

THE RESEARCH DIRECTIONS OF INCREASE EFFECTIVENESS OF THE FUNCTIONING OF THE RSA WITH REGARD TO SPECIALIZED TRANSPORT

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Abstract: *The article concerns on a methodological approach to design Rest and Service Areas. Because there is recorded steady growth in food cargo that require specific temperatures its resulting in an increase in demand for specialized transport. Transportation of food is usually done using vehicles equipped with refrigeration or heating. The article presents the design requirements for Rest and Service Areas (RSA), which is one of the most important elements of the road network, that condition affects the safety of drivers and cargo. Based on growth assumptions of effectiveness a functional model of RSA consisting five data bases and nine research tasks has been proposed. As a primary parameter studied in the model was the RSA effectiveness assessed by the rate of parking spaces utilization. The values of this index were estimated according to the share of traffic cars leave the motorway to the traffic flow of cars on the motorway. Evaluation of test results was based on the indicative comparative analysis of the existing and forecasted traffic flows of trucks with loads sensitive to the conditions and the time of their carriage.*

In the article pointed out that decisions taken in the course of modernization of the national RSA network should be reviewed and assessed through simulation studies of the transport process taking into account different boundary conditions, a risk analysis of transport depending on the type of transported cargo and analyze the efficiency and profitability of the national network creation of parking places adapted to specialized service of trucks carrying food cargo.

Key words: *Rest and Service Areas, RSA designing, parking places for specialized trucks, RSA functioning effectiveness*

1. Introduction

According to GUS data, the national truck rolling stock at the beginning of 2015 consisted of over 3 million vehicles. Nearly 90 thousand road cargo transport transported in the previous year a total of more than 1.3 billion tons of cargo. In these companies are employed over 550 thousand. truck drivers. In addition, according to Eurostat, national carriers represent the largest force in the international transport of goods (CSO, 2012, 2013 2014, 2015; Wiśniewski, 2014).

Total length of the public road network in Poland is over 415 thousand km, of which approx. 3 thousand km are expressways and highways. Condition of polish road infrastructure depends not only on the construction of new motorways and expressways, but also from the launch of new Rest and Service Areas (RSA), which constitutes one of the most

important elements of the road network because their condition affects the safety of drivers and cargo transported. For example McArthur et al. (2013) suggests that roadside rest areas provide a safety benefit, and the crash prediction models developed as a part of this research provide a starting point for quantifying these impacts. Authors described that public roadside rest areas were developed largely to alleviate motorist fatigue and reduce the opportunity for crashes by providing safe parking areas for tired drivers. Similar conclusion we can find in article Blomquist et al. (2002) authors discussed a survey of Montana rest area users conducted to assess overall public satisfaction and to target specific areas for improvement.

Ameri et al. (2015) defined service area as a place along the a major road where facilities such as rest rooms, restaurants, repair shops, prayer rooms, and

so on offer services to the public. The purposes of such an area are to provide a safe place for passengers and drivers to rest and to meet them and their vehicles with basic necessities. Authors proposed some frameworks of formulating different scenarios for locating the service areas and defined the parameters affecting the site selection and modeling of site selection for service areas. According to local regulations, the RSA definition is very general. Rest and Service Area is an area separated in the road lane (in the close vicinity of the road), equipped with parking and in infrastructure providing comfort and relaxation to travelers. Categories of RSA are presented in Table 1.

Table 1. RSA category

RSA cat.	FUNCTIONS AND EQUIPMENT
I	for recreational function, equipped with parking spaces (parking), roadways maneuvering, recreational equipment, sanitary ware and lighting; equipment are allowed in small catering facilities
II	the function of leisure and services, featuring a lens referred to in paragraph 1 and the gas station, the position of vehicle service facilities catering trade, tourist information points,
III	for recreational function and service, featuring a lens referred to in paragraph 2, accommodations, and other commercial and service depending on your needs.

Source: GDDKiA (2015).

Developing transport market makes the current total number of RSA and the range of services becomes insufficient. Is worth noting that on the routes linking the western and eastern border of the country

and the voivodeships warmińsko–mazurskie, podlaskie, lubelskie, are missing, are missing even plans to build a new RSA (GDDKiA, 2015).

It is worth noting that the functionality of existing RSA generally is limited to service passenger cars and trucks with conventional cargo. There were not included, among others, needs arising during performing specialized carriages ie.: transport of dangerous goods, oversized cargo or cargo requiring controlled temperature. They take up year over year growing segment of the transport market, which makes it necessary to adapt RSA to new needs. The answer to the increasing problems could be renewal of existing car parks distinguished by their increased functional effectiveness through increase the level of innovation of the services offered. The conceptual directions of operating effectiveness development of RSA is shown in Fig. 1.

For the past 15 years the world market situation is conducive to the implementation of specialized carriages, including groceries. According to research conducted by scientists of the Worldwatch Institute quantity of food transported worldwide is over 800 million tons per year (Halweil, 2002). It is estimated that half of these carriages need freight transportation at appropriate temperatures, which is a difficult task in the implementation of the carrier (Idaszewska and Bieńczyk, 2011). In Poland, both food production and its exports continued to rise, causing a growing demand for specialized transport. Loads of food carriage usually is done using vehicles equipped with refrigeration or heating equipment. Road transport in the food sector enjoys great popularity.

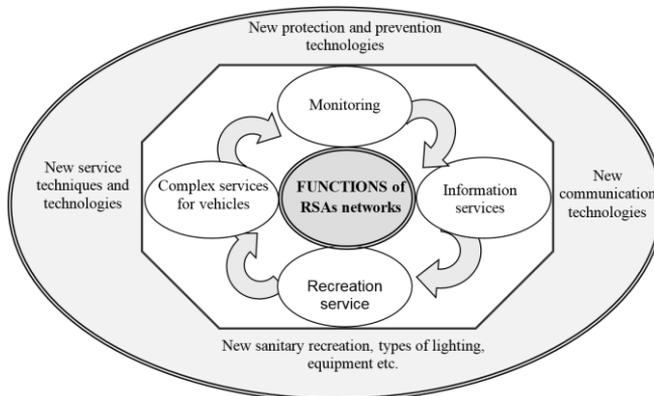


Fig.1 The conceptual directions of operating effectiveness development of RSA

In Poland in 2013 was recorded more than 78 thousand refrigerated vehicles, cooling and icehouses (CSO, 2014). Ensuring appropriate conditions for the transport of these loads requiring eg. a temperature controlled especially during hot weather or at the very "severe" winter requires not only reliable vehicles and skilled drivers, but also a well-planned transport route.

The analysis shows that an appropriate choice of transport route forms the basis for the elimination of most of the problems and simultaneously provides both barrier-free carriage of so called sensitive cargo heavy goods vehicles with trailers or articulated vehicles in the most efficient manner and to minimize the negative impact of these carriages on the environment, and comfortable working conditions of drivers (Semenov et al. 2015).

Difficulties arising during the preparation and implementation of these carriages usually are caused by various factors (NTSB, 2000). Such factors are both objective in character, eg. large differences in the above-mentioned cargoes and subjective, eg. due to irregularities in the service of vehicles. Causes of problems during the transport of goods sensitive to the conditions and time of carriage are shown in Table 2.

Table 2. Causes of problems during the transport of sensitive goods

RATIO	REASON
Informative	Made the wrong decision because of uncertainty of information;
	Lack of discernment concerning. The development potential of the market as a result of incomplete information;
Human	The application of past solutions to new transport tasks without adequate adaptation to current conditions;
	Failure to take account of indirect or postponed during pros and cons of their decisions;
	Failure to take account adequately the impact of transport risk;
	Postponing for later that is "secondary" issues of modernization and adaptation of RSAs to specialized service vehicles
Technology	Using a design shipping route from the bottom up "based on the fragmentation of transport tasks";
	Lack of RSAs equipped with devices to specialized service vehicles loaded cargo sensitive to conditions and transport.

2. Methodological basis of modernization process

Unfavorable conditions for implementing the transport of goods sensitive to transfer time can cause a significant reduction in the quality of work of transport. It is estimated that food losses caused by such changes reach 30%, which translates into huge financial losses (Halweil, 2002). For this reason, during the implementation of transport tasks of such cargoes is required a compatible service of them. Taking into account the requirements of parking spaces specificity at the point of heavy duty vehicles with trailers or articulated vehicles service, there are three key factors influencing the choice of a network modernization strategy places:

- the degree of demand for new services,
- the degree of suitability on existing experiences in the provision of services,
- the degree of effectiveness of the solution to the problem of matching supply of new services to demand.

While on the aptness of modernization strategy affect both the results of performed tests in order to evaluate the states of network of car parks and the complexity of the modernization process. Therefore, there is need to take into account:

- the current state of RSAs network (actual usefulness of RSAs),
- the transition state of RSAs network (RSAs utility in the process of modernization) and
- the future state of RSAs network (RSAs networks utility after modernization).

There are different approaches to solve transport problems (DFT UK, 2008, 2009, 2014a, 2014b) among which we will focus on two:

- approach promoting Incremental Growth Development Models, involving the search of small improvements within existing solutions aimed at eliminating mistakes made before (Table 3); Such an approach is characteristic of the performance of the tasks relating to the modernization of individual RSA;
- approach promoting Exponential Growth Development Models, consisting in the search for such modernization solutions that give not only direct network effects on the existing network structure of the RSA, but also indirect network effects implemented in the functional (operating) structure of this network; The result is original modernization projects implemented on the entire

network, which gives the ability to create a new qualitatively generation of RSAs.

Table 3. Analysis of the results of the preliminary analysis of problems related to the national RSA network

No	Identified problems	Design error diagnosis	Preventive measures
1.	Ineffective land use land occupied existing RSA	The layout of the RSA made on the basis of information from a high level of uncertainty	Changing the methodological bases designer jobs by modernizing the level of RSA
2.	The use of solutions that are not based on the synergy of services offered to existing the RSA	Not taken into account in the course of modernization works deposited during pros and cons of previously constructed the RSA	Network modernization the RSA by the requirements of the implementation of innovative services and generate positive network effects
3.	The application of past solutions for new tasks modernization without appropriate adaptation;	No analysis of the development potential of the market for goods, logistics centers, etc.	Development of the project to modernize the RSA using linear growth strategy
4.	Using a 'design from the bottom up "based on the fragmentation of tasks on modernization projects the RSA	Offsetting that is. "Secondary" design issues for later	Modernization of the RSA should take into account the positive and negative effects of modernization on other car parks included in the network

The advantages of the design project using such models include:

- expansion of RSAs provides full compatibility of modernized network;
- provides for obtaining not only a direct network effects, but also indirect effects implemented in the short and medium term.

Defects of the performed project using the above-mentioned models include increasing the probability of:

- errors caused by the lack of experience in implementing Incremental Growth Models;

- extension of the RSAs modernization process, and consequently increase the cost of investment;
- the risk of discrepancies between the objectives of RSAs network modernization and the objectives pursued in the process of upgrading individual car parks;
- an excessive freedom in the treatment of modernization tasks that can be carried out by the so-called. Wish Lists.

3. Modeling of the modernization process

Supporting sensitive cargo transportation is aimed at increasing the level of comprehensive functionality of RSAs and their structural flexibility and, consequently, increasing the efficiency of the whole transportation and logistics process as part of the freight. Specific objectives include:

- identification of potential solutions for the development of the national network of RSA with regard to technical, economic, legal and information technology aspects;
- determination of development plan of the national network of RSA by selecting the optimal set of RSAs, matched to the principles of functioning of the European TEN-T and the development strategy of this system, taking into account the expected effects of investment realization, the existing constraints (budget, terrain, etc.) And the relationship between existing projects.

Based on assumptions: increasing effectiveness has been proposed test model, to the structure which include, among others five databases (BD) and nine research tasks (Fig. 2).

Stages of research work and databases create a logical sequence having the task of facilitating the study of RSA network modernization projects variants as well as evaluating functionality of this network in different states of worthiness. The above mentioned databases include:

- I. Infrastructure Corridor Layer database. It consists of the characteristics of roads and highways and exits providing access to the RSA network. It is intended to indicate the streams of cars traveling between RSAs.
- II. *Methods of Construction of Models And Scenarios database.* Implementation of these measures is implemented, taking into account the specifics of the research task.
- III. *Transport Node Layer (RSA) database.* It presents a set of characteristics and indicators of land management of existing RSAs.

- IV. *Core Layer database*. It reflects the scope and structure of services provided to RSA-s and indicators of demand for particular services.
- V. *Economic Assessment Tools* database. It consists of investment plan indicator assessment and the verification of assessments carried out.

The development of the above-mentioned databases allows on the one hand to perform various simulation tests, and on the other for inclusion in the model new data sets, enabling to perform research to an increasing extent.

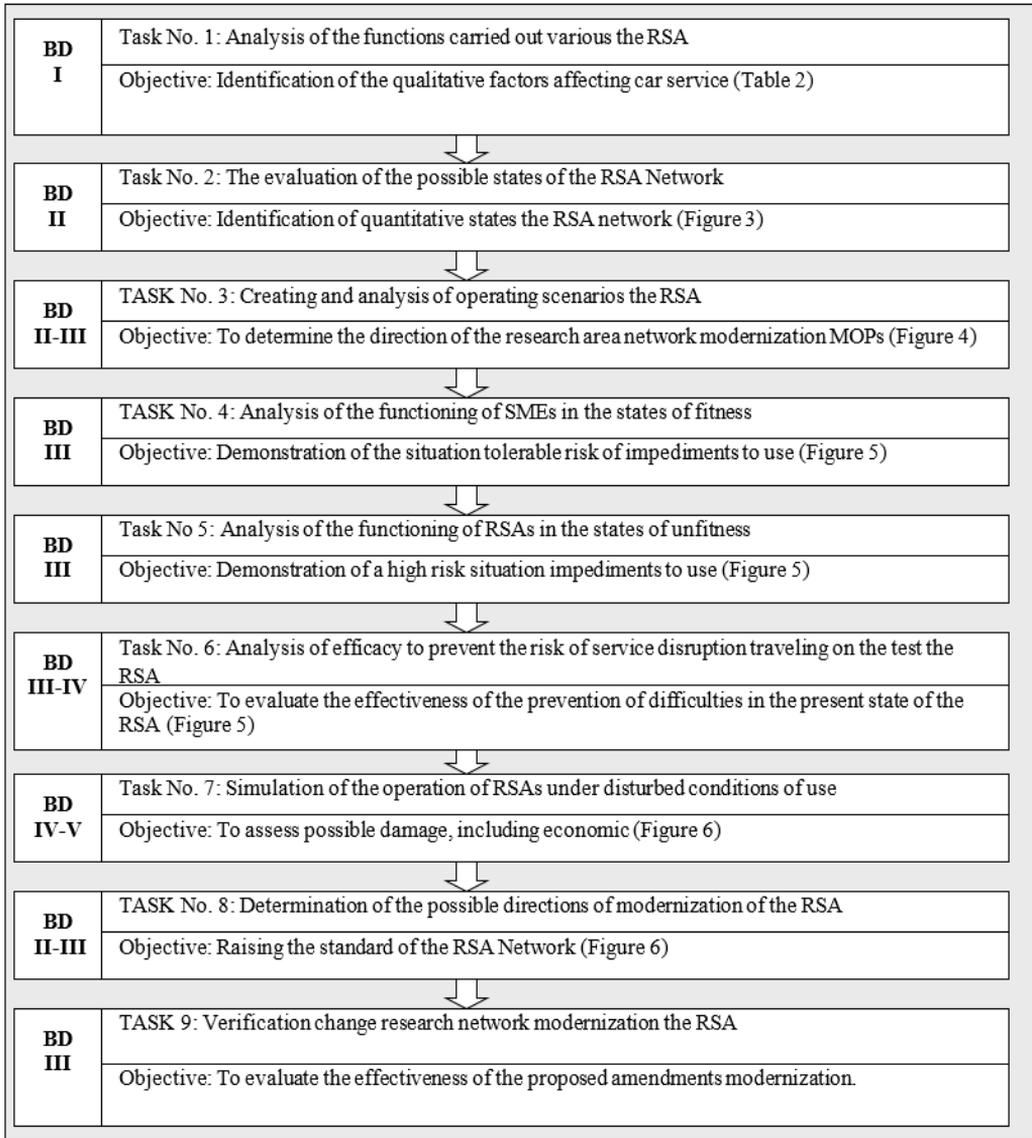


Fig. 2. The structure of research model

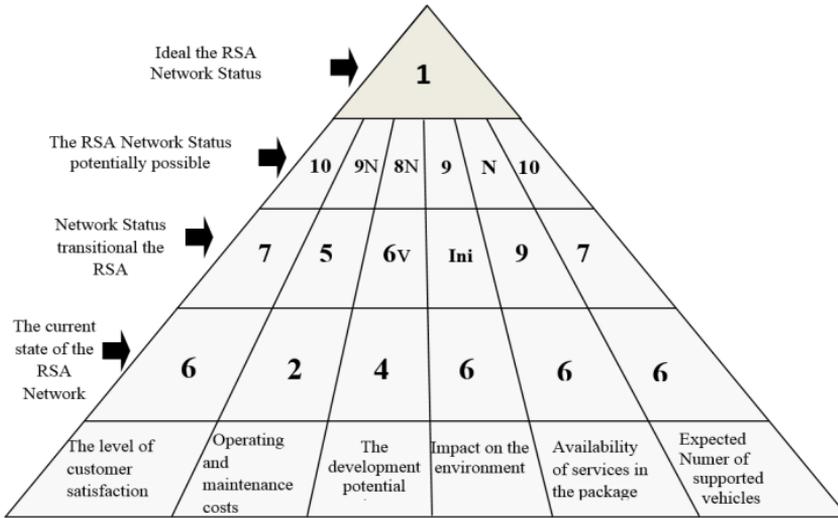


Fig.3. Point evaluation of the possible states of RSA Network

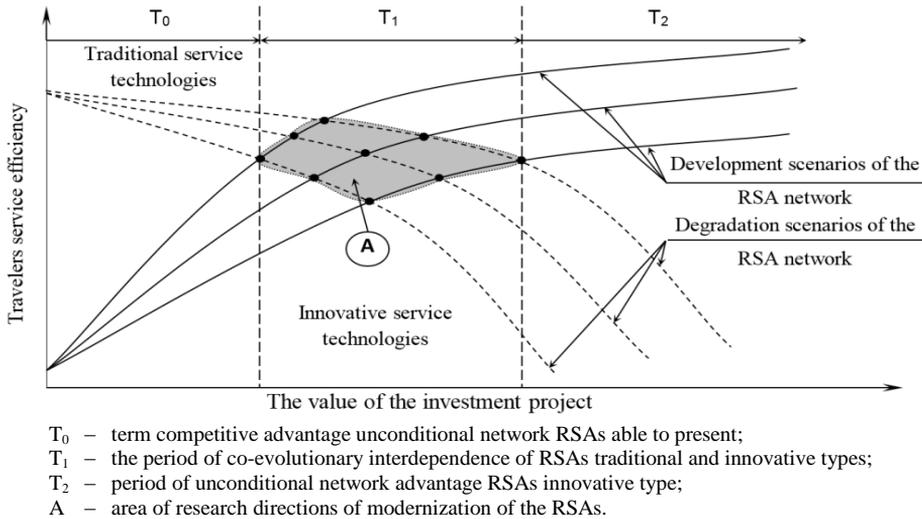


Fig. 4. The dynamics of the efficiency of passenger service by the value of the investment project for RSAs network modernization

As a primary parameter studied in the model it was assumed efficacy of RSAs assessed by the rate of utilization of parking spaces (K). The values of this index were estimated depending on the share of car traffic volume leaving the motorway to the traffic flow of cars on that highway and is equal to the index of traffic disruption.

As Al-Kaisy et al. (2011) described many components which are directly influenced by one critical factor: entering traffic volumes. In the article authors presented that the rest areas provide the occupants of passenger vehicles and the operators of heavy vehicles an opportunity to use a restroom, walk around, stop for a meal, sleep for a while, or

pause to use a cellular phone. These activities have a direct impact on several aspects of the design of rest areas, from parking to facility sizing, water needs, and wastewater generation and handling. The study of Al-Kaisy et al. (2011) identified two peaks during the day for the percentage of main-line traffic using the rest area, but vehicular counts at rest areas showed only one peak at about midday. In authors' opinion given this peak demand, the midday period should be considered in the planning and design of rest area facilities.

In order to increase transparency in the transport of goods in international and national relations, it is very important both to generate detailed information on traffic on national roads and highways by European standards for all relevant technologies that are necessary for the implementation of pan-European sensitive cargo transportation, eg. to temperature changes in accordance with the requirements of the ATP Agreement, as well as ensuring the exchange of data concerning transport management of the above-mentioned types of cargo to optimize the movement heavy duty vehicles, trucks with trailers or articulated vehicles and organize of their streams (Giannopoulos, 2004; Van Hoek, 2002).

During the development of the RSAs network modernization project should take into account that (Semenov et al. 2015):

- increase the number of RSAs increases the freedom of choice when planning transportation routes;
- extending the offer of services to the RSA-s raises the cost of capital for their modernization,
- reduce the number of RSAs increases the time searching for available parking spaces and consequently raises the level of risk in traffic and increases delays and costs in the supply of goods;
- no RSAs equipped with devices to specialized service trucks with trailers or articulated raises the risk of damage during transport of goods sensitive to conditions and transport.

In order to evaluate the effectiveness of decisions made in the study were used three indicators:

1. *Absorbency of parking*. Estimated as the largest number of vehicles parked in the measuring period by particular groups of cars,
2. *Reserve for parking spaces*. Determined on the basis of the local vision,

3. *Rotation of parked cars*. Estimated as the degree of utilization of the same parking place for cars-trucks with trailers or articulated vehicles.

The basic features of modern RSAs are (DFT UK, 2009, 2014c; EASYWAY, 2012; Marchwiński, 2006; The Ministry of Infrastructure of Poland, 2002; Moradijuz et al. 2013; Policy UK, 2008); :

- fulfillment of a wide range of rest and service functions;
- having covered parking spaces equipped with devices providing specialist service vehicles transporting sensitive loads, including electrical outlets, measurement and control devices, barriers, components ensure safety, etc.
- the proper configuration of parking spaces;
- reduction of operating costs resulting from the symptom, ie. a synergistic effect ensuring the long-term increase in the effectiveness of cargo transportation that are sensitive to the conditions and time of transport, and consequently improving the competitiveness of Polish transport companies.

During the RSA designing one of the most important aspects is an information system for drivers about parking places available. Benjamin et al. (2015) presented the VicRoads Truck Rest Area Vacancy Information System (TRAVIS) as an information system designed to provide truck drivers information about truck parking available at rest areas. Communication of parking availability to heavy vehicle drivers will allow more efficient use of the rest areas. It will also allow drivers to plan ahead by providing information on the next option should their target rest area be full.

In Chapter 2 of this article was highlighted the need to perform RSAs network testing in the current, transient and the future state. It is worth noting that:

- in the current state possible situations are “*Normal RSA network operation*” and “*Closing dangerous RSA networks parking*”;
- in the transition state possible situations are “*Required continuation of the modernization of the RSA network*” and “*Pause decision on modernization of the RSA network*”.

The order of testing the advisability of modernizing the the RSA should depend on the type and size of the threats to the effectiveness of modernization, which can be subjective, eg. Human error or objective, eg. The lack of funds for investment. Each situation (of those in Fig. 5) requires proper analysis

where the input we have the results of the analysis of the effectiveness of services provided to existing the RSA-s, while the output - selection and acceptance towards a more efficient functional RSAs. Stages of research advisability of modernization were presented in Fig. 6. As a criterion for assessing the impact of network modernization project RSAs chosen the effectiveness of the implementation of new solutions, which can be assessed by using the following equation:

$$W = S_p - S_b \tag{1}$$

where:

W – contribution to the modernization project on network efficiency RSAs;

S_p – the effectiveness of sensitive cargo truck in the situation “with the implemented network modernization project on the RSA”

S_b – the effectiveness of perishable cargo in the situation “without the modernization project on the network RSAs”.

while:

- situation “modernization project at the RSA networks” = dot the state. Viability of sensitive cargo truck after the introduction of the modernization project;
- situation “without the modernization project” = most probable situation is concerning. Viability of sensitive cargo truck in case, if the modernization project will not be implemented. The situation "without
- modernization" = the situation "before modernization" (except that it does not take into account the evolution of road infrastructure in time).

Additional criteria include functions:

- maximize the security of sensitive goods such. Require controlled temperature;
- maximizing the complementary actions during service;
- minimize the risk of investment in road infrastructure.

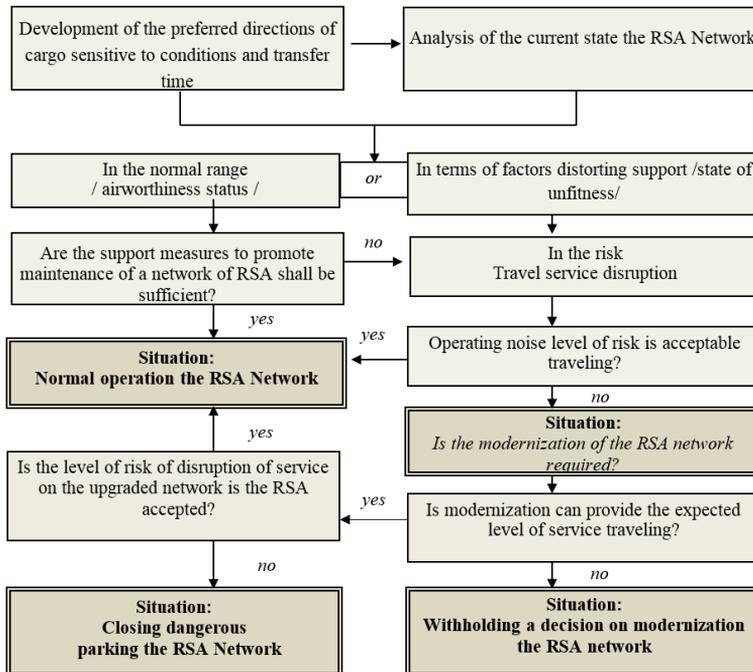


Fig. 5. The logic of possible changes in the suitability of the RSA network

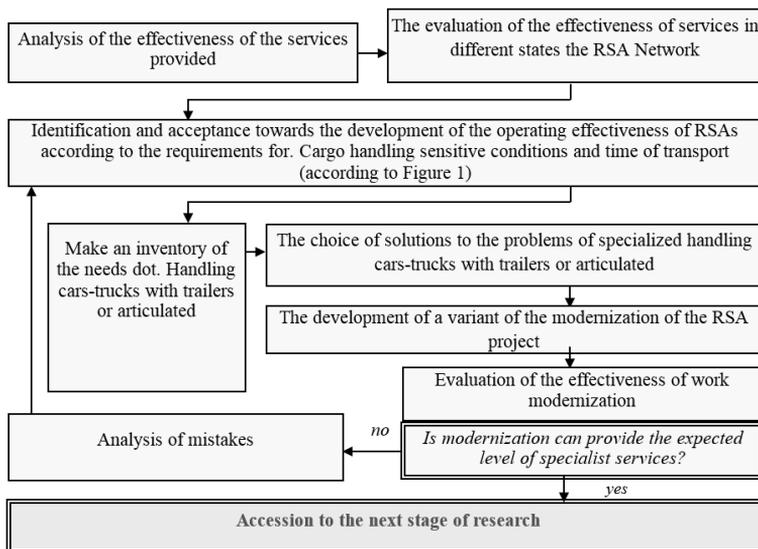


Fig. 6. The order of testing the advisability of network modernization the RSA

4. Preliminary test results

Parking in the RSA must be designed to ensure:

- one way traffic within the complex of the ILO;
- free access to any object services within the complex of the ILO;
- moving cars at speeds up to 25 km/h;
- minimum values of road traffic noise;
- the maximum values of the availability of places to parking.

The study was carried out at the RSA-s on three categories of parking spaces (Figure 7). During the study found that the vast majority of them meets all the requirements of the legislation. Their size (Table. 4).

At the location of each the RSA in the national network must ensure the availability of trucks with trailers or articulated vehicles.

Analysis of the results shows that the value of the above. rate depends on the place which is guided by a car. In the case of the ILO conventions to that category and equipped with parking spaces, recreational equipment, sanitary and small catering facilities, etc. Road traffic noise ratio is in the range of 0.01 - 0.005. In the case of conventions cars to RSAs Category II or Category III of the functions of leisure and services, the value of this ratio is 0.1 to 0.005 (Table 5).

Analysis of the availability of parking spaces in selected the RSA for trucks along the national roads and motorways in 2012-2014 indicates that during the winter drivers is much more difficult to find a free parking place for hours around noon, and almost not possible late in the evening and at night (Figure 8).

All the RSA by their location in relation to major roads can be divided into two types: those situated parallel to the perpendicular roads and located in a loop. The most common and most adapted to the needs of travelers to locate parallel. It is characterized by placing the whole or part within a branch of the main road or directly adjacent to the road. This location provides the need for separated entry and exit of vehicles from the organization one-way traffic. Perpendicular to the main route locating RSA is performed in the loop. This is accomplished through a combination of building the highway one exit, which performs the functions of entry and exit to the RSA. The results of analysis performed tests show that the dynamics of operating efficiency of vehicles carrying loads sensitive to the conditions and time of delivery depends not only on the accuracy of decisions made during the development of network modernization investment project RSAs, but also on the level of innovation solutions used in the project.

Table 4. Dimensions of parking stations for trucks

Vehicle type	Located in relation to the roadway alpha [°]**)	Length [m]	Width [m]	Located in relation to the edge of the carriageway [°]	The width of the roadway maneuver [m]
Truck	90 0	8,00 15,00	3,5 3,0	90 60 45 0	12,00 7,50 6,00 3,50
Truck and trailer or membered	90*) 60*) 0	19,00 19,00 30,00	3,50 3,50 3,00	The position of parking trucks with trailers or articulated should be done as through.	

*) The position of parking trucks with trailers or articulated should be done as through.

***) Dimensions of parking spaces at other angles location in relation to the road than specified, should be set to the dimensions given for alpha = 90°

Source: GDDKiA (2015).

N	The plan of parking spaces	The results of the analysis
1		<p><u>Through a parking position</u></p> <p>Advantages: thin strip occupied, lack of required belt maneuvering, good visibility when turning the movement, no speed limits of vehicles in circulation, parking of long combination vehicles.</p> <p>Disadvantages: collision exit, difficult parking maneuver, the required point there are no obstacles.</p>
2		<p><u>Parking position located in relation to the edge of the road 45°</u></p> <p>Advantages: good use of the car park, easy collision-free to get on / egress</p> <p>Disadvantages: dealing with 2-ch belts or surface width of up to 7 m, bad visibility when turning into traffic</p>
3		<p><u>Parking position located in relation to the edge of the road 90°</u></p> <p>Advantages: very efficient use of space and the length of the RSA, easy setting cars, collision-free exit</p> <p>Disadvantages: dealing with 2-ch belts or surface width of up to 7 m, bad visibility when turning into traffic, low speed during the maneuver packaging.</p>

Fig. 7. Analyzed categories of parking spaces

Table 5. The values of the availability of parking spaces for trucks on selected the RSA-s per day

No	Episode of time	The summer period		The winter period		Spring and Autumn Period	
		K_{let}^1	K_{let}^2	K_{zim}^1	K_{zim}^2	K_{wi}^1	K_{wi}^2
1	00.00-02.00	0.005	0,72	0.005	0,10	0.005	0,50
2	02.00-04.00	0.015	0,60	0.009	0,10	0.012	0,40
3	04.00-06.00	0.017	0,98	0.012	0,15	0.018	0,65
4	06.00-08.00	0.024	0,96	0.020	0,60	0.024	0,80
5	08.00-10.00	0.056	1,0	0.051	0,77	0.058	0,70
6	10.00-12.00	0.074	0,95	0.062	0,77	0.079	0,85
7	12.00-14.00	0.078	0,90	0.064	0,48	0.086	0,86
8	14.00-16.00	0.010	0,68	0.017	0,55	0.010	0,78
9	16.00-18.00	0.067	1,00	0.039	0,77	0.075	0,97
10	18.00-20.00	0.092	0,95	0.047	0,79	0.100	0,90
11	20.00-22.00	0.018	0,60	0.009	0,37	0.014	0,70
12	22.00-24.00	0.008	0,8	0.005	0,01	0.008	0,65

K^1 – traffic rate for cars leaving the highway to vehicle traffic on tested highway

K^2 –availability of parking spaces rate for trucks on selected RSA

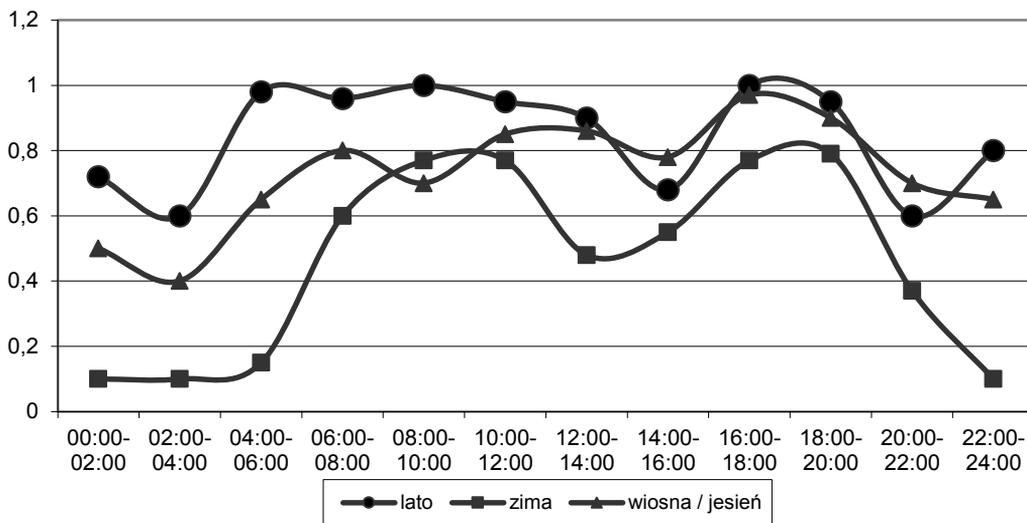


Fig. 8. Availability of parking on selected the RSA-s for trucks along the national roads and motorways in 2012-2014

5. Conclusions

Polish-sensitive freight market conditions and delivery time each year notes steady growth resulting in an increase in demand for specialized transport. Therefore, the implementation of transport tasks requires, inter alia proper use of vehicles transporting the above. Trucking places where they stop. In order to meet the requirements

necessary to extend the functions of RSAs through their comprehensive modernization. Decisions made during the development of a national network modernization project RSAs should be reviewed and evaluated by:

- simulation studies of the transport process carried out in the framework of the pacts “Cargo vehicle-driver - cargo sensitive” depending on the length

of the route; category traffic and traffic during the day; the speed of movement; duration of working time, mandatory breaks and rest periods and seasonality using real data for the northern, central and southern regions of Polish;

- a risk analysis of transport depending on the type of cargo transported; weather conditions; performance of work conducted under national or international transport divided into methods based on causal models, models of risk assessment models, transport and human errors;
- efficiency analysis, cost-effectiveness and feasibility of establishing a national network of car parks adapted to specialized service vehicles carrying loads sensitive to the conditions and time of delivery, to allow for objective assessment of the effectiveness of planned changes to modernization.

Evaluation of the results of the studies are based on the indicative comparative analysis of existing and structured (forecast) traffic streams trucks with trailers or articulated showing the necessity of modernization works on the network of car parks to make them suitable for specialized handling vehicles with loads sensitive to the conditions and time of their transport.

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