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ASSESSMENT AND CONTROL OF QUALITY IN TRANSPORT PROCESSES

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1. Introduction

Quality from technical view is connected especial with final quality of material products. Technical normalization, technical check and technology of production are essential presumption for achievement of technical quality of product. This is one of the main reasons why the field of production has very good sophisticated quality system.

More complicated and less elaborated is this system in the field of services including transportation services. Non-material character of outputs in services makes more complex already measurement and assessment of quality properties of these outputs. In the past quality of transport was attended less attention then it would be merited. This approach changed at end of the 20th century.

2. Quality and transport

Transport is phenomenon that influences not only quality of life everyone but also development of all human society. Existence of adequate transport system is one of the crucial conditions in the social-economic development of state. The market conditions in transport and its opening for foreign business subjects generate qualitative pressure on forwarders and carriers in the Czech Republic. They can become more competitive only

with high level of reliability, safety and trouble-free operation of transport services, it means - high quality of transport processes and services.

The final quality of transportation is influenced by quality of all elements in transport system: quality of transport means, transport infrastructure, technology of transport processes, information system, human factor and legislative.

Perception of quality in transport processes we can characterize from two aspects: - external quality and internal quality.

External quality

The external quality is quality from customers' view. This quality of transportation processes makes itself felt in places of customer connection, e.g. order acceptance, ticket sale, handing over of shipment and its commitment to consignee etc. Control of transportation processes deals mainly with external customer relationship - technical, economics and legal connection between transport and its users – and it covers:

- freight transportation
  - treaty commitments and order of transportation,
  - handing over of shipment, its acceptance and loading,
  - safety and integrity assurance,
  - commitment of shipment to consignee and its discharge,
  - account of transporting charges,
  - clearance of complaint on consignment.
- passenger transportation
  - treaty commitments,
  - issue of timetable,
  - safety assurance,
  - boarding and information of passenger,
  - passengers' transportation,
  - statement of account (irregular transportation) and execute of complaint.

Internal quality

Every operator of transport services needs to know cost that will be used on attained guarantee of rendering service quality or optionally on higher level of quality. From the technological view it is emphasis on operation organization, assurance of economic, safety and environmental in appropriate way of transport technological processes.

Control of traffic processes addresses internal transport technology and it represents package of these operations:

- pursuance and control of vehicle's move,
- operations maintenance of vehicles and other equipment in failure free state.

Quality requirements on transportation processes we can define from above mentioned two views that are completed with interest of society on development of superior transport system.

The transportation processes are described by the requirements of society by following factors:

- region service capability,
- ability to transport various amounts of passengers and cargo with various attributes,
- "door-to-door" transport ability,
- guarantee of transport time,
- transport safety, minimised damage costs of customers, on cargo and of the third persons,
- environmental impact,
- additional services.

3. Guarantee of transport time

Guarantee of transport time is one of the basic factors describing a concrete transport company. Also it is possible to determine probable transport time guarantee from typical attributes of the transport modes and reliability of vehicles used there. The carrier can only partly influence on this value, but he is not able to eliminate all negative impacts. It is not possible to eliminate the influence of weather conditions, delays on border crossings, infrastructure repairs, breakdowns of the technical systems etc. These factors in various combinations have typical impact on any of transport modes and they determine the transport time guarantee probability of any connection on any route.

Typical technological processes should respect the influence and reasons of the deviations from expected timing of the transport process. Moreover, the some deviations are caused by more reasons affecting together, by negligence or by intention. In these cases we can only estimate the probability of the deviation, its character and its impact to the process.

Quality indicators of cargo transport can be theoretically guaranteed deadlines of delivery in various conditions and for various types of cargo compared with other transport modes. In passenger transport it can be comparison of average travel speed of various routes with focus on transport time reliability guarantee by evaluation of external influences on it.

4. Critical points in technological processes of transport

Data for specification of critical points in technological processes of transport are technological operations, which are different in passenger and freight transport. The critical points we can divide into their relevance:

- high relevance,
- medium relevance,
- small relevance.

Other dividing of critical points can be according to time horizon of their elimination:

- short-term,
- medium-term,
- long-term.

In the end we can ones divide according to subjects, which they on the instant involve. Critical points for:

- carriers, transporters,
- customers,
- society.

The specific critical points in public passenger transport, which ensue from the type of the technological operations, are especially:

- timing and spatial variety of option ticket buying, small scale integration and unification of tickets with utilization of chip card,
- correct and early information in all phases of transport processes – before beginning of transport, during transport and after ending of transport,
- personal experience (positive and negative) influences repeatedly using of transport mean,
- behaviour and approach of operating employees under transportation assurance and operative solving diverged from declared quality.

From analysis of critical points in freight transport we can assign first of all to following critical phases:

- contracting,
- preparation of vehicle for transportation performance,
- loading and shipment acceptance,
- discharge and shipment delivery.

Each of these phases is at issue in function of customer and carrier. However both contractors must follow common target that is resultant to well quality of shipment transportation.

5. Prevention of diverged from declared quality

Generally prevention of diverged from declared quality of transport we can summarize into main points:

- the basic measurement must be address to carrier ensuring quality (quality carrier) in critical points;
- the important role in measurement plays:
  - correct selection of quality carriers,
  - assurance of permanent connection quality carriers with control structures,
  - charge of employers' professional qualification and its permanent increase,
  - creation of reliability documentation of technological processes development and diverged reasons;
- assurance of reliable and systematic connection with customers and well notifying of creation diverged from declared quality;
- draft of algorithm that defines procedure as an answer on diverged of quality with expert systems and computer support utilization.

Prevention of diverged from declared quality of transport processes is very important part that we can apply International Standards ISO 9000 and principles of Total Quality Management. On the other hand only passive access to these standards doesn't guarantee improvement of quality in transport processes.

6. System of control quality in passenger transport

Creating and control of quality system in passenger transport is based on cycle of quality of service (see ***Fig. 1***).

Principles of this quality cycle we can divide into 5 parts:

- definition of explicit or implicit customer's transportation expectations;
- specification of feasibility of transportation;
- creation of concrete transportation service which is consistent with specification including performance measuring and corrective action;
- announcement of results to costumers;
- analyse of results and implementation, optionally corrective action.

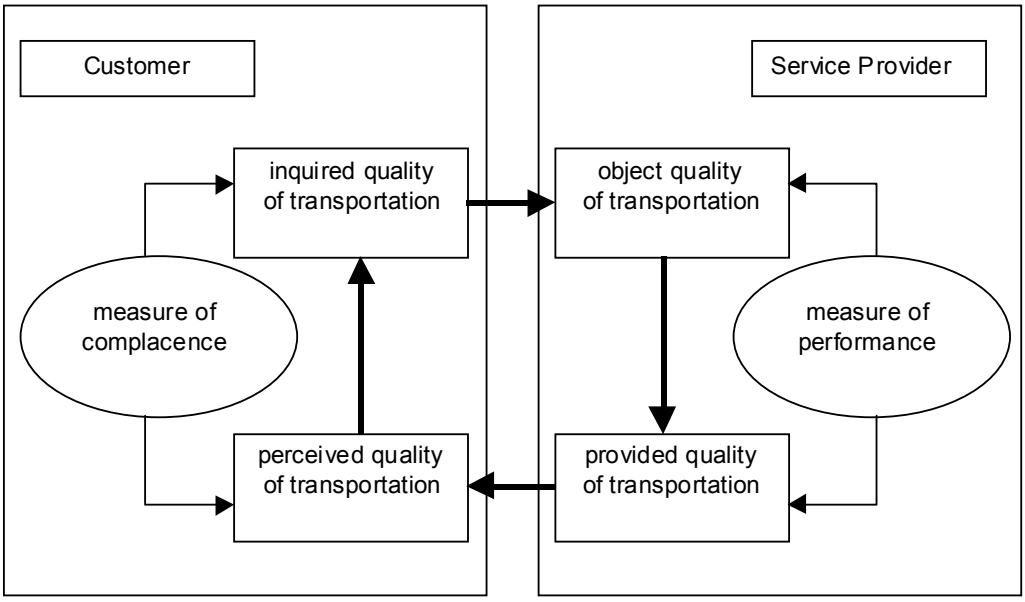

Fig. 1 *Cycle of quality of service*

Definition of requirements on quality control system in transport processes is very important part for correct comprehension of relationship between customer inquired and perceived on transportation quality and carrier real provided quality of transportation.

Resulting level of quality can be appreciated as aggregate of weighted criteria of quality. Target quality of service is such level of quality which carrier exerts provide to passenger. Target quality is influenced by:

- level of quality which is advertised by customers,
- external and internal conditions,
- financial means,
- activities of competitive operators.

Operator must define standards of transport processes, level of record and especially treshold of unacceptable performance. Quality of criteria (through is assessment achievement of target) may not decrease under value defined legislative or technical regulation.

Level of customer's satisfaction is difference between inquired and perceived quality. Level of efficiency is difference between target and provided quality.

7. Assessment of quality in transport processes

Assessment of quality in transport processes is multi-criteria problem. The process of multi-criteria solution is possible to divide into 4 parts:

- Setting specific aim of assessment;
- Selection set of variants $V = \{v_1, v_2,...,v_n\}$ and set of criteria $K = \{f_1, f_2,,...,f_n\}$;
- Partial assessment of all variants according to particular criterion;
- Aggregation partial assessments into final assessment and optimal variant selection.

By reason that this is a large and complex problem we target in the next part only the problems of suitable selection of criteria and useful modification method of distance in multi-criteria assessment.

7.1 Criteria selection

The criteria are one of the basic components of assessment process. Every selected criterion is instrumental to evaluate, compare and sort of variants. Aggregate of criteria must fulfil specific requirements:

- completeness,
- operation-ability,
- un-redundancy,
- minimal size.

Aggregate of criteria must be so as it has enabled to review and evaluate all (negative and positive) variant's consequence. File of criteria that comply with this requirement is completeness. Incomplete file of criteria means that some aspects of problem solution are not revolved. We can often meet with pass by some problems in transport as its negative impact to environment or ineligible consequences of congestions in road and air transport. Operation-ability of criteria file means that every criterion must be clear and single-valued meaning and what is more, it must be fully intelligible. Quantitative criteria achieve operation-ability more easily than qualitative criteria. Operation-ability criterion direct bears on its measurability. Un-redundancy of criteria file means that every assessment aspect is occurred only once. Minimal size of criteria file enables considerably simplifying final assessment of variants.

Some specifications listed above are opposite and it is impossible to meet a requirement all at once. For example requirement of minimal size points to criteria aggregation and herewith operation-ability and measuring of criteria is decreasing at same time. Correctly definition of criteria is especially problematic in transport. Many qualitative criteria have few operation-ability but size of criterion file is decrease after their decomposition. Solution can be construction hierarchical configuration of criteria e.g. by form of criterion tree.

7. 2 Criteria measurement

The criteria we can measure with the aid of different scale. Measurement is process that enables order objects without necessity assigns specific number.

Nominal scale S has not property of ordering i.e. there is not defined any relation. Valuation of variant $v \in V$ according to criterion f denoted variant v only its single-valued name $f(v) \in S$. Mapping f must be simple.

Criterion $f: V \rightarrow S$ is nominal if f is simple and S is nominal scale. Nominal criterion f assigns to each variant exactly one natural number from set $\{1,2,\ldots,n\}$. This number is only signification.

Ordinal scale S is ordered set i.e. relation R that is relation of ordering on S. Valuation of all variants $f(v_j) \in S$, $j = 1,2,\ldots,n$ d allows to order all variants v_j from the worst to the best.

Criterion $f: V \rightarrow S$ is ordinal if S is ordinal scale.

Ordinal scale is generally used for measurement of quality criteria. The number assigning to variant indicate only order of variants with respect to given criterion. We cannot deduce from their gap intensity of preference proper variants.

Cardinal scale S is subset of real number set e.g. $S \subseteq \boldsymbol{R}$ including its natural ordering „less or equal $\leq$ „.

Criterion $f: V \rightarrow S$ is cardinal if S is cardinal scale and f is invariant against linear transformation $\varphi(x) = ax + b,\ a > 0$.

Cardinal scale can be interval or ratio. Interval scale is basic type for quantitative criteria and from difference two values we can deduce their preference.

In transport is often occurred qualitative (aggregate) criteria measured by ordinal scale, which is necessary transform into criteria measurable in cardinal scale:

- either creating of artificial cardinal (subjective) scale,
- or decomposition qualitative criteria into specific number of quantitative criteria.

7.3 Criteria transposing into a comparable scale

The problematic point in assessment of final quality in transport processes is heterogeneity of units in which criteria are measured. In case, when is not appropriate or possible expressing all criteria in money form, we can use e.g. standardization of criteria (i.e. transformation of cardinal scale into scale $S = [0,1]$). For every $I = 1,2\ldots,m$ is signed

$$f_i^{min} = min\{\ f_i(v_j)\ |\ j = 1,2,\ldots,n\ \} \tag{1}$$

$$f_i^{max} = max\{\ f_i(v_j)\ |\ j = 1,2,\ldots,n\ \} \tag{2}$$

Additional presumption is that all criteria have positive values, e.g. $f_i(v_j) \geq 0$ for all $I = 1,2,\ldots,m$, $j = 1,2,\ldots,n$ and holds $f_i^{max} > f_i^{min}$.

For maximize criterion (higher value is better) is defined transformation φ_i: $S_i \rightarrow [0,1]$, $I = 1,2,\ldots,m$ in this form:

$$\varphi_i(x) = \frac{x - f_i^{min}}{f_i^{max} - f_i^{min}}, \quad x \in S_i \tag{3}$$

For minimize criterion (lower value is allowed to be better) is defined transformation φ_i: $S_i \rightarrow [0,1]$, $I = 1,2,\ldots,m$ in this form:

$$\varphi_i(x) = \frac{f_i^{max} - x}{f_i^{max} - f_i^{min}}, \quad x \in S_i \tag{4}$$

Then we can defined with the aid of mapping φ_i new criterion:

$$F_i(v) = \varphi_i(f_i(v)),\ v \in V. \tag{5}$$

New created criterion takes for the worst assessed variant value 0 and for the best variant 1, for each criteria $I = 1,2,\ldots,m$.

7.4 Application of distance method in multi-criteria assessment

Let each criteria $f_i \in C$ are cardinal and standardized. Two basic distance methods exist for total valuation of variant $v \in V$:

- Method of the least distance from the ideal variant,
- Method of the greatest distance from the basal (the worst) variant.

Function of distance has this form:

$$d(x,y) = \left(\sum |x_i - y_i|^p \right)^{\frac{1}{p}} \tag{6}$$

For parameter's value $p = 2$ is used term Euclidean metric and function has this form:

$$d(x,y) = \left(\sum_i \left(x_i - y_i\right)^2 \right)^{\frac{1}{2}} \tag{7}$$

This metric is used in procedure assessment of quality transport processes.

Modification method of the least distance from the ideal variant evaluates aggregate valuation $D(v)$ variant $v \in V$ and uses not only value of modified criterion but it takes into account importance of criterion by required value weight w_i.

$$D(v_w) = d(\mathbf{v}_w, \mathbf{1}_w) \tag{8}$$

where:

d.....function of distance,

$\mathbf{v}_w$, $\mathbf{1}_w$.….....vectors.

Vector $\mathbf{v}_w = (F_1(v).w_1, F_2(v).w_2,\ldots,F_m(v).w_m)$ and $F_i(v)$ is defined by (5).

Vector $\mathbf{1}_w = (1.w_1, 1.w_2,\ldots,1.w_m) \in \boldsymbol{R}^m$ is compact of standardization valuations respective to ideal variant multiplied by weight of criterion.

Function of distance has this form:

$$D(v_w) = \left(\sum_i \left|F_i(v).w_i - w_i\right|^2\right)^{\frac{1}{2}} \tag{9}$$

The optimal variant is that variant $v^* \in V$, for which holds:

$$D(v^*) = min\{D(v); v \in V\} \tag{10}$$

After this manner obtained result better fact that not all criteria must have same importance and choice of optimal variant accounts for all preferences of evaluator.

8. Conclusions

The authors resume some important conclusions from institutional research project [2] that inquired with quality problems in transport processes. The term "quality" is very frequented word in the connection with improving of public transport in the last years. The statistics say intelligible speech: traffic volume during 10 years in Europe increase - especially the road transport. These trends will be to continue in after years. The expansion of infrastructure has its limit. Further develop of the transport system interfere with operative limiting. Dimension of traffic processes significant influence quality of transportation services. It means - to solve equipment capacity, permeability and optimization of traffic and transportation without assignment of requirements on quality has not reason.

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Resumé

HODNOCENÍ A ŘÍZENÍ KVALITY V DOPRAVNÍCH PROCESECH

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Příspěvek se zabývá problematikou hodnocení a řízení kvality v přemísťovacích procesech. Hodnocení kvality dopravy je možné provádět z hlediska zákazníka (externí) nebo dopravce (interní). Pro realizaci přepravy je jedním z nejdůležitějších kritérií čas přepravy. Při realizaci konkrétní přepravy se vyskytují kritická místa, ve kterých mohou vzniknout odchylky od deklarované kvality. Z tohoto důvodu je nutné dělat preventivní opatření, aby k odchylkám nedocházelo. Významným nástrojem k udržení kvality přepravních procesech je systém řízení kvality, který vychází z cyklu kvality služeb. Hodnocení kvality přemísťovacích procesů je problémem multikriteriálním.

Summary

ASSESSMENT AND CONTROL OF QUALITY IN TRANSPORT PROCESSES

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The paper deals with problems of assessment and control of quality in transport processes. Assessment of quality transport is possible from view of customer (external) or carrier (internal). One of the most important criteria is time of transportation. Fruition of factual transportation contains critical points in which can grow deviation from declared quality. By this reason of is necessary to make preventive action and eliminate deviations. Important tools to keep level of quality in transportation processes is creating of control system of quality which is based on cycle quality of services. Assessment of quality in transport processes is multictiteria problem.

Zusammenfassung

DIE BEWERTUNG- UND DIE STEUERUNGSQUALITÄT IN DEN VERKEHRSPROZESSEN

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Dieser Beitrag beschäftigt sich der Problematik der Bewertung- und Steuerungsqualität in den Verkehrsprozessen. Die Bewertungsqualität des Verkehrs ist möglich von Hinblick Kunden (extern) oder Beförderer (intern) verführen. Für die Verkehrsausführung ist die Verkehrszeit einer von den wichtigsten Kriterien. Für die Ausführung des konkreten Verkehrs finden sich kritische Stellen vor, in denen Auslenkungen von der verlangten Qualität entstehen können. Deshalb muss man präventive Massnahmen bilden, um zu keinen Auslenkungen zu kommen. System der Steuerungsqualität stellt bedeutendes Instrument der Behauptung der Qualität in den Verkehrsprozessen. Dieses System geht vom Zyklus der Dienstqualität aus. Die Bewertungsqualität der Verkehrsprozesse stellt multikriteriales Problem vor.