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Transposing constraints into feasible alternative solutions by using intermodal passenger transport in Timisoara city

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Abstract

Rural population migration in the urban area attracts a high rate of mobility, especially in cities with university centers and renowned companies. The emergence of these transitions also generates some saturation problems, such as socio-economic and social issues. The need for improvement in transport services are mandatory to change the travel behaviour. This paper provides solutions and ways to improve public transport services by using intermodal passenger transport. Transport services for the population need to be met at a higher level, both quantitatively and qualitatively. The paper illustrates the steps of integrating the Theory of Constraints Thinking Process (TOCTP) by diagnosing the problems encountered, designing the solution plan, and integrating the solution plan to resolve constraints. The paper explains how the TOCTP application detects reliable solutions to solve urban population saturation problems by identifying alternatives to public transport mobility benefits using intermodal passenger transport.

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Keywords: intermodal transport, public transport, TOCTP, travel behaviour

1. Introduction

Using excessively of vehicles over the last decade has led to pollution effects on the population and, implicitly, on the environment. Discussions on environmental issues, such as the big debates on global warming, carbon dioxide emissions, fuel burning, have concluded that the use of motor vehicles on the road should be limited. The increase in

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the number of private vehicles continues to cause traffic jams in major cities, while public transport is still trying to increase the number of users. In the past 20 years, urban areas have seen a dramatic rise as a result of the rapid population and world economy growth has been transformed by a combination of rapid technological and political change. [1] Cities dictate an increasingly dominant role in the global economy as centers of production and consumption. The rapid growth of cities exceeds capacity to provide adequate services to their citizens. [2] For Timisoara, if we refer to transport services, they require continuous improvement for the comfort, the duration and safety of all residents. Rural population migration in the urban area attracts a high rate of mobility, especially in cities with university centers and renowned companies as they are found in the Timisoara city. This trend clearly stands for cities in developing countries, by attracting young population eager to gain a quality education in order to guarantee entry into the labor market. The university centers offer free transport for students and companies have gradually focused on the services quality and employee satisfaction by offering them different services, namely the public transportation settlement. This solution solves many problems (eg. reducing traffic congestion, noise pollution and energy consumption), because individual transport can be used less. [3]

Concluding all aspects discussed above, as an alternative to ensuring effective mobility of the inhabitants of Timisoara city, is desired to be introduce intermodal passenger transport. The introduction of this segment will be achieved through the Timisoara Autonomous Transport Administration (RATT), which could benefit by an intermodal transport depot. According to a project carried out by a private company in Timisoara, the tram depot in the Dâmboviţa area could become a real logistic hub and public transport. Thus, all means of transport in Timisoara, the trolleybus, the bus, the tram and the bicycle would be concentrated in the intermodal depot and coordinated by a command center. It would follow that the intermodal depot would also be responsible for the coordination of the vapors, but also of the future electric taxis. Five public transport services are offered under the RATT: the tram service, the trolleybus service, the buses, the bicycles, the vaporetto, and in the near future electric taxis. Through the facilities offered by intermodal passenger transport they can become a fundamental and functional service within Timisoara city. [4]

2. Obtaining alternative solutions through mobility management

The interdependence between public transport ways and the implications they generate require the development of a public transport system with the objective of integrating all existing means of transport in a city. In this way, it improves the participation degree to meet mobility that has beneficial long-term effects on the community.

Mobility Management (also called- mixed-mode commuting or Transportation Demand Management (TDM) includes a variety of strategies that change travel behavior to increase the efficiency of the transport system [5]. Mobility management is increasingly used to help achieve different planning goals for public transport. [6] [7] By using this concept are provided necessary information to identify an optimal framework and to make daily journeys as environmentally friendly as possible. The main objective of mobility management is to reduce the use of vehicles and to use more ecological alternatives (walking, cycling, public transport). Practically, mobility management offers alternatives to personal car transport. Mobility management contributes to meeting transport problems and seeks to stop demand for personal car transport and change the transport behavior of citizens.

Sustainable transport takes into account the needs of travelers, so their transport behavior is at the forefront of the operators' efforts. Their main task is to find solutions for transport services improvement such as: comfort, duration, safety, regularity and rhythm of traffic. Operators' efforts to provide clear information on the various transport alternatives and their chaining through the organization of new mobility services is a fundamental task that contributes to new travel transport behavior.

The paper illustrates the steps of integrating the Theory of Constraints Thinking Process (TOCTP) by diagnosing the problems encountered, designing the solution plan, and integrating the solution plan to resolve constraints which may change transport behavior of citizens. The paper explains how the TOCTP application detects reliable solutions to solve urban population saturation problems by identifying alternatives to public transport mobility benefits using intermodal passenger transport.

3. Transposing constraints into feasible alternative solutions by using intermodal passenger transport

Through intermodal passenger transport several modes of transport are combined. The advantages provided by using intermodal passenger transport reduce dependence on the individual vehicles and increase use of public transport. Also, community support provided by intermodal transport is extremely important because it reduces traffic congestion and provides more environmentally-friendly transport. Day travel often consists not only of a single journey, in most cases connections with other modes of transport are made. In this case, the exact correlation between the means of transport offers the inhabitants the possibility to choose the optimal transport route, thus contributing to the modification of the passenger behavior in better. However, erosion for using different means of transport appears to be inevitable. The lack of more special circuits for public transport makes it difficult to combine major routes.

The major challenge of using intermodal passenger transport involves switching from the use of personal car to public transport and more sustainable modes of transport such as walking or cycling. Cycling is a healthy, easy, fast, and sustainable way of transport in the city.

4. Theory of Constraints - The Thinking Processes

Through creative methods are exemplifies traffic jam situations that alter the behavior of travelers. These methods identify by specific techniques certain suitable solutions that effectively manage the problems generated in traffic by the inhabitants of Timisoara, especially during the peak hours. To highlight the efficiency in obtaining and implementing the right solutions are illustrated steps of Theory of Constraints Thinking Processes (TOCTP).

Following the study, the TOCTP integration steps are highlighted to identify alternatives on the benefits of mobility management through the use of intermodal passenger transport. The TOCTP method, developed by E.M. Goldratt presents logical diagrams that identify feasible solutions. [8] [9] TOCTP provides a toolkit that guides the user to find answers to the basic questions through which the change occurs. Consequently, the process of transposing constraints into feasible alternative solutions answers the questions:

What to change? What to change to? How to make the change happen?

TOCTP defines the context according to the generic goals, which will be processed through the answers given to the three questions. In this context, the method involves the development of trees, namely "Evaporating cloud" (EC), “The Current Reality Tree” (CRT), "Future Reality Tree" (FRT), "The Prerequisite Tree"(PRT) and "The Transition Tree"(TT). By using the TOCTP method and the logic trees, the efficacy in achieving the right solutions is emphasized to continuously improve the process in the use of intermodal passenger transport. Thus, the TOCTP integration stages are highlighted through problem diagnosis, solution design and solution integration. [9]

4.1. *Stage 1: What to change?*

In this stage, the method involves the development of the "Evaporating Cloud" (EC), which is used to address the question: What to change? EC helps solve the root causes of a problem by identifying their hypotheses. Treating the alternative hypothesis can lead to undesirable situations that need to be changed, specifically helping to visualize solutions or strategies that can solve the problem. In this way the existence of conflicts is inevitable and their solution involves the distraction from the fulfillment of the important objectives (the transport network must cover the entire region, information about the choice of transport must be easily accessible and also the use of convenient conexion transfers and hubs, a centralized and synchronized monitoring system on the intermodal network). In this way, it is necessary to identify the main conflict (EC), which produces unwanted effects (UnDesirable Effects-UDE). [9]

This stage is very important, given that, only the correct definition of the problem can change the behavior of the passengers. To avoid these obstacles was conceived an EC based on the TOCTP philosophy, which identifies the root of each node of possible disagreement. (Fig.1)

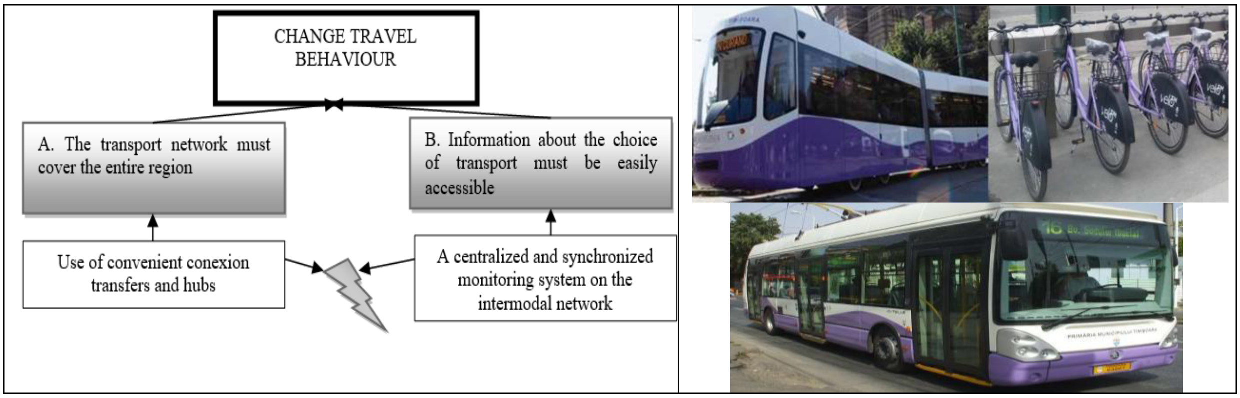

Fig. 1 "Evaporating cloud" adapted after [Goldratt, 1990]

EC can be read as follows:
To satisfy the higher level must be satisfied the lower level, respectively the intermediate level represented by A and B. Solutions must also be found to resolve the conflict.
In addition to the EC, it is configured “The Current Reality Tree” (CRT) to help visualize the links between unwanted effects and deep causes. CRT Is used to understand existing relationships by identifying policies, measures and behaviors that give rise to unwanted effects (UDE). CRT is a logical structure designed to illustrate the current reality, as it is now, or how it has existed before. As such, it reflects the intrinsic order of cause-effect-cause phenomenon. CRT identifies the main conflict.

4.2 Stage 2: What to change to ?

At this stage we find a solution to the main conflict by presenting the logical arguments. Starting from this point, complete solutions are developed that together create a viable strategy. This strategy must ensure that the benefits of intermodal passenger transport contribute to changing long-term passenger behaviors. Also to be possible to change behaviors all the negative effects that prevent the process must be identified. The cloud conflict has the role of recognizing and excluding hypotheses that allow the main conflict to persist. The cloud allows a clear statement in solving the perceived dilemma and provides a way for leveling and controlling these hypotheses. Hypotheses are actually injections that lead solving the central problem by which unwanted effects (UDE) are transformed into desired effects (DE). [9] Transforming UDE into DE is done by building "Future Reality Tree" (FRT) (Fig. 2). The initial injection leads to the desired effects without producing any negative effects.

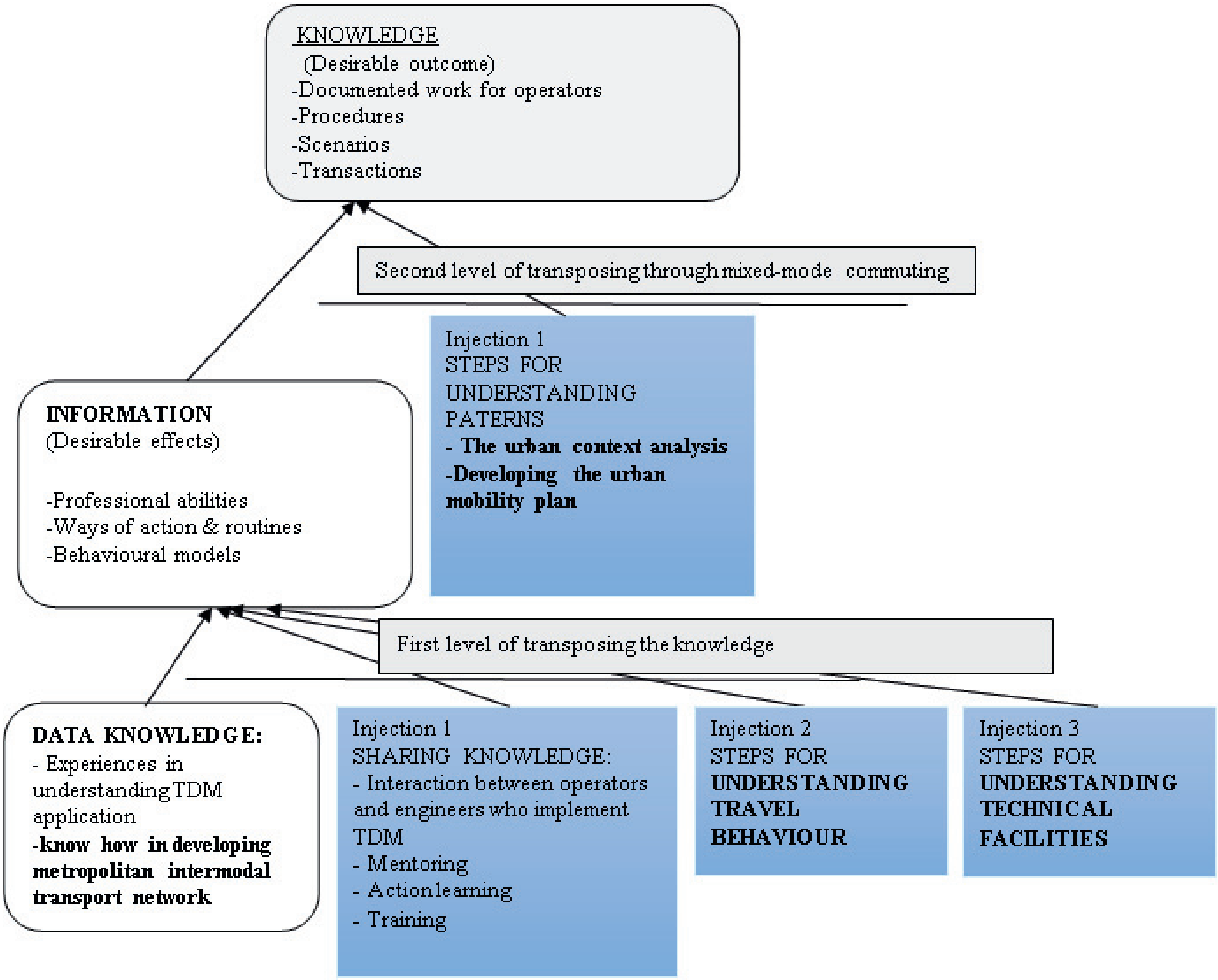

Fig. 2 "Future Reality Tree" adapted after [Goldratt, 1990]

One of the FRT goals involves validating that the solutions or strategies identified will achieve the desired effects (DES). The FRT setup is done as follows : start by replacing the unwanted effects (UDE) with the desired effects (DES). DES are placed in the top boxes of the FRT. At the bottom of the FRT, assumptions are placed along with the necessary injections (solution or resolution strategies). The idea is to get a picture of how an injection (a breakthrough) could affect the overall performance of the system. FRT is the validation that a collection of injections will convert all UDEs into DES. In this paper we combined the two approaches described above in FRT through injection 2 and 3. In order to materialize the new vision, at this stage both the FRT and "Negative Branch Reservation "(NBR), which allows analysis of all positive and negative aspects of change. (Fig. 3) The Negative Branch Reservation was based on the data obtained from the area traffic analysis, based on which it is desired to model the travel behaviour, to stimulate more frequent use of bicycles. (Table 1)

Table 1. Passenger weight on the transport means

Traffic Line Indicator	Route length [km]	Time range [Monday-Friday]	Passenger weight on the transport means	
			Bus	Bicycles
L18	11,2	06:00-11:00	85%	15%
		11 :00-16 :00	70%	30%
		16 :00-20 :00	75%	25%

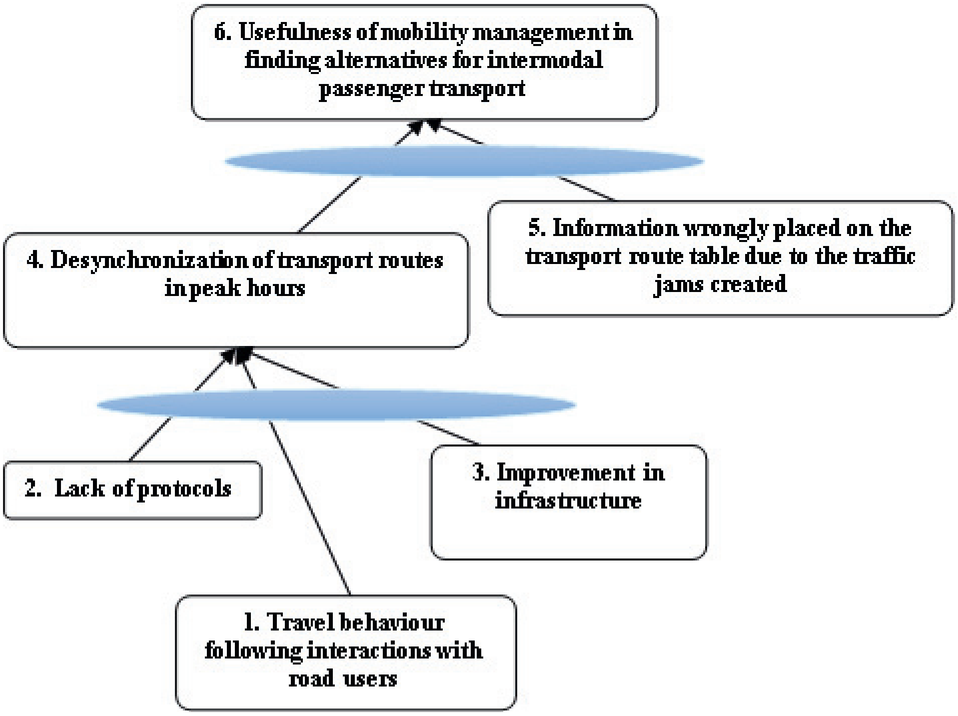

Fig. 3. Negative Branch Reservation adapted after [Goldratt, 1990]

4.3 Stage 3: How to make the change happen?

Answering the question *How to make the change happen?* is achieved by developing the "The Prerequisite Tree" (PRT), which is based on individual inputs, to transform obstacles into an implementation plan. In this stage is realized the plan for implementing the created strategy. Operator activities should be evaluated so that their outcome can help meet the targets for influencing travel behaviour. PRT highlights all possible obstacles (Obs) (Fig.4.) Exceeding each Obs involves an intermediate goal (IO) achieved. Any obstacle encountered must be overcome in order not to create a blockage in the implementation of the proposed strategy. It establishes the order in which intermediate objectives (IO) are implemented. IO are rather some kind of intermediate states or milestones necessary to move forward in overcoming the obstacles created. IO must be staggered. Every person involved in this process needs to understand its key role, implementing new solutions to produce the change and optimize the system for intermodal passenger transport. PRT lists any possible obstacle that may be encountered by the operator during the implementation process. For each obstacle, an intermediate goal is met so as to overcome the obstacle. To find out what actions should be taken to implement each intermediate goal (IO) within the PRT, one Transition Tree (TT) is built for each IO.

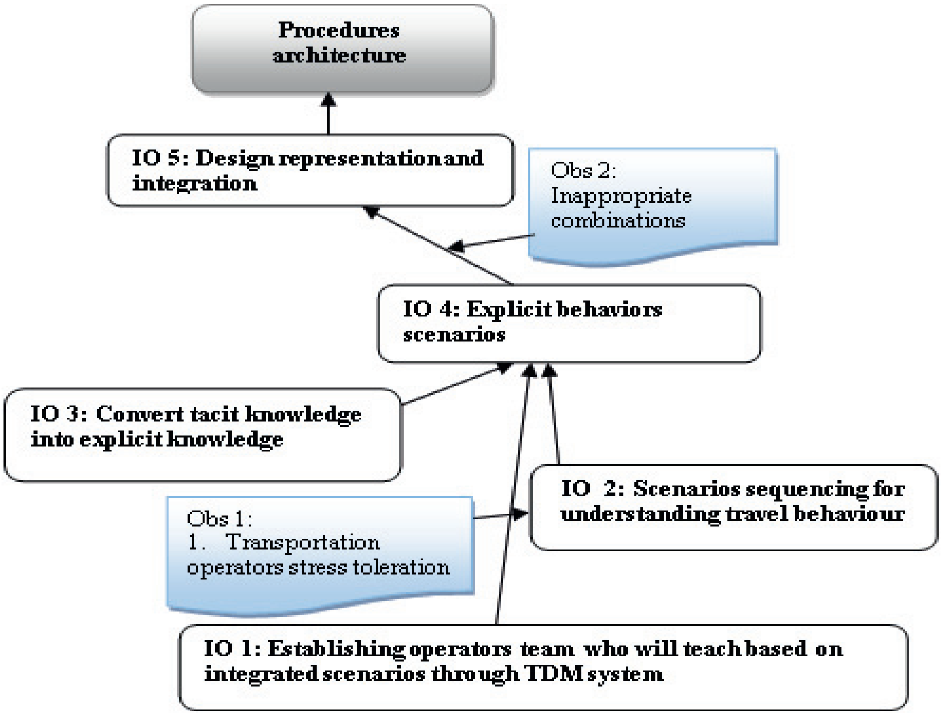

Fig. 4. Prerequisite Tree adapted after [Goldratt, 1990]

In Fig. 5 is presented TT built for IO2 within the PRT. TT produces a map, a route that leads us to the desired result. Completing the PRT implementation involves creating a TT for each IO. TT produces a map, a route to reach the desired destination.

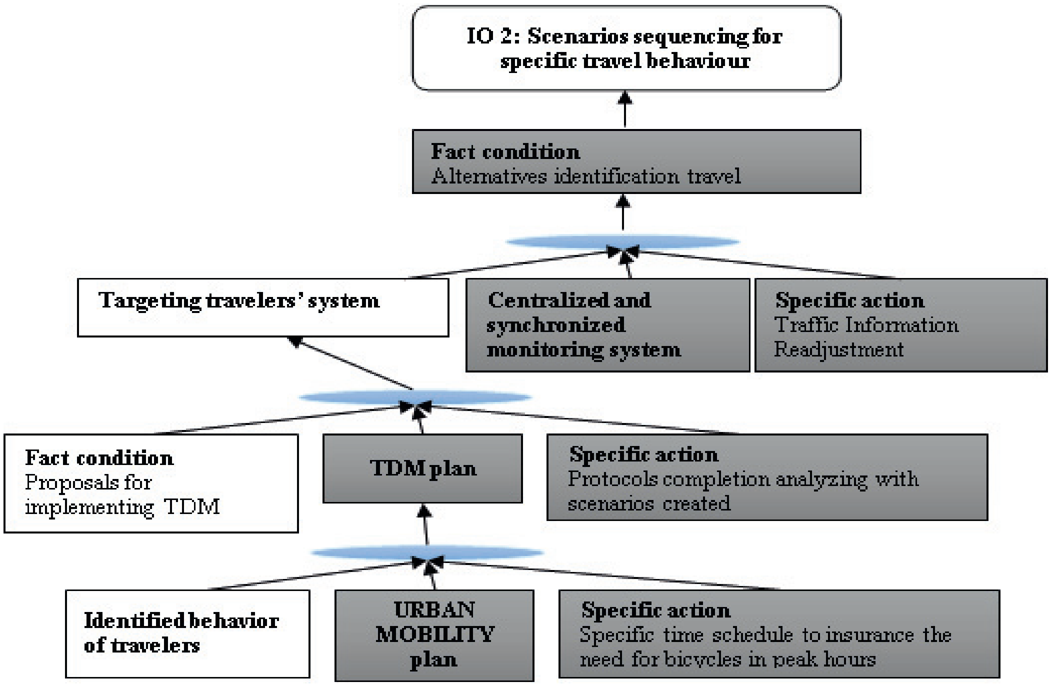

Fig. 5 Transition Tree for IO2 adapted after [Goldratt, 1990]

Timisoara city is in full economic development, which leads to the development of public transport and automatically to the occurrence of traffic jams and implicitly influences travel behaviour. This is noticeable at peak times in the central areas as well as in the city's entry / exit areas. Although improvements have been made in terms of infrastructure over time, traffic jams can also be observed in peak hours and beyond. These traffic jams are formed especially in the morning when most of the city's inhabitants go to their workplace, kids go to school units and in the afternoon, they return home at the end of the program.

Thus, through the implementation of trees obtained through the TOCTP method, improvements were made to urban public transport in very crowded areas, bringing significant changes in the travel behaviour. They were much more receptive to use intermodal transport, using trams, trolleybuses and bicycles. Implementation of TOCTP trees was achieved for 2 months, providing optimum results for a public transport line whose route is influenced by areas with high levels of agglomeration. If before the identification of the optimal solutions offered by TOCTP between 17:30 and 20:00 there was an 80% blockage, after implementation has been achieved a 15% improvement in use of intermodal transport. More precisely, *line 18* was analyzed, which required a larger bicycle run for the "Piata 700" station. This analysis was conducted during the school period when students attended the courses, also taking into account the high demand for public transport. The intensity of road transport that contributes to traffic congestion has also been taken into account including the means of public transport. (Table 2) (Table 3)

- **Line 18** has the following route: "Solventul" – "Gelu" – "Gh. Pop de Basesti" – "Gara de Nord" – "Jiul" – "Piata Regina Maria" – "Piata 700" – "Piata Marasti" – "Consiliul Europei" – "Remus Radulet" – "Piata Verde" – "Calea Torrontalului" and return line: "Calea Torontalului" – "Miresei" – "Consiliul Europei" – "Piata 700" – "Piata Regina Maria" – "Jiul" – "Gara de Nord" – "Gh. Pop de Basesti" – "Gelu" – "Solventul".

Table 2. The tracking intervals made on Line 18, Baritiu-Aqua Arena between the hours 07: 00-11: 00.

Station	Tracking interval [IU]		
	Scheduled hours [hh:mm]	Scheduled hours achieved before TOCTP implementation [hh:mm:ss]	Scheduled hours achieved after TOCTP implementation [hh:mm:ss]
Solventul	00:12	00:13:50	00:13:15
Jiul	00:12	00:13:43	00:13:05
Piata 700	00:12	00:13:55	00:13:00
Consiliul Europei	00:12	00:14:25	00:14:05
Liege	00:12	00:14:45	00:14:00

Table 3. The tracking intervals made on Line 18, Baritiu-Aqua Arena between the hours 17: 30-20: 00.

Station	Tracking interval [IU]		
	Scheduled hours [hh:mm]	Scheduled hours achieved before TOCTP implementation [hh:mm:ss]	Scheduled hours achieved after TOCTP implementation [hh:mm:ss]
Liege	00:19	00:22:35	00:22:05
Consiliul Europei	00:19	00:23:07	00:22:55
Piata 700	00:19	00:25:11	00:25:00
Jiul	00:19	00:27:24	00:27:00
Solventul	00:19	00:28:17	00:28:00

In order to modify the traveler behavior by using intermodal transport, it is proposed to reorganize the "Piata 700" station to a much larger number of bicycles, thus increasing the attractiveness of the urban public transport to renounce the use of the individual car transport.

5. Discussion and conclusions

The paper highlights two important aspects for the needs existing in today's society. First of all, there is an increasing need to implement TDM systems that have the ability to record information through practical scenarios that are much easier to perceive for operators. In this sense, the TOCTP methodology provides creative solutions for procedures in managing travel behaviour in constrained situations. It also identifies the scheduled hours, taking advantage of situations produced by traffic jams. However, there are several layers of obstacles or resistance during the actual implementation of the TOCTP method. By developing CRT, EC, FRT, NBR, PRT and TT, the entire implementation process is complete. The combination of the methodology trees provide by TOCTP illustrated through the process of diagnosing, designing the solutions plan and integrating the solutions plan for the problem solving, provide a new structure for different viewing perspectives for a wide variety of issues, including modify the behavior of the traveler by using intermodal transport.

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