Advances in Economics, Business and Management Research, volume 131
"New Silk Road: Business Cooperation and Prospective of Economic Development" (NSRBCPED 2019)

Digital Technologies Preconditions in Traffic Management and Passengers' Fare Collection on Commuter Trains

Viktor Sankov
Department "Economics of labour and industrial complexes"
Yuri Gagarin State Technical University of Saratov
Saratov, Russian Federation
sankovvg@mail.ru

Sergey Morozov
Department "Economics of labour and industrial complexes"
Yuri Gagarin State Technical University of Saratov
Saratov, Russian Federation
morozovsa@sstu.ru

Mikhail Bochkarev
Department "Economics of labour and industrial complexes"
Yuri Gagarin State Technical University of Saratov
Saratov, Russian Federation
bochkarevmv@mail.ru

***Abstract*—The relevance ensuring collection of transportation fares from passengers in full by Suburban Passenger Companies (SPC) is an especially important aspect of their operation as it forms the companies' income in its fullness from their main activity. It can be effective only on the assumption of comprehensive integrated interaction of passenger flows and inspecting-cashing apparatus. As the functioning of passenger flows has a random, uncontrollable nature, it is the primary, determining element in the system to be served and submits a dynamic demand for generating an adequate reactive inspecting-cashing impact on the flow, by the criterion of completeness of revenue collection – that is, ensuring the required quality of their service in aspect of the revenue collection. The research methods were the author's developed complex of models for constructing particular models necessary for the effective solution of individual tasks of managing the process of inspecting-cashing management on suburban passenger transportation. The result of the study is the theoretical justification for solving the company's internal target – to achieve the most complete collection of passenger transportation fees according to the criterion for the company in the form of a minimum amount of costs for the maintenance and operation of the service and losses on unearned income for the transportation of passengers.**

Keywords: fare collection, transportation, commuter train, analytics, passenger traffic

I. INTRODUCTION

Modern systems of commuter passenger transportation services operate on a cyclical basis – with daily repetition of frequency dynamic characteristics, according to stable schedules of electric trains on routes. Passenger flows are, to a certain extent, "deformed" in time characteristics according to the timetables of electric trains following routes. But at the same time, daily passenger flows on routes have random fluctuations in their absolute characteristics, i.e. in size, thereby confirming the random nature of their formation, and at the same time the random nature of functioning with statistically regular dynamics of mathematical expectation and dispersion at the same intervals of day.

In accordance with the trains' schedule, daily commuter passenger transportation services are carried out along the existing routes of the transport hub. The transportation is preceded by preparation in the form of operational planning of all the processes carried out in a coordinated interaction of participants serving commuter transportation of passengers: crews of locomotive drivers, teams of inspectors-cashiers, security escorts. These groups of workers perform different functions in carrying out passenger transportation: locomotive drivers are responsible for observing the schedule of the electric train and its safety in accordance with the instructions of railroad regulation workers on the route; inspecting-cashing teams are responsible for the timely service of passengers in the form of identifying the availability of travel documents and selling tickets, if passengers do not have them; security escorts of inspectors-cashiers are responsible for their safety and the safety of proceeds from the sale of tickets. In exceptional cases, with a high occupancy of train cars and safety threats to the passengers and the train, it is possible to

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organize escort of electric trains by law enforcement officers – police officers.

II. Publications Review and Research Methods

Collecting from the passengers the cost of their journey is a function of not only the inspectors-cashiers, but also the cash services at the stopping points along the route of the electric train. At the same time, the collection of the full fare for the transportation of passengers on the route can be ensured, in essence, only by inspectors-cashiers accompanying electric trains [1, 2, 3, 4]. The current state of things is such that part of the passengers, which, as practice shows, can be quite significant, does not display activity in the issue of buying tickets for their trips [5]. In this connection, inspectors-cashiers must compensate for such "passivity" in the matter of passenger fare payment by their activity in performing the inspecting and cashing functions. Considering the ensuring of the collection of full fare from all passengers, it should be noted that this problem is solved primarily by planning the operational staffing of electric trains with the necessary number of inspectors-cashiers teams. It is completely determined, firstly, by the rating of the passenger flow and, secondly, by its characteristic in relation to "paying attitude" – i.e., the percentage of the fare-beaters landing at the stopping points of the train [6, 7]

The efficiency of cashiers in selling the tickets is lower than checking for a passenger's ticket, and therefore a change in the portion of fare-beaters will affect the performance of the team in serving the passengers on the route, and, consequently, the loss of revenue. Hence, the planning of staffing the electric trains with teams of inspectors-cashiers should take into account these two factors: the rate of the served passenger flow and the state of its structure in terms of how many passengers boarding the electric train have tickets. The iterative nature of the daily logistics cycle of management's operational activities in the organization and implementation of inspecting and cashing services for trains on commuter routes determines adequate continuous information maintenance, supported by a self-improving information platform and information technologies of iterative nature as well [8, 9]. In previous studies of the problem of collecting the fare for commuter transportation, the need was shown for building and using a set of models that bring operational inspecting and cashing activities in commuter transportation to an effective level of organization [6].

However, the set of models was formed from the construction of particular models necessary for the effective solution of individual tasks of managing the process of inspecting and cashing service of trains on commuter passenger routes. Daily iterations of preparing and obtaining rational decisions, and then using them in operational regulatory inspecting and cashing activities, determine the requirements for the accuracy of the content of information services and the timeliness of the receipt of relevant information in the links of logistics management.

Opportunities for the optimal functioning of the inspecting and cashing services of suburban passenger companies on the network of commuter passenger transportation in transport hubs are opened only on the basis of modern digital technologies for processing all operational information in the inspecting-and-cashing subsystem and maintaining its information platform at every moment and at each level in adequate informational condition [10, 11, 12]. The creation of a technical and technological complex for the total provision of a multitude of information-generating points of a geographically dispersed fare collection system also involves their continuous technological interaction in information-exchange activities, determined by the totality of the tasks to be solved and their information support in the required time frame of the daily iterative cycle.

If the set of tasks characterizes the completeness of the list of constructive coverage of the solution tasks in the list of iterative daily procedures, then integrating it with a system of automatic information collection and communicating the results of the solution to the performers in the activities in operation units forms a system of an automated cycle for implementing the iterative operation process on a high-quality information basis.

System management, on the principle of continuous approximation of its functioning to the optimum, is based on the inclusion to the software complex the tasks for continuous monitoring of the state of the managed system, and keeping it in the optimal region of the optimum criterion.

The replacement of the list of management actions of the completed operational cycle to the next one, i.e. to the list of actions on the next day, is provided by a system algorithm, which, along with the new information, also uses reports on the results of the previous day. This allows the management system to take into account and use information about changes that occurred in it at the previous operation cycle, in decisions to be implemented at the next management cycle. So in this logistics system the principle of adaptability to changes, both in the system itself and in the external environment, is implemented.

III. Results

The addition to the system with a complex of analytical tasks makes the control part tuned to the solution of improvement and development tasks as well, i.e. self-optimizing and improving in the direction of ensuring the highest possible collection of revenue when servicing passengers on commuter rail transportation. What is also important is the presence in the suburban passenger service system of two types of service devices – stationary and mobile – for selling and purchasing the tickets, due to which an operational justification of the reasonability of such service is possible, with regard to each stationary point on the route. The relatively small flows of passengers at many little-busy stations today do not justify the maintenance of stationary ticket offices: their running costs exceed the proceeds from the sale of tickets.

Thus, the transfer of the management of commuter passenger transportation within the powers of the suburban regional companies to the level of integrated problem solving in the connected areas of activity of the main functional structures is the today's problem of improvement. Considering

the above-mentioned points in the program and statistical interaction of information related to the management of the process of commuter passenger traffic, let us present a systematic connection of information support with the basic functions of managing all elements of the process of commuter passenger transportation.

In accordance with the existing concept of the functional composition of controls [13], it can be schematically represented as following:

1) All information is collected and stored in a single place, structured according to the directions of the operation processes of the system.

2) The management objects are the operation processes: coordination of demand for commuter transportation of passengers with the work schedule of electric trains (marketing complex of tasks); collection of fare for the transportation of passengers (operational unit of ensuring the collection of passengers' fares); providing electric trains for passenger transportation on route (operational and dispatching support for the transportation process).

3) Coordination of the demand for commuter passenger transportation with the schedule of electric trains (marketing complex of tasks) is a set of tasks for studying the demand for transportation formed by the structure of passenger flows [8, 16] based on targeted travel of passengers, and the development of schedules of electric trains that are adequate (fully satisfying) the needs of the main categories of passengers on trips.

4) Passenger transportation fare collection (operational unit of ensuring the collection passengers' fares) is the largest unit in terms of the number of employees. The service solves the problem of ensuring the full collection of fare from the passengers travelling with suburban trains. The effective activity of this service is ensured by solving a set of economic and statistical tasks that monitor the process, analyze its economic assessment and constantly improve it by continuous search for and implementation of effective measures.

5) Provision of the electric trains for passenger transportation on route (operational and dispatching support for the transportation process). The unit is responsible for transport support, i.e. the supply of electric trains to routes in accordance with the current schedule.

IV. Discussion

The marketing and operational-dispatching activities of suburban passenger companies are working to achieve the main goal – satisfying the transport needs of the population of suburban area for transportation. At the same time, as shown above, they each implement their own tasks, agreed within the framework of the target orientation of the entire system.

The fare collection service, although it interacts with a client – an external consumer of services, – solves the internal target of the company – to achieve the most complete collection of passenger transportation fees according to the criterion for the company in the form of a minimum amount of costs for the maintenance and operation of the service and losses on unearned income for the transportation of passengers.

V. Conclusion

The determining information for all processes is data about the passenger flows served by the company and the proceeds from the servicing of these flows. Processes are repeated every day, forming this information. However, the element of randomness introduced by the nature of the formation of these flows makes it necessary, by using and accumulating these data, to refine and develop the methods for predicting, planning, organizing, controlling, analyzing and regulating the functioning of the "suburban passenger transportation company" system, improve them and look for ways to increase the effectiveness of its work.

A very positive point is that the collection of information on the served passenger flows through their migration lines between stations and on the cash flows of receipts from them is already quite well established. It allows you to quickly build an objective picture of their values and dynamics over short- and long-time horizons, measure all the characteristics of interest and solve all problems in the whole complex of processes of the company's functioning in an interconnected form. All this is effectively solved on a single digital platform [14]. Of course, the solution of all the tasks of the existing services in the company requires large amounts of information of state, macroeconomic, regional, sectoral and private levels in terms of the use of elements of its operational subsystems. However, hierarchical databases and rational exchange technologies between them simplify the solution of the problems at the level of individual enterprises, which improves the management process, increasing its effectiveness [15, 16]. The current state of information support for the management of suburban passenger companies is moving in the direction of increasing information links, providing ever greater information sufficiency, close to an integrated, all-inclusive, systematic reflection of the necessary characteristics, their dynamics, reliable analysis of situations, perfect forecasting and valid planning for solving short-, medium- and long-term tasks of integrated system functioning and development.

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