A-FTS Flexible routing planning program design

László Erdei *PhD student*
Institute of Logistics, University of Miskolc, Hungary

Prof. Dr. habil. Péter Tamás
Institute of Logistics, University of Miskolc, Hungary

Prof. Dr. Béla Illés
Institute of Logistics, University of Miskolc, Hungary

DOI: http://dx.doi.org/10.25673/103476

Abstract
Currently, there is no widespread and free validation tool for examining flexible public transportation systems and testing theories. In transport, the application of reimagined flexible passenger transportation systems, which generate lower energy need and provider's cost, is becoming more and more popular. Based on previous own research results and new flexible transportation management theories (A-FTS), this validation program will be described. The flexible transport systems currently in use provide the design concepts on the basis of which a full validation system can be developed. This will provide the basis for starting to explore and implement flexible transport systems to exploit their potential.

1. Introduction
DRT (Demand Responsive Transportation) is a type of public transportation service that operates on a flexible schedule based on passenger demand. In contrast to traditional fixed-route transportation services, DRT services are designed to be more responsive to the specific transportation demands of the community, particularly in rural or low-traffic period where traditional public transportation is not feasible. DRT services typically use smaller vehicles, such as vans or minibuses, and can be booked in advance or on demand via phone or mobile app. Routes and schedules of DRT services are often determined by passenger demand and can vary based on time of day, day of the week, and specific passenger demands [1].
Moreover, the DRT services are often used to transport senior citizens, people with disabilities and people on low incomes who do not have access to private cars or traditional public transportation. DRT services can also provide transport for commuters in areas with limited public transportation options.
Because of scientific knowledge and our own research, the facts described in the previous paragraphs can also be said in general about FTS (Flexible Transportation System) systems [2]. FTS and DRT systems are used in the same social cases, but different tools and problem-solving procedures are used. Figure 1 is intended to illustrate this correspondence.

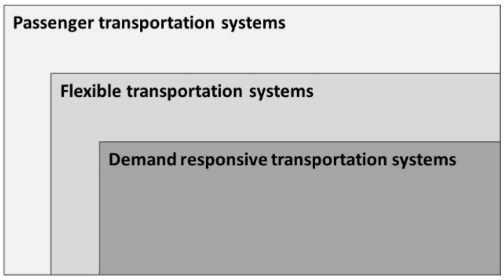

Figure 1: Sets of different transportation service systems

From this perspective, passenger transportation service systems form the largest group, which includes all mobility options, but in this case only FTS and DRT are considered. FTS is also a broader term that includes various types of transport services, including DRT. DRT is a type of FTS that uses small-capacity vehicles to provide transport services that adjust to meet the actual demands of travelers [3]. Therefore, while DRT is a type of FTS, not all FTS are DRT. As FTS is a passenger transportation system in a wider terminology, systems can be found in the literature operating under ready-made FTS systems and sold as a service [4]. Since all DRTs are FTS, but not all FTS

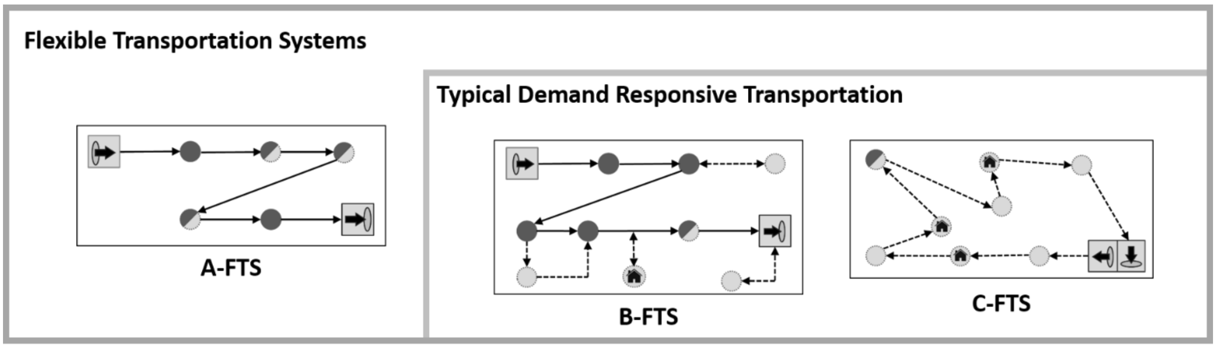

Figure 2: Group of FTS systems based on [3], [5]

are DRT systems, the methods and implementation concepts used in DRT systems can be transferred to the practical design project of the FTS.
According to our previous research [3] and [5], according to the above terminology, A-FTS is an FTS system that cannot be DRT, but B-FTS and C-FTS embody the conditions for DRT. It can be concluded that DRT schemes provide both temporal and spatial flexibility in route planning (B-FTS and C-FTS are such) as shown in Figure 2.
As far as FTS that are not DRT (such as A-FTS) are concerned, only temporal flexibility appears. Furthermore, DRTs can operate in smaller service areas if an A-FTS-like FTS system can operate at the macro-regional level.
In order to start to illustrate the journey route-planning of an FTS system through a practical example, it is necessary to review what solutions are already in use in the world and what approaches have been used in the literature. Therefore, the aim of this research is to find out what software solutions exist to support flexible transportation management (mainly in Europe and North-America). Examine the systems that have been found and are widespread and popular, what special services they provide, whether special tools are required, etc. In addition, using the results of the above research, the goal is to implement a flexible transportation scheduling method that can manage the schedule and communication of a passenger train → running in the low-traffic period. Therefore, the paper continues with an overview of software supporting flexible transportation systems in the next paragraph. It will be followed by a description of a previous research on A-FTS flexible transport concept design.

2. Literature review

The literature database will be defined as the research begins. The literature for FTS systems can be drawn from both scientific databases such as the Web of Science (WoS), Scopus, etc. and by analyzing the DRT and FTS service support systems available on the Internet [3]. In the second case, Google can be a great help in finding flexible transportation planning software and applications. As they are products of market-based businesses, advertised through marketing tools via the internet. Such marketing descriptions tend to list only the positives and benefits of a system. This is why it is essential to check the systems found in scientific publicist databases. It should be ascertained whether the DRT systems in discussion have been tested.

a) The first is **MOIA**, which is a "carpooling" application. It is a fully self-organized system, where you can enter travel requests via a phone app. The requests received are assessed by the driver of the minibus and the route of the vehicle is modified accordingly [6]. What changes is the travel distance and travel time. It can handle the demands of several passengers at the same time on an ad hoc basis, but no information is available on flexible tariffs. It could be used to calculate a more favorable fare for some travelers as the distance and time of the journey increases. The MOIA solution in Hamburg is already integrated into the urban public transportation system. This has a major advantage for the passenger, which is the one-stop fare system [7]. The future perspective for providers is seen by owners as a shift towards e-mobility and autonomous vehicles.

b) The second is **Pantonium**, which provides macro-level transportation services in a wider service area. As a result of the demand reports, the transportation vehicle is affected by the stops and they can optimally select the stops to be served [8]. An important feature of this system is that the stops are pre-defined, so that boarding and/or alighting can be easily predicted (Figure 3.).
It is important to note that the Pantonium system has managed to use excess capacity during periods of low-traffic utilization [8]. Consequently, the fixed stop and forecasted demands can be met by the system, which has been applied at the macro level.

Figure 3: Pantonium journey plans [9]

c) **Liftango** is a complex management system solution for flexible transportation planning. The company helps you from the start, if your service provider is just thinking about using flexible transportation in its own network [10]. Using similar solutions as for the previous products, a system has been developed that can integrate with the existing public transportation network [11].

Figure 4: Different user platforms of Liftango [12]

Furthermore, Liftango is not only a service for flexibility, but also for planning and providing other mobility and transportation alternatives. For example, the company is also involved in the sensing of existing public transportation systems, followed by data collection and digitization solutions. As a result, by processing Big Data [13], the company can propose optimal operations [14] and increase the efficiency of the system.

d) **Drip** is a complete booking and planning system for passenger transportation and scheduled trips according to your travel needs. The system is cloud-based where booking and planning can be done. This system is mostly used to organize collection and distribution journeys efficiently [15]. There is no automatism, because it is a ride-pooling system that the individual can specify the free seats in the car that can be reserved when he or she has his or her own commuting habits. It differs from the first system in that you have to follow the route you have been given, or you can negotiate your way in and out of the car.

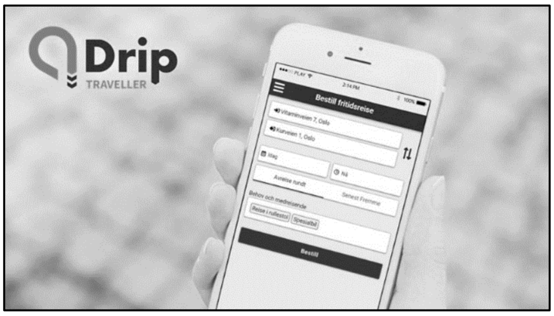

Figure 5: Drip DRT user interface [15]

It can be used to drip to school to work or even to connect a large shopping trip together in scattered villages where traditional public transport is not available. This also shows that this is a Swedish application and that in Sweden, outside the large cities, there are scattered municipalities from which access to the city is difficult and cannot be served by public transportation. The Nordic (Scandinavian) countries have a low population density, ergo low population density and dispersed municipalities [16].

e) **Spare** is the result of a Canadian-Norwegian collaboration and its products are already used in Asia, America and Europe. The solution is not specifically designed for providers. Rather, it is designed to extend and improve the service of existing transportation systems. To this end, they provide software solutions the development of software solutions tailored to the needs of the service provider is their task. At the same time, they provide access to analyses such as the potential for demand responsive transportation on a traditional public transportation route. Spare can also make multimodal transport possible within its own system, where there is overlap between the two mobility support solutions it develops. In addition, it provides services for microtransit, paratransit, ride-sharing, ride-hailing and NEMT (non-emergency medical transport). However, the website (as a marketing platform) gives little insight into the exact operation and application of Spare solutions [17], and no literature is available.
f) **Padam Mobility** provides DRT to transit operators, local and transport authorities. Their smart and dynamic solutions optimize DRT services for efficient itineraries [18] and vehicle occupancy, utilizing powerful algorithms and artificial intelligence [19]. Their aim is to get users, operators, and public authorities moving efficiently. Typical ese cases: Off-peak hours,

Paratransit, Business areas, First and last mile, suburban and rural, regional mobility.

g) **Via** is a transportation network company that offers shared rides in cities around the world. Via's mission is to provide affordable, efficient, and sustainable transportation options that reduce congestion and improve access to mobility [20]. Via's algorithm matches multiple passengers traveling in the same direction into a single vehicle, reducing the number of cars on the road and lowering emissions. Via also partners with public transit agencies to offer on-demand, first-mile, and last-mile solutions that integrate with existing transit infrastructure. Via's platform is available through a mobile app and web interface, and the company also offers a suite of enterprise solutions for corporate travel and logistics [20].

h) **Moovit** is a smart urban mobility app that offers a comprehensive on-demand transportation solution [21]. The service includes multimodal trip planning, mobile ticketing, and real-time transit information for buses, e-bikes, scooters, and ride-hailing services. Moovit's Mobility as a Service (MaaS) pilot project in Tampa aims to optimize and simplify urban mobility for riders. The city is seeking 200 people to take part in the pilot project, which includes surveys and feedback on the app's functionality over a six-month period. Moovit's MaaS solutions provide cities [22], transit agencies, and corporations with new opportunities to improve connectivity between modes of transport and address gaps in access to transit.

3. Literature review conclusion

When designing and implementing flexible transportation systems, it is important to have an action plan for the user interface and the operational concept. This is necessary because if there is no transparency in the operation of the FTS, the flexible transportation concept will not be popular during the incubation phase due to bad impressions. In many cases, this is why flexible transportation systems have not spread so widely around the world. At the same time, the limited availability of software to support DRT is not conducive to widespread adoption. Designing with supporting software is costly and ongoing product support and maintenance is an ongoing cost. And transportation companies do not always operate on a profit-oriented basis, so there is no financial scope for DRT services other than traditional transportation as a basic service. At the same time, it can be seen that most DRT solutions try to take advantage of the benefits of digitalization technology, such as live tracking via phone app, fast response to travel needs, etc. Several of the DRT solutions listed are available in the literature and have been the subject of research, but the mathematical models and algorithms used in their solutions are not available. This is obvious, as the scientific and innovative activity of these companies is to solve optimization method in transportation planning to serve travel demand, so they treat mathematical models as a business secret. If we consider the literature review in [3] and [5] and the present survey, it can be seen that the major differences in DRT systems are not in the vehicle route-problem search performance and response time. Therefore, the following points should be considered when designing efficient and popular FTS systems: (i) define a transparent operational concept, separating the user and the service provider/operator side; (ii) integrate the system as much as possible with the existing public transportation ecosystem; (iii) design a simple and transparent platform, i.e. user-friendly interface. In addition, there are a few FTS guidelines that can be developed to assist in conscious FTS planning [9]:

- declare service territory: micro, meso, macro, macro-regional;
- the proper selection of the service area and period;
- the system must be prepared to cope with extraordinary travel needs;
- adequate automation of system operation (this is not a barrier nowadays);
- use existing infrastructure as a baseline.

In Hungary, there are no reports of the use of software supporting flexible transportation management such as the above. Therefore, the use of flexible transportation systems is not widespread (neither in a spatial not in a temporal context).
For this reason, there are plans to design A-FTS at a level that would provide time flexibility for off-peak passenger services, especially on rail.

4. FTS software developing advices

One important fact should be pointed out before going into the details of A-FTS. Systems supporting flexible transport must satisfy several software requirements in order to operate efficiently and satisfy the needs of users.
The software should have an **intuitive and user-friendly interface** that allows users to easily browse the system, enter the desired travel parameters and monitor actual journeys. The user interface should be simple and easy to understand, especially for non-technical users. [23]
Flexible transportation software should be able to **integrate** with other systems and services, such as map applications, payment systems, APIs for traffic data and internal company databases. [24]

The software must have efficient **algorithms** for route planning, passenger coordination and efficient vehicle utilization. **Optimization** can help to minimize empty journeys, reduce waiting times and optimize transportation costs. [25]
The software must ensure efficient **data management**. Data must be stored and retrieved quickly and reliably. The database must be able to store and process large datasets, since traffic management systems generate a lot of data, such as vehicle information, routes, passengers, etc.[26]
The software must include appropriate security measures to protect the data and the security of users' personal data, including encryption and access authorization management. [27]
This summary was necessary for the A-FTS system, which will be presented in the next chapter. It should be noted that scheduling information is received and processed through software solutions, from which the system makes decisions and communicates with users.

5. A-FTS journey planning parameters

Previous research results on the A-FTS flexible transportation concept have been published in [5]. However, for the purpose of the following chapters, the A-FTS will be presented in the following paragraphs based on the research in [5].
A-FTS is a transportation concept that can be used to meet travel demand during low-traffic periods. It is a novel approach to the organization of transport, which differs from inflexible ("traditional") transportation in that the passenger vehicle stops only at stops where there is a demand for travel from the pre-announced schedule. During high-traffic periods, flexible transport such as A-FTS cannot be used effectively. Effective long- and short-term demand forecasting is necessary to identify dead periods. The A-FTS covers essentially the same distance (fixed in spatial terms) but reduces travel time to an optimum by making stops according to travel demand. This means that the transport vehicle (in this case the train) stops at the relevant stop/station when there is a demand for passengers to alight and/or board. The assessment of travel demand and the corresponding transportation management and communication is an important part of a functioning FTS. Therefore, the A-FTS flexible transportation concept includes 3 subsystems that perform different functions during operation: (i) PDMS (Passenger Demand Management Subsystem), (ii) VRTMS (Vehicle Registration-Tracking Management Subsystem), (iii) RTIS (Real-Time Information Subsystem).
The VRTMS subsystem is the vehicle and tracking module, which is informationally linked to the train scheduling system and the HR planning software. For this research, the PDMS subsystem is of primary importance and the RTIS subsystem is of secondary importance. Travel demand from the period pre-departure for the j-th journey ($\overline{PD}^{j}$) and ad hoc travel demand ($\overline{AHD}^{j}$) are received via the PDMS subsystem.
Figure 6 shows the timetables before the departure time of a given train j, which provide information at different levels. $\overline{SCH}_0^j$ is identified based on the long-term passenger demand forecast, which includes stops with higher boarding/ alighting passenger volumes during the low-traffic periods. In the days before departure, the system starts the registration of travel demand PD(j) which is used to automatically generate the $\overline{SCH}_{real}^j$. This schedule already includes the stops indicated by the claim, and $\overline{SCH}_0^j$ and $\overline{SCH}_{real}^j$ create a time window (MIN-MAX) schedule. This is the norm according to which ad hoc travel demands for the $\overline{SCH}_{act}^j$ i.e. actual schedule can be accepted if the later arrival time included in the $\overline{SCH}_0^j$ schedule cannot be generated at the position.

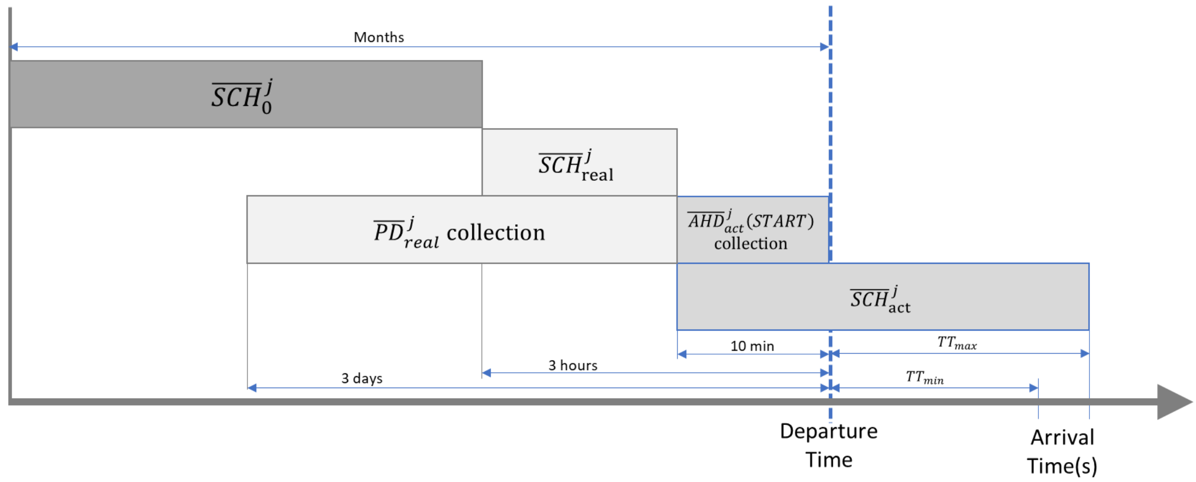

Figure 6: A-FTS scheduling plan based on [5]

Thus, it is a safety design constraint to ensure predictable transportation management for the system's existing journeys.
The schedule variations briefly described must be able to be handled by a system that calculates, manages, and evaluates the information (passenger side and provider/crew side).

6. Further research directions definition

The availability of open-source systems and database structures for flexible transportation can increase the popularity of this research area. Compared to the last 5 years, technology has developed a lot, which can open new research directions for this field. These directions are worth following as energy costs has increased and transport providers must rationalize the use of resources. Depending on this, a partially demand-responsive flexible transportation system can be well parameterized. If you like, it is a nice transition between inflexible scheduling and full demand responsiveness.

7. Conclusion

The paper demonstrates that it is possible to distinguish between DRT and FTS systems. The flexible transportation systems currently in use in the brain are constantly evolving, so it is worth keeping an eye on them in the future. It can be concluded from the analysis that the efficient and safe operation of flexible systems depends on software solutions. The A-FTS framework is presented in the context of such software solutions.
The A-FTS validation system has already been accepted in a prestigious scientific journal, but the main goal is to put it into practice. To prepare a pilot, this literature and practice review was necessary. It provides a good basis for testing a pilot A-FTS system. At the same time, the expectation of automated operation can be conceived as management and control from generated datasets.

8. References

[1] Deka, U.; Varshini, V.; Dilip, D.M. (2023): The journey of demand responsive transportation: Towards sustainable services, Frontiers in Built Environment, vol. 8.

[2] Mulley, C.; Nelson, J.D. (2009) Flexible transport services: A new market opportunity for public transport, Research in Transportation Economics, vol. 25, no. 1, pp. 39-45.

[3] Erdei, L.; Illés, B.; Tamás P. (2022): Analysis of flexibility on the FTS. 15th International Doctoral Students Workshop on Logistics Magdeburg, Deutschland Otto-von-Guericke-Universität Magdeburg. dx.doi.org/10.25673/85944

[4] Nelson, J. D.; Wright, S. D. (2016): Flexible transport management. In M. Bhemer, C. Mulley, & C. Moutou (Eds.), Handbook on transport and urban planning in the developed world (pp. 452—470). Edward Elgar Publishing.

[5] Erdei, L.; Péter T.; Béla I. (2023): Improving the Efficiency of Rail Passenger Transportation Using an Innovative Operational Concept, Sustainability 15, no. 6: 5582. https://doi.org/10.3390/su15065582

[6] Gilibert, M.; Ribas, I.; Maslekar, N.; Rosen, C.; Siebeneich, A. (2019): Mapping of service deployment use cases and user requirements for an on-demand shared ride-hailing service: MOIA test service case study, Case Studies on Transport Policy, vol. 7, no. 3, pp. 598-606.

[7] MOIA, Ridesharing (2018), https://www.moia.io/de-DE/hannover Overviewed: 10/03/2023.

[8] Pantonium website https://pantonium.com/ Overviewed: 10/03/2023.

[9] Mellor. L. (2018): 4 Lessons From Deploying On-Demand Public Transit, Pantonium Blog Downloaded: 10/03/2023.

[10] Teseen N.; (2021): Demand Responsive Transportation (DRT) Industry Analysis on Shuttle and Liftango, Presentation, DOI: 10.13140/RG.2.2.18235.90404

[11] Liftango Website https://www.liftango.com/ Overviewed: 10/03/2023.

[12] Liftango DRT module https://www.liftango.com/public-transport/demand-responsive-transport Downloaded: 12/03/2023.

[13] Franco, P. (2021): Emerging Trends in Transport Demand Modeling in the Transition Toward Shared Mobility and Autonomy, International Encyclopedia of Transportation: Volume 1-7, pp. 331-339.

[14] Tan, Y., Sun, B., Guo, L. & Jing, B. 2022, "Novel model for integrated demand-responsive transit service considering rail transit schedule", Mathematical Biosciences and Engineering, vol. 19, no. 12, pp. 12371-12386.

[15] Drip Solutions website https://www.drtsolutions.eu/en/products-and-services/drip/ Overviewed and downloaded: 13/03/2023.

[16] Leiren, M.D.; Skollerud, K. (2016): Demand responsive transport and citizen experiences: Insights from rural Norway.

[17] SpareLabs website https://sparelabs.com/en/solutions Overviewed: 13/03/2023.

[18] Padam Mobility website https://www.padam-mobility.com/en/ Overviewed: 13/03/2023.
[19] Telhada, J.; Dias, A.C.; Sampaio, P.; Pereira, G.; Carvalho, M.S. (2013): An integrated simulation and business intelligence framework for designing and planning demand responsive transport systems.
[20] Ride With Via website https://ridewithvia.com/news Overviewed: 10/03/2023.
[21] Moovit website: Comprehensive On-Demand Operations https://moovit.com/on-demand Overviewed: 10/03/2023.
[22] Rubén, F. P.; Mark, R. W.; Juan, J. V. D.; Ana, B. R. G. (2022): Data-driven analysis of the impact of COVID-19 on Madrid's public transport during each phase of the pandemic, Cities, Volume 127, 103723, ISSN 0264-2751, https://doi.org/10.1016/j.cities.2022.103723
[23] Sano, Y., Sugata, Y., Mizumoto, T., Suwa, H., & Yasumoto, K. (2020). Demand collection system using LPWA for senior transportation with volunteer. Paper presented at the 2020 IEEE International Conference on Pervasive Computing and Communications Workshops, PerCom Workshops 2020, doi:10.1109/PerComWorkshops48775.2020.9156218
[24] Shrivastava, P., & O'Mahony, M. (2010). Integrated approach towards sustainable development. World Review of Intermodal Transportation Research, 3(1-2), 26-45. doi:10.1504/WRITR.2010.031578
[25] Wang, H., Guan, H., Qin, H., & Zhao, P. (2023). Towards a more flexible demand responsive transit service with compensation mechanism considering boundedly rational passengers. IET Intelligent Transport Systems, doi:10.1049/itr2.12347
[26] Önden, İ., Deveci, M., Çancı, M., Çal, M., & Önden, A. (2023). A spatial analytics decision support system for analyzing the role of sea transport in public transportation. Decision Analytics Journal, 6 doi:10.1016/j.dajour.2022.100149
[27] Baç, U. (2020). An integrated swara-waspas group decision making framework to evaluate smart card systems for public transportation. Mathematics, 8(10), 1-24. doi:10.3390/math8101723