the city is slowly shifting to 9:00 AM, while the work often ends after 6:00 PM. The number of employees working in flexible worktime, university students etc. is steadily increasing.

The commuters generally travelled by car, but the roads leading to the cities were not prepared for mass traffic. The traffic infrastructure problems immediately occurred as the suburbanization has begun. The most efficient solution would have been public transportation, more precisely the guided land transport in order to avoid the constant traffic jam on the roads.

2.2. Passenger Demands in the Suburban Traffic

Suburban traffic can only be efficiently offered in individual transportation if commuters' demands are completely stated. From Western European experiences it can be declared that commuters prefer short journey time and frequent services to comfortable travelling. As a consequence, both already existing and potential commuters have the following expectations towards rail traffic. *Fig. 1* shows the coherence of passenger satisfaction, the correspondence to passengers' demands and priorities of developments. [1].

3. Development Possibilities in the Suburban Railway Traffic

The railway companies can easily meet the expectations of the commuters adapting their demands on the following development areas:

- timetable development,
- travel comfort improvement,
- standard of services at the stations,
- prices, tariffs.

The parameters mentioned above achieve the long term purposes in synergy although priorities based on investment and feasibility studies must be declared regarding customer demands.

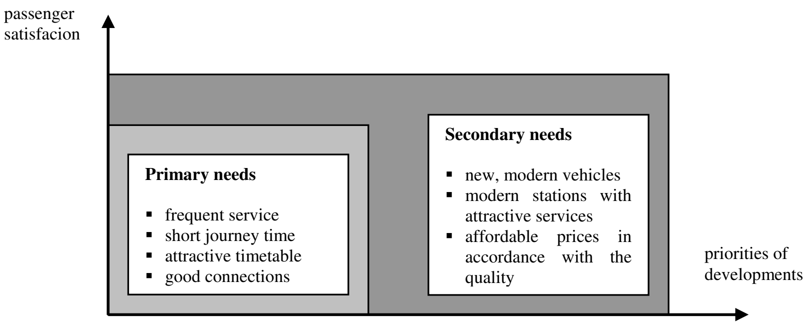

Fig. 1. Coherences of passenger satisfaction, the correspondence to passengers' demands and priorities of developments

3.1. Timetable Development

The timetable has the most connections with service development. The timetable has strategic importance, since it plays significant role in the planning process of optimal infrastructure and rolling stock development [2]. The market position of the railway passenger transport is significantly influenced by the quality of the timetable. However timetable development can only be efficient keeping the market position, if not only one line or train but the whole system is developed. In most of the Western-European countries there are complex timetable development programmes focused on a regular interval timetable structure. Based on the characteristics of road traffic which assures better mobility than railway transport, service frequency and short journey time are the most essential elements of timetable supply.

3.1.1. Regular Interval Timetable

Regular interval timetable means an easy-to-remember timetable system for the travellers with unambiguous information system. The technological operations are periodic, track utilization is optimal, and vehicle demand is minimal. Regular interval timetables were introduced in the suburban traffic of many European countries as early as 1960.

The whole service system must be organized and developed in advance while market supply will presumably only appear as a consequence of reliable existing demand. The supply strategy can be efficient on one hand as an alternative of individual transport, and on the other due to economic reasons, coming from constant high cost ratio of railway transport (by an attractive timetable offer combined with a relatively small variable costs, in case of increasing the traffic efficiency [trainkilometer or seatkilometer] the marginal revenue exceeds the marginal costs, so efficiency improves.)

3.1.2. ITF – more than a Regular Interval Timetable

ITF[1] means a complex network-wide regular interval timetable structure with systematic and symmetric connections, covering every layer of the public transportation system. A modern intermodal timetable structure relies on three basic factors: periodicity, symmetry and the everywhere-to-everywhere connection system at the network nodes. The greatest advantage of the system is: it is able to provide new, attractive passenger services without requiring expensive investments. The basic intermodal public transport system can be developed on the infrastructure at disposal. ITF 'automatically' highlights those bottlenecks the liquidation of which is essential to improve the timetable (increase of service frequency, decrease of journey time). [3]

The first real ITF system was introduced in Switzerland in 1982. The new system provided 21% increase in the number of train services, with only 4% increase of costs. As a consequence of the unquestionable results, the system has spread all over in Europe. ITF has reached such amazing results in Switzerland that infrastructure development became inevitable to satisfy the increasing passenger demands. In the programme called 'Bahn 2000' launched by SBB, the cost-effective infrastructure investments optimalized to the timetable structure enabled SBB to a further 12% increase in the number of trains from 12th December, 2004. [4]

3.2. Characteristics of Travel Comfort

In order to win the potential commuters travelling by car over to railway traffic, it is essential to improve the existing comfort level. The modernity and the convenience of the vehicles measurably determine the comfort of travelling. Based on experiences it can be stated that the comfort level is not only a subjective element but it also strongly influences the travelling willingness. In spite of the fact that the decrease of the comfort level does influence the number of travellers, it means a great extra cost for the railway company.

By satisfying the *basic requirements* which cover the essential needs, the already existing commuters can be kept (clean and attractive interior, safe vehicles, appropriate temperature, and high standard quality toilets). The *complimentary requirements* are to be fulfilled to get new travellers who otherwise are not commuters (comfortable seats, multi-function area – place for bicycles and wheelchairs, wheelchair-accessible toilets). By satisfying the *comfort requirements* the users of the high quality road transportation system may be induced to travel by train (low floored and air-conditioned vehicles, first class service, automatic integrated information system, dining car, closed-circuit toilets) [5]. However, it supposes new vehicle investments where the expenditures are recovered only in long term.

[1] Integrierter Taktfahrplan: Symmetrical regular-interval timetable. Also known as 'Intelligent Timetable', or 'Clockface schedule'.

3.3. Station Infrastructure Development

Intermodality, P+R and B+R services are primary demands at the railway stations. By improving these services the market position can be developed as well. Covered and high platforms, clear access and underpasses/overpasses are basic requirements. Information system and ticket offices are also primary service in suburban transportation.

Similarly to vehicle development, station service development can only be executed also in long term and by significant investments.

3.4. Suburban Tariff-Structure

It is necessary to introduce attractive tariffs as well as tariff systems, which are corresponding to basic requirements of price/value ratio, and proportional to the usage, as well as enables the competitiveness of public transport against the individual transport.

The traffic associations in Western European countries have been starting to evolve already in the 70's. The common tariff system and the adjusted timetables developed within the frames of transport associations, contributed – if only to a small extent – to the improvement of competitiveness.

The information assured by the up-to-date, comprehensive ticket validitation system, which incorporates the whole passenger traffic by directions, enables the effective development of traffic system corresponding to the passenger traffic.

4. The Budapest Suburban Railway Development Project

In 2004 according to the current strategy of the Hungarian State Railways (MÁV Rt.) a project called Suburban Railway Development Project was started.

4.1. The Aim and the Results of the Project

The aim of this project is to determine the passenger's demands to provide better services with a basically new timetable structure, with new vehicles and infrastructure developments.

Declared objectives in suburban service development include:

- introducing regular interval timetables on each suburban railway line with increasing the service frequency,
- modernizing the vehicle stock by reconstruction and purchase (improving comfort on the trains),

- improving infrastructure at the stations by modernizing the platforms and by creating P+R and B+R system,
- modernizing information systems and settling ticket vending machines.

The result of the project – from the point of view of the passengers – is a plannable, comfortable daily journey on favourable price while the journey time is shorter. Decreasing number of accidents and improvement of environmental conditions are considered as advantages for the public.

The advantage for the MÁV is the dramatic increase of the number of passengers, thus the increasing income and the constant capacity utilization. The decrease of road traffic is a great advantage to the capital Budapest. As a result of the suburban programme the capital receives the following advantages of the project:

- the number of cars arriving at the capital is decreasing, what is very favourable for road traffic and parking as well. Thus, in some cases road investments way be delayed
- less traffic causes less environmental damage (noise, vibration, accidents)
- new lines and stops help to divide the commuters within the capital.

4.2. Characteristics of Suburban Traffic in Budapest

In the past 15 years the population of Budapest has decreased by about 300.000. More and more people move to the rapidly growing cities within a distance of 50–60 km-s around the capital. This mass migration out of the city and into the suburbs resulted in a formidable increase of commuters. On each day about 600.000 people commute between the city and the outskirts. Present partition of Budapest commuters according to transport methods is: by car 68%, by suburban train 16% and by bus 16%. Should no significant changes happen in the field of public transport in the coming years the proportion of suburban commuters of the public transport will be decreasing to 20%.

However, in the past 5 years the number of passengers travelling by train in the suburban area stagnates, what clearly shows that the time has come for the railways to respond. Most of the existing suburban timetables do not mean a real alternative for the commuters while the journey time is relative long, the service frequency is very low, and the peak hours have postponed.

4.3. Commuters of Budapest – Determining the Demands of the Commuters

In 2004 a non-representative survey was made on the homepage of the Hungarian State Railways to determine passengers' priorities for improvements to the quality of suburban railways. The major finding of the study was that most of the passengers require short journey times (31%), frequent services (25%) and no crowded trains (17%), while the comfort (13%) and the price (14%) seem to have much less importance. In the meantime, another survey was made of the commuters travelling by car to/from the city. 84% of the responders said that the most important reason for using the car is the short journey time. 36% of car commuters answered that they would switch to train if there were regular train services with competitive journey time at least in every hour [6].

This means that replacing the rolling stock with new, comfortable vehicles would not solve the problems in the suburban area. The vast majority of the commuters just need fast, frequent and predictable services, which can be achieved by the development of the timetable. To get clear picture of the existing passengers' habits a comprehensive survey was carried out by the means of a questionnaire. The results of this survey helped to decide which development area should be chosen.

4.4. Efficient Development Methods in the Suburban Railway Traffic of Budapest

Due to the bad economic situation and the financial problems of MÁV it is impossible to execute all the above mentioned suburban service development methods in a short run. Therefore that particular development field must be determined which satisfies the consumer needs most efficiently while it burdens executable encumbrance to the company, and on the other hand it can be executed in a relative short period of time while it brings significant income.

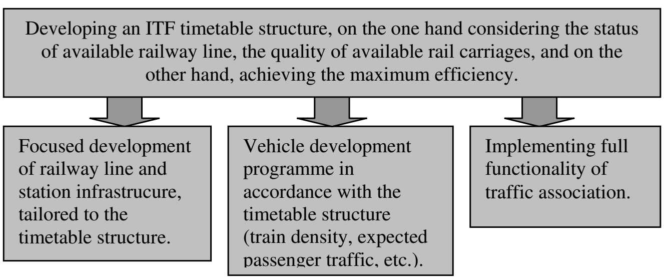

Fig. 2. Steps of Budapest suburban railway traffic development

Passenger surveys in the Budapest suburban traffic give an unambiguous priority to development of timetables. This expectation is fully harmonizing to those of Western European experiences. Accordingly, in case of planning the development of Budapest suburbs, as well as the whole Hungarian railway passenger services, it is useful to start a systematic development process considering the development concepts of Western European railway companies, which strives for satisfying passengers' expectations to the greatest extent, and in addition for improving the efficiency of railway company, furthermore it functions at the principle of gradation.

It is a positive fact that ITF has now proven its efficiency in practice for MÁV.

So, the chance is given to adapt it in order to interconnect the railway networks in an attractive way at the earliest convenience. As it is stated above, *Fig. 2* shows the necessary steps for the development of Budapest suburban railway traffic:

It is practical to apply development support methods which are suitable to consider both economic aspects and market expectations.

5. Adapting Value Analysis by Effective Development of the Suburban Railway Traffic

5.1. Value Analysis by Railway Traffic Services

Value analysis is a cost-conscious method which helps to improve the operators' market position by adapting rational and innovative operation. The systematic adaptation of value analysis methods determines the functions by representing user demands as goods or services, and satisfies them with the possible minimum costs. The aim of adapting value analysis by railway service development is to produce functions which meet passengers' demands, while keeping the production costs as low as possible [2].

5.2. Value Analysis Adapting Timetable Development

The most appropriate area of service development where value analysis can effectively be adapted is the development of the timetable, as it has the greatest flexibility in spite of the limited available resources. The identification of the timetable's functions can most precisely be realized by the adaptation of the four-vector-model [2]. For the easier delineation of the vector of values the co-ordinates of the model's vectors should be reduced, so that we get reduced vectors. *Fig. 3* shows the sophisticated relationship between the reduced vectors of the four-vector-model. According to passenger's demands, the functions of the timetable (which compose the vector of values) are service frequency, journey time and timetable structure.

To determine the optimal value combination of the timetable a delineation method has been created to represent the vector of values concerning the route between two given stations. On the basis of the reduced vector model the coordinates of the vector of values are the average service frequency, the average journey time and the ITF-index. The ITF index which renders to the given timetable's system-structure can be calculated for each route as the product of multiplication of periodicity factor and symmetry factor [2]. ITF index can be calculated for various basic intervals (e.g.: 30 min., 60 min., and 120 min.).

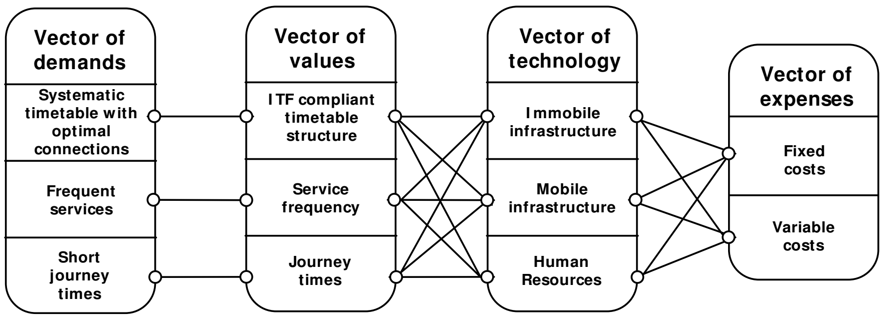

Fig. 3. Reduced vector model

6. The Applicability of Value Analysis for Timetable Development in Practice through the Example of a Suburban Pilot Programme

A pilot programme has been elaborated by applying value analysis, the target of which was to establish complex suburban railway development and to gather experiences. The suburban routes of Budapest–Vác–Szob (no. 70) and Budapest–Veresegyház–Vác (no. 71) were chosen for the pilot project, since these lines had good infrastructural conditions and multimodal interchange nodes while there is no long distance traffic to be found [6].

6.1. Process of the Value Analysis

To satisfy passenger's demands completely, not one or two timetable functions should be developed, but all of them should be improved as far as possible. In this adaptation of value analysis we have focused only on those improvement proposals which aimed at a more efficient utilization of the limited available resources, keeping the improvement costs minimal.

The four-vector-model in timetable development is built up in the following steps:

I. demand survey (passenger questioning, passenger count),

II. definition of timetable functions (average service frequency, ITF-index, average journey time),

III. survey of available resources (infrastructure, rolling stock, staff etc.),

IV. elaborating calculation methods rendering the costs of the functions (track charges, costs of traction energy, maintenance costs, staff costs etc.) [2]

6.2. The Increase of the Timetable's Value

A timetable model which satisfies the surveyed passenger demands has been elaborated with the help of optimizing techniques. By refining and iterated optimization of the basic model a brand new and advanced timetable structure has been created. The increase of the timetable's value could be realized by the adaptation of the following efficiency improving orders:

- elaborating an ITF-compliant timetable structure on both examined lines,
- according to the passenger's demands, a new zoning system[2] and suburban semi-fast trains (in the peak hours) were introduced,
- optimal train allocation and lower turnaround times,
- efficient staff assignment, based on train allocation,
- eliminating bottlenecks (by reassigning less utilized resources) [6].

Table 1 shows the data of vector of value coordinates of the two suburban lines, considering the two timetable versions. The vector of value is calculated in both lines, for all directions starting from Budapest (n: line no. 70, m: line no. 71), regarding to the corresponding ratio of passenger traffic per directions (w_i). As for the value vector introducing the whole timetable development has been calculated considering the ratio (w_{70}, w_{71}) of the complete passenger traffic of both lines.

$$\begin{bmatrix} t_v \\ f_v \\ I_v \end{bmatrix} = w_{70} \cdot \begin{bmatrix} \sum_{i=1}^{n} t_i \cdot w_i \\ \sum_{i=1}^{n} f_i \cdot w_i \\ \sum_{i=1}^{n} I_i \cdot w_i \end{bmatrix} + w_{71} \cdot \begin{bmatrix} \sum_{i=1}^{m} t_i \cdot w_i \\ \sum_{i=1}^{m} f_i \cdot w_i \\ \sum_{i=1}^{m} I_i \cdot w_i \end{bmatrix} \tag{1}$$

where: t_v means the average journey time
f_v means the average service frequency
I_v means the ITF index.

Fig. 4 delineates the vectors of values rendering given routes of the mainline no. 70 and 71. By introducing a regular interval and zoning timetable system and elaborating a complete connection system a real quality improvement could be achieved, i.e. journey time has decreased, while ITF-index has been multiplied, and even service frequency has increased a little.

[2] *Zoning system:* The zoning system consists of two types of trains, both departing from the same station. The stopping trains which travel only to the zone border and stop at all stations; and the zoning trains which stop at all stations only from the zone border to the end of the line.

Table 1. Vector of value coordinates at the existing and at the new timetable

	existing timetable			new timetable		
lines	average journey time [min]	average service frequency [pieces/h]	ITF-index [%]	average journey time [min]	average service frequency [pieces/h]	ITF-index [%]
70	33.6	1.4	45.8	30.2	1.7	77.4
71	44.3	0.7	0.0	41.1	0.9	85.5
70–71	35.7	1.2	36.6	32.4	1.5	79.0

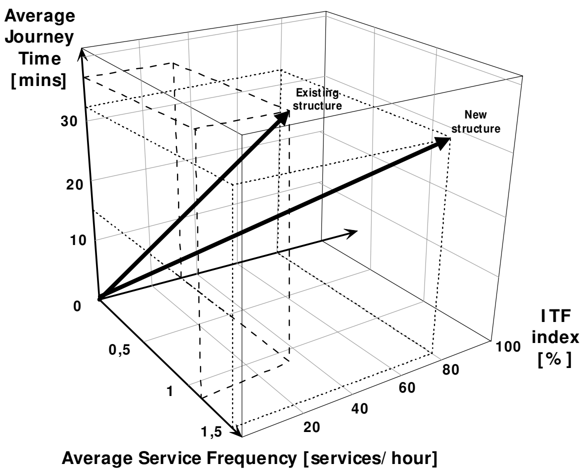

Fig. 4. Comparison of the new timetable structure to the existing one on the mainlines no. 70 and 71 from station Budapest to every station in the reduced vector space

6.3. The New Timetable – the Financial Side

The new timetable has quickly brought new passengers. The increase of the number of passengers in the first year was about 10%, and is still rising. Revenue on tickets and season tickets has been increased by 12%. Due to the new timetable 3% of the current passengers changed from car and 4% from bus to train. On the whole, the cost increase of the new timetable is only 10% of the income increase. [6]

7. Further Development Suggestions

Regarding the success of the pilot programme, value analysis can also be applied for further developments in order to achieve prompt and efficient improvement. It can be stated that the new system can be realized from the existing rolling stock and staff.

Throughout the presented suburban pilot project many experiences were gained which will be employed in the further timetable development plans. In the framework of Budapest Suburban Railway Development Project new regular interval and zoning timetable structure will be put into service on most suburban railway lines. *Fig. 5* shows the whole suburban network of Budapest.

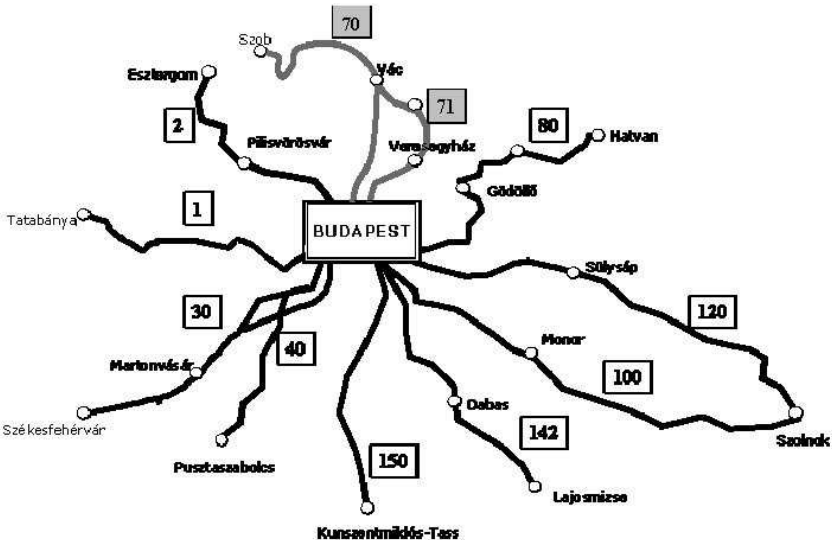

Fig. 5. Suburban network, pilot project-lines no. 70 and 71

7.1. Determination of the Timetable Value in the Whole Suburban Network

The parameters applied as co-ordinates of vector value during the value analysis can be defined for other suburban lines as well in order to promote further developments (see *Table 2*). In *Table 2* below the technical parameters of the suburban lines and average values calculated from the given lines are shown. These data serve as start-up for timetable developments. (Averaging has been done by directions and not by passenger traffic.)

Fig. 6 shows the delineation of two coordinates of the vector of values in given routes for all lines. The average journey time is not indicated for the sake of comparability. The figure clearly indicates improvement of timetable-value of

Table 2. Technical parameters of suburban lines and timetable characteristics, calculated by the value analysis

line number	track	maximum velocity [km/h]		suburban section	distance [km]	average service [pieces/day]	average journey time [min]	average service frequency [pieces/h]	ITF-index 120 min [%]	ITF-index 60 min [%]	ITF-index 30 min [%]
1	double	120/140		Tatabánya	64	18.2	25.2	0.8	32.6	14.4	0
2	single	50/60		Esztergom	53	23.6	31.4	1.0	0	0	0
30	double	120		Székesfehérvár	67	17.9	27.3	0.7	14.6	5.0	0
40	double	100/120		Pusztaszabolcs	67	11.4	22.1	0.5	0.5	0.5	0
70	double	100/120		*Szob*	*64*	*30.2 37.7*	*24.6 18.1*	*1.2 1.6*	*47.5 80.2*	*36.5 77.4*	*0.0 63.1*
71	single	60	Budapest	*Veresegyház – Vác*	*34*	*18.3 23.9*	*34.0 29.0*	*0.7 1.0*	*0.0 86.0*	*0.0 85.5*	*0.0 36.1*
80	double	120		Hatvan	60	21.1	27.5	0.9	16.2	9.8	0
100	double	120		Cegléd – Szolnok	100	20.7	38.6	0.9	41.8	38.5	0
120	double	100/120		Újszász – Szolnok	100	19.4	42.2	0.8	19.1	13.1	0
142	single	60		Lajosmizse	62	13.5	38.3	0.6	0	0	0
150	single	100		Kunszentmiklós – Tass	60	10.5	28.6	0.4	0	0	0

lines which were developed in the pilot programme. During further developments it is essential to improve the timetable characteristics of a given line at the greatest extent and to approach the circled area shown in *Fig. 6*.

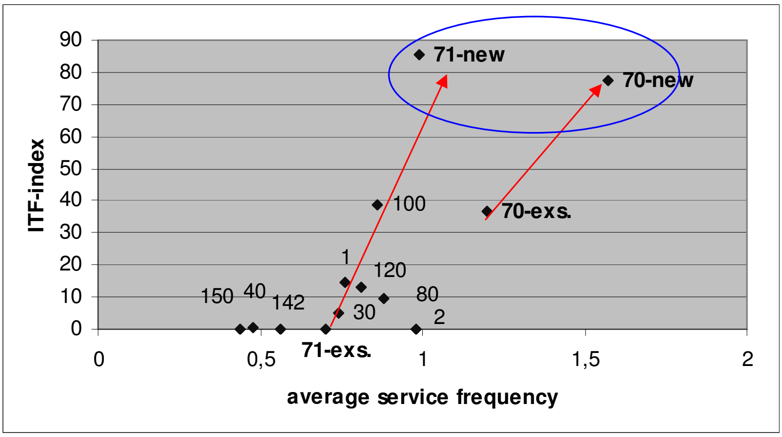

Fig. 6. Average service frequency and the change of ITF index calculated for suburban lines no. 70 and 71

7.2. Expected Supply of the Suburban Railway Traffic from the Point of View of the Timetable

Following expectations can be put up for timetables of suburban lines based on passenger demands and on the successful pilot project:

- In all suburban lines a 30–60–minute interval should be available which can be further developed during the peak-hours according to the real passenger traffic – obviously by not harming the basic interval.
- Peak hours from the point of view of additional trains are positioned from 5:30 AM till 9:00 AM and from 2:00 PM till 7:00 PM, considering the continuously changing lifestyle and the more and more lengthening working hours.
- A whole-day 60 minutes service frequency is necessary at the weekends, because a significant part of the people living in the suburbs are working even on these days, or just simply travel to the capital with administrative or amusement purposes.

7.3. Recommendations for Timetable Development on Further Lines

Table 3 shows the primary demands of a timetable structure which is acceptable by the passengers. The technical development of the lines is inevitable to realize a 30 minute interval (building of turnouts and third tracks, raising the speed-limit etc.) where *infrastructural development* is written. However, there is an improvement potential on the lines where *timetable development* is indicated.

The international, the domestic long-distance and the suburban passenger traffic are all concentrated on the majority of the lines leading to Budapest, and furthermore, going outwards from the railway network of the capital, the passenger traffic runs together with the freight traffic. While the different types of trains all use the same lines, it is not only difficult to declare the train paths in the suburban regular interval timetable structure but to increase the service frequency is difficult as well. However, this will require the harmonization of the suburban and the long-distance traffic, thus the introduction of the national ITF system.

By considering the innovative efficiency improving methods applied by the value analysis and by harmonizing the long distance traffic a more valuable timetable can be developed.

Table 3. Development criteria of Budapest suburban lines

line number	track		suburban section	60 min basic interval	30 min basic interval
				development method	
1	double		Tatabánya	timetable	timetable
2	single		Esztergom	timetable	infrastructure
30	double		Székesfehérvár	timetable	timetable
40	double		Pusztaszabolcs	timetable	timetable
70	double		Szob	✓	✓
71	single	Budapest	Veresegyház – Vác	✓	infrastructure
80	double		Hatvan	timetable	timetable
100	double		Cegléd – Szolnok	timetable	timetable
120	double		Újszász – Szolnok	timetable	timetable
142	single		Lajosmizse	timetable	infrastructure
150	single		Kunszentmiklós – Tass	timetable	infrastructure

The next possible pilot project where the long distance traffic may be integrated with the suburban one can be elaborated on the Budapest-Hatvan-Miskolc-Sátoraljaújhely line (in Eastern Hungary) which covers almost 10% of the Hungarian main lines. Thus the ITF connection system can be tested in practice.

8. Conclusion

The Budapest Suburban Railway Development Project is considered to be successful, due to the joint adaptation and application of an efficient suburban railway development and value analysis method, enabling emergence of passenger's requirements.

The practical adaptation of the value analysis method by timetable development on the two lines, giving 18% of total Budapest suburban traffic, has pointed to the fact that the improvement of competitiveness without significant increase of costs is possible by the means of efficient utilization of the available resources and innovative way of thinking.

A significant increase (15–20%) in the number of railway commuters and a further improvement of Budapest suburban railway traffic competitiveness can be achieved by the gradual, network-wide introduction of ITF, parallel with the systematic realization of vehicle and infrastructure developments related to the timetable developments.

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