Nodes and Corridors of Metropolitan Structure Development. Identification and Parametrization Issues On Example of Krakow

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Abstract. The subject of the author's research is planning and urban aspects of modelling the spatial structure of cities being in the metropolitan development phase, with particular emphasis on the problems typical of their inner city. The research approach consists in an attempt to define the main elements forming the urban structure of this structure. It is assumed that these are nodal locations and development corridors, i.e. points and bands distinguished by accessibility by transport, diversity and intensity of land use, increased investment traffic and significance for the urban composition of the city. The purpose of research is to define the basis of spatial policy for particular types of development corridors and the corresponding nodal sites, also called urban centres. The article presents the assumptions of the method of identification, classification and parameterization of these elements. The criteria and factors were derived from the following assumptions and experiences: a) there is a close relationship between spatial development policy and transport policy, where pedestrian and bicycle traffic is becoming a higher priority, b) metropolitan centres are shaped in places with the highest availability of collective transport, and these places form a network of public spaces of the contemporary city, c) the importance of ecological, architectural and urban quality factors increases, as well as the values that create the identity of particular spaces that build the metropolis, d) the main corridors of spatial development should integrate sensitive and strategic areas, including areas requiring revitalization and areas of intense and spontaneous transformations. Conclusions from the research based on the example of Krakow allowed for the refinement of factors assessing the potential of activation and integration of development corridors.

1. Introduction

1.1. Research problem

The spatial structure of cities in the metropolitan development phase undergoes significant changes leading to polycentralization. As a result of the law of concentration, in places, areas and along the routes with the best transport accessibility, activities generating new investments accumulate. This process may lead to the disintegration of the spatial structure of the city, when there is a lack of coordination between the development of concentration and the crystallization of various functional and spatial connections. An unfavorable phenomenon, especially in the case of Polish city centers, is the scarcity of public spaces and their faulty solutions. This is a particularly undesirable effect in the case of revitalization of valuable areas in the city center. In Polish conditions, this situation is a consequence of certain shortages of the spatial planning technique in the context of very strong investors' pressure on the city key parts. According to the researchers of this problem, too little attention is devoted to the role

of research methods and scientific theories that could be used to verify the substantive correctness of assumptions and solutions applied in spatial development plans and urban projects [1].

1.2. The purpose and scope of research

The author's research efforts concentrate on the planning and urban planning methodological basis of constructing the spatial structure of the metropolis. The overarching idea of the node-corridor model is, among others, the ability to generate a city's urban structure. This model would serve as a helpful tool in determining spatial policy assumptions for planning documents at appropriate levels of city development management, as well as to simulate changes in the spatial structure of the city. The aim of the research presented here was to refine the methodology applied in the tested spatial structure model.

2. Research contexts

2.1. Theories

Defining the city's construction model and rules governing it is based on premises read in real space as well as concerning future directions of its development [1]. This means the need for synthetic notation of elements that make up this space, their characteristics that determine the development and functioning as well as the relationships between these elements. Also significant is the "genetic code" recorded in the geometrical features of the city plan and related location conditions.

Model approaches to shaping the city guided the creators of the concept of ideal cities, city-gardens, cities of the industrial era, and modernist cities. Nowadays, model approaches are developed by researchers to analyse the functioning and crystallization of the spatial structure of cities (Batty M., Salingaros N., and Domański R., Zipser T.). A review of approaches to modeling is presented by Batty M. [2] and Mironowicz I. [3]. The author focuses on planning modeling, in particular based on establishing interdependencies between the development of the transport system and changes in land use [4] and the role of nodal places in the crystallization of the spatial structure of the city [5].

2.2. Practice

The methodological assumptions of modelling research should be preceded by a review of examples important for a planning workshop. The development plan for Copenhagen (S. E. Rasmussen, 1947) is based on the principle of buildings concentration in corridors served by collective rail transport and on the order to locate services and jobs within the pedestrians access to stops. The principle was consistently continued in subsequent plans, as evidenced by the implementation of the Ørestad district in the form of a multifunctional building strip (600x5000m), shaped along the direction of the transport link between Copenhagen and Malmo [6]. A similar rule applies to the Curitiba plan (Brazil), taking into account the decrease of the buildings intensity in the transverse directions to the transport corridor.

New Amsterdam centers are being developed in nodal sites on the main integrating directions of the city spatial structure, which include the development corridor between the city center and the airport (Zuidas center) and the road-rail downtown bypass (Sloterdijk center) [7].

The main message of the Milan General Plan (Metrogramma, 2005-2009) is the polycentric development of the metropolitan region based on the principle of concentrating development and activity in the best equipped with infrastructure areas that create strands concentrating and integrating the city's tissue. At the same time, the zones of valuable natural areas protection and of tissue deconcentration are introduced, creating a "green grid". In such a defined model of city spatial structure there are strategic projects included, such as: Centro Direzionale (new administrative and office center), revitalization of the Bicocca district (70 ha), the "CityLife" project (a prestigious business district) [8].

An interesting example of a node-corridor model in planning the city's development is Turin, in particular the "Spina Centrale" project. Along the modernized transport corridor (the railway line moved to the tunnel, above it a representative street) four areas of strategic revitalization projects have been designated, the aim of which is to crystallize the city spatial structure in its nodal fragments.

Among the Polish achievements interesting from the subject matter point of view, the “Functional Warsaw” project (J. O. Chmielewski, Sz. Syrkus, 1934) should be mentioned, in which the band-like character of settlement in the Warsaw region was noticed and developed, assuming that modernized transport corridors will be social-economic development axes [9]. An interesting inspiration is the method of "Warsaw optimization" supporting the city development planning (Broniewski S., Jastrzębski B., 1961-1963), the aim of which was to rationally locate workplaces and residences in the well-served bands of rail transport [10].

The review of the examples confirms the following premises and postulates adopted for research on the spatial structure model:

- clarity of the planning concept expressed, among others in geometrical relations between the transport network and shaping the urban tissue, as well as in the configuration of connections between the main city centers and strategic areas for the metropolitan area development,
- development of city and metropolitan centers in hubs of public transport,
- crystallization of development corridors through the creation of public spaces network,
- buildings and activities concentration and the pedestrian traffic network within reach of the public transport hubs,
- balancing the spatial structure: the concentration and intensification strips and the deconcentration “green” zones [see also 11].

3. Methodological assumptions of the model - on the example of Krakow

The assumptions and research results described in this article are the effects of the author's participation in the works on the spatial structure model of Krakow (SSK model) carried out at the request of the Krakow Spatial Planning Office, by a team led by Z. Zuziak, A. Szarata and M. Gyurkovich in 2016-2017. In the node-corridor model accepted for research, the concept of city's urban construction plays a special role, which means the skeleton of the urban tissue created by functional and spatial, natural and cultural elements of spatial development, among which the public spaces network has a significant importance [12].

3.1. Methodological assumptions and definitions.

The main components of the model are nodes and corridors. Corridors are linear systems defining the main directions of building concentration and its integration. This group includes the main routes of public transport, streets with high pedestrian traffic, urban streets distinguished by the composition, as well as important sequences of public greenery.

Nodes are defined as places or configurations of places focusing various activities and corresponding structures. For the research methodology of the presented model, the concentrations located at the main nodes of the mass transport and pedestrian network connections, ie the place where the locality connects to the network of the "flow space" are particularly important. Their privileged position is determined by the characteristics of these locations, which cause that the most active and specified functions concentrate there. Groups of nodes form clusters connected spatially and functionally, which at a higher level of development create urban centres.

Directions marked by important corridors, characterized by high density of nodes and connecting main node clusters (urban centres) are defined in the model as development corridors. Among them, strategic connectors were distinguished, i.e. the strips of areas along the directions of the highest structure-forming potential, which determines the ability of the model's elements to accumulate activity and integrate the structure. The concept of a strategic connector is significant for the concept of the model, and its definition includes:

- routes of high-capacity public transport,
- existing and predicted directions of the occurrence of building and activity concentration processes,
- axes and directions of integrating nodal places and their clusters,
- potential nodal sites at urban axes and corridors network [1].

The research on the SSK model was divided into three stages: identification, parameterization and synthesis, the final effect of which was to interpret the structure-forming potential of particular elements defining the spatial structure model of the city. The results of the research were compared with the findings of the Preconditions and Directions of Spatial Development Study for Krakow (2014) in order to visualize real changes in space against the background of planning arrangements.

3.2. Identification and typology

Two criteria were used to identify nodes and corridors: convenient accessibility by means of collective transport and a higher rates of building intensity and diversity of use. The obtained set of elements was divided according to the criterion of location in specific zones of the city (downtown, six city zones), and then assigned to a fixed typology. For nodes, these are:

- historical nodes - nodes of historic city centres,
- nodes of urbanity - distinguished by the activity of public space,
- mobility nodes - important interchange nodes,
- other nodal locations (e.g. concentrations of metropolitan functions).

The corridors of the SSK model were divided into: 1. urban corridors (in other words: building corridors) - downtown and city streets, compositional routes (e.g. avenues), 2. important transport corridors, 3. “green-blue" corridors - sequences of public greenery, including river beds.

3.3. Parameterization.

In order to determine the structure-forming potential, the following transport, planning and morphological attributes were estimated:

- accessibility by collective transport (number of connections),
- attractiveness and functional and spatial diversity (eg number and standard of usage programs),
- concentration (social and economic activities as well as total floor area),
- identity (cultural values).

The investment activity was also measured by examining the intensity of construction traffic in a given time interval. The range of the area covered by the study was determined accordingly:

- for the corridors of downtown and city streets: a 200 m wide band, i.e. 100 m from the axis,
- for commercial urban corridors and other significant transport routes: a 400m wide band, i.e. 200m from the axis,
- for nodal sites, the area defined by a circle with a radius of 500 m, denoting the range of pedestrian access.

3.4. Synthesis.

The next stage of the work on the model was to determine the key elements for the model construction, i.e. places and nodal areas and urban corridors with the highest potential sum. For this purpose, a synthesis of the obtained research results was carried out based on the algorithm of the total structure-forming potential of the node or city corridor according to the formula:

$$\mathbf{CPs = \Sigma\ Pw / k \times 0.5Pk / w} \quad (1)$$

where: CPs - total structure-forming potential of the node or corridor,
Pw / k - potential of individual nodes / corridors, 0.5Pk / w - correction factor (weight).

CPs of the urban corridor is determined by the sum of potentials of nodal sites located along the given corridor; this value is adjusted by the factor 0.5 of the potential value of a given corridor.

Interpretation was given to data resulting from the study of the traffic flows structure for the mass transport system comparing the relations in this structure with the distribution of nodal sites concentrations and structure-forming corridors (figure 1). The main links of the traffic structure were

identified and conclusions were drawn about new possible relations of significant development potential that is would connect important communication areas.

The results of the conducted analyzes are illustrated with graphical schemes of the spatial structure model of the city (see figure 2) which presents configuration of development corridors and nodal sites clusters. The studies of the structure-forming potential of identified development corridors in the context of the city's relationship with the metropolitan area as well as the distribution and hierarchy of connections in the mass transport network have allowed to distinguish three strategic links:

- on the N-S axis passing through the present downtown,
- E-W axis tangent to the city center from the north,
- on the transversal axis SW-NE, which is justified by: clear and strong connections in the mass transport traffic flows, the intensity of nodes and investment areas, the integration of metropolitan function areas.

The model also distinguishes the Vistula river corridor as the most important strategic link, cumulating cultural and natural values as well as compositional potential. Figure 3 presents synthetically the configuration of corridors and clusters of nodal sites in the city center. Investment areas which co-create the main development corridors have been distinguished.

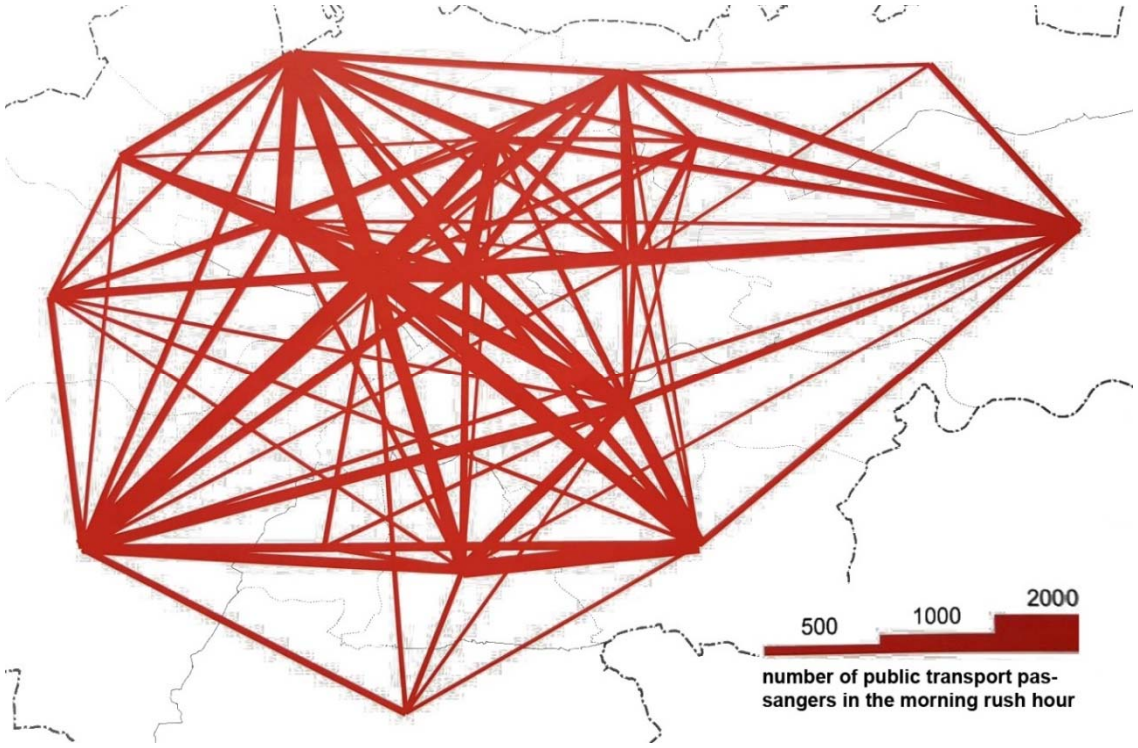

Figure 1. Model of spatial structure of Krakow – vision for year 2030-50. Diagram of spatial distribution of traffic flows in the public transportation system. Source: "Krakow Traffic Model" [13]

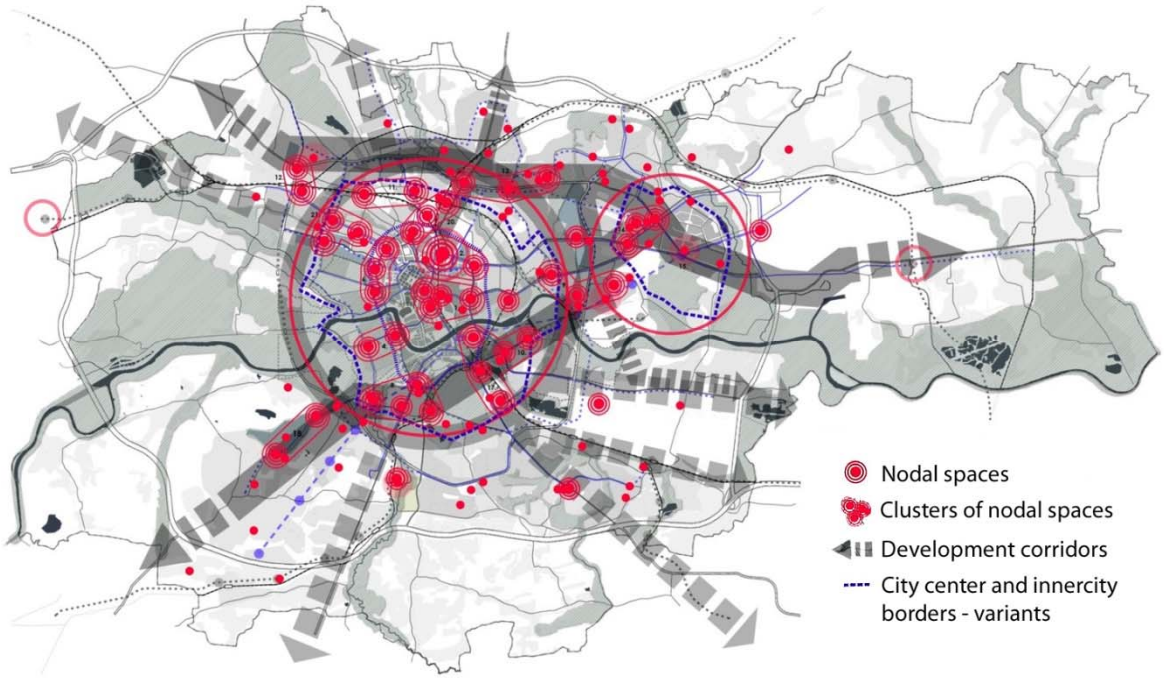

Figure 2. Model of spatial structure of Krakow – vision for year 2030-50. Clusters of nodal spaces and strategic corridors. Source: "Model of spatial structure of Krakow. Planning perspective" [12]

3.5. Strategic link - a metropolitan development corridor. Introduction to the case study.

The presented idea of the model highlights the priority strategic link on the SW-NE direction between the districts of Sidzina – Czyżyny (see figure 4). This connector is shaped by two urban corridors created by the downtown and city streets. This band is interwoven with the Vistula river corridor (strategic link - river park). This axis of intensification and integration is reinforced by the planned first metro line. In the model diagram, investment areas have been distinguished. Due to the strategic location in the model geometry and existing and developing functions, this area is expected as a new metropolitan center. The existing program of culture-forming services (sports and entertainment hall, higher education, exhibition and conference center, media center) would be developed and supplemented with office workplaces, including public administration and housing areas. An important component of the new metropolitan center would be the public greenery, including the river park on the bend of the Vistula. Transport accessibility of the center would be strengthened by the planned metro stops, stops on the existing railway line and possibly planned tram line.

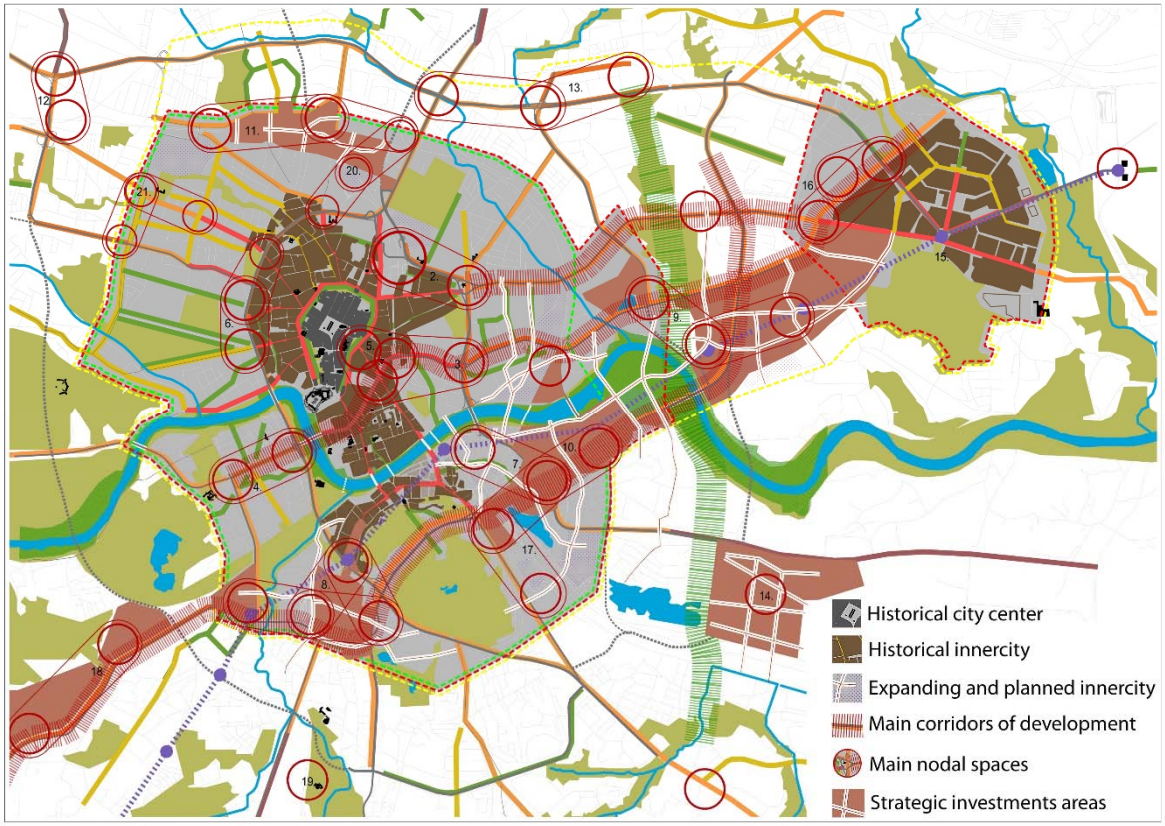

Figure 3. Model of spatial structure of Krakow – vision for year 2030-50. Structure-forming potentials of inner-city. Source: "Model of spatial structure of Krakow. Planning perspective" [12]

4. Conclusions. Premises for the development of the research methodology.

The next step in the work on the spatial structure model will concern the detailing of the research method of structure-forming potential of development corridors. It is assumed that the model will be a helpful tool for preparing planning documents on the general city scale as well as local spatial development plans. Therefore, the basis for determining the analysis criteria are the premises derived from the analysis of, among others, the formulas of spatial policies used in these documents. It seems particularly important to refine the analysis problems including two groups of functional and spatial relations: along the corridor axis and perpendicular to the axis. One should look for them among the following types of relationships [1]:

- functional - transport connections,
- natural / ecological - protection of natural values,
- cultural - elements of spatial development with cultural values and corresponding relations, essential for urban composition,
- economic - identification of economic activities focuses and networks of their connections,
- social - objects and relations that crystallize the social space.

As already mentioned, two groups of relationships were distinguished:

1. axial connections that create bundles of parallel connections to the corridor, which include:

- connections in the mass transport network - functional link between transport nodes, interaction of traffic generators integrated by the corridor (internal and external relations),
- functional and spatial relations of nodal sites located along the corridor, interactions with synergy features (internal relations),

- external relations resulting from the role of the corridor in the context of development elements configuration that integrate the spatial structure of the metropolitan area.

2. transverse connections to the corridor, resulting from:

- relations between corridor nodes and the surroundings: eg corridors of "railway station streets", i.e. walking routes integrating urban tissue with public transport nodes,
- relations with other corridors:
  - development corridors of lower rank,
  - greenery complexes, green-blue corridors,
  - corridors of historical streets and architectural-urban compositions, existing public spaces networks,
- relations with important elements of the city structure, such as functional-compositional connections with important activity centers located beyond development corridors.

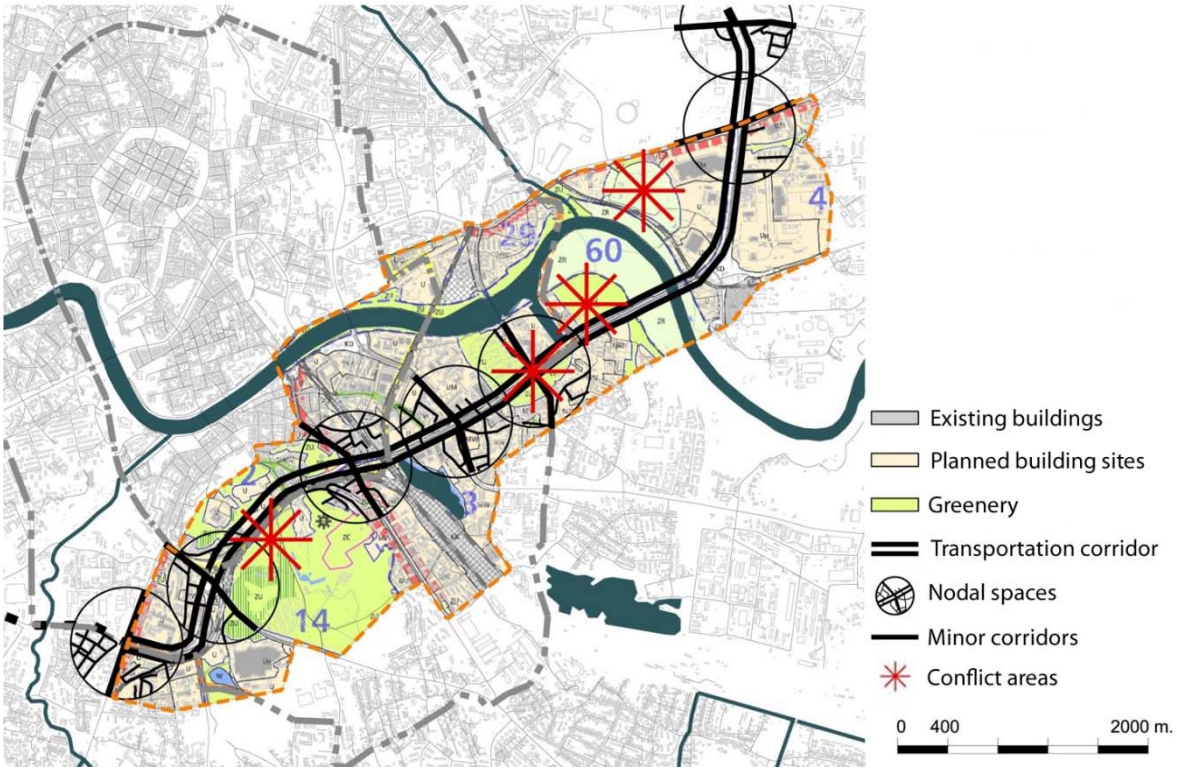

Figure 4. Model of spatial structure of Krakow – vision for year 2030-50. Planning preconditions and directions of development for chosen corridor – interpretation, synthesis. source: "Model of spatial structure of Krakow. Planning perspective" [12]

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