ANNALS OF THE ORADEA UNIVERSITY
Fascicle of Management and Technological Engineering
ISSUE #1, MAY 2015, http://www.imtuoradea.ro/auo.fmte/

RESEARCHS ON RELIABILITY OF URBAN PASSENGER TRANSPORT IN SIBIU

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***Abstract*—**The aim of this paper is the analyze of reliability indicators for public transport system of Sibiu city, specially one of the most crowded route. The approach is applied to the real task of the reliability estimation for Sibiu city public transport route. This way, the assessment of public transport benefits will be substantially improved.

***Keywords*—** urban public transport, reliability, passenger waiting time

I. INTRODUCTION

THE current passenger transport has become an element of human life standard, offering everyone the opportunity to travel, communication, perception, assimilation etc.

This transport activity has come to account for 10% of EU GDP, namely 4.5% in Romania. In the context of the development of urban area, passenger transport plays a vital role because it contributes to the transport demand rhythmically, safely and with an appropriate degree of comfort. Parallel to these positive aspects it has also negative aspects:

1) Traffic jams;
2) The time lost in traffic jams;
3) Environmental pollution by exhaust gases;
4) Noise etc.

Ensuring a quality public transport has become a priority issue because of traffic congestion in big cities because of the increasing number of cars. Using public transport instead of private cars would solve both traffic congestion and negative issues derived from it: pollution, congestion, stress, delays, etc..

Increase of economic efficiency in transport activity must be conducted through the rational use of vehicles and high problem - solving and programming modernizing transport capabilities [1]. For this it is necessary to know the transport demand, to determine the most economical routes and deploy vehicles depending on the size of passenger flow distribution by developing so-called free programs that meet the demands of the route. Urban transport, in particular, its main component, public transport of passengers, must be viewed in the context of the overall development of the city, its political and social cultural importance, determined by the extent of the territory served, number of inhabitants, transport demand and the specially volume variation in time and space.

By the urban passenger transport we achieve a reduction in lost time for moving to time for rest, relaxation, self-training, children's education, business and political concerns [2] - [4].

Lack of transport system reliability affects the travelers by additional increasing of the waiting time early or late arriving at destination, lost of the links [3].

The aim of this paper is the analyze of reliability indicators for public transport system of Sibiu city, specially one of the most crowded route.

II. RELIABILITY OF URBAN PUBLIC TRANSPORT IN SIBIU

A. Factors affecting the reliability

Reliability of a transportation system depends on a number of factors such as traffic volume carried by a bus/day trip, transfer time, waiting time, transport network density, coefficient of agglomeration [5] - [6].

Thus,

1) Traffic volume (number of passengers carried is given by:

$$\mathbf{Q_{zi}} = \sum \mathbf{Q_i} \quad (1)$$

where:

Q_{zi} - the amount of traffic carried by a car per day

2) Journey time is determined by: position stations, service frequency influencing waiting times, traffic characteristics, the system of payment of the journey, etc.

3) Waiting and transfer times are delaying trip. Passengers value the waiting time for urban transit almost twice the in-vehicle time, [7] - [8].

$$\mathbf{RW_{is}} = \mathbf{AWT_{is}} - \mathbf{SWT_{is}} \quad (2)$$

where:

AWT- Actual wait time

SWT -Average scheduled wait time

High waiting times in a public transport network is highly likely to affect the patronage and is therefore an important factor to focus on.

4) Average length of travel

$$\mathbf{P_{zi} = Q \cdot l_{medcalatori/km}} \quad (3)$$

B. Reliability analyze at S.C. Tursib S.A.

Concerning for introducing means of transport in the city of Sibiu, dates back to 1893, when they started official talks in this direction. SC TURSIB S.A. - Is local public transport company from Sibiu, founded in 1993 whose sole shareholder is the City Council Sibiu, is also a member of the UITP (International Union of Public Transport).

According to the company's mission Tursib SWOT analysis as public transport provider, is to meet customer requirements and apply attractive prices as they yield based on respect and loyalty of customers.

The company currently Tursib serves a population of approximately 200,000 inhabitants divided into five zones, a figure in which we find both permanent residents as well as those in transit (students, tourists, etc.), with a daily average of more than 95.000 passengers, Fig.1.

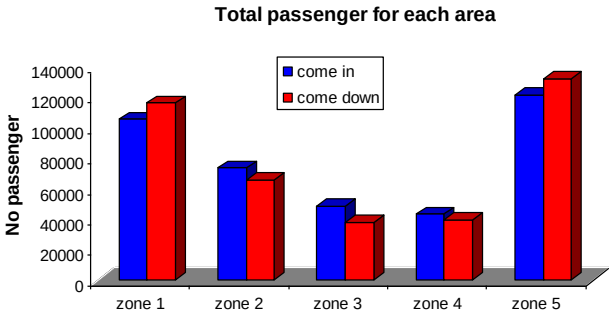

Fig. 1 Total traffic areas Sibiu, Monday - Sunday range

In Tursib society is performing a transport network mesh to a single tariff for the whole distance and transport activity is spread fairly evenly developed area. In exchange for transport optimization measure was concentration transport services to large centers of economic development of Sibiu.

Due to the managerial decisions and implemented on the ground there is a doubling of the number of passengers over the last 5 years, compared with an increase of only 1 million kilometers traveled routes, with passenger growth index / km by 84% .

The five areas are crossed daily by a total of 22 races of which 2 are tourist routes, route 22 between Sibiu and Păltinis and route 23 between Sibiu and Răşinari, so demand for transport is influenced by the number of buses or the number of kilometers performed daily route. It is closely related to what differentiates demand, transport, technology and infrastructure.

For an in-depth analysis and evaluation of reliability of bus services in Sibiu, it was decided to take up one service as the test route.

The selection of the route was made on three criteria:
1) Frequent service having headways of less than 10 minutes: in cases of frequent service, the average wait time is half the headway as passengers arrive randomly at the bus stop.
2) Availability of secondary information: the collects data on bus arrival times at the bus stops with their on-board GPS-based own vehicle tracking system.

To analyze the reliability of passenger transport in Sibiu with students of transport and traffic engineering specialization I picked the number of passengers per day on 22 routes, comprising 215 stations, obtaining data in Table I.

TABLE I
TOTAL TRAVELERS PER DAY

Route/ Day	Monday	Tuesday	Wednesday	Thersday	Friday
A1	8,560	9,573	9,529	9,551	8,612
A2	9,392	9,465	9,449	9,469	9,494
A5	6,811	6,551	6,719	6,688	6,896
A10	4,833	4,815	4,802	4,703	4,810
A11	**9,831**	**10,374**	**9,573**	**9,487**	**10,199**
A12	7,227	7,406	7,306	7,962	7,997
A13	4,684	4,882	4,884	5,147	5,967
A14	4,684	4,882	4,884	5,147	3,967
A15	3,537	3,719	3,719	3,790	3,600
A16	6,329	6,454	6,667	6,964	6,635
A17	7,576	7,478	7,306	7,220	7,890
A18	2,016	2,044	2,070	2,070	2,022
A111	1,948	1,974	1,954	1,980	1,905
A112	1,467	1,503	1,437	1,510	1,525
A113	1,639	1,679	1,690	1,602	1,551
A114	1,489	1,604	1,565	1,645	1,543
A115	1,869	1,871	1,941	1,974	1,956
A116	1,314	1,339	1,333	1,393	1,389
A117	1,482	1,599	1,569	1,585	1,660
A118	1,293	1,251	1,199	1,224	1,267

The data sources for the model are as follows:
1) The results of traffic flow survey, which has been conducted in 10 - 15 november 2014 between 7:00 and 9:30 at workdays (morning peak hours), between 16:30 and 17: 30 (afternoon peak hours);
2) Public transport routes and schedule;
3) Entry time in roundabouts;
4) Parking places and their capacity.

After the collected data there were established the stations serving mostof the routes. These are: Mc. Donalds and Simerom stations with 10 routes, also we have 3 stations serving eight routes.

They are: the Theatre, Nufarul and Lidl Alba Iulia. A double number serving seven routes: Alba Iulia station, Muzeu, Parcul tineretului, Polsib 1 Simerom, County Hospital. Serving a large number of routes some stations have a flow of over 5500 travelers from Monday to Friday, Fig.2.

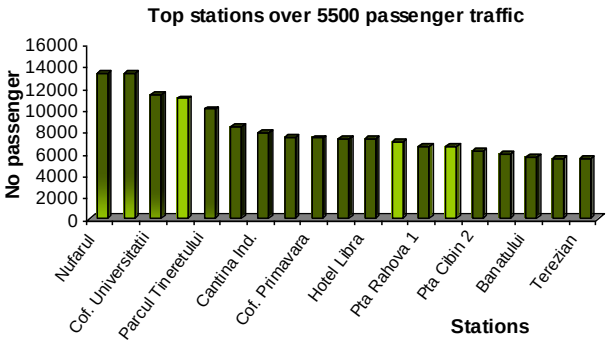

Fig.2 Top stations over 5500 passenger traffic

Since A11 route serving West Platform is one of the busiest routes in the city reliability of this route was examined.

This route stretches along Boulevard and Highway V. Milea and Alba Iulia streets that are crossed by a large number of vehicles.

The streets served by route, passing through the center of Sibiu, a situation that leads to heavy traffic they intersect the majority arteries often resulting in traffic jams.

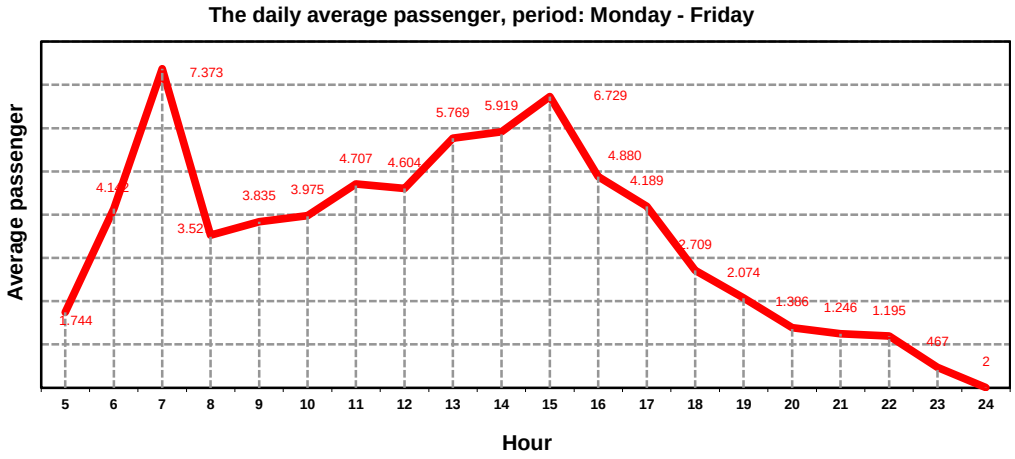

Fig. 3 Average daily passengers every hour from Monday to Friday

At the requirements of passengers there was a deviation of the route to facilitate access to jobs. It created a reconfigured route, creating one-way streets, and subsequently went to the creation of new streets for this route, by the Municipality of Sibiu.

The average number of passengers on this route can be seen in Fig. 3 with the 2 peak hours. To assess the reliability of public transport system in Sibiu we took into account the indicators in table II. They are the ones who minuses and pluses highlighted transport activity evaluated.

TABLE II
BASIC INDICATORS OF PASSENGER TRANSPORT SIBIU
(SOURCE TURSIB SA)

Indicators	Buses
The annual volume of transportations (million passengers)	33.002.831
Route number, units	22
Park transport units in inventory units	91
The number of units of transport routes, units	72
Coefficient of use of the park, to units in operation	79,12 %
Safety travel Acc / 1mln passengers	1,90
Number of passengers transported per square bus, step / sqm per day	3.54
Cost/ km (lei/km)	5,6
Nominal capacity, travelers	8.882
Cost/ 1 nomin pas. *km	0,7

On the basis of these parameters were calculated as follows:

1) The volume of passengers

According (1) the number of passengers carried on the route A11 is $Q_{zi} = 176 * 12.5 = 2200$ bus/day, and for all buses $Q_{zi} = 176 * 50 = 8800$.

2) Travel Time

The reliability of travel duration was calculated for the entire route of the bus A11, and the results are shown in table III.

TABLE III
TRAVEL TIME RELIABILITY MEASURES

Route section	*Average travel time (mins)*	*Standard Deviation (mins)*	*Travel time reliability*
Cedonia	0	-	
Complex luptei	2	1.60	**3.63**
Moldoveanu	2.5	0.20	**2.72**
Politie	3	0.14	**3.15**
A. Saguna	5.27	0.49	**5.77**
Mol	7.5	2.10	**9.61**
Polsib 2	3	3.67	**6.68**
Mc donald's	2.34	0.49	**2.84**
Turnisor	1.5	0.028	**1.53**
Ambient 1	3.20	0.56	**3.77**
Simpa 2	1.45	0.63	**2.09**
Aeroport 2	2	0.91	**2.92**
SNR Rulmenti	4.20	1.27	**5.48**
SC Continental	**2.3**	**1.34**	**3.65**

The standard deviations in travel times are high, and

the result travel time reliability measures low, on route sections A11 to Cedonia and from Continental to the bus station, indicating that the measure is capable of depicting the observed problem areas.

3) Passenger wait time

The last reliability measure calculated was the excess wait time. The average wait time for boarding a frequent service is half the headway; in the case of Route A11, it was 2.52 min.

The actual wait time of passengers were derived from the model outputs on total passenger waiting time and the number of waiting passengers. The expected wait time of 3 minutes was subtracted from this to get the excess wait time for each service at each bus stop.

4*) The average length of a passenger traveling* on the A11 route according to (3) is 3.7 Km.

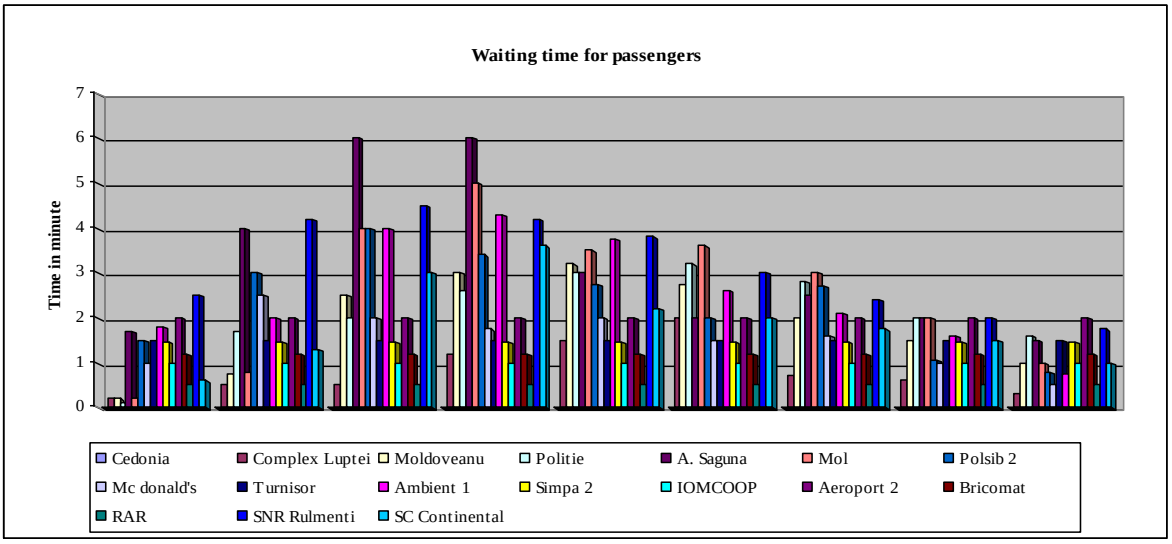

Fig. 4. Wait time of passengers for different station

The excess wait time for the individual services are shown in Fig. 4. When the (actual) headways were over 4 minutes, the excess wait time increases with increasing headway. The highest excess wait time was observed on the 07:30 service which had an actual headway of 20 minutes.

To make this route reliable and reduce waiting times in stations, 2 more buses were introduced between the hours 07.15-9.10 AM and 14.30-16.30 PM, because the first interval is passenger flow by moving to jobs, and the second interval is largely return to their point of origin or moving purposes other than professional.

III. CONCLUSION

This study was aimed the reliability of Sibiu public transportation performed by S.C. Tursib S.A. and the particular route A11. We chose this route because it serves the western industrial zone, which has undergone an extensive and rapid development through the set up of multinational companies that attract a large number of employees.

After analyzing the resulting increase in the number of buses serving the route that rose to 4 in the hours 07.30-9.10 AM and 14.30-16.30 PM.

The monitoring of reliability of public transport from Sibiu and in particular quality its should be a daily practice.

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