ASSESSMENT AND EFFECTIVE DEVELOPMENT OF TIMETABLES ADAPTING VALUE ANALYSIS

László Kormányos[1], Béla Vincze[2], Viktor Borza[3]

Summary: In order to make railway passenger transport attractive, timetable development according to changing passenger demands is needed, which furthermore renders the optimal harness the rail operators' available resources possible.
The paper introduces railway passenger development from a market-oriented point of view by adapting the method of value analysis. Within service development it emphasizes the development of the timetable, determines the functions of a timetable, and by adapting the four-vector-model in value analysis it introduces the comparing method of different timetable variants. It illustrates the applicability of timetable analysis in practice through the example of a Hungarian suburban railway service development program.

1. Introduction

Because of increasing competition in railway passenger transport it is essential to change to market-oriented development of services and to improve economic efficiency in order to increase competitiveness. To reach these goals, the method of value analysis can be easily adapted for the process of service development. Together with an innovative way of thinking and making proper arrangements for optimal utilization of the available resources, the method of value analysis can help to satisfy passenger demands, while keeping the costs as low as possible.

In the following sections through an example of a Hungarian suburban timetable development pilot project we will present how value analysis in railway passenger transport services can be adapted.

2. The theory of value analysis [1]

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

[1] Hungarian State Railways (MÁV) Department of Passenger Transport
Address: H-1062, Andrássy út 73-75., Budapest, Hungary
Phone: (+36 1) 322 0660/7459; E-mail: kormanyos.laszlo@szesza.mavrt.hu
[2] Budapest University Technology and Economics, Dept. of Control and Transport Automation
Address: H-1111, Bertalan Lajos utca 2., Budapest, Hungary
Phone: (+36 1) 463 1044; E-mail: egzo@axelero.hu web: http://web.axelero.hu/egzo
[3] Hungarian State Railways (MÁV) Department of Traffic Management
Address: H-1062, Andrássy út 73-75., Budapest, Hungary
Phone: (+36 1) 432 3168; E-mail: borzav@mav.hu

value analysis methods determines the functions by representing user demands as goods or services, and satisfies them with the possible minimum costs.

Functions are those duties which the goods (or service) have to fulfil in order to satisfy the users' demands. The complete set of the goods' functions determines its consumption value. By analysing the functions we meet the concept of valuableness, which is the quotient of the function satisfying costumer needs and the expenditure needed to execute the function. The value combination is optimal when the goods' value is possibly the maximal.

After determining the goods' functions (e.g. with demand analysis or statement of functions) the next step is to measure the necessary features for fulfilling the functions and the costs (such as function bearer and function costs) to produce them. This is followed by the review of function costs and function fulfilments, which is needed by the so-called creative phase. In the creative phase solutions with optimal value combination are selected for further feasibility study. The essence of the method is based on the results of the study, i.e. the final proposal and the decision.

3. The four-vector model of value analysis

For modelling and introducing the value analysis process, the four-vector-model [2] is one of the best examples (Figure 1). By defining the functions of the goods to be developed we have to interpret the users' demands to the operators (vector of demands, vector of values). The optimal value combination can be determined by the parallel consideration of technologies needed for producing a service (vector of technology) and the costs assigned to it (vector of expenses). The elements of the vector of technology stand for the function bearers, and the elements of the vector of expenses cover all the occurring costs by producing a function bearer. The vector of technology and the vector of expenses define together the codomain of the vector of values. The vectors may change according to the model's resolution, and the number of the vector coordinates may not be the same on a given level of examination.

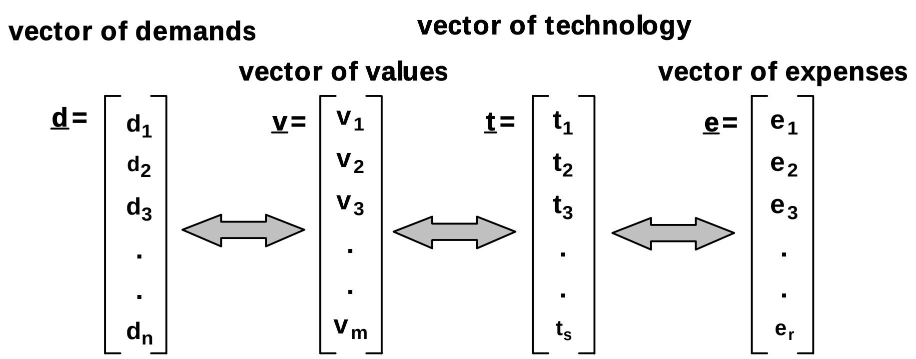

Fig. 1. Model of value analysis using the four-vector-model

4. Adapting value analysis by developing railway transport services [3]

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. For the appropriate adaptation of value analysis the segmentation of passenger transport services is needed in order to define what has to be developed (Figure 2).

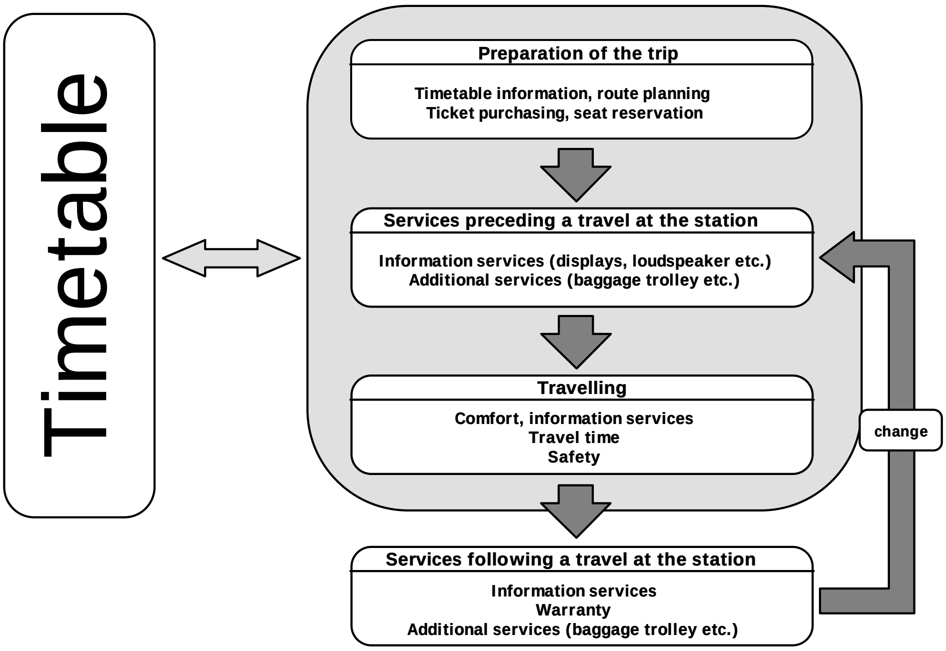

Fig. 2. Service development possibilities in chronological order

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 timetable, especially the united European ITF[4] system in Western Europe, has strategic importance, since it plays significant role in the planning process of optimal infrastructure and rolling stock development.

As Figure 2 shows, the timetable has the most connections with the areas of service development. The quality of the timetable significantly influence the market position of railway passenger transport.

5. Identification of timetable functions by adapting the value analysis model

The two most significant methods of value analysis are

- *value improvement* for goods already being on the market and
- *value planning* for increasing the value of new goods or services under development.

Both methods of value analysis mentioned can be adapted for timetable development. Through value improvement only a superficial correction can be realized, while by value planning passenger demands can be completely satisfied as far as possible.

The identification of the timetable's functions can most precisely be realized by the adaptation of the four-vector-model. For the easier delineation of the vector of values the coordinates of the model's vectors should be reduced, so that we get reduced vectors.

Passengers' general timetable demands are:

- the train should depart as soon as possible, after the passenger's arrival at the station,
- short journey time and
- predictable transport system.

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

According to these demands, the functions of the timetable (which compose the vector of values) are service frequency, journey time and timetable structure. Figure 3 shows the sophisticated relationship between the reduced vectors of the four-vector-model [3].

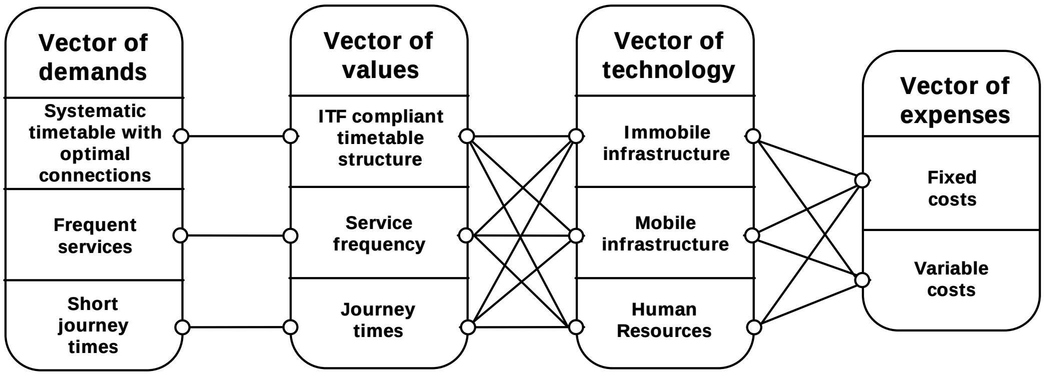

Fig. 3. Reduced vector model

To determine the optimal value combination of the timetable we have created a delineation method which represents 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 either as the product of multiplication of the two factors or as the weighted average of them:

- The periodicity factor, which represents the percentage of train paths properly aligned in the periodic structure:
-

$$P = \frac{N_{aligned\_paths}}{N_{total\_paths}} \qquad \text{or} \qquad (1)$$

$$P = \frac{N_{aligned\_paths}}{N_{maximum\_paths}} \qquad (2)$$

where $N_{maximum\_paths} = \frac{24\,hours}{T_{period}}$

- Symmetry factor, which represents the percentage of symmetric connections in the system:

$$S = \frac{N_{symmetric\_connections}}{N_{total\_connections}} \qquad (3)$$

Figure 4 shows the delineation of the vector of values in a given route where the frame space includes the codomain and the optimum space includes the set of function combination of passenger demands. With the help of improvement solutions and the application of value analysis, we have to achieve that the vector of values points at the point in the optimum space where the function costs are possibly minimal.

When „moving" the vector of values we can determine:

- how much cost expenditure increase the value of a given function or
- which function's value can be most increased by one unit of assigned expenditure

that's what we call sensitivity analysis.

With the above introduced delineation technique it is possible to compare different timetable improvement versions. Moreover the given vector of expenses belonging to the vector of values to be compared determines the cost expenditure demand of the given timetable improvement version.

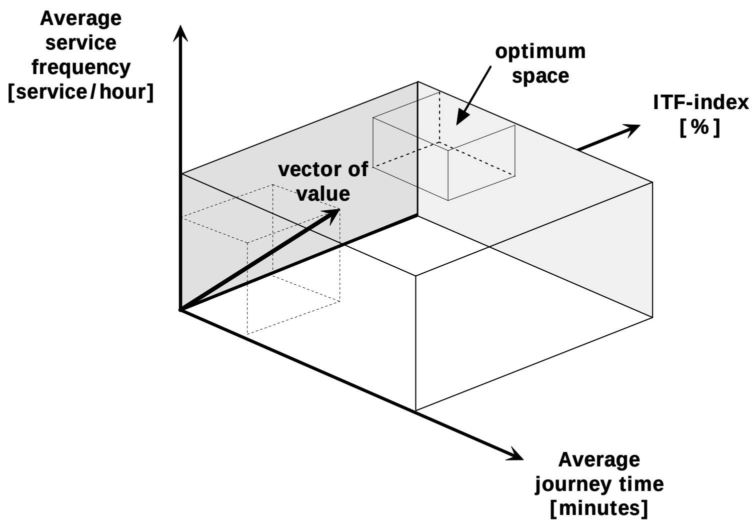

Fig. 4. Graphical delineation of the vector of values in the reduced vector space

6. The applicability of value analysis for timetable development in practice through the example of a Hungarian suburban pilot program

The value improvement of a timetable according to the reduced vector model can achieved by:

- increase of service frequency,
- increase of ITF-index or
- decrease of journey time.

To satisfy passenger demands completely, not one or two timetable functions should be developed, but all of them should be improved as far as possible.

By adapting value analysis we have elaborated a pilot project on timetable improvement on the suburban routes of Budapest-Szob-Štúrovo (no. 70) and Budapest-Veresegyház-Vác (no. 71). The main reason for improvement was the outstanding decrease of the number of suburban passengers. 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 was built up in the following steps:

- demand survey (passenger count, passenger questioning),
- definition of timetable functions,
- survey of available resources (infrastructure, rolling stock, staff etc.),
- elaborating calculation methods rendering the costs of the functions (track charges, costs of traction energy, maintenance costs, staff costs etc.)

The value analysis pointed out the fact that without short term timetable improvement the number of the passengers will keep on decreasing. After processing the gathered data, we had chosen the areas of service development during a brainstorm session. With the help of optimizing techniques and advanced graphical representations implemented in our custom software system [4] we have elaborated a timetable model which satisfies the surveyed passenger demands. By refining and iterated optimisation of the basic model we have created a brand new, advanced timetable structure. The increase of the timetable's value could be realised by the adaptation of the following efficiency improving orders:

- elaborating an **ITF compliant timetable** structure on both examined lines,
- according to the passenger demands, with the conversion of the existing timetable structure, a **new zoning system[5] was introduced**,
- **optimal train allocation** and **lower turnround times**,
- **eliminating bottlenecks** (by reassigning less utilized resources),
- **efficient staff assignment**, based on train allocation.

The new timetable absolutely complies with the ITF requirements [5]. The examined suburban lines together with the connecting railway lines, the regional buses and the ferry on the Danube construct a complete transport system based on changing relations. The one-hour service frequency in the rush hours is doubled to 30 minutes, and the application of the zoning system resulted in a significant journey time decrease approximately to about 30% of the passengers. It is important to note that the new system did not cause unfavourable change in service frequency or journey time to any of the passengers.

The change of the timetable's value is delineated by the deviation of the vectors of values rendering the existing and the new timetable. Figure 5 describes the vectors of values attached to the given routes of the railway line no. 71. In this case, there was no solution for outstanding improvement of service frequency or journey time, since this railway line is single tracked and the location of crossing stations are not optimal. Quality improvement could only be achieved by the increase of the ITF-index, i.e. introducing periodic timetable and developing connection possibilities.

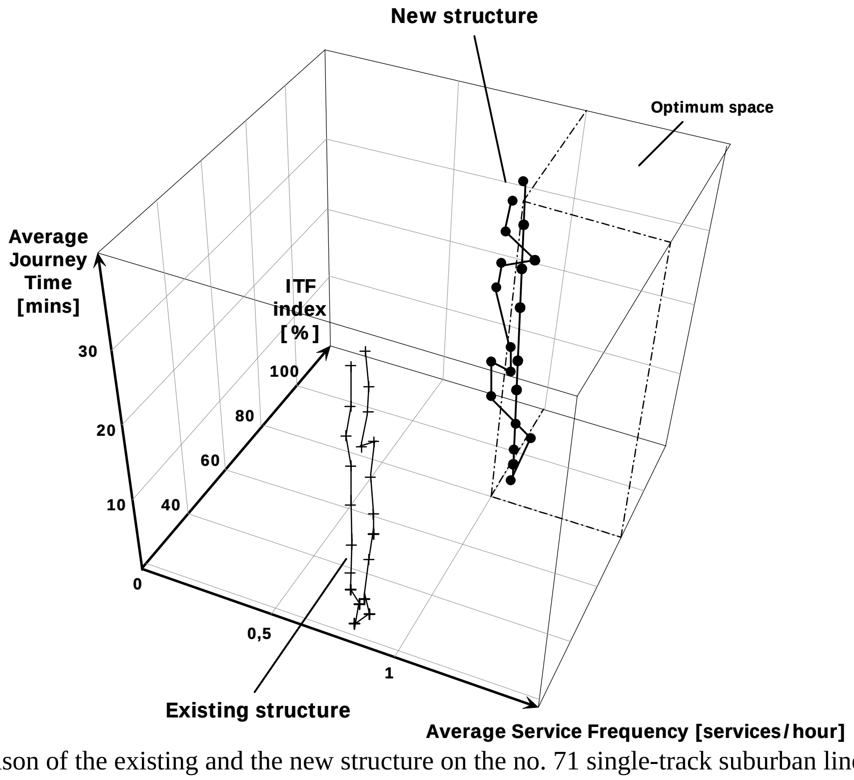

Fig. 5. Comparison of the existing and the new structure on the no. 71 single-track suburban line in the reduced vector space. Each point represents a journey from Veresegyház station.

[5] **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.

Figure 6 delineates the vectors of values rendering a given route of the mainline no. 70. By introducing a periodic and zoning timetable system and elaborating a complete connection system we could achieve a real quality improvement, i.e. journey time has dramatically decreased while ITF-index has been multiplied, and even service frequency has increased a little.

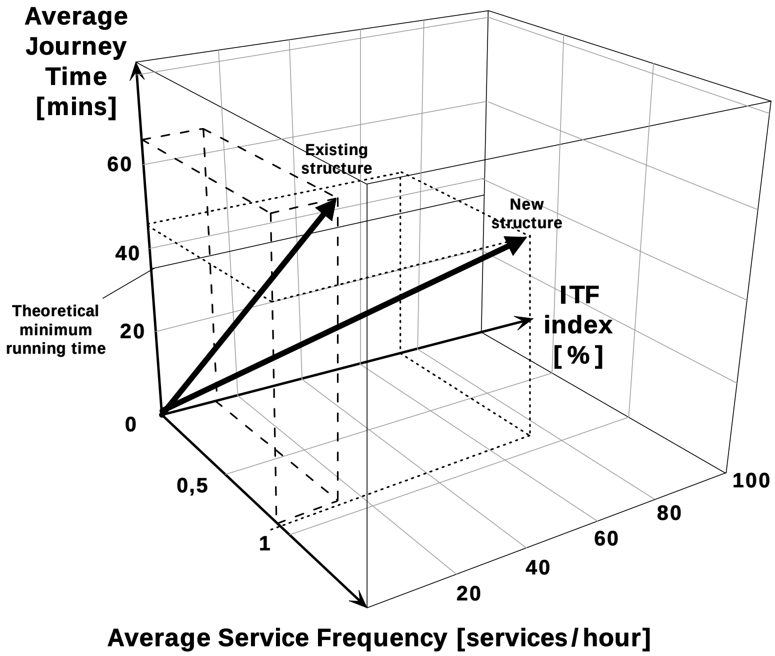

Fig. 6. Comparison of the new zoning structure to the existing one on the mainline no. 70 from station Nagymaros to station Budapest-Nyugati in the reduced vector space.

The new timetable structure can be described by the following statistical data in comparison with the existing timetable (Table 1).

Train km.	Gross tkm	Axle km.	Seat km	Traction energy
+31%	+8%	+8%	+7%	-5%

Tab. 1. (Source: Hungarian State Railways)

We could point that the new system can be realized from the existing rolling stock and staff. Due to the improvement of the timetable system which we have introduced in this paper, railway becomes competitive over other means of transport, and a significant increase of the number of passengers can be realised in short term.

7. Conclusions

With the theoretical and practical adaptation of value analysis in railway passenger transport service development an economically effective and competitive service can be created which is also conform to the given market features. The practical adaptation of the value analysis method by timetable development 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.

8. References

[1] Körmendi L., F. Nádasi: The theory and practice of value analysis, Info-Prod Kiadói és Marketing Bt, Budapest 1996 (in Hungarian)

[2] Borotvás E., L. Bújdosó, E. Legeza, I. Magyar, L. Tánczos, L. Tóth, L. Tóth: Transport economics, Budapest University Technology and Economics, Budapest 1991, (11. section) (in Hungarian)

[3] Kormányos L.: Putting the development of the railway passenger transport service onto market bases using the value analysing method; Scientific review of transport 2003/12. pp. 456-464 (in Hungarian)

[4] Vincze B., L. Kormányos, V. Borza: Methods and tools for designing modern timetable structures, ŽEL 2004, Zilina 2004

[5] Borza V., B. Vincze, L. Kormányos (2004) Periodic timetable-map for the Hungarian railway system by the adaption of the European structure, ŽEL 2004, Zilina 2004