Faculty of Operation and Economics of Transport and Communications
University of Žilina
Žilina, Slovakia

TRANSPORT AND COMMUNICATIONS

Scientific journal

tac.uniza.sk

II/2014

ISSN 1339-5130

TRANSPORT AND COMMUNICATIONS

Scientific journal intended to combine theory and practice in the field transport and communications and thus advancement of transport and communications sciences

DOI: 10.26552/tac.J.2014.2
ISSN 1339-5130

Table of contents

Transport and Communications, 2014; Vol. II.
ISSN: 1339-5130 DOI: 10.26552/tac.C.2014.2.1

Effect of Injection Advance Angle on Auto-Ignition Delay and Response of Ad3.152 Ur Engine

Andrzej Ambrozik, Tomasz Ambrozik, Dariusz Kurczyński, Piotr Łagowski[1]

[1]Department of Mechatronics and Machine Building, Kielce University of Technology, Kielce, 25-314, Poland

Abstract The paper presents the results of experimental investigations into the effect of injection advance angle in the AD3.152UR engine on auto-ignition delay time and engine response coefficient value. In the tests, the engine operated under the full load characteristics and was fuelled by commercial diesel oil. The injection advance angle ranged $\alpha_{ww} \in <13, 21>$ CA deg. The tests aimed to assess the engine ability to adapt to variable load conditions.

Keywords CI internal combustion engine, engine response, injection advance angle, auto-ignition delay

JEL R41, R49

1. Introduction

In positive ignition engines, the combustion process is initiated with spark-over across the spark plug electrodes. The start of combustion in compression ignition engines is related to injection advance angle and auto-ignition delay time.

In compression ignition engines, it is difficult to determine auto-ignition delay time because its value is affected, in a very complex manner, by multiple factors. A lot of dependencies and methods of determining the auto-ignition delay time are found, which is related to the necessity to specify the beginning of fuel injection and the start of the combustion process [1, 2, 3, 4].

The auto-ignition delay is the time that elapses from the fuel injection beginning to the instant of chain-thermal explosion of pre-flame reactions. In the indicator diagram that is manifested as the beginning of a quick rise in pressure and the working medium temperature, which results from the start of fuel combustion α_{ps} (point 3 in Fig.1). An increase in those quantities, caused by fuel combustion, is shown in the indicator diagram as a departure of the combustion pressure curve from the curve representing compression pressure [5].

The total auto-ignition delay time consists of two components: a physical one τ_f, and a chemical one τ_{ch}. The first component corresponds to the time necessary for the fuel spray to disintegrate into droplets, their partial evaporation and air/fuel vapour mixing. The other component, i.e. τ_{ch}, represents the delay in auto-ignition of homogeneous gaseous mixture.

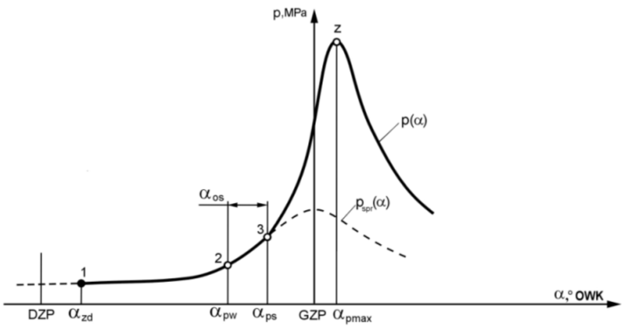


Figure 1. Auto-ignition delay time in the developed indicator diagram, where: α_{pw} – the beginning of fuel injection, α_{ps} – the start of fuel combustion, $p(\alpha)$ – combustion pressure curve, $p_{spr}(\alpha)$ – compression pressure curve, $\alpha_{os}(\alpha)$ – auto-ignition delay time [1]

Taking into account that the chemical and physical processes occur simultaneously, with a slight shift in time, it is difficult to assess the duration of these components. The interrelation of both components is expressed by the dependence [1]:

$$\tau_s = \tau_f + \tau_{ch} \qquad (1)$$

where: τ_s – auto-ignition delay time , τ_f – physical component, τ_{ch} –chemical component of auto-ignition delay time

The value of auto-ignition delay time α_{os} is calculated from the dependence:

$$\alpha_{os} = \alpha_{ps} - \alpha_{pw} \text{ , CA deg} \qquad (2)$$

where: α_{ps} – the start of combustion, α_{pw} – the beginning of fuel injection

Auto-ignition delay affects the rate of combustion, and also that of pressure and temperature increase. Additionally, it influences the engine starting characteristics, the exhaust gas toxicity and noise. This time is of fundamental importance for the quality of the whole combustion process, especially for the process dynamics, which, in turn, affects the engine response.

Internal combustion engine response is a parameter determining the dynamic performance of the vehicle, i.e. such traction properties as the ability to climb a grade in different gears, or time necessary to complete an overtaking manoeuvre. Those quantities are directly related to the active safety of the vehicle. Engine with high response allows drivers to go in a particular gear at both low and high speeds, so that they do not have to continually change gear [6 , 7].

Response is one of the most important indicators defining the in-service properties of the engine, which by definition [5, 6] specifies the engine ability to adapt to variable load operating conditions. The higher is the value of the response coefficient, the greater is the vehicle ability to accelerate, climb grades, etc. The current advancements in internal combustion engines are also associated with their increased response by applying pressure charging systems that operate in a wide range of engine rotational speeds, or high-pressure multi-stage fuel injection. The paper demonstrates the impact of injection advance angle on the value of the engine response coefficient [6, 7, 8].

The coefficient value is determined on the basis of full-load characteristics, Fig. 2 which contains the power and torque curve. It is done by determining the values of rotational speed response coefficient e_n and torque response coefficient e_M. The product of those coefficients gives the value of the engine response e which is specified by the dependence:

$$e = e_M \cdot e_n \tag{3}$$

The coefficient of engine torque response e_M is the ratio of the maximum torque value M_{omax} to the torque at which the engine generates the rated power M_{oNemax}:

$$e_M = \frac{M_{omax}}{M_{oNemax}} \tag{4}$$

The coefficient of the rotational speed response e_n gives the ratio of the engine rotational speed at which the engine generates the maximum effective power n_{Nemax} to the rotational speed at which the engine produces the maximum torque n_{Momax}:

$$e_n = \frac{n_{Nemax}}{n_{Momax}} \tag{5}$$

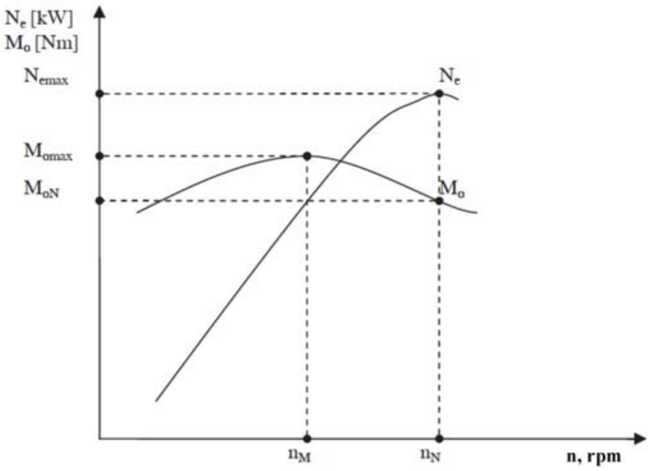


Figure 2. The engine full-load characteristics: M_{omax} – maximum torque, N_{emax} – maximum effective power, n_M –rotational speed at the maximum torque, n_N – rotational speed at the maximum power [6]

2. Object and range of experimental investigations

Tests were performed on three-cylinder, compression ignition Perkins AD3.152 UR AD3.152 UR engine with direct fuel injection into the combustion chamber [9]. Investigations were conducted on the engine test bench equipped with a water brake and control-measurement unit. A block diagram of the test bench is shown in Fig. 3.

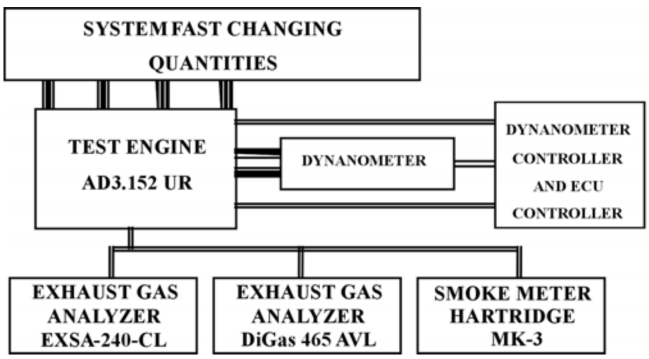


Figure 3. Block diagram of the test bench [10,11]

The basic parameters and specifications of the AD3.152 UR engine are presented in Table 1.

Table 1. *Basic specifications of the engine [10]*

Compression ignition AD3.152 UR engine		
Parameter	Unit	Value
Cylinder arrangement	-	in-line
Number of cylinders	-	3
Type of injection	-	Direct
Cylinder working order	-	1 – 2 – 3
Compression ratio	-	16.5
Cylinder bore	mm	91.44
Piston travel	mm	127
Engine cubic capacity	dm^3	2.502
Connecting rod length	mm	223.80÷223.85
Maximum engine power	kW	34.6
Rotational speed at maximum power	rpm	2250
Maximum torque	Nm	168.7
Rotational speed at maximum torque	rpm	1350
Static angle of injection advance	CA deg	17
Idle rotational speed	rpm	750±50

The tests aimed at measuring fast-varying quantities, including in-cylinder pressures and the injector needle lift, and those quantities that are necessary to compute the response indicators of the engine operating under full-load characteristics for three injection advance angles, i.e. 13, 17 and 21 CA deg. In the tests, the AD3.152 UR engine was fuelled by Ekodiesel Ultra D commercial diesel oil (DO). On the basis of real indicator diagrams, the start of combustion was determined. The graphs of the injector needle lift were used to determine the beginning of the fuel injection. Those quantities made it possible to determine auto-ignition delay time. On the basis of full load characteristics, the coefficients of engine response were determined.

3. Experimental results

Figure 4 shows the full load characteristics taken for three injection advance angles. Tables 2, 3 and 4 present the results of computations of auto-ignition delay time, torque response, rotational speed response, and the response of the AD3.152 UR engine operating at the injection advance angle α_{ww} = 13, 17 and 21 CA deg.

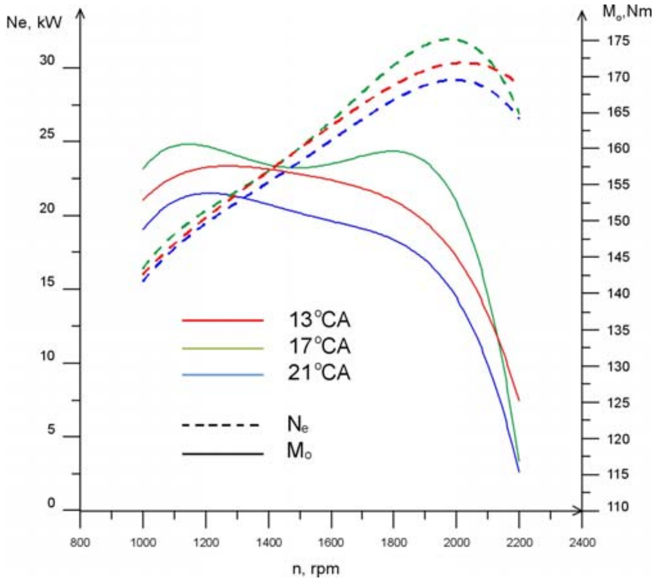


Figure 4. Full load characteristics of the effective power and torque in AD3.152 UR engine fuelled by diesel oil, for three injection advance angles α_{ww} = 13, 17 and 21 CA deg

Table.2. Auto-ignition delay time and torque response, rotational speed response, and the response of the AD3.152 UR engine operating at the injection advance angle α_{ww} = 13 CA deg

n, rpm	α_{pw}	α_{ps}	Auto-ignition delay time	Torque response	Rotational speed response	Engine response
1000	344.7	351.56	6.86	1.089	1.428	1.555
1200	345.14	352.96	7.82			
1400	346.26	354.37	8.11			
1600	347.42	355.78	8.36			
1800	348.82	355.80	6.98			
2000	348.25	357.18	8.93			
2200	348.25	357.20	8.95			

Table 3. Auto-ignition delay time and torque response, rotational speed response, and the response of the AD3.152 UR engine operating at the injection advance angle α_{ww} = 17 CA deg

n, rpm	α_{pw}	α_{ps}	Auto-ignition delay time	Torque response	Rotational speed response	Engine response
1000	341.3	349.6	8.3	1.031	1.428	1.472
1200	341.9	349.2	7.3			
1400	342.9	351.2	8.3			
1600	343.3	352.4	9.1			
1800	344.3	353.8	9.5			
2000	345.1	354.4	9.3			
2200	345.3	354.8	9.5			

Table 4. Auto-ignition delay time and torque response, rotational speed response, and the response of the AD3.152 UR engine operating at the injection advance angle α_{ww} = 21 CA deg

n, rpm	α_{pw}	α_{ps}	Auto-ignition delay time	Torque response	Rotational speed response	Engine response
1000	339.46	348.75	9.29	1.092	1.428	1.559
1200	339.64	348.75	9.11			
1400	–	–	–			
1600	341.67	350.15	8.48			
1800	343.27	355.78	12.51			
2000	343.67	355.78	12.11			
2200	343.95	355.78	11.83			

4. Conclusions

On the basis of the experimental results, the following conclusions can be drawn:

- a change in the injection advance angle does not change the rotational speed that corresponds to the generation of the maximum power or achieving the speed of the maximum torque,
- the maximum values of the effective power and torque in the engine operating at three settings of the injection advance angle occurred for the same rotational speeds, i.e. the maximum power for n=2000rpm, and the maximum torque for n=1400 rpm. The computed value of the engine rotational speed response was e_N=1.428,
- the highest value of the engine torque response, equal to e_M=1.092, was obtained for the injection advance angle α_{ww}=21 CA deg, the lowest value, namely e_M=1.031, was found for α_{ww}=17 CA deg,
- with an increase in the injection advance angle, the value of auto-ignition delay grows. The highest value of this quantity, namely α_{os} =12.51 CA deg, was found for α_{ww}=21 CA deg,
- the highest value of the engine response, e=1.559, was obtained for the injection advance angle α_{ww}=21 CA deg.

REFERENCES

[1] Ambrozik A.: Analysis of the work of four-stroke internal combustion engines (in Polish), Kielce University of Technology, Kielce 2010.

[2] Ahmet Murcak, Can Hasimoglu, Ismet Cevik, Murat Karabektas, Gokhan Ergen. Effects of ethanol–diesel blends to performance of a DI diesel engine for different injection timings. Fuel 109 (2013) 582–587

[3] Ying Wang, Yuwei Zhao, Fan Xiao, Dongchang Li. Combustion and emission characteristics of a diesel engine with DME as port premixing fuel under different injection timing. Energy Conversion and Management 77 (2014) 52–60.

[4] G.H. Abd Alla, H.A. Soliman, O.A. Badr, M.F. Abd Rabbo.: Effect of injection timing of the performance of a dual fuel engine, Energy Conversion and Management 43 (2002) 269–277, 2013.

[5] Duran Altiparmak, Ali Keskin, Atilla Koca, Metin Gürü: Alternative fuel properties of tall oil fatty acid methyl ester–diesel fuel blends, Bioresource Technology 98 (2007) 241–246, 2007.

[6] Mysłowski J., Kołtun J.: Response of piston internal combustion engines (in Polish), WNT, Warszawa, 2000.

[7] Boltze M., Wunderlich C.: Energiemanagement im Fahrzeug mittels Auxiliary Power Unit in Entwicklungstendenzen im Automobilbau, Zschiesche Verlag, Wilkau-Haßlau 2004.

[8] Mysłowski J., Gołębiewski W.: Response of Fiat engines (in Polish). Archiwum Motoryzacji. 4, pp. 319-325. 2009.

[9] Kruczyński S.: Performance and emission of CI engine fuelled with camelina sativa oil, Energy Conversion and Management 65 (2013) 1–6, 2013.

[10] Ambrozik A., Orliński P., Orliński S.: Impact of compression ignition engine fuelling with selected hydrocarbon and plant fuels on the injection delay angle and auto-ignition delay (in Polish). PTNSS Kongres – 2005. Rozwój silników spalinowych, Paper No. PTNSS P05-C024. 2005

[11] Ambrozik A., Ambrozik T., Kurczyński D., Łagowski P.: Report on the research project No. 4T12D05328: Model of heat release and exhaust NO_x emissions in compression ignition engine fuelled with diesel oil and plant-derived fuels (in Polish), 2008.

Defining Standardized Quality Level in Suburban Bus Transport

Vladimír Konečný, Mária Kostolná[1]

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Žilina, 010 26 Žilina, Slovak republic

Abstract The article deals with the possibilities of standardizing the quality level of suburban bus transport services. The procedures respect the legislative requirements which are valid in the Slovak Republic. The proposed theoretical methods are applied to specific measurement results of expectation and perception of the quality by the passengers in a significant transport hub of northern Slovakia, the region of Žilina. The findings will be applied in development of the standardization quality level in suburban bus transport to its anchoring into the service contract between self-governing region and operator of bus transport. This approach has not yet been applied in the Slovak Republic.

Keywords quality, suburban bus transport, passenger, expectation, satisfaction

JEL R41, R49

1. Introduction

The quality of suburban bus transport (SBT) is characterized by a set of quality criteria. It includes criterions related to quality of transport services (soft quality criterions) and quality of transport serviceability of territory (hard quality criterions). The following legislation deal with the issue of service quality in public passenger transport in Slovakia:

Act No 56/2012 collection of Laws on Road Transport in Article 21 (Service contract), part 1 states that the purpose of a service contract, concluded between the public authority and the operator, is to provide safe and effective public transport and quality services. In part 9 this law adds that part of this contract are requirements for quality standards, i.e. STN EN 13816 and STN EN 15140.

STN EN 13816 –Transportation. Logistics and services. Public passenger transport. Service quality definition, targeting and measurement. This European Standard specifies the requirements to define, target and measure quality of service in public passenger transport and provides guidance for the selection of related measurement methods. The standard defines a set of eight quality criteria for public passenger transport- availability, accessibility, information, time, customer care, comfort, security, and environmental impact. The standard classifies each criterion in more detail into sub-criteria. Services are determined by the quality loop.

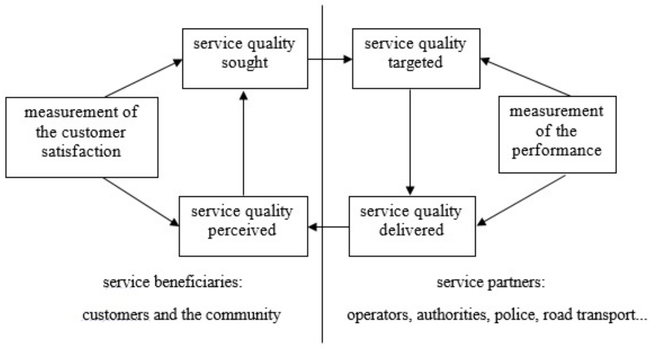


Figure 1. Service quality loop

STN EN 15140 – Public passenger transport – basic requirements and recommendations for systems that measure delivered service quality. This standard provides guidelines and recommendations for measuring the quality criteria defined by standard STN EN 13816.

Regulation (EC) No 1370/2007 on public passenger transport services by rail and by road. The purpose of this Regulation is to define how, in accordance with the rules of Community law, competent authorities may act in the field of public passenger transport to guarantee the provision of services of general interest which are, among other things, more numerous, safer, and of a higher quality. When competent authorities, in accordance with national law, require public service operators to comply with certain quality standards, these standards shall be included in the tender documents and in the public service contracts.

Transport and Communications, 2014; Vol. II.
ISSN: 1339-5130
DOI: 10.26552/tac.C.2014.2.2

The particular design of measurement and assessment must be based on both the legislative requirements associated with the measurement and assessment of quality. It must also respect the current status and requirements for quality assessment in terms of specific areas as well as already implemented procedures and experience in quality measurement and assessment in other regions of the SR or abroad, if appropriate.

The measurement and assessment system must be designed respecting the simplicity of measurement and to ensure satisfactory expressing power of the results of the provided transport services quality assessment. The diagram of certain steps in the design and implementation of measurement and assessment is shown in Figure 2.

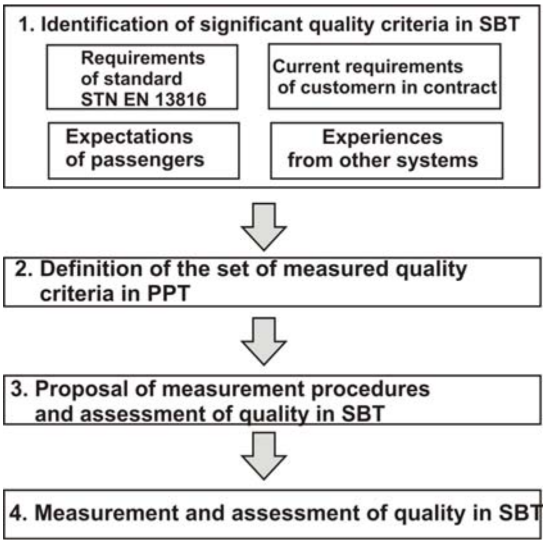


Figure 2. Quality measurement and assessment procedure diagram

Quantification of standardized quality level is needed for stages 3 and 4 of Figure 2.

2. Analysis of quality requirements in current contracts between self-governing regions and operators

We analyzed quality requirements in current contracts between self-governing regions and bus transport operators in concrete eight self-governing regions of the SR. It is on the right side of the quality loop, Figure 1. There are great differences between contracts.

Comparative analysis of quality requirements and financial sanctions in current valid contracts between self-governing regions and bus transport operators is presented in Table 1.

Table 1 Selected quality criterions required and sanctions in current valid contracts

Self-governing region	Quality criterion	Sanctions
ZA, TT, PO, BB, BA	safety, comfort, peaceful transportation (active safeguarding by staff in an accident)	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, PO, BB, BA	identification of bus, information about a bus line in the bus stops	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, PO, BB	clean and operational facilities for customers	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, PO, BB, BA	provision and disclosure of information	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, PO, BB, BA	skills of staff	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, PO, BA	transport of handicapped and visually impaired people	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, PO, BA	more comfort for mothers with children, senior people and pregnant women	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, TT, NR, KE, BB, BA	fluency, regularity, quality and safety of services and vehicle load factor	to 300 € (ZA)
ZA, TT, PO, BB, BA	information about modification of timetable, street direction, change and removing of bus link	to 300 € (ZA), to 6,638 € (PO, KE)
ZA, NR, KE, BB	electronic check-in system of passengers	to 300 € (ZA)
ZA	omitting over 6% bus links from overall number of bus links	the end of contract (ZA)
ZA, PO, NR, KE, BB	the end of public interest for services	the end of contract (ZA, PO, KE)
ZA, NR	buses maximum 16 years old	No sanction
ZA, NR	early bus departure from bus stops	to 500 € (ZA, NR)
ZA	delay of bus over 15% from overall travelling time from not objective causes	to 500 € (ZA)
ZA, PO, NR, KE	omitting of bus link (without reason)	to 1,000 € (ZA), to 6,638 € (PO, KE), to 700 € (NR)

Source: elaborated by authors on the basis of valid contracts

Note 1: Acronyms of self-governing regions: ZA- Žilina, TT-Trnava, PO- Prešov, NR- Nitra, KE- Košice, BB- Banská Bystrica, BA- Bratislava.
Note 2: The data from the self-governing of Trenčín were not found. Neither the penalties in BA, BB and TT were provided

The limits for meeting / not meeting the quality criteria is the most discussed in the contract for operator of Žilina. The given contract deals mainly with punctuality of buses. Financial sanctions are the highest for the omitting of bus and for its earlier departure from bus stop. The contract involves customer satisfaction, i.e., their complaints about the service that was provided for them. The contract deals mainly with security, fluency of transport, punctuality. The operator´s objective is to increase transport quality and comfort.

Public contracts in Prešov and Košice self-governing regions are very similar. They both have specified quality criteria which primarily related to security, comfort and fluency in transport. The individual conditions, which determine the meeting of targets, are not specified.

The Nitra self-governing region published its financial sanctions only for omitting a bus or its earlier departure from bus stop. The fines are imposed for unheated buses or failure to issue ticket or an incorrect issue ticket for passenger.

The self-governing regions Banská Bystrica, Bratislava and Trnava did not publish their financial sanctions related to low quality level services. They published only general targets of quality increasing. The self-governing region Trenčín did not provide its contract.

3. Standardizing the quality level in suburban bus transport from passenger point of view

The primary objective is to define a standard of the service quality level as a requirement for public procurement in suburban bus transport. Another equally important objective is to guarantee the level of quality requirements set down in contracts between the public authority and the operator throughout the duration of the contract. For each quality criterion included in the system that measures and evaluates the quality, the evaluation parties (public authority and operator) have to define the standardized parameters of the evaluation of criterion. The results of standardization are a necessary basis for measuring and assessing the quality level. The structure of parameters and their relationships are shown in Figure 2.

Methodology for standardization of quality criteria includes the following steps:

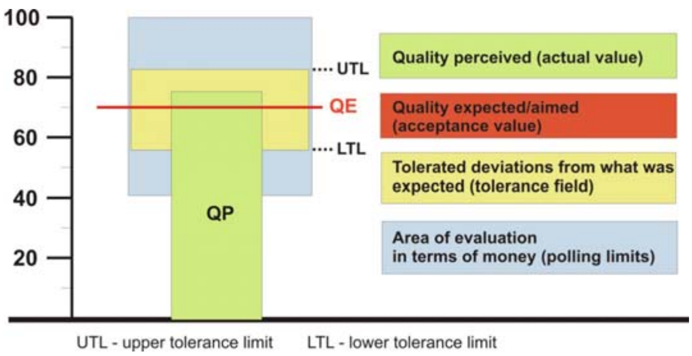
I. Definition of the level of expected / target quality - standard STN EN 15140 recommends that a set of measuring and evaluating quality criteria is based on customer expectations. Expected / target quality can be defined as a mean value calculated on the basis of a statistically significant sample of statements obtained through a passenger survey. It is a red line in Figure 2.

II. Definition tolerated deviations from the mean expected quality - in terms of descriptive statistics standard deviation to define the tolerated deviations of expected quality can be used; it is a yellow field in Figure 2.

III. Determination of the perceived quality level- based on a passenger's perception survey of quality criteria, their fulfillment by the operator. Perceived quality can be defined as the mean value calculated on the basis of a statistically significant sample of passenger statements obtained from the survey of passenger's quality perception. It is a green field in Figure 2.

IV. Calculation of passenger satisfaction with the performance of quality criteria- evaluation the relationship between perceived and expected quality. In the case of a satisfied passenger the passenger perception has a higher level than the level of passenger expectation, i.e. perceived quality is higher than the minimum value of the tolerance field. The red and green fields in Figure 2 are compared together. If the tolerance is not zero, it is a comparison of the green and the yellow field. In this case, tolerance limits have to be defined.

V. Measurement and evaluation of quality criteria by contracting parties (public authority and operator) based on contractually defined practices. The results are compared with a specified level of quality standard which is defined in the contract of public passenger transport services on the basis of steps 1 and 2.



Source: elaborated by authors

Figure 3. Definition of parameters for the quality evaluation – general approach

This approach based on passengers quality requirements and on the measurements of satisfaction is used to determine the measurement and evaluation of quality criteria. Now, in the Slovak Republic this approach is applied neither in transport organizations nor in public authorities.

Based on this approach an extensive research of passenger requirements and their satisfaction with the provision of transport services was carried out in autumn 2013 (left side of service quality loop). The objectified measurements were made by controllers in the area of transport services provi-

DOI: 10.26552/tac.C.2014.2.2

sion. This part of research is still under development due to the scale of data; and it represents the right side of service quality loop. The research was carried out in October and November 2013 on a sample of 2,868 respondents. The research was performed in the region and the city of Žilina. 931 passengers and their opinions on quality in SBT were investigated.

To identify the passenger requirements and to determine their level of satisfaction standardized questionnaires for several modes of transport were used; they respected differences of the individual transport modes. For the purposes of this article analysis and evaluation based on a standardized part of the questionnaire were processed; they take into account the quality criteria and requirements that are common to all reviewed transport modes. The individual aspects of quality criteria by mode of transport are subject to independent research. As an evaluation tool of respondents´ view the point scale with a range of 0-5 points, 0 - minimal importance, 5 - maximum importance was used.

Table 2. Values of average expectations and perceptions of selected quality criterions in suburban bus transport

Criterion	expectation		perception	
	average	σ	average	σ
punctuality	3.61	0.619	3.20	0.645
speed of transport	2.81	0.464	2.42	0.418
safety	3.27	0.665	3.17	0.230
cleanliness	3.69	0.621	3.00	0.747
behavior of driver	3.28	0.538	3.34	0.561
information	3.45	0.578	2.80	0.642
in vehicle comfort	3.2	0.638	3.03	0.641
ride comfort	3.10	0.651	3.19	0.840
bus stop/station comfort	3.24	0.955	2.77	0.469

Source: elaborated by authors

3.1. Identification of passengers´ expectations and perceived quality in SBT

Passenger requirements for quality represent expected quality level. The indicator says that the level of customer requirements should be on the basis of their legitimacy. This specified level should respect the opinion of the majority, i.e., the mean value has to be set. In our case, it is the weighted arithmetic average. Analyses were performed with the help of median values. The calculations of analyses did not confirm the occurrence atypical extreme values in the reviewed statistical files.

Then these results are used for determination of target quality level from the position of public authorities. This quality level should be a part of the contractual relationship between the public authority and operator and should contain the measurement procedures of individual quality criteria included in the set of criteria. This approach respects the recommendations of STN EN 15140.

Table 2 contains the results of analyses including a variability which expresses passenger's requests by using standard deviation. The variability value of passenger´s expectations can be used in the standardization of quality level for determination called tolerance deviations for individual quality criteria included in the methodology for measuring and assessing the quality (the yellow part of Fig. 3).

Table 2 includes the results of quality perception by passengers too. Perception of quality is expressed in the form of the arithmetic mean for each mode of transport and quality criteria. There are given the values of the standard deviation too.

3.2. Analysis of the relationship between expected and perceived service quality in SBT

For assessment of perceived and expected quality absolute and relative indicators can be used. Absolute indicator is, for example, *the Customer Satisfaction Value*. It is the absolute difference between perceived value and expected value. If the positive value is achieved, the operator provides a level of service exceeding customer expectations. A negative value indicates the customer dissatisfaction. Set of quality criteria for measuring satisfaction usually consists of more than one criterion therefore this indicator should be relativized through theory of indices.

This indicator:

$$CSV = \bar{x}_{QP} - \bar{x}_{EQ} \quad (1)$$

Where

$\bar{x}_{QP}$ is the average value of quality perception by passengers

$\bar{x}_{EQ}$ is the average value of expected quality by passengers

The relationship between what the customer perceives and what he expects can be expressed by *Customer Satisfaction Index*:

$$CSI = \frac{\bar{x}_{QP}}{\bar{x}_{EQ}} \quad (2)$$

If the value is more than 1, the level of quality perception is higher than his expectations. If the value is less than 1, the customer´s expectations are not met.

The equation (2) is used for calculating the degree of passenger satisfaction if no deviation from the mean value of the passengers expectation is tolerated (yellow field of Fig. 3 is identical with marked red line).

To define the tolerance limits of the expected quality is possible when the theory of control charts where the limits are defined as ± σ from the mean value is used. If we respect this approach we can modify the equation (2) for customer satisfaction index as equation (3):

$$CSI = \frac{\bar{x}_{QP}}{LTL_{EQ}} = \frac{\bar{x}_{QP}}{\bar{x}_{EQ} - \sigma_{EQ}} \quad (3)$$

Where

LTL_{EQ} is the lower tolerance limit of the expected quality by passengers

σ_{EQ} is the standard deviation of expected quality by passengers

3.2.1. Customer satisfaction index in conditions of Žilina region

We made two calculations of CSI.

Approach 1: No tolerance of expected quality

Based on the research of passengers´ expectations and their perceptions of the quality level, the relational analysis of the results by the equation (2) was performed. The calculated values of customer satisfaction index are shown in 2nd column of Table 3. Only two of nine quality criterions have been met.

Approach 2: Tolerance of expected quality ±σ of average expectations

Values of CSI were calculated on the basis of formula (3), the calculation respects lower tolerance limits (LTL) of customer expectations. The calculated values of CSI for this approach are shown in 3rd column of Table 3. Seven of nine quality criterions have been met.

Table 3. CSI for selected quality criteria with no respecting and respecting LTL of expectations

Criterion	CSI	CSI with LTL
punctuality	0.886	1.070
speed of transport	0.861	1.032
safety	0.969	1.217
cleanliness	0.813	0,978
behavior of driver	1.018	1.218
information	0.812	0.975
in vehicle comfort	0.947	1.183
ride comfort	1.029	1.303
bus stop/station comfort	0.855	1.212

Source: elaborated by authors

Note: The red cells represent the values were passengers have higher expectations than the actual performance by operators. The green cells represent the opposite, when the fulfillment of quality criteria from operators is higher than the passenger requirement.

3.2.2. Standardization of quality level from customer point of view in SBT in Žilina region

The standardized parameters were calculated on the basis of research of expected and perceived quality in public passenger transport in the region of Žilina. Figure 4 depicts standardized values of quality expected, quality perceived and tolerated deviations for selected quality criteria. Expectations and perceived values of quality reached by research were transformed from the point scale (from 0 to 5 points) to points (from 0 to 100 points or percentage).

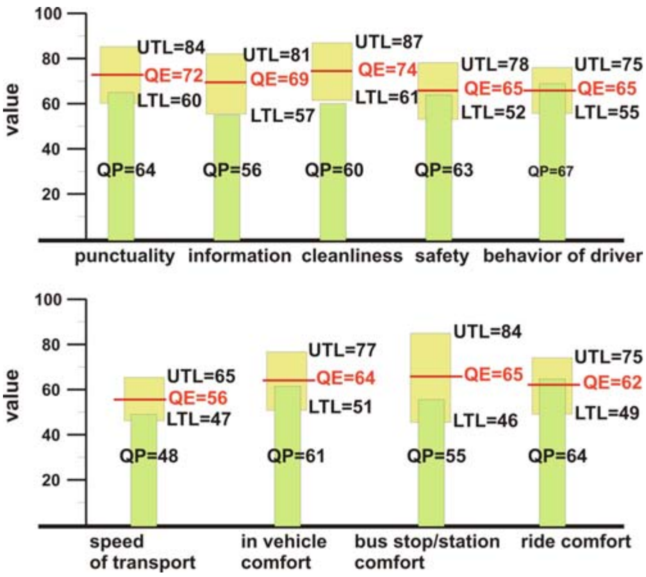
Tolerated deviations of expected quality were calculated on the basis of following formulas:

$$UTL_{EQ} = \bar{x}_{EQ} + \sigma_{EQ} \quad (4)$$

$$LTL_{EQ} = \bar{x}_{EQ} - \sigma_{EQ} \quad (5)$$

Tolerated values (UTL, LTL) reached the values from 0 to 5 points, the values for selected quality criteria were transformed to percentage too.

There are differences between expected and perceived quality in relation to concrete quality criterions in suburban bus transport. The greatest differences are in cleanliness, information and bus stop/station comfort, Fig.4.



Source: elaborated by authors

Figure 4. Standardized parameters for selected quality criteria for SBT in the region of Žilina

4. Conclusions

There are no unified methods for measuring and evaluating the quality of public passenger transport. There are European standards (EN 13816 and EN 15140) providing guidelines for measuring and evaluating the quality of public passenger services. Recommendations of standards are general. Only application of recommendations is insufficient. Application of general guidelines causes differences in approaches to measuring and evaluating the quality of public passenger transport at national and international level.

The results of research in the field of customer expectations and perceptions will be compared with results of measuring concrete quality criterions of public passenger transport in the region and the city of Žilina.

The results should be an important source for definition of standardized level of quality for contracting in public passenger transport and for proposal of methodology of measuring and evaluation of concrete quality criterions in public passenger transport.

Standardized level of quality in public passenger transport can be the base for comparison of quality of provided services by different operators. It should respect the customer´s expectations too.

ACKNOWLEDGEMENTS

This paper has been developed under the support of project: MŠVVŠ SR - VEGA č. 1/0320/14 POLIAK, M.: Road Safety Improvement through Promoting Public Passenger Transport

REFERENCES

[1] L. Eboli, G, Mazzulla, "A Stated Preference Experiment for Measuring Service Quality in Public Transport". In.: Transportation Planning and Technology, Rotledge publisher, member of the Taylor and Francis Group, Vol. 31, No. 5, 2008, ISSN 0308-1060, pp.509-523

[2] M. Friman, M. Fellesson, "Service Supply and Customer Satisfaction in Public Transportation: The Quality Paradox", In.: Journal of Public Transportation, Vol. 12, No. 4, University of South Florida, 2009, ISSN 1077-291X, pp.57-69

[3] J. Gnap, V. Konečný, "Quality measurement of suburb bus transport. In: Quality 2009. 18. International conference, Ostrava: DTO CZ, 2009. - ISBN 978-80-02-02153-7.

[4] J. Gnap, V. Konečný, "The evaluation of transport services suppliers. In: Quality 2008: 17. . International conference, Ostrava: DTO CZ, 2008.

[5] V. Konečný, "Quality measurement and evaluation in public passenger transport". CEDOP: University of Žilina, Žilina 2011. ISBN 978-80-554-0361-8.

[6] V. Konečný, "Quality management tools. Practices for quality management subject". University of Žilina, Žilina 2012. ISBN 978-80-554-0601-5

[7] A. Mateides, "Customer satisfaction and methods for measurement of satisfaction" EPOS, Bratislava 1999, ISBN 80-8057-113-9.

[8] Regulation (EC) No 1370/2007 of the European Parliament and of the Council on public passenger transport services by rail and by road

[9] STN EN 13816 – Transportation. Logistics and services. Public passenger transport. Service quality definition, targeting and measurement. Slovak Office of Technical standards, Bratislava 2003.

[10] STN EN 15140 - Public passenger transport. Basic requirements and recommendations for systems that measure delivered service quality. Slovak Office of Technical standards, Bratislava 2006.

[11] The Act No. 56/2012 Coll. on Road Transport

Non Directional Beacons Checking

Ján Pitor, Filip Škultéty, Karol Götz [1]

[1]Air transport department, Faculty of Operation and Economics of Transport and Communications, University of Žilina, 010 26 Žilina, Slovak republic

Abstract This paper aims to familiarize experts from other fields with issues of flight check of Non Directional Beacon (NDB) and its assessment. The AT-940 Automatic Flight Inspection System and the aircraft PIPER SENECA are described followed by flight check specifications and procedures. Evaluated were the coverage of NDB Z, NDB ZLA located at Žilina airport and Standard Instrument Approach Procedure for runway 06. The results of evaluation are in paragraph 4. The paper is based on project "Centre of excellence for Air Transport" focused on the impact of air transport on environment photogrammetry, surveillance of electromagnetic compatibility of radio navigation aids and radio communication equipment.

Keywords checking, surveillance, radio navigation aids, radio communication equipment environment, photogrammetry.

JEL L93

1. Introduction

This paper describes one of the results of scientific research project "Centre of excellence for Air Transport -ITMS 26220120065" focused on the impact of air transport on environment, photogrammetry, surveillance of electromagnetic compatibility of radio navigation aids and radio communication equipment.

The aim of the paper is, apart from the project results and gained knowledge dissemination, to familiarize experts from other fields with issues of procedures for the flight check of communications, navigation and surveillance systems (CNS).

This paper concentrates on flight check of NDBs located at Žilina airport.

2. The AT-940 automatic flight inspection system

The AT-940 Automatic Flight Inspection System is a computer based, fully automatic flight inspection system used for testing, calibration and certification of ground based navigation aids. [1]

The AT-940 has the following capabilities:

- ILS Categories I, II and III
- VOR
- DME
- NDB
- 75 MHz Marker Beacon
- VHF Communications

The AT-940 consists of four primary components (see Figures 1-4)

Figure 1. Signal Processing Unit (SPU)

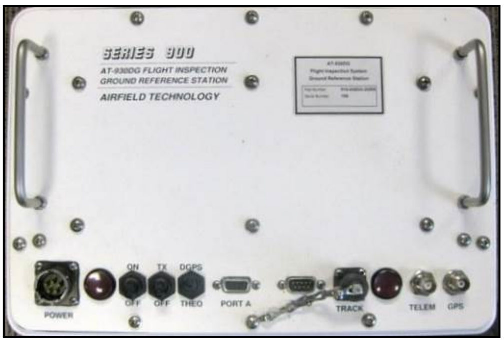


Figure 2. Ground Reference Station (GRS)

Figure 3. Avionics Sensor Unit (ASU)

Figure 4. Host Computer

The AT-940 airborne equipment consists of the SPU, ASU and associated cables, aircraft antennae and accessories. The AT-940 can operate either in single or dual ASU modes. The airborne equipment receives the radio signals from the navigation aid being inspected and extracts the flight inspection parameters from the receivers for the selected mode of operation. It also receives the GPS corrections being sent from the GRS, and uses this data with its own internal GPS receiver to accurately determine the position of the aircraft antenna. All of this data is then transmitted to a portable computer or "host" either locally through a serial port or to the ground via a telemetry link.

The AT-940 airborne equipment is installed in the aircraft in the compartment behind the rear seats of the aircraft. The AT-940 ground equipment consists of the GRS and associated cables, antennae and accessories. The GRS contains a telemetry transmitter and dual frequency GPS receiver. The GRS is set-up at a known location on an airfield, and provides GPS differential corrections for the airborne GPS receiver over a radio telemetry link.

The host computer records and displays the real time flight inspection data in both graphical and numerical formats on a high resolution colour display. After a flight inspection measurement is completed, the recorded data is saved to the host computers internal hard disk drive. Each measurement is archived as an independent disk file. The computer performs an automatic analysis of common parameters and presents the results on the screen.

When a hard copy is required, recordings may be printed on a portable printer. Previously recorded data may also be displayed and printed for comparison purposes.

2.1. Aircraft's installation

The AT-940 Automatic Flight Inspection System is installed at the airplane **PIPER PA34-220T SENECA** Reg./ MSN: OM-UTC / 3449443. [2]

Figure 5. PIPER PA34-220T Seneca V

PA-34-220T is a twin-engine, piston powered airplane with low-mounted wings and retractable landing gear.

Standard data:

- Gross weight. 2165 kg
- Empty weight. 1548 kg
- Fuel capacity 362 l
- Engines 2x220-hp turbocharged TSIO-360-RB

Performance:

- Top Cruise 197 kts
- Stall 61 kts
- Initial climb rate 1,550 feet per minute
- Ceiling 25,000 feet
- Range 730-820 nautical miles
- Take-off distance 1,707 feet
- Landing distance 2,180 feet

3. Non directional beacons checking

A Non directional Beacon is a low or medium frequency radio beacon that operates in the frequency range 190 to 1,750 kilohertz (kHz). A radio beacon used in conjunction with an Instrument Landing System marker is called a Compass Locator. [3]

3.1. Flight check specifications

Coverage Orbit. Coverage must be evaluated by flying an orbit with the radius equal to the area of intended use.

Standard Instrument Approach Procedure (SIAP). Altitudes flown must be the minimum proposed or published for the segment evaluated, except that the final segment must be flown to 100 ft below the lowest published Minimum descent altitude (MDA).

3.2. Flight check procedures

The primary objectives of flight check are to determine the coverage and quality of the guidance provided by the NDB system and to check for interference from other stations.

These assessments are to be made in all areas where coverage is required and with all operational procedures designed for the NDB, in order to determine the usability of the facility and to ensure that it meets the operational requirements for which it was installed. [4, 5]

Coverage Orbit. Standard service volume coverage is evaluated by flying orbits at the lowest coverage altitude. Facility Maintenance determines the reduced power output of the facility during coverage checks. At facilities where dual transmitters are installed, facility coverage for maximum useable distance may be evaluated by alternating transmitters.

Manoeuvring. Fly an orbit about the facility at the maximum distance specified by the facility classification. The orbit altitude must be 1,500 ft above facility site elevation, or the minimum altitude which will provide 1,000 (2,000 ft in designated mountainous areas) above intervening terrain or obstacles, whichever is higher as determined by map study. Coverage orbits are usually completed counterclockwise, as the ADF navigation needle parks to the right if the signal has an unlock (this is true for mechanical instruments; however, the needle may disappear on electronic displays). Sectors found out of tolerance must be evaluated using orbits at reduced distances or increased altitudes in an attempt to determine facility restrictions. Monitor the facility identification during coverage checks, as the loss of the identifier usually corresponds with the loss of the NDB signal.

Standard Instrument Approach Procedure

Manoeuvring - Periodic Checks. Required coverage evaluations during periodic checks are limited to surveillance checks of any airways, routes or transitions to the extent the aircraft is manoeuvred to position for other required checks, as well as all SIAP final approach segments. For SIAP(s) with a Final Approach Fix (FAF), cross the FAF at the minimum published altitude and descend to at least 100 feet below the minimum descent altitude for that segment. For SIAP(s) without a FAF, fly the final segment from the procedure turn distance at the minimum published procedure turn completion altitude and descend to at least 100 feet below the minimum descent altitude for that segment. In addition, descend to 100 feet below all step-down fix altitudes inside the FAF.

4. The results of evaluation

There are two NDBs at Žilina aerodrome (Z and ZLA, see Figure 6 to 8). Their coverage and Standard Instrument Approach Procedure were evaluated using Seneca aircraft equipped with The AT-940 Automatic Flight Inspection System.
The following flight checks were executed:

- coverage orbit of NDB ZLA, manoeuvring depicted in Figure 6, the results depicted in Figure 9,

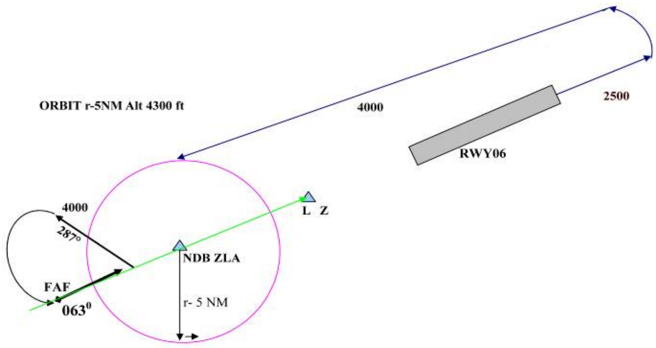


Figure 6. Coverage orbit of NDB ZLA

- coverage orbit of NDB Z, manoeuvring depicted in Fig. 7, the results are in Fig. 10,

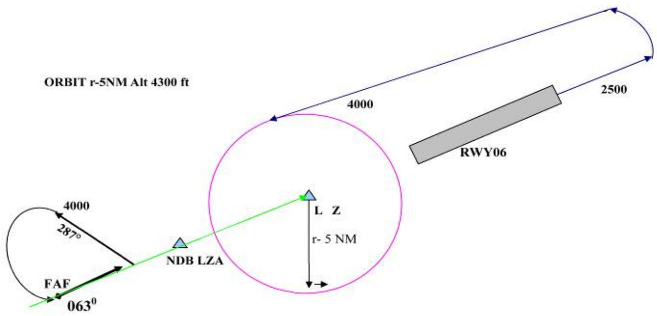


Figure 7. Coverage orbit of NDB Z

- SIAP RWY 06, checked navaids NDB Z and ZLA, manoeuvring depicted in Figure 8, the results depicted in Figs. 11 and 12,

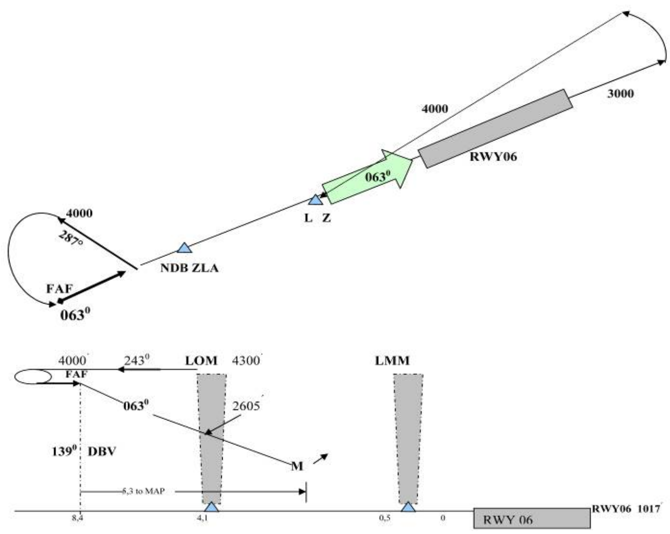


Figure 8. SIAP RWY

DOI: 10.26552/tac.C.2014.2.3

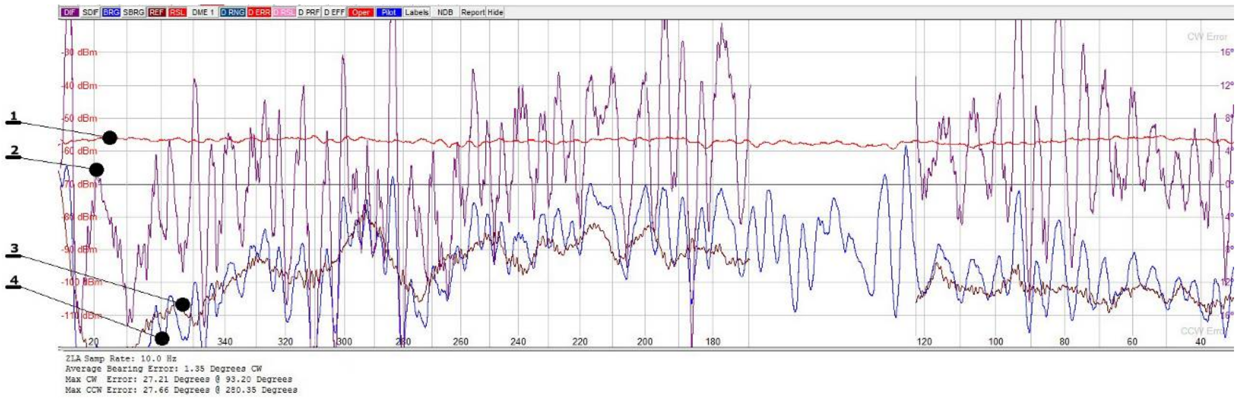


Figure 9. Results of coverage orbit of NDB ZLA

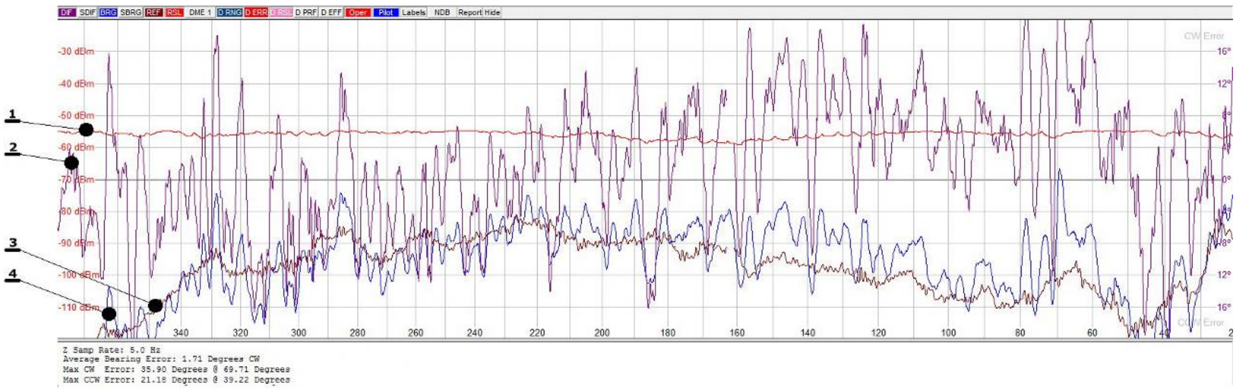


Figure 10. Results of coverage orbit of NDB Z

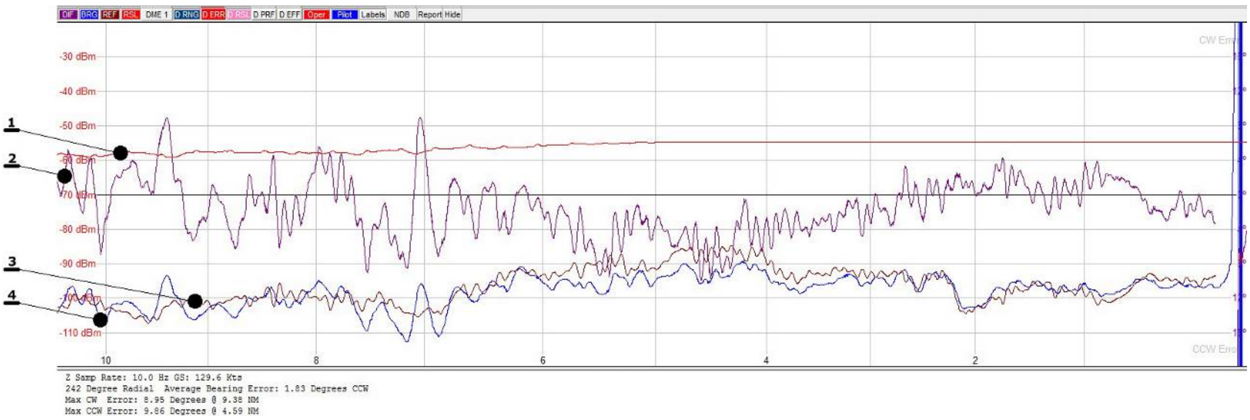


Figure 11. Results of SIAP RWY 06 for NDB Z

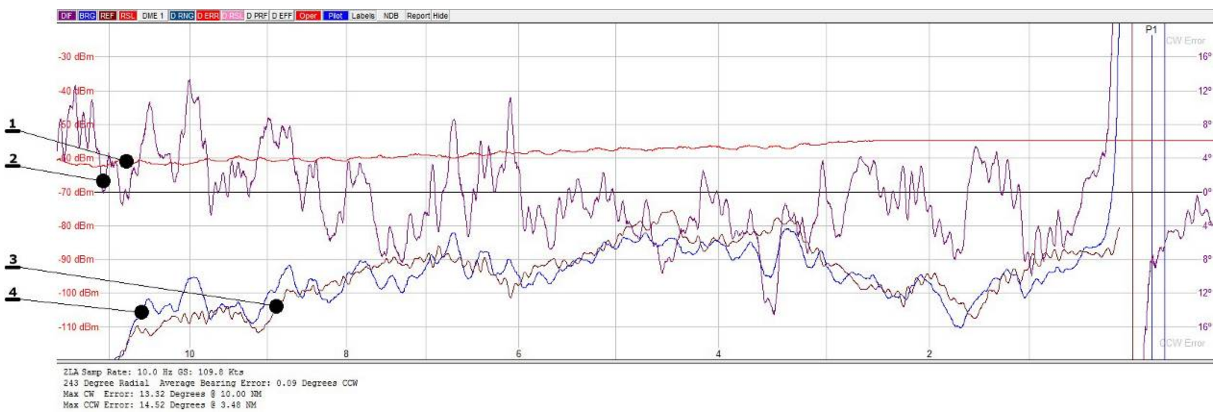


Figure 12. Results of SIAP RWY 06 for NDB ZLA

The legend

1. Received signal level
2. Difference between bearing to NDB (reference value) and measured bearing to NDB,
3. GPS reference (reference value),
4. Measured bearing to NDB.

5. Conclusions

The coverage and Standard Instrument Approach Procedure were evaluated during four flight checks using Seneca aircraft equipped with The AT-940 Automatic Flight Inspection System. The results are not mandatory for Air navigation services provider because they are product of research and development. The University of Žilina is not certified to perform flight checking, The Centre of excellence project is oriented on both the research and development. Such projects are necessary to build information and communication equipment of university laboratories and CNS facilities evaluating system for experimental verification of new knowledge and technology.

ACKNOWLEDGEMENTS

This paper is published as one of the scientific outputs of the project:"CENTRE OF EXCELLENCE FOR AIR TRANSPORT", ITMS: 26220120065.

Operačný program VÝSKUM a VÝVOJ

Európska únia

We support research activities in Slovakia. Project is co-financed by EU.

REFERENCES

[1] AT-940 FLIGHT INSPECTION SYSTEM MANUAL, Radiola Aerospace Flight inspection, USA, August 2011

[2] PIPER PA34-220T Seneca V – specs., USA, January 2013

[3] International Civil Aviation Organization. doc. 8071 - Manual on Testing of Radio Navigation Aids Volume II, Fifth Edition, December 2007

[4] United States Standard Flight Inspection Manual, USA, March 2005

[5] International Civil Aviation Organization, Annex 10, Volume 1, August 2008

DOI: 10.26552/tac.C.2014.2.4

Competitiveness of Enterprises in Polish SME Sector

Anna Wolak-Tuzimek[1], Elżbieta Noworol-Luft[2], Radosław Luft[3]

[1] Ph.D. University of Technology and Humanities in Radom, Chrobrego 31 St., 26-600 Radom, Poland,
[2] Msc, University of Technology and Humanities in Radom, Malczewskiego 29 St., 26-600 Radom, Poland,
[3] Msc, University of Technology and Humanities in Radom, Chrobrego 31 St., 26-600 Radom, Poland,

Abstract. Growth factors of competitiveness are presented empirically. Conditions of competitiveness are determined by internal factors, dependent on enterprises themselves, and by a wide range of internal factors, dependent on the macroeconomic environment. Analysis of statistics concerning 2004-2011, collected as part of the author's research, leads to the conclusion that enterprises gain competitive advantage by low pricing and high quality of their products. A growing importance of quality as a factor determining enterprise competitiveness can also be noted.

Keywords competitiveness, small and medium-sized enterprises, sources of competitive advantage

JEL L200, L290

1. Introduction

The contemporary economy relies on continuing change and growing levels of uncertainty. The accelerating globalisation requires businesses to use resources increasingly effectively, states and institutions to create conditions for development of entrepreneurship, innovation and productivity. Integration of Poland into the European Union supports this process by compelling all market players to meet demands of growing competition.

The objective of this paper is to discuss factors affecting competitiveness of Polish enterprises.

Operation of enterprises in circumstances of continuous change related to the IT revolution and proceeding globalisation is not an easy task. They must have the ability to maintain the existing or build new competitive advantage. This is made possible by effective change management, or management of business competitiveness. It involves treating innovation as the objective and condition of continuous restructuring of resources and development of competitive potential in order to achieve, maintain and reinforce standing in the market. It can be said, therefore, that development of business must rely on overcoming of weaknesses and transforming threats into opportunities.

2. Nature of enterprise competitiveness

Competition is an important tool, a principal dimension of economic life and a major source of wealth creation in any economy as it enforces reduction and rationalisation of manufacturing costs, improved organisation and introduction of changes and innovations [1].

Competition characterises certain relations between entities that compete with one another, namely, some pursue their objectives in rivalry against other entities. Such a situation can be avoided if both entities conclude that agreement is more beneficial. This is very rare, however.

This phenomenon has always driven human creativity in all areas of public life [2]. It mobilises enterprises to take the most efficient advantage of their resources.

Competitiveness can be seen in three dimensions, as:

- competitive standing, that is, performance competitiveness,
- competitive potential, or resource competitiveness,
- competitive strategy (instruments of competition), or operational (processual, functional) competitiveness.

Competitive standing of an enterprise is a function of assessment by the market (in particular, by customers) of what the enterprise has to offer, that is, all products and services offered in the market. Market share and financial position of an enterprise are the most fundamental and synthetic measures of competitive standing of an enterprise [5]. It must be remembered that financial standing of an enterprises to a considerable degree depends on the extent of its self-financing.[6]

Competitive potential of an enterprise can have narrow or broader definitions. In its narrow sense, competitive potential comprises all resources that are actually or potentially used by an enterprise. The broader meaning of an enterprise's competitive potential includes not only resources but also the following elements: corporate culture, organisational structure, employment health and safety [3],strategic vision, mission and conduct (process of strategy creation) of an enterprise.

Table 1. Selected definitions of competitiveness

Author	Definition
Cyrson	Process in which all market players take part who try to realise their interests and offer better prices, quality or other characteristics which affect transaction decisions
Lubiński	An enterprise's capacity for long-term sustainable growth and its desire to maintain and expand its market share
Jakubik	Relative ability to enforce an own system of objectives, intentions or values
Gorynia	Ability to compete, that is, survive and operate in a competing environment
Jantoń-Drozdowska	An enterprise's capacity for improving effectiveness of its external operations by strengthening and improvement of its market standing
Flejterski	Ability to design, manufacture and sell goods whose prices, quality and other characteristics are more attractive than the corresponding features offered by competitors
Hampden-Turner, Trompenaars	Rivalry and cooperation which help both to acquire knowledge of key technologies and customer needs and requirements
Adamkiewicz-Drwiłło	Competitiveness of an enterprise, understood as a property, defines an enterprise's ability to continually create a development trend, growth of productivity (measured on the micro scale) and to effectively develop sales markets in the context of newer, better and cheaper goods and/or services offered by competitors

Source: the author's own compilation on the basis of [8].

Put simply, competitive strategy is a set of instruments applied with a view to gain competitive advantage. Diverse methods of gaining the advantage can be employed depending on objectives. Competition instruments include, for instance, product quality, price, range, advertising, sales promotion, guarantees, distribution network, etc.

Enterprises in a market economy eager to boost their competitiveness must apply competitive advantages gained by [4]:

- unique products, technologies,
- low prices,
- high qualifications of management,
- effective strategy,
- effective management of innovations.

Suppliers of goods are growth factors of enterprise competitiveness as well. Their highly efficient delivery of orders and reliability are sources of competitive advantage.[7].

Each enterprise strives to perform better than others in a given sector and, to do so, needs to have a competitive advantage over its rivals.

3. Methods of research

Test enterprises were selected from the catalogue www.bazafirm.pl, a contact database for businesses operating in Poland.

The survey sample was selected at random, in line with the first and second principles of randomisation, namely, each element of the general population had a chance to be included in the sample and elements of the same category were taken into account.

The simple variant of random choice was applied. A sample is random where all probabilities of selection of the sample elements are identical and constant in the entire process of selection.

A random sample allows for determination of a sample's representativeness for a population in probabilistic terms, though in all possible respects. Simple random samples are regarded as the most appropriate for objective research.

Interviews with the respondents were carried out by means of electronic mail surveys in two test periods. In November 2007, the survey questionnaire (research tool) was distributed to 1100 enterprises and in March 2012, to 400 enterprises. In parallel, phone calls were made to invite participation in the test and to monitor its progress. In effect, 318 correctly completed questionnaires were returned for the period 2004-2006 and 107 for the years 2007-2011, which corresponds to feedbacks of 28.9% and 26.8 %, respectively.

The research involved private enterprises, that is, firms owned by individuals running their own businesses, and companies with domestic capital.

4. Competitiveness of enterprises – the empirical view

In the period under discussion, enterprises competed mainly in two categories, namely, price and quality of their goods and services.

Innovativeness of products as a factor contributing to competitive advantage was variously perceived depending on company size. The regularity can be observed: as an enterprise grows, so does its interest in innovative activities. In the end of the tested period, only 9.45% microenterprises treated innovation as a source of competitive advantage, compared to 38.27% of medium-sized firms.

This situation may be caused by lack of state support for the process of innovation transfer. Legislation and regulations concerning innovation will not boost enterprise innovativeness by themselves. Financial aid of the state is required to implement innovations in businesses.

Treatment of product originality as a factor determining competitive advantage depended on size of a company. Medium-sized companies clearly stand out in this respect. 23.5% of them pointed to this factor on average, whereas the proportion among the other two business groupings averaged 14.8%.

DOI: 10.26552/tac.C.2014.2.4
ISSN: 1339-5130

Table 2. Sources of competitive advantage (%)

Explanatory variable	Explanatory variable category	Price	Quality	Innovation	Originality	Staff
2004						
Company size	Micro	68.75	60.42	18.75	12.50	22.92
	Small	57.14	71.43	25.00	7.14	17.86
	Medium-sized	55.56	72.22	44.44	16.67	22.22
2005						
Company size	Micro	69.77	67.44	20.93	16.28	18.60
	Small	61.76	73.53	23.53	14.71	14.71
	Medium-sized	55.56	72.22	50.00	27.78	22.22
2006						
Company size	Micro	76.27	66.95	15.25	17.80	15.25
	Small	62.73	75.45	27.27	19.09	21.82
	Medium-sized	47.37	73.68	47.37	26.32	26.32
2007						
Company size	Micro	75.24	65.17	14.19	15.70	9.37
	Small	69.35	63.29	29.38	19.03	10.24
	Medium-sized	52.18	65.76	35.46	35.75	16.72
2008						
Company size	Micro	75.80	67.48	13.50	13.25	8.46
	Small	72.43	65.14	32.19	17.83	9.14
	Medium-sized	58.45	62.14	37.75	23.39	16.02
2009						
Company size	Micro	78.20	71.39	12.95	12.80	7.23
	Small	74.72	70.15	33.87	17.80	8.75
	Medium-sized	63.53	65.83	39.24	21.45	14.35
2010						
Company size	Micro	75.18	68.21	11.00	11.11	8.43
	Small	75.21	69.18	25.97	15.43	9.67
	Medium-sized	67.58	65.02	38.65	17.99	15.39
2011						
Company size	Micro	69.87	69.59	9.45	9.18	7.43
	Small	71.60	71.29	21.34	16.93	9.07
	Medium-sized	68.32	68.00	38.27	18.48	16.98

Source: the author's compilation of survey results.

Effect of company size on selection of management staff as a factor generating competitive advantage was maximum in 2004. It was indicated by 22.92% of micro-enterprises. A declining trend set in the following years, with merely 7.43% of these firms pointing to management staff as a source of competitive advantage in 2011. A similar tendency could be observed in the remaining two groups of companies. The factor fell by 8.8 percentage points for small and 5.2 percentage points for medium-sized enterprises.

Impact of the company size on frequency of selecting higher domestic demand as a factor stimulating competitiveness was statistically significant throughout the research period. Evaluations of the factor varied over individual years. In 2004-2006, it was most commonly selected by small businesses (54.01%) and most seldom by micro-enterprises (26.75%). The indication declined by 12.89 percentage points for small enterprises and rose by 8.33 percentage points for micro-enterprises.

Table 3. Factors enhancing competitiveness of businesses (%)

Explanatory variable	Explanatory variable category	Domestic demand	EU demand	Tax relief	Export opportunities	Innovative nature
2004 – 2006						
Company size	Micro	26.75	4.06	33.99	10.31	28.32
	Small	54.01	19.99	25.01	13.38	30.85
	Medium-sized	45.39	23.14	30.56	7.73	45.92
2007 – 2011						
Company size	Micro	35.08	2.10	15.22	11.02	32.18
	Small	41.12	12.78	17.69	10.67	34.21
	Medium-sized	45.87	24.09	22.45	15.90	48.43

Source: the author's compilation of survey results.

Positive assessments of the role of increased EU demand differed depending on the company size. It ranged 4-23.14% in 2004-2006, to rise only in the case of medium-sized enterprises in the next period under discussion.

The effect of company size on the rate of indications to another factor boosting market competitiveness, i.e. tax reliefs, varied across the periods. Its role was substantially greater at the initial stage, demonstrated by 34% indications by micro-enterprises. The figure fell in each enterprise grouping in 2007-2011, owing to stabilisation of the Polish tax laws which have become more transparent and comprehensible recently.

The company size determined choices of another factor, export opportunities, to a lesser extent (7.0% to 13.0%) in 2004-2006 than in 2007-2011 (between 11% and 16%).

Positive opinions about innovative nature of products varied depending on the company size. In 2004-2006 and 2007-2011, it was most frequently selected by medium-sized businesses (46% and 48% indications, respectively) and most rarely by micro firms (28% and 32%, respectively).

Favourable assessments of business location were common only among micro-enterprises and small businesses in both the research periods.

The share of companies selecting narrow specialisation was low in both the periods. Only micro-enterprises (19%) regarded the factor as influencing improved competitiveness of enterprises.

5. Conclusions

Competitive standing of enterprises depends on a number of factors under control of businesses and of many external variables. Earlier research demonstrated pricing was the key factor used to build competitive standing. Importance of quality of goods and services had been increasing, yet strategies of enterprises were still based on unit costs and price competition.

Marked shifts in business approach took place in 2011, from a heavy focus on pricing towards quality of goods and services, with regard to building of the market position. On average, 69.93% businesses indicated price and 69.62% the quality of goods and services as the prevailing factors which decided their market standing. The difference between these factors shrank substantially, however. In 2008, it averaged 4 percentage points, to fall to merely 0.31 points four years later. That change proved so significant that enterprises managed excellently competing with price and quality even at the time of the economic slump. Such efforts are proof of positive development trends in enterprises.

REFERENCES

[1] Becht, A. 2009. *Budowanie konkurencyjności organizacji*, Łódź: Media Press. 2009. p. 250, ISBN 978-83-61215-22-6.

[2] Frejtag-Mika, E., Sieradzka, K. 2006. *Poland`s competitive challenges and absorption of the European Union structural funds*. In J. Misala (ed.) Polska w Unii Europejskiej, Wstępny bilans członkostwa, Radom: Wydawnictwo Politechniki Radomskiej, 2006, p. 190-197, ISBN 83-7351-236-5.

[3] Lotko A., Lotko M., 2015. Luster analysis of knowledge workers assessment of occupational threats and attitudes to charakter of work, Maintenance and Reliability Warszawa 2015, Vol.17, Issue 1, ISSN 1507-2711.

[4] Porter, M.E. 1990. *The Competitive Advantage of Nations*. New York: The Free Press.1990, ISBN 978-0684841472.

[5] Sieradzka, K., Wolak-Tuzimek, A. 2012. *Forms of obtaining capital by growth companies*. In T. Meluzin, M. Zinecker, J. Hornungowa, M.Klimkova (ed.), *Trends in Economics and Management for the 21st Century*, Brno University of Technology, Faculty of Business and Management, Czech Republic 2012, [CD] ISBN 978-80-214-4581-9.

[6] Vaceková, G., Svidroňová, M. 2014. *Benefits and Risks of Self-Financing of NGOs - Empirical Evidence from the Czech Republic, Slovakia and Austria*. In: E+M Ekonomie a management, Vol. 17, Issue. 2.,Technická univerzita v Liberci, 2014. p. 120 – 130, ISSN 1212-3609.

[7] Wang Y., Xiao Y., Yang N, 2014. *Improving reliability of a shared supplier with competition and spillovers*. European Journal of Operational Research Volume 236, Issue 2, 2014, p. 499, ISSN 0377-2217.

[8] Wolak-Tuzimek, A. 2010. *Determinanty małych i średnich przedsiębiorstw w Polsce*. Warszawa: Wydawnictwo Naukowe PWN. 2010. p.93-94, ISBN 978-83-01-16332-7.

TRANSPORT AND COMMUNICATIONS

Scientific journal intended to combine theory and practice in the field transport and communications and thus advancement of transport and communications sciences.

Each paper was reviewed by two reviewers.

The Scope of Journal: Transport and postal policy, Public passenger transportation systems, Quality of transport and post services, Demand and supply in transport, post and telecommunications, Logistic systems, Road transport, Rail transport, Water transport, Air transport, The business environment in the SR, The cross-border cooperation.

Frequency of publishing: Twice per year.

Publishing language:	English
Publisher:	The Faculty of Operation and Economics of Transport and Communications, University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia
Printed:	EDIS – Printing House of the University of Žilina, Univerzitná 1, 010 26 Žilina, Slovakia
IČO	00 397 563
Edition:	60 pc
Registered No:	EV 4902/13
Tel:	++421/41/5133051
Email:	tac@fpedas.uniza.sk
Web:	http://tac.uniza.sk

December 2014

DOI: 10.26552/tac.J.2014.2

ISSN 1339-5130

ISSN 1339-5130

DOI: 10.26552/tac.J.2014.2