

UDC 711

A.G. Bolshakov, S.S. Belomestnykh*Irkutsk National Research Technical University**e-mail: andreybolsh@yandex.ru***MORPHOGENESIS OF THE STREET NETWORK
AND QUARTERS OF THE CITY OF IRKUTSK**

Abstract: *The article consists of two parts. The first part gives a brief overview of the existing historical architecture and Irkutsk downtown state of development. The second part carries out the blocks of built-up area morphology analysis, and topological analysis of the streets network changes during 290 years of its evolution. The aim is to identify patterns that can be used as the basis for land use and the building activity rules to the Irkutsk downtown.*

Keywords: *urban morphology of Irkutsk, street network, types of intersections, street network evolution, block morphotype, morphological zoning, planned morphological zoning.*

Part One

Irkutsk was founded in 1661 on the banks of the Angara River at the point of its confluence with tributaries, the Irkut and Ushakovka rivers by the pathfinder, sovereign serving man Jacob Pokhabov from Yeniseik town. The city is located on both banks of a mighty river. Historically and morphologically, the city is interesting with a complex and at the same time harmonious architectural and planning structure. [7] The city was included in the list of historical cities. In 2010 this list contained 41 cities. Moscow and Krasnoyarsk are not included in this list, Petersburg and Irkutsk are included. Obviously, this list is not complete. It is clear that belonging to the list means a special urgency of the problem of preserving heritage and modernizing the urban environment.

Figure 1 shows that the center of Irkutsk has a complex skew street network that serves as the basis of its identity. The Angara River in this place makes turn from the meridional direction to the latitudinal one. Then the river goes north again. In this bend of the river the center of Irkutsk city is located. The main part of the coastal area is framed as an embankment boulevard characterized by mostly pedestrian movement and good landscaping [1].

Figure 2 shows some important locations of Irkutsk downtown and its modern development. The arrow to the north is directed from the middle of the picture to the river bank, the meridian passes through the semicircular element of the embankment. So you see the main pedestrian axe going as a diagonal in this picture. We know that these locations had another functions initially. In the center of the picture is the green square, where the GOSTINIY DVOR (Trade yard or the medieval shopping mall) was built in 1778 by Giacomo Quarenghi and in 1879 it was burn by the fire. Now it is the KIROV square. The Kirov Square was designed by the regional architect V. Shmatkov.

On the east side of the square are the buildings of the classical and pedagogical university and the soviet “Angara” hotel between them. On the west side is the linguistic university, the buildings of central bank and the Irkutsk City Council.

The big dome upper right in the picture is the circus building (to the east of the Kirov Square). On the embankment, where the Epiphany Temple stands, the city historical trading axis was begun. The circus building is adjacent to this axis. On the Cirkus lot at former time was the petty bazaar - the clothing market.



Figure1. Irkutsk downtown skew street network

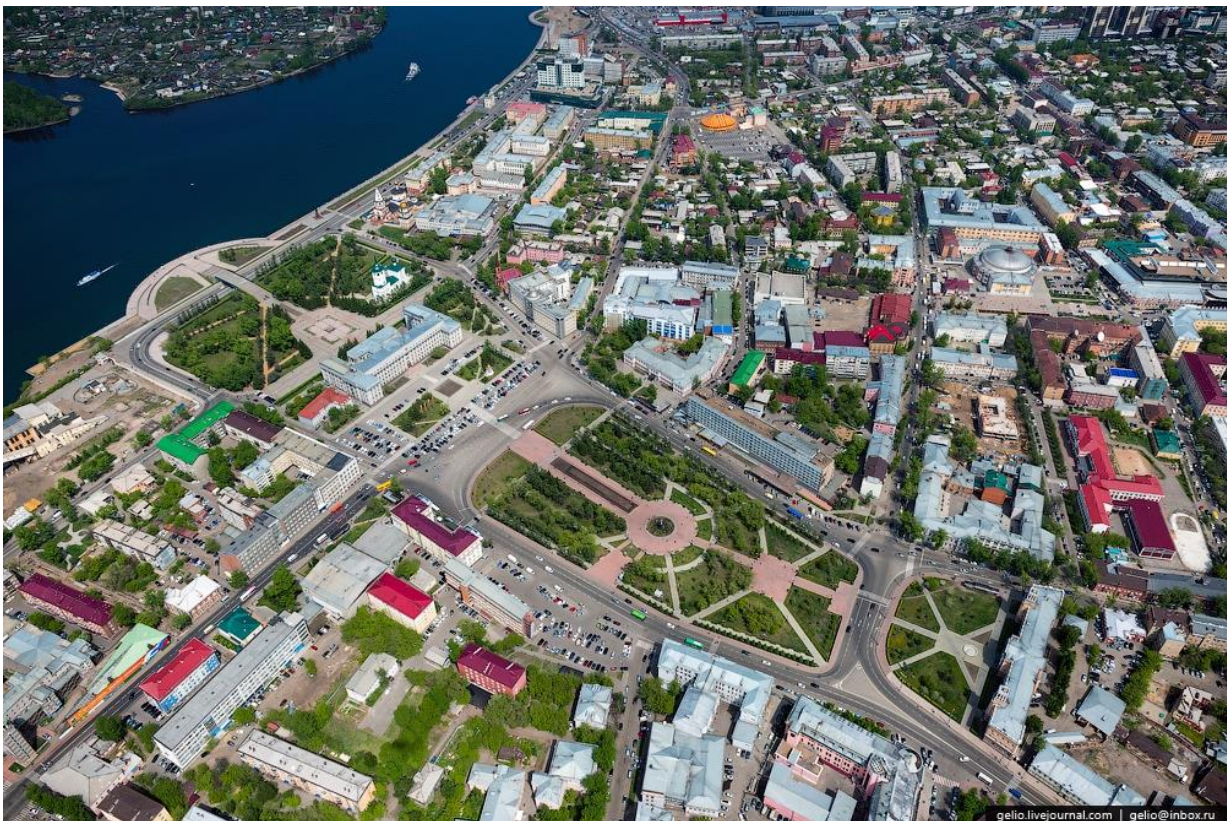


Figure 2. The old places have new functions

The green spot to the north of the square is the main historical core of the city. It is the place of OSTROG, the Russian version of the western burg. This place is on the Angara river embankment. It was surrounded by a wooden wall, guard towers stood at the corners and in the middle of the walls. Inside the fenced area there was a church, an arsenal and administrative buildings. Figure 3. Now, on the place of the OSTROG, there is a stone Savior Church has preserved. It was built in 1710. On the riverside in OSTROG place now is the Sukachevsky garden. Instead of the largest in Siberia Orthodox church, the building of the regional administration in 1938-1959 was built. Also the “Eternal Flame” is dedicated to the victory of Russia over Nazi Germany in 1941-1945 memorial is in the center of the former OSTROG plot. On figure 7, the place of the former OSTROG is considered in more detail. The mentioned Savior Church is visible here. In the center of the picture is the regional administration building by the architect K. Guryev. The administration building was built in 1938-1959. It was built on the site of the famous Kazan Cathedral. The cathedral was blown up in 1932.

On the 350-th anniversary of the city, a lower embankment with a sheet piling of shore protection was built. On the embankment is the arch of the Moscow gate, 1811. The construction of the Moscow gates was dedicated to the Tsar Alexander I rule 10th anniversary. Figure 6.



Figure 3. The OSTROG reconstruction. Author Boris Yarovoy. Museum of Irkutsk City history

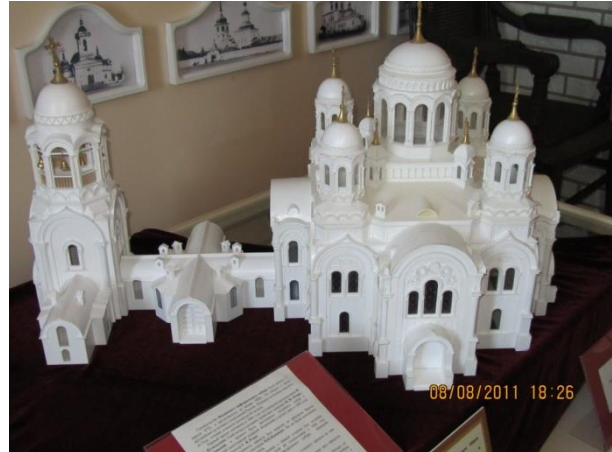


Figure 4. The Kazan Cathedral Temple. The model. Author of the model Yakovlev A.V.



Figure 5. The project of Kazan Cathedral Temple restoration. Virtual model

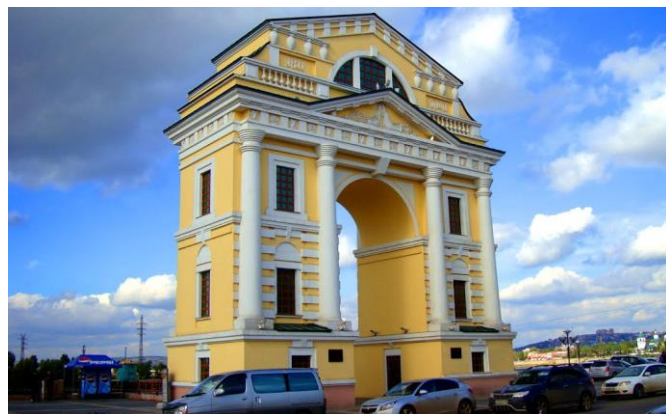


Figure 6. Moscow Gate

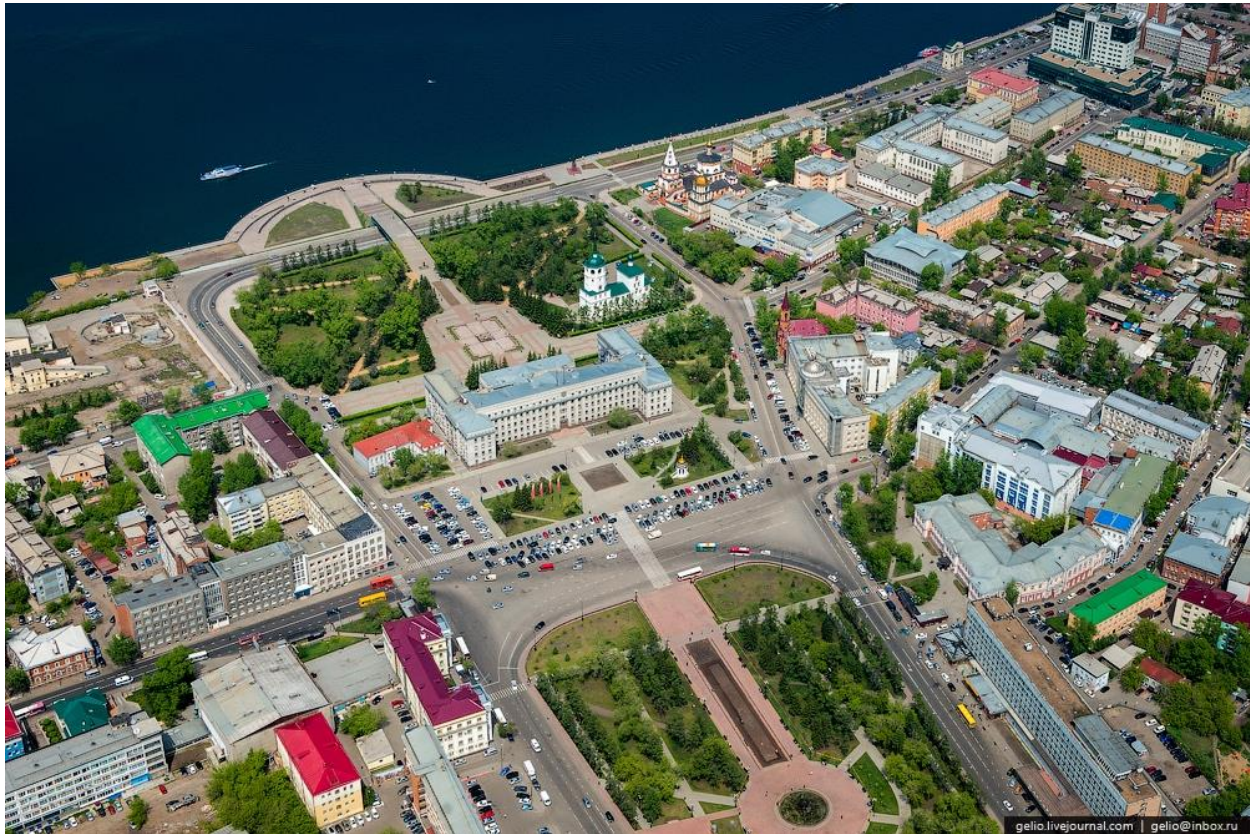


Figure 7. The Ostrog plot today

In 1849 millionaire gold miner Evfimy Andreevich Kuznetsov made a donation in the amount of 250 thousand rubles for the construction of the Kazan Cathedral on the site next to the OSTROG. The construction began according to the project of the Irkutsk architect Vladislav Andreevich Kudelsky. April 17, 1875, the new cathedral the temple was consecrated by Bishop Benjamin. By June 1879, the walls of the cathedral were erected to the height of the second level of windows. At 1879 terrible fire destroyed half of the city. This fire stopped construction for next 6 years. Construction resumed in 1885. Engineer-architect Baron Georgiy Vasilievich Rosen was invited to lead the work. The project of G.V. Rosen was made in the Russian-Byzantine style. Figure 4. The Virgin-Kazan Cathedral was a five-domed cross temple in the Russian-Byzantine style. The centricity of the composition is softened by a long gallery that connects the temple and the bell tower. By 1894, the construction of the temple was completed. Irkutsk Cathedral was one of the largest in Russia. It accommodated 5,000 believers, and its height reached 61 meters. In the ranking of beauty and size, he was the fourth in Russia. In 1930, by order of the Irkutsk administration, despite protests from the Irkutsk diocese, the church was closed. Disassembling the temple into building material attempt was not successful. Then it was decided to blow it up.

The first explosion of the cathedral was carried out in August 1932. A total of four explosions were made. There was so much rubble that it was enough to fill the access road to the bridge over the Angara River, which was being built at that time. The debris of the cathedral was taken away on trolleys along temporary rails laid across the square. When the local square was covered by the cathedral's rubble, its level rose by 1 meter. Figure 5 shows the Virgin-Kazan Cathedral restoration project, the idea of which originated in 2009.

Streets play a leading role in the city space structure. In Irkutsk, the streets form a complex oblique network. The arterial streets and local residential streets are in the network. The main streets connect the city with the outside world. From the fortress to the southeast is Amurskaya

street, named in honor of Count Muravyev-Amursky. See Figure 8. Muravyov was Governor of Eastern Siberia.

He prepared the Aigun Treaty of 1858 with China on the inclusion of Amur and Ussuri territories into the Russian state. According to the agreement, the border between China and Russia was laid along the Amur River. Trade was established. For this, he received a count title and an honorary prefix Amursky to his surname. Now the street is named after Lenin. On the street there are historical buildings: a Public Meeting (now a Theater of the Young Spectator), the University of Economics and Law, the building of the Russian-Asian Bank (in “modern style”, the architect Vadim Kolyanovsky) and several others. In Soviet times, the street morphology has changed. The architecture has become larger and simpler.

The city has preserved areas of historical buildings, the end of the 18th and 19th centuries. One of the authentic areas is the Jerusalem layout element. It is located on the brow of Jerusalem Hill. Until the 19th century, the mountain was called Petrushina. Figure 9. The center of the district is the Holy Cross Church. It was built in the period 1747-1760. The style of the church is Siberian baroque, with a rich plastic decoration of the facades. The building fabric is formed by single-storied wooden single-family houses located on the slope of the Jerusalem Hill. In the background is the Jerusalem cemetery, which currently has the status of a memorial area. In the upper right-hand corner of the photo the Musical Theater building is facing the Sedov Street (a continuation of Amurskaya Street).

Figure 10 shows the Uritsky pedestrian shopping street (Pesterevskaya). Here are two-story historic stone buildings. They are made in the modern style and eclectic style. After the fire of 1879 the street was built up with stone buildings. The rich merchants Vtorov, Youcis, Meretskoy were well known in Irkutsk in the late 19th and early 20th centuries. Their stores form the basis of street building. The first cinema, the auto show, the first printing house appeared here among the innovative objects of its typology. The street has a wonderful atmosphere. The architecture authentically reflects the Irkutsk merchants' activities. [3]

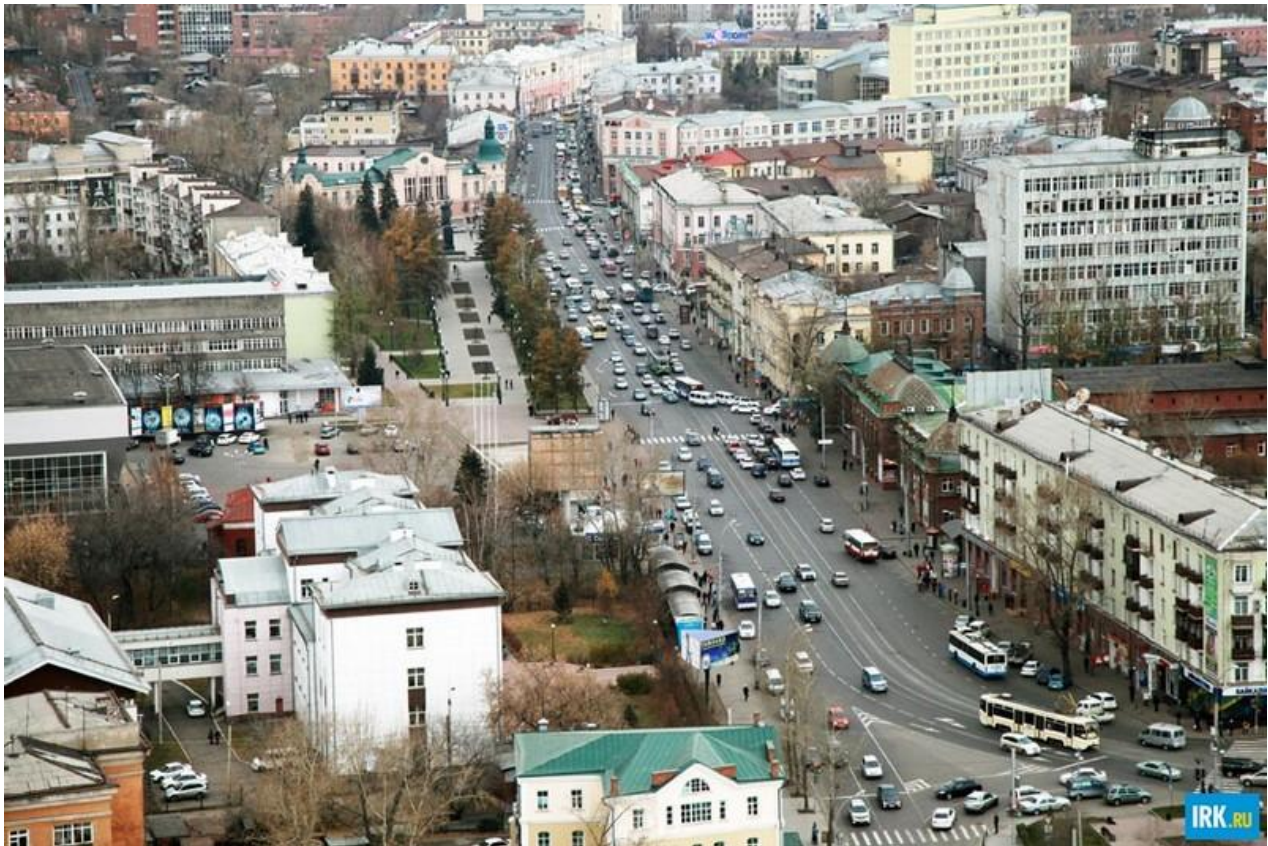


Figure 8. Lenin street (former Amurskaya)

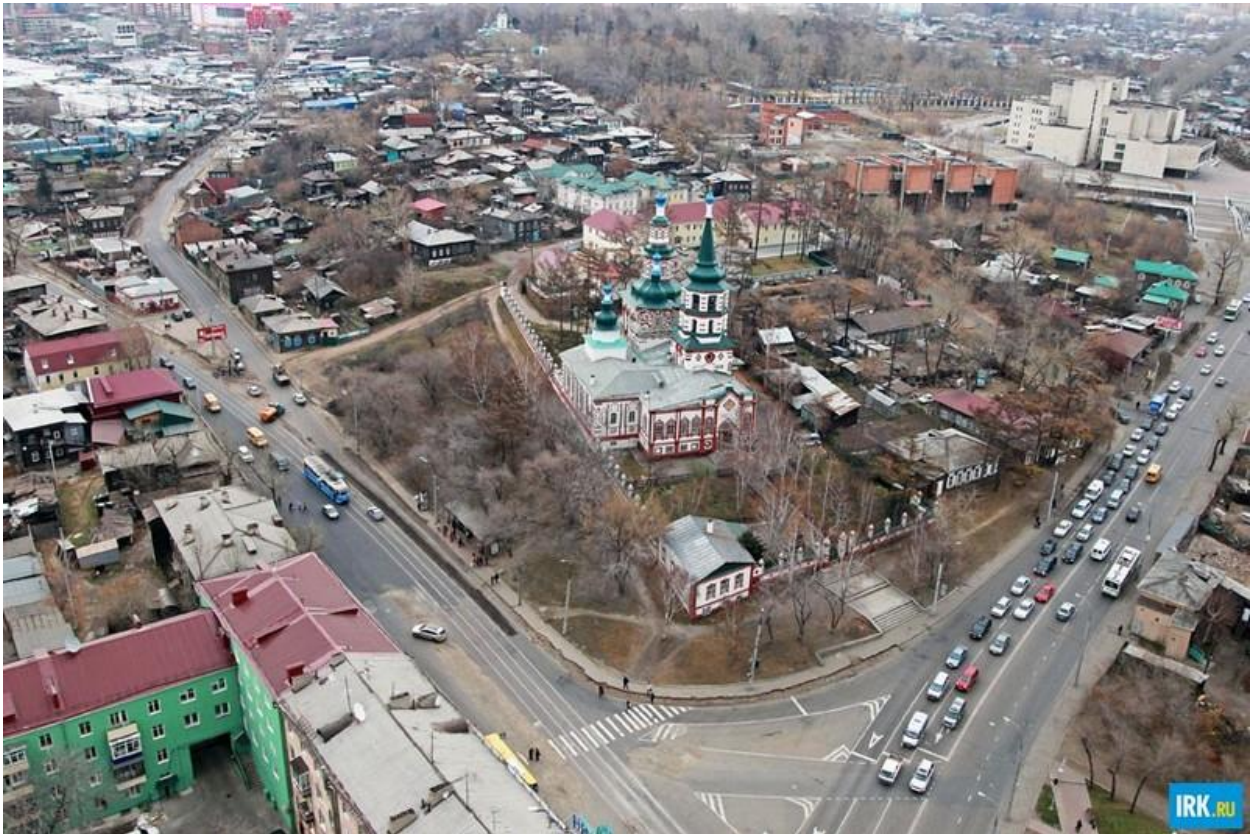


Figure 9. Holy Cross Church and Jerusalem layout element

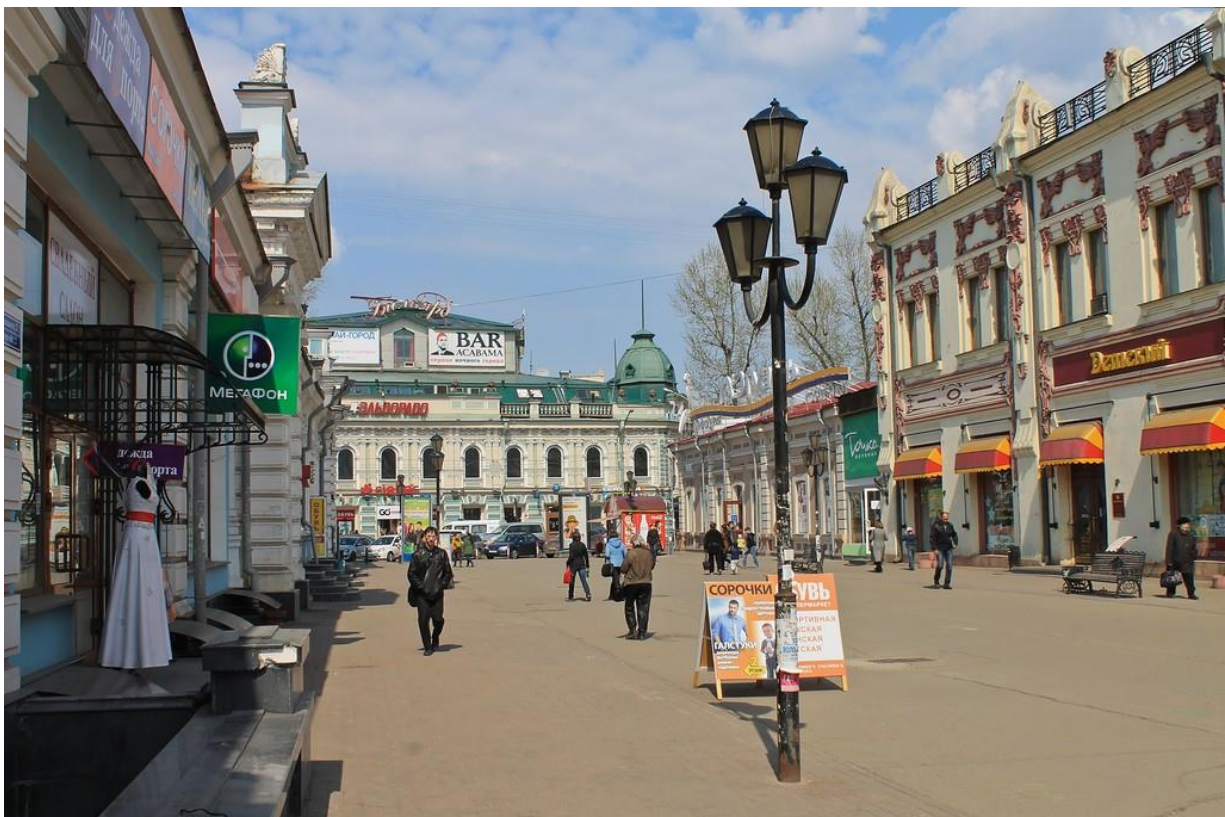


Figure 10. Uritskiy pedestrian street. The main function is retail. Architecture of modern style and eclectic style are maintained



Figure 11. 130-th block. The public space instead the residential area.
The old wooden Irkutsk houses remake

In 2010-2011 on the border of the historical center of the city, residential block at number 130 was reconstructed. Before the reconstruction, it was a dilapidated, uncomfortable built-up area with one-story wooden houses. Among this built-up area were 74 monuments of wooden architecture. By 2010, the city Mayor V. Yakubovsky intended to demolish the quarter and build high-rise buildings here. The creative public union of Irkutsk architects and the guild of urban planners of Russia were two public organizations that stood up for the historical merits of wooden Irkutsk architecture and this project was completed. Grigorieva E.I. is an author of the planning project. For each individual house, a single author was involved in a project for the reconstruction and restoration of the house. See figure 11. The quarter is basically newly built wooden houses, in the image resembling old monuments, like a remake. But significant changes were made to their architecture. A high stone basement appeared which was not in the original. The planning structure of the quarter was changed: a promenade appeared along the longitudinal axis of a long narrow quarter. In the original, this was a typical two-row manor quarter with perimeter building along the outer streets. The parcels were blocked with each other along the longitudinal internal border. And inside there were gardens and courtyards. The residential quarter turned into public space instead of longitudinal interi - pedestrian promenade. Instead of two rows - three and four rows were created. The historic quarter has failed to be established as a result of the so-called "restoration". But it turned out an excellent public space, a successful commercial project, the most visited and popular place in the center of Irkutsk city. Cafes, shops, museums and even an observatory attract hundreds of thousands of people here. Wooden houses are decorated with traditional carvings, platbands. The promenade is well paved and landscaped.

Part Two

The second part is about an analysis of the territory, architectural and planning structure changes that occurred in the period from the second half of the 17th century to the end of the 20th century. [3].

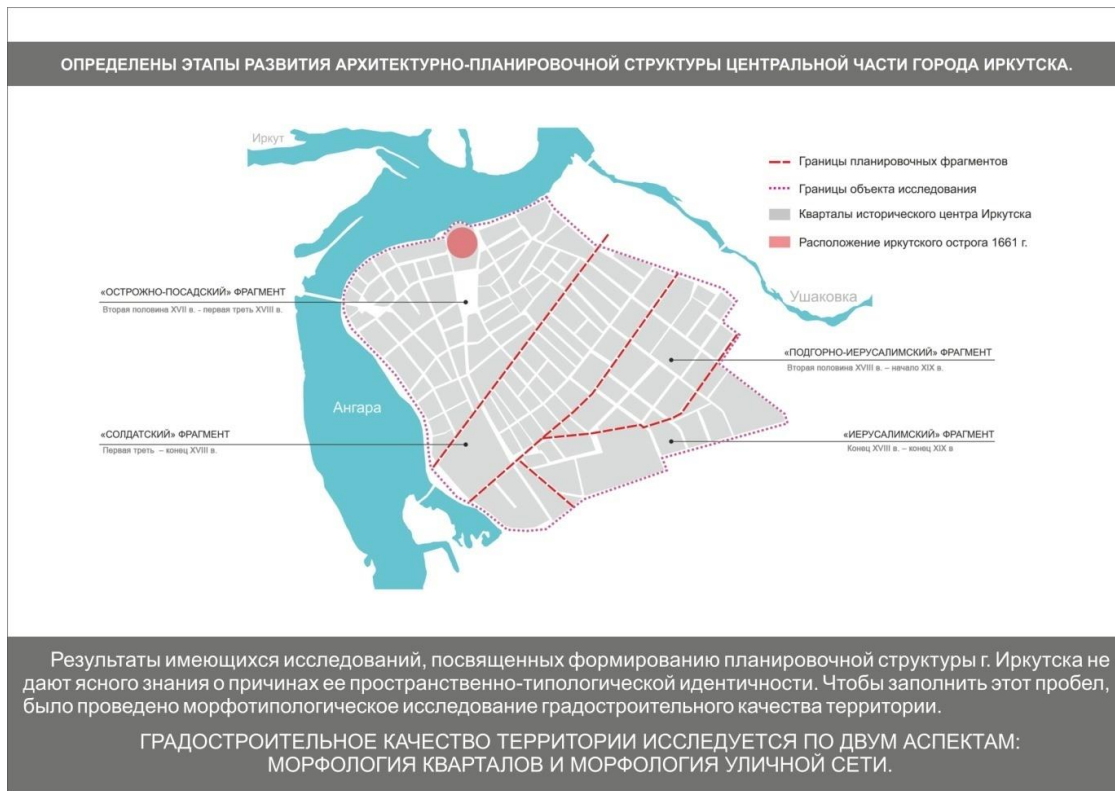


Figure 12. Layout fragments and the city development stages

Methodological traditions of the analysis of urban morphology go back, in particular, to the work of Konzen M.R.G. [4] See also [10].

See figure 12. The city foundation first step was the construction of the OSTROG in 1661. On the map it is shown with a red dot. Around the OSTROG the POSAD was formed (the settlement close to the fortress walls). By 1729 POSAD was surrounded by the second fortress wall. This fortress wall is the red dashed line located southeast of the fort. After the construction of the second fortress wall around the POSAD and the unification of the OSTROG and the POSAD, an Ostrog-posad fragment of the city was formed.

This was the essence of the first stage of morphogenesis (the second half of the 17th century - the first third of the 18th century). In this fragment the street network is irregular. All blocks have unique individual geometry. The streets were mainly oriented towards the coastline, which is like a parabola. The second stage of morphogenesis result is the formation at the end of the 18th century of the Soldier Sloboda (1729-1800). Here, the long narrow quarters in the form of elongated parallelograms are adjacent to the fortress wall. Archers, Cossacks, other service people settled here.

Arsenalnaya Street and Preobrazhenskaya Street cut along strip of Soldatskaya Sloboda, which is 400 to 600 meters wide and more than 2 km long. Cross lanes cut Sloboda into 17 narrow blocks. At the end of the Arsenalnaya Street there was an arsenal. At the end of Preobrazhenskaya Street, the Savior Transfiguration Church was built by 1811, architect Anton Losev. The third planning area is formed as an orthogonal lattice at the end of the 18th century under the influence of the ideas of the West European “regularity”. And it gets the name of Podgorno-Jerusalemkiy (figure 12). At the fourth stage (the end of the 18th - the end of the 19th centuries) the city approached a natural barrier - the ledge of the Jerusalem Mountain and crossed the barrier. A Jerusalem layout district was formed on the edge of the hill.

At all stages the city growth is directed to the south-east. The First Jerusalem Street served as the border in the southeast. This is the boundary of the study object as the historical part of the

Irkutsk city. The Jerusalem fragment has an orthogonal principle in the basis of geometry; however, according to the landscape geometry, the area layout follows of the hill edge.

We analyzed the intersections of the street network by type. Types include crossroads with different geometry of streets intersections and junctions with through passages and dead ends. In the course of evolution over 290 years, *the node type share changed in a certain pattern*. Figure 13 shows the results of the intersection types share analysis in the city fragments. Through intersections have the shape of either an orthogonal cross or the letters X. The dead ends have the shape of either the letters T or the letters Y. The T-shaped intersection dominates in the network. The analysis shows *the first pattern*: each stage in both temporal and territorial aspects, through rectangular nodes proportion rises while the dead-end proportion is relatively reduced. This has led to the connectivity and centrality degrees are increase in the network. [3]. The concept of centrality is one of the basic ones in the theory of spatial syntax [5].

Figure 14 shows of the city's networks development, namely that the second pattern is a high share of Y – shaped and X – shaped nodes remain. This pattern indicates such a network property as oblique. This property contributes to the street network adaptation to the diamond shape of the territory within which the city layout structure morphogenesis took place.

Figure 15 shows the third pattern. In connection with the enlargement of quarters in the 19-20th century, the total length of streets decreases, and when considering the territory both from fragment to fragment and in time, the streets network density decreases. However, this applies mainly to local short streets. The main streets are growing in number and length.

Figure 16 shows the formation pattern of the blocks layout structures. The ratio of solids and voids is the main indicator that was considered in this case. The solids and voids relations are the main characteristic that allows us to distinguish one type of block from another by our method. These characteristics form the basis of the block morphotype. The following actions were performed to identify morphotypes. In all blocks of each layout district the graphical contours of void cells were detected. These voids were painted blue. The buildings remained white. Also the street corridors were remained white. As a result, for the entire built-up area the solids and voids ratios were identified. In the city as a whole, it was revealed that the solids and voids ratios distribution obeys two patterns that were valid at two stages of the city evolution.

Before the fire in 1979, a certain solids and voids ratio is observed on the map. In the nature of this ratio changes there is a gradient. This gradient is visible on the 1843 map. In the POSAD by this time a very dense wooden building was formed. The open space cells are small and have a complex, non-convex configuration. In the direction of the hill, towards the PODGORNO-JERUSALIMSKIY layout district, there is a noticeable and continuous increase in the share and convexity of void cells in quarters. We call this pattern the linear gradient of the voids distribution. The development of the city after the fire is characterized by another pattern. [3] The highest density of buildings moves to the central market, as well as to the main streets that cross the market area. The main streets are meridian: Karl Marx, Dzerzhinsky, Timiryazev, and latitudinal: Baikalskaya str., Partizanskaya str., Proletarskaya street. Roughly, the main streets form a cross, with an intersection in the central market area. And along the main axes and in the area of their intersection, by the end of the 20th century, maximum building densities were formed. On the periphery of the city (now it is the historical part of the city), there was some decompression of the building. This is due to two reasons. The first reason is that the development along the banks of the Angara River has become less dense, with large distances between the houses, according to the building rules then in force. The second reason is that large open spaces have formed on the ledge of Jerusalemkiy Hill. These include: the estate of the mayor (1885-1898) Sukachev V.P., the city cemetery at the Holy Cross Church. In addition, on the slope there is a manor building. These are single-storied single-family houses with gardens. The relief did not allow the use of heavier and dense buildings. The gardens of the estate building together form a green array. The result was a ring of voids along the periphery of the city and the density of solids in the center and along the diameter of the circle (along the meridian and latitudinal). [6] Regarding evaluating the configuration of quarters, see, for example, [9].

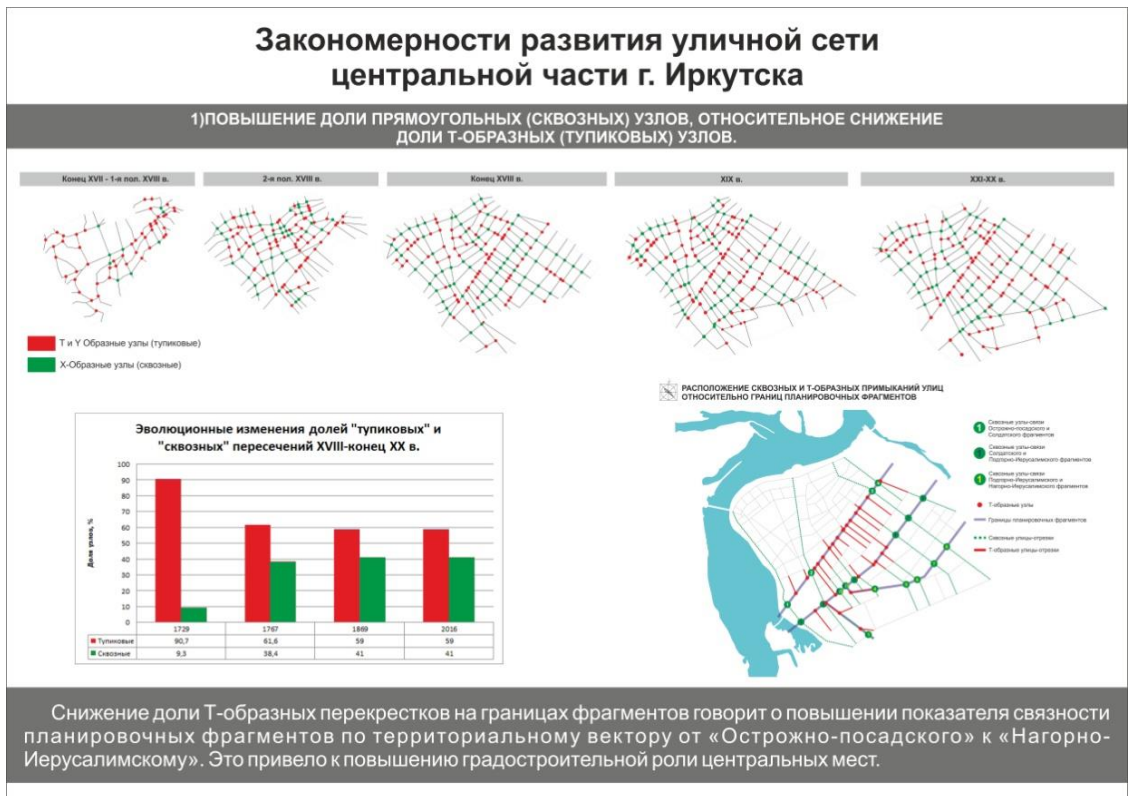


Figure 13. Analysis of Irkutsk's downtown street networks according to the criteria of intersections with through passages and dead-end ways. *The first pattern:* each stage in both temporal and territorial aspects, through rectangular nodes proportion rises while the dead-end proportion is relatively reduced

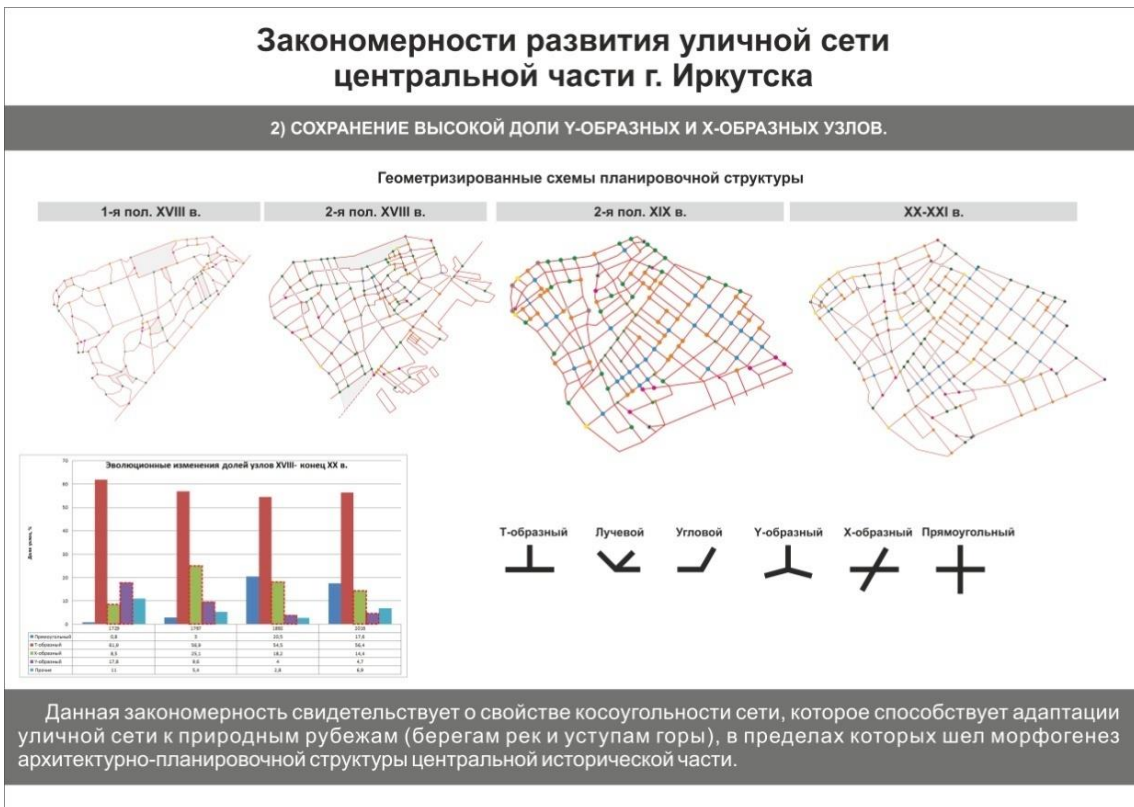


Figure 14. The second pattern of the city's networks development: the Y-shaped and X-shaped nodes high share preserved



Figure 15. Comparison of the city layout district and the stages of its formation in terms of the street network density

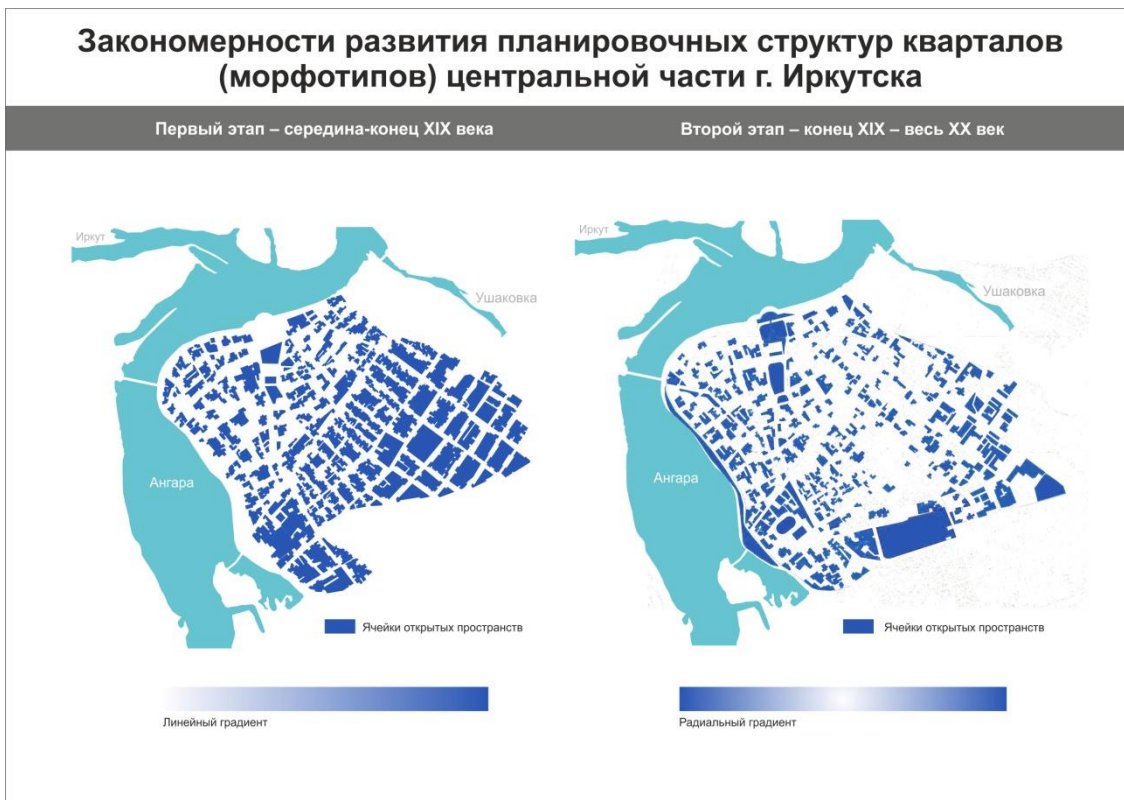


Figure 16. The patterns of building density before fire 1879 and after it. The white is solids, the blue is voids. The left map show the linear gradient. The right map shows the radial gradient



Figure 17. The classification the blocks morphotypes. The morphotypes distribution on the map

To define and classify the morphotypes of blocks, the following indicators were used. First, in block the solids (buildings) and voids (open spaces) ratio was taken into account. Secondly, in block the open cells number and size was considered. And thirdly, open spaces interconnectedness was taken into account. [2].



Figure 18. Irkutsk blocks morphotypes

The blocks morphotyping was carried out on the basis of generalization of the mass-void relations in real blocks. See Figure 18. In Irkutsk city, such types of blocks as dense, perimeter and sparse are highlighted. The dense block morphotypes include cell-free, a block-building, single-cell landscaped, porous, medium-cellular, large-cell. The perimeter block morphotypes include single-cell, multicellular, large-cellular non-closed, closed with external green cell, mixed cellular. Sparse block morphotypes include medium-cellular, porous, large-celled, a square, a park[3].

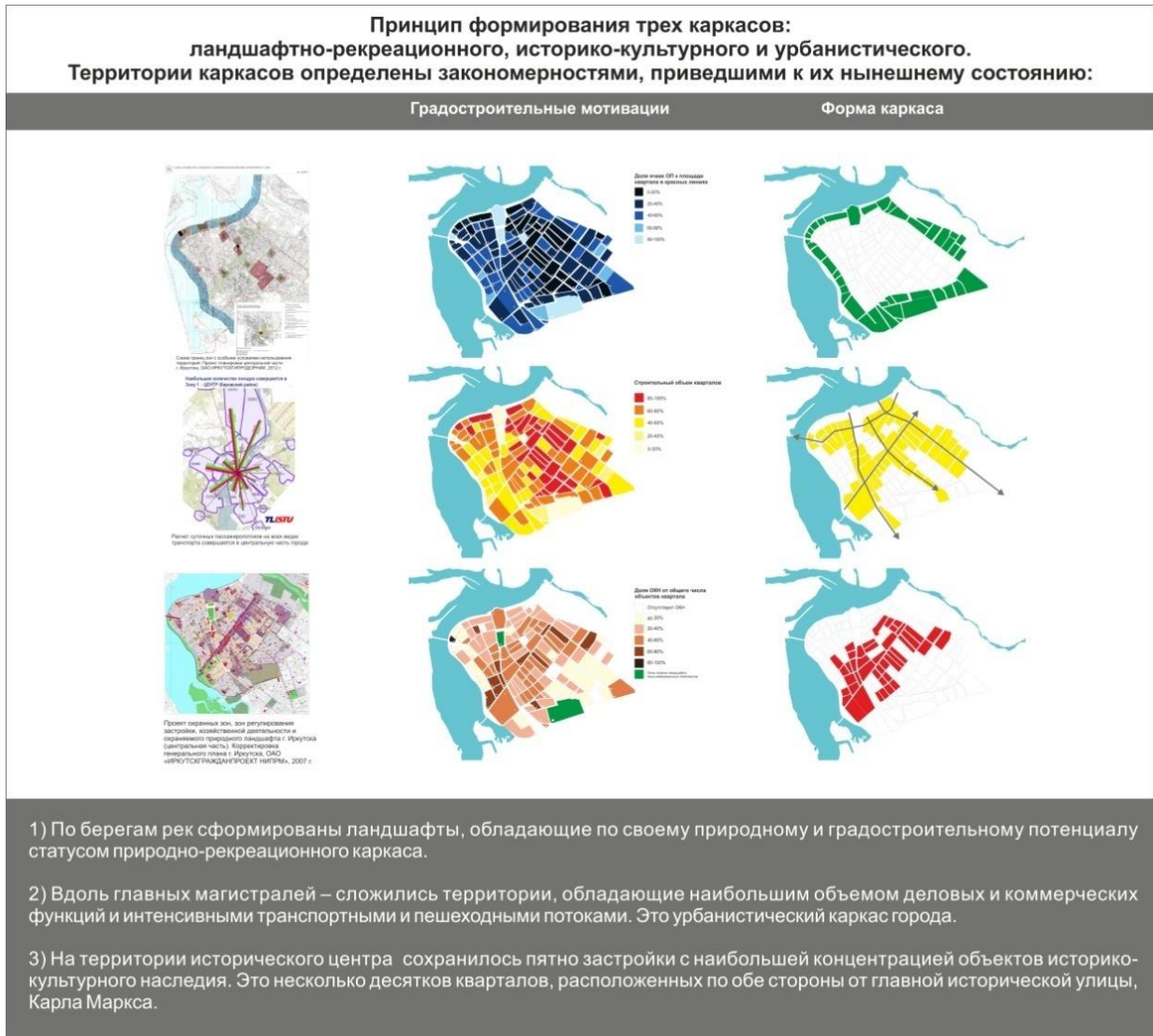


Figure 19. Three frameworks of the territory: a) natural recreational framework, b) urban frame of the city, c) historical and cultural framework of the city

On basis of the density, historical and cultural blocks characteristics analysis, the morphotypological zoning are drawn up. Zoning of the city was carried out in three aspects: the predominance of valuable landscapes, the prevalence of architectural monuments in the blocks and the highest density of buildings and traffic. As a result, three frameworks of the territory were identified (Fig. 19). 1) In terms of their natural and urban environment potential the river banks landscapes have the status of a natural recreational framework. 2) The largest volume of business and commercial functions and intensive traffic and pedestrian flows territories formed along the main highways. This is the urban frame of the city. 3) In the historical center the greatest concentration of historical and cultural heritage objects building spot has been preserved. These

are several dozen of blocks, located on both sides of the main historical Karl Marx street (Bolshaya Perspektnaya). These blocks form the historical and cultural framework of the city.

Urban policy in the city morphology regulation principle is formulated. This principle means that the morphology of the block has to be corresponded with its location relative to the main urban and natural axes and historical and cultural monuments areas. Fig.20. Relevant regulations on land use and development rules should be as follows. Located on respective frameworks territory the blocks should acquire morphotypes, which have to be, firstly, closest to the historical prototype, and secondly, corresponding to the urban-planning motivation of their development. Urban development three generalized motivations (attractors) were identified, its own for each framework (landscape-recreational, historical-cultural, and urbanistic), where the corresponding dominant values blocks are located. The models of blocks morphotypes are proposed in accordance with the emerging frameworks of the territory. Dense morphotypes are for the urban framework. Perimeter closed and semi-closed morphotypes are for the historical and cultural framework. Sparse large-mesh morphotypes are for natural recreational framework.

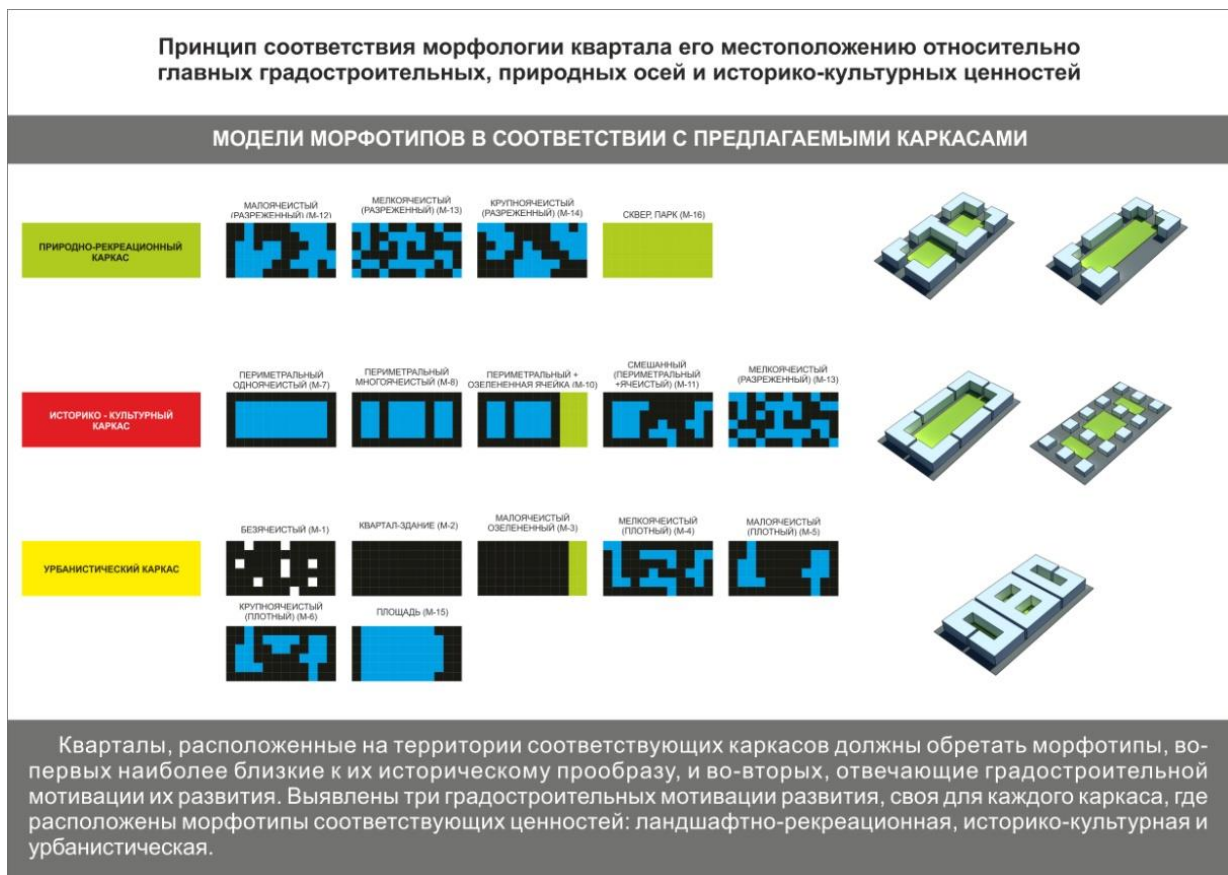


Figure 20. The blocks models proposed for corresponding frameworks

As a result, for the central historical part of the Irkutsk city the prospective morphological zoning model was developed on the basis of the revealed patterns of the morphological structure of the city and three frameworks principle. See Fig.21. Within the proposed morphological zones, blocks of both “pure” and “mixed” morphology should be formed. In case the imposition of urban and historical-cultural, natural-recreational and historical-cultural frameworks and with the imposition of all three frameworks in one problematic area the mixed morphological policy is inevitable. In the case of complex overlaps, building and land use regulations should ensure the historical, cultural and ecological values priority in relation to commercial values.



Figure 21. Irkutsk's downtown prospective morphological zoning model

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