

# Intelligent Solutions in Sustainable Transport Upper Silesia Agglomeration

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**Abstract.** The metropolization processes in Poland are currently in progress. The tools for these changes are the following: implementation of EU urban policy (in particular by implementing Integrated Territorial Investments (ITI) strategy) and formation of metropolitan associations. The implementation of the ITI strategy requires formation of ITI associations. In the case of Upper Silesia, such association covers a territory extending beyond a highly urbanized area - the Association of Municipalities and Districts of the Central Subregion includes over 80 municipalities and districts. This situation causes the dispersion of the integration of the metropolitan area. The Metropolitan Association (MA) will be formed in accordance with the Act of 6 October 2015 on Metropolitan Associations, which became effective on 1 January 2016. Both ITI and MA will deal with sustainable transport and mobility, and the basic instrument for sustainable transport is the development of public transport. The sustainable mobility plan, which is already being developed for the ITI strategy of Upper Silesia, provides for the application of Intelligent Transport Systems (ITS). ITS enables the restriction of the fundamental barrier of metropolization - the activity of 5 public transport organizers characterized by different systems of organizing transport market, financing and transport tariffs. The purpose of the article is to present the conditions for use of selected types of ITS in order to provide sustainable transport for the Upper Silesia Agglomeration, which should lead to an increase in the importance of sustainable public transport.

**Keywords:** Sustainable transport · Sustainable mobility · Integrated Territorial Investments · Metropolization · Intelligent Transport Systems · Public transport

## 1 Introduction

The metropolization processes in Poland are accelerating. The tools for these changes are the following: implementation of EU urban policy (including in particular through implementation of Integrated Territorial Investments (ITI)) and formation of metropolitan associations. The implementation of ITI requires formation of ITI associations. In the case of Upper Silesia, such association covers a territory extending beyond a highly urbanized area - the Association of Municipalities and Districts of the Central Subregion includes over 80 municipalities and districts. The Metropolitan Association will be formed in accordance with the Act of 6 October 2015 on Metropolitan Associations,

which became effective on 1 January 2016. Both ITI and MA will deal with sustainable transport and mobility, and the basic instrument for sustainable transport is the development of public transport. The sustainable mobility plan, which is already being developed for the ITI strategy of Upper Silesia, provides for the application of Intelligent Transport Systems (ITS). The implementation of MA tasks will also require the application of ITS, including the existing solutions already applied by transport organizers in the Upper Silesia Agglomeration. ITS enables the restriction of the fundamental barrier of metropolization – the activity of 5 public transport organizers characterized by different systems of organizing transport market, financing and transport tariffs. The purpose of the article is to present the conditions for use of selected types of ITS in order to provide sustainable transport for the Upper Silesia Agglomeration, taking into consideration the specific character of this urban area.

## 2 Metropolization Tools in Poland

In metropolitan areas, there are numerous problems concerning the cooperation between local government units, in particular related to network tasks - public transport, road management, water supply and waste management. At the same time, the attempts to create a uniform administrative structure have not fully succeeded anywhere - apart from Verband Region Stuttgart, where representatives of the metropolitan association are elected directly [7].

At the beginning of the political transformation in Poland, in 1991, municipalities were allowed to form voluntary intermunicipal associations and enter into agreements. For various reasons, these associations were formed slowly and many issues requiring cooperation did not function efficiently. Therefore, certain regulations intended to integrate the largest agglomerations were implemented in 2013 and 2016 respectively. The created tools include:

- Integrated Territorial Investments (ITI), which are implemented by ITI associations,
- metropolitan associations which are to be formed in the areas inhabited by over 500,000 citizens, pursuant to the Act on Metropolitan Associations, which became effective on 1 January 2016.

The adopted solutions are not free from defects, however, each of them provides financial resources directed towards municipalities and districts in metropolitan areas. According to the assumptions of ITI, they are intended to integrate metropolitan cities (province capitals) with their immediate surroundings. Therefore, it was emphasized in the Partnership Agreement that integrated activities for sustainable development of urban areas will be particularly supported - pursuant to Art. 7 of the Regulation of the European Parliament and Council (EC) 1301/2013 of 17 December 2013. It was specified as mandatory that “provincial” ITI shall be implemented in the territories of province capitals and related cities, indicated in the functional areas. Accordingly, 17 mandatory areas for implementing ITI were determined (Bydgoszcz and Toruń form one area in the Kujawy-Pomerania Province, whereas in the Lubusz Province there are two such areas). Provinces can also launch ITI in the functional areas of cities of regional and

subregional significance. Currently, EUR 3.5 billion was allocated for this instrument (including domestic and regional funds), and the total number of ITI is 24 [16]. The concept of ITI implementation in the Silesia Province was based on allocating funds in subregions and related agglomeration centers. In particular, ITI financed at the national level was included in the central subregion (including Katowice). The allocation provided for ITI for the central subregion of the Silesia Province is the highest in Poland, with the value of EUR 793 million. The dominating activity within this ITI is “low emission urban transport”, to which 50.2 % of funds were allocated. The majority of financial resources for ITI in the central subregion are intended for tasks located in the central area of Upper Silesia Agglomeration. Therefore, although its scope of activity is too broad, we can say that ITI instrument is a factor of metropolization, also in the case of Upper Silesia Agglomeration.

**Table 1.** Basic measures and indicators characterizing the population of the province of Silesia (as of 31.12.2014) [own study based on 12]

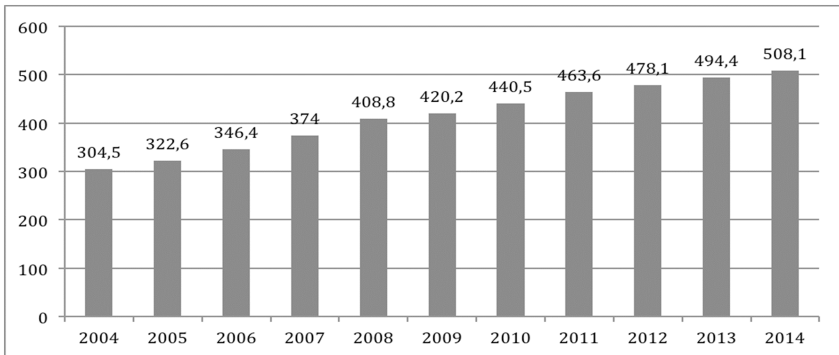
Specyfification	Silesian province	Poland
Total population in thousands. People as of 31.12.2014	4 585,9	38 478,6
Participation in [%] of the total Polish population	11,9	–
The age structure of the total population [%]:		
The population of pre-working age	16,8	18,0
The population of working age	63,2	63,0
The population of post-working age	20,0	19,0
The density of population per 1km <sup>2</sup> in [persons/km <sup>2</sup> ]	372	123
Natural increase per 1,000 people	–1,1	0,0
The feminization	107	107
Net migration per 1,000 population	–1,6	–0,4
The level of urbanization in [%]	77,3	60,3

Metropolitan associations can be formed pursuant to the Act of 6 October 2015 on Metropolitan Associations, which became effective on 1 January 2016. The Act had been drawn up for several years and its provisions currently raise many doubts. The formation of metropolitan associations is encouraged by statutory funding at the level of 5 % of tax on personal income of citizens of metropolitan municipalities. According to the Act, the only network services provided by metropolitan associations are transport-related tasks. In particular, this concerns public transport and cooperation for determining the course of national and regional roads. In this situation, the problems related to organization of public transport are becoming a key issue, especially that the Act specifies that an association should be responsible for organizing metropolitan transport and a source of integrated tariff within a metropolis. However, the conditions and procedures for formation of associations specified in the Act are relatively complicated and not free from discrepancies. There is a high risk that the Act will become a dead letter, since a metropolitan association can only be formed on the condition that the prime minister issues the relevant regulation until the end of April in the year preceding actions

taken by an association. The very problem of delimiting metropolitan area raises doubts - according to different studies, metropolization processes in Poland are poorly advanced [7].

Metropolisation in the Silesian province covers the area of the Upper Silesian agglomeration. Province is the largest and most urbanized areas in Poland (indicators presented in Table 1). Silesian province is characterized by the high levels of industrial development, investment attractiveness, as well as a good location.

A particularly important factor for mobility is the growing number of cars per 1,000 inhabitants (data presented in Fig. 1), which in the metropolitan area increases congestion. The growing number of cars will increase in car journeys, and thereby causes that mobility is not sustainable.



**Fig. 1.** The number of cars per 1,000 inhabitants in the province Silesian [own study]

### 3 Models of Organizing Metropolitan Transport in the Upper Silesia Agglomeration

Assuming the statutory formation of metropolitan association in the Katowice Agglomeration, certain model solutions can be adopted in the field of performing tasks related to public transport by the Metropolitan Association.

Depending on the scope of metropolitan transport system, two approaches to organization of public transport in a metropolitan area can be distinguished:

- cooperative model: metropolitan association is the organizer of metropolitan transport and coordinator of tariff system, whereas other transport (municipal, district, regional) in the metropolitan area is organized by the existing organizers (with the exception of tariff determination),
- centralized model: metropolitan association organizes the entire public transport in the metropolitan area (including coordination of the tariff and ticket system).

The cooperative model seems to be easiest for implementation, in particular for the following reasons:

- within the meaning of the Act, metropolitan transport is a small fracture of the currently provided public transport. In fact, it seems that in metropolitan areas it will be difficult to identify such transport (it will probably be transport between municipal operators and a part of intercommunal transport),
- required level of co-funding for such a small system will be significantly lower than statutory resources from personal income tax, therefore, it will not be necessary to provide additional funds for public transport to the association from municipalities and districts within the metropolitan area.

At the same time, it shall be noted that such narrow approach to transportation tasks of the Metropolitan Association will have the following negative effects:

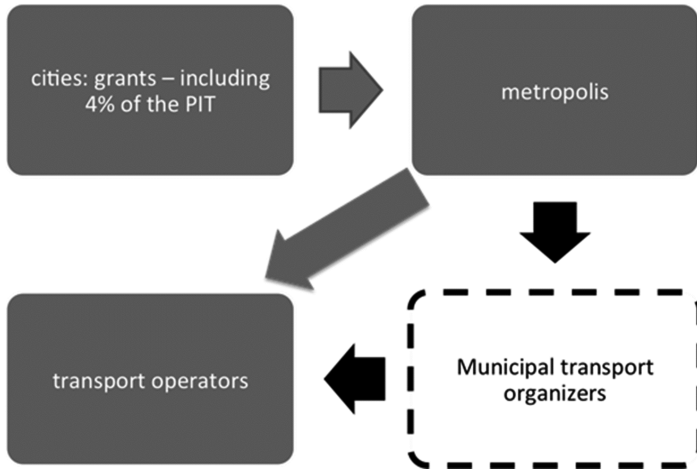
- low progress in the field of actual and required integration of public transport in metropolitan areas (especially in case there is a number of organizers, actual barriers and instances of discontinuity of integration),
- incompatibility of tariff and organization competences of the Metropolitan Association (the Association will have an impact on the tariffs of all public transport organizers in the metropolitan area, whereas as an organizer, it will only be responsible for metropolitan transport),
- overall: lesser efficiency of public transport.

The cooperative model can be implemented in the following manner (alternatively):

- appoint an organizer, such as an office or a separate unit (department) of the Metropolitan Association and entrust it with organizational tasks related to metropolitan transport and metropolitan tariff,
- entrust the duties of organizer of metropolitan transport to another organizer (e.g. leading organizer of public transport in the metropolitan area) and provide supervision of transport and tariff determination performed by a separate small organizational unit of the Metropolitan Association (department).

The centralized model has its origin in the experiences of European metropolitan areas and it can be considered as a recommended and universally applied solution. However, in the conditions of the Polish Act on Metropolitan Associations, it will be hard to implement in the areas where the lack of integration causes the biggest problems (Tricity, Upper Silesian Industrial Region, Warsaw), in particular the following (shows in Fig. 2):

- appointment of one metropolitan transport organizer in the metropolitan area - due to the scope of activity, it would be a large unit with a significant budget. This would lead to the process of liquidating the existing structures of public transport organization,
- development of the metropolitan system of financing public transport - tax revenue provided for the Metropolitan Association will definitely not cover all expenses related to public transport in the Metropolitan Association, and various methods of financing public transport used by particular organizers are a further complication.



**Fig. 2.** Cash flow in agglomeration [own study]

The centralized model ensures full integration of public transport in a metropolis. Although it will result in issues related to transfer of competences, it will ultimately allow to:

- intensify transport integration in the metropolis,
- increase the efficiency of transport system,
- increase sustainable mobility.

The centralized model can be implemented by appointing one organizer of metropolitan transport, such as:

- separate Metropolitan Association unit (large department),
- metropolitan budget entity,
- external unit (however, Polish experiences and conditions allow to conclude that this solution is rather unlikely).

#### **4 ITS in Sustainable Mobility in Metropolitan Areas in Poland**

The development of transport is one of key factors behind the formulation of the smart city concept, and smart mobility is one of the key areas of smart cities [10]. At the same time, such shape of cities is becoming one of the key megatrends in the economic development of urban areas [15]. Projects undertaken in the field of smart mobility are implemented in accordance with the principles of sustainable development, which means focusing on minimization of the negative impact of transport on the environment, especially through the development of public transport, preferential traffic and access to services. Particularly significant in this field are the projects which use Intelligent Transport Systems (ITS), including projects related to: vehicle traffic management, congestion

charges and smart cards [10]. In Poland, projects concerning urban traffic control system and tariff and ticket integration by means of smart cards are implemented.

Vehicle traffic management is the key problem solved by means of ITS - one of the pioneers in this field is USA, where the significance of this element was emphasized in the federal ITS programme as early as in 1991. Currently, urban traffic control systems in Poland are only applied in few cities, most notably in Tricity and Wrocław, where solutions covering large urban zone areas have been implemented. Due to the large scope of the system and necessity to integrate metropolitan areas, it is worth noting the system implemented in the Tricity in 2015 - TRISTAR, the value of which amounts to approximately PLN 160 million (including PLN 136 million co-financed by EU). The system takes into consideration the fact that both vehicle flow management and public transport management are dispersed in particular cities, and the integrated metropolitan transport management is assumed only as a target. The current regulations concerning metropolitan areas will not ensure integration of these systems. However, with reference to the impact on drivers in both individual and public transport, TRISTAR system offers access to advanced traffic information, which allows to optimize behaviors of drivers (apart from that, TRISTAR system also provides information for passengers in public transport, as well as parking information). By means of traffic detection, data on road incidents and meteorological information, TRISTAR system makes use of information boards to provide drivers with information concerning:

- traffic obstacles,
- journey times on main and alternative routes (e.g. journey time to Gdańsk via Tricity bypass and intercity road),
- detour recommendations [11].

In conjunction with adapting traffic signals to traffic conditions, TRISTAR system should support sustainable transport in the Tricity agglomeration, in particular reduce congestion and increase road transport security through more efficient use of transport infrastructure [8]. This is consistent with the expectations related to the benefits of implementing ITS. The literature on the subject widely presents relatively optimistic forecasts, which in practice seem to be unrealistic. It is sufficient to recall predictions from almost 20 years ago, when it was assumed that the implementation of ITS in road traffic management would lead to 50 % reduction in the number of car accidents, 25 % reduction in journey times and 50 % reduction of air pollution caused by transport in cities until 2017 [6]. In practice, ITS systems are not implemented according to the assumptions: even if the ITS architecture advocated by the specialists exists, the organization of transport systems for which ITS solutions are prepared does not correspond to it. Moreover, the costs and duration of project implementation are increasing, which is the effect of underestimating the risk resulting from the specific character of the decision-making processes in the public sector responsible for the functioning of transport infrastructure [2]. In particular, it is difficult to achieve the scale effects related to integration, which is the key factor limiting IT effects.

The barriers of integration in metropolitan areas, where it is frequently necessary to diversify tariff solutions applied in different parts of metropolis, have a similar limiting impact on the effects of applying ITS in tariff systems. Striving for tariff integration in

metropolitan areas requires applying flexible and intelligent ticket systems. An example could be universal tickets, providing access to transport services and other urban services, especially when the ticket performs the function of the so-called electronic purse. It seems that progress in this field will be encouraged by dissemination of modern ticket systems. They do not necessarily have to be tickets in the form of electronic cards. The so-called virtual tickets, once rare, are developed thanks to the widespread use of smartphones. In Poland, these two directions of ticket system development are widely used, however, the biggest number of implementations are related to electronic cards applied mainly in public transport systems [14].

Cards allow to:

- integrate payments in transport systems (not only public) in metropolitan areas where many transport organizers operate,
- perform measurements of transport size, which is particularly significant for financial settlements of municipalities subsidizing public transport,
- integrate urban functions.

The main problems characterizing electronic card systems in Poland include:

- different technical standards of cards,
- adjustment of solutions to possibilities of obtaining support from EU funds - adapting programmes to conditions specified in operational programmes leads to creation of functionalities which will be characterized by low efficiency during the period of system utilization,
- closing the areas of card application within the existing organizational structures of public transport,
- investment expenditure and costs of system operation [5].

Implementation of electronic card systems faces smaller problems than in the case of urban traffic control systems, however, in the case of large projects and extended functions, the investment expenditure is increased and the implementation period is clearly extended. An example of such problems is Silesian Public Services Card (ŚKUP), which was put into use on 1 November 2015.

ITS projects applied in public transport undoubtedly raise the level of economy digitization and have a positive impact on the development of social capital, however, large projects are almost entirely financed from EU funds. Formal restrictions are a source of expensive project management during the so-called project durability period, moreover, they petrify the existing organizational structures due to the necessity of determining the so-called support beneficiary. In particular, this could be the reason for preserving ineffective solutions which block changes in the organization of metropolitan structures.

## **5 Directions for Application of ITS in Sustainable Transport in the Upper Silesia Agglomeration**

The implementation of intelligent transport systems in Silesia is in the initial phase. In this respect, it is clearly noticeable delay in relation to the countries of Western Europe.



So far completed projects concerns in the area of public transport, among them can be replaced:

- dynamic passenger information system comprising a number of main lines of communication on the network KZK GOP,
- a network of electronic passenger information boards in the city of Rybnik including 167 stops of public transport,
- card systems enabling urban performing the function of an electronic ticket and e – wallet (SKUP, e-Bilet in Jastrzębie, Electronic City Card in Rybnik, Electronic City Card in Jaworzno, Electronic City Card in Częstochowa).

The problem of sustainable transport in the area of Upper Silesia Agglomeration is the subject of programme documents prepared within the framework of changes occurring in metropolitan area management. These issues were exposed in the “Strategy of Integrated Territorial Investments for the Central Subregion of Silesian Province for the years 2014–2020” [13], where sustainable mobility was distinguished among 9 strategic activities. Currently, the subregion prepared “Sustainable Mobility Plan” within the framework of ITI strategy, which should take into consideration key areas of activity for sustainable mobility, including in particular [3, 12]:

- in the field of public transport, e.g. application of attractive and flexible tariff solutions, electronic tickets and increased transport integration,
- in the field of vehicle traffic, especially dynamic systems of information for drivers are recommended.

The activities mentioned as elements of sustainable mobility plan will be implemented (not only by means of the ITI instrument) by the application of ITS, including also development of urban vehicle traffic control systems and electronic ticket systems. Apart from ITI Association (Subregion), the institutions which implement or may implement such projects include Komunikacyjny Związek Komunalny GOP (Communal Transport Association of Upper Silesia, associating 29 municipalities) and future Metropolitan Association (it is currently assumed that 24 municipalities will be included in the Association, including 10 cities of Upper Silesia Metropolitan Union). The organizational complexity of metropolitan management in the area of Upper Silesia Agglomeration will definitely increase the investment costs and risk in the field of ITS (shows in Table 2).

Until now, urban traffic control system in the Upper Silesia Agglomeration on a larger scale has only been implemented in Gliwice (for the cost of over PLN 30 million). KZK GOP has developed the concept of a system covering the Association area, whose functionalities are similar as in the case of TRISTAR system, although the costs of such project would undoubtedly be several times higher [9]. The uncertainty concerning the implementation of such project is increased due to the initiatives taken within the framework of ITI - including Gliwice and Tychy, which want to either expand (Gliwice) or create (Tychy) urban traffic control systems (at the total cost of approximately PLN 120 million). The projects related to urban traffic control are so little advanced and the number of stakeholders is so high that quick improvement of the situation concerning this system cannot be expected. It seems that such system should be designed and

implemented in a completely different manner than resulting from the experiences of Tricity and Wrocław. The basis should be the approved system architecture and strategy of solution implementation in stages (per function and region).

**Table 2.** Result indicators SUMP's Central Subregion (2016) [12]

Strategic goal	Result indicator	Target value	Data source
1. Increase the competitiveness of sustainable transport	The number of units purchased rolling stock of public transport [szt.]	165	Operators of public transport
	The capacity of rolling stock purchased in the public transport [person]	8 250	Organizers and operators of public transport
	Length built bicycle paths [km]	1 113	Local government units
	The length of newly built sections of the tram network [km]	23	Tramwaje Śląskie SA
	The length of the modernized sections of the tram network [km]	100	Tramwaje Śląskie SA
2. Integration of transport	Number of new integrated transport interchanges	53	Local government units
	The number of new buildings Park & Ride	53	Local government units
	Number of parking spaces in built facilities Park & Ride [pcs.]	3 225	Local government units

With reference to ŚKUP, KZK GOP is the unit which coordinates implementation and manages the system, therefore, the situation looks much better from the organizational perspective than in the case of urban traffic management system. The system was launched with two-year delay. It had been prepared since 2008 (design) and expected to be put into use in 2013, however, the system launch did not begin until the end of 2015. Within two months, only 20,000 cards out of the expected number of 700,000 cards were issued. It appears that the system has too many functionalities, which were expected to be ready and provided “on a turnkey basis” [4], and such ambitious assumptions increased the financial risk, as well as the risk related to the deadline for completing the project. This will probably also be the reason of errors in the operation of the system, which is public in its essence.

## 6 Conclusion

The regulatory changes, including especially changes related to implementation of ITI and formation of metropolitan associations, provide the opportunity to accelerate activities related to sustainable transport and mobility in agglomerations in Poland. The efficiency of ITS means that these systems are increasingly used for providing sustainable transport. In metropolitan areas, a significant problem is the integration of operations of many public administration units. ITS, and particularly urban vehicle traffic control systems and systems applied mainly in public transport of urban electronic cards are financed from public funds, especially EU funds. Therefore, the problem of cooperation between public administration and other stakeholders of metropolization processes is becoming a factor of success and risk related to implementation of large projects.

In the area of Upper Silesia Agglomeration, urban vehicle traffic control management is used to a limited extent, whereas e-ticketing in public transport, common in Poland, is implemented in the form of the largest domestic electronic card system, which has the most expanded functionality. The specific spatial and organizational character of the existing metropolitan area means that ITS system architecture should take into consideration the barriers of integration. Moreover, the system of ITS implementation has to be different than in other agglomerations - the functionality and scope of systems should be implemented in stages. This concerns not only the presented examples, but also other e-systems, which should function in the territory of a metropolis striving towards the concept of smart city.

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