

*edited by*  
SANDRO PARRINELLO  
FRANCESCA PICCHIO

**Historical  
architecture  
and  
settlements  
along Kama  
river in the  
Perm region**



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## Introductions



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# THE RUSSIAN EXPERIENCE IN THE PRESERVATION OF THE HISTORICAL ARCHITECTURE OF PERM REGION AND THE PROMOTION OF UPPER KAMA CULTURAL HERITAGE ROUTE THROUGH A DIGITAL DOCUMENTATION PROJECT

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The research activities in Central Russia, more specifically in the Ural area, started in 2012 through academic collaboration activities between the Department of Civil Engineering and Architecture of the University of Pavia and the Department of Urban Planning of the Polytechnic University of Perm. These activities, which involved researchers and students, were focused on summer schools and research seminars with the aim of developing a research laboratory at the Russian University that would deal with the preservation of historical and architectural heritage. Specifically, since 2015, systematized investigation of the Upper Kama historical-architectural heritage has been carried out by the International architectural schools, starting a process of getting to know this region, its inhabitants and its traditional architecture, which is undergoing a slow and inexorable process of disintegration and disappearance.

The format of architectural schools includes field research and theoretical component (discussion) and immerses in the historical context and mysterious atmosphere of the study area.

The International architectural school is an opportunity to unite the joint efforts of students, scientists, restorers, museum and archival staff to study and preserve the architectural heritage in the North of the Perm region.

Upper Kama (*Verkhnekamye*) is a unique phenomenon at the crossroads of different cultures. The culture of the upper Kama region has absorbed the national features of the pre-Christian period in the Urals, Russian historical and cultural heritage and European traditions.

Side page, Fig. 01

### Watercolour and Architectural Memory

The watercolour drawing interprets the Cathedral of the Transfiguration of the Savior, capturing the architectural presence of the complex through a synthetic and evocative representation. The use of colour contributes to defining the atmosphere of the view, highlighting the relationship between the built elements and the surrounding landscape. (Drawing credit: Sandro Parrinello)



Fig. 02

### Study activity conducted at the Stroganov Museum in Usolye

The students involved, together with the researchers, learn the decorative patterns of traditional ceramics through a practical workshop. (Drawing credit: Sandro Parrinello)





↑  
**Fig. 03**  
**Student Presentation on Stroganov Baroque Architecture**  
 Mixed groups of Italian and Russian students engage in a shared discussion based on experiential models for heritage analysis. (Drawing credit: Sandro Parrinello)

Side page, Figs. 07  
**Navigation along Kama River**  
 To reach the most remote locations, it is necessary to navigate along the Kama River using boats, and the landscape of the riverbanks becomes a thin strip of land defining the horizon. (Drawing credit: Sandro Parrinello)

↓  
**Fig. 04**  
**Break moments during the missions**  
 When the research group, exhausted at the end of the day, takes time to rest and gather around a table for discussion. (Drawing credit: Sandro Parrinello)

Over the 20th century more than 30 % of the Upper Kama architectural heritage has been lost; many objects are in the dilapidated state. Now it is possible to notice a fast degradation and abandonment of the rural environment throughout Russia, which is the last stronghold of the provincial architectural tradition. Its losses are deeply felt in the Urals, known as a natural territory, which preserves numerous examples of vernacular stone architecture. Meanwhile, the unique style of the Upper Kama direction of Russian architecture formed under the European influence in the 16th-19th centuries has not been studied enough. Preservation and reconstruction of the lost require the modern approach to documentation, to the use of new instruments for the examination of the monuments, to the planning of their transformation and valorization processes. Digital technologies present larger possibilities and means of preservation of the existed and reconstruction of the lost heritage.

Recently in the process of the Russian-Italian cooperation it has been carried out perceptive and accurate digital measurements of the most important objects of architectural complex in Usolye, of the churches of Cherdyn, Nyrob and rural settlements lost in the depth of the inhospitable Urals nature. Definite steps in the direction of creating digital database of these objects have been made. Landscape and ecological aspects of the monuments and their surroundings have been studied and documented.






The ambitious is that the Urals architecture become a source of inspiration for the international researchers and for local communities that lives in this area in order to preserve this relevant heritage, at the edge of Europe, from the disappearing process.

The documentation of a cultural heritage, as dispersed as that of Upper Kama traditional architecture, requires the elaboration of a new way of understanding the meaning of the target sites. Upper Kama Region has always attracted the interest of historians and researchers, representing a border territory between East and West and a meeting point between European and Asian culture. The region preserves several examples of a peculiar architecture, reach in orthodox complexes and neoclassical industrial settlements of the eighteen century. The Upper Kama heritage is currently experiencing a period of decay and abandonment, concentrated on the rural landscape, the last stronghold of the tradition of provincial Russian architecture. The aim of the research is to integrate different digital documentation methodologies, in order to create an instrument of analysis and evaluation of the condition of the cultural heritage for the development of territorial renewal plans. The importance of Upper Kama documentation is due particularly to the lack of a detailed census archive from survey analyses that provides precise information on the quantity and quality of monuments and environment. During the 20th century, numerous historians and researchers have attempted to document the wide phenomenon




**Figs. 05, 06**  
**Students drawing while framing different angles of the landscape** (Drawing credit: Sandro Parrinello)



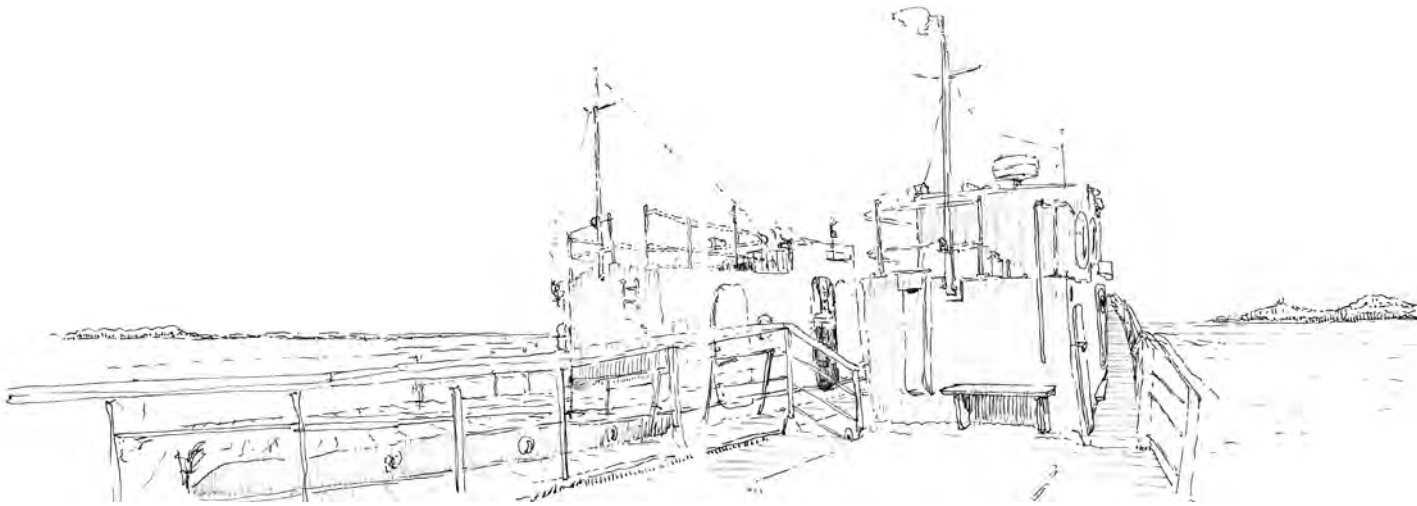


Fig. 08

**From the boat**

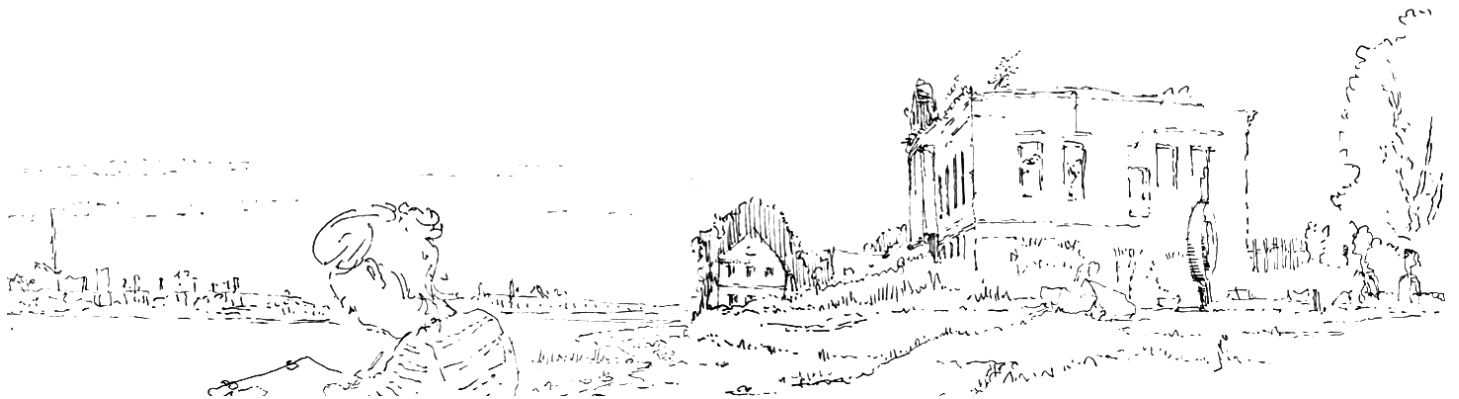
A promontory comes into view from time to time, and on its summit the ruined remains of a monumental church emerge. The vessel crossing this river, vast as a sea, reveals the connective scale of these immense territories. (Drawing credit: Sandro Parrinello)



of these religious buildings combined with industrial archeology complexes. Nevertheless, these researches do not provide a global heritage census and the technical basis for preservation processes, which are necessary to maintain and promote the cultural tradition of the region.

If the choice of this territory was approached by virtue of its historical architecture and heritage, it should be noted that through applied research other results were also achieved. In particular, these results concern the process of knowledge and awareness of the value of the historical architectural heritage, both on the part of the personnel involved in the fieldwork and the local communities. In the numerous missions carried out over the years, villagers have undergone modest invasions where students of various nationalities, researchers and teachers have been confronted with the life of these remote regions, the rhythms of living, the resources of the taiga and the value of the river and water. This interpenetration and contamination of knowledge took place not only by venturing into the forest in search of ruins, but by participating in cultural and social activities that were organised to encourage the involvement of local communities.

Drawing courses open to all, conferences, restoration and green maintenance workshops near the main buildings, interviews on local broadcasting stations, and all that was necessary to create a cultural inducement that would stand in the way of the normal industrial and productive dimension that is normally associated with such places. The character of the traditional architecture of Upper Kama is strongly connected with industry, first with the industry of the Stroganov family and then with the models of the industries of the Soviet Union. Solikamsk originated as an industrial district, as did Usolye, production areas linked to the salt trade, inextricably linked by the presence of the river that connected these urban and industrial realities with the entire system of central Russia. The echo of this dimension, which built its own style by imitating the models of Moscow and St. Petersburg, reaches as far as Perm, as far as Kazan and the Tatar regions, and then continues, skirting the mountain chain on the bed of the Kama and Volga rivers, as far as Samara and, descending further, to the Caucasus. It is a border region and for these very reasons it is a region that absorbs styles



and twists them in an eclectic, unpretentious way. The Upper Kama is a model of the intersection of Asia and Europe, but one that thrives on the relationship between north and south, following the direction of the river as the main road that connects and links. Thus, if the view of the mountains from the great plains of Cherdin is a reminder of the boundary towards the great Siberia to the east, the sunsets and the northern light seen from Nyrob during summer nights make one imagine the lands of the Komi or, further north, the boundless territories of the Nenets. This remote region has the power to thicken meanings, convert them and create a centre, with linguistic specificities, and with a decorum that is very strong and has managed to overcome any decadence induced by the communist purge. A reason that places itself at the centre of its own world and that dialogues, by virtue of the romantic landscape, with a dimension that is in some way cosmic, finding its sacredness in the small monuments, convents, churches, chapels, right down to civil architecture, right down to the inside of houses, in the red corner, and even more so in the detail, right down to the decoration of wood, in the carving, where the language of tradition, of rituals and shamans, is combined with the settlement process to find the stars.

*Figs. 10, 11*

**Preserving Moments**

There is something at once melancholic, romantic, and quietly hopeful in watching the students draw beside the monuments in this forgotten oasis, distant and yet close to civilization, a romantic feeling that compels one to preserve these very moments through drawing. (Drawing credit: Sandro Parrinello)

*Side page, Figs. 09*

**Looking beyond the river from the monumental area of Usolye**

The new urban district of Berezniki comes into view, with its factories and chimneys, while a bucolic scene brings together students sketching and people bathing in the river. (Drawing credit: Sandro Parrinello)





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Constitution of Russian Federation guarantees any citizen the right to take part in the cultural life and to use the cultural establishments as well as the possibility to access the cultural values. The Law on Cultural Heritage objects (the monuments of history and culture) of the people of Russian Federation (further, the Law) allocates the general guarantees of conservation of the objects of Cultural Heritage and the right of these objects' access for everybody.

The standards of the international agreements are integrated in the mentioned Law. Convention on the protection of the world cultural and native heritage is included in the number of constitutive acts of international law. This convention was adopted by UNESCO on November 16th, 1972. Russia became the participant of this Convention in 1988<sup>1</sup>. In the List of UNESCO World Heritage there are 29 Russian objects, so Russia takes the 9th place in this List.

Moreover in 1990 the USSR joined the Convention on the protection of European architectural heritage (Granada city, October 3rd, 1985, ETS N 121)<sup>2</sup>. The definitions of Conventions have found their reflection in the Law. Thus, conceptual framework in the sphere of immovable monuments of history and culture has been formed. The Law defined three types of the Objects of Cultural Heritage (further, OCH): monument, ensemble and site (place of interest).

Separate constructions, building structures and facilities with historically established territories and the objects of archeological heritage are treated to be the monuments. Ensembles are the groups of isolated or joined monuments, buildings and facilities of different destination. The fragments of historical planning and development of settlements may be treated as the architectural ensembles. The pieces of the landscape architecture and art as well as necropolis may be also attributed to ensembles.

The places of interest are considered to be the man-made creations or the joint work of man and nature. The centers of historical settlements or the fragments of architectural planning and development are recognized to be the places of interest. Within the boundaries of the site, the monuments and/or ensembles can be located. The territory of OCH is the territory occupied with the given object and/or connected with it in historical or functional aspects.

*Side Page, Fig. 01*

**Onion domes**

A distinctive regional expression of Russian religious architecture in the Upper Kama region.

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<sup>1</sup> Cf. European Cultural Heritage - Volume I, II; the Decree of the Presidium of SS USSR from 09.03.1988 N 8595-XI "About Ratification of Convention on Protection of cultural and native heritage"

<sup>2</sup> The Resolution of the Council of Ministers of the USSR from September 26, 1990 N 973 "About accession to a convention on the protection of the European architectural heritage, concluded in Granada on October 3, 1985".

The boundaries are determined by the project of boundaries on the basis of archive documents, historical land planning and scientific research.

The objects of cultural-historical heritage are divided into three categories according to their importance: Federal, Regional and Local. The criterion of their attribution to one or another category is the historical-architectural value having the considerable importance for the history and culture of Russia in whole, for the history of the region or of municipality.

Despite the significant notions, the Law has regulated the other problems as well. Powers and authority of the public administration in the sphere of conservation, use, promotion and governmental protection of the OCH have been constituted. Considerable power on the Federal level is provided by the Government of RF and RF Ministry of Culture is authorized to a greater extent.

Assignment of definite powers makes possible to develop and adopt own regional legislation. Today practically every region has its own special laws. In Perm Krai this is the Law of Perm Krai about the OCH (Monuments of history and culture) of the Peoples of Russian Federation living in the territory of Perm Krai. Local administrations or their functional bodies act as the municipal authorities in the sphere of protection of the OCH. As a rule, such authorities appear in case of existence of OCH of the local importance in the boundaries of settlement.

In Perm Krai the functions of the regional authority in the sphere of conservation, use, promotion and governmental protection of OCH of the peoples of Russian Federation living in the territory of Perm Krai is realized by the State inspection in the field of protection of OCH of Perm Krai<sup>3</sup>.

The Law defines the sources of financing the arrangements in the field of conservation, promotion and governmental protection of the OCH. In case of performing works aimed at conservation of OCH, the benefits are stipulated. Regional administrations can approve state financial programs aimed at conservation, use, promotion and governmental protection of the OCH. In Perm Krai the program “Perm Krai – the territory of culture” has been functioning.

According to the Law, the United State Register of OCH has been kept in Russia (further, Register). The Register is the main source of information about the OCH and the territories of their location as well as about the areas of the OCH protection. The Register<sup>4</sup> is formed by the introduction and exclusion of the OCH of Federal, Regional and Local importance. Statutory act of the power authority is the reason for such steps.

The aims of public historical-cultural examination, and the principles of its performing, are stipulated by the Law. Also the order of the assignment of such examination and requirements for the experts' reports are stipulated by the Law.

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<sup>3</sup> See web-site: <http://nasledie.permkrai.ru/about/function/>.

<sup>4</sup> Actual Register of the objects of Cultural Heritage is available in the site of the Ministry of Culture of Russian Federation: <http://mkrf.ru/ais-egrkn/>



*Fig. 02*

**Kerchevo. Wooden Chapel (lost),  
c. 1801-1850**

Slender wooden bell tower  
with open belfry and spire,  
emblem of vernacular sacred  
architecture in the Perm region.

The meaning of governmental protection of OCH as well as the measures aimed at supporting the preservation of OCH during reconstruction or any other works have been discovered in the Law.

Special attention is paid to the areas of protection of OCH. These areas include conservation zones, zones of regulated housing development and zones of regulated natural landscapes. The zones differ by the strong determined regimes of the objects in use. Such zones can be determined only by the special projects, the projects of zones of Cultural Heritage protection. Protected areas are determined in case of the lack of zones of OCH protection.

Preservation of OCH involves the measures aimed at supporting physical conservation and keeping of historical-cultural value of OCH. Such measures include conservation, repair, restoration, adapting the OCH for the current use. The protection of the OCH involves such important work as research, survey, design and production, scientific guidance in the process of preservation of the object, technical and field supervision of this work. The work on preservation of the OCH is carried out according the task. Resolution of the work performance is given by the authorized body. The same body coordinates design documentation.

The Law regulates the peculiarities of the ownership, use and dispose of the OCH. It stipulates the definite conditions of the contract of tenancy and of the contract of free use of the OCH. Special features of the legal regime of historical-cultural national parks and historical settlements are also stipulated by the Law. The notions have been introduced; the order of organization and delimitation for the national parks and historical settlements has been defined.

The common base of legal responsibility for the offence in the sphere of conservation, use and state protection of the OCH has been stipulated by the Law.

The problems of conservation, use and state protection of the OCH connected with the land tenure and town planning are regulated by the Architectural Code of RF (further, AC RF). Complex regulation allows forming the strategies of conservation of heritage on the level of definite objects, territories, settlements and region in whole. Town planning qualifying the conservation of the OCH is one of the main principles of architectural activity. Integration of the policy of conservation of the OCH in the policy of spatial growth of territories with historical development is the the main point of this principle. AC RF continuously discovers the mechanism of taking into account the requirements of protection of the OCH in the process of preparing document of spatial planning, in the schemes of different public authorities' spatial planning and in the general plans, in the rules of land use and development, in planning documentation. The fundamentals of the state cultural policy, governmental formation strategy of the sites system, of historical-cultural national parks and parks-museums in Russian Federation, the strategy of tourism development in RF for the period up to 2020 and other documents are used in the process of preparing spatial planning for the regions and towns. The maps of the general plans show the borders of the OCH protection areas.

The requirements of protection of the OCH should be taken into account in the process of forming the parameters of the planned development of the functional zones in the general plans of settlements. On the maps of architectural zoning, it is obligatory marked the limits of zones of protection of the OCH. The requirements of protection of the OCH are surely taken into consideration when the town-planning order determining the parameters of development is worked out.

For the historical settlements, it is stipulated special regulation of town-planning. It is necessary to coordinate the tasks on the general plan project planning, the rules of the land use development and the documentation on the territory planning. Prepared projects of the listed documents are subjected to endorsement. The accordance to the approved object of historical settlement protection is the matter of examination.

In the documents of the general plan justification, the territories of historical settlements of Federal and Regional importance are mapped and obligatory marked on the maps of architectural zoning. Thus, the Law of the objects of Cultural Heritage conservation and town planning legislation interactively solve the problems of protection of the OCH in the process of preparing documents for the spatial development of regions and towns taking into consideration all the requirements.

For a long time the realization of the projects for the areas of conservation of the OCH has not been financed. The budgets of the works touching upon the conservation the OCH were small. In the strategies of the town development, namely the Perm Krai strategies, the heritage as factor of development was not considered. And this factor influenced negatively on the state of the OCH. The number of destroyed (ruined) objects has increased. Due to the poor regulation the objects alien to the historical environment appeared.

But the situation is seriously changed. RF government and RF Ministry of Culture have formed the new notice paper of the heritage conservation. Special attention has been paid to historical settlements. The plan of initiatives aimed at legislation improvement including the Russian participation in the international agreements in the field of conservation of the Objects of Cultural Heritage (international Charters and Conventions) has been made.

These changes are very important for the settlements of Upper Kama. Cherdyn, Nyrob and others require the development of such measures of protection which would promote the support and popularization of cultural and tourist possibilities, the development of economics of Cultural Heritage in these towns. And award of historical settlements status could be among possible directions.



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## A LANDSCAPE TO BE PRESERVED FOR THE PROTECTION OF HISTORICAL CULTURAL IDENTITY

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Crossing the great countryside of central Russia is like navigating in a boundless sea of fields, forests and prairies. The roads that run north from Perm pass through industrial areas, forests and woodlands, interrupted occasionally by the presence along the way of small villages and fields, sparsely cultivated, stretching as far as the eye can see. Through the taiga the coach makes numerous ups and downs along the hills, and at each bend one expects to see a change in the landscape, an unexpected event that breaks the incessant rhythm of the trees, that allows one to find a reference to which one can cling for orientation. This does not happen, for hours. The boundless size of the land leaves no room for any apparent change, and the landscape, shaped by the ice ages, shows rounded mountains in the distance and occasionally opens up into wide valleys with numerous lakes and streams.

Size and extension are the main characteristics of each view that transforms the forest into a desert, devoid of references, as if we were in the middle of the sea. A sea whose reflexes rest on every shade of green, filling the eyes. Contrasting with such visual stillness, supported by a clear light that relaxes and embraces the eye and an air full of oxygen, is the image of the same landscape during winter. The snow, towering over everything, eliminates all contrast by flattening shapes and distances, forcing the eyes to squint. These two contrasting dimensions are the soul of this place that succumbs to the forces of nature and where the harshness of the winter landscape is contrasted by a summer landscape, which expresses itself as a consequence of an explosion of life that nature gives to the visitor. The horizon line slowly moves, opening up the view to the caravan of large trucks rushing northwards.

*Side page, Fig. 01*  
**A fragment of the “interior” space of the church of Pokcha**  
Traces remain of a highly sophisticated construction system and formal composition.

↓  
*Fig. 02*  
**The ruined church of Nativity of Iskor, enclosed within its boundary**  
Tall grass makes it difficult to walk around, and the geometric space of the church feels even more sacred, in contrast with the romantic dimension of the surrounding landscape.





*Above and side page, Figs. 03-05*

**Everything unfolds in the shadow of the river, flowing relentlessly**

From the banks of the villages, when one feels still and distant from everything, it is meaningful to draw the river, even if only as a line, imagining that this line will travel far, connecting these places with the rest of the world. (Drawing credit: Sandro Parrinello)

The echoes of the Ural Mountains reach here, through a succession of hills, plateaus and long valleys topped by a flat, romantic sky. In these ancient lands, the landscape is soft, with long hills that chase each other to the horizon, flowing into the folds of streams that end in the great Kama basin. The river is the great presence that flows through these lands. The river is linked to the legends and folk traditions that have travelled through the flow of water to unite tribes and peoples. The river is a metaphor for the flowing of time and the life that takes place around it. The entire settlement process of these lands is bound to the river. The possibility of procuring food, of travelling along a safe route, the river links the most remote corners with the great sea of Kama, and along it developed the civilisations of merchants who made these lands rich. I imagine that always along the river, transported by myth, travelled those





symbols, those signs of the landscape that over the centuries have united different ethnic groups and cultures. Tartars, Russians and Siberians, are just some of the many peoples who have inhabited these lands and have elaborated from this territory the decorative methods to define over the centuries a cultural landscape and a stylistic language that is so recognisable today.

People who inhabit a territory and a landscape put the meanings of these landscapes into action by creating boundaries, enclosures and artefacts in general that draw inspiration from this place. These same objects end up inhabiting this space, defining an artificial landscape that cohabits with the natural landscape.



**Fig. 05**  
**A small wooden house with a garden and tractor in the Cherdyn region**  
 A mythical, archetypal atmosphere links the way of life and dwelling dimension of these places to the settlement patterns of Neolithic villages. It offers an authentic glimpse into the relationship between civilisation and nature. (Drawing credit: Sandro Parrinello)





**Fig. 07**  
**Reading Industrial Heritage in Khokhlovka**

At the open-air museum of Khokhlovka, it is possible to study the main models of industrial and religious systems that belonged to this landscape and maintained a harmonious relationship with it. Understanding industrial systems is essential for investigating the historical social dimension and, consequently, the spirit of the architectures that have survived to the present day.

Architecture stands in the middle of this dialectic by defining forms and models that summarise the cultural tensions that man experiences when inhabiting a place. The churches and monuments of Upper Kama in this sense describe a cultural route, they draw a place between streams and mountains that in the forest and in the villages express and tell the memory of a time. Time is, in this landscape, suggested by the flow of the river water and the rapid passage of clouds across the low sky that almost seem to touch it as one remains grounded in a tiny place in front of the vastness of nature from which one cannot escape. Observing the wooden architecture of the villages, the blockbau technologies and building systems, the gardens and domestic vegetable gardens with the wetlands, I am reminded of the Karelian villages and the studies conducted on the traditional landscape of Russian villages to understand the transformations taking place in western Russia<sup>1</sup>.

In the villages that one encounters in the Perm region, especially those along the main road, the production logic of decorative elements, the craftsmanship of defining containers and storage systems,

<sup>1</sup> The Resolution of the Council of Ministers of the USSR from September 26, 1990 N 973 "About accession to a convention on the protection of the European architectural heritage, concluded in Granada on October 3, 1985".



the organisation of life in general in the face of the great cold that overlooks everything, have long since disappeared. Fibro-concrete roofs have replaced wooden planks, bituminous sheathing surrounds every face, while moss, as insulation, has been replaced by orange foam. The pastel colours of tradition, applied to the irregular wooden surfaces, first gave way to bright colours alternating with unpainted houses because they were abandoned, and then over time wooden elements were replaced by plastics and sheet metal of various makes.

However, an important cultural debate is animated in these villages. The foreword is that the monumental architecture of these territories, built for the most part between the 18th, 19th and 20th centuries, is an almost colonial, imported architecture, whose forms are the happy meeting of European-style models, which found expression over the centuries in the great cities of Moscow and St Petersburg, with a more modest architecture in whose vernacular stylistic features one finds the signs and symbols of local cultural models. In general, however, what characterises this precise moment in architectural history is the desire to construct architectural models that are aimed at urban models.



**Fig. 08**  
**Church and Bell Tower in Khokhlovka**

The church and bell tower at the Khokhlovka open-air museum exemplify the architectural and spatial organisation of traditional religious complexes, integrated within the cultural landscape.



**Fig. 09**  
**Facing the River Landscape**

Everything opens towards the river, where spatial extension gains strength through the horizontal perspective of the water's surface. (Drawing credit: Sandro Parrinello)

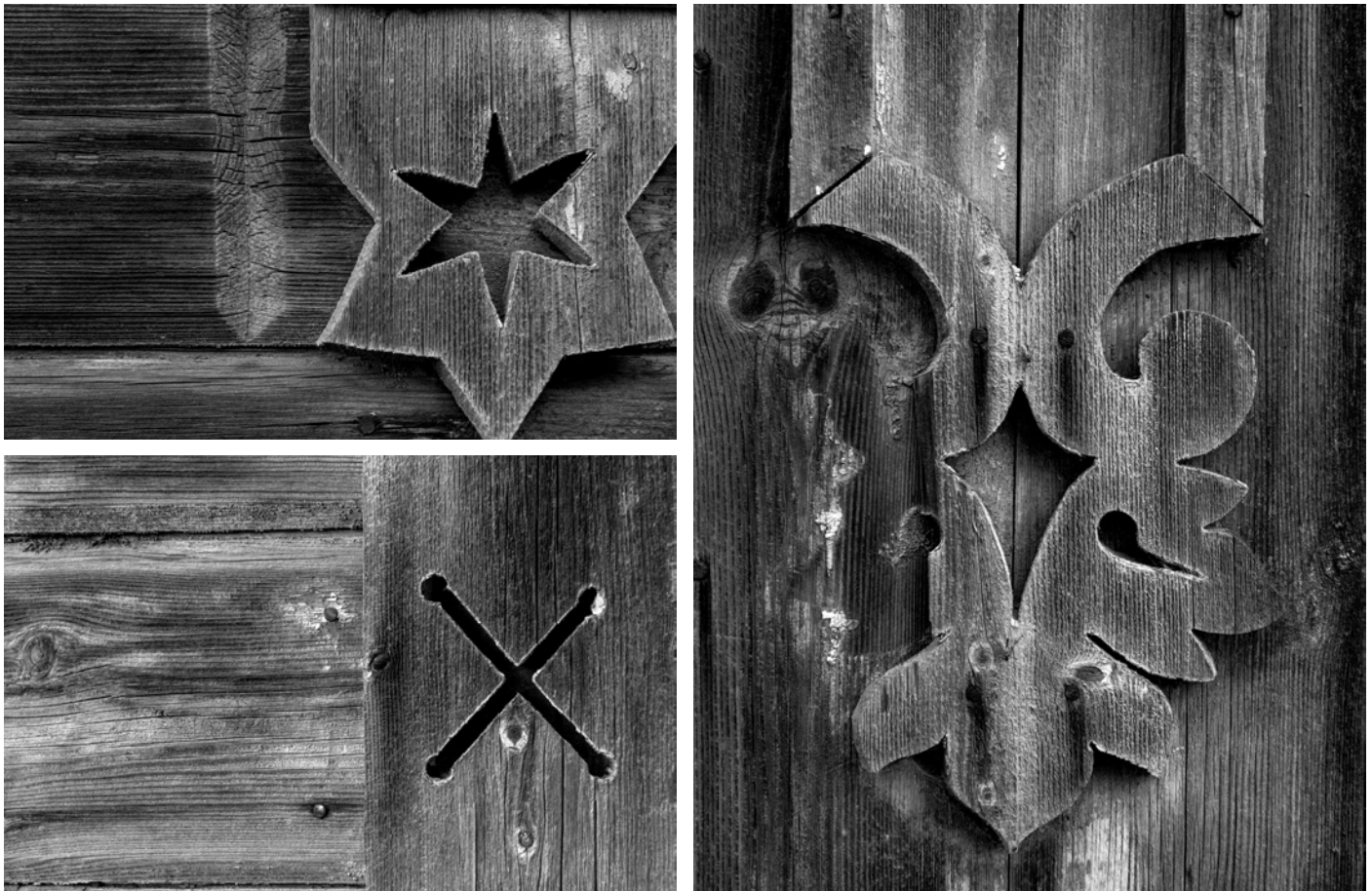




**Fig. 10**  
**From Vernacular Roots to**  
**Regional Baroque**

In traditional wooden architecture, early forms can be found that merge with “urban” models to shape the distinctive Baroque of this region.

It is not the architecture of the village that evolves into a traditional urban model, but rather the model of the city, of the palace, of the new geometric forms and new public functions that animate the great city of Russia, aimed at the European capitals, that infuse the architecture of the villages, thus transforming the rural space of the province into an echo of Greater Russia. Industrial structures, housing and, first and foremost, religious architecture and monuments, acquire this tendency to reflect and express the cultural and economic wealth of these territories. The reasons for such a numerous presence of monuments are to be found in several factors: the extreme religiosity of the population, the desire to express their faith and their economic capacity through the construction of religious buildings, the ability of some churches, located in the villages, to express not the wealth of a single family, but to describe the cultural and religious identity of the entire community that orbited around this same church. This is why, when passing by these villages, it is possible to find the remains of a monumental architecture that firmly detaches itself from the rest of the built environment to express stylistic and formal models that not only qualify the expression of a specific historical architectural current, but also determine a deeper cultural substratum to which the entire local identity refers. If wood is the main source used for the construction of houses and monuments, in these territories characterised by the clayey basins of the smoke beds, it is bricks and brick architectures that stylistically define the formal leap that qualifies the monument. In the decorations of the brick architectures, the wall faces are woven



through skilful geometric plays that animate in the solidity of the front the fine decoration that recalls that theory of facing so dear to Semper.

In the heaths of the Russian landscape, the hearth truly expresses the symbol of the birth of community, and the shy bell towers topped with a bright, lit dome express this very concept of the hearth. Thus the art of weaving and the art of weaving branches to generate a roof and an enclosure, which see the carpet as the object around which the theory of covering revolves<sup>2</sup>, has a special value here. Carpet culture arrives from the south with the Tartars, crosses the Urals with the Mongols, and in the simplicity of Russian decorative expression on the border finds its own identity that is configured as a baroque detail but which, in being so deeply connected to local traditions and this specific territory, seems almost to anticipate or in some way confirm those currents that animated the cultural scene of the 19th and 20th centuries. The façades of the large brick volumes, which evoke the space of the city, express a formal rigour that is realised in a regular layout, in an alternation of full and empty spaces to which the corresponding internal structure of the church does not necessarily correspond. The façades are scenic backdrops intended to dialogue with the landscape, while inside, the rooms gather to seek shelter from the cold.

<sup>2</sup> The Resolution of the Council of Ministers of the USSR from September 26, 1990 N 973 "About accession to a convention on the protection of the European architectural heritage, concluded in Granada on October 3, 1985".



**Fig. 11**  
**A Language of Carved Geometries**

The geometries of decorations and carvings reflect a meaningful vocabulary that connects the architectural organism with the territory, its spirits, and its languages.

The many windows provide a pretext for enriching the façade with brick weavings and for inserting, in the embroidery of the designed geometries, large ‘tapestries’ with images of saints placed in the centre of the bell towers on the front that observes the sacred enclosure that one crosses to access the monument. The churches in these territories maintain the traditional layout of Russian and Orthodox churches. A narthex is accessed by passing under the bell tower, arranged on the façade, then there is a refectory, usually with a contained volume, the hall that houses the iconostasis and separates from the apsidal part. Numerous variations are applied to this model, but they tend to have perimeter load-bearing structures organised in regular geometries. The roofs and everything above the vaults and the brick structure are made of wood. It is in fact from timber architecture that to a large extent these models draw their formal and distributive layout, and although the structural conditions change and although the distributive layout is complicated, many technologies remain unchanged in defining imposing castles of beams and support structures to support the roofs and horizons.

As a result of the history of the 20th century, today this heritage is in an extremely precarious condition. Almost all of these churches are abandoned or reduced to ruins. Like the villages that housed them, now gone or profoundly transformed, these structures are abandoned, emptied, decaying, and year after year they try to survive the weight of the snow and the atmospheric agents that make their way through the rubble. The first signs are inflations in the roofs, which are quickly followed by real gaps, partial failures and the start of a process that leads to the collapse and total collapse of the roofs.

Making the image of these places as we encounter them and know them today live in the memory becomes extremely important, not only for the documentary value of an area whose culture and identity is slowly disappearing into something else, but to testify to what is happening in the absence of adequate maintenance and management of the historical heritage. Architecture is man’s highest cultural expression, it does not only describe his ability to live in a place, but it makes every cultural expression explicit by defining the identity and representing those who live there. The loss of historical architecture means the loss of a cultural identity of a fragment of our civilisation. The loss of this fragment limits us in our awareness of a better design capacity for the future. In order to allow the monuments, the technologies that characterise them, the historical events that produced them, and the people who worked out their every detail, structure and decoration, to survive, the totality of this information becomes a digital organism, a data bank that can prolong its life by projecting the monument and the landscape connected to it into the future. The digital database can contain not only images and descriptions, but also dimensional information that qualifies as a set of three-dimensional co-ordinate points, like a point cloud with millimetre-accuracy, from which drawings and models can be worked out to study the object and interact with it. Cultural identity can thus be preserved, at least as a historical fragment, if those relationships that qualify the structure of a complex space, at least on an architectural level, such as the one examined here, are reconstructed in a digital environment.



**Fig. 12**  
**Churches and Landscape of Cherdyn**

The Church of the Transfiguration of the Saviour and the Chapel of the Saviour in Cherdyn, with the Ural mountain range outlining the horizon. Mount Poljudov Kamen' rises above and dominates the surrounding territory. (Drawing credit: Sandro Parrinello)



**Upper Kama Route**



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Upper Kama district with its center in Usolye city, then in Solikamsk, existed as administrative and territorial unit from 1923 to 1930 as a part of the Urals region. Since that time the territory of the Urals region experienced several stages of administrative transformations as a result of which the word combination “Upper Kama” remained as social-cultural name of Usolye, Solikamsk and Cherdyn municipal districts of Perm Krai. In the native literature the territory of Perm Krai situated on the banks of the Kama River is often called Prikamye. Prikamye is the unique region having the rich history. In ancient times the land of Prikamye was the part of the legendary Biarmy spreading from the basins of the North Dvina, Pechora and Kama to the coasts of the Arctic Ocean (Stralenberg). Later in the territory of Prikamye Biarmy was called Perm the Great.

As early as in X-XII century Perm the Great had trade and cultural links with Volga Bulgaria, Byzantium, Iraq and Asia Minor. Arab coins of IX-X centuries and numerous silver goods found in the territory of Perm the Great are the definite evidence of this fact.

From the 12th century Prikamye appeared to be influenced by Novgorod. Novgorodians settled on the banks of the river Usolka in the 15th century and founded “Sol Kamskaya”, today’s Solikamsk. Undoubtedly, in the process of construction of the first churches they used the models of their far native land. It was the wooden churches, and perhaps they were created by masters-carpenters from Novgorod and Pskov who moved to the north by the whole artels. The Upper Kama Wooden architecture of that period adopted the style of Novgorod cathedrals, successors of Byzantine traditions. The Russians introduced agriculture and handicrafts, arts and weaving in Prikamye. Russian culture was mixed with the culture of the local peoples, Komi and Udmurts.

After the downfall of Novgorod Novgorodians were changed by the Moscow members of the armed forces of Ivan III (1452) together with Galitskaya, Ustyuzhskaya and Vologodskaya armies. Novgorod cathedrals were destroyed by fires and invasions. The churches of Moscow style which was formed under the influence of two strong directions of art (Novgorod-Pskov and Byzantine-Lombard) appeared on their place. From 1472 Cherdyn was the advanced post of Moscow state and had the name Perm the Great Cherdyn. It preserved the administrative, military and trade importance till the 17th century.

Unique wealth of bowels and nature defined the peculiar features of the region’s development. In 1430 the Kalinikovs who had come from Vologda founded the first salt mines in Solikamsk.

*Side page, Fig. 01*  
**Church of Transfiguration in Usolye**  
Historical pictures describing the image of the traditional village of Usolye view from the bell tower.



*Fig. 02*  
**Trinity Cathedral in Solikamsk**  
 Historical pictures of the main monument of the city of Solikamsk, captured before the restoration of the external surfaces. On the background, the bell tower in its original aspect.

*Side Page, Fig. 03*  
**Memories of traditional landscapes**  
 Historic towns of Verkhnekamie (Upper Kama area). Pictures of Solikamsk, Pynatneg, Nyrob, Pyskor, Verkh-Botovoe, Cherdyn and Oryol. Source: Stroganovs Chambers Museum archive.

By the 17th century the citizens of Usolye, Lenva, Dedyukhino (the settlements which became the basis of Berezniki) were occupied with salt-making.

Due to the efforts of the Stroganovs family by 1579 Solikamsk had become the well-fortified settlement with the trading quarter and industrial structures which were of decisive importance. It was counted 16 saltpans, 27 shops and 190 homesteads. At the beginning of the 17th century there were 5 churches and 2 cathedrals in Solikamsk.





Fig. 04

**Traditional construction material**

A bell tower (on the left), and a altar volume crowned by domes, (on the right), both in traditional bricks, used as a construction (structural) element and as a decorative element.

Only a few of these structures still have visible bricks, most of which have been overgrown by restoration work, not always preserving the original image.

The Stroganovs' family is one of widely known Russian dynasties. The direction of the Russian icon-painting at the end of the 16th – the beginning of the 17th centuries (Stroganov's school of icon-painting), the school of the church embroidery of the 17th century (Stroganov's embroidery) and architectural direction of Moscow baroque were named after them.

Descendants of A. Stroganov constructed towns all over Perm Krai: Upper and Lower Chusovskie Towns, Orel-town (Kargedan), Kankor (Pyskor), fortresses and cloisters.

Economic flourishing of Solikams in the days of its unique architectural development continued during relatively short period of time. At the end of the 18th century there appeared new Siberian trade route through Kungur city in the south of Perm guberniya, and Solikamsk gradually turned into the secondary chief town of a district. That period was characterized by the rapid development of mining industry. It is known that by the end of the 17th century more than one hundred ferrous metallurgy plants had been operating. During that historical period new type of settlement – town-plant – was formed. Developing industry united residential settlement and industrial buildings (salt pans, dams, workshops, offices, warehouses, etc.) and due to this the native industrial architecture was founded. Architecture of the Upper Kama was formed not only under the influence of the natural, historic and economic conditions. In addition to the developing industry it was determined by construction and art traditions of the Russian North and Central Russia.

In our book we consider the architecture of the Upper Kama formed in the period from the end of the 17th to the beginning of the 20th century. From the large architectural-construction experience of the Upper Kama we choose stone monumental constructions in historical town and settlements (Cherdyn, Usolye, Nyrobandothers) and don't mention national wooden architecture and industrial architecture.

In the territory of Upper Kama stony architecture is represented by the Orthodox Churches of the 17th -20th centuries. Now all these churches except the Trinity Cathedral in Solikamsk have turned over to the Orthodox church: Church of the Epiphany (1687-1695, Solikamsk); summer (1684-1697); Cathedral of the Exaltation of the Holy Cross (1698-1709); Church of the Transfiguration (1683-1692), Church of the Savior (1689-1725 ); Church of the Holy Cross (1678, Vekh-Borovskoe settlement); Church of the St. Nikolas the Wonderworker (1655 -1660, Pyskor settlement); Church of the Holy Trinity (1688, Lenva settlement, Beresniki city).

All these objects are the monuments of history and culture of Federal importance. Meanwhile, the Church of the Holy Trinity in Lyonva settlement is in the ruined condition, the Church of the St. Nikolas the Wonderworker in Pyskor settlement is in the dangerous structure, practically it is close to be destroyed. In contrast to the rest churches situated in the center of Solikamsk and forming its historical architectural complex which is supported by the tourist infrastructure of Perm Krai, they are lost in the Urals backwoods and inaccessible for the history and architecture buffs as well as for supervisory organizations.

*Next Page, Fig. 06*

**Image of ruined churches in Upper Kama territory**

Above, Lenva. The church of the Life-giving Trinity in 2016 (years of construction 1687 and 1688). Below, Pyskor. The Church of the St. Nikolas the Wonderworker in 2018.



*Fig. 05*

**Pyskor in its original landscape**

The church is isolated and surrounded by a natural landscape, in an integration of nature and architecture that provides an impressive traditional panorama.





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Upper Kama Region has always been of great interest for historians and researchers because of its position between East and West (it indeed represents the border between Europe and Asia). A.S. Teryohin, G.D. Kantorovich, I.V. Makovetskiy and V.A. Tsyushtanov provided the most important contribution to this research and presented their work on culture and architecture of Upper Kama localities in ‘Monuments of stone architecture of XVI-XVIII in Solikamsk’ (1970). In 1988 V.V. Kostochkin, Moscow historian and architect, wrote a monograph entitled “Cherdyn’. Solikamsk. Usolye”, where he integrated all the previous research activities in the Region. In the XX century Perm Scientific Restoration Atelier carried out inventories, documentations, surveys, conservation and restoration projects for the Upper Kama region.

The surveys conducted by the Perm Scientific Restoration Atelier in 1986 provide reliable data about the majority of existing monuments of the complex. Recently, a study on the Upper Kama architecture was conducted by W. Brumfield in form of photographic surveys “Solikamsk: Architectural Heritage in Photographs” (2007), “Cherdyn: Architectural Heritage in Photographs” (2007), “Usolye: Architectural Heritage in Photographs” (2012).

In the native literature it is accepted to single out three main directions of the Urals architecture development: popular wooden architecture (residential and public worship buildings), wooden industrial architecture and stony monumental objects in historical towns (Cherdyn, Solikamsk, Usolye, Kungur and others) which “[...] are worthy to rank with architectural objects of such widely known cities as Yaroslavl and Vologda, Kostroma and Ryazan, Uglich and Murom, Toropets and others”<sup>1</sup>.

Architecture of Upper Kama was formed under the influence of the general Russian architectural styles of the 16th-20th centuries and imbibed their inherent historical features.

Cherdyn and Solikamsk similarly took in the Novgorod culture at the dawn of their development. In Solikamsk this culture has preserved per se even longer than in Cherdyn. Both cities were influenced by Moscow’s architecture the traces of which have been noticed in the architecture of Solikamsk churches. However, the Novgorod survivals are noticeable as well.

*Side page, Fig. 01*  
**Detail of decorative apparatus**  
Church of the Icon of the  
Mother of God in Solikamsk.

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<sup>1</sup> Kostochkin (1988), *Cherdyn*.



Fig. 02

**Urals Baroque**

On the left, church of the Transfiguration of the Savior in Alapaevsk, Sverdlovsk district. Source: <http://sobory.ru/photo/8696>.

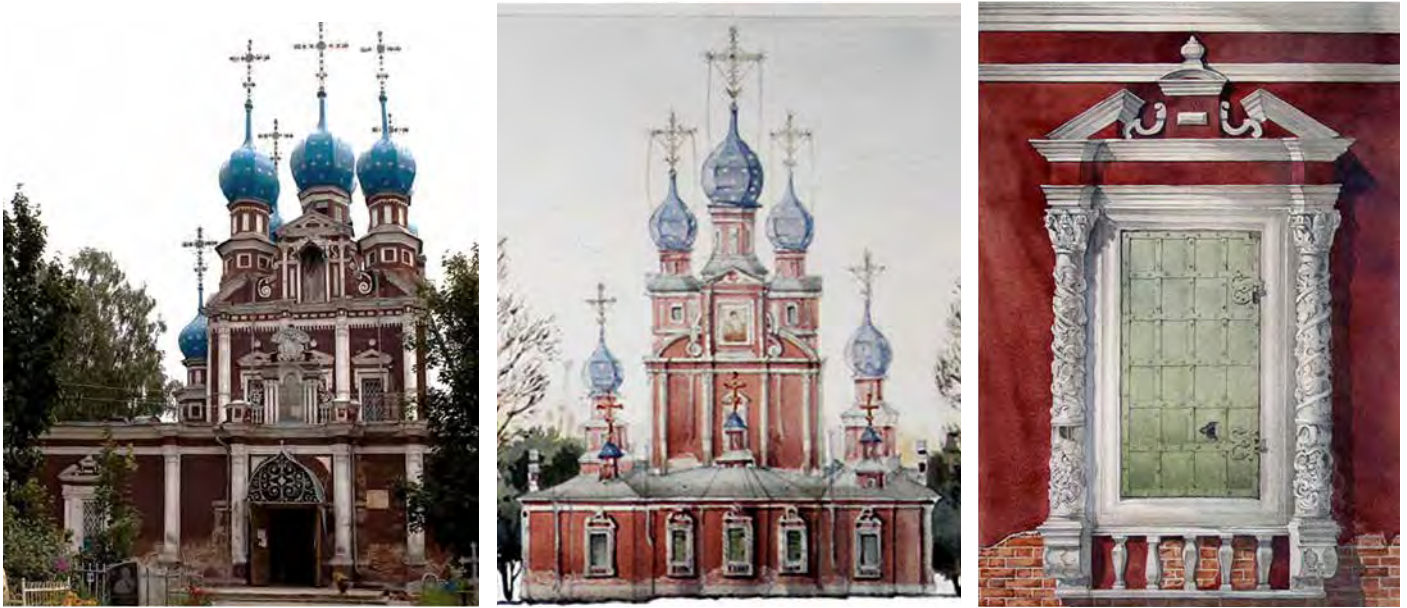
On the right, Church of the Icon of the Mother of God in Solikamsk.

In the 16th century temple architecture was generally represented by wooden buildings with the inherent decorative effect of the Russian wooden architecture. This effect was named as “Carved decorations”.

Despite the wide spread occurrence of wood in some districts of Upper Kama the natural stone was used just in the early times. That stone was applied for construction foundations, basements of buildings, fire separations and even whole buildings (residential buildings, storehouses and shops). At that the architectural forms of the first stone buildings were made by traditions and methods of the wooden architecture.

It is usually considered that in Upper Kama construction from stone appeared in the 17th century. Stone (brick) was used primarily for construction buildings for public worship and palaces for nobility. First it was separate buildings and further – the whole architectural complexes. “Stone masters” applied not only ordinary brick but cut stone, radiating, clay cavities, multicolored glazed tiles, glazed ceramic tiles.

Due to the rich choice of such materials by the end of the 17th century Perm constructors had established the method named “stony carved decorations”. The walls of the buildings were ornamented by decorative lodgments and cornices from the colored tiles and figured placing, window openings and doorways were framed with beautiful stony cases. The cubage of buildings was consciously complicated and acquired monumentality at the expense of constructed aisles, terrace steps and porches (Cathedrals of Solikamsk and Usolye). Large premises had the arched floors: cylindrical, linked and etc. When necessary there were constructed metallic bonding and tightening from the flat iron.



The most impressive examples of the architecture of the 17th century are as follows: in Usolye, Stroganovs' palace; in Solikamsk, Cathedral of the Exaltation of the Holy Cross and in Kungur, the House of the voivode.

From the first half of the 18th century the buildings of Upper Kama demonstrate the features of the Russian baroque: pilasters and columns repeating the classical examples, severe framing of the windows opening, geometrically strong configuration of the cornices and strings. In Russia baroque has its typical directions and schools. In the theory of the Russian architecture it is accepted to mark out Moscow baroque (the end of the 17th century), Peter's baroque (the beginning of the 18th century) and Elisabeth's baroque (the middle of the 18th century). These directions initiated different provincial schools' development.

Capriciousness of composition and richness of decorative elements, lively colors, and splendid decoration of facades, cornices, pilasters, tiles, fretted plat bands and twisted columns, cascades of corbel arches are the typical instruments of the stony architecture of that period. Many characteristic features of the style had the Western roots and were full of mannerism and traces of the late Renaissance architecture.

The most characteristic feature of Moscow baroque was the presence of fretted details from the white stone against the background of the red brick wall. The premises became larger due to the application of metallic bonding imbining the arches thrust. Windows were made of the same size, situated in row and equidistant. Spreading of brick which was cheaper than cut stone promoted construction of houses from this kind of material in all territories of Russia.

Fig. 03  
**Detail of Stroganov baroque**  
 Church of the Kazan Mather of God in Ustyug. Pictures of the student of St-Petersburg State Academic Institute of Painting, Sculpture and Architecture by the name of I.E.Repin under the Russian Academy of Arts are presented by the Museum of the Chamber of Stroganovs.



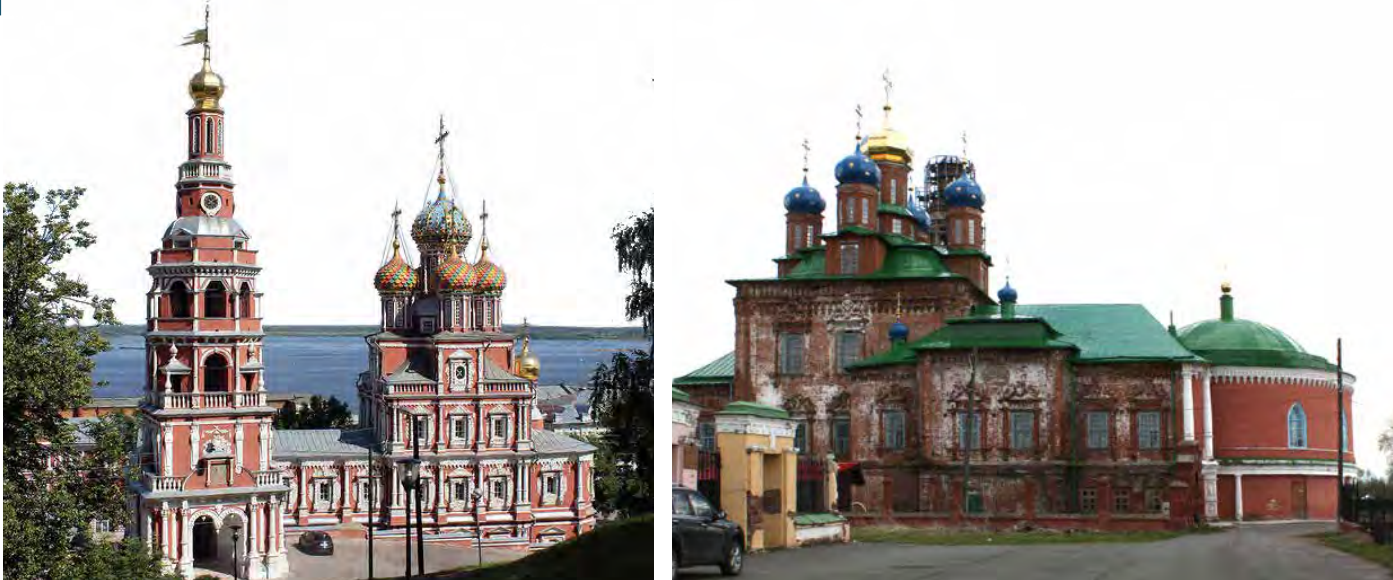


Fig. 04

**Stroganov's baroque**

Church of the Synaxis of the Most Holy Theotokos in Nizhny Novgorod.

On the right, Cathedral of the Transfiguration of the Savior in Usolye.

In temple architecture of the first half of the 17th century there was dominated the churches with the cloistered vault, on the high basement, with refectory, aisles and bell tower. Usually they had five domes, domes over the aisles, hipped roofs over the porches and bell tower, tiers of kokoshnicks over the domes. Religious architecture continued to develop under the tangible influence of the wooden architecture. For example, bell towers were constructed according to the system of the tower churches with pavilion roofs. Moreover, it was applied tier construction of churches, the origin of which was the Ukrainian wooden architecture<sup>2</sup>.

At the end of the 17th and the beginning of the 18th centuries Russian architecture uses ever more the Western European decorative elements. Sometimes the forms of the Russian architecture were quite similar to the Western European ones (the Nativity Church in Novgorod, 1719), and sometimes they were considerably modified.

Gradually, there appeared the features which demonstrated the end of the style evolution. The décor of facades was becoming more balanced, its placing was complied with the order and composition of buildings became clear. Church buildings lost the inherent features: buildings for public worship were constructed with same architectural details as the civil ones. The first third of the 18th century in the history of Russian architecture is connected with construction of St-Petersburg and the Order of Peter I of 1714 about the prohibition of constructing buildings from stone and brick in all towns except the capital. This Order was in force up to 1728. Partly due to this Order, partly due to the fact that provincial architecture began to develop independently the features of Peter's and later of Elisabeth's baroque are not mentioned in the literature of Upper Kama architecture examination.

But province had been under the influence of baroque for a long time despite the fact that in Moscow and in St-Petersburg formation of classicism took place in the second half of the 18th century. In Totma, Great Ustyug, in Vятka region, Siberia and Urals provincial schools of baroque have been marked out<sup>3</sup>. Urals baroque was developed in the architecture of the Solikamsk John the Forerunner Krasnoselsky

<sup>2</sup> Goldstein (1979), *The Architecture*.

<sup>3</sup> Kuptikov (2011), *Solychegodsk Churches*.



convent and in some churches of Sverdlovsk district. Stroganov architectural school or “Stroganov style” is considered to be the separate branch of “Moscow baroque<sup>4</sup>. The most noticeable features of Stroganov baroque can be found in the architecture of the Church in the name of the Kazan icon of the Mother of God in Ustyug, Vologda district (1694).

Kazan church is one of five cathedrals of “Stroganov’s” baroque. Its building is differed by traditional for the Russian cathedrals five-domed silhouette which is covered with magnificent white stone baroque décor. Over the low one-storey aisles playing the role of stylobate well-proportioned content of the main church is raised. Application of order in façades decoration and their completion by fractured sash pediments add “Italianized” baroque view to the building. But traditional five-domed type determined by the faceted double-deck dome drums betray the hand of the architect educated in the frames of the native architectural school and studied attentively the examples of the Western European baroque. Against the background of dark-brown, “brick-colored” walls white-stone columns and window cases, volutes and cables crowning the facades of icon-cases are distinguished effectively.

The peculiarities of construction and architectural décor of the Kazan Church are similar to the other Stroganovs’ cathedrals of the end of the 17th century – the Cathedral of the Presentation Monastery in Solvychegodsk (1688-1697), the Church of Smolenskaya Mother of God in Gordeevka (1694-1697). Octagonal domes crowned with the “bloomed” crosses are put on the two-level octagonal dome drums worked with raised panels and bordered by cornices of complex configuration. The main motif of décor is the vine – symbol of the New Testament Church.

The typical example of the Stroganov’s baroque is the Church of the Synaxis of the Most Holy Theotokos in Nizhny Novgorod (1697-1703). The elements of décor of this Church could be found in décor of the Cathedral of the Transfiguration of the Savior (1724) in Usolye.

In the territory of Upper Kama there are 44 churches in baroque style. The most preserved are the Cathedral of the Transfiguration of the Savior and the bell-tower in Usolye (1730), Dormitory Church



Fig. 05

**Baroque in Orel**  
Usolye region. Church of the Praise of the Holy Mother. 1735.

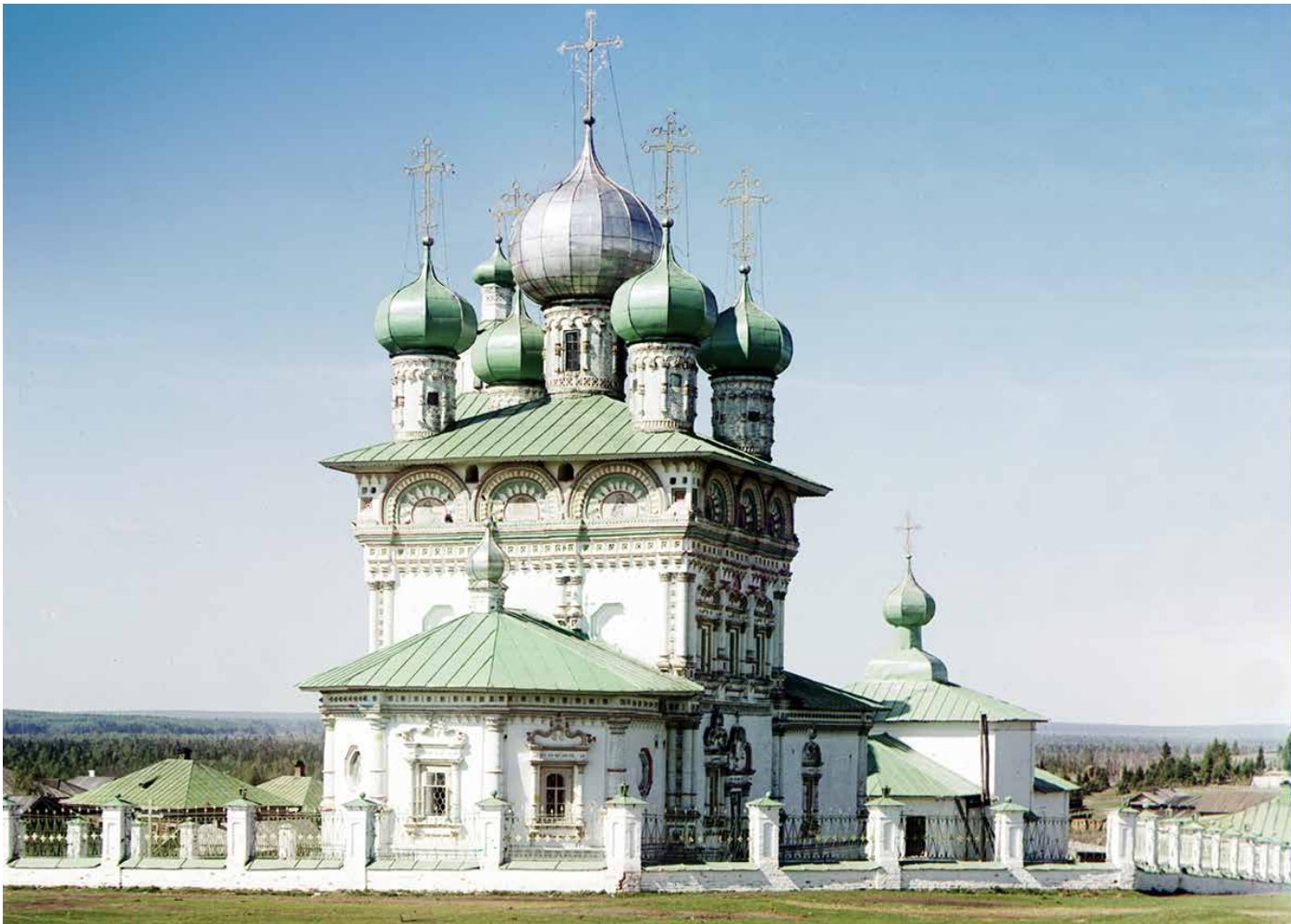


Fig. 06

**Examples of Ural baroque**  
Trinity Cathedral in Osa, Perm region. Architect A. B. Turchevich, 1916 (Image from: <http://sobory.ru/article/?object=08390>). On the right, Church of the St. Peter and St. Paul in Severouralsk, Sverdlosk district.



<sup>4</sup> Cf. Kuptikov (2011), *Solvychegodsk Churches*; Braitseva (1977), *Stroganov buildings*.



↑  
 Fig. 07  
**Nyrob, Church of St. Nicholas**  
 Photograph by Sergey  
 Prokudin-Gorsky, c. 1907–  
 1913 (Image from: [https://commons.wikimedia.org/wiki/File:Gorskii\\_20670u.jpg](https://commons.wikimedia.org/wiki/File:Gorskii_20670u.jpg))

(1784-1845) in Cherdyn, Church of the St. Nikolas the Wonderworker (1704) in Nyrob, and Church of the Praise of the Holy Mother in Orel.

The typical combination of the Urals baroque and provincial classicism of the 19th century is the Church of the St. Peter and St. Paul in Severouralsk, Sverdlovsk district (1787-1798).

Two first tiers of the church are constructed in baroque style. The exterior finish of center forms are made with special fashioned brick. Three-level bell-tower is constructed in classic Russian style and includes feebly marked elements: octagon on quadrangle.

Similar combination of styles was occurred in the Church of the Nativity of Christ in Verkhnechusokie Gorodki (Perm Krai). Today this church is lost.

The churches in the style of classicism are preserved mainly in the middle and south Urals, in Sverdlovsk and Kurgan districts. In the architecture of Perm Krai classicism is presented quite poorly. Only two churches have preserved: the Church of the St. Nikolas the Wonderworker in Usolye (1820) the author of which is supposedly the prominent Russian architect A.N. Voronikhin; and the Church of Michael the Archangel in Ocher (1830-1835). The second half of the 19th – the beginning of the 20th centuries is characterized by different architectural styles.



The reflection of the Russian-Byzantine style, Old Russian buildings of the 17th century, eclecticism and modern is possible to meet in historical part of Perm.

Several churches in the territory of Upper Kama are considered to be the objects of the so called retrospectivism – the direction of architecture in the first half of the 20th century. This direction was based on the examination of architectural heritage of the previous epochs – from Renaissance and Old Russian architecture to classicism, eclecticism and modern. The typical example is the Holy Trinity Cathedral in Osinsky region of Perm Krai constructed by the well-know Perm architect A.B. Turchevich in 1916.

Retrospectivism is the worldwide but at that deeply national phenomenon. Some professionals treat it as neoclassicism – the architectural direction of pre-revolutionary years (1900-1917). This school appeared due to the turning to the Russian classicism of the end of the 18th and the first third of the 19th centuries.

In Upper Kama this direction is presented by the Church of St.Peter and St.Paul in Taman settlement of Usolye region (1912) and Church of Annunciation in Pokcha settlement of Cherdyn region (1910 - bell tower and reconstruction of the church).



Fig. 08

**A landscape baroque**

The Church of the Nativity of Christ in Verkhnie Gorodki settlement.

Photo by S.M. Prokudin-Gorsky, 1912 (Original: <http://dn.loc.gov/service/pnp/prokcl/20700/20712v.jpg>).

Upper Kama architecture, influenced by specific local conditions (natural, historical, economic, ethnic, etc.), emerged as a unique phenomenon at the crossroads of different cultures. In addition to the developing industry, mainly the mining and construction, the influence of metropolitan trends brought by western merchants was also determined by the artistic traditions of the Russian North and Central Russia.

Tangible and intangible heritage of the cross-cultural origin of the region is still widely present along the Upper Kama. Usoleye together with Cherdyn' and Solikamsk are three main elements in the urban structure of historic Upper Kama localities. These three towns represent the best examples of cross-cultural integration, each being authentic and forming a cultural code of Prikamye identity. magnificent white stone baroque décor. Over the low one-storey aisles playing the role of stylobate well-proportioned content of the main church is raised. Application of order in façades decoration and their completion by fractured sash pediments add "Italianized" baroque view to the building. But traditional five-domed type determined by the faceted double-deck dome drums betray the hand of the architect educated in the frames of the native architectural school and studied attentively the examples of the Western European baroque. Against the background of dark-brown, "brick-colored" walls white-stone columns and window cases, volutes and cables crowning the facades of icon-cases are distinguished effectively.



**Fig. 09**  
**Cherdyn, northeast view from the water tower, 1912**  
 Early colour photograph by Sergey Prokudin-Gorsky (Image from: William Brumfield, *Cherdyn: In the shadows of the Romanovs*, GW2RU Travel, 28 September 2024, <https://www.gw2ru.com/travel/3082-cherdyn-shadows-romanovs>).



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## SIGNS, TRACES AND DRAWINGS OF AN ARCHITECTURE THAT GOES BEYOND THE CENTURIES

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The Upper Kama Region is an emblematic site where monumental architectures and widespread criticalities coexist: heterogeneity of architectural features, stylistic and constructive variety, multiplicity of construction materials and related pathologies of degradation and conservation. This characterizes Upper Kama basin as a dispersed system of potential cultural value added to the territorial context, explicable through a targeted system of knowledge, intervention and promotion. The territory extends in the north of Perm Krai, west of Ural Mountains, bounded by Komi region in the North. Mineral resources and the role of commercial crossroads of imperial period has led the territory to an intense cultural and architectural development focused between the 15th century, with first industrial settlements, and the 18th century, till the rapid decline of Russian October Revolution (1917).

The territory rich in mineral sources, wood and peltry, located in the strategically important point on Kama River, which flows into Caspian Sea and provides a commercial trade link with Middle East, was chosen for salt-production industry establishment. The most important ancient trading routes between Western Europe and the Russian Plains with taiga regions and countries of the Far East went through Perm the Great, the territory of present Upper Kama. As early as in X-XI centuries Perm the Great had trade and cultural ties with the Volga Bulgaria, Byzantium, Iraq, and Asia Minor.

Due to the geographical position representing the frontier between Europe and Asia, the region was a key point in the system of trade links between East and West that contributed to its economic development and prosperity.

The founding of salt pans by merchant families, such as Stroganovs or Golitsyns, led to the development of urban settlements with residential buildings and orthodox complexes, churches, bell towers and

*Side page, Fig. 01*  
**Church Façade and Bell Tower**

The front elevation, with the bell tower rising above the entrance portal of the now-ruined Rubezhskaya Church. The building is one of the most evocative within the Usolye enclosure, as it preserves its original character, with numerous traces of construction systems and floor structures still clearly visible. (Drawing credit: Sandro Parrinello)



*Fig. 02*  
**The Khokhlovka Open-Air Museum Complex**

The monumental complex of the Khokhlovka open-air museum, featuring a collection of traditional wooden architecture set within a reconstructed historical landscape. (Drawing credit: Sandro Parrinello)





*Above and side page, Figs. 03, 05*  
**Drawing Exercises and Line Definition**

Drawing exercises aimed at defining a graphic line capable of conveying the character of these architectures.

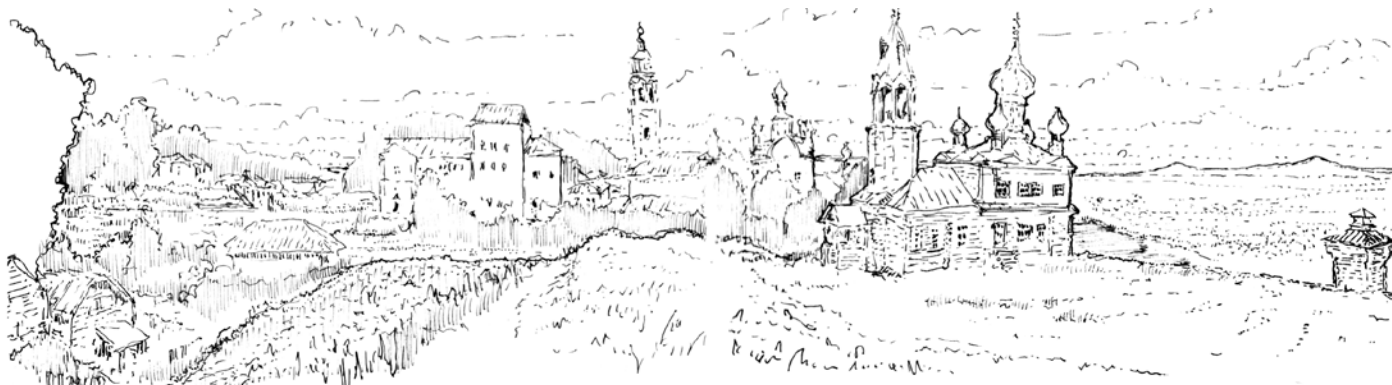
In particular, the progression from the first drawing in 2011 to the most recent sketches produced during the study trips of the Prometheus project. (Drawing credit: Sandro Parrinello)

*Below and side page, Figs. 04, 06*  
**Between Building and Landscape**

Within the drawings, the scale of the building coexists with that of the territory, defining iconemes and graphic signs that contribute to narrating the research experience. (Drawing credit: Sandro Parrinello)

family chapels. Salt trading business, that through Urals reached Siberia and, then, China, led to the spread of numerous urban centers, associated to current districts; Solikamsk (1430), Cherdyn (1535) and Usole (1606). The archival documents show that the stone construction in Kama region dates back to the beginning of the XVII century. Initially, mainly religious buildings and residential properties for nobility were built from stone (brick) in a form of separate facilities, and later, other architectural complexes appeared. Local craftsmen used not only ordinary brick, but also hewn and molded brick, multi-colored glazed tiles, and glazed clay shingles intrinsic for the region.

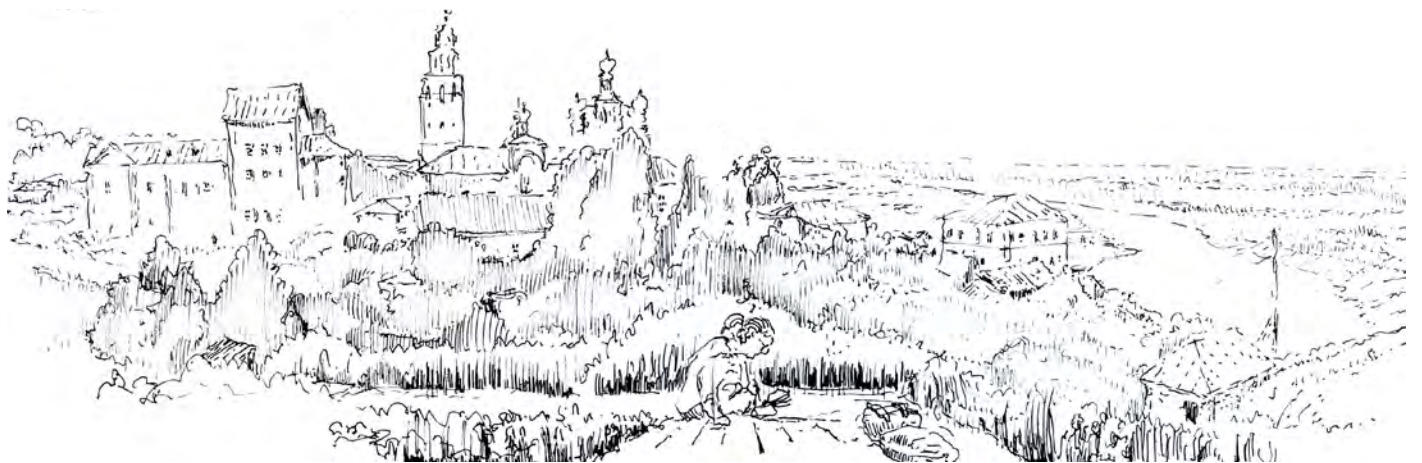
Architecture of the region represents a cross-cultural phenomenon that appeared due to the interaction of Western and Oriental cultures on that specific territory. The area of Upper Kama represents a unique territory known for being one of the main baronies of Stroganov family in Russia. There are several towns in Upper Kama area that comprise the frame of the architectural heritage of the region appeared in the XVII-XX centuries and representing the age of salt-production prosperity.





The comparative study of sites highlights stylistic coherence and unitary shapes and themes, related to each other. Masonry buildings, characterized by a mixed style between Muscovite baroque and European influences, gradually replaced the typical wooden architecture of industrial settlements. Monumental sites and isolated religious architectures enriched the landscape along the river basin, characterized by stylistic uniformity in decorative brick elements, such as frames with “zuchkov” motif and majolica theme of “sirens”.

The style of Stroganov Baroque derived from Moscow Baroque, which remained the main architectural style in Russia during XVII-XVIII centuries. From the most radical monuments of the Moscow Baroque, Stroganov’s constructions are distinguished by the preservation of the five-domed silhouette, traditional for the Russian church, on which an extremely magnificent and fractional, as if created by hand, baroque decoration is produced. The style is only characteristic of the constructions built by the order of the merchant Grigory D. Stroganov in the baronies (Solvychevodsk, Ustujna, Gordeevka,





Nizniy Novgorod, Nyrob and Usolye), mostly religious buildings. In fact, the only Stroganov Baroque civil construction, the Stroganov Chambers is retained in Usolye. Many churches have a main space covered by onion domes with a large entrance refectory, while bell towers have an octagonal plan section, surmounted by thin pinnacles, with semi-circular “zakomary” covered in colored ceramic tiles. Residential buildings are divided into two main types: winter residences, characterized by wooden roofs with trusses, separated entrance compartments and decorated stoves; and summer residences, with similar constructive technologies but stylistically simpler and more contained.

Architectural heritage of Upper Kama derives by a localized cultural development contained in a limited historical duration, with European influences in constructive and stylistic characteristics, spread through cultural exchanges along commercial routes. The region consisted in numerous sites interconnected by a unified historical, architectural and stylistic language that distinguishes the territory as a unique cultural basin, requiring equally unified practices of study, expression and communication.



Above and side page, Figs. 07-12  
**Colour and Visual Tension**  
 Colour follows a similar process in defining visual tensions and characteristics that qualify the image of the landscape. Colours are schematised and simplified to achieve a narrative effectiveness that will later be integrated into digital models. (Drawing credit: Sandro Parrinello)



The decline of Upper Kama region, due to the collapse of middle-class society, at the beginning of the 20th century, left its architectural heritage to decay. The opening of railway lines decentralized the districts with respect to new commercial routes, and development plans of Kama River involved widespread flooding of many settlements and sites, reducing to one third of the original the existing heritage. The need of a unified digital documentation, in support of administrative management and conservation practices, reflects the definition of complex databases rich in information models libraries on constructive elements typical of Upper Kama architecture.

In terms of historic aspect the Upper Kama Region has always been of great interest for study. At the national level there has been a profound research done focusing on the historic evolution of Upper Kama territory, providing paper archives, photographic documentation and state of preservation of the architectural site. Well-known Russian art historians A.S. Teryohin, G.D. Kantorovich and I.V. Makovetsky provided the most important contribution to this research and presented their work on culture and architecture of Upper Kama localities in the monograph *Monuments of stone architecture of XVI-XVIII in Solikamsk (1970)*.



In 1988 V.V. Kostochkin, Moscow-based historian and architect wrote a monograph entitled “Cherdyn’. Solikamsk. Usolye” integrating all the previous research activities on the region demonstrating the peculiarities of traditional architecture, restoration and reconstruction projects made for the area. As a result of historic findings the set of documentary and graphic materials was collected featuring archival records dated XVIII and XIX centuries including first graphic representation of Usolye.

In the XX century Perm Scientific Restoration Atelier carried out inventories, documentations, surveys, conservation and restoration projects for the Upper Kama region. The census conducted by the Perm Scientific Restoration Atelier in 1986 provided reliable data about the majority of existing monuments of the architectural complex in Usolye. In the second half of the XX century V.A. Tsypushtanov has contributed to the development of Usolye conservation measures as a local art historian. Recently, the representation study of the Upper Kama architecture was conducted by W. Brumfield in a form of photographic survey<sup>1</sup>.

The Upper Kama Region stands as a testament to the intersection of architectural brilliance and the challenges of preservation. Its historical and cultural richness, shaped by centuries of interaction between Eastern and Western influences, positions the area as a unique repository of architectural heritage. The Stroganov Baroque, with its intricate motifs and fusion of Muscovite and European styles, epitomizes the region’s artistic and structural achievements, while the monumental stone churches, bell towers, and merchant family estates highlight the wealth and ambition of its salt-trading past. This distinctive architectural language not only reflects the cultural exchange fostered by the region’s strategic position on the Kama River but also underscores its historical significance as a hub of trade, production, and artistic development.

However, the region’s decline following the 20th-century socio-economic upheavals has left much of its heritage vulnerable. The opening of railway lines and subsequent shifts in trade routes marginalized these historic settlements, while industrial development and widespread flooding further exacerbated the loss of architectural treasures. Today, the remnants of this once-thriving cultural landscape face the dual threats of natural degradation and neglect, highlighting an urgent need for conservation efforts. To address these challenges, the integration of modern digital tools offers a promising path forward. Comprehensive digital documentation, employing advanced techniques such as 3D modeling and information-rich databases, can facilitate the effective management, restoration, and promotion of Upper Kama’s architectural heritage. By creating detailed inventories of construction elements and stylistic features unique to the region, stakeholders can ensure that restoration projects remain true to the original designs while fostering a deeper appreciation for this cultural legacy.

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<sup>1</sup> Brumfield (2007), *Cherdyn: Architectural Heritage in Photographs*; Id. (2007), *Solikamsk: Architectural Heritage in Photographs*; Id. (2007), *Usolye: Architectural Heritage in Photographs*.

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# Methodology and tools of architectural survey



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# TERRESTRIAL LASER SCANNER FOR CERTIFIED ACQUISITION OF ARCHITECTURAL DATA

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## Criteria and potentiality of laser scanners for the survey of historical heritage

The development of integrated databases on architectural heritage survey inevitably passes through the requirement of certification of the acquired data, in terms of both reliability to the “real” configuration of conservation and architectural status and in terms of completeness and management of documentation data.

In particular, the metric component is confirmed as primary information, even if not exhaustive, required to start the architectural analysis approach. It is applied to define the documentary base to which referencing the complete database of data, upgraded of metric, historical and landscape features, necessary for the global understanding of the built site.

In these terms, the adoption of a metric surveying methodology implemented with Terrestrial Laser Scanner (TLS) instrumentation presents itself as a strategy capable of providing an adequate dimensional basis for the structuring and certification of the metric database and of the supplementary photographic, critical and census data, acquirable on architectural and territorial components. The choice is made with the awareness of the need for fast-operability and adaptability required to the digital survey, to decline to the many spatial and morphological configurations of the wide historical-architectural catalogue of Upper Kama sites. In particular, their complexity is due to the stylistic variety (from Baroque Stroganov to the Twentieth Century restorations) and architectural distribution, found within blocks, environments and apparatuses belonging to the built complexes diffused on territory<sup>1</sup>. The parameters and capabilities of laser scanner instrumentation, applied for documentation and preservation of Orthodox churches and cathedrals, demonstrate competitiveness compared to traditional measurement techniques in terms of accuracy, automation and velocity, with an increase in speed and acquisition capacity of points, respect to the topographic procedures, in the order of 700,000 points/sec, with a reliability defined by the error range of  $\pm 1$  mm and a measurement density increased to the millimetric fraction.

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<sup>1</sup> The characteristic configuration of the historical built sites of Upper Kama is mainly due to the monumental “enclosure”, divided into different architectural blocks: summer cathedral, winter church, sacristy, bell tower in religious contexts; residential palace, warehouses and chapel or family church in private/productive context. Moreover, for each site, the distribution of the environments varies between double-cased rooms, double-vaulted systems, false towers and onion domes with an ephemeral wooden structure. The same decorations can constitute overlapping finishing levels, in wooden strips, overlapped to the main structures in Blockbau, or wall reliefs, with formal varieties and layouts of the brick blocks in the realization of the external masonry walls.



**Fig.02**  
**Acquisition set for Terrestrial Laser Scanner applied in Upper Kama site during 2018 and 2019 on site campaigns**  
 Wider opportunities of documentation on the morphometric character at the urban, architectural and constructive scale by the operators of the international team on both conserved sites and ruins.

The constant progress of models and technologies has also led to an increase in TLS characteristics and compatibility of data, integrated by the joint measurements of a wide range of sensors and units aimed at improving the quality and management of metric information both in the processes of origin that in post-production phase<sup>2</sup>. This is the case of instrumental integration with Global Positioning System (GPS) sensors, calibrated for both latitude/longitude, UTM position and altitude, compass for the orientation of Nordic axis, and inclinometer, thus also compensating to operational error attributable to the manual topographic adjustment in tripods of laser scanners. In addition to sensor integration, not variable in time and acquisition methods, further characterizations of metric data are defined with a colorimetric component, developed in a medium-fast process through acquisition modalities associated with the measurements of Scan Stations. The photographic acquisition allows to be operated in a consecutive way to the measurement stage, with photographic cameras integrated to the scanner, using resolutions increased up to 165 megapixels and High Dynamic Range (HDR) mode set in semi-automatic variable; photographic parameters are optimized with the balancing of colour on priority bands of acquisition of space and objects.

### **Methodologies and parameters of certified TLS point clouds for architectural analysis**

The calibration of laser scanner survey, nowadays enlarged by the wide variety of sensors and acquisition parameters made available by the instrumental production, must not however detach itself from the purpose of the requested metric products. Even if the integration with photographic material and census is planned at the beginning of the architectural documentation procedures, the objective of laser scanner methodology is still to guarantee itself optimal and primary features of documentation, to define a gold standard for the certification and integration of the other data.

Side page Fig.03

**Quality of data correspondence**  
 Instrumental operability and technical features of terrestrial static laser scanners applied during Upper Kama surveys (Leica Scanstation C10 and FARO S150).

<sup>2</sup>The major procedural innovation concerns the registration algorithms used by the main TLS scanning management platforms, to produce unified 3D point clouds. The need for Reference Points identified by specific graphic targets placed on site (Black & White, spherical, reflective) is now superseded by Visual Registration methods. Cloud-to-cloud registration is developed with a wide matching calculation mediated on the totality of the superficial data, through a first positioning of the scans using the information of TLS sensors (GPS, UTM, compass), and then a subsequent optimization of the specific metric correspondence.

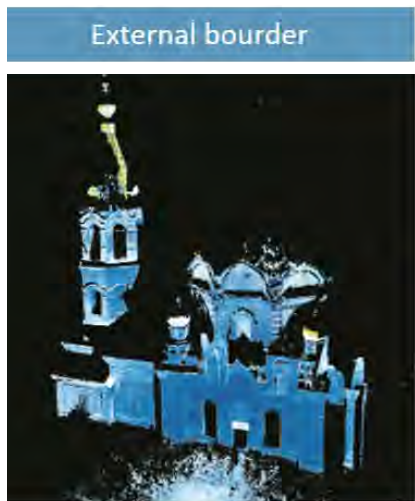


Laser Scanner LEICA Scanstation C10

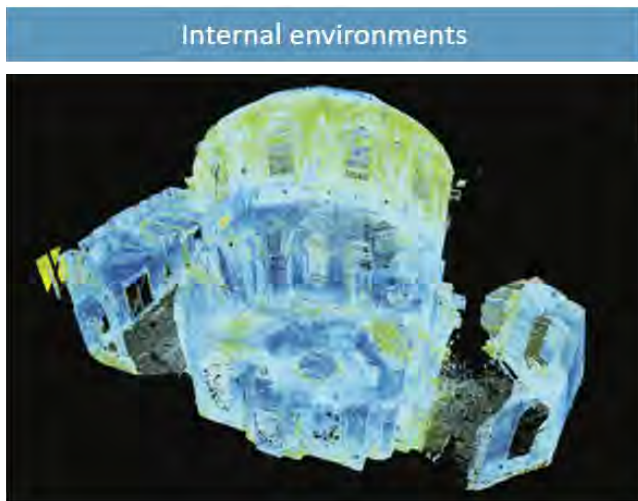
Laser Scanning System	
Type	Pulsed; proprietary microchip
Color	Green, wavelength = 532 nm visible
Laser Class	3R (IEC 60825-1)
Range	300 m @ 90%; 134 m @ 18% albedo (minimum range 0.1 m)
Scan rate	Up to 50,000 points/sec, maximum instantaneous rate
Scan resolution	
Spot size	From 0 – 50 m: 4.5 mm (FWHH-based); 7 mm (Gaussian-based)
Point spacing	Fully selectable horizontal and vertical; < 1 mm minimum spacing, through full range; single point dwell capacity
Field-of-View	
Horizontal	360° (maximum)
Vertical	270° (maximum)
Aiming/Sighting	Parallax-free, integrated zoom video
Accuracy of single measurement	
Position*	6 mm
Distance*	4 mm
Angle (horizontal/vertical)	60 µrad / 60 µrad (12° / 12°)
Modeled surface precision**/noise	2 mm
Target acquisition***	2 mm std. deviation

Scanner Faro focus S150

Measurement speed (pts/sec):	122,000 / 244,000 / 488,000 / 976,000
Ranging error <sup>1</sup> :	±1mm
Angular accuracy <sup>2</sup> :	19 arcsec for vertical/horizontal angles
3D position accuracy <sup>3</sup> :	10m: 2mm / 25m: 3.5mm
Color unit	
Resolution:	Up to 165 megapixel color
High Dynamic Range (HDR):	Exposure Bracketing 2x, 3x, 5x
Parallax:	Minimized due to co-axial design



External boulder



Internal environments



Density of acquired points



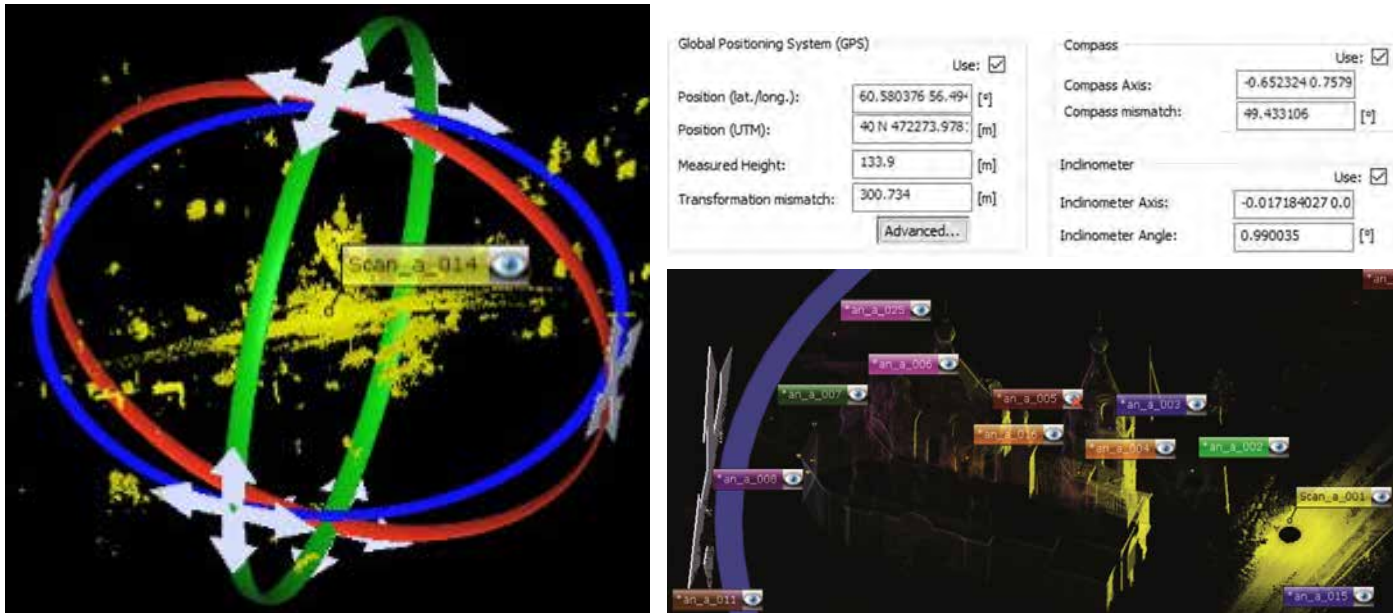


Fig.04  
**Workflow of management and alignment of Scan data into referenced Scan Worlds**  
 Scans are primarily set with their acquired metadata of GPS, compass and inclinometer, and then they can be moved in the virtual space to better be fitted and aligned each other, containing the error of deviation between the single partial clouds.

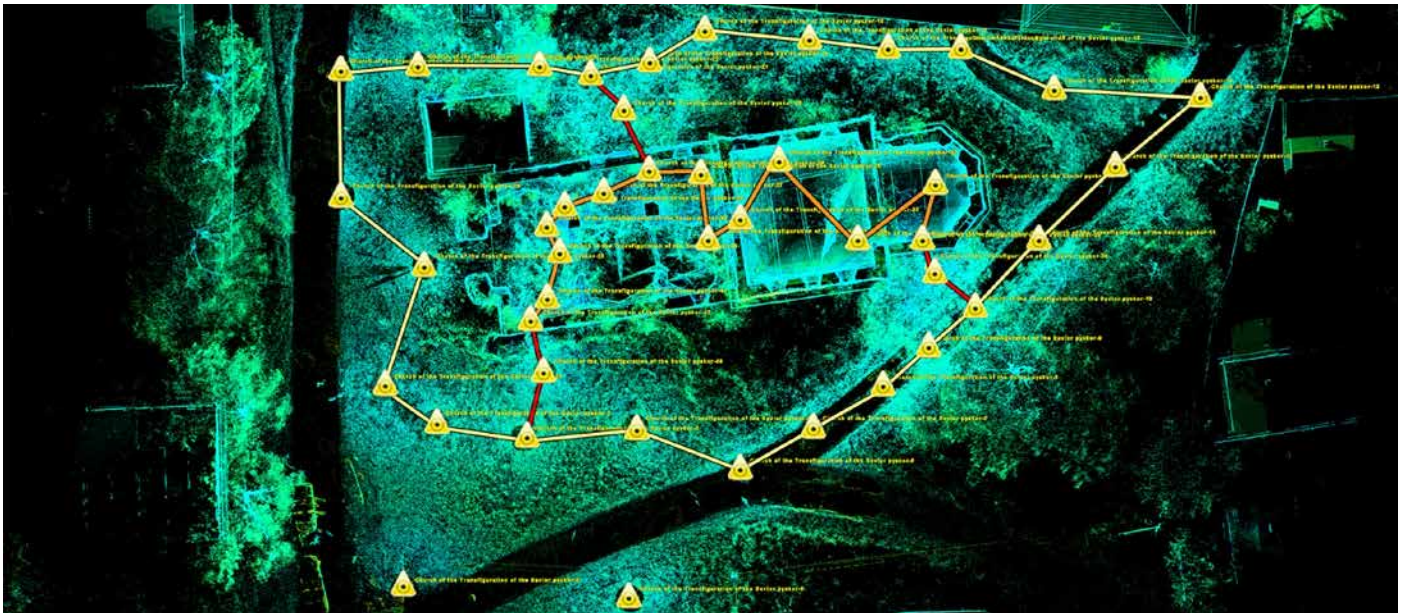
It is possible to classify primary evaluation parameters considered in TLS survey, developing a procedural code of operational evaluation that is preliminary to metric acquisition. This is intended to be previously developed, in function of considerations relating to procedures of post-production of point-clouds envisaged in the overall documentation campaign on the architectural monuments.

The Range survey is characterized primarily in terms of “shape”, which evolves, from the visual perception into the site, in a methodological criterion of architectural understanding for the acquisition project. The acquisition campaign is programmed precisely according to the specific morphological reality, where the formal complexity of historical paraments, environments, frames and covers is both a visual obstacle and a criterion of manifoldng Scan Stations, as an increased parameter of formal correspondence for the overlapping and cloud-to-cloud registration of individual scans.

In the same way, the “surface range” of the point cloud defines the close correlation between the density of scanner acquisition and the processing and reading capabilities of surfaces’ metric properties. This is central both in the level of three-dimensional graphic detail, provided in correspondence of portions of high decorative and constructive complexity, that in the qualitative and quantitative analysis of materials and mechanical characteristics of the states of conservation and instability of stone, brick and wooden masonry structures.

Finally, considerations on “reflectance” lead to appropriate estimations both of materic analysis and technical specifics of the instrument itself, evaluating opportunities and critical aspects in the relationship between the laser beam and the architectural surfaces. The digital acquisition of architectural apparatuses, from plastered or exposed materials and with different reflective properties of degraded surfaces, is thus configured to guarantee qualitative reading properties of point clouds that do not compromise the metric quality of data and that are already preliminary to the reporting of widespread and localized criticalities for detailed photographic integrations.

Side page (above) Fig.05  
**Poligonal paths in laser scanning acquisition**  
 It ensures total coverage of morphological data and metric correspondence of alignment between exteriors and interiors ScanWorlds within connection Scans.



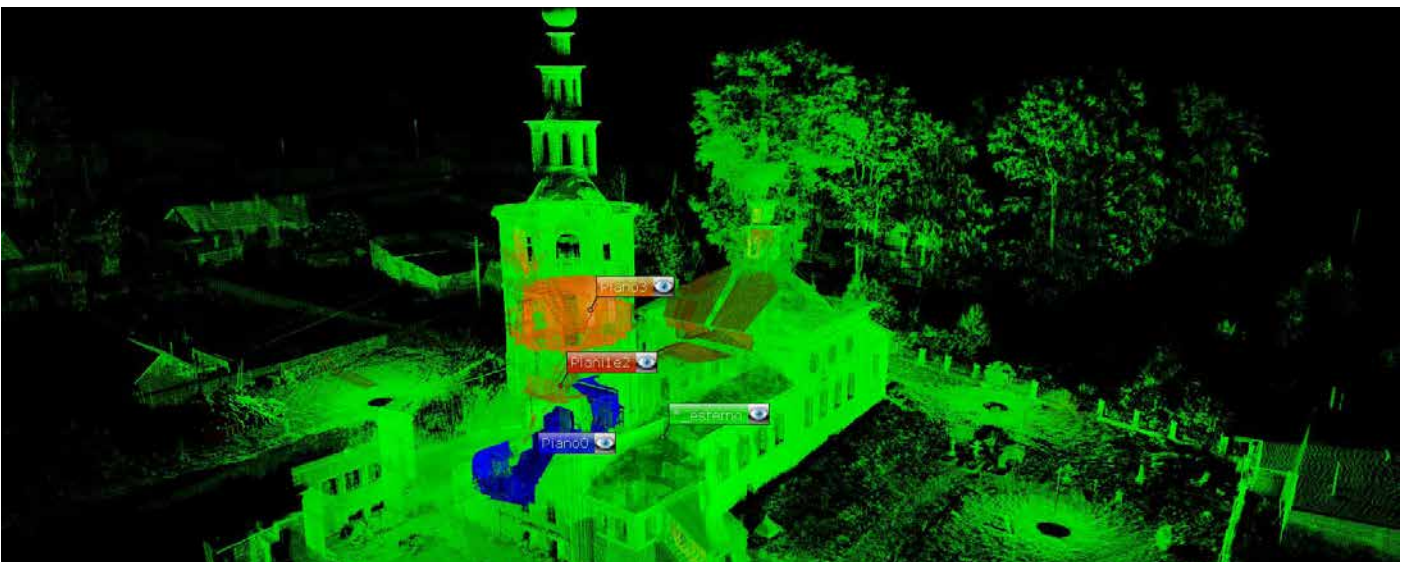
### Considerations on objectives, methods and quality of past and present experiences of laser scanner documentation on Usoley and Cherdyn heritage

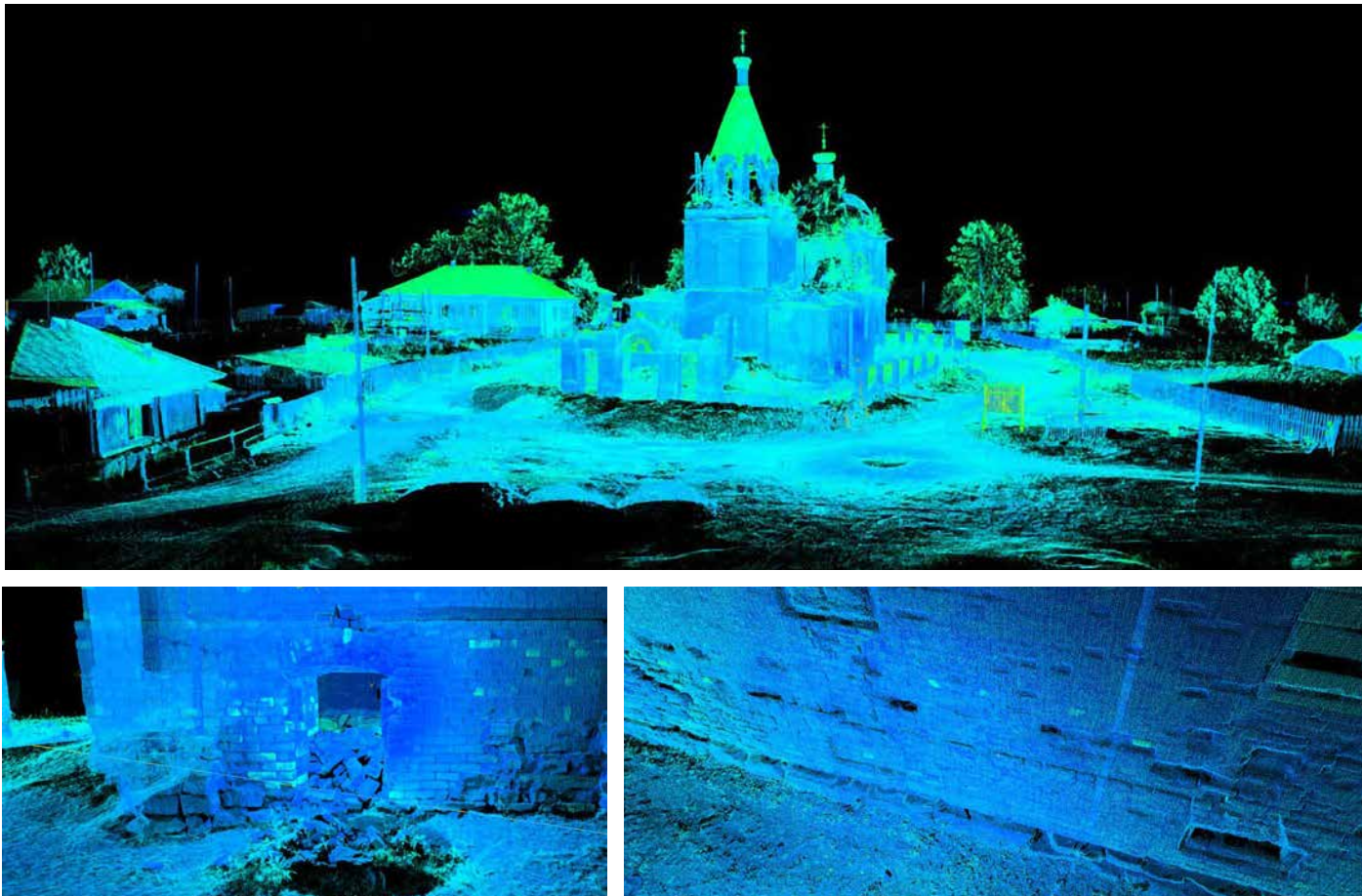
With the development of information technologies in the sphere of architecture and construction design, the transformation of architectural survey techniques has been taken place. Classical approach has undergone drastic modification in tools application; location measurement and photo fixation have been changed by such technologies as photogrammetry and laser scanning have high accuracy and make possible to reduce considerably the time of execution of works. Laser scanning systems (LSS) are nowadays the most effective instruments for object geometry data collection. The result of the laser scanner operation is the point cloud (the collection of points with three-dimensional coordinates).



**Fig.06**  
**Macroblocks of registration and control in the alignment of laser scanner data**

The alignment organized by clusters supports the management of workflow computing in the reduction of deviation error, with an increased control in spatial data of subdivided environments, as in the case of bell tower's floors connected to the main spaces of the church (Solikamsk district).





**Fig.07**  
**Point cloud of Bondjug site**  
**(Cherdyn district) in Intensity**  
**map visualisation**

The visualisation mode shows the reflectance parameter acquired by laser scanner, characterising the morphometric quality of the distribution of points, extended from the monument to the border of its influence area on the surrounding settlement and landscape.

Due to the high rate of Terrestrial Laser Scanner operation, the necessity of selective survey is fallen away. In short periods of time the most complete and true information about the current geometry of object could be obtained by the application of LSS. The higher the density of point's clouds, the more detailed and informative is the model. The discrete model gives the full realistic view of the research object on conditions that the scanning system is equipped with the high-resolution camera.

Discrete model is the stitched point cloud from all stations of laser scanner standing. This model provides the solution of the tasks:

1. Execution of measuring works including the places of complicated access;
2. Obtaining the measuring diagram of facades (floor plans, longitudinal plans, roof plans, walls scan, drawing of décor) at scales of 1:50 - 1:200 with mapping of actual dimensions, elevation marks of different elements of building or structure with indication of the design values deflection;
3. Localization of faults by means of comparison with the project model;
4. Obtaining the most accurate dimensional parameters of irregular architectural shapes;
5. Definition and estimation of deformation values by means of their comparison with the earlier made instrumentation (monitoring);
6. Making of accurate three-dimensional models.



*Fig. 08*

**Point cloud views in Leica Cyclone software of Upper Kama monuments**

Above, workspaces of management and interaction with the discontinuous databases of point clouds. The availability of software tools to orbitate, section and navigate into the virtual space enable the database to interact as a 'discrete' model of the scene, for primary opportunities of analysis regarding geometrical and spatial features of the architectural and landscape site. Point cloud of Taman site (Usolye district) in Colour map visualisation. The RGB photographic data acquired by the laser scanner is particularly descriptive in case of coating apparatuses, frescoes, decorations or superficial pathologies of decay, where the colorimetric data adds a fundamental information of mapping to the morpho-metric data.



**Fig.09**  
Global archive of ScanWorlds for different sites in Upper Kama survey documentation  
Point clouds strategy of acquisition as considered the different availability of access to monument's space (interiors and exteriors inside the fences) and the complexity of surrounding environment (alone standing in the forest or in the middle of villages and cities).

**Fig.10**  
Summary table of the databases and outputs produced during the summer schools and survey activities

Technology of terrestrial laser scanning involves two main stages: field (survey of the object) and office analysis of field observation results. Field stage includes the next steps:

- Making the sketch map of stations' arrangement;
- Placing of the scanning station in the design spot;
- Placement of marks for stitching workstations of scanning;
- Scanning of terrain and objects around the point of scanner standing and digital survey by integrated high-resolution camera;
- Scanning of marks;
- Dislocation of scanning station to the next point.

The average number of stations on one object scanning, considering only façades but not the internal layout design, is 10-14. This number depends on the façades complexity, extent and height.

Comparing to traditional methods of measuring (handle measuring and sketching) from field survey by means of laser scanning, it considerably reduces the time of work and makes possible to avoid

Site	Point Cloud		2D Drawings		3D model discrete	3D model polygon	Prototype
	Exterior	Interior	Plan	Elevation Section			
Stroganovs Chambers building (Usolye)	X			X	X		
The Church of the Transfiguration of the Savior (Usolye)	X	X	X	X	X		
The Bell-tower with bazaar (Usolye)	X	X	X	X	X		
The Manor House (Usolye)	X		X	X	X	X	X
The Golitsyns' estate, 2 buildings (Usolye)	X				X		
Office and archive of the Stroganovs' salt works (Usolye)	X				X		
Tarasov'sprint shop (Usolye)	X				X		
Church of the Assumption of the Blessed Virgin Mary (Cherdyn) (the Uspenskaya church)	X	X	X	X	X	X	
All Saints Church (Cherdyn)	X		X		X		
Church of the Nicholas the Wonderworker (Nyrob)	X	X	X	X	X	X	
Church of the Nativity of Christ (Iskor)	X		X	X	X		
Church of the Presentation of the Virgin in the Temple (Kamgort)	X	X	X	X	X	X	
Church of the Annunciation to the Blessed Virgin Mary (Pokcha)	X	X	X	X	X	X	
Chapel of the protection of the Blessed Virgin (Usolye)	X	X			X		
Rubezhskaya Church (Usolye)	X		X	X	X	X	
Church of the Elevation of the Holy Cross (Bondjug)	X		X	X	X		
Church of the Nicholas the Wonderworker (Uzhginskay)	X				X		
Church of St.Peter and St.Paul (Taman)	X	X	X	X	X	X	

mistakes. At the stage of office work it takes place the field survey data processing. All the results are estimated in terms of their accuracy and further the measurement diagrams are made, and three-dimensional models are constructed. In data processing it is obtained the point cloud with three-dimensional coordinates, the map of points' standing and panoramic imagery of high resolution giving the possibility to gain measurement information.

Three-dimensional model of the object can be supplemented by different attributive information: the type, the material, the time of erection, of repair, of reconstruction, detected defects, the results of structures examination and other characteristics.

In the period of 2015-2018 in the frames of international summer schools, the architectural survey and documentation of the objects of historical-cultural heritage in Usolye, Cherdyn and their regions was carried out.

The methods of terrestrial laser scanning and photogrammetry were applied in the process of survey.

The most work was carried out in historical-architectural museum in Usolye. The most number of monuments were scanned and certificated: the Stroganovs' Chambers, the Church of the Transfiguration of the Savior and the Bell-tower, the Manor House, the Estate of the Golitsyns, the print shop of Tarasov and the adjacent landscapes.

Similar work was started in summer 2018 in the territory of Cherdyn and its region. During the summer period it was scanned the next objects: the Church of Dormition of the Mother of God (Cherdyn), All Saints Church (Cherdyn), the Church of the Nativity of Christ (Iskor), the Church of the Presentation of the Virgin in the Temple (Kamgort), the Church of the Annunciation to the Blessed Virgin Mary (Pokcha), the Church of the Elevation of the Holy Cross (Bodyug), the Church of the Nicholas the Wonderworker (Uzhginskay), the Church of the Nicholas the Wonderworker (Nyrob).

The detailed information about spatial-geometric characteristics of the objects of historical-architectural survey has been the result of the joint work of the universities. Gathering of such information and database forming is the stable foundation for monitoring the state of historical-cultural objects and development of the timely measures on their conservation and reconstruction, which especially concerned the historical object of the far regions of Russia.

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## PHOTOGRAMMETRY FOR THE DOCUMENTATION OF LANDSCAPE AND MONUMENTAL ARCHITECTURE

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The landscape and the issues related to its representation have always been the subjects of numerous investigations in survey and documentations activities. Undertake an analysis of the architectural and landscape heritage of Upper Kama appears necessary to define a system of representation through which to make explicit the heritage identity. For a long time, photography and painting has been considered the privileged means to describe the identity values and the features<sup>1</sup> of the Russian heritage and landscapes, help giving to the image of the landscape its own dignity. The troubles in using these tools are often linked to transposing the material and immaterial aspects that affect a specific context. Representing through drawing or through photography emerges from the need to organize the complexity of the space that surrounds us, to give a common sense, a unique representation to the multitude of information related to a landscape, urban or building context.

The problems related to the documentation for the conservation and maintenance of many historical and rural realities in the Upper Kama region, from small peripheral settlements to the most famous monumental religious complexes, stimulate the desire to experiment with new methods of investigation and representation. The application of photography, associated with a critical analysis of the context, allows to overcome the communicative level given by the output obtainable from each instruments, generating new mode to analyze the space, much more transversal and multidisciplinary, capable of considerably increasing the level of knowledge of specific building or territory.

To recognize the qualities of a complex space and to be able to interpret, analyze and graphically transfer its contents, the space must be considered from a dual perspective. A first perspective implies an aseptic approach to the place, sectioning it, breaking it down, decoding it and thus facilitating its interpretation on the basis of the formal relationships that connect its parts. A second point of view collaborates with those areas that deal with social and anthropological aspects and it is aimed at reconstructing a qualitative image of the place, endowed with those immaterial values that contribute to making it perceive as a highly identifying landscape<sup>2</sup>. Thanks to the recent development of photogrammetry in digital documentation field, this qualitative division of space becomes not only possible, but also necessary, for the purposes of a correct and exhaustive documentation activity of any complex areas<sup>3</sup>.

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<sup>1</sup> Feature is referred to as the constituent quality of the place, according to the theories of Norberg-Schulz (1992), *Genius Loci*.

<sup>2</sup> For a specific understanding of the application of these methodologies of breaking down the territorial structure, cf. Parrinello, Picchio (2014), *Recomposing the landscape*.

<sup>3</sup> Photogrammetry is able to capture all that information thanks to which is possible to describe the environmental qualities of the

*Side page, Fig. 01*

**A picture of Cherdyn landscape**

In the foreground the Cathedral of the Resurrection of Christ; in the background Cherdynsky Monastery of St. John the Theologian. These two monuments are connected by a road clearly visible from the images taken at altitude, which also highlights the relationship with the river landscape.



*Fig. 02*

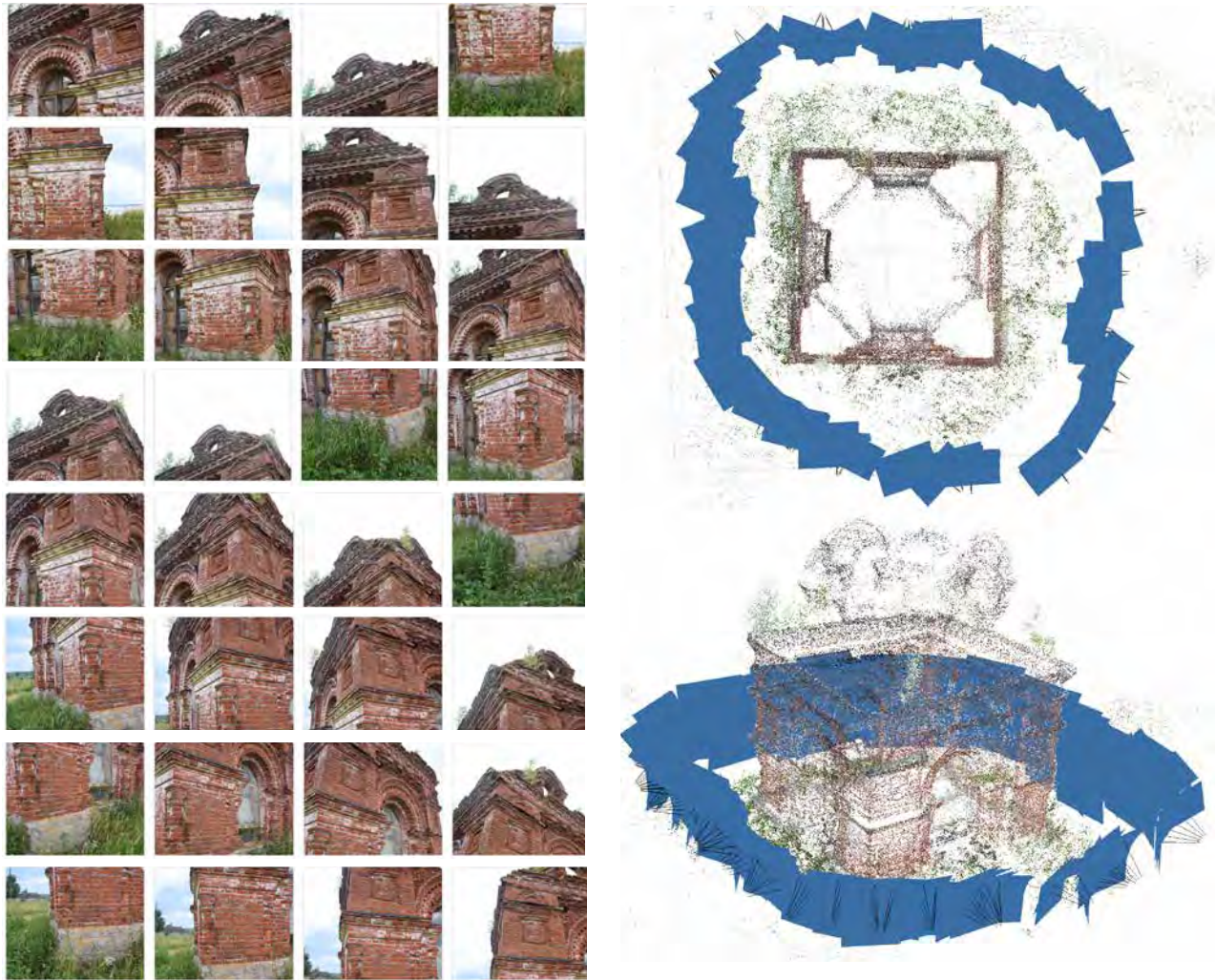
**Dataset of pictures acquired by UAV**

The images were acquired following the logic of photogrammetry techniques: around a geometric axis of the object under investigation, sequences of images are created whose data overlap between each other is at least 70%. These should be realised maintaining the same distance from the object and the same focus.

The photogrammetric survey method experimented during the acquisition campaigns in Upper Kama region is based on the acquisition of 2D images from which to process data to create three-dimensional models and / or virtual prototypes of the investigated space or object. The SfM methodology is able to produce graphic documents that faithfully describe what has been acquired, in a very short time and low instrumental cost, with a verisimilitude to reality that comes very close to the needs of a constitution of a common language in landscape representation<sup>4</sup>. The type of output produced by the

space. Photography, by integrating increasingly sophisticated software and multimedia communication systems, sets out to clearly express the relations between the individual photograph and its orientation within a structure of the place, made increasingly simple and schematic.

<sup>4</sup> Every idea or image of landscape derives from a personal background shaped by the perceptual systems through which each individual assimilates images as part of their own experience, cf. Pandakovic, Dal Sasso (2013), Saper vedere il paesaggio,



application of this method will allow specific investigations to be carried out on the territory, both as regards a hierarchical division of the landscape and for the possibility of analyzing qualitative aspects that emerge from the photographic image.

A first level of knowledge of the site and landscape features is necessary to understand what are the possibilities and critical points, the potential and the limits of the application of this instrumentation and photogrammetric methodology on the field. In fact, the use of the photographic instrument, with respect to other digital instruments, is constrained by external aspects, which force a time schedule to be taken of the acquisition activities in relation to the object to be acquired. Often, these limits



**Fig. 03**  
**Dataset of pictures acquired by SLR**

With a reflex camera operators moved around the object investigated, generating a sequence of pictures which enable photogrammetry software to easily recognise image pairs by generating a pre-alignment of points in space (sparse point cloud).



Fig. 04

#### Double view of the same landscape

The technological potential in landscape description lies in combining ground-based and overhead instruments, capable of representing, thanks to different viewpoints, relationships not visible from either perspective.

Side page, Fig. 06

#### Weather and light conditioning

Images highlighting key issues in photogrammetric acquisition: uneven exposure and disruptive shadows from external elements and between surfaces.



Fig. 05

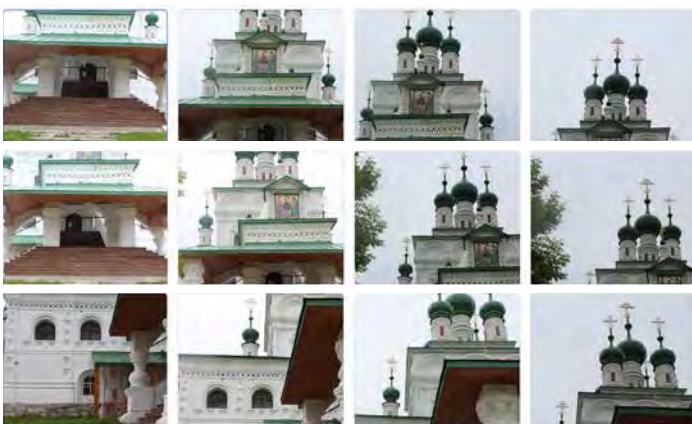
#### Combining of data acquisition

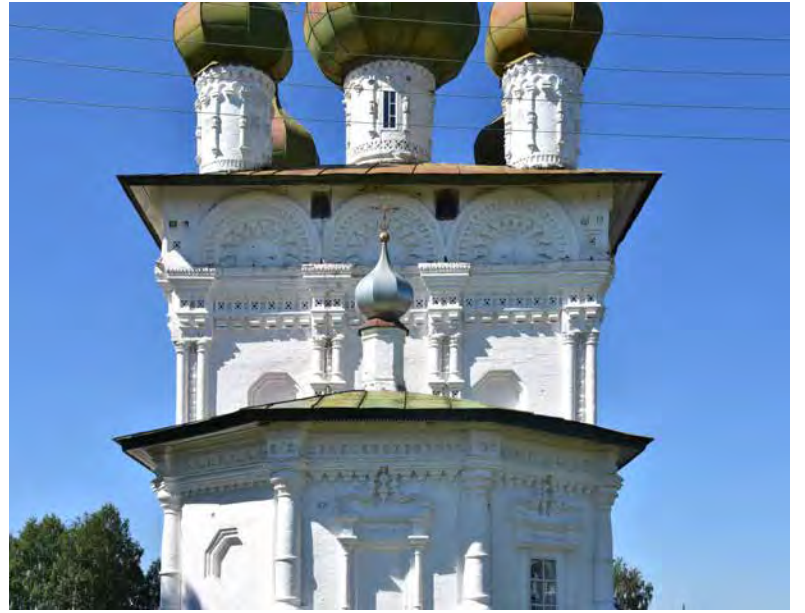
Dataset of pictures acquired by SLR (on the left) and typology of general landscape image acquired by UAV (on the right).

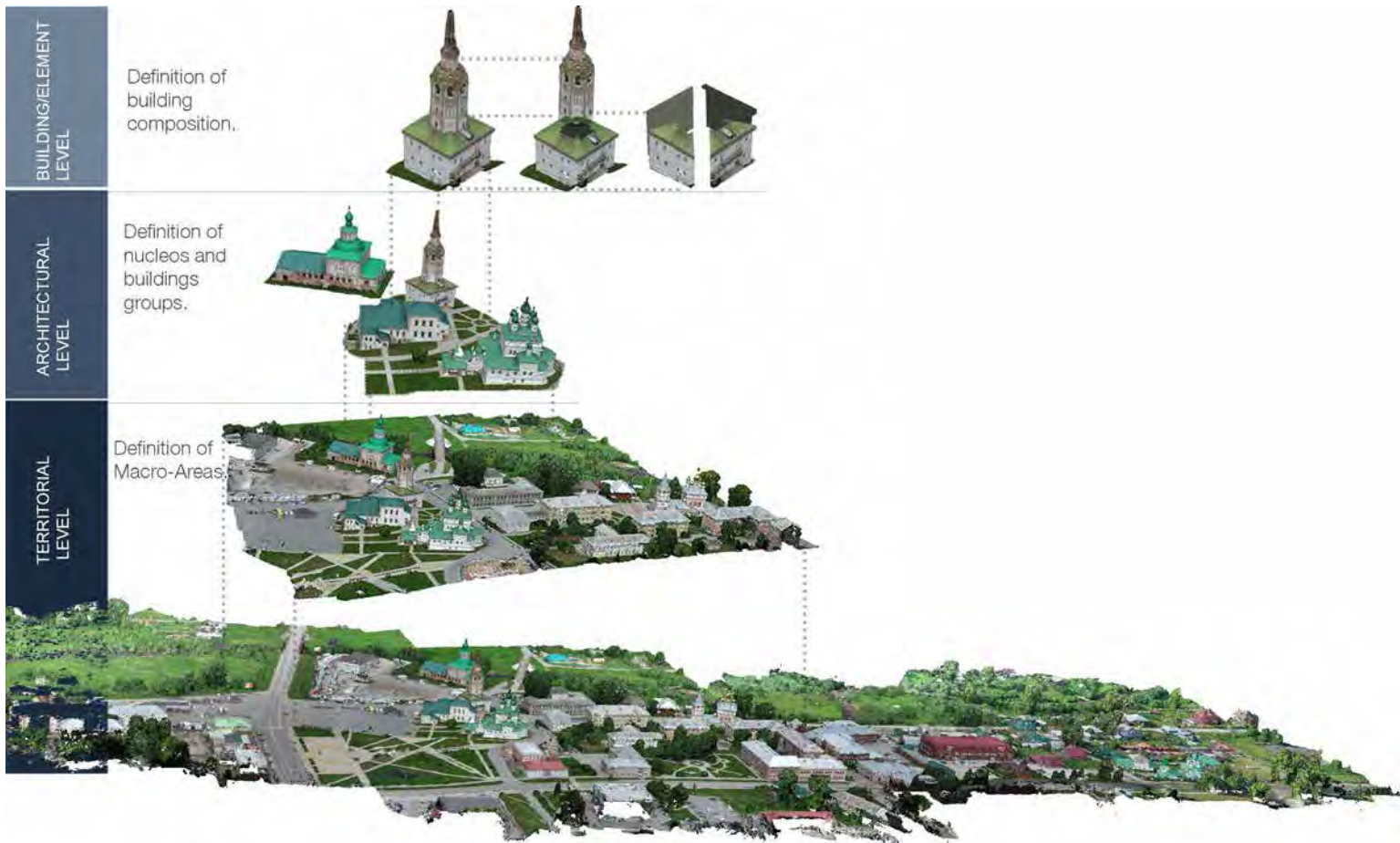
are represented by natural elements (the river, the forest, slopes and zones of difficult access) which obviously limit the free and complete movement around a building or above an extended area. With the exception of some monuments or isolated buildings, around which free movement is often permitted to allow the complete acquisition of external architectural surfaces, most of the residential buildings are located within a fenced perimeter, which completely surrounds the block in which it is located in spaces that are not always accessible from the public road.

This aspect limits the possibility of entirely solving the problem of the representation of the place with the sole photographic tool, that implies the adoption of further systems of data integration, for example from drone aerial photogrammetry.

At the same time, photogrammetric acquisition activities are also constrained by weather and lighting conditions. The frequent presence of entirely plastered surfaces of a white plaster, especially for religious buildings and some monumental complexes, forces the planning of photographic campaign in relation to the incidence of light on the surfaces. The glare given by the white surfaces, due to the strong lighting conditions present both in summer and in winter, forces the operator to take into







↑  
**Fig.07**  
**Decomposition of landscape for data management**  
 From the territorial level, to the architectural level, till the building element level, photogrammetry techniques defines a strategy to optimize data acquisition and postproduction, in order to generate a semantic database usefull for the following steps.

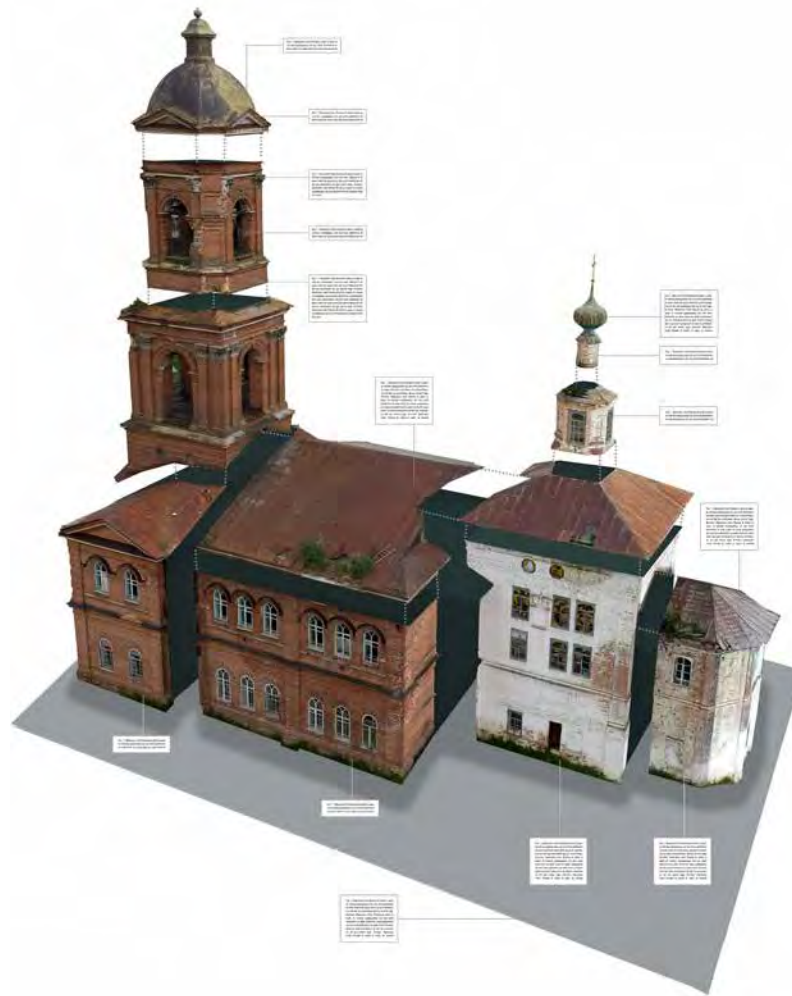
account, during the acquisition phase, the problems related to the photogrammetry software<sup>5</sup> used for data post-production and, therefore, to optimize the acquisition campaign<sup>6</sup>.

A further aspect, that decisively affects the operational choices for the photogrammetric shooting, is relates to the geometry and the complexity of the object to be acquired: the semantic organization of architecture and landscape is one of the most important operations in the definition of the photogrammetric survey campaign, because the decomposition of the object or of an area of territory into easily identifiable elements, allows the acquisition of architectural structures that are even very large or extremely complex.

Therefore, before undertaking and building an analysis framework and a photogrammetric acquisition, a first decoding process of the main elements had been performed, selecting the unique aspects of each

<sup>5</sup> The photogrammetric software used for the alignment and the realization of 3D SfM models is Agisoft Photoscan, and the next Agisoft Metashape. These softwares allow to realize, with semi-automatic procedures, the entire process of creating the photogrammetric point cloud and the texturized mesh model, thanks to which programs can be started for the analysis and management of the acquired data.

<sup>6</sup> Generally, the SfM photographic campaign is carried out with the care to acquire, in each single shot, sufficient homologous points in common with the subsequent shot, to facilitate the photogrammetry software in the alignment of the consequent image pairs. In cases where the chromatic contrast is poor, such as for surfaces entirely plastered in white, the photographic campaign will take into account the inclusion of further reference points within the individual shots, moving away from the object of the acquisition or using appropriate targets positioned on the surfaces.



rural aggregate or historical monument and beginning a process of discretization and synthesis of the information collected.

To analyze and represent the complexity of a monument or a landscape, the first operation concerns the breakdown into levels of investigation. These levels, including both the formal structure of the place and the set of specific descriptive features of each subset, are defined through the structuring of a drawing capable of describing the sphere of interest that generated them. The drawing must thus include the physical limits between the different systems of relations, both at the macro-scale, setting the limits between clearings and forest, and at a smaller scale, going to define individual portions of building units to investigate further. When the operator has become aware of the intrinsic and extrinsic characteristics of the instrument (terrestrial camera or drones), as well as of the analysis framework for defining the structure of the site, the shooting operations can be performed following the semantic decomposition established a priori, starting from the macro structures up to the detailed objects.

For the photogrammetric documentation of monumental buildings, a hierarchical structure of acquisition phases has been prepared:

1- The building in its entirety, acquired by performing a 360° rotation around the object, with shots with axes converging towards the geometric center of the building. The distance from the object has



Fig.08

**Decomposition of building sub-system**

The possibility to semantize the photogrammetric model allowed the definition of hierarchical structure of the building, that will be the base for the informative parametric modelling phase.

been established on the basis of the frame, following the criterion of framing as much of the building as possible. The focal length and exposure settings are established constant.

2 - External facings, acquired trying to perform a type of shot parallel to the vertical surface. The distance from each elevation has been established based on the level of details present and on the required definition of the model.

3 - Single elements. Bell towers, small chapels and other structures detached from the complex, which in the first phase re-entered within the complete acquisition of the building, were acquired as points of interest. During the acquisition, it was prudent to also consider points in common with the previously acquired general structure.

4 - Valuable elements, openings, architectural details or other small systems of interest for the acquisition campaign.

In the same way, a critical landscape reading process was started. The analyzes were aimed at structuring hierarchical systems that regulate the open space and that allow a multilevel reading of the space, functional to the diversified management of information of landscape features. In this way, each urban or rural context analyzed was acquired by camera or by drone with the aim of structuring a database of descriptive 2D images, point clouds and 3D models, capable of completing the datas obtained from other tools.

To carry out the hierarchical decomposition of the landscape, the following aspects has been considered:

1 - The extent and limits of the area to be acquired with a photographic instrument. For each area acquired, a perimeter was identified within which the elements of the landscape were identified. The conformation of each area depends on the distribution of the elements inside it, on the proximity relationships and on the links between built and natural elements. The choice of a terrestrial (camera) or aerial (drone) instrument will affect the way in which the area is acquired.

2 - The division between groups of buildings and open areas. In the case of a compact set of elements around which 360° movement is possible, a SfM campaign was carried out from the ground, idealizing an ideal geometric axis at the center of the system to be acquired. When the extension or distribution of volumes did not allow this type of acquisition, an aerial drone acquisition campaign was planned. In this case, the distance of the drone camera from the horizontal surface of the ground is constant, even if the inclination of the pick-up axis is adjusted to acquire vertical surfaces.

3 - The characteristic of each of the sub-systems of which the area is constituted. For each of the elements present, depending on the importance it assumes at the landscape level or the level of detail to be obtained, the acquisition methods used for the SfM photogrammetry of the buildings, described above, has been applied. The foresight in the acquisition phases is to consider each of these elements as part of a system. Therefore the recovery must also include part of the surrounding space, in order to allow its alignment within the macro system of the area.

With the aim of establishing databases capable of describing the architectural and landscape heritage, the hierarchization and semantic breakdown of the territorial system becomes fundamental in the process of documentation and restitution of data, functional for its reading.

The amount of information that can be recorded during the photographic acquisition phase is huge, complex and not discretized. The purpose of this methodology is to define the level of accuracy and discretization of information, or the final amount of useful data that the model will have to generate for the description of that particular monument or territorial context. The generated 3D model, in addition to offering useful support for the qualitative understanding of the spatial development of the elements present in the territory, develops a new approach to image education, and consequently to new forms of representation aimed at a more conscious management of the landscape. Complexity is acquired, elaborated and codified on a single three-dimensional object, equipped with all the quantitative and qualitative information necessary for its complete configuration.

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# DRONE PHOTOGRAMMETRY SURVEY FOR THE RECONSTRUCTION AND ANALYSIS OF THE IMAGE OF THE TERRITORY

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Photography has become a privileged tool in the documentation field: nowadays, the software for the production of images are within everyone's reach, immediate and easily shared by the community. The growing use of low cost drones allows a rapid increase and an exponential spread of territorial aerial images, even those sites of which today there is not much documentation. This allows to update the image archive of each urban context, and to develop an update on the "state of the art" of each territory. Thanks to the close range photography planned from the ground is possible to obtain a high level of detail of the surfaces, verify in punctual way the conservation of each building, street and public spaces. Instead, from a higher level, is possible to have a more global vision of the entire urban fabric or settlement, evaluating the large-scale relationships among the elements that make up the landscape and, thanks to the satellite localization systems (GPS), create reliable archives of the generated models, which can be integrated with other digital database. The drone produces images from which analyze the full and empty spaces, green areas and built architecture, routes path and relations with the surrounding natural environment, that is helpful to understand the main changes that have affected the city, its main urban transformations, to define a more conscious way to manage the urban planning development and to structure a system on which to develop more aware landscape analyzes in which to plan urban interventions.

For this reason, to develop a large-scale survey activity in the Upper Kama region, an aerial photogrammetry was performed in addition to the traditional photogrammetry from the ground, with the use of specific photogrammetric survey tools that have expanded the production of image-based archive.

In the activities that concerned the documentation of historical monuments, rural settlements and traditional landscape territory, different drones has been used.

The DJI Spark is a small drone that has been used for photographs in detail, given its ability to approach the architectural surfaces, without causing possible damage to the structure. With this tool, easily transportable and without any impact of danger for both the population and the building, many sites and monuments located along the Kama river have been documented. Specifically, the following activities have been planned and carried out with DJI Spark:

1 - Close inspections of buildings. The maneuverability and performance characteristics of the camera allow this instrument to be used for both exterior and interior spaces, even in the absence of

*Side page, Fig. 01*

**Cherdyn general view from drone**

The underlined of main road access in relationship with the settlement grid and natural landscape on the background.



Fig.02

**Landscape transformation**

On the left, historical picture of the road fronts from a bell tower (nowadays disappeared). On the right, the related image of the actual configuration of Cherdyn road. The image, captured by drone, emphasize the changed relationship between open and green areas, built volumes and typological styles.

a GPS signal, to monitor inaccessible surfaces, document roofs, structural and detailed elements at high altitude, build detailed image archives about the state of conservation of construction material.

2 - Panoramic images in the historic center. Thanks to the lightness and non-dangerousness of the instrument, the drone was used to produce a series of panoramic images in some streets of urban centers. Referring to some historical images depicting the Cherdyn site in the middle of the last century, the instrument was used with the aim of reproducing the same view from the same shooting point used in the historical image (in many cases from buildings or bell towers no longer existing or from points nowadays inaccessible). Thanks to this instrument, historical images were compared with those of the current townscape, to better highlight the transformations and pre-existences.

The DJI Phantom 4 pro, larger than the DJI spark but still small in size, has been used with the aim of documenting the territory on a large scale, through flight territorial settings and planned movements around each object. Developing the acquisition campaigns with this drone, thanks to which many images have been obtained, has made it possible to constitute a substantial update of the cartography currently existing of each site.

Also in this case, the Phantom has been used in different ways according to the specifications required by the project.

1 - Specific acquisition of each building or set of buildings. The easy handling of the instrument, the stability in wind conditions and the quality of the camera make it more predisposed for SfM photogrammetry acquisitions. Specifically, 360° shooting mode acquisitions have been arranged for each monument or group of religious buildings around their geometric axes. The isolated conformation of each of these buildings allowed the full and free movement around them, except,

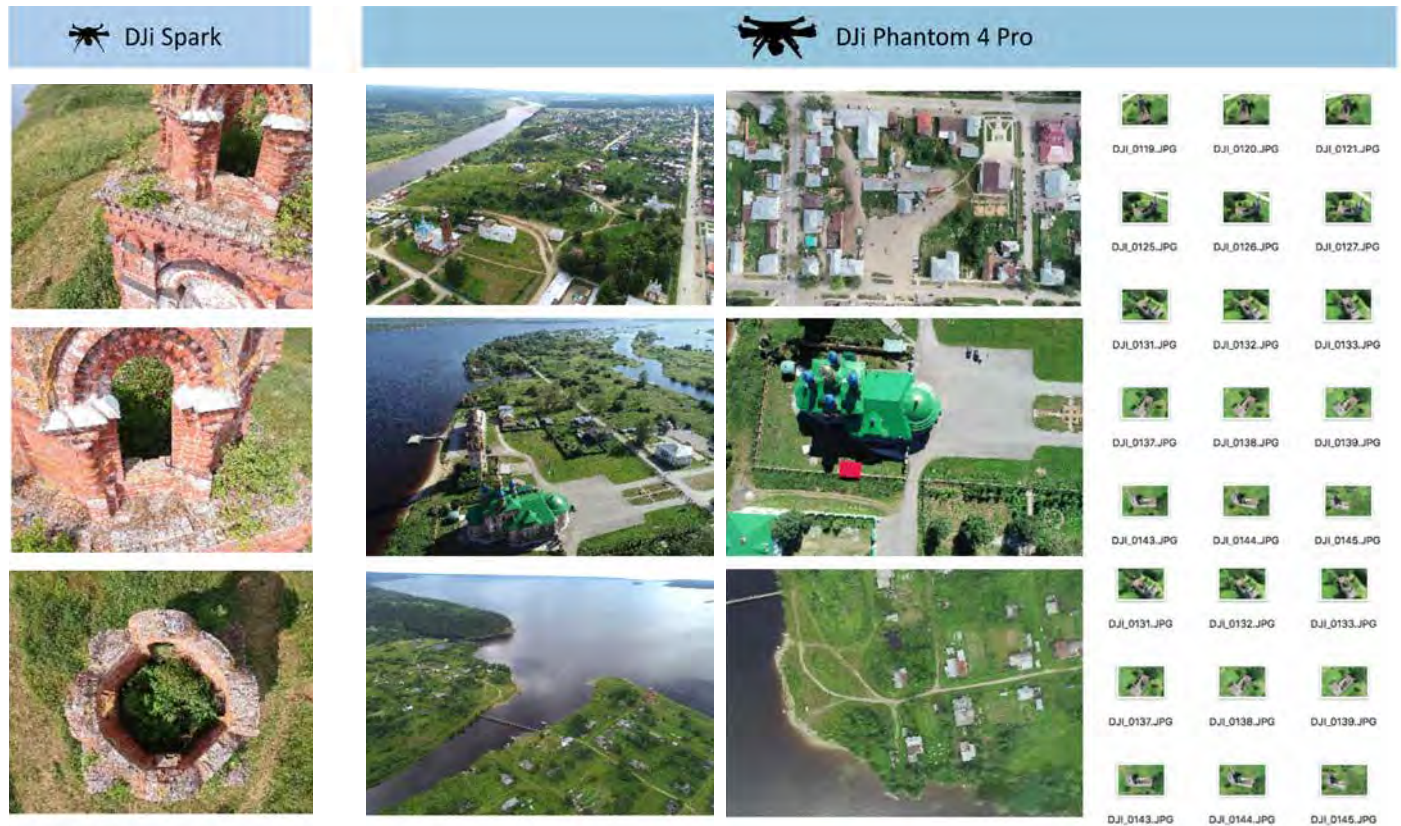


Fig.03

**Typologies of drones (UAVs) used for landscape documentation**

From the left, DJI Phantom RTK, DJI Phantom 4 Pro, DJI Mavic 2 Pro, DJI spark, DJI mini 2.





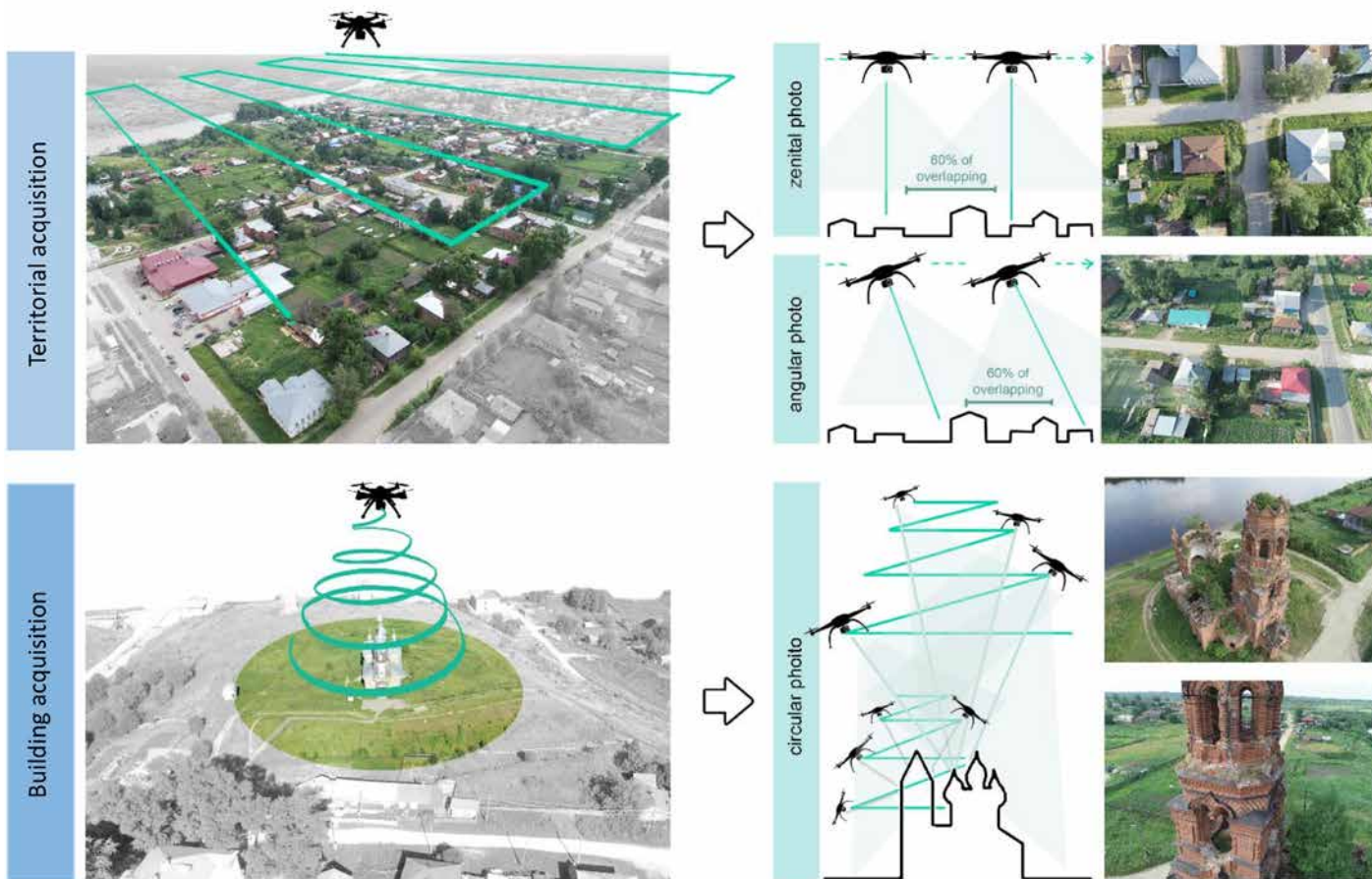
in some cases, for the presence of tall trees or electric cables, which constrained the flight plan. The spiral movement on a point of interest identified by the center of the system to be acquired allowed to completely cover the object. In the shooting phase, the camera axis was turned towards the geometric center of the building, rotating it in relation to nadir axis to acquire surfaces not visible from the ground and to facilitate the alignment of the sequential images for the SfM reconstruction methodology. In some cases this type of acquisition made it possible to document and obtain 3D models of inaccessible or difficult to acquire monuments with other instruments. In other cases, the acquisition from drone integrated the photogrammetric one performed from the ground, producing a sparse cloud of points but necessary to fill those data gaps present from the outputs of instruments used from the ground. When the building system is distributed over an area of a certain extent, the drone must increase the radius of the spiral, inevitably losing data quality on the surfaces most distant from the camera. This involves a loss of resolution and definition of the generated point cloud and 3D model, which implies a different planning of the drone acquisition campaign. For this reason, it is preferred to use flight planes at constant altitude and inclined axes capable of covering a vast territorial surface in a short time and capable of returning a cloud of points that no other instrument is capable of producing.

2 - Acquisition of areas and vast surface territory. This type of acquisition was used to completely cover the landscape system from above, generating databases that contained the building and the landscape context at the same time. The Phantom 4 Pro has the possibility to use automatic flight



**Fig. 04**  
**Different use of UAVs for heritage description**

Close range photogrammetry had been applied with two main micro and small UAVs: a DJI spark, usefull for the possibility to go closer to the building, had been used for the inspection of idden or inaccessible surfaces; a DJI Phantom 4 Pro had been used for a general acquisition at context level, both architectural and landscape.



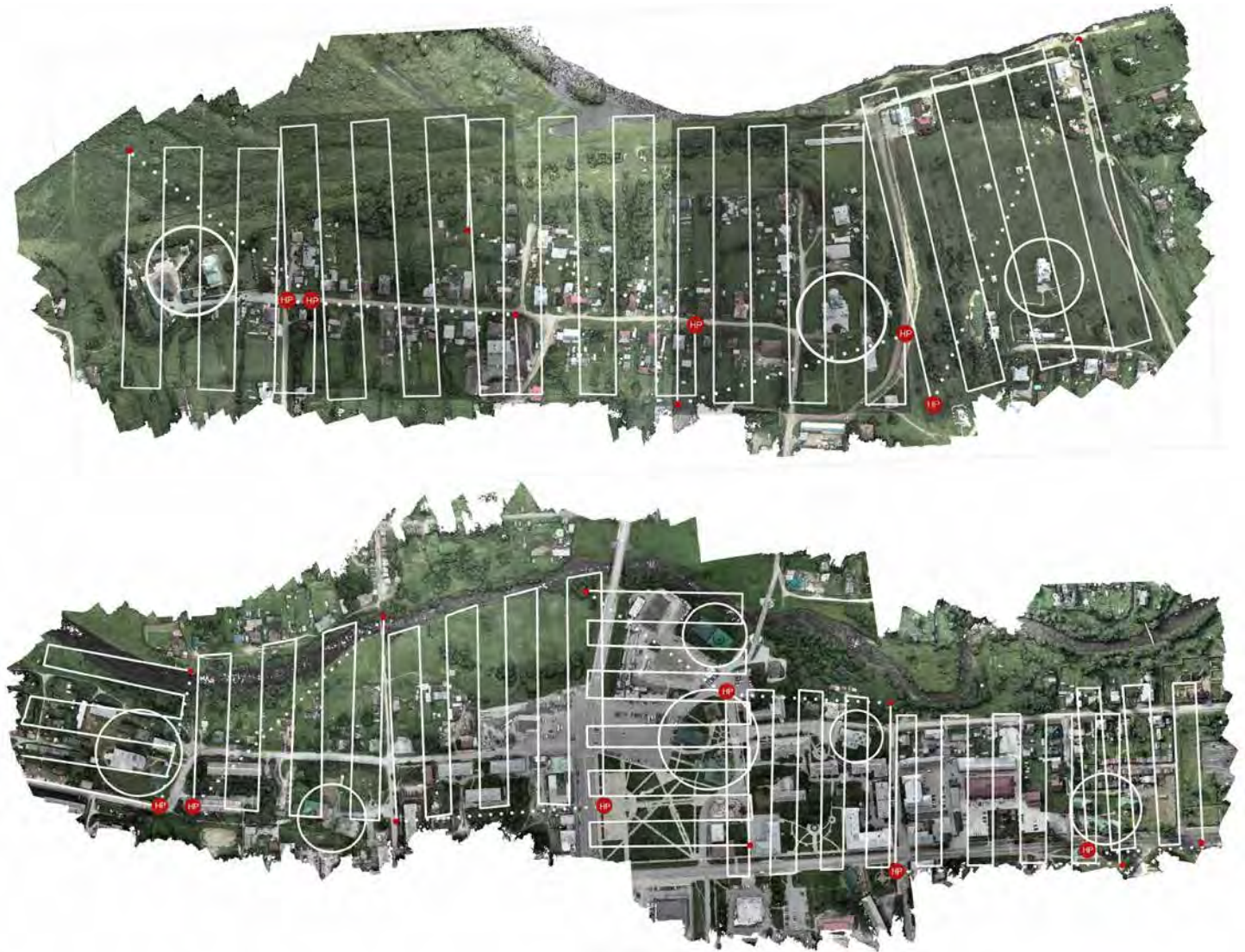
**Fig. 05**  
**Extended area and single element data acquisition**

With respect to the geometry of the element to be acquired and the purposes of data management, it is necessary to define an acquisition strategy that allows for completeness of data, in order to define a multi-level knowledge of the landscape and historical heritage. To cover a horizontal surface, a flight was performed at the same height. To cover a building or monument, different heights and distances from the object were ensured for better acquisition of vertical and horizontal surfaces.

programs, in which the operator has the task of organizing the flight mission on the territory and checking that, during the acquisition phase, the instrument will not experiencing problems. For each area that had to be acquired through photogrammetry, which is established by the operator based on the complexity of the area and the duration of the instrument's batteries, the operator will establish a series of parameters that will affect the automatic taking of images in flight.

The main parameters that affect the quality of the photographic survey campaign are the height of the instrument from the object, which will determine a better or worse quality of the acquired image, the quantity of images for each established path, the angle of the camera and their overlap, both in the horizontal and in the vertical sequence. For each area at least five path are established. The first set of photographs is always set with the camera perpendicular to the ground plane, so as to acquire images that, overlapping, can generate ortho-images of the ground, containing a minimum error of deformation of the lens, and update the current cartography of the territory or portion of the urban center analyzed.

The other four settings of the drone route foresee an inclination of the camera of about  $45^\circ$ , such as to cross the axes and allow to acquire all four sides of the elements contained in the area. The inclination of the camera axes will make it easier to recognize the points and surfaces in each element, facilitating the software in reconstructing the three-dimensional scene without occlusions.



The set of images generated by drones at the same altitude is then loaded into photogrammetric software capable of transforming them into 3D drawings through semi-automatic processes of orientation of the camera. The generated 3D model, provided with a good metric reliability, a georeferenced system and real correspondence to the building state of conservation given the higher quality of the texture component, can be used to export 2D images but also to set environmental sections, export portions of the model to analyze the volumetric relationships between spaces built and green spaces, develop a support that can be useful for creating thematic maps and other landscape analysis.

Obviously the best output is obtained by integrating the flight plans (for the definition of the surface of the area to be acquired) and the points of interest generated for the individual buildings.

This allows a multiscale reading of each area, whose landscape analysis can take place for different definition levels. A first level on a general scale, within which the understanding of the relationships between the elements of the system takes place through semantic reading which include the



Fig. 06

**Integration data acquisition methodology from UAVs**

For both Cherdyn (above) and Solikamsk (below) center, different flight plans with different trajectories were combined to cover the entire landscape. In addition, point acquisitions of monuments were carried out to improve the quality of the final model. The integration of the two typologies of point cloud acquired took place using selected common points on horizontal planes.



*Fig. 07*

**3D model data integration**

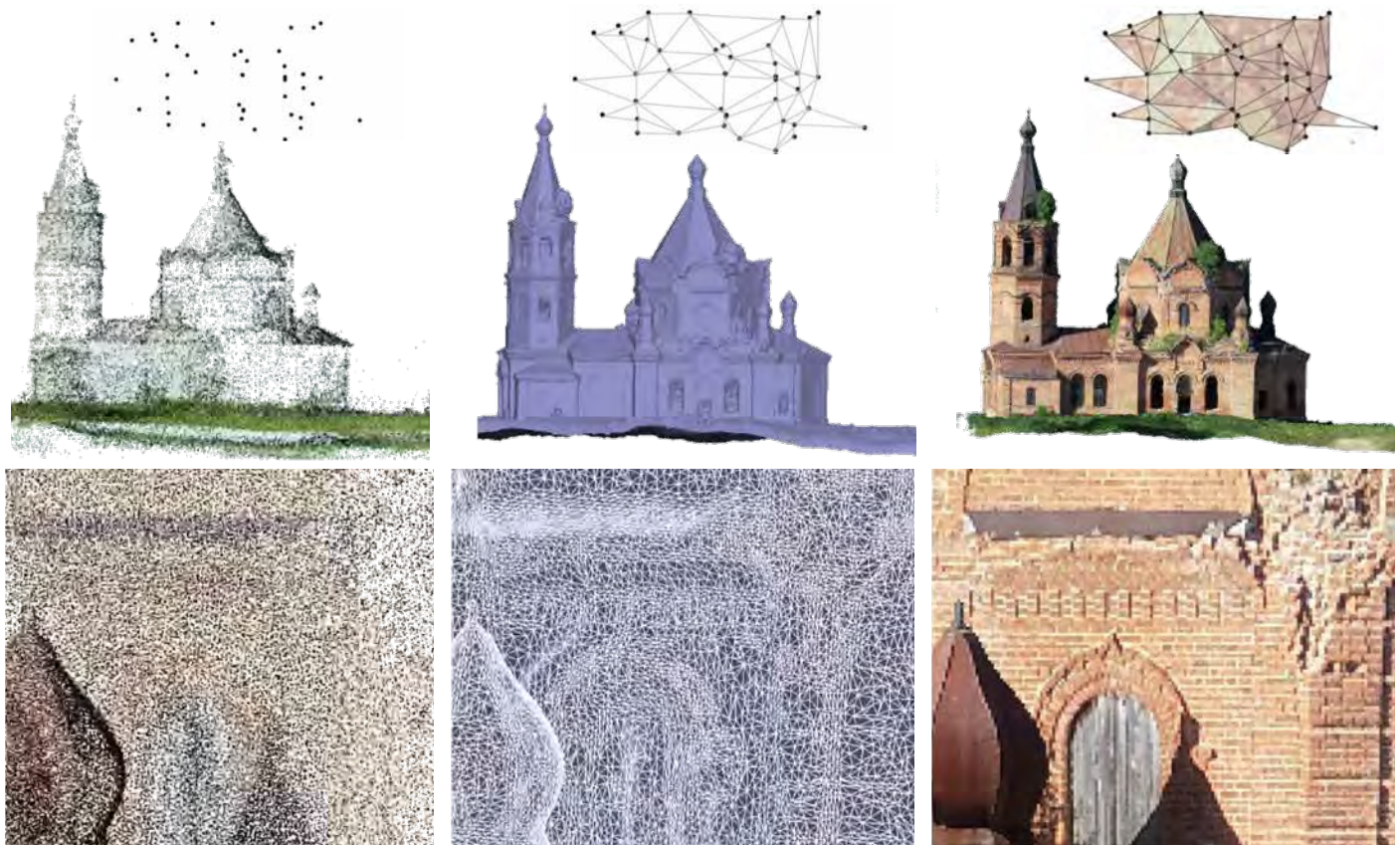
On the left, images of the general textured model obtained with flight plan acquisition. On the right, the visible integration of different density mesh models.

association of certain relationships with specific meanings; a second level is a detail of the building, represented both in the general structure and in the decorative element, on which to deal with more precise analyzes.

The outputs produced at the general level of each area or territorial surface, carried out for example for some blocks of the historic center of Cherdyn or Solykamsk, allowed to generate a knowledge base of these contexts which was then deepened with investigations on the individual building. From these spatial models and databases it is possible to produce a whole series of drawings and considerations concerning the landscape material and immaterial relationships. The general dimensional relationships between built and open space emerge from the visualization of the three-dimensional model, as well as the conformation of the ground, the visual emergencies, the discrepancies and formal inconsistencies between historic and contemporary buildings, and all the information that characterizes the analysis for a qualitative reading of the landscape system. To these aspects is added the enormous advantage of obtaining qualitative information related to the colorimetric component of the space. Correspondence with color is added to the discrepancies or uniformity of shape, in order to highlight how this tool can also be valid for planning recovery of surfaces suitable for historical buildings and landscapes.

Such a structured model, to which it is necessary to apply hierarchical and organized selection systems of the data produced, can be configured as a valid tool for studying the architecture and traditional landscapes of the Upper Kama. The decomposition of the landscape, necessary to plan the photogrammetric acquisition phase both from the ground and from drone, solved the ordering element of these semantic models, whose reading can be addressed by the general at detail. Each of the descriptive levels produced can be associated with a type of information, a census form, a system of use for images, a descriptive text or a further model.

Different type of information, such us descriptive data, models, geolocation and spatial data, needed to be in one structured system to complete entire database. The historic environment is composed by the complicate elements, which has to be accurately represented with the geometry, metadata and semantic structure to build the most complete model. Reality-based approach of



aerial photogrammetry is an instrument for data acquisition and visualization for 3D modeling and Geographic Information System (GIS). The aerial photographs provide the basic spatial information such as roads, vegetation, environment features, etc. and became basic for 3D models. In case of combination aerial and ground photogrammetry the creation process point clouds leads further to 3D models. Through orthorectification process acquired photos became ortophotoplan that is useful for a GIS system. In the documentation structure GIS environment represents a common information system for the management of entire city model.

The detailed geometry of building components of 3D model derived from photogrammetry point clouds could be supplemented by geospatial data in GIS model. Due to collected georeferenced system acquired with drones it is possible to use the opportunities of 3D-GIS. After creation of BIM 3D model it may be integrated into GIS for further analysis. Integrating models with the descriptive and spatial data provide easy access to spatial analysis tools. This gives opportunities for the analysis and interpretation in office after the field work finished.

The challenge is don't lose information while integration (H)BIM-GIS process is completed. GIS model considers buildings combined with environment, road, trees, etc, while BIM model considers building as the whole entity with detailed structural elements. The problem of semantic structure of the model is appeared. The primary standards for exchanging semantic and geographical information are Industrial Foundation Class (IFC) and City Geography Markup Language (CityGML) allow to avoid details losses.



Fig.08

**Process of photogrammetric model creation**

For both drone acquisition modes (automatic flight plan and manual), the model processing is the same: from the scattered point cloud, a triangular mesh model of varying density is created, depending on the purpose of the project, to then obtain a model characterised by a defined geometry and specific associated textures.

The 3D historic models appeared at different scales ranging from areal sites to individual building using methodologies based on different accurate data acquisition techniques such as photogrammetry or laser scanning. Developed Levels of Details (LOD) helps to represent an object in different scales. To define LOD for every scale of the territory and objects necessary for further work. It also will help to develop 3D semantic database including the 3D models and attributes of buildings and environment basic elements, which also could have both geospatial and geometry information.

Applied to Upper Kama region such structured semantic 3D database will help to describe the conditions of saved monuments. Due to different urban environment of Upper Kama region settlements it is important to understand the monument location in different scales: global – the type of surrounding environment, and local – visibility and location within group of buildings. Difference of urban blocks and location of monuments in main Upper Kama region cities is the feature which has to be recorded in accordance to further management of knowledge about territories. The 3D database aimed to preserve and manage not only information about buildings, but urban and environmental features as well.

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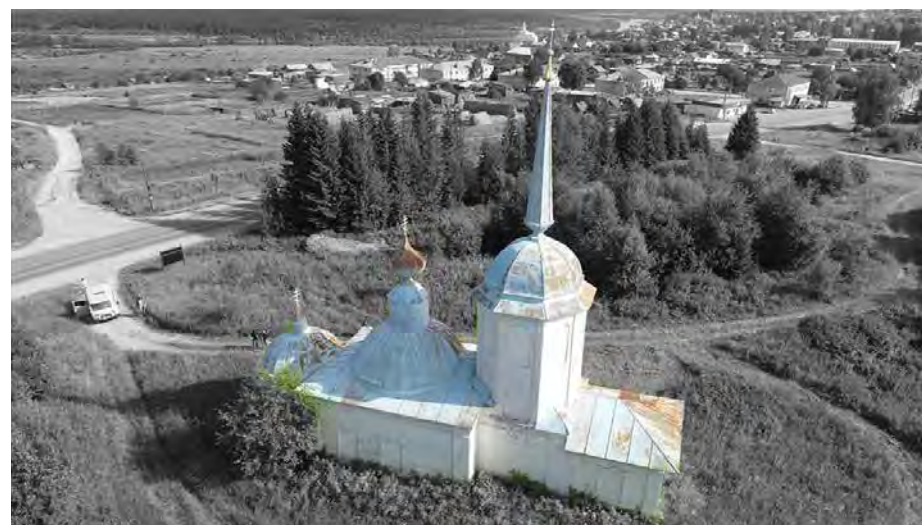
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The preservation of the historical image of the landscape is an issue that is fundamental in a unique cultural context, such as that of the Upper Kama region. Crossing the area, the territorial identity dictated by the construction tradition of 17th-century brick architecture, a symbol of when the territory was the salt trade nerve center, is easily observed. Today its slow decay is evident, which began with the abandonment of large building systems after the fall of bourgeois society and new trade routes. In the twentieth century, it affected the largest districts of the region: Solikamsk (1430), Cherdyn (1535), and Usolye (1606).

In today's image of the Upper Kama's monumental architecture, the signs of time appear as a strong and identifying feature. However, these entail a slow deterioration of the structures that will inevitably converge in the heritage's disappearance.

While in the cities, the chaotic ensemble of flows has remixed the architectural typologies creating new mixes and hybridizations, in the villages, the image of the place remains uncontaminated. In both cases, the identity fulcrum that finds its embodiment in Orthodox religious architecture remains clear, maintaining its individuality as a central place of aggregation and identifying symbols within the new territorial expansion. The Russian countryside places are a reflection of what was one of the most insidious aspects of the Soviet regime, the attempt to erase the cultural memory of a people. The incisive action of dematerialization of memory was implemented in particular towards religious worship and its forms of expression. The massive destruction of buildings and sacred art has caused untold losses in Russian cultural heritage baggage.

*Side page, Fig. 01*  
**A disperse heritage**  
Drone views of several monuments and their contexts around Upper Kama territories.

↓  
*Fig. 02*  
**Features of architectural elements**  
Images of the Church of the Epiphany in Solikamsk, showing the decorative elements that characterize the building.





*Above and side page Fig.03*

**An abacus of decorative elements**

A variety of materials, forms and architectural solutions characterise the monuments of Upper Kama territory.

William Brumfield<sup>1</sup>, a historical researcher and photojournalist, was one of the few to study and document the vernacular architecture of this region by creating a photographic catalog that could somehow freeze the historical image's memory on a slide. By crossing the countryside, he finds the distinctive characteristics of the remaining legacy of Russian architecture in the abandoned buildings, where the original visions of the builder are found along the rural roads. He talks about the Russian provinces' places and landscapes through the framing using a medium format camera Bronica or with a Nikon FE. He motivates in his writings that one was used for black and white and to frame the landscape's image and the other to describe the color of the decoration of the late medieval churches. Thus, the images become documentary forms of a subjective nature capable of illustrating a critical reflection of reality, not a silent portrait of lines et colors. An intertwining result of an action of observations and analyses conducted on the ground, which allow to distinguish those typological characters that characterize the vertical and horizontal dimension of the territory. To preserve the historical and cultural image of the place, it appears necessary to identify and define those elements of the natural system and the anthropic system that characterize it while preserving its peculiarities.

The landscape analysis of a large territory, such as the area covered by the three districts covered by

<sup>1</sup> William Craft Brumfield contemporary historian of Russian architecture, lived in Russia for fifteen years researching the Moscow and St. Petersburg State Universities, traveling to the northern part of the region to document and study Russian vernacular architecture. Brumfield's photographic work is collected at the Department of Images Collections of the National Gallery of Art, Washington, with 12,500 black and white photographic prints, 40,000 negatives, and over 89,000 digital files.



the project, was based on a knowledge path to identify those different signs within the environment to define defined hierarchies between macro and micro territorial structures.

Through the definition of a representation grammar that allows to describe and leave a trace of the reading of the image as a historical memory of the Upper Kama territory, restoring through the graphic representation the connection relationships that exist between territory, city and places of worship.

To this end, it is necessary to define, as in a language, those grammatical rules designed to describe the landscape through the identification of all the elements that directly or indirectly influence his image<sup>2</sup>.



Fig.04

**Monument and landscape relationship**

The understanding of a territory, in which architecture and landscape are closely connected, passes through a graphic decodification, consisting of unambiguous lexical rules, capable of relating the levels in which the image of a territory is composed.

<sup>2</sup> Reference is made to the concept of landscape discourse, where the term discourse refers to the Foucaultian meaning. See Jakob (2009), *Il paesaggio*, p. 15.





Spontaneous vegetation has invaded the church area growing up to the level of the roofing. on the wall surface numerous degradations are visible including efflorescence, detachments and biological patina.



Chromatic alterations of the material of the dome.



Vegetation creates a visual limit

Virgin Presentation Church



Isolate houses

Main Road to the church



Traditional house in wood

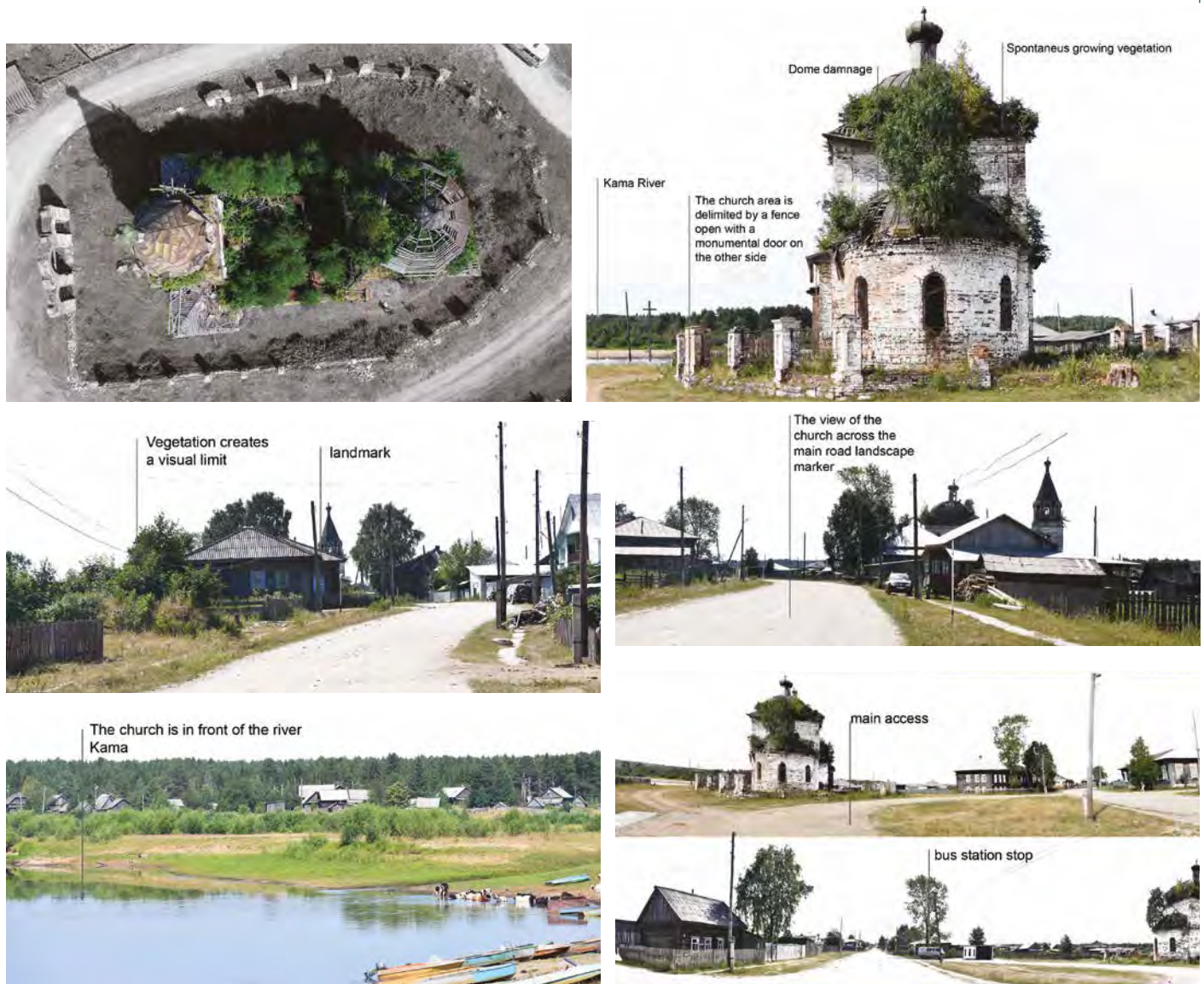
Virgin Presentation Church

**Fig.05**  
**Views of the Virgin Presentation Church surrounded by greenery**  
 The image of an area is also constituted by the multitude of viewpoints that accompany the understanding of a monument. Around the church in Vilgort, there are traditional wooden architectures, which, with their horizontal course, facilitate the visibility of the landmark of the church drum. The vegetation, both horizontal and vertical, remains one of the predominant elements in the reading of the space.

The first phase of the investigation aimed to study the relationship between the network of Orthodox churches in the region and the urban centers, which, with their development, have incorporated religious structures, which have thus become the focal point of the city.

The space was investigated at different levels by identifying a specific structure within the Upper Kama area consisting of systems and subsystems. The analysis carried out has identified the descriptive connotations of the territory in a descriptive scale that from a first level of investigation on a territorial scale of the image of the three districts up to the level of study of the detail of the different construction and decorative systems of the Orthodox churches that go to qualify the identity of the landscape itself.

The single religious building becomes a strong sign character within the urban nucleus for the place's image. In the church structure, the observer finds a reference point and a functional territorial orientation system. The place is read and remembered based on the presence or absence of a religious structure, if present, this inevitably typifies it.



During the objective reading of the landscape, all the finite elements that characterize the multiple dimensions of the natural and anthropic system were identified: administrative boundaries, plantations, spontaneous vegetation, the network of paths, rivers, the structure of buildings, and the different spatial relationships that exist between these elements. These elements contribute to the definition of physical, perceptive limits, and limits of the visual, which create a discontinuity in the reading of the landscape.

Through a perceptual analysis, the territory was interpreted by the observing subject, who represented the place's image through drawings and photographs.

The analytical interpretative methodologies of reality in close contact with local cultural components are part of the perceptual level, offering different interpretations of the qualitative aspects.

During the act of landscape analysis, for Simmel's philosophy concept<sup>3</sup>, to get closer to the object,



**Fig. 06**  
**The Bondyug monument and its relationship with a water landscape**

Some monuments stand out from the context because they appear isolated, either from other buildings or from wooded areas. The church of Exaltation of the Holy Cross adds to this aspect the fact that it has an enclosure that takes it out of context, and that it is located on the riverbank, thus possessing an additional aspect of isolation and monumentality in relation to the surrounding landscape.

<sup>3</sup> The landscape, let's say, is formed when the various natural elements lying close to each other on the earth's soil come together in a very particular kind of unity, different from that glimpsed by the scientist with his causal thought, by the worshiper of nature with

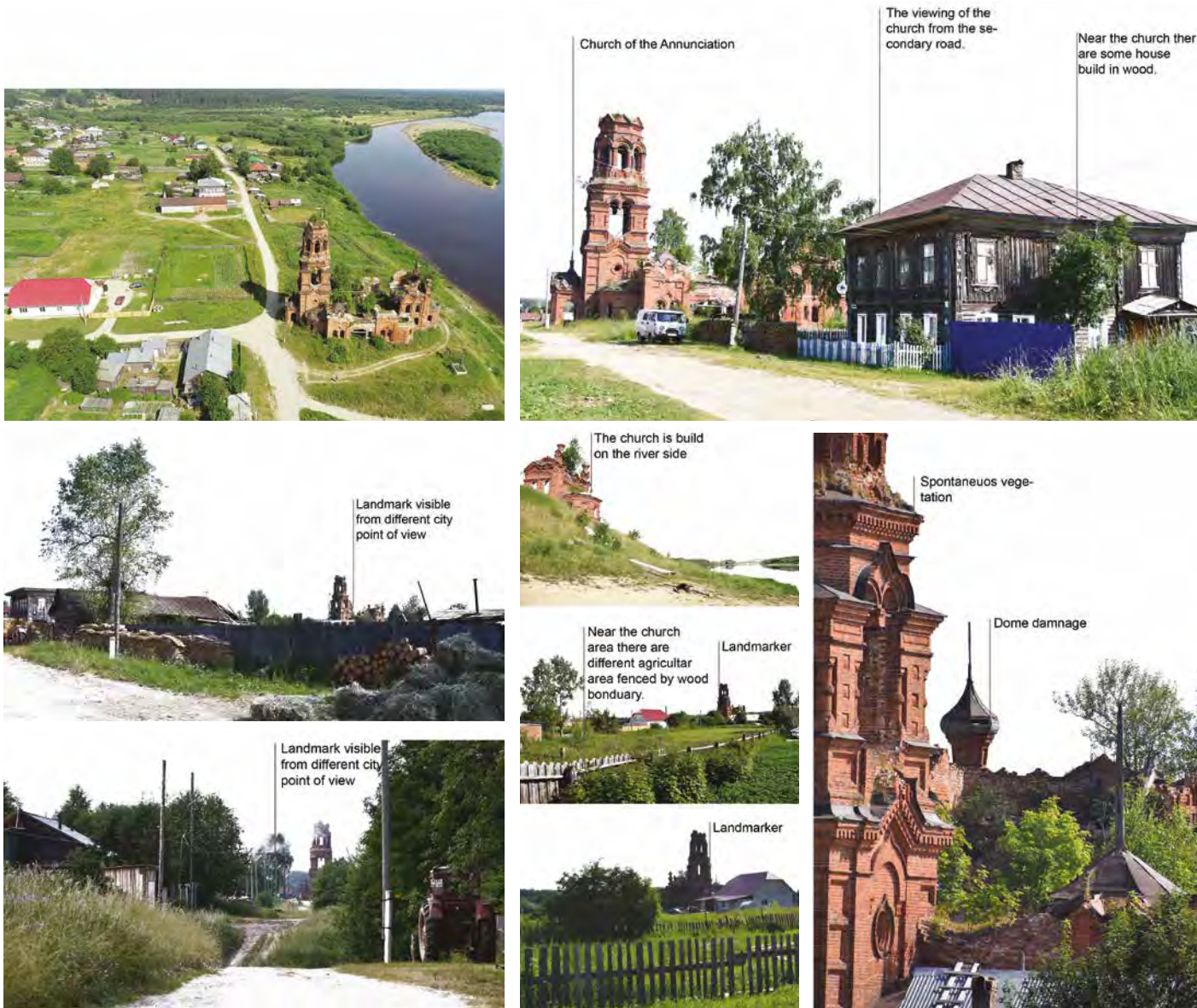


Fig. 07

**Pokcha, an unfamiliar ruin to be preserved**

Other monuments are detached from their context in shape and size, creating visual landmarks that stand out amid the landscape. This is the case of the Church of Annunciation in Pokcha, a ruined monument that has taken on a character of monumentality quite independent of the landscape in which it stands.

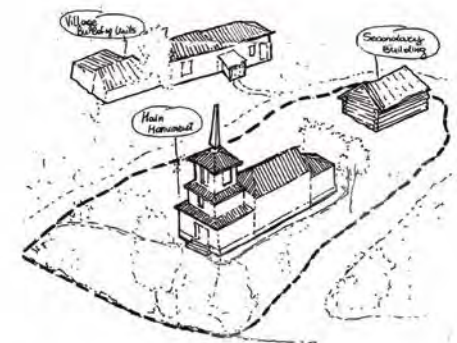
the subject implements an enumeration of the elements received present, in a hyperbole given by the perception of the place through an automatic process of filtering the acquired data conditioned by the experiences of the subject. In addition to the individual's experiences, external factors such as light, sound, color, and time must be considered, which implicitly change the perception that the subject has of the place<sup>4</sup>. An example of the distinctive character of the place is represented by the common presence of the three districts of the Kama river and its tributaries create a distinctive sign like a thread

*his religious sentiment, from the peasant or strategist with their theological approach. Simmel defines the Stimmung, quality of the landscape as a human feeling. Without this feeling, the landscape would be only a sum of natural elements. However, this is not so since man contemplating it has an attitude of elaboration, in the sense that he perceives the elements of nature and unifies them. Making them his own, he absorbs the substance given by nature and re-elaborates it through the act of contemplation. Cf. Simmel (1913), Philosophie der Landschaft.*

<sup>4</sup> For the perceptual analysis, reference was made to urban planners Gordon Cullen and Kevin Lynch's theories.



Traditional building abandoned



Limit by vegetation



Traditional house abandoned

of a skein that winds through the entire territory, it becomes the identifying descriptor of the three realities taken into analysis generating in each of them different landscape scenarios. The Cherdyn district with its development above a hill overlooking the valley, the gaze is lost in the pristine natural landscape and sees the Ural mountain range on the east bank of the Vishera river.

The urban center of the Cherdyn district develops above a hill that, positioned parallel to the west bank of the Vishera river, dominates the valley. Here, the gaze is lost in the uncontaminated natural landscape until you see the Urals chain on the east bank of the Vishera river.

The urban center was structured according to a defined grid of blocks, by the architect Ivan Lem<sup>5</sup> who in the urban plan took into account the irregular shape of the land and the surviving churches,

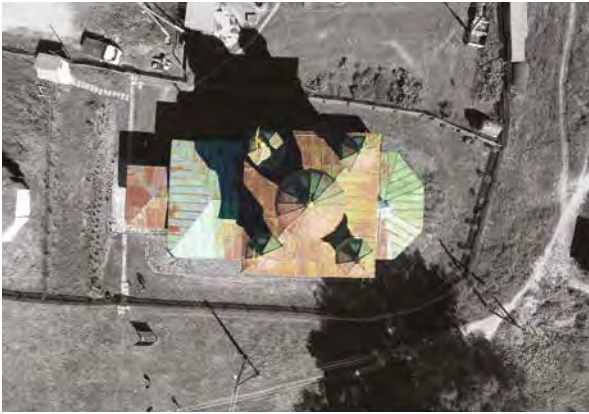


Fig.08

#### A ruin familiar to the landscape

There are special monuments along the Upper Kama territory, such as the churches of St. George, in Lekmartovo, and the Church of St. Nicholas, in Uzhginskaya. These are specimens built entirely of wood that, in terms of size and material, blend in perfectly with the surrounding forest, maintaining an aura of monument-ruin to be discovered.

<sup>5</sup>The reference is to the city development plan of 1790.



**Above and next page Fig.09  
Change of perception with the seasons**

Colour plays an important role in the perception of the monument. The church of St. Nicholas in Nyrob appears immersed in a landscape that enhances the white geometries of its surfaces during the summer period, encompassing them under a blanket of snow during the winter period. White, a neutral colour, thus takes on the temperature of the atmosphere surrounding the building depending on the lighting and the time of year.

structuring valuable views to form a rich network of visual connections that draw the dominant characters of the city landscape.

The protagonist of the Cherdyn skyline is the brick bell tower built between 1908 and 1911 of the Church from the Resurrection, a veritable vertical center that dominates the whole city. To the west of this is the Cathedral of the Transfiguration, which contributed to the vertical development of the city with its high bell tower and domes, no longer visible today as they were removed following the closure of the Church and its conversion into a forestry school during the early 1930s.

On the west bank of the river is the Church of the Epiphany (1751) at the end of the nineteenth century, the bell tower and domes were also removed since the Church was converted into a bakery still active today. The area had its most remarkable development in the sixteenth century thanks to its favorable geographical position, and it was an obligatory road and customs point (1597) for river and land trade between the East and the Urals and Siberia. For this reason, the city of Cherdyn is the

most developed center in the whole district and a reference point for all the satellite hamlets that meet along the only connection road in the area. Along with this are the smaller towns Pokcha, Vilgort, Kamgort, Iskor, Nyrob, which developed between the eighteenth and nineteenth centuries around the corresponding religious buildings. The small villages do not have the same grid urban conformation. Still, they are composed of traditional wooden doma on one or two floors surrounded by a wooden fence dividing the different properties.

These are often visible along the main road, where the number of houses is higher, a series of dirt roads branch off from the main road leading to the different properties.

During the summer season, piles of wood are neatly prepared next to the house, used for heating during the winter season.

The industrial character of the Usolye district is immediately evident due to its origin as a focal center for the salt extraction activities of the Stroganov family on the banks of the Kama river. In 1715 led to the city's foundation, with the construction of the first chapel of the Savior in Ubrus, followed by the buildings that went to define the architectural character of the Stroganov baroque. This reached its maximum expression with the Church of the Transfiguration's construction, still today the identifying symbol of the city. The city's historic layout underwent two significant changes, the first following a fire, which razed all the industrial wooden architectures to the ground. The road layout was redefined with two main axes perpendicular to each other, still recognizable today in the district. The second radically changed the Usolye landscape image in 1954 following the construction of the dam of the Kama basin for the hydroelectric station located north of Perm. The entire historic center was submerged as a result of rising waters. The inhabitants were forced to take refuge and rebuild the New Usolye in the hinterland, which has a standard checkerboard layout. The territory was divided into four islands, connected by bridges and elevated roads immersed in a linear landscape punctuated by uncultivated marshes, vast meadows, and medium height hydrophilic trees such as the black poplars, which in orderly rows cover and mark a physical limit in the observation of the landscape. Observing the passage from the west bank of the Kama of the monumental area of Usolye, the characteristics of the natural landscape completely change, interrupted by the massive industrial construction by the city of Berezniki in stark contrast to the rural and romantic landscape of the west bank.

The district of Solikamsk, like that of Usolye, owes its foundation to the opening of a salt extraction plant in 1430 the wooden walls of the ancient village are still visible in the urban fabric of the present city, the small perimeter enclosed the area today occupied by the 5 main religious complexes of the city. At the end of the seventeenth century, it was an important transit point for Eastern trade routes between Siberia and China. The contrast between the green nature of the Russian countryside and the piles of sterile mountains of potassium and salt extraction is evident from the south. The transformation of the natural landscape into an industrial landscape is then confirmed by the large buildings of the mines

belonging to the Soviet age that alternate with the different dark mounds. Despite the rules imposed by the Soviet regime, Solikamsk has preserved most of the buildings built starting from 1600 in its historic center, concentrated around the main market square. The primitive citadel was constructed entirely of wood, its identity was lost following nineteen great fires (1581-1806). Arriving in the central square, one immediately perceives the economic and industrial development that the city has had during the last century. On the one hand, the historical monuments represented by the whole of the Trinity Cathedral, the Church and the Bell Tower of the Resurrection of Christ, the Church of the Exaltation of the Holy Cross which with their oversize interrupt the linearity of the landscape characterized by the plastic architectures of the rich decorations of the zhuchkovyi facades (ZH) peculiar to the architecture of Solikamsk. On the other, a few meters alternate in series palaces built during the late nineteenth century with popular characteristics found in the Russian provincial cities where there are shops, restaurants, and shopping centers. The characters of traditional wooden industrial architecture are linked to the 19th-century salt refining. They have been uprooted from the city and relocated for their preservation inside the open-air museum of wooden architecture of Khokholovka a few kilometers from Perm.

The three districts, Cherdyn, Solikams, and Usolye were analyzed, starting from identifying the mutual urban limits within. These vertical structures are territorial landmarks of fundamental importance for the orientation of the observer who “getting lost” along the different paths finds in the known point a reference point on which to base his exposure.

Secondly, the main routes and access points to the religious complex and the various services present along these (bus stops, refreshment points, museums, other monuments) were analyzed to create a catalog of the different points of interest and differentiate those paths that are privileged compared to others. The analysis was then concentrated on the perimeter area surrounding the single Church by analyzing whether the Church is protected by fences, by plant or architectural barriers, if it is closed or has free access if there are residences or other activities around it.

For the representation from the analysis data, it was necessary to define the communication vectors and the functional schemes to represent the data collected on the landscape study.

Drawing and photography were found to be the most suitable tools for the representation of the image-landscape. Two types of study eidotypes were developed on-site. They aimed to describe the relationship between the individual religious complex and the physical and perceptive limits that delimit the area, and those aimed at analyzing and categorizing the architectural structure’s decorative set. At the same time, a photographic campaign was structured to improve the macro territorial system and the description of the single religious complex. Up to the analysis of the detail of the single constructive element and architectural decoration, to create a data library for the definition and the census of the elements characterizing the place.

To this end<sup>6</sup>, the development of panoramic photos made by taking frames in series then processed through specific programs on which the relevant observations on the church-territory's perception. System, on color, has been particularly useful for the description of valuable views on the presence or absence of physical or perceptual limits that in some cases hinder its visibility.

Finally, a drawing and photographic campaign was carried out to describe the current state of the building. Where possible, all the external fronts and internal environments were photographed with the general ground and aerial photos with the use of UAV systems for the inspection of roofs and elements at height. The photographic campaign aimed to represent the detail of the decorative apparatus and the story of the brick construction techniques typical of the area. For a detailed analysis and census of the materials still legible in some cases (flooring, remains of frescoes, plastering) and the collection of a complete abacus, describing all the degradations present. The set of information and data collected through this first phase of investigation on the Upper Kama territorial system has its objective the first delineation of a general picture of the condition in which the various churches are concerned, on which more specific analyzes concerning the single specific case.



<sup>6</sup>The photos were taken with a Nikon 7200 reflex camera for each panorama a series was taken that oscillates between 5 and 10 post-processed images through the Ptgui software.

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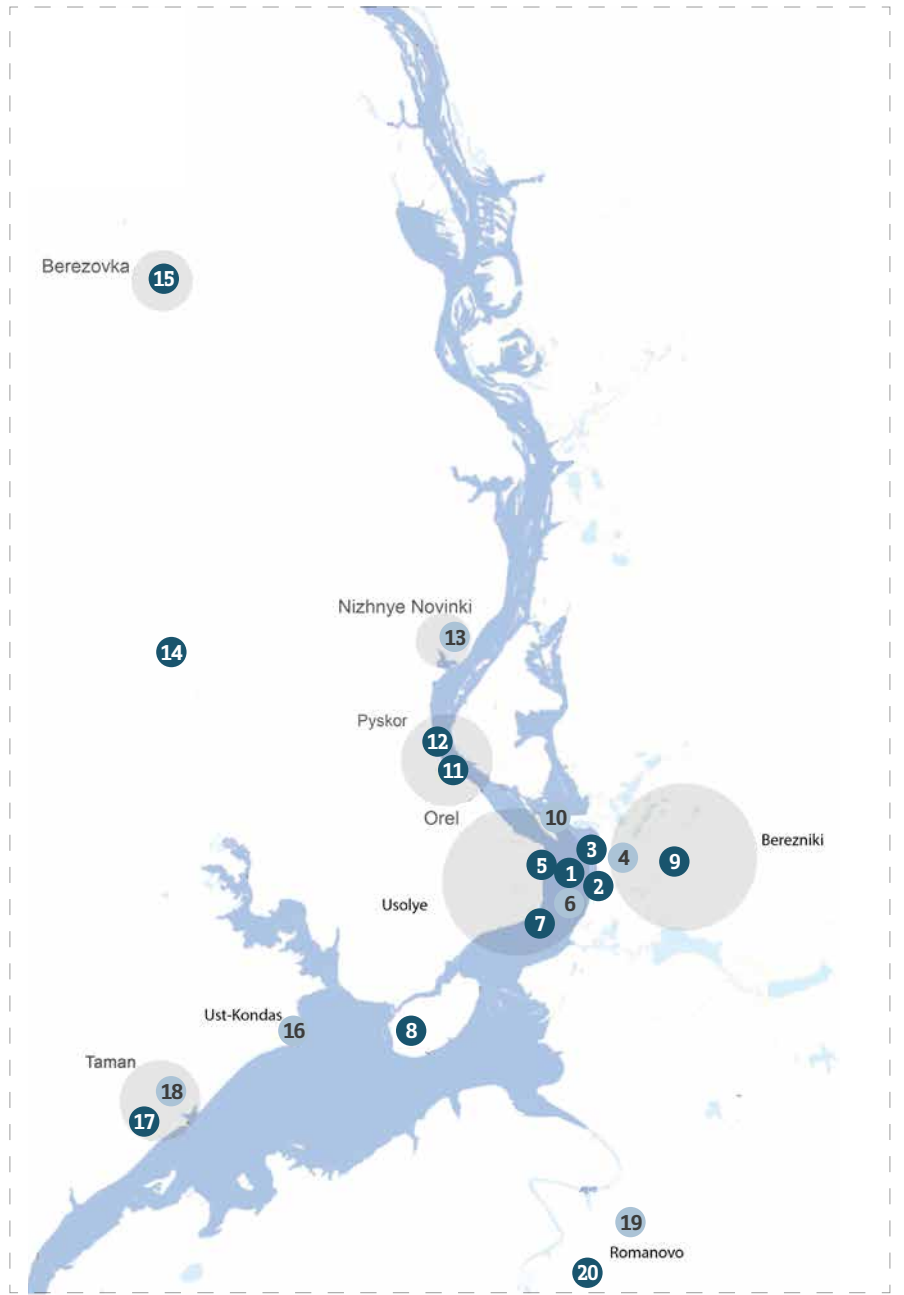
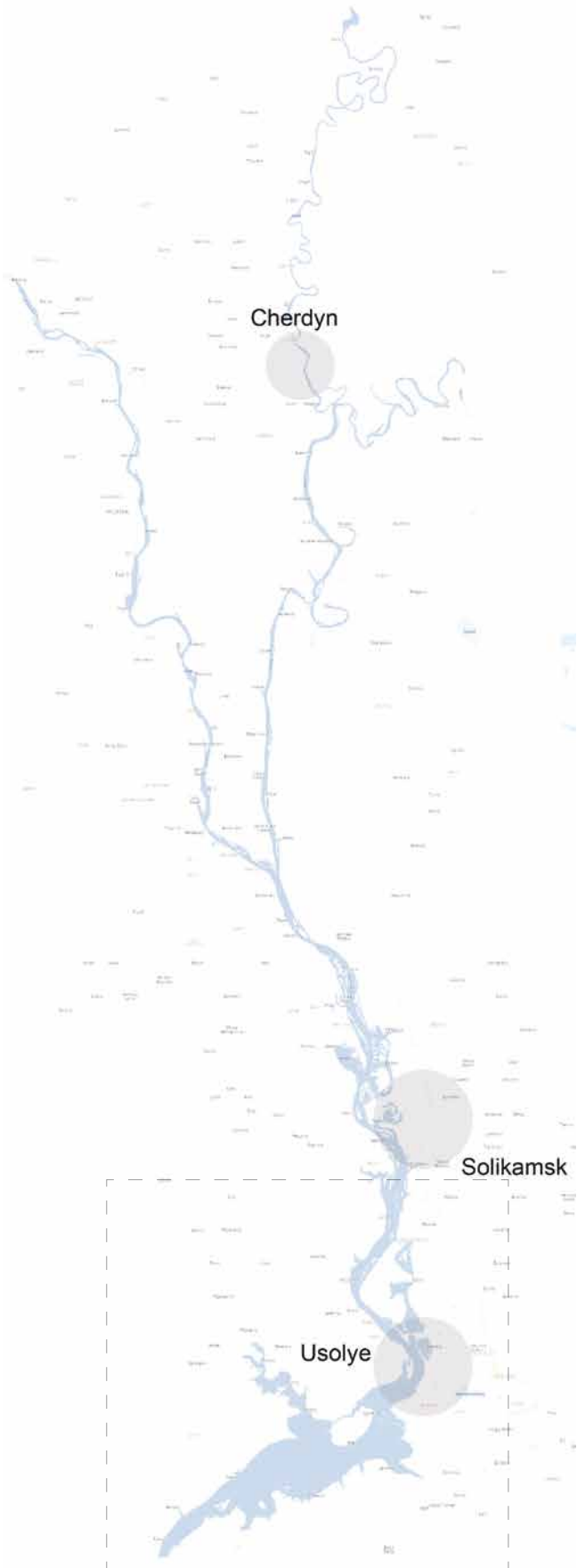
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**Usolye: historical heritage  
and industrial archaeology**



CHURCH  
CHAPEL

## LIST OF USOLYE MONUMENTS

- 1\_ **Cathedral of the Transfiguration**, *Собор Спаса Преображения*, Usolye. 59.412916, 56.708111, Date: 1724 - 1731.
- 2\_ **The bell tower of the Transfiguration Cathedral**, *Колокольня Спасо-Преображенский женский монастырь*, Usolye. 59.412412, 56.708435, Date: 1730.
- 3\_ **Stroganov Chambers**, *Соборная колокольня*, Usolye. 59.411819, 56.708399, Date: 1724.
- 4\_ **Savior Transfiguration Convent**, Chapel of the Savior of Ubrus, *Спасо-Преображенский женский монастырь. Часовня Спаса Убруса*, Usolye. 59.41272, 56.708787, Date: 1667 - 1699.
- 5\_ **Church of the Vladimir Icon of the Mother of God (Rubezhskaya)**, *Часовня Покрова Пресвятой Богородицы*, Usolye. 59.403757, 56.700767. Date: 1810 - 1850.
- 6\_ **Chapel of the Intercession of the Holy Virgin**, *Часовня Покрова Пресвятой Богородицы*, Usolye. 59.403757, 56.700767. Date: 1810 - 1850.
- 7\_ **Church of St. Nicholas**, *Церковь Николая Чудотворца*, Usolye. 59.410609, 56.696008, Date: 1820.
- 8\_ **Church of Praise of the Mother of God**, *Церковь Похвалы Божией Матери*, Oryol. 59.33615, 56.58607, Date: 1735.
- 9\_ **Church of the Beheading of John the Baptist**, *Церковь Усекновения главы Иоанна Предтечи*, Berezniki. 59.38745, 56.778894. Date: 1757.
- 10\_ **Trinity Church**, *Троицы Живоначальной*, Lenva. 59.442195, 56.715197. Date: 1687 - 1688.
- 11\_ **Church of the Transfiguration of the Savior**, *Церковь Спаса Преображения*, Pyskor. 59.48299, 56.588677, Date: 1830 - 1840.
- 12\_ **Church of St. Nicholas**, *Церковь Николая Чудотворца*, Pyskor. 59.487128, 56.584305, Date: 1695.
- 13\_ **Unknown Chapel**, Nighnie Novinki. 59.523831, 56.611599, Date: -
- 14\_ **Church of St. Nicholas**, *Соликамский Иоанно-Предтеченский Церковь Николая Чудотворца*, Oshcherkovo. 59.507821, 56.350218, Date: 1875.
- 15\_ **Church of the Nativity**, *Церковь Рождества Христова*, Beryozovka. 59.655467, 56.065968, Date: 1885.
- 16\_ **Unknown Chapel**, *Неизвестная часовня*, Ust'-Kondas, 59.341517, 56.479844, Date: -
- 17\_ **Peter and Paul Church (stone)**, *Церковь Петра и Павла (каменная)*, Taman. 59.303427, 56.356151, Date: 1912.
- 18\_ **Chapel-tomb of Kiryanov**, *Часовня-усыпальница Кирьяновых*, Taman. 59.303416, 56.356629. Date: 1913.
- 19\_ **Chapel of St. Nicholas**, *Часовня Николая Чудотворца*, Maloe Romanovo. 59.183674, 56.746335, Date: -
- 20\_ **Church of the Presentation of the Lord**, *Церковь Сретения Господня*, Romanovo. 59.156752, 56.784382, Date: 1867.



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At present Usolye is composed from two defined parts: the ‘new town’ on the mainland, which is formed by two parallel streets, built-up by small wooden houses (urban wooden buildings generally only extended to the Urals and Siberia) and the Old Town standing on the islands on the bank of the Kama River.

Almost all of the structures found on the Old Town territory are identified as cultural heritage monuments having federal or regional importance status. Due to lack of financing throughout several decades the condition of the majority of buildings have become very poor. At present the destiny of the Architectural complex is obscure. Whereas certain monuments are taken care of, others are left behind without any certain future and the possibility of improvements. There are around 2 dozens of valuable monuments such as the Bell Tower, Ensemble of industrial warehouses, Rubegskaya Church, Abamelek-Lazarevs House and others that are being gradually destroyed under the influence of natural and anthropogenic factors.

The main urban composition of the Old town, the Stroganovs Ensemble, comprising Transfiguration Cathedral and the Bell Tower, Stroganovs Chambers preserved better than other buildings of the complex.

The Bell Tower requires immediate rehabilitation actions as its constructive elements are severely damaged, the brick laying lacks a significant percentage of elements, inner floor slabs are absent and the spire base is partially destroyed. The physical condition of other Historic Architectural Complex examined buildings is shown on the map of buildings’ state of preservation.

Today coastal ensemble of historical-architectural complex of Usolye town united the centuries-old history of the Upper Kama architectural development being the high-rise standard for all buildings located in this territory.

Stone cathedral was built in 1724 in the style of “Stroganov’s baroque” instead of previously existed wooden Kazan Church. Arrangement of domes is not typical. Four lateral domes are placed according to the four corners of the earth (north, south, east, and west) but not in the corners, as it is usual for the five-dome churches. This technique was spread at the end of the 17th century in the territory of the Ukraine and it was used in Moscow during the construction of New Donskoi Monastery in 1684-1688. The same technique was applied in 1719 by the Stroganovs at the exaltation of the Church of the Nativity of the Blessed Virgin in the estate of Nizhny Novgorod. According to the corners of the earth it

*Side Page Fig. 01*  
**Bird view of the Usolye monumental complex**  
Panoramic view of Usolye “Stroganov Baroque”: a monumental and storage buildings waterline from Kama River.



*Fig. 02*  
**Old Town and New Town location map**  
Карта расположения Старого города и Нового города.





Fig. 03

**A monumental waterfront**

Residential and storage monumental buildings grow up in the horizontal skyline of the Usolye landscape, revealing constructive techniques and decorative baroque motifs that qualify the site.

Side page, Fig. 05

**Un-vealed monuments**

Ruins of churches and buildings, such as Rubegskaya Church, Abamelek-Lazarevs House, Residential House, Goltsyn's house, constitute a landscape of Usolye to be rediscovered.



Fig. 04

**State of conservation issues**

On the left, a decadency condition of the Material store and warehouse. On the right, the early restoration of Stroganovs Master's House.

was put the small domes drums of the Holy Trinity Cathedral in Verkhoturye constructed in 1703-1710 by the artel of masons from Moscow<sup>1</sup>.

It is evident that wide geography of cathedrals with unusual placing of domes shows the special techniques of the so-called style of "Stroganovs" baroque and real preference of the Stroganovs family<sup>2</sup>.

In respect of structure the masons repeated the scheme used in the earlier Stroganovs constructions, namely the Church of the Nativity of the Blessed Virgin in Nizhny Novgorod. The most distinctive feature of the Cathedral of the Transfiguration of the Savior is the high annex and wonderful illumination obtained due to the wide bow lintel windows of quadrangular frame located in two tiers. It is necessary to mention that in façade composition the main role is played by rich thick stone cases, which are "laid" on the contour "filler plate" with the half-round corbels in the bottom. The ornamentality of cases of the quadrangular frame first tier is wonderful.

One more feature of this cornice is the low attic continuous row of the often put rail posts. The total décor of the cathedral is made of the circle brick.

The characteristic features of Usolye architecture are the bands of the square circle brickworks forming "beetle décor", fretted attachable cases, and five-domed cathedral with the special placing of the domes.

In 1809 after the fire, the southern part of the church porch was dismantled. As well, the southern-west part of the church frame was destroyed. As a result in the plan the frame has the orthogonal form. In 1821 invited from Nizhny Novgorod mason Belonogov and his assistants bricked the half-round porch

<sup>1</sup> Cf. Kantorovich, Terekhin (1971), *Ancient Russian builders*.

<sup>2</sup> Cf. Braitseva (1977), *Stroganov buildings*.





with the lancet windows <sup>3</sup>. In 1730 after another large fire that had destroyed the wooden belfry of the Cathedral of the Transfiguration of the Savior they began the construction of the stone bell-tower. The bell-tower has been built in stylistic unity with the Cathedral and the Stroganovs' palaty.

The height of the bell-tower is about 50 meters. Before the large fire of 1842 the sixth-tiered tower was crowned with high broach due to which it was similar to the Moscow Church of the Archangel Gabriel (the tower of Menshikov, 1701-1707). In 1844 over the bell's tire it was built the lantern with the onion-shaped dome similar to the central dome of the Cathedral<sup>4</sup>.

Architectural design: in the plan the bell-tower is irregular octagonal structure which promotes the change of its contour in the view from the different points. The corners of the archways are detached by the clusters of semi columns. Complicated tiers of the tower were later changed by the dome-shaped ones. Polychromatic painting of facades has not been preserved as well.

The column of the bell-tower is viewed from the top to the base only from the west since in 1832-1835 the bottom tier



Fig. 06

**The monumental complex**

The view of the Cathedral of the Transfiguration of the Savior and its belltower in 2015.

<sup>3</sup> Cf. Shilov (2005), *Berezniki–Usolye complex*.

<sup>4</sup> Cf. Terekhin, Kantorovich (1974), *Architectural ensemble*.



of the bell-tower was built on with the stone row of shopping stalls connected with the rearrangement of the town and with aim of strengthening the bell-tower having a set. Simultaneously it was built up the row of shopping stalls parallel to the southern side of the Cathedral of the Transfiguration of the Savior. The bell-tower is very simple in its shape and its view is somehow ascetic, which corresponds to the style of “classicism” of the 19th century<sup>5</sup>. Only the modest belts of square decorative circle brickworks repeat the: beetle” décor of definite elements of cornices and cases of the house of the Stroganovs and the Cathedral of the Transfiguration of the Savior. “Only two belts of the beetle ornament prevent the bell-tower in its shapes from the alien view”<sup>6</sup>.

The composition of the historical-architectural complex is closely connected with the river space. Town panorama is in full opened from the river. All complex is constructed along the coastline and so it has appeared the impression that the objects stand in line<sup>7</sup>.

The fire of 1842 damaged greatly both the wooden buildings and the stone ones. All the constructions were in want of considerable repair. In its turn, this fact promotes the change of Usolye appearance. The bell-tower lost nine small bells and the onion-shaped dome changed the burnt broach later. The tiers of the bell-tower received half-round dome shape. Barely noticeable corbel arches on the faces of



**Fig. 07**  
**Views from the Stroganovs Chamber**  
 The coloured buildings surfaces, made after the recent restoration, constitute nowadays a feature of this landscape.

<sup>5</sup> Cf. Pilyavskiy, Tietz, Ushakov (2003), *History of Russian architecture*.

<sup>6</sup> Cf. Terekhin, Kantorovich (1974), *Architectural ensemble*, cit.

<sup>7</sup> Cf. Kuptikov (2011), *Solychegodsk Churches and architecture of the Russian North in the 18th century*.





⬆  
 Above and below Fig. 08  
**Usolye bell tower as a  
 landmark**  
 Photo a. the view of the bell-  
 tower from the Stroganovs  
 palaty. Photo b. The view of the  
 arc-shaped detached corners.

the crowned part of the middle octagonal structure, which underline its intensity, and dynamics of shape became the details of the bell-tower décor<sup>8</sup>.

The construction of the Kamskaya hydroelectric power station assisted the modification of Usolye appearance. The water of the river came against the historical-architectural complex. The level of water became the same as the level of the spring flooding. Residential buildings and considerable part of industrial objects arrived from the historical part of the town. Every spring the bank of the river continues to be undermined.

Large industrial center situated in the neighborhood (Berezniki city) completed the stage of forming the historical-architectural appearance. The complex has become the outdoor architectural museum.



<sup>8</sup> Cf. Kuptikov (2011), *Sohyehogodsk Churches*, cit.

Despite different existed research limited by the value of the monuments the realized systems of documentation, demonstrate multiple discrepancies which lead to the necessary development of common instruments promoting the possibility to compare the architectural elements of the complex and to present the status of the objects preservation to the foreign scientists. In the last years, the level of damage and instability of these monuments increases which threatens their existence; the development of the topic cognitive system supporting by the digital archive will make possible to realize the measure of this phenomenon, the rate of the monuments loss, etc.

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WESTERN AREA

NORTHERN AREA

CENTRAL AREA

SOUTHERN AREA

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# THE STRUCTURE OF THE LANDSCAPE FOR A PROPOSAL OF ANALYSIS IN USOLYE

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Historically many Russian cities were founded on the banks of the rivers. Rivers were the source of water and fish, trade routes, base for the industrial development. Usolye as the most settlements of Perm Krai is situated on the banks of the Kama River. During a long period of time its citizens' life and welfare was depended on the River. Construction of the Kamskaya Power Station dyke in 1954 changed the appearance of Usolye. The part of the city situated in the shortest distance from the River was submerged by the formed Kamsky reservoir. Some cultural heritages, for example, the Church of Preobrazhenie, were not directly destroyed but the other buildings suffered from flooding and now they are continuously ruined.

Today the historical part of Usolye turns into the island every spring and it is separated from the residential districts by several bridges. The aim of the landscape-visual analysis was to study the interaction of historical architecture and its water surroundings.

Since the results of the landscape-visual analysis should be included in the integrated database of architectural complex the areas were preliminary differentiated and every zone (Rubezhskaya, Kapustinskaya, Nizovaya, Posadskaya) was given a color code. Then the zones were divided into subzones, small territories (indices Ki, Pi, Ni, Ri) in which the relationship of land and water, the height of the bank, relief, flora, existence and state of buildings, paths and roads, legal form of lands were registered.

Further all this information in the form of the map will be included into the graphical digital database of the georeferential system on the basis of GIS.

Rubezhskaya part is situated in the north of historical area of Usolye. Today there is only one preserved building—Rubezhskaya church. Facades of the church are hidden by poplar trees; however its belfry remains the main high-rise dominant. Due to the natural landscapes formed by marshland and backwaters this part of historical island is valuable.

There are four main buildings in Kapustinskaya part: Nikolskaya church which has recently been restored, the house of priest and two small lagricultural buildings.

In Nizovaya part (the southern part of the island) ruins and the rest of infrastructure have been persisted. They could be divided into three categories: buildings, man-made coastline and infrastructural elements.

*Side page Fig. 01*

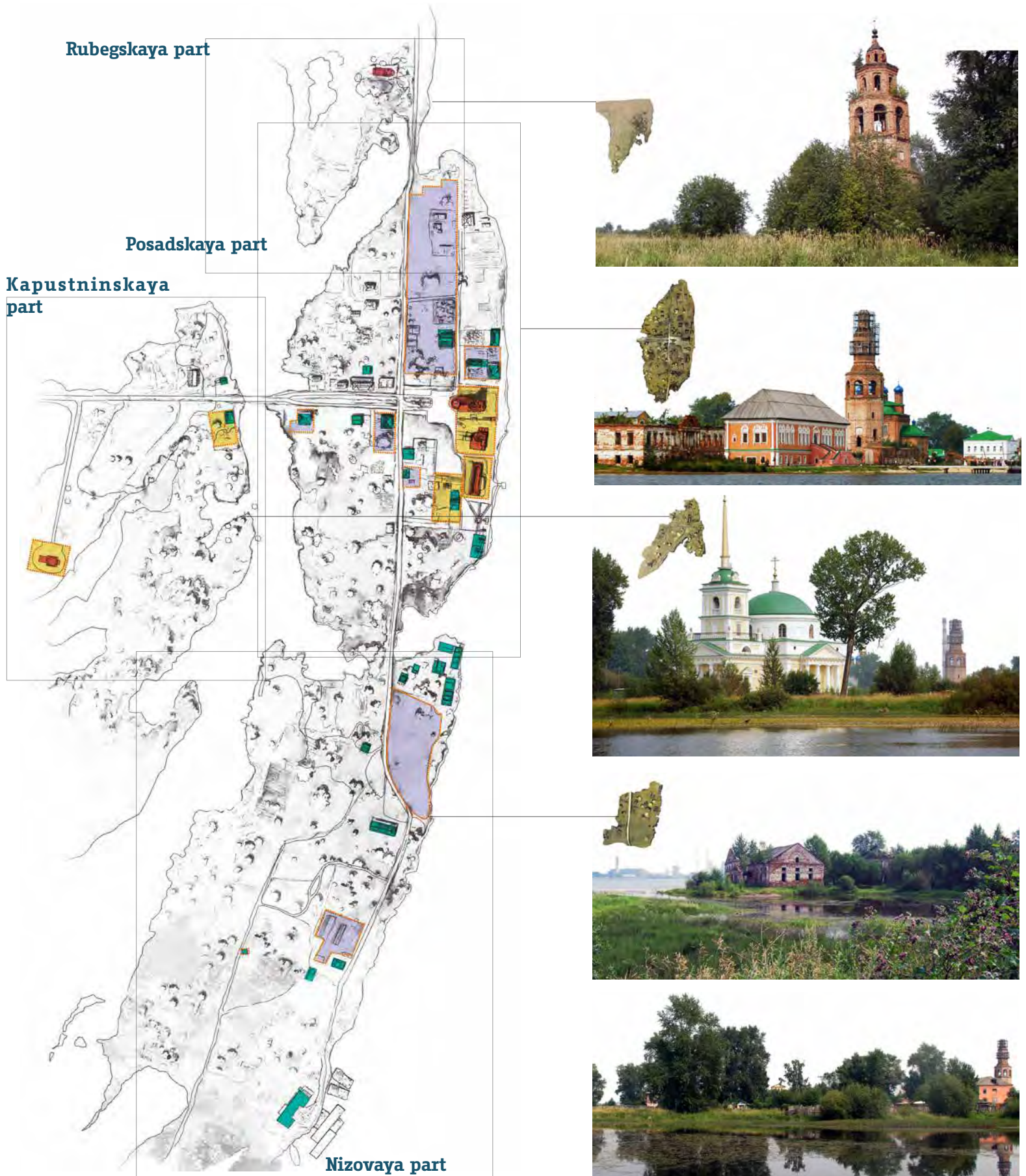
**Area division of Usolye peninsula**

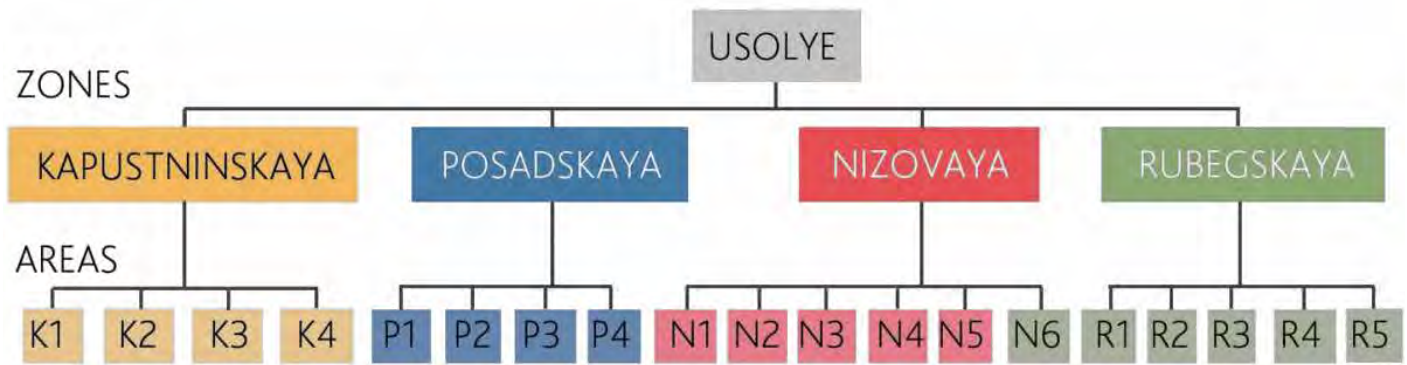
A macro sub-division of Usolye territory based on the formal, functional and architectural characteristics of the area.

*Next page Fig. 02*

**Zoning of the territory**

The plane of monuments, the form of property, regarding the macro sub-division in areas.





Most objects of architectural heritage are situated in Posadskaya part which is in the center of the island. Historical-architectural complex surrounded by the natural landscape (river, lakes, and small islands) is situated here.

General attention was paid to the analysis of specific points and revealing those which has the view of architectural monuments. Techniques of photo fixation, panning and creation of spherical panoramas were used for such analysis.

All panoramic pictures were analyzed in three directions:

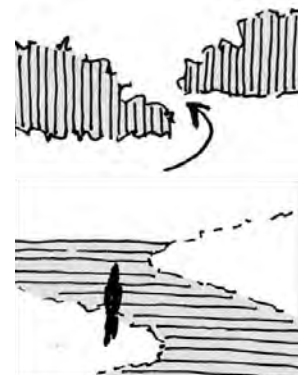
- Visibility of architectural monuments and view of natural landscape;
- Color scheme of panorama and the degree of its harmony;
- Line of sky (identification of dominants and panorama nature).

Mapping of information has made possible to identify the panoramas which are mostly “saturated” with historical architecture, which could be the basis for the foot-passengers’ and waterway tourist routes.

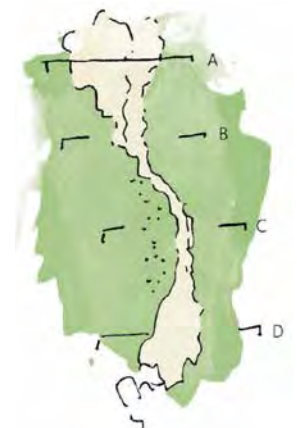
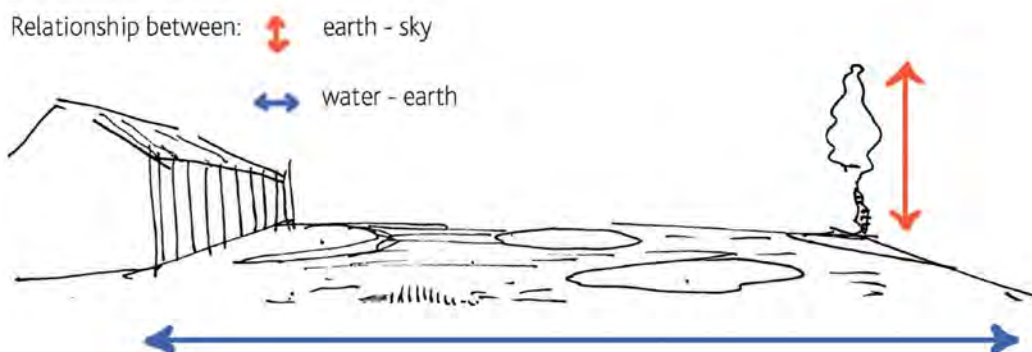
Panoramas were studied by the spherical panning method. Ordinary digital camera and tripod were used for creating photosphere. Photospheres are interactive photos for which the series of photos is made from one point. Further the pictures are processed by PTGui program. Virtual tour of GoogleStreetView is created by the application of spherical panoramas.

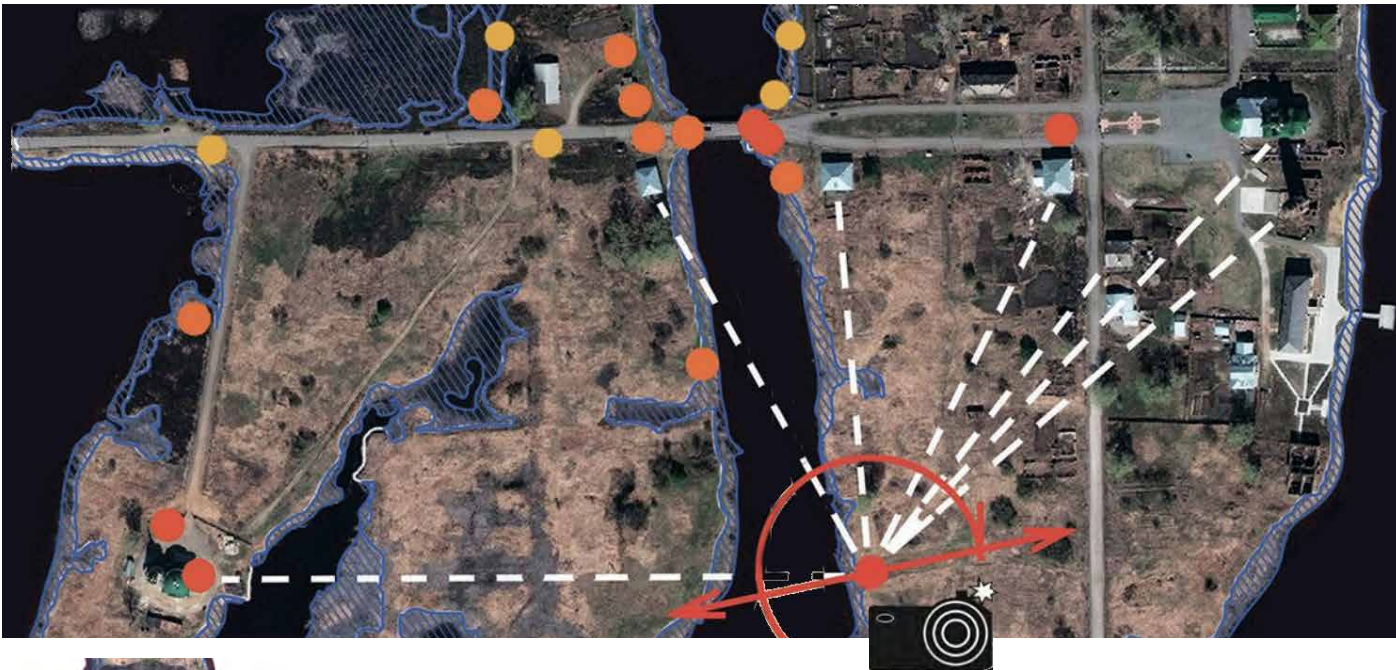
The landscape of historical part of Usolye is the plane surface, so all reserved architectural objects are the dominants in a varying degree. Against the background of the general development the bell towers of churches act as the dominants. The natural dominants are the large free-standing trees.

**Fig. 03**  
**Macro and Micro subdivision**  
 Each zone had been sub-divided into several areas, coded with capital letters and sequential numbers.



**Above and below Fig. 04**  
**Analysis of inner and coastal space**  
 sequential sections were prepared to understand the changing relationships between naturalistic elements and architectural monuments in the various areas.





- High
- Medium
- Low

### The map of impressions

Simultaneously with the search of specific points study of impressions was carried out. Impressions were written down and recorded by dictating machine, sketches of nature were made and then they were formed as the map of impressions.

In the landscape-visual analysis “impressions” reflect the appearing thoughts of the opened views, pleasant and unpleasant smells, the possibility to move, improvement of territory, emotions, etc. Impressions formed as a map assist to construct tourist routes, to find new places which are interesting for visitors, workers, fishermen, holidaymakers.

Three types of areas were singled out in the process of impressions mapping:

- Area with good rich views, good availability and lack of negative emotions;
- Place with quiet atmosphere, applicable for the rest, having satisfactory approaches;
- Place, difficult of access, noisy, generating negative emotions.

Places of difficult access were marked in the map of limits since the physical borders (fences, guards, high bushes and grass) were the obstacle for the construction of walking routs around the territory.



Above Fig. 04  
**Privileged viewpoints map**  
Key viewpoints used by visitors, usefull for an analysis of more characteristic panoramas.



Fig. 05  
**A key viewpoint**  
One of the most photographed vantage points in Usolye.



### Analysis of coastal territories

Coastal territories bordering upon the apartment block of Usolye and territories of the museum complex have considerable natural potential and require the systems approach for the development. To determine strong and vulnerable places there were investigated in detail the landscapes on the water-earth interface. It was taken into considered the coastline and adjacent territory as well as its connection with the other urban territories and recreation objects.

During the analysis visual and physical bonds between the river, museum territory and development were determined. Also the present pedestrian tourist routs was analyzed; waterways and barriers were studied. The scheme of investigation and the structure of data collection are presented.

On the basis of the results obtained subject maps were made. In the aggregate they give complete view of the territory: objectively about actual condition (the map of flooding, scheme of specific points, the map of accessibility) and through subjective perception about emotions and thoughts appearing with the opening views in historical part of Usolye (the map of emotions, written record of thoughts, sketching).

One of the indicators of possible usage of the coastal space is the accessibility of the river banks both from the side of the water and the land. For this purpose the banks accessibility was analyzed.

The possibility of the coastal space usage in Usolye is mainly depended on its flooding in the period of high water. In spring considerable part of historical territory of Usolye is found itself under water. Sometimes flooding lasts up to the middle of the summer. And there is a chance to boat round the islands admiring the architecture from this position. The level of maximal flooding of the territory was estimated by the superposition of satellite maps made in different seasons.

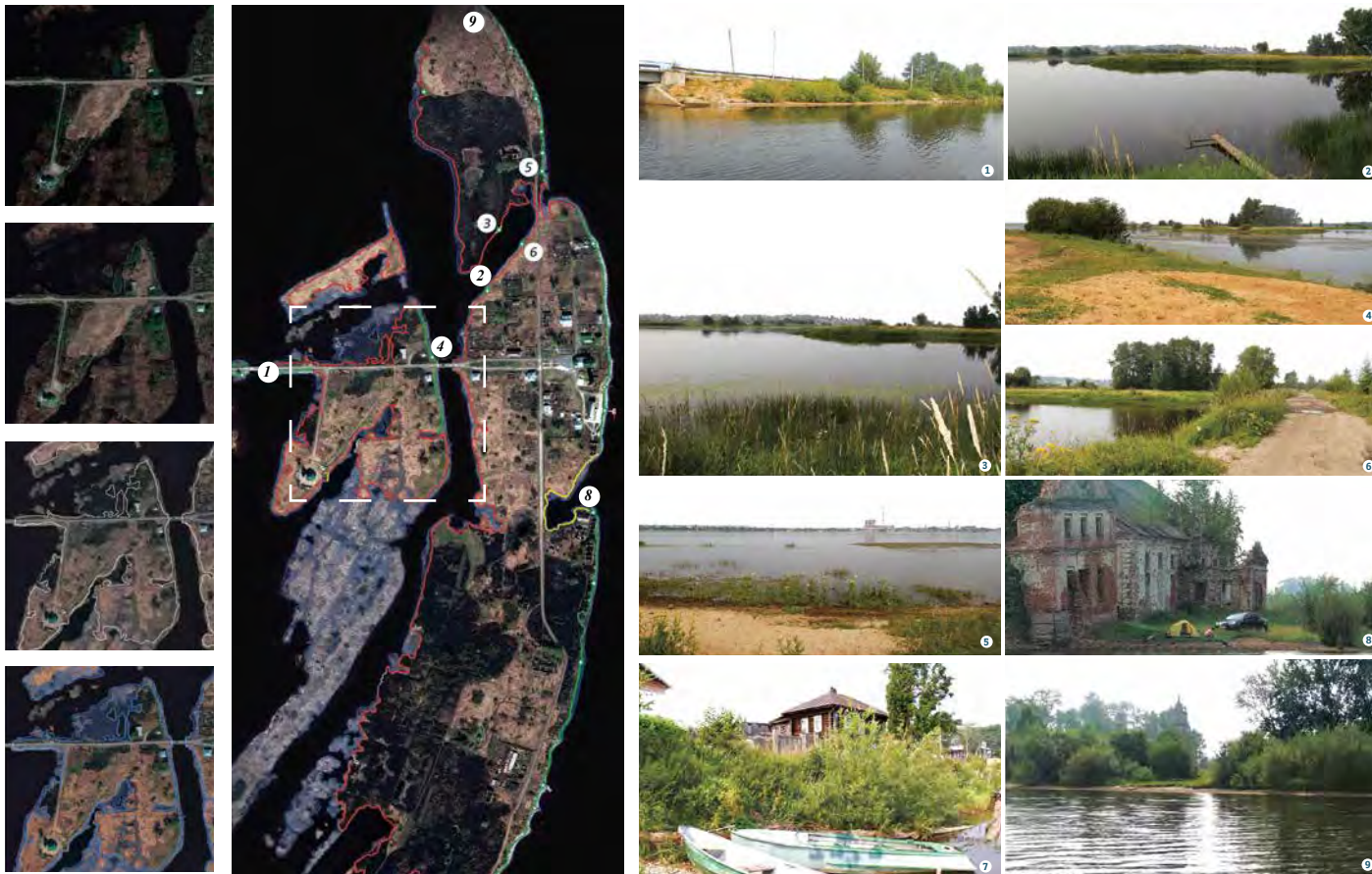
Further the thickness and height of vegetation, the possibility to move along the banks without special cloths and the possibility to sail and to moor to the bank were analyzed. In every section the relationship of the bank and the river was considered: the height of the bank, vegetation, the distance of the paths/roads from the water, the possibility of water approach. In the process of investigation there was singled out four types of coastal spaces in the interface “water-land”:

- Sloping bank; water view is hidden by the shrubbery, high grass or trees;
- High bank; impossib le to walk down;
- Sloping bank with direct access to the water;
- Sloping low bank, partially flooded or swamped.



Fig. 06

**A panorama of an inner area**  
A road showing one of the possible ways to access the river banks from the land, passing by some historical monuments that characterise the site.



*Above Fig. 07*

**The map of the bank access**

On the left, change in coastal orography as a function of rising/lowering water levels. On the right, indication of the main mooring points for small boats along the entire Usolye territory.

## Conclusion

Conducted research made possible to determine visual and physical relationship between the river and the coastal territory, to reveal the most saturated panoramas, architectural and natural dominants, the regularity of pedestrian tourist routes, to mark the availability of physical internal territory limits and to make proposals concerning the provision of new infrastructure and improvement.

With the aim to transform coastal space it has been found specific points for the arrangement of observation areas, beach zones, picnic places. The walking down paths to the river made in the places of observation areas, boat stops and small boathouses will cost little money but promote the attraction of tourists and help the museum complex in its immediate economic problems solution.



*Fig. 07*

**A dockable coastline**

In the bank accesses the coastline is fairly uniform, so it can be docked from several points.



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## GEOGRAPHIC INFORMATION SYSTEM OF USOLYE'S HISTORICAL AND ARCHITECTURAL COMPLEX

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Usolye is a town located on the Middle Urals (Russia, Perm region). The town has rich historical and cultural heritage whose definition herein used of the Federal Law “On the objects of cultural heritage (monuments of culture and history)” (Law 73-FZ). According to this law, the objects of cultural heritage are “objects of immovable property [...] were created as a result of historical events”. These objects are valuable “from the point of view of history, archeology, architecture, urban planning, art, science and technology, aesthetic, ethnological or anthropological, social culture” and are evidence of epochs and civilizations, original sources of information about cultural origin and development.

Several times, Usolye appeared in the catalogs of cultural heritage's objects of the Perm region. As a rule, such publications do not contain information about all Usolye monuments, but only outstanding monuments of Baroque and Classicism, which received of the cultural heritage of Federal Importance<sup>1</sup>. Remaining monuments which are important urban objects unfairly remained outside researchers' field of attention. Vladimir Kostochkin<sup>2</sup> had been studying of the cultural heritage of the historic settlements in the Urals. He had published a short essay about the history of Usolye in which he highlighted the events that influenced the history of Usolye urban planning development and described outstanding architectural monuments. Grigoriy Golovchanskiy is the first researcher who has been attempted to describe the urban development of Usolye in the context of the town's history from the foundation until 1917<sup>3</sup>. At the end of 2018, the historical and architectural museum “Stroganov Chamber” had published research on the material culture of the town. The collective monograph contains a detailed division of the urban planning of the territory<sup>4</sup>. Further studying of the historical and cultural heritage of Usolye, including the use of digital documentation, is necessary for developing strategies for the conservation of cultural heritage in circumstances of urban planning development.

The principal sources for studying the historical and architectural environment of Usolye are old maps of the town; therefore, geographic information systems (GIS) are an invaluable instrument for processing geospatial data. Using the opportunities GIS and geoinformation mapping allows obtaining

*Side page Fig.01*  
**Views of Usolye from the Northern Area**  
the image highlights the main road that crosses the entire peninsula and now connects all areas.

↓  
*Fig. 02*  
**Historical maps collage**  
Historical cartographies are superimposed on the current satellite image in order to assess changes on a landscape and urban planning scale.



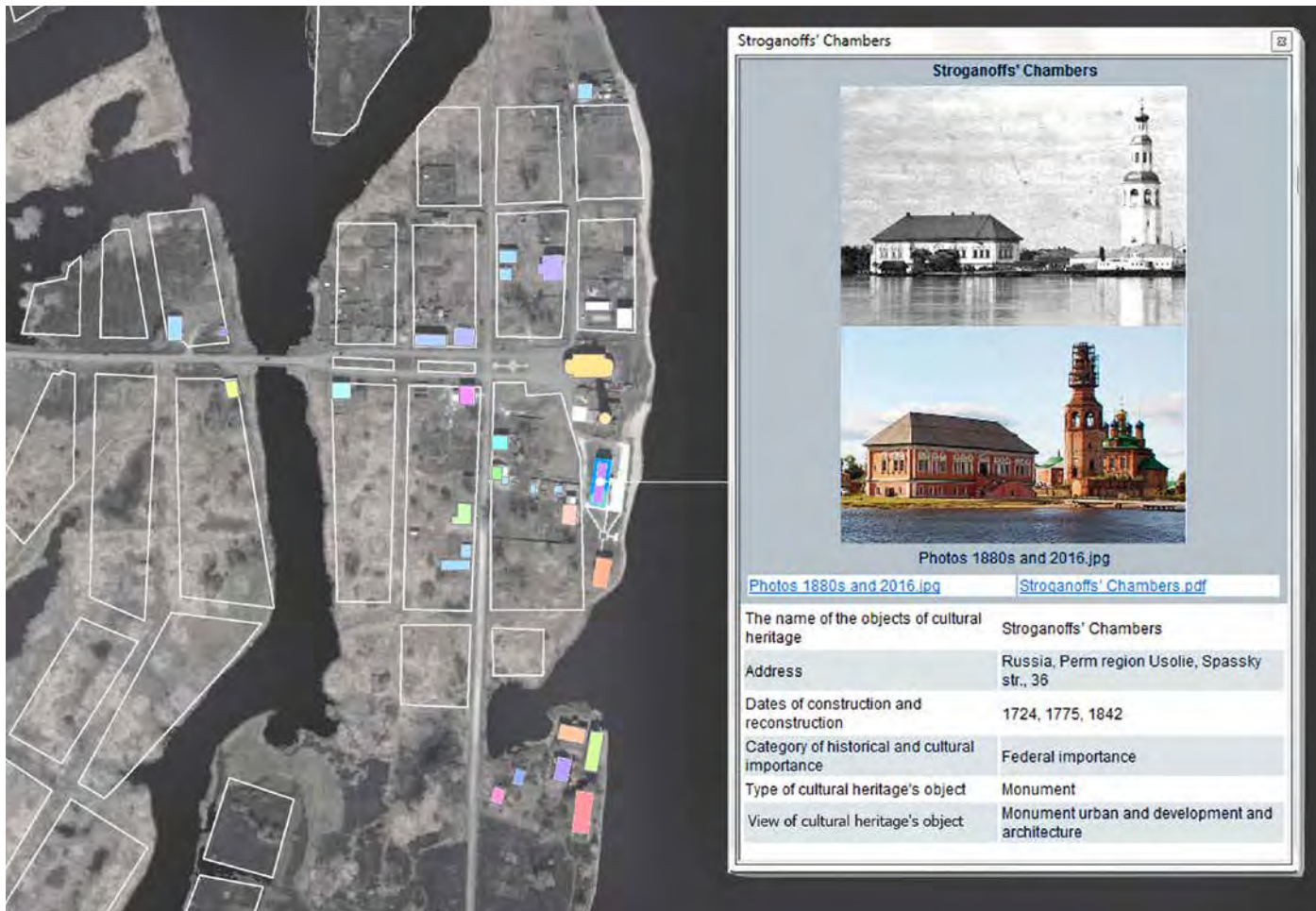
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<sup>1</sup> Shatrov (1976), *Pamyatniki istorii i kul'tury*; Kiselev, Yakina (2011), *Istoriko-arkhitekturnoe nasledie*.

<sup>2</sup> Kostochkin (1988), *Cherdyn*, pp. 113-154

<sup>3</sup> Golovchanskiy, Melnichuk (2005), *Stroganovskie gorodki*, pp. 95-99, 150-159, 186-201.

<sup>4</sup> Bushmakina (2018), *Ocherk arkhitekturno-planirovochnoy istorii*, pp. 27-56.



**Fig. 03**  
**A GIS structure for the monumental area**  
 The informative system developed for the connection between territorial cartographic representation and census cards. In the image, the Stroganovs' Chambers with the main informations related to placement, historical dates, typology of building.

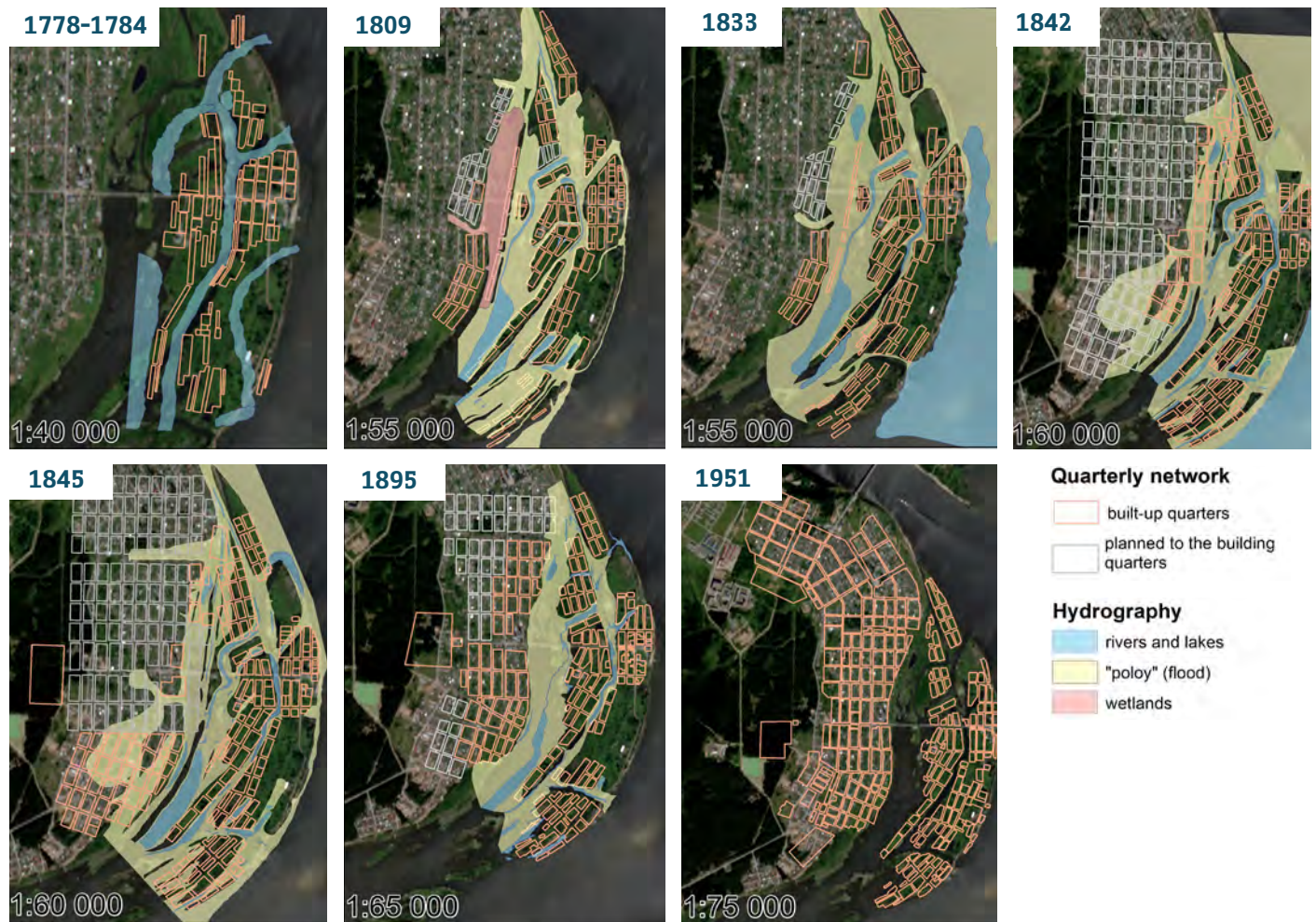
a new product including new historical information in the processing of historical archive sources. GIS-technologies as part of GIS do not only allow to work with maps and text materials, but also visualize them in readable form.

Using GIS-technologies applied to the study of cultural heritage was formed as an interdisciplinary field of research. In the last decades, GIS is used as a tool for monitoring and management of cultural heritage for their protection<sup>5</sup>. Urban history is one of the most developed research directions with the use of GIS, besides many aspects of urban history are associated with cultural heritage. Anne Kelly Knowles has been allocated the application of GIS in scientific practice in several areas, including empirical research on the history and to visualize past landscapes and the changing morphology of built environments<sup>6</sup>.

The present research was the implementation by the licensed software ArcGIS 10.2 (ESRI). The geospatial model «Cultural and historical heritage of Usolye» was created with the collaboration of

<sup>5</sup> Cf. Agapiou et al. (2015), *Cultural heritage management*, pp. 230-239; Cano, Garzón, Sánchez-Soto (2013), *Historic preservation and GIS*, pp. 34-47; Evans, Fielding (1998), *Giza*, pp. 82-99; Al-Kheder et al. (2009), *GIS analysis of urban heritage*, pp. 81-92; Kornienko et al. (2015), *Historical and cultural heritage of Perm region*, pp. 124-132.

<sup>6</sup> Knowles (2008), *GIS and history*, p. 8



the Department of Ancient and Medieval history of Russia at Perm State Humanitarian Pedagogical University and the Department of Cartography and Geoinformatics at Perm State University in 2015-2017. For the correct work with spatial data needs a common coordinate system, accordingly, all historical maps were brought to coordinate system WGS 1984 Web Mercator Auxiliary Sphere. For the substrate used photographs of different spatial resolution: the territory of Usolye archives «PSU Space Monitoring Center»: LandSat (spatial resolution of 30 m, 2001), Spot-6 (natural colors, the spatial resolution of 1.6 m 2014) and ArcGIS Online base maps.

The developing of the geospatial model took place in several stages. First, the quality cartographic materials were selected and scanned. Cartographic and iconographic materials dated the 18th – beginning 20th centuries from the funds of national and regional archival repositories used in the preparation of projects. Among which the Russian State Archive of Ancient Acts, the Russian State Historical Archive, the State Archive of the Perm Region, History and Art Museum of Berezniki, the Solikamsk local history museum and the historical and architectural museum in Usolye. Methodological approach for the analysis of old urban maps had developed by Pavel Korchagin<sup>7</sup>.

**Fig. 04**  
**Quarterly network and hydrographic situation in Usolye**  
 The image describe the changes of existing quarters, and the planned quarters, in their relation with the hydrographic situation, from 1778 till 1951.

<sup>7</sup> Korchagin (2008), *Vozможности planigraficheskikh istochnikov*, pp. 7-27.

The following stage was the georeferencing of each cartographic source to the modern topographic base and bringing them into a single coordinate system. The final stages of the work were the digitization of maps and creation on their basis of the geodatabase. The geodatabase is necessary for structuring available positional and attributes data, which facilitates to work with them. Raster and vector map layers were attributed to positional information. In turn, the raster map layers were divided into cartographic materials and data of the Earth remote sensing, which were used as supporting material for digitization, georeferencing, and identification of objects. Vector map layers represent digitized maps, which include the information of the following classes of objects recorded in the geodatabase:

- borders of the town and urban sprawl;
- existing brick and significant wooden buildings;
- built-up and planned for building quarters;
- water bodies;
- communication and infrastructure (roads, bridges, dams).

Attribute data contains comprehensive information obtained from historical cartographic sources and represents tabular information, which is the basis of geographical objects, allowing to visualize and analyze data. Geodatabase allows creating attachments, which store the detailed information (non-geographic) about the objects of cultural heritage. The user can click on the object and view necessary information in the pdf-document.

The result of the investigation was the development of the geospatial model, which contain information about the planning and urban development of the Ussolye in the 18th – beginning of the 20th century. In the attachments of geodatabases gathered information about all the Ussolye objects of cultural heritage, dated the 18th – beginning 20th centuries. The attachments include public information from the national cultural heritage register of Russia: the name of the object, its address, the date of construction, reconstruction and/or dates associated with historical events, the category of historical and cultural importance and type of cultural heritage's object. Moreover, the attachments represent archival and contemporary photographs of monuments, names of the architects or builders (if known), brief historical information, architectural description of objects and drawing or building project.

Geodatabases allow storing the information in an orderly manner, to produce accounting and systematization of cultural heritage's objects and to implement spatial monitoring. It is possible to use a query to search, do samplings on the set parameters and analyze the requested information. These samplings can be helpful for research purposes or in the practical activities of the executive power authorized in the sphere of cultural heritage protection.

It is important to point out that GIS-technologies allow studying the heritage of historical settlements in their integrity and diversity, not only the cultural heritage's objects, but also the historical and

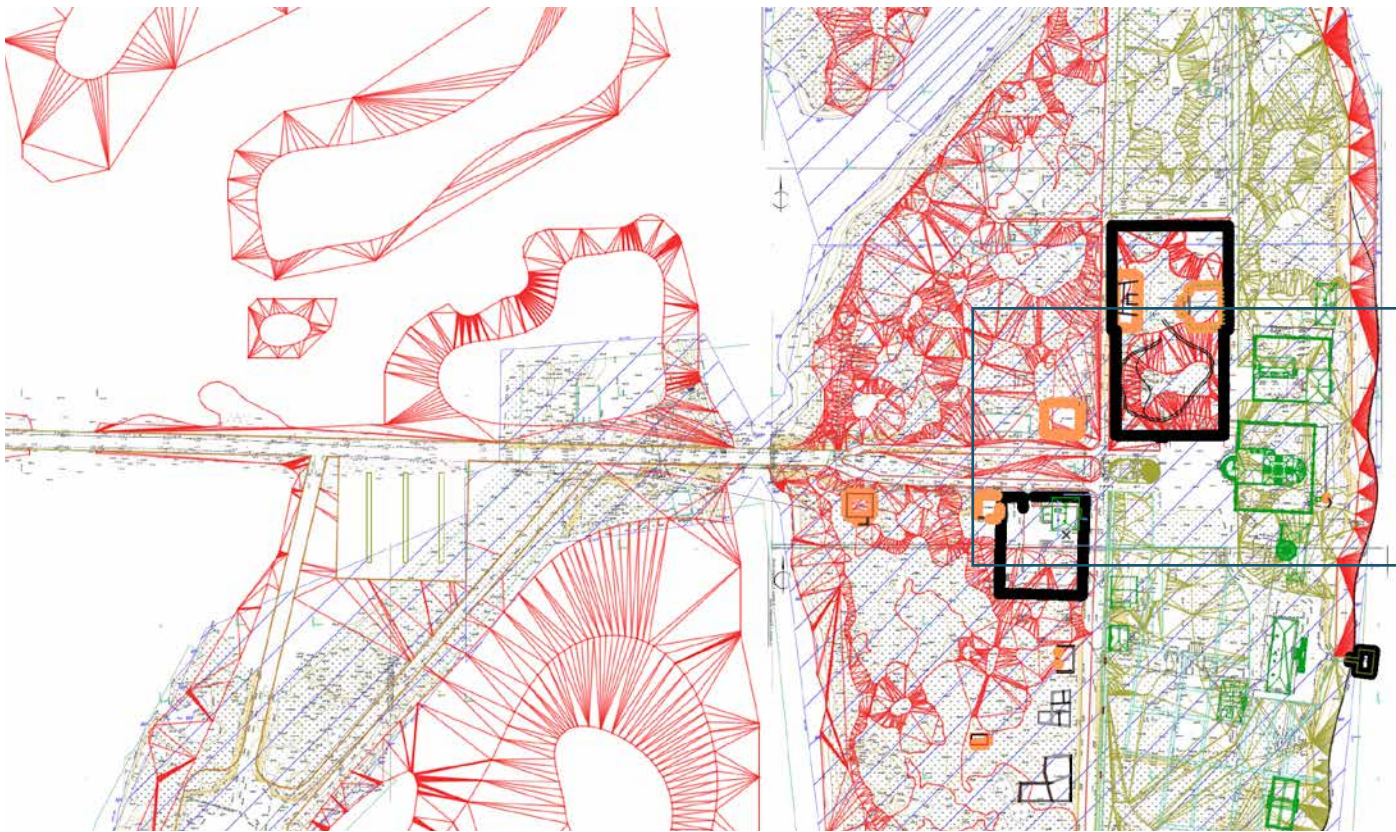
architectural environment: the existing system of verticals and spatial relations, the main streets and squares, the cultural landscape and the natural environment. Through the using archival maps and plans which were brought out to the modern topographic base, we have recreated the urban development of Usolye. Within the imposition of the archival cartographic sources, we have been able to identify new information which not recorded in writing sources. Integration of historical maps in GIS has allowed localizing the borders of the town, the historical building lines, the density of development, highlighting the historical urban center and separate functional zones, ownership (the whole town divided between several noble families). Interrelation old master-plans and maps reflected real development of the town has provided an opportunity to identify divergences from the original intentions (cemetery placement closer to the residential area) and the experience of failed planning decisions which had rejected (the placement shops along the bridge and quarters at flooded lowlands). Availability of such information now helps to weed out failing urban planning and design decisions. Moreover, through the use of GIS, we have received qualitatively new information, especially in a changing cultural landscape because of the active channel processes and anthropogenic factors.

Synthesis archival maps and modern topographic proved useful for the fixing changes coastline of the Kama and the location of the oxbow lakes in boundaries of Usolye before commissioning of the Kama hydroelectric station. Finally, it was possible to clarify the historical functional and the date of construction of industrial architecture's monuments, including which in a ruined condition.

The industrial area was densely built up, therefore, it would be very difficult to verify this without georeferencing, and the present situation of the monuments would not allow for clarifying the original buildings purposes with on location surveys.

Thus, the analyze maps of Usolye with application geoinformation methods has revealed features of the urban planning organization, define the boundaries of a spread of building, identify patterns of folding of historical and architectural environment of the town that will be useful for the study of the socio-economic sides its history. Besides, the GIS-project managed to bring together all information about the cultural heritage (monuments of history, architecture, and urban planning) of the town that allows implementing spatial analysis and monitoring of cultural heritage, predict potential risks on the basis of the information included in the geodatabase. The employment of digitized maps facilitates the use of archival sources in solving various historical and architectural problems of applied quality, given the plethora of information contained in archival maps. Therefore, the use of GIS with drawings, photographs, and other historical data is valuable to the restoration monuments and conservation of the historic environment.

The GIS-technologies as a method of digital documentation is an excellent tool not only for visualization but also for studying cultural heritage and history of urban planning development, providing new opportunities for historical research. Using GIS for studying historical and cultural

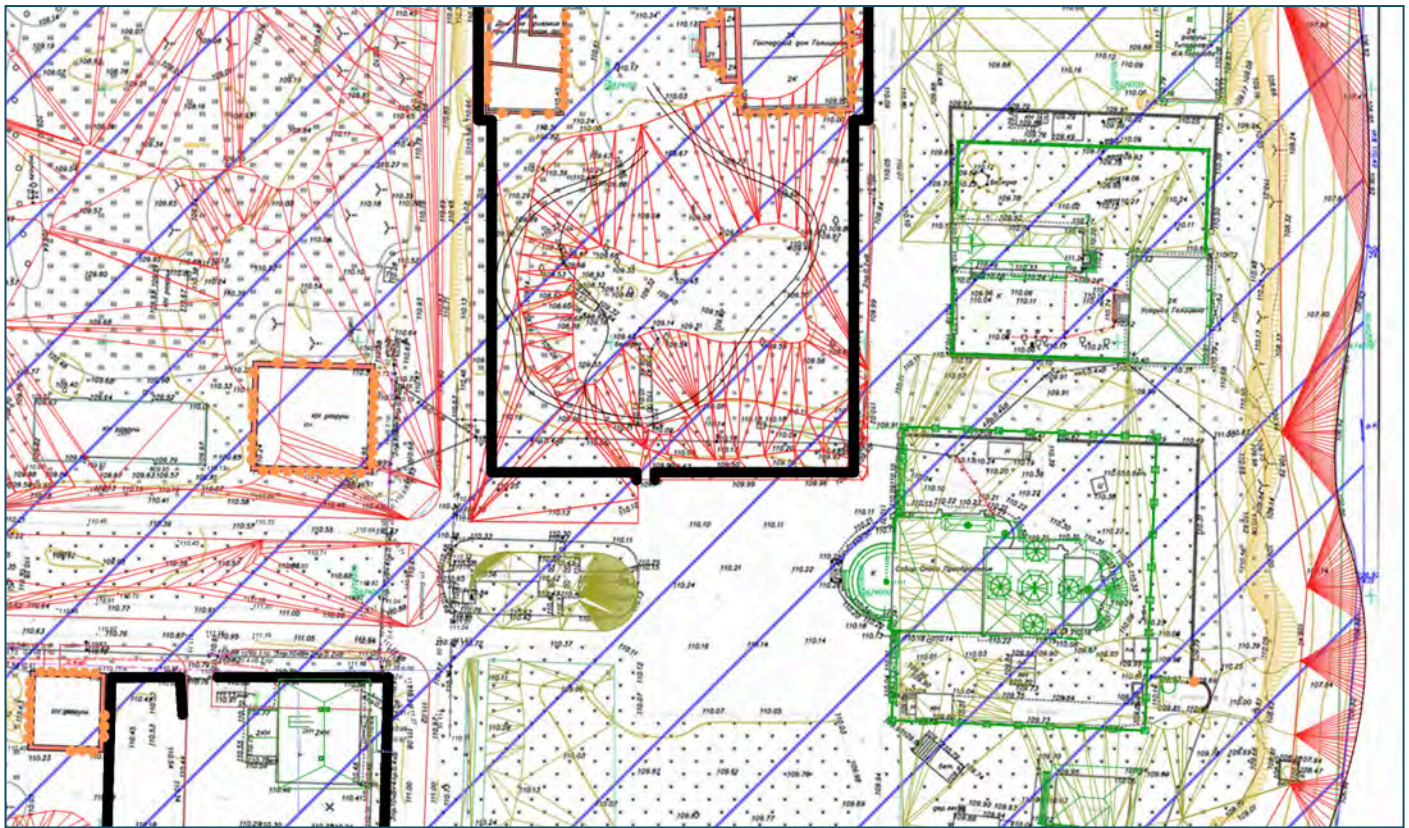


**Above and next page Fig. 05  
A 3D model for an interactive  
informative platform**  
With the intention of collecting  
historical-architectural-  
landscape and spatial data,  
useful for better planning of  
interventions on the built  
heritage, a vector model of the  
peninsula was prepared, on  
which individual architectural  
artefacts could be inserted and  
made searchable.

heritage provided an opportunity to confirm or refute the established historiography judgments concerning the urban development of Usolye. The information obtained as a result of developing GIS project can be applied in practice. Digital data can be used to work with objects of cultural heritage (to carry out their spatial analysis, monitoring, and accounting), in conducting archaeological research. The interconnection of geospatial models and modern buildings might be used in the development or correction of the urban-planning regulations.

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## THE IMAGE OF STROGANOV HISTORICAL SITE: CONSIDERATIONS ABOUT SURVEY AND RESTORATION

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The heart of Usolye is the Stroganov Complex, which, at the time of its construction, contrasted with the numerous wooden buildings and imposed itself through a leap in scale over the minute dimensions and narrow streets of the first settlement. The architectural style of the complex is that of the so-called 'Stroganov School', founded in the 17th century, which deviated significantly from the aesthetics of the Russian capital at that time, although the buildings retained a strong formal connection to the architectural heritage of the region, due to the involvement of local artists and craftsmen in their construction. That of Usolye is one of the rare examples of the Stroganov Baroque, a stylistic current that appeared mostly in the places where the family's properties were located, from Solvychevodsk in the north to Nizhny Novgorod on the Volga and Ustyuzhna on the Mologa River (today's Vologda region), thus conferring a considerable value on the complex, hence the administrations' motivation to promote its preservation.

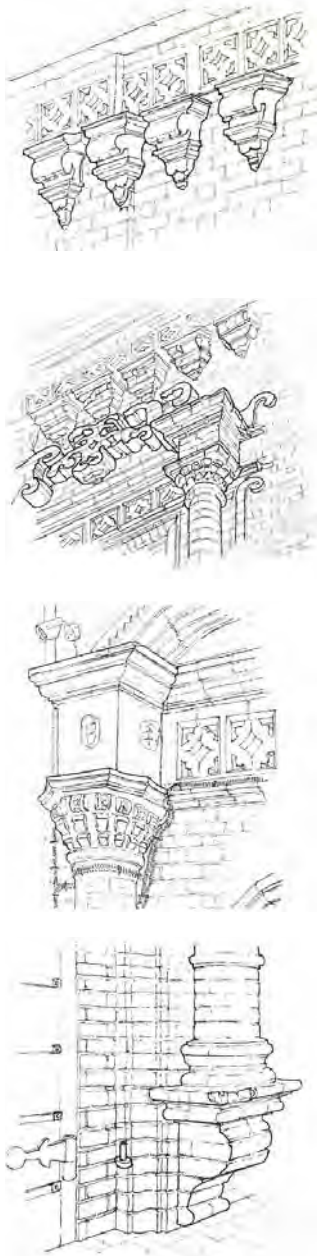
The Stroganov residence was built in 1724 under Sergei G. Stroganov as the first Stroganov residence in the Urals. It had the typical features of the late Baroque Moscow style, being structured on two floors, one for servants and one for the owners, with the façade surrounded by angular half-columns that mark the formal partitioning of the front decorated with a cornice at the top with the 'zuchkovo' (Ж) motif and richly decorated windows. The different social function of the two floors is emphasised on the outside, the ground floor, devoid of decorative motifs, takes on the value of a large basement of the noble floor by deforming the proportion in the corner pilasters that become the base of the half-columns above. The main entrance faces east, towards Kama, and is accessed via a monumental staircase built in the early 20th century. The residence was restored in 2013 and now houses the Museum of Usolye History.

The bell tower has suffered numerous damages throughout history; its original pinnacle was lost during a fire in 1809 and the tower was later restored in 1842. As a result of rising water levels during the 1950s, a subsidence of the foundation apparatus occurred, inducing a rotation that caused the new pinnacle to collapse. Recently, a new pinnacle was purchased to crown the building, but unfortunately, the excessive weight of the element makes its positioning impossible due to the instability and slope of the structure. According to historical surveys, the main entrance was located on the south side, while on the north-west side, there was a staircase going up inside the masonry. Now the entrance is made possible through an opening to an intermediate floor, connected by a temporary external staircase. Inside, wooden stairs connect the ground floor to two intermediate floors, until reaching the belfry. At its base is the

*Side Page Fig. 01*  
**Bird view of the monumental complex of Usolye**  
An evocative image of the monumental buildings that constitute the most representative image of the whole Upper Kama territory.

↓  
*Fig. 02*  
**Watercolour detail of Stroganov' Chambers**  
Drawings are the first tools used to capture the image of the place, analyse its constituent features and direct the documentation activity towards its enhancement. (Drawing credit: Alexey Leybchik)





**Fig. 03**  
**Study Drawings**  
 Construction details of Villa Stroganov and the Church of the Transfiguration, preparatory to the elaboration of 2D drawings and 3D models. (Drawing credit: Alexey Leybchik)

covered market complex, originally provided with a portico that extended into the riverfront elevation, which is now in ruins. The vaulted rooms are overgrown with spontaneous vegetation and the rubble from the partial collapse of the roof. The most impressive building in the complex is the Church of the Transfiguration, which was built starting in 1724, the same year as the Stroganov residence, thanks to donations from Sergei Stroganov. Work continued slowly and was completed in 1731. The church, with an asymmetrical layout, has a central block consisting of a cubic volume crowned by five domes supported by drums resting on dormer windows inserted into the roof. This conformation is typical of many churches in the region, which have an external volume of considerable size and decorated in imitation of an urban façade, but which constitutes a scenic backdrop that covers the much smaller church hall, also for climatic reasons. In the church of Usolye, the internal volume reflects the external one, giving an extreme monumentality to the hall, which is nevertheless well separated from the large refectory in which there are numerous altars. The original external access staircase was later incorporated by a semicircular block, which today forms the unusual façade of the monument<sup>1</sup>.

The documentation of Usolye, conducted over the past three years, constitutes the first episode of a much more ambitious project aimed at rehabilitating the technological and constructive qualities, as well as the landscape, of this enormous monumental heritage residing in the Upper Kama regions. To this end, the Usolye complex was chosen for the diversity and number of monuments present, but also as a convenient training camp in which to experiment the various monitoring techniques useful for developing recovery proposals for similar but more isolated systems in the northern forests. The notoriety of the complex also ensured good visibility for the project, which fuelled a debate in the area led by administrations and associations for the benefit of protection and education in the knowledge of monuments for the inhabitants of these places.

In addition to a census of the buildings and the design of a special card for the cataloguing of each building unit, 3D laser scanning and SfM photogrammetry surveys were carried out to develop three-dimensional databases on which information from other surveys such as thermographic surveys and essays on the state of health of the structures could be integrated. Reliable drawings and 3D models were returned on which the degradation analysis could be recorded and then virtual simulation operations could be carried out to understand the possible intervention variables. The laser-scanner survey campaigns, conducted using a Leica ScanStation C10, are divided into three main missions. The first in 2014 covered the survey of the fronts of Villa Stroganov, the second carried out in 2015 focused on the area of the Stroganov complex, with particular attention to the bell tower and the covered market and the Church of the Transfiguration, of which the interior and exterior areas were acquired. The third campaign, carried out in 2016, focused on the residential complex along Kama, with particular attention to the Stroganov manor house.

<sup>1</sup> Cf. Brumfield (2011), *Usolye*.



Examination of the objects of historical-cultural heritage in Usolye historical-architectural complex was carried out by Leica ScanStationC10 laser scanner. On the first stage of cameral treatment the obtained data have been processed by Leica Cyclone program. Since the buildings of the ensemble have the complex geometry with architectural décor laser scanning was made high point density. Scanning stations were located in short distance from each other (in 10–20 meters along the perimeter of the building in average), thus, the visibility of the scanned elements was optimal from every point and the beam of laser could approach the cornice level. So, the distance between the wall and the scanner standing point amounts to 10 meters. Scanning made possible to obtain volumetric point cloud and to create identical 3D image of the ensemble with exact spatial characteristics

To obtain external and internal geometry of the surveyed ensemble it has been done 75 points of standing of LeicaScanStationC-10. As a result it has been made the broad picture of the object and surrounding area. Moreover, there has been discovered and fixed the ways hidden in the walls of the bell-tower which have the arched ceilings and brick steps. Measuring drawings made on the basis of point cloud radically differ from the archive ones. In the plans comparison it has discovered the loss of some constructions as well as the change of the mass-planning design of the ensemble in whole.

In the process of discrete models' analysis it has been found that the bell-tower of the Cathedral is out-of-plumb, internal edges of the bell-tower are being parallel to the external ones with light bias while the walls of the shopping street are not parallel.



**Fig. 04**  
**Comparing images**

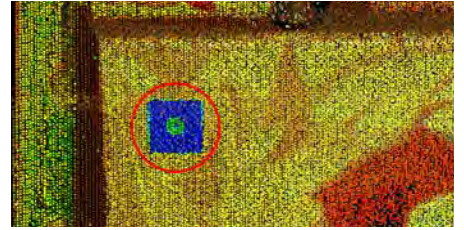
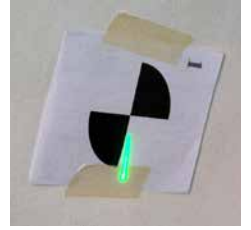
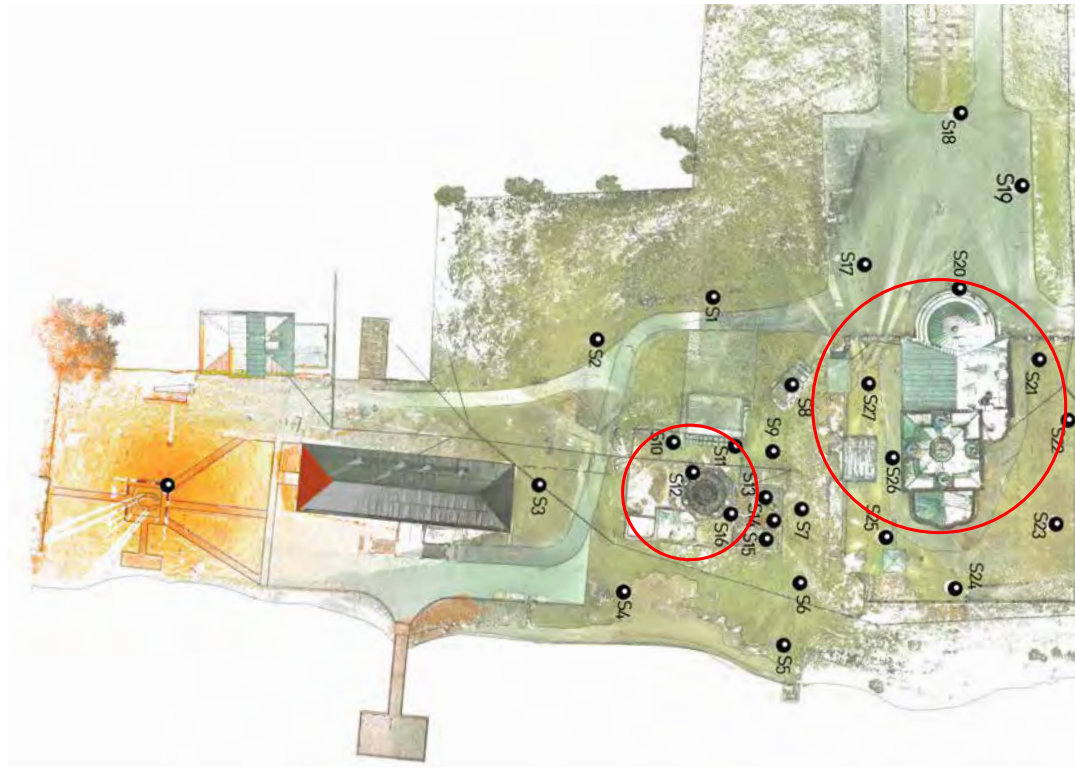
The two historical images from the early 1900s on the left and from 2013 those on the right, show the architectural transformations (both in the shape of the bell tower and in the colouring of the building surfaces), as well as the great urbanistic changes that affected the area.

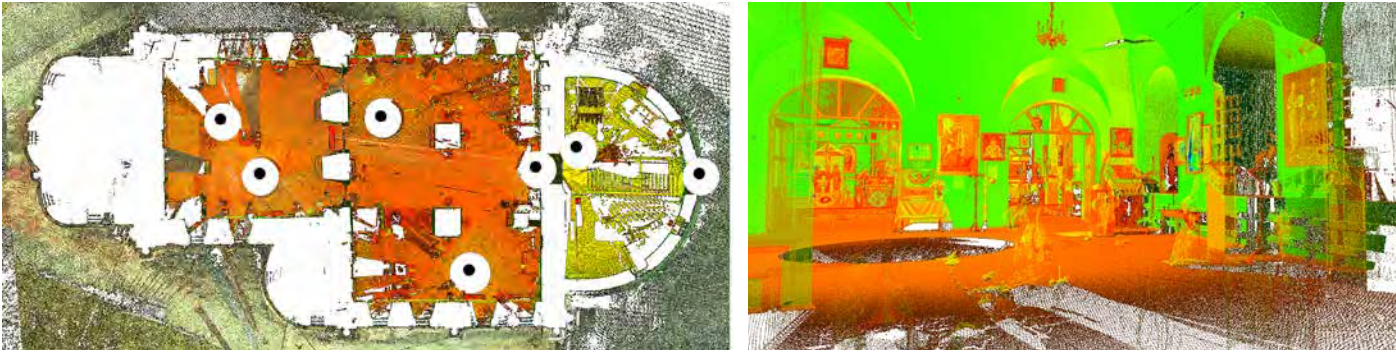


**Fig. 05**  
**Shapes and colours**  
Perceptions of an eternal and changing space.

*Side page Fig. 06*  
**Laser scanner campaign**  
Typologies of targets, planning of scans positioning and final general 3D point cloud obtained with TLS instrument.

Similar to the survey of the Cathedral ensemble it has been made visual analysis of the situation for the other objects. The points of standing the scan SSC-10 including 24 stations outside and 30 stations inside were preliminary mapped. In the process of measuring drawings making accurate geometrics of the whole building, definite lost elements, the places of locating the women and lion masks on voussiors and the modification of the entrance space have been defined. In comparison of archive and measuring plans there were found the destroyed in the process of maintenance the partition walls, the arches on the first floor and etc.





↑  
**Fig. 07**  
**Scan of the Church**  
 Images of the plan section and the interior of the Church of Transfiguration.

↓  
**Fig. 08**  
**Scan of the Bell tower**  
 View of the scans position inside the tower. This image is the result of data registration between interior and exterior part of the building.



In the process of arrangement of points of standing of SSC-10 work station the possibility of obtaining complete information about surroundings and buildings has been taken into consideration. It has been received the discrete models of the estate of Golitsyn and the print shop of I.I. Tarasov. Currently the electronic archive includes the point clouds with three-dimensional coordinates, panoramic images of high resolution and attributive information.

On the basis of scan data of the Manor House it was make architectural model which is located in the exhibiting space of the museum and is being the working unit. Besides the objects considered above in the architectural ensemble of Usolye it has been scanned the Church of the Vladimir Icon of the Mother of God, the Chapel of protection of the Blessed Virgin, the Church of the Nicholas of the Wonderworker (Usolye town) and the Church of the Nocholas the Wonderworker situated in the settlement Pyskor, located in some kilometers from Usolye. The work on these objects scan data processing has not finished yet. As a result of accurate systematic approach realised in the process of architectural survey of Usolye it has been collect extensive information which is supposed to be systematized and include into the digital database in the nearest future.

The laser-scanner survey work was flanked by a close-range photographic campaign aimed at the restitution of detailed 3D models from which it was possible to extrapolate metrically reliable textures that constituted an archive of information useful for studying the morphometric qualities of the building elements and functional for the elaboration of the photo-plans. Photographic campaigns were conducted to develop point clouds to supplement the laser ones, extending the analysis with the acquisition of environmental data, through photos from the river, aimed at the restitution of the elevation along the Kama, and the acquisition of photographs of the architectural details through the use of telephoto lenses. The archive of the various decorative elements, oriented on the coordinates of the general survey conducted, constitutes a considerable part of the database produced on the surveyed buildings.

In the process of reconstructing the historical memory of the place, imagining that the database produced could then be thematically interpreted to define historical scenarios and settings in which the events of Usolye took place, the research started from the analysis of historical cartographies, which, correctly interpreted, made it possible to search the site for traces of the past. The maps and drawings, and in general the documentary apparatus of the archives kept at the municipality and at the Stroganov Centre, served as a starting point for an analysis that covered the entire territory of the old town, allowing us to develop, following numerous inspections, thematic maps on which to identify the main types and functional

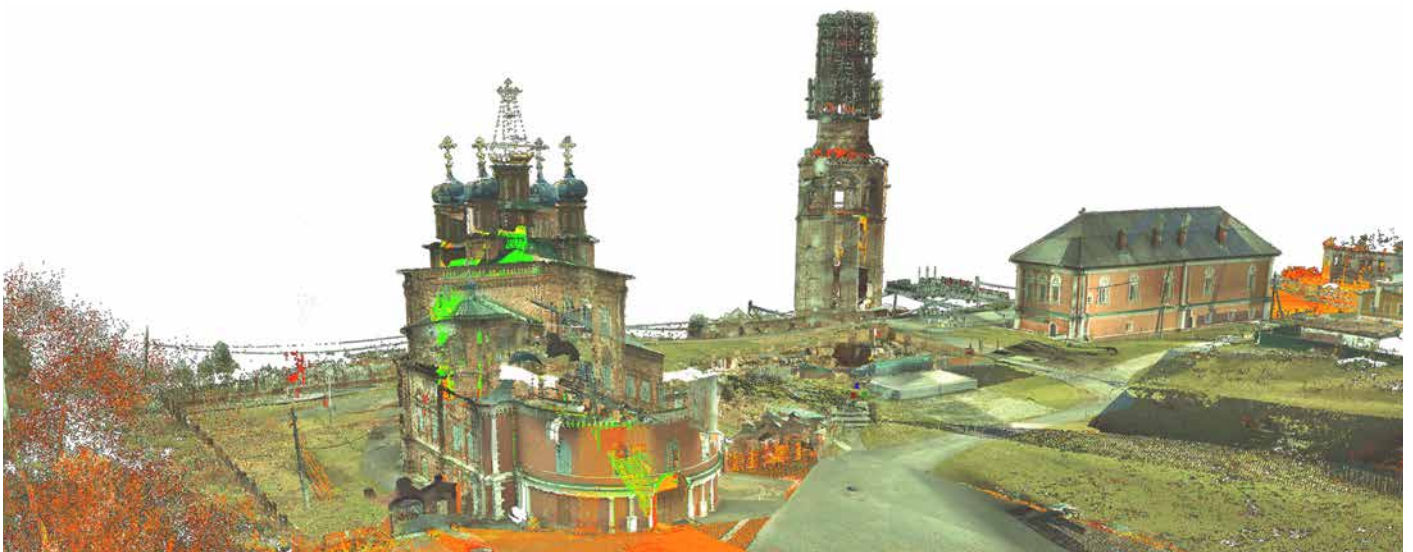


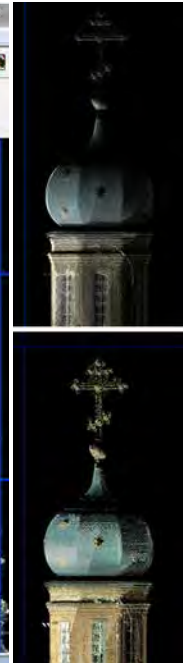
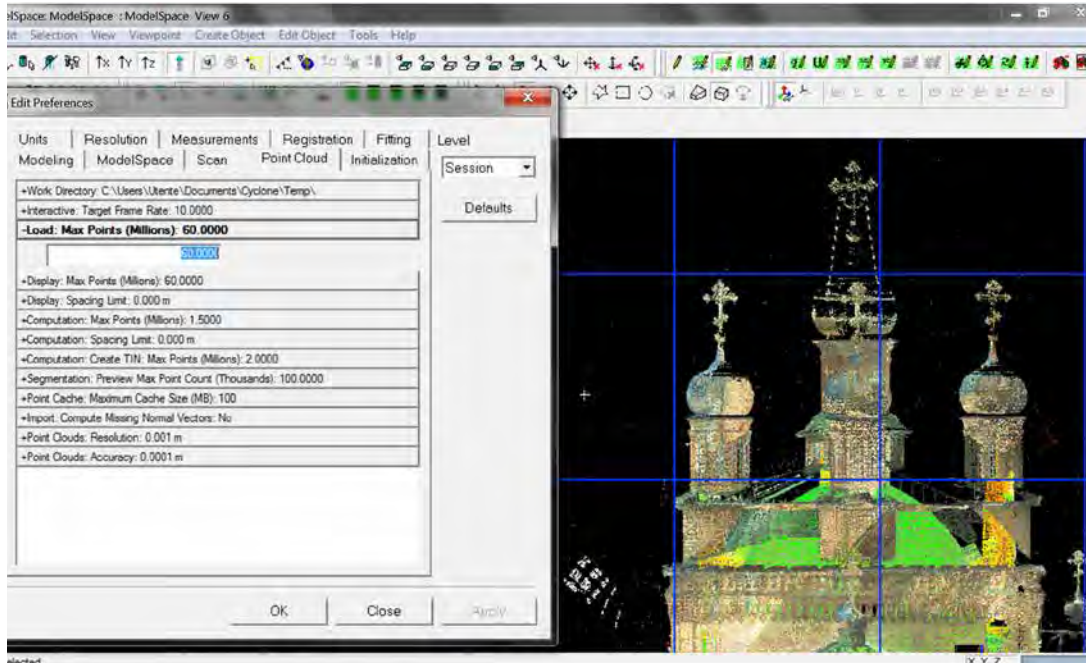
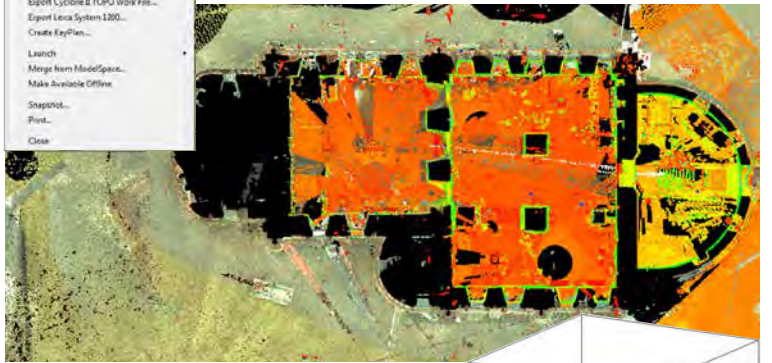
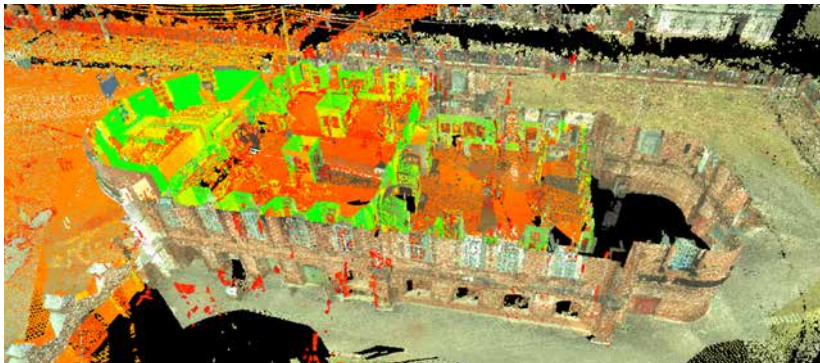
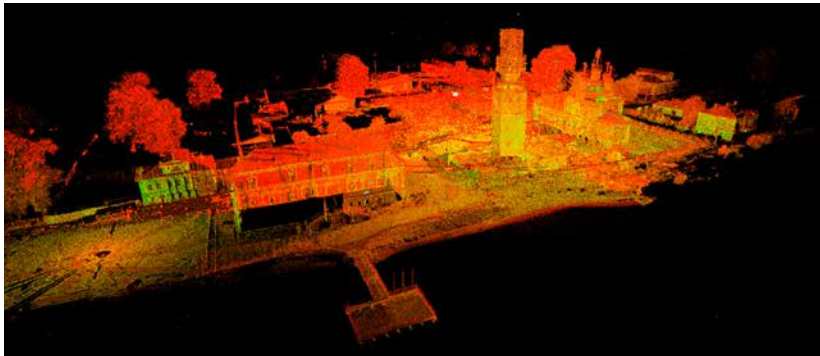
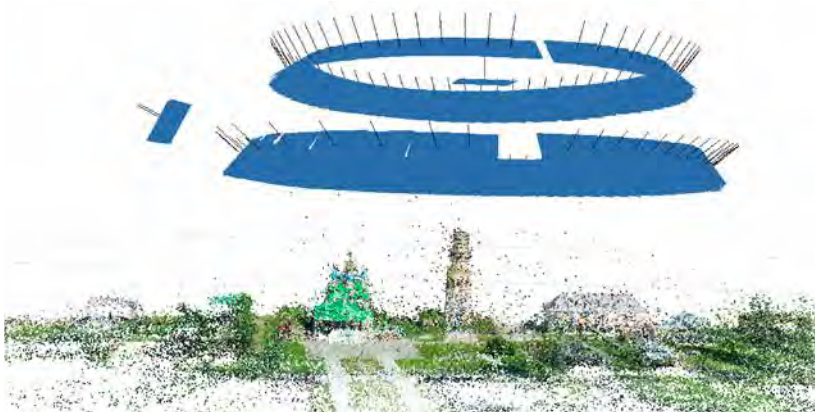
characteristics of the architectures that have disappeared and of which, in some cases, there are still traces. The fieldwork involved the census and cataloguing of building systems and technological details, of what could be documented by the remains of industrial buildings or small votive chapels now isolated in the lagoon.

The standard form is divided into three main sections. The first, named ‘general information’, provides a framing of the building within the historic centre, flanked by a representative photo, specifying the area of settlement, its location in relation to the urban fabric and its relationship with the main architecture. In the second section, defined ‘visual description’, the characteristics that determine its appearance and impact with the context are highlighted, through the identification of the dominant colour, its degree of visibility and a brief description of the surrounding environment. The ‘architectural-constructional analysis’ reports eidotypes and images taken from 3D models representing plans, elevations, significant

⬇️  
**Above and Below Figs. 09, 10**  
**General scan views**  
 Image of the coloured point cloud of the registered database.

Next page Fig. 11  
**Data integration and post-production**  
 Integration with photogrammetric survey by drone and definition of section plans for the description of elevations.







views of the architecture under examination, specifying its construction system, the materials used, the type, material and condition of the roofing. The name, historical and current function are also reported.

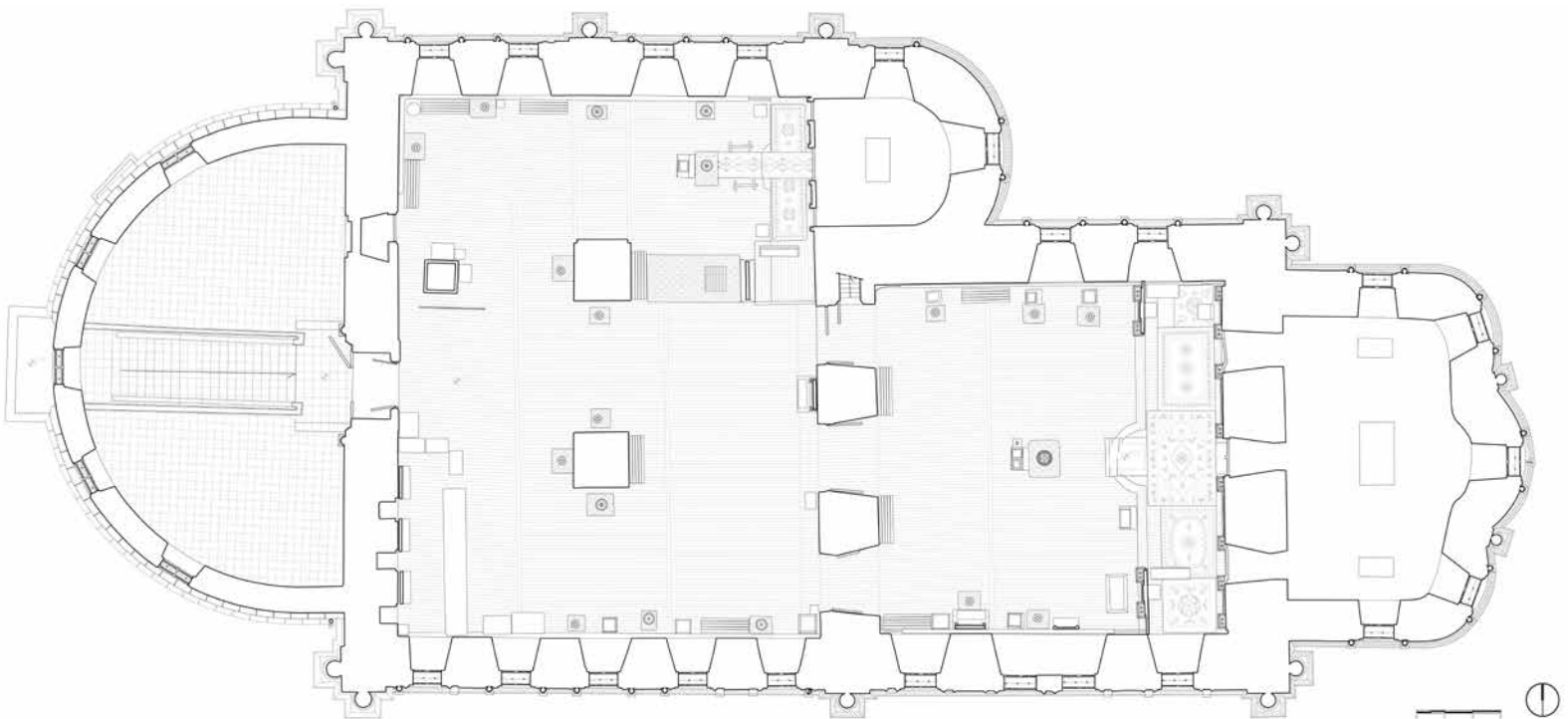
The structure of the database, georeferenced on infographic platforms, constitutes a unique archiving system that makes the data accessible and easy to interpret, allowing a dialogue and deepening of the knowledge of the complex thanks to a cascade system that relates the territory with the architecture and the individual construction details. The data collected during the survey process were used to create detailed two-dimensional drawings that faithfully represent plans, projections and sections of the Stroganov complex, as well as 3D models of the decorative elements, which in turn became integral and integrable tools of the digital database.

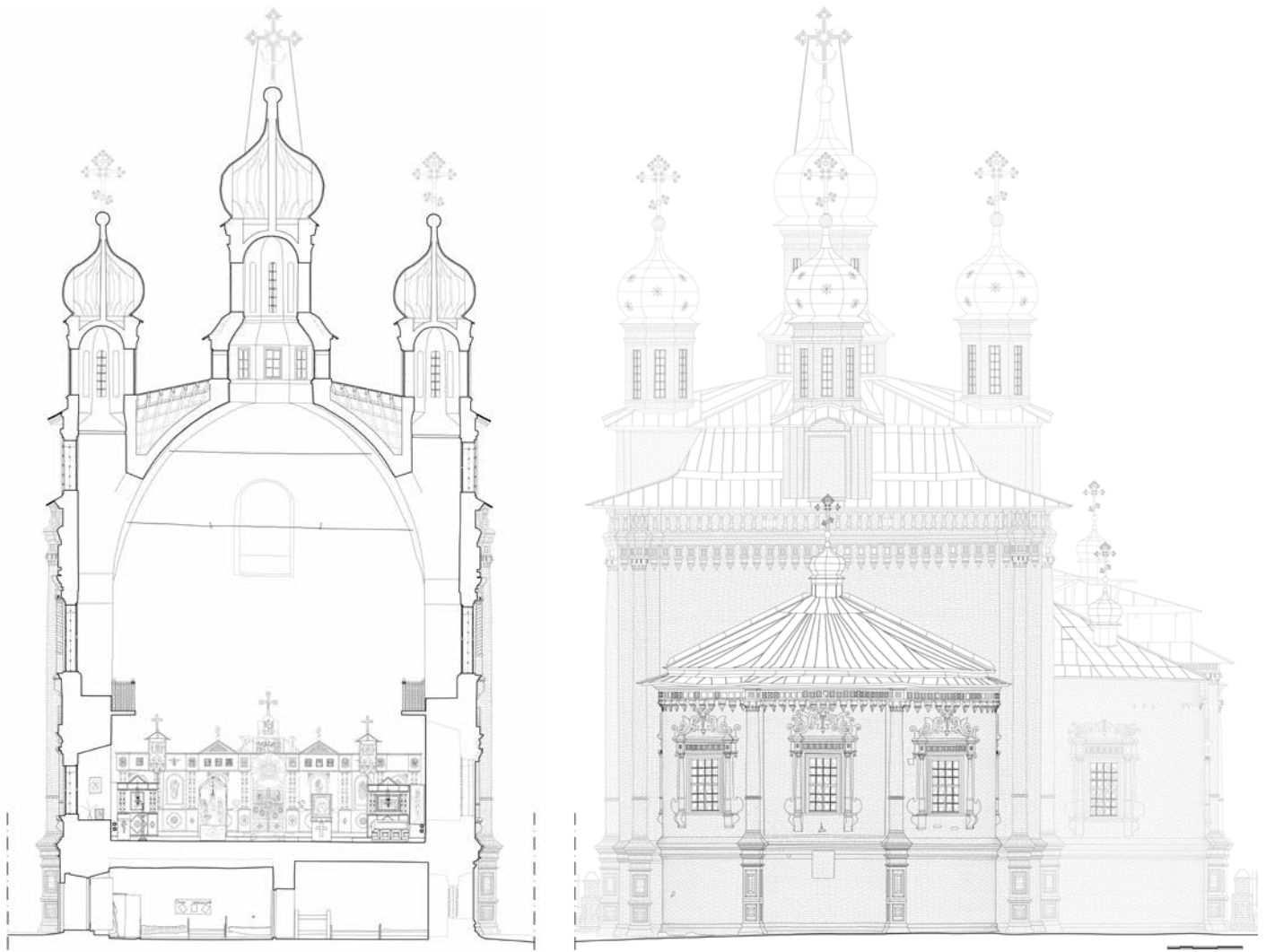
The review of the monumental fronts and the description of the brick face with the analysis of the gaps and different forms of decay also aimed at defining an operational model for a cultural exchange with Russian researchers on the operational methodologies of a conservative restoration.



*Above and below Figs. 12, 13  
Detail of point cloud surface  
Here and below, several image  
at different scale of integrated  
point cloud obtained.*





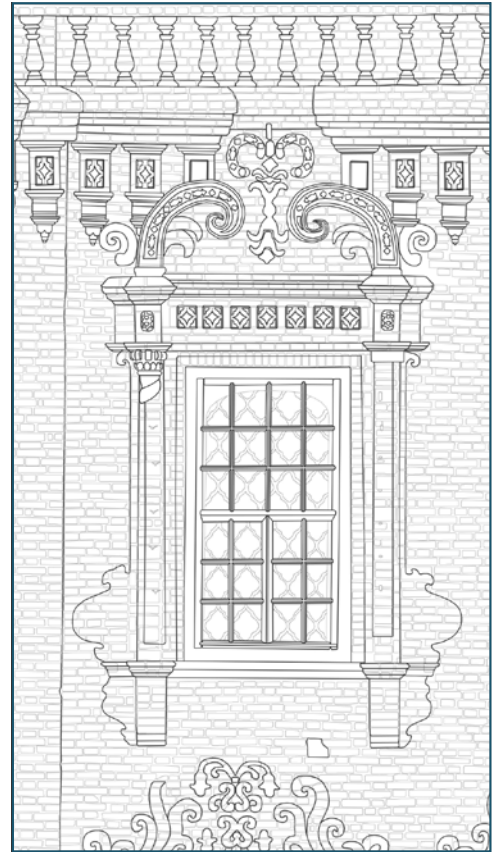
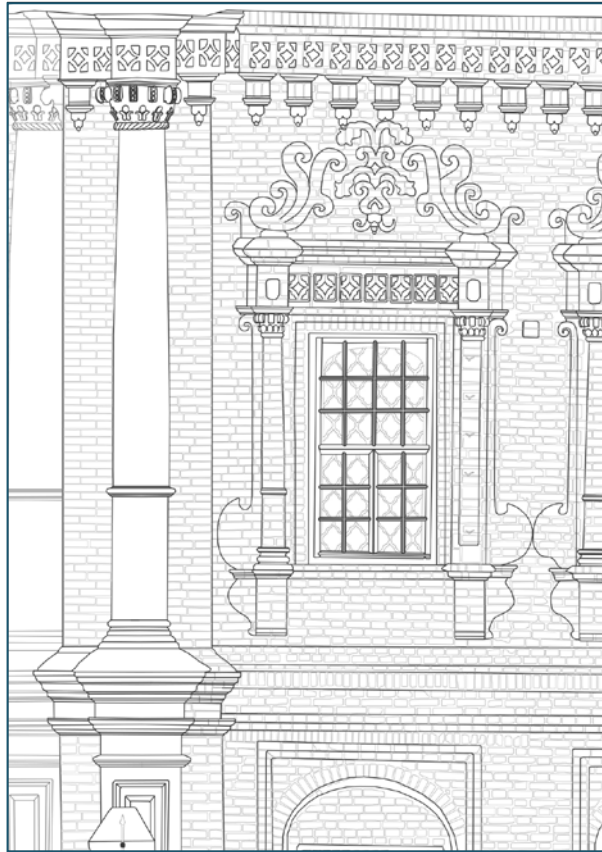
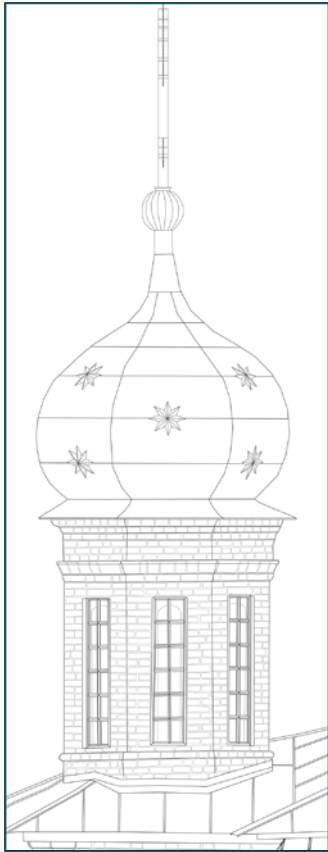
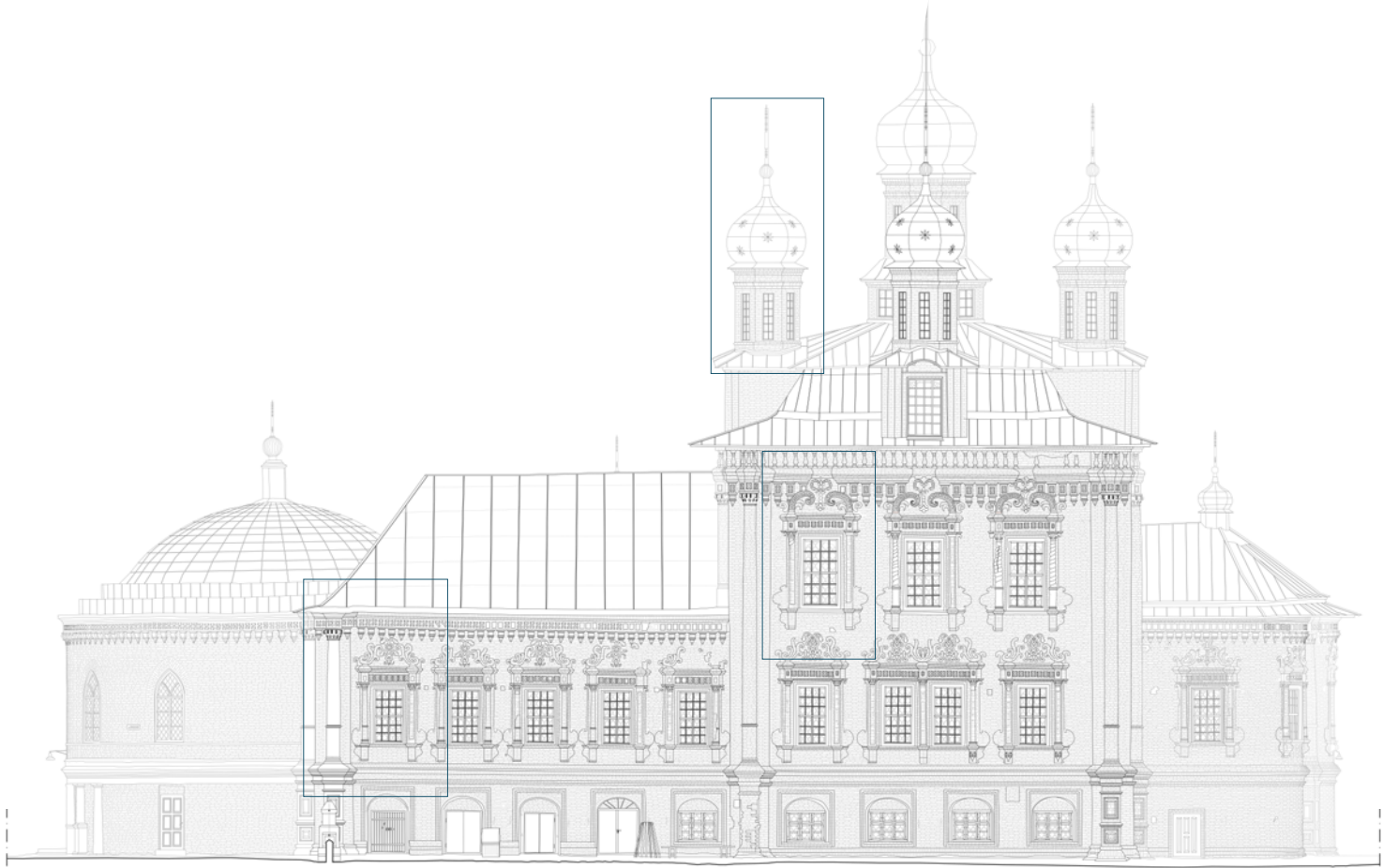


The drawing of the imperfect, of the gap, by breaking down the architectural layout and giving structure to the sign as a critical interpretation of the qualities of the built system, defined an operational paradigm for local government bodies to use on monumental complexes, while at the same time creating a typological atlas of the characterising elements, allowing an integrated comparison between the various settlements, necessary for the development of an intervention plan on a territorial scale.

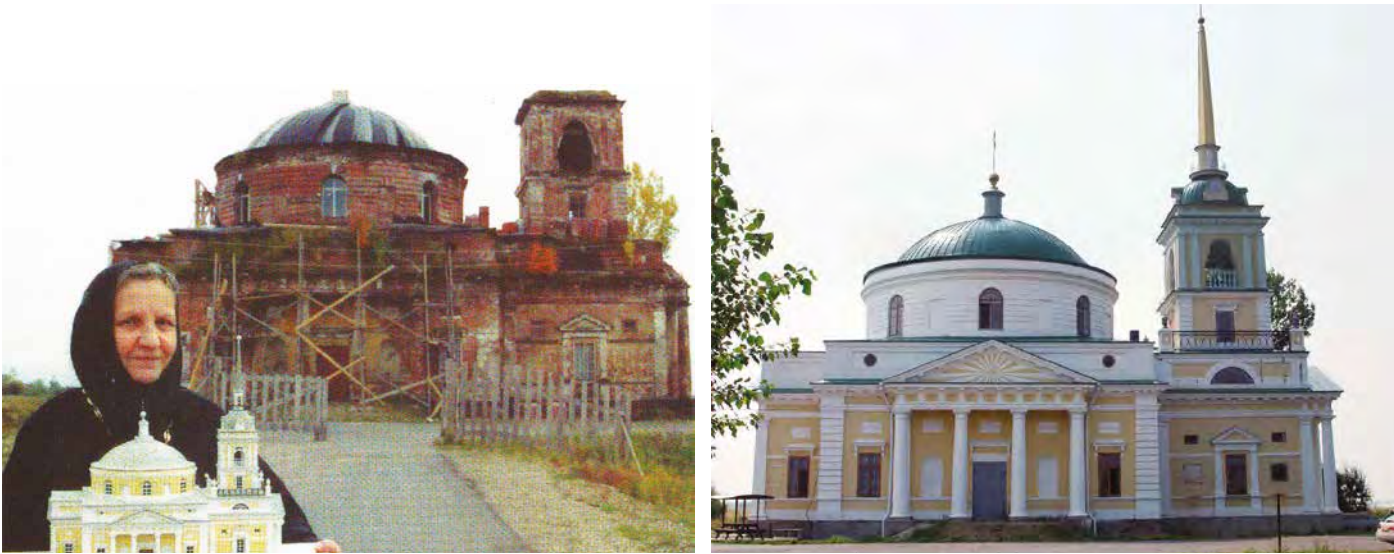
These products, which have the primary recognition of bearing witness to the state of the art of this heritage, extending its life to a digital dimension, have thus made it possible to identify the deterioration and problems affecting these architectures, enabling the development of recovery hypotheses and an a priori assessment of the impact they would have on the general image of the complex.



*In this page and nexts Fig. 11*  
**Architectural drawings**  
 Main sections, plans and details  
 of the Church of Transfiguration.  
 (Drawings credit: Federico Cioli)







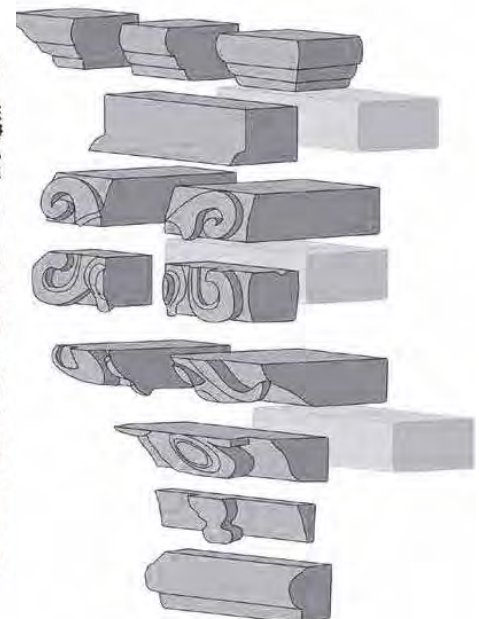
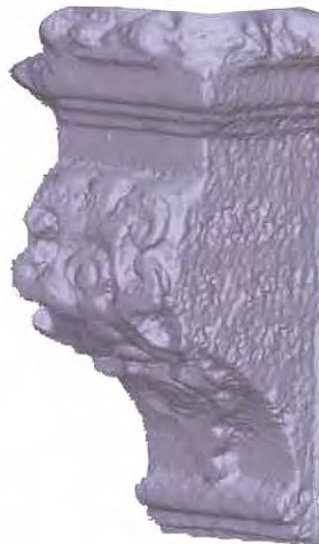
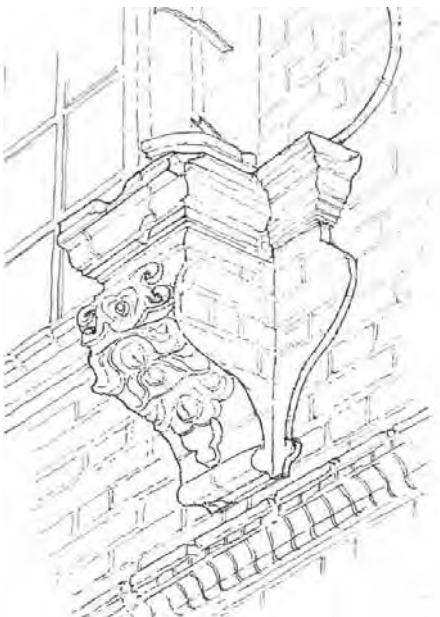
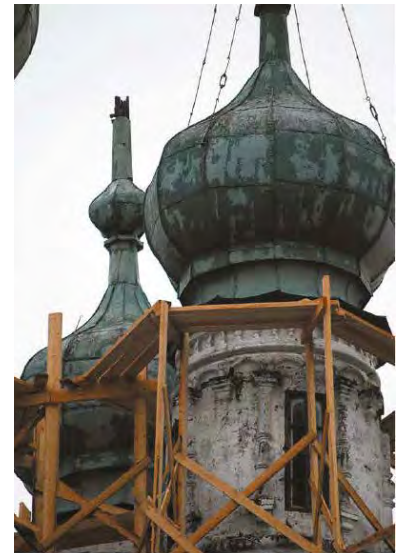
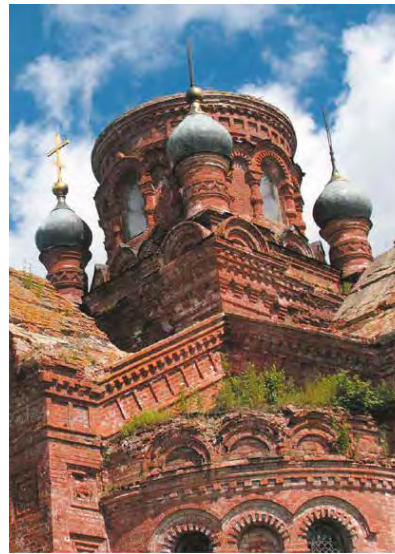
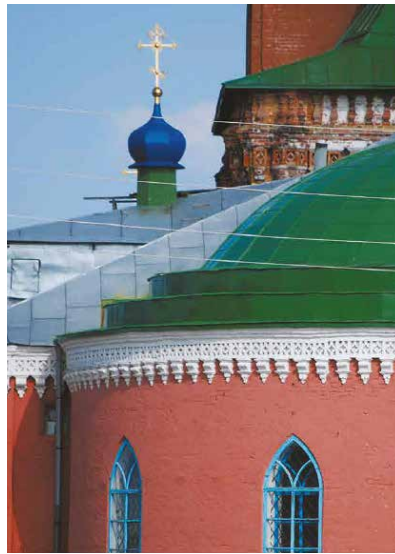
**Fig. 12**  
**Representation vs reality**  
 A nun from the Church of the Transfiguration complex in Usolye holds the model of the St. Nicholas Church restoration project. Unfortunately the construction site has completely distorted the image of the original church.

### Restoration issues in the Upper Kama area

The digital survey records form the necessary basis for any conservation and restoration work on the historical complex of Usolye. The climatic conditions, characterised by harsh winters, mild summers and flooding in the spring period, put a strain on buildings already damaged by time and neglect, accelerating the deterioration process of the monuments. In order to counter this phenomenon, in recent years there has been an incentive to restore roofing systems whenever possible, but without taking into account historical peculiarities related to the stylistic canons of local architecture.

The interventions of ‘restoration’ often do not respect traditional materials, nor the formal and constructive aspects, but mostly involve a process of demolition and reconstruction or replacement with prefabricated elements, or, reintegration and partial reconstruction of the building, but drastically altering its geometry and proportions, as well as its decorative devices. Clear examples of this are the monuments in Solikamsk and the recent restoration of the Church of the Resurrection in Cherdyn’ or the Church of St. Nicholas in Usolye. Comparing the examples found in the various settlements, another problem that emerges is that of the restoration of finishes and plasters, which have a strong impact on the overall image. Traditionally, the buildings in this region were plastered with a thin layer of white lime, which integrated the complex decorative system into the masonry and gave a strong sense of uniqueness and lightness. The presence of interventions carried out without regard for the historical and technical-artistic significance of this area, through the use of incompatible materials that do not guarantee their survival over time, is also highlighted in the less problematic details where a progressive layering of incongruous glazes transforms the plasticity of the ornamental apparatus. In any case, the continuous disappearance of the decorative brickwork apparatus is one of the most significant phenomena and problems. By means of 3D modelling and the creation of an abatement of these elements, it is possible to understand their composition and to develop design drawings to a scale that allows them to be reproduced. Moreover, there is no lack of initiatives in the area to revive small craft activities that could animate a return to tradition with clay work and terracotta production. This

*Side page and next page Figs. 13, 14*  
**Reality vs restoration**  
 Improper restoration work carried out on existing heritage. Below, a study from the drawing till the 3d model to help to support greater awareness of restoration work.

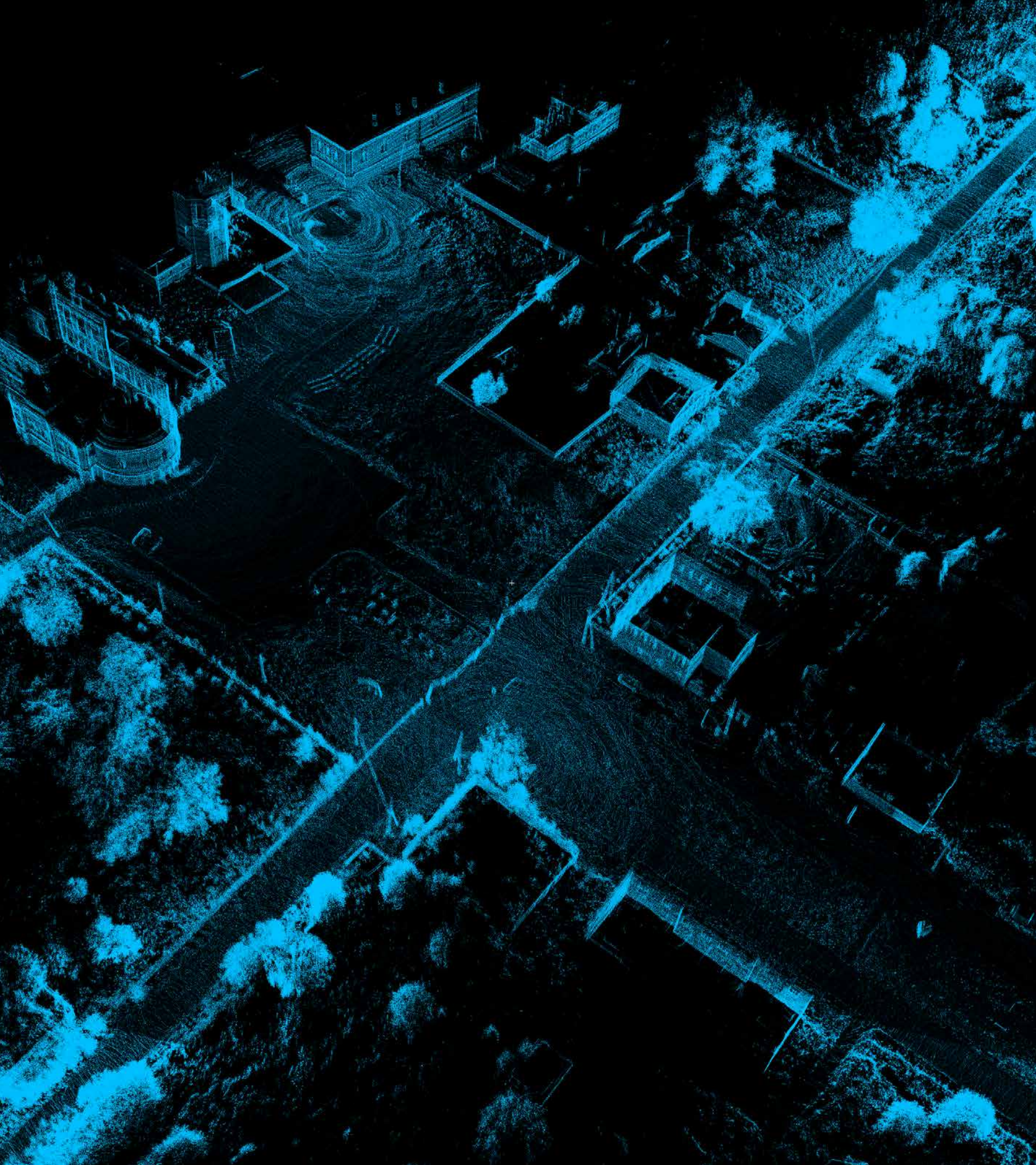




necessary respect for the slow workmanship of ornamental models is countered by the natural Russian tendency not to consider as valuable what is not strictly listed as monumental, leading, especially in villages transformed into dacha settlements and seasonal dwellings, to a rapid transformation of even historicised buildings into prefabricated models made of steel and plastic. For the engineering and industrialisation of the reconstruction of the ornamental features, in an attempt to build a dialogue and compromise with the normal tendency towards transformation and loss of stylistic language, it was possible, through the use of 3D printers, to obtain, from the negative of the model of the architectural detail, the mould for the reproduction of serial elements in clay. On a virtual level, moreover, by operating directly on the 3D model it is possible to reconstruct and evaluate the insertion of similar decorative elements without having to operate on the original artefact. Unfortunately for Usolye, the radical change in the hydro-geological system that occurred with the construction of the dam in 1954 makes a functional consolidation action for the recovery of the entire complex extremely costly, but effective restoration work that can trigger a process of reasoned maintenance and a community dialogue on the symbolic value of the architectural fabric opens the way to possible developments to promote and incentivise tourism in this region.

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# THE APPLICATION OF SLAM TECHNOLOGIES FOR THE DETECTION OF USOLYE HISTORICAL CENTER

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## **Introduction considerations about fast survey and mobile scanner technology**

In recent years, mobile 3D mapping has developed various types of portable solutions for close-range mapping systems, developing systems and product categories designed for rapid detection procedures and associated with scan-to-modeling operations. Model find their employment in the construction sector in the various fields of application from architectural surveying to plant engineering and analysis of the territory.

The research introduces a reflection on a series of test datasets resulting from the mobile system's application in an urban context taken as a case study and aimed at the representation and 3D modeling of architectural complexes. The experimentation divided by set of analysis and data collection was aimed at analyzing the accuracy and type of information content that can be read on the point clouds of the KAARTA system, imagining the Mobile Terrestrial LiDAR System (MTLS) as possible autonomous detection solution or as a combined action through data integration by combining mobile technology with multi-sensor detection systems.

Within the PROMETHEUS project, an integrated documentation strategy was used, which saw the use of the mobile laser scanner to integrate the metric data of the TLS laser for the acquisition when aimed explicitly at the documentation of the religious complexes the surrounding area urban. The instrument's versatility allows a significant reduction in acquisition times, covering large areas in a short time. The tool is used through the direct control of a qualified operator who moves along the projects of acquisition paths.

## **Urban route system of Usolye historical part**

Old Usolye is located in lowland near the river. The length of the historical part along the river is more than three kilometers. Such emplacement of the settlement determines its planning features and general appearance of architectural and landscape panoramas. In the past the territory of the town was composed of two parts separated by 700 meters lowland. This lowland annually flooded by spring floods of Kama river. The connection of two parts was provided by bulk dam and seven bridges.

The planning structure originally formed as linear structure gradually transformed in linear spatial with two perpendicular compositional axes. One of the axes is Kama river supplemented by the equally strong perpendicular axis is main dam. This dam connects each main part of the town and

*Side page, Fig. 01*  
**Mobile LiDAR point cloud of Usolye historical centre**  
Low-density mobile LiDAR point cloud showing the urban layout along a main axis and the spatial relationships between buildings and open areas.



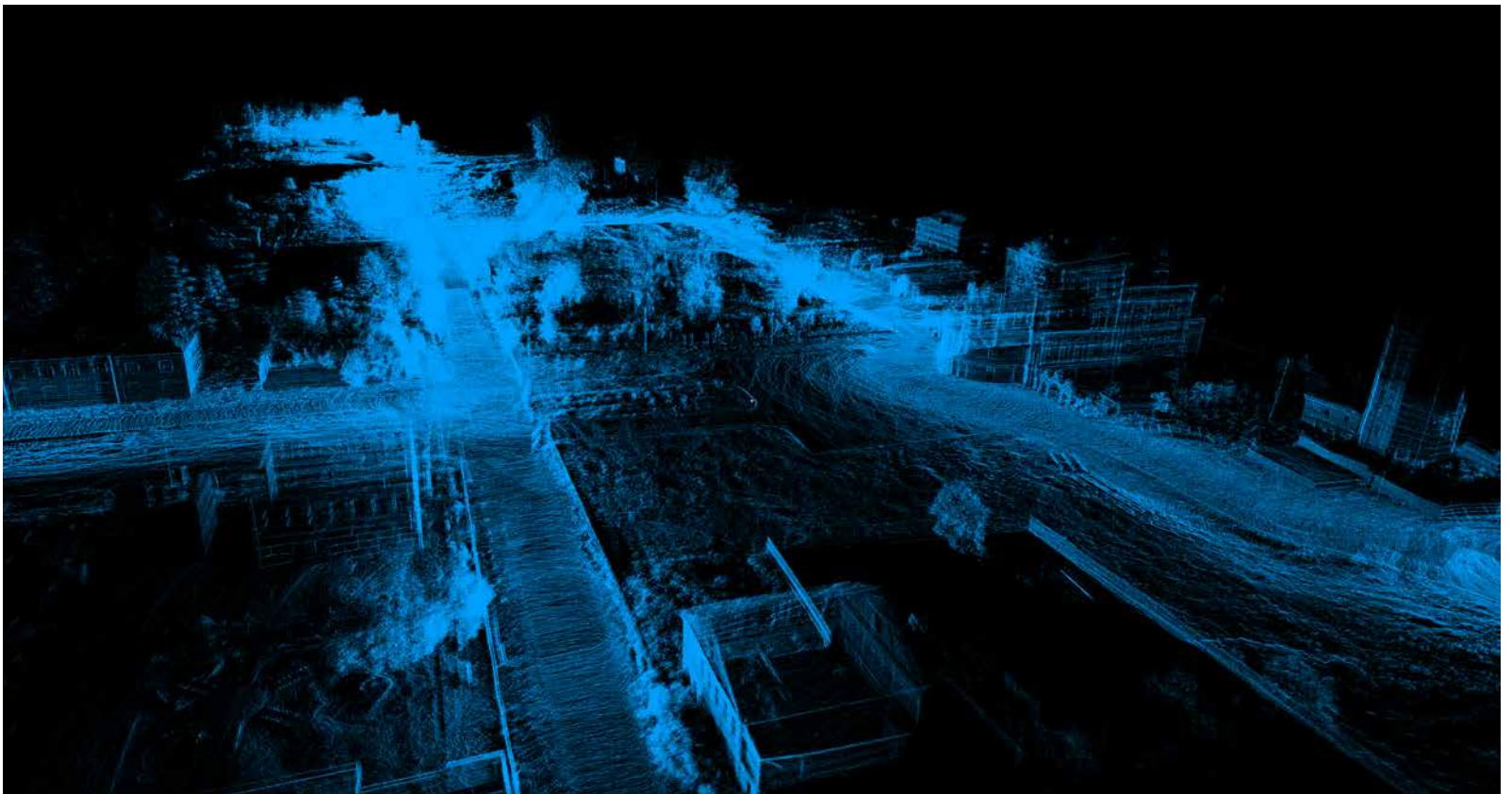
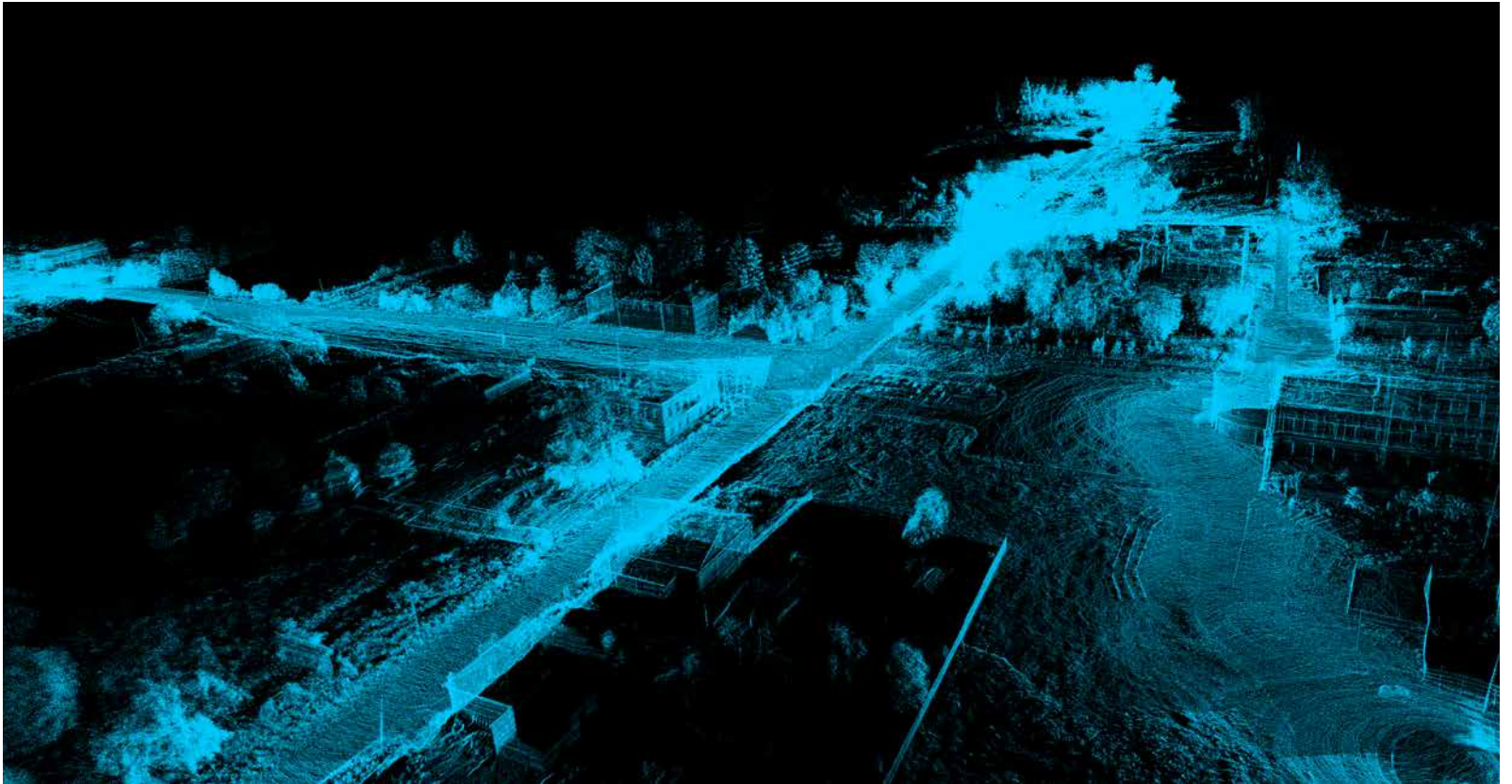
**Fig. 02**  
**Mobile laser scanning acquisition**

Phases of data acquisition using the KAARTA mobile mapping system: operator-controlled scanning, handheld configuration, and vehicle-mounted acquisition for rapid survey of urban routes and architectural elements.

passed from west to the central place till the main cathedral. Basis of the urban structure in historical part of Usolye is formed in Posadskaya part, which was the central part with the main administrative and residential buildings. According to the retrospective data in the Posadskaya part also the central public space was formed. This place became the main core of spatial composition of whole old Usolye which also existing today. The orthogonal planning system was formed after the fire in 1809. Two-story buildings were prevailing as most convenient in conditions of annual floods. The streets profiles are wide with the buildings along the red building line according to exemplary projects. In the central part buildings were mostly by stone, but in the parts which are distant from Posadskaya area buildings were mostly wooden or half-stone. The industrial and warehouses territory was located on the river bank due to technological features. In the planning structure of the old Usolye were two industrial areas: Low industries and Rubezhskaya part. Both of these areas are located adjusted to central Posadskaya part from different sides. The salt industry buildings and warehouses were located in these places. Residential territory which was consisted of many parts further considered as a holistic residential area. The industrial part with different owners of the factories in the urban plan of 1895 was considered as an entire industrial area. In the urban plan of 1895 shows that the central public space, main planning axis, residential and industrial areas were constituted a single interconnected organism. Nowadays this holistic system as the urban structure formed in 1809 and 1895 is mostly lost. The main reason of such outcome is the moving of the whole residential part of the town. In 1950s Usolye was flooded because of the hydropower electro station construction. Residents of this territory had to move wooden houses to new place to avoid this flood. The historical part of Usolye lost its inhabitants and became the islands. The planning module with the specific features of blocks and connections of the streets do not exist in contemporary structure. Only two main perpendicular axes are preserved for today. The Bogorodskaya street which goes to Spasskaya Street exists as one of the planning axes parallel to Kama river. The second is the Preobrazhenskaya Street (perpendicular axis) connecting of the main architectural ensemble with the contemporary city. This street consists of the several bridges are leaded

**Side page, Fig. 03**  
**Point cloud representation of the urban axes**

Perspective views of the point cloud dataset highlighting the main infrastructural and morphological axes of Usolye. The data allows recognition of road networks, vegetation, and building volumes within a unified spatial framework.



to the central place and provide transport and pedestrian accessibility to the island of Usolye historical part. Moreover the part of the Respublicanskaya Street is preserved on the same place. This street provides the additional access to the main square of the Cathedral and to Golitsyn house as well.

In the historical part of Usolye there are three churches and one bell tower which are present architectural dominants: Transfiguration Cathedral, St Nikolas church and Rubezskaya church. Each of these dominants is located in different planning axes. The main (perpendicular to Kama) axis leads to the main public space where the Transfiguration Cathedral and the Bell tower are situated. Going on the parallel axis to the north Rubezskaya church appears. The residential buildings are located near the cross of two main axes. Most of industrial buildings and warehouses are preserved in low industries area which is located on the Bogorodskaya Street in the south direction from the central place. In the soviet time the ideas about architectural and historic heritage have changed.

The religious buildings were destroyed or changed for different functions; other civil buildings had lack of maintain. It is directly influenced on nowadays conditions of historical buildings. All preserved buildings are made by bricks and exist in different conditions (destroyed, partially destroyed, and workable). To survey the modern condition of the old Usolye territory the investigation of two main axes has to be carried out. To access other territories out of the main roads not possible due to vegetation, floods, and lack of paths.

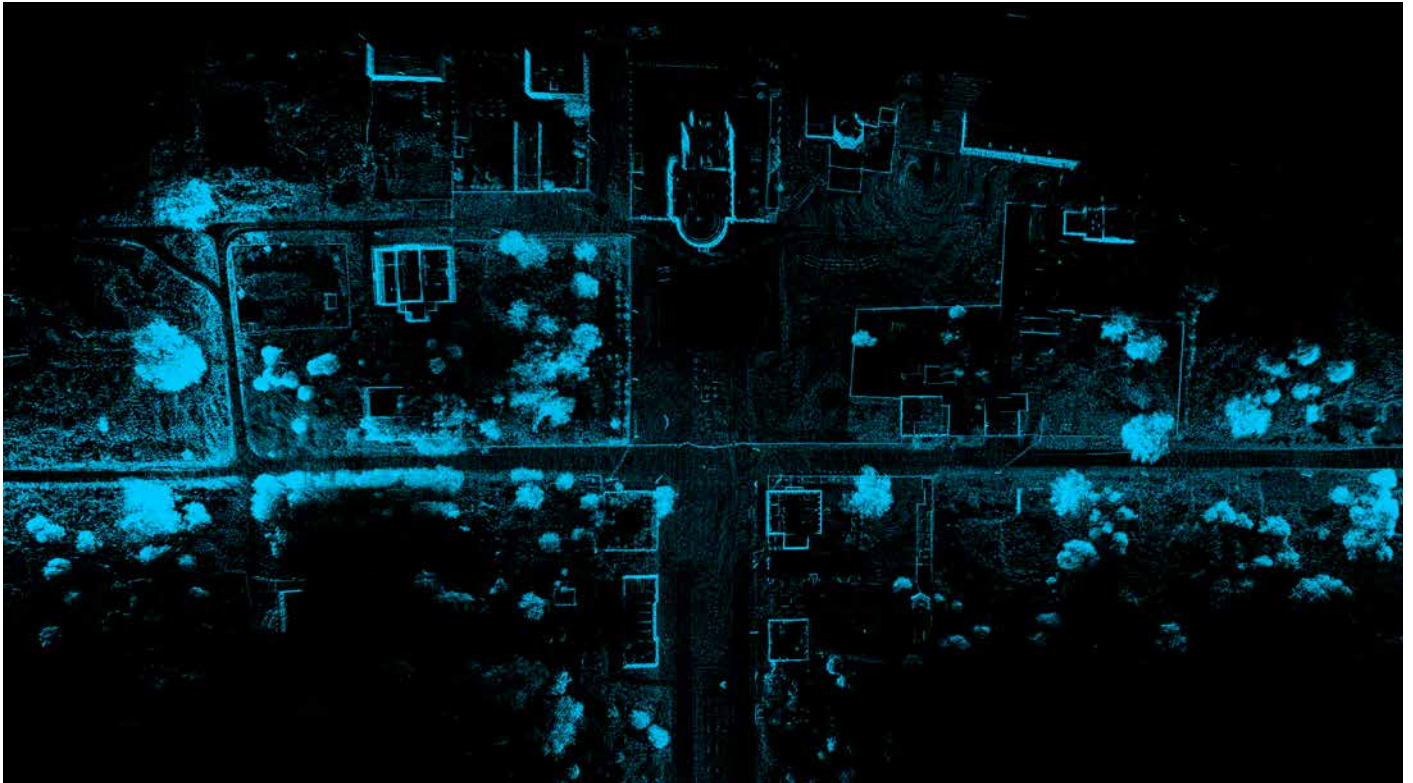
### **The project to acquire the relevant data**

The survey project aimed to document the connective tissue for the representation of the landscape and the connections between the various monuments located in the old part of the Usolye territory.

The project involved the use of the tool by installing it on a vehicle. This was an opportunity to experiment the instrumental response in proportion to the speed of movement of the operator.

The data acquisition path saw as connection points the pivotal points of the road layout of the center of Usolye along the two main perpendicular axes. The first route saw the departure from the monumental square along the entire axis of access to the city up to the road that leads to the St Nikolas church along which the monumental block with the Transfiguration Cathedral church, the church of St. Nikolas, is located. The second path was aimed at acquiring the church of St. Nikolas; in this case the road allowed a 360 ° view of the monumental body of the church.

The third path was aimed at acquiring the minor axis connecting the Rubeskaya church and the Chapel of the Intercession of the Holy Virgin. During the acquisitions along the three paths, the operator held the instrument firmly through the use of a stand, and the machine did not exceed 20 km /h to avoid sudden movements or sudden changes in instrumental inclination that could have caused an error in the acquired data. In some cases, it was necessary to repeat the scan due to an instrument error caused by sudden changes of light and therefore the consequent loss of points and in others by jolts of the vehicle due to the irregularity of the road surface.



### The recording of the data

While the process of laser scanning was carried out about 25 point clouds were acquired. The point clouds processing usually take most of the time of the all postproduction process. To obtain the entire point cloud of the research territory the combination of several software programs was used. The original files from laser scanner contain several types of files for each record. PLY files are represent the unregistered point clouds in KAARTA laser scanner. Such type of the files less commonly used than LAS files. However, it could be easily readable and represented in CloudCompare software, which is recommended on web-site of KAARTA. CloudCompare is one of the free software for work with point clouds. As the acquired point clouds do not have targets, the registration process is based on finding common points. In CloudCompare there is such possibility for registration. The process does not so evident due to colorization of the point clouds. In case of the consolidated number of the points single-colored point clouds do not give the correct appearance of the environment. In this case it could be a problem to find the common points. To register point clouds the Cyclone software was used. It needs to resave PLY files to LAS using CloudCompare. Further process is going on usual scenario of the registration point clouds in this program. Due to uncertain geometry of the natural elements in the case of the natural landscape it is quite difficult to find the common points. The problem became smaller when the man-made elements with the strict geometry appear in the landscape. In the Usolye case study the different urban elements were included in the point cloud scene. The number of the architectural heritage buildings and the poles for electricity features are accelerated the point clouds registration process. The acquired point clouds give the representation of the main



Fig. 04

#### MIS Point cloud

Combined point cloud obtained from multiple acquisition paths, representing the urban fabric and the distribution of architectural elements.

points of the landscape. The total amount of points is 139.256.301. This point cloud can be used in three-dimensional georeferenced system as the more accurate LAS file for the obtaining of the relief. However, to acquire more information demands the pedestrian way of the acquisition as the lack of the car-road system.

The common file included the all of the acquired records do not has GPS tracking. It has to be defined for further work. Georeferenced information gives us the possibility to work in worldwide referenced system. This also can be acceleration of the sharing the data. The possibility to define the main geometry of the buildings can be useful in case of the lack information about architecture.

### **Considerations on the quality and possible readings of the data**

The analysis involves a breakdown of the problem of representation, identifying protocols that can be applicable at different levels and scales of reading aimed at the representation and discretization of parts and elements linked together in a hierarchical or interconnected relationship, outlining their criticality and potential in the representation of the landscape.

The analysis involves a breakdown of representation, identifying protocols that can be applicable at different levels and scales of reading aimed at the representation and discretization of parts and elements linked together in a hierarchical or interconnected relationship, outlining their criticality and potential in the representation of the landscape.

This action has led to a low-density point cloud that allows us to read the urban fabric of the Usolye district. This type of data integrated with the high-density point clouds describing the historical architectures of the city allows us to quickly obtain a descriptive 3D database of the center through a simplification process of the complexity of the real space. Through the construction of the image, digital transposition replicates in all respects the act of drawing. Digital products become tools from which to derive simplified and critically interpreted information. A metric data help structure the consequent information model based on the three-dimensional database to produce representations drawings, and models capable of transmitting and documenting the Cultural Heritage.

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# RUBEZHSKAYA CHURCH: CENSUS AND DIGITAL SURVEY FOR A RENEWED DOCUMENTATION REPORT

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## General considerations and development of the project of documentation

Stone Vladimirsкая church, in the common people lexicon “Rubezhskaya”, was built in 1754 to the north-west of Stroganovs’ ensemble. The location of the church in the territory of Rubezhskaya suburb of Usolye became the source of its name. In 1929 the church was closed. Further, the building was used by different urban organizations as utility structure. After the flooding of the island in the process of Kamskaya hydropower station construction, the building of the church was deserted.

Rubezhskaya church is a part of ensemble of Usolye cathedrals and it is the second town planning and high-rise dominant building of the historical-architectural complex, due to the surrounding landscape. Rubezhskaya church was built a quarter of a century later than the Stroganov’s ensemble. So, it differs by the laconism of architectural forms and décor modesty. Facades décor includes old elements of the local character (molding, basement, quoin accomplishment) which are combined with baroque features in the profiles of window openings, roof and patronal section. The portico of the doorstep in the southern façade, built later than the main complex, has the style of Tuscan order<sup>1</sup>.

The church is related to the churches-naves with the bell tower over the ante-church and it has their typical planning: all general cubic contents are located along one axis. Its arrangement resembles Moscow-area churches of the 18th century, in which the bulk of refectory is also crowned by the high bell tower. The building clearance, in the plan of the first storey, is 42,6 x 11,2 m<sup>2</sup>.

Stone bell tower, built instead of the burnt wooden one, was completed with the dome and crowned with an octagonal dome drum and the cross. The architecture of the bell tower is typical for Prikamye churches: three octagonal structures reducing along the height are placed on quadrangular frame. The bottom octagonal structure and quadrangular frame are two-high.

In 2015, the Department of Architecture and Urban Theory of Perm National Research Polytechnic University was given the archive documents containing the material of Rubezhskaya Church survey, developed by Perm Special Scientific-Restoration Workshop in 1986. These materials have been supplemented with data prepared for the project of preservation of Usolye areas, by professionals of

Side Page Fig. 01

### Today's image of the church

The building, now reduced to ruins, still retains the appearance of an imposing church, characterised by a single-nave, with a central double-height structure, and a bell tower that is easily recognisable in its surroundings.

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<sup>1</sup> Cf. Makovetsky 1992.

<sup>2</sup> The information about project areas is from Perm regional monuments Protection Center. Great gratitude is expressed to The “Perm Regional Research and Production Center for the Protection of Monuments (Objects of Cultural Heritage)” for the provided information from their own archive.



**Fig. 02**  
**A brick landmark of the northern area**  
 Rubeghskaya Church and surrounding natural landscape.

Perm Regional Research and Production Center for the Protection of Monuments in 1988. In 2018, in the process of Architectural School studies, more detailed analysis have been developed, with the use of Terrestrial Laser Scanning and aerial photographic survey.

### Comparison and development of a census action between 1986 and 2018

Vladimir Mother of God Church, “Rubezhskaya”, is the monument of provincial cult architecture of the second half of the 18th century. The church has important composite value in the old Usolye context as an architectural dominant of the upper craft. After 1929, the church has ceased to be an iconic building and it was used for household needs at different times by various municipal institutions. According to the archive data of the “Perm Regional Research and Production Center for the Protection of Monuments”, the first survey was made by the architect Zlatogorsky L.B. on August 25th, 1948. In October 1952, the survey works were conducted on foundations condition, for the definition of a geological structure of the territory and of the characteristics of soils. Measurement work headed by the architect Zykov V.I. was carried out with the participation of students of the Moscow Architectural Institute. The restoration projects were saved in the archives. Between 1954 and 1958, repair and restoration works were made for the replacement of roofs and the restoration of the basement structure. With the resolution CM of RSFSR of 30.08.1960 No. 1327, Rubezhskaya Church attained the status of a federal level architecture monument.

In 1962 and 1968, technical inspection reports were drawn. Result of the inspection is the recognition of satisfactory condition of the church. In 1978, a similar survey revealed the bad condition of decoration of the facades and interiors. Other structural elements appeared to be in allowable condition.

Until the flood on February 1988, restoration work was completed to restore the roof construction with coating. A scaffolding on the church perimeter was constructed for the subsequent work.

Due to constantly water logging of the church territory, by flood and ground waters, a statement on the impossibility of implementation of restoration work was drawn on May 29th, 1989. Archives technical inspection drawings of 1964-66 are the fullest information about layout and arrangement of the church. Further statements of technical condition were based on these drawings.



**Fig. 03**  
**Construction site**  
 An image of the restoration activities undertaken after the survey campaign.

**Side Page Fig. 04**  
**Historical pictures of Rubezhskaya church**  
 Above, historical general pictures of Rubezhskaya church, from the funds of the Historical and Architectural Museum “Stroganovs Chamber”. Below, interiors photographed in 1986 for a first census and survey activities.

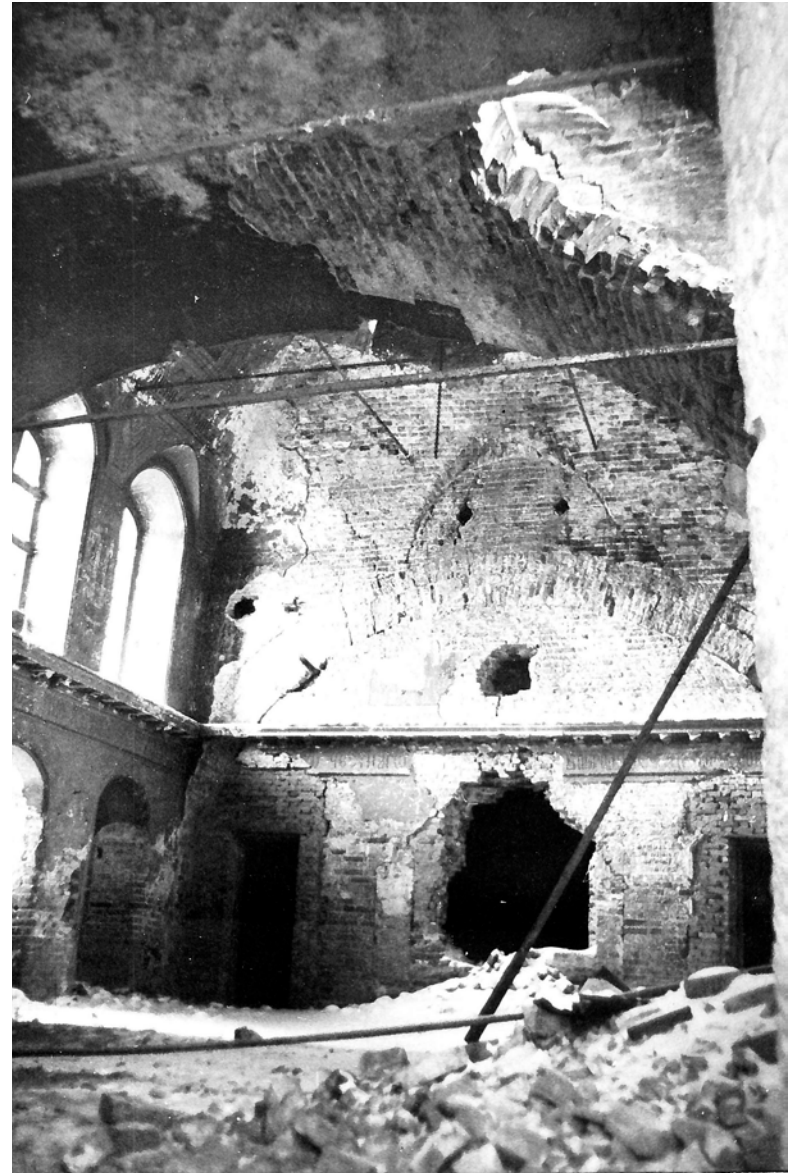
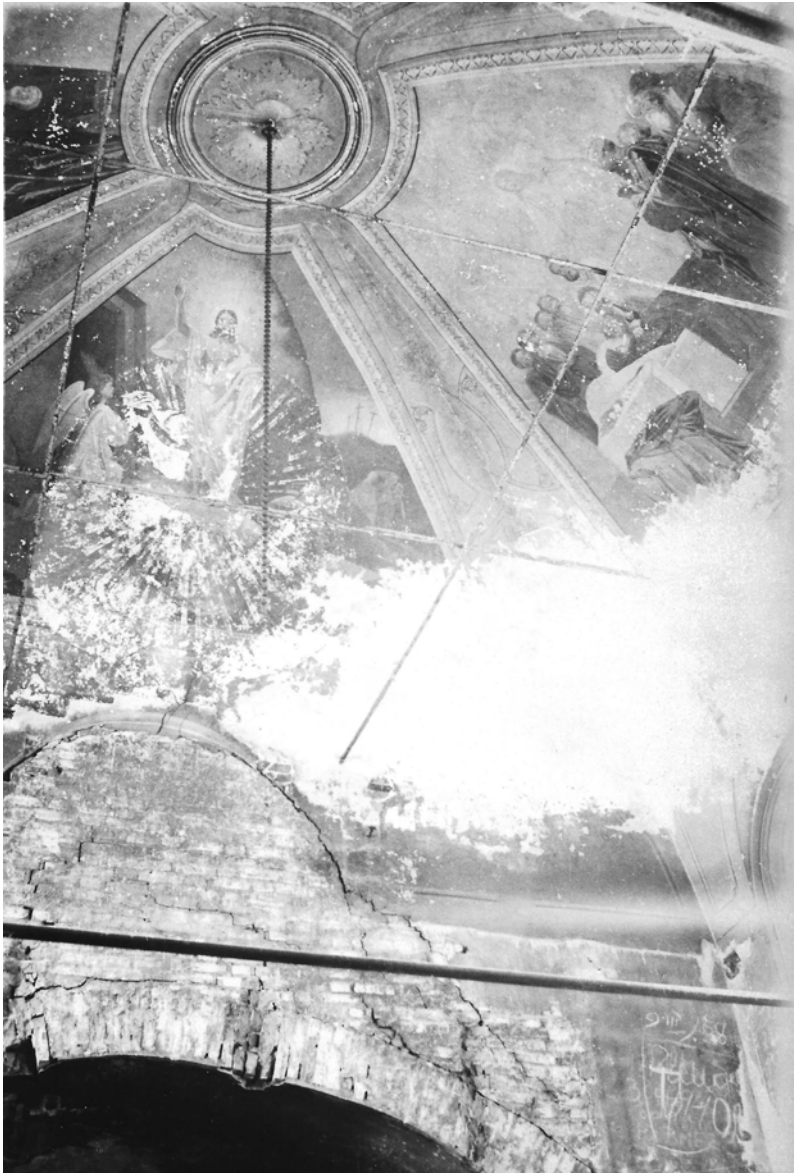




Fig. 05

**Comparing images**

the central body of the church in an image taken for the 1986 survey campaign (left) and the 2018 survey campaign (right). The most visible change is the disappearance of the roof, which has resulted in the appearance of plants and bushes inside the hall.

Side Page Fig. 06

**Previous survey campaign**

planimetry of the church and bell tower levels with indication of partial measurements acquired by direct survey. Survey campaign 1896.

Next Pages Figs. 07,08

**A digital survey campaign**

On the left page, point clouds describing the current condition of the church. On the right page, 2D drawings obtained from the management of the cloud data, through which it is possible to geometrically compare the dissimilarities and changes undergone by the building's wall faces.

The condition of the church deteriorated, as shown by technical inspection in 1990. Scaffoldings were left since 1988-89. Interiors were partially preserved.

In 2001 a permission to conduct the preservation work on the roof was issued, essential to prevent further destruction. The conservation work was done. For the year 2007, the church had ruined condition. The statement of technical inspection was drawn up to record this state.

In 2009, the application for participation in the federal target program for 2006-2010, "The culture of Russia". was submitted by the regional scientific and production center on the protection and use of the historical and cultural monuments of Perm Krai. Proposed activities were a preservation work and the project of restoration. The application was rejected. For the following years, no restoration activities were provided. In 2014, the monument condition was ruined: the roof, as well as all bearing structures and coating, was absent; the arches were partial collapsed; the bricked openings were destroyed; the front decoration was lost. Since 2015 until present, collecting data and documentation activities of the object have been conducted within the collaboration of University of Pavia (Italy) and Perm National Research Polytechnic University (Russia). Plans of 1964 and 3D laser scanning of 2018 are taken as a basis for working on the digital reconstruction of the church.

The analysis of technical conditions of Rubezhskaya Church has showed that all the attempts of restoration have failed, therefore the destruction cause could not be stopped. One of the main factors interfering with the restoration is the raise from the ground of salty waters.

Sprouting trees and bushes, which seeds with wind and rain, have entered inside the building, as important factors of huge damage to bricks masonry. The deciduous trees roots get harm to the arches and the walls of the church and, as a result, the arches have been destroyed. The uncontrollable growth of vegetation in close proximity to the building, with mosses, mushrooms, mold and bacteria cause different types of biological corrosion of materials in the bases, walls and on the arches. The corrosion rate of structural elements is growing rapidly because of sudden fluctuations temperatures in the winter and summer periods on the Ural, with atypical continuous heavy rainfalls of the last years. The church is disappearing.

The “crude” data of the terrestrial laser scanning, obtained during the research, is a unique archive of the most exact and detailed information about object geometry. Further work on preservation of the disappearing heritage of Upper Kama region will be conducted based on these data and on archives information.

### A digital survey campaign for the update documentation of Rubezhskaya site in 2018

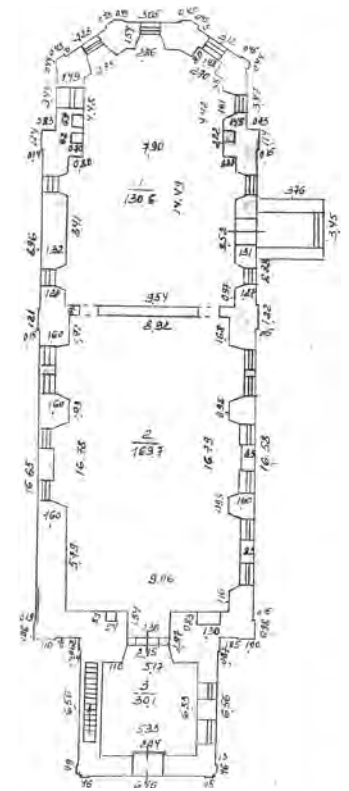
The updating of information on the architectural permanence of the complex of Rubezhskaya Church has motivated the 2018 documentation campaign, with the aim of representing a renewed image of the state of conservation of the church, actually in critical conditions of ruin of wall structures and interior rooms, accentuated by the collapse of the vaulted roof of the main nave.

The critical condition of abandonment, also affected by the invasion of wild vegetation within the site, highlighted the need for a particular reflection on the reading of its current architectural shape according to the historical information of the archive, comparing the current image of the church with its design drawing, to define and update census characters and descriptors.

The building is compromised by the lack of large portions of the wall structure: these gaps are perceived both at the constructive level, in the morphological reading of the volumes of environments, and in the modelling of the decorative brickwork on external facades, directing the documentation from the architectural scale to the detail. Further criticality is given by the state of conservation of the elevation units: the absence of the large central dome, whose ruins obstruct the access to the internal nave, modifies the graphic sign of the church in the skyline of the surrounding context, leaving only the bell tower as identifying element in the monumental landscape of Usolye.

In the same way, the conformation of the interior rooms, originally arranged in sequence from the narthex to the iconostasis as an architectural filter between the river landscape and the religious core of the building, is modified by the collapse of the roof.

The rubble, accumulated in the internal nave and surmounted by land and vegetation, have changed the architectonic relationship of the monument, modifying the access, the equilibrium between



5-этаж



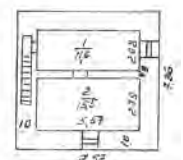
4-этаж



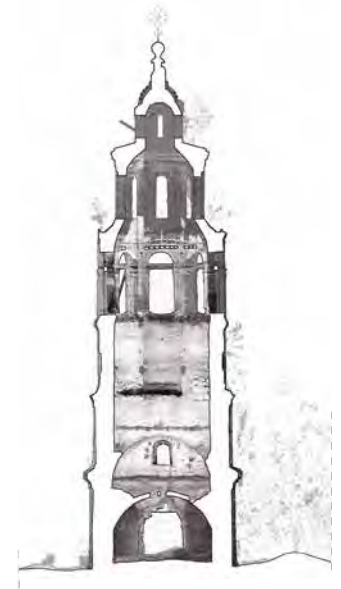
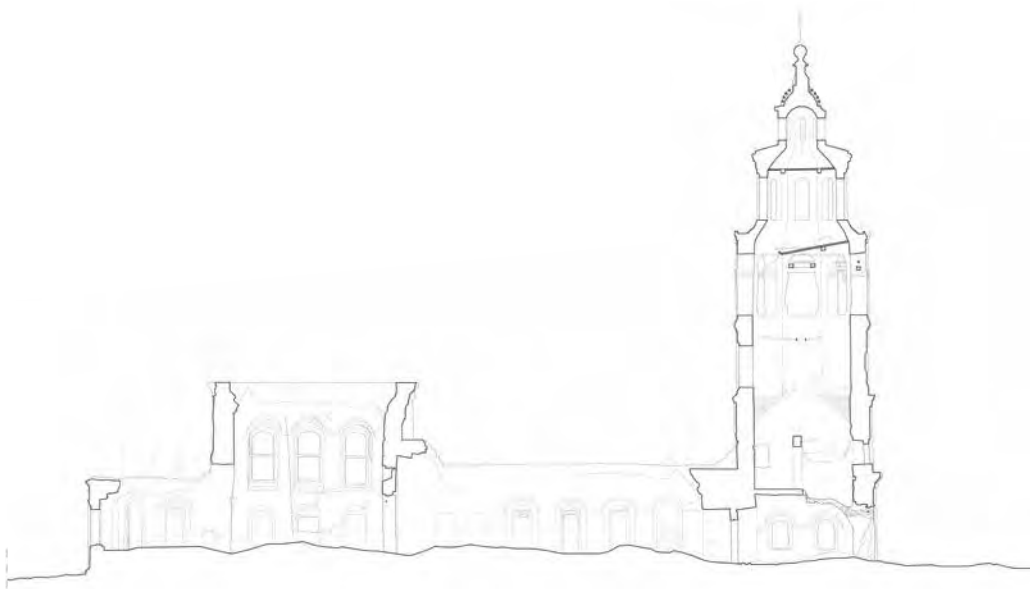
3-этаж



2-этаж





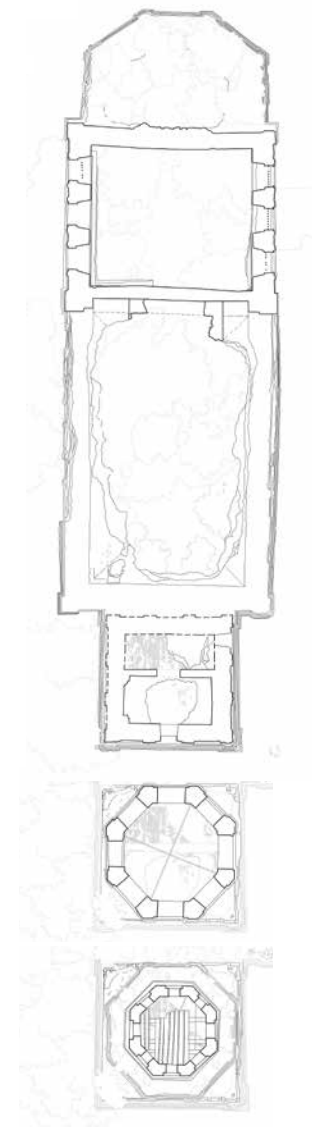


empties and volumes, and the corner views from openings, as well as damaging the plastered coatings and manipulating the spatial and visual perception of the built space.

The digital documentation initiative, developed over a couple of days of work at Rubezhskaya Church site, has been based on an integrated analysis of the morphological and colorimetric complex, applying procedures of differentiated LiDAR and UAV instruments supported by terrestrial photographic cameras. In particular, the survey was conducted with a metric and photographic laser scanner acquisition campaign<sup>3</sup>, both outside and inside the building, integrated with a UAV flight plan<sup>4</sup>, only external and concentric to the monumental site, and a close-range photographic acquisition with camera reflex, for external and internal surfaces<sup>5</sup>.

The instrumental application has provided a total and global digitization of the architectural complex, deliberately redundant in the parallel information provided by the various instruments. This strategy allowed a comparison between the quality of the information acquired from the joint systems, developing methodological considerations on the optimal data standards for the typological documentation of the ruined site.

The overlapping data have undergone discretization and selection procedures according to their descriptive correspondence at each specific level of analysis, from the urban scale to the covering detail.



<sup>3</sup> The range-based metric survey has been conducted with Laser scanner FARO CAM2 Focus 150S, with a joint photographic acquisition realized through the integrated camera. Scans have been performed between the setting Medium (2.54 minutes + 4.00 of photos) and High (4.58 minutes + 4 photos); the integrated camera, operating at the end of each scan, was set with a balanced colour calibration on the horizon level. Through this strategy, a greatest attention was also in the design of the scan stations evaluating at the same time both the morphological distribution complexity of masonry structures, for a complete overall acquisition, and the specific light exposure of each acquisition point, for a balanced colour of result. The survey campaign tried to balance the methodological strategy for an optimized result of global representation of the architectural image, in the compromise between morphological coverage, colorimetric quality and on-site work.

<sup>4</sup> The aerial photogrammetric survey was conducted with drone UAV DJI Phantom 4 Pro, with a flight mission for the acquisition of 70 frames of 12 MPx, 5472x3648 size, for photographic coverage of the entire site.

<sup>5</sup> The terrestrial photographic survey was conducted with camera NIKON D7200, 24 MPx, for 2D photographic and 3D photogrammetric data, and with camera RICOH THETA V for the development of spherical panoramic photos.


ИСТОРИЧЕСКОЕ НАСЛЕДИЕ МЕСТО		ОБЪЕКТ		АНКЕТЫ						
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м. Пермская-21		Церковь		ДАТА ОБСЛЕДОВАНИЯ		Июль 1986г.				
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НО ИСПОЛЬЗУЕТСЯ		Рубежская (Владимирская) церковь		один этаж			УДОВЛ.	ХАРАКТЕРИСТИКА		
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					ПЕРЕКРЫТ	кирпичи		ЦЕННОСТНАЯ		
					КРОВЛЯ	желези	НЕУД.	А. АРХИТЕКТУРНАЯ		
					СТРОПИЛ	деревян.	АВАРИЙ.	Г. ГРАДОСТРОИТЕЛЬ		
								И. ИСТОРИЧЕСКАЯ		
ОСНОВНАЯ ДАТА		Церковь построена в 1756 - 1774 гг.						РЕКОМЕНДАЦИИ ПО СОХРАНЕНИЮ И ИСПОЛЬЗОВАНИЮ		
АВТОР								Оконные и дверные проемы 1го		
ЗАКАЗЧИК								этажа заложить кирпичем. Окна		
ОХРАНА-УЧЕТ		Республик значения, пост. Сов. Мин. РСФСР №327 от 30.08.69						второго света заделать деревянными щитами. Трещины в стенах и сводах		
ДОПОЛНИТЕЛЬНЫЕ СВЕДЕНИЯ		Церковь одноглавая, одноэтажная, с одним приделом, двусветным основным храмом, двумя алтарными апсидами; трапезной, папертью и четырехъярусной колокольней с притвором						заделать раствором. Произвести		
МК РСФСР ОБЪЕДИНЕНИЕ РОСРЕСТАВРАЦИЯ		Пермская специальная научно-реставрационная производственная мастерская						ремонт кровли. Можно использовать как административное здание		
								СОСТАВИТЕЛЬ		Н. Белов
								РУКОВОДИТЕЛЬ ОБСЛЕДОВАНИЯ		Г. Канторович

Fig. 09  
Inventory card 1986  
Organisation of the paper sheet produced for the 1986 building survey and census campaign. In spite of the problems related to the non-interoperability of the data entered, the descriptive apparatus created by the fieldworker remains an invaluable document for evaluations of interventions to be developed.


Side page, Fig. 10  
Inventory card of 2010  
The structure of today's digital map is configured to be versatile in the field, with the possibility of inserting images from the archive or taken on site, and thus being able to be updated both remotely and in situ.

The experience allowed to derive a quality certification report on instruments and conditions of optimal survey, indicated for specific altimetric conditions, morphological scales and colorimetric variables calibrated on the complexity of investigation of the architectural ruin.


### Towards a protocol of management and valorization of Rubezhskaya historical site

The development of a certified and reliable documentation system on the monumental complex of Rubezhskaya Church represents only a first step of knowledge of the site. The total complexity of the church, at the same time considered as built structure, landscape monument and historical site, recalls the need for a multidisciplinary approach, able to contextualize the information acquired on-site in the different levels of technological, conservative, urban planning and design knowledge. The census action, in a single path of implementation and updating from the historical archive to the digital information system, identifies an organizational hierarchy able to give structure to the multiplicity of information, previously selected in the corresponding gold standards, and to make them easily usable.

**Census of Usolye "Stroganovs Island" architecture**  
 Analysis for understanding the cultural value and the state of preservation



Situation plan



General appearance

**Name**

**Address**

**Author | Person | Organisation**

**Type**

**Location**

On the river bank  
 On the main (parrallel) road  
 On the axis (perpendicular) roa  
 In the monastery area  
 In the Solzavod area  
 Separately from the complex  
 Inside a defined perimeter

**Original function**



Absent  Church  Drug store  Granary  Monastery  Residence  School  Warehouse  
 Barn  Drafting office  General store  Guest house  Museum  Pantry  Stable

**Present function**  **Changes of the function**

**Ownership | Occupation**  **Legal status of preservation**

**Architectural style**  **Century**  **Date of construction**

**Historical note**

**Past actions**  Reconstruction  Refurbishment  Restoration  Other

**Original color scheme**

**Volume**  Simplex  Complex

**Composition**

**Visibility**

**Compositional role**

**Current color scheme**

**Surroundings description**

GENERAL INFORMATION

HISTORIC INFORMATION

VISUAL DESCRIPTION



**Fig. 10**  
**Decay analysis on Rubezhskaya church**  
 Mapping of the main degradations revealed by the 2018 survey, preparatory to the definition of a restoration intervention strategy.

The information content is supported by the need to provide suitable visual tools for data referencing: 3D containers, in the form of models, can be enabled to geometrically parameterize contents and shapes, and to dynamically follow the evolution of the architectural site in parallel with initiatives of restoration, rehabilitation and cultural enhancement of the area.

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## PYSKOR: AN HISTORICAL COMPLEX DEVELOPED ALONG CENTURIES AND LANDSCAPE

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### The history of Pyskor and its monyuments

Pyskor is a historically significant site of Upper Kama route, located in the district of Usolye. The village (limited to one thousand people) is located on the right bank of the Kama River: the original settlement was founded in 1558 by the Stroganov salt producers, and it was assumed as their first capital (Kankar)<sup>1</sup>. For the cultural central role of the the settlement, between 1560 and 1755, it was promoted the foundation of Pyskorsky monastery, with many building phases of reconstruction and expansion. The first temple in the monastery was consecrated in honour of the Transfiguration of the Lord (named Spaso-Preobrazhensky), and its buildings were originally wooden. Since the monastery was located on the banks of the Kama, the soil under the buildings collapsed, and after 10 years from the construction, the Stroganov moved the monastery to the mouth of the river. In 1623, 50 years after the founding of the monastery in another place, it had two churches, a bell tower with clocks and bells, and eighteen brotherly cells. After moving to another open-field site, the monastery expanded till 1645, when a fire destroyed the wooden complex. In this way, a new complex was built in stone, and in 1646 the Stroganovs layed the first stone of the church above the mountain<sup>2</sup>. These buildings transfer to the Lysva River (1755), to Solikamsk (1775) and finally to Perm (1781). When moving from Pyskor in 1756, all the buildings of the monastery (except for the Nikolskaya Church) were destroyed to reuse their material in the construction of the new complex, arising legends of secrets and treasures hidden by the monks in the underground passages of the ancient ruins<sup>3</sup>.

Side Page Fig. 01

#### Drone View

Pyskor church in its relationship to the river, the naturalistic context, and the built-up area.

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<sup>1</sup> In 1558, after obtaining the zar's right on the land, the Stroganovs founded a small town on the right side of the Kama River on the Pyskarka River and named it Kankar ("Канкар"), or Kam-Yurt ("Кам-юрт"). In addition to natural protection on the mountain, Kankar was surrounded by a fortress. Ensuring the protection from Siberian attacks, the Stroganov funded the construction of a religious temple, which became the complex of the monastery, including churches, bell towers, cells and other environments of monastic life. See <http://pyskor.cerkov.ru/istoriya-skita/pervonachalnyj-oblik-monastyrya/> [Access on 06/01/2021].

<sup>2</sup> Anika (Ioannikiy) Feodorovich Stroganov decided to build a monastery in 1560, founding it on the right bank of the Kama at the mouth of the Nizhnyaya Pyskorka river. The construction lasted at least 30 years. The second stone church of St. Nicholas the Wonderworker was erected at the end of the 1600s by the dependents of Grigory Shustov, the owner of the Lenvin salt mines. In 1753, the monastery properties already included 4 stone churches, 2 in Pyskor and 2 in the surrounding lands. See <http://pyskor.cerkov.ru/istoriya-skita/obitel-na-pyskorskoj-gore-i-na-lysve/> [Access on 06/01/2021]

<sup>3</sup> The existence of underground passages around the former monastery site was confirmed in 1915, when Pyskor inhabitants discovered a tunnel entrance. An expedition headed by P.S. Bogoslovsky, for about two months, worked continuously to clear the tunnel, in parallel to archaeological excavations on the hill at the site of the monastery. It was discovered a system of underground tunnels linked to the previous religious complex, and the entire area of the mountain, strewn with bricks overgrown with greenery, is fenced with ramparts - the remains of stone walls of former buildings and pits - probably the former cellars under the monastery buildings. Unfortunately, the expedition was stopped waiting for funds and the entrance to the tunnels was temporary closed. The Revolution suspended the research, and in Soviet times a landslide hid the entrance to the underground. Nowadays,

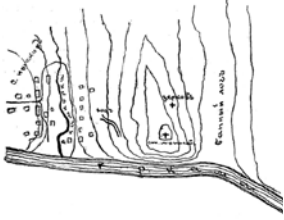


Fig. 02

**Diagram of the historical settlement system of Pyskor** the image highlights the predominant position of the church, set on a hillside overlooking the river, and its relationship to the inhabited settlement downstream.

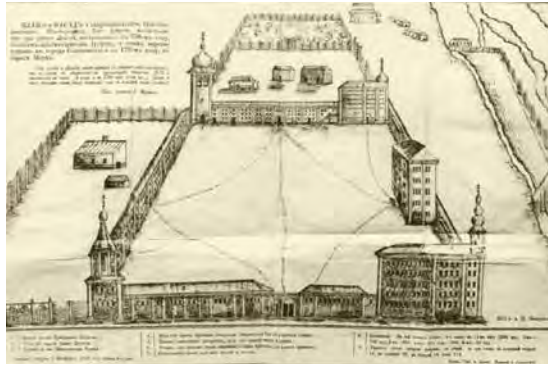


Fig. 03

**Changes of Pyskor configuration**  
Above, plan of the Pyskor Stavropigial Spaso-Preobrazhensky Monastery on the Lysva River. The second half of the 18th century (illustration reproduced from the edition: *Art of the Perm fiefdoms of the Stroganovs*. Perm, 2007). On the right, Archimandrite Kolotsky, moving the monastery to the Lysva River, left one church - St. Nicholas Church, which is now located in the village of Pyskor. (Photo of the early twentieth century, State Archive of the Perm Region). Below, an image of the San Nicholas church in Pyskor as it appears today.

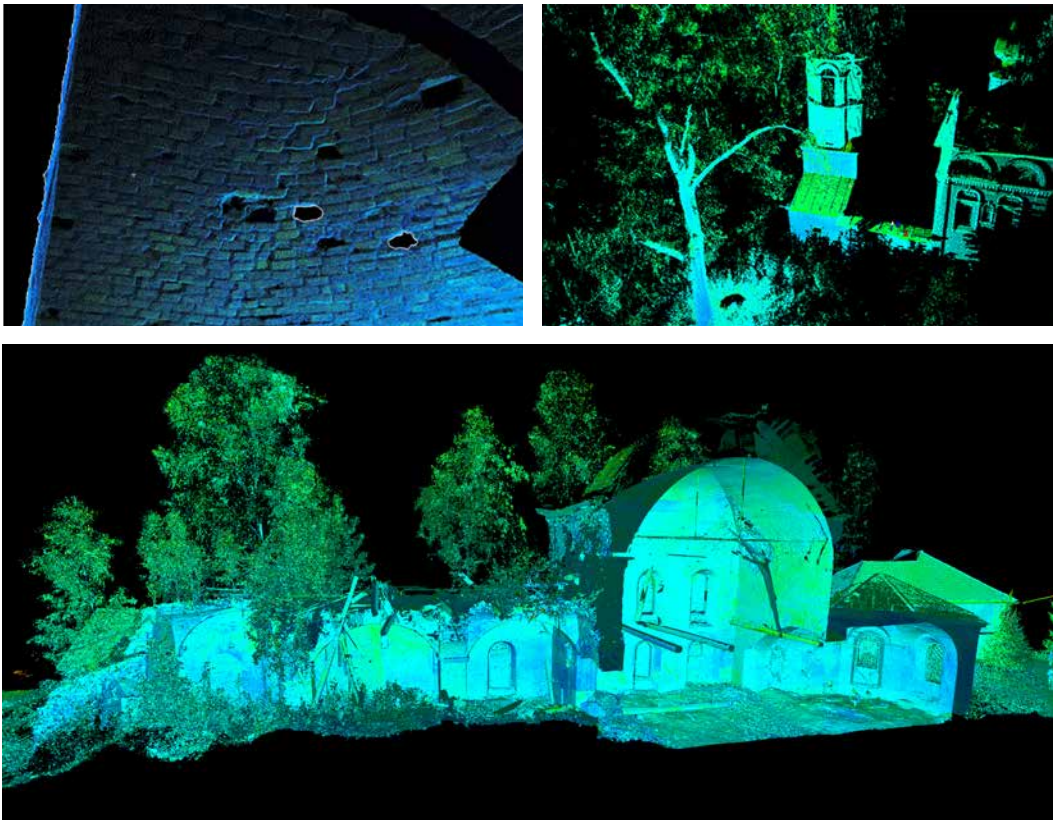
Another cultural change of the site, opposite to the hermitic tradition, is linked to the construction in Pyskor of the first copper smelter in the Urals in 1630. Closed and restored later in 1723, it transformed the historical site in an industrial network.

Today, the historical nucleus of Pyskor still extends in a landscape dimension within the monumental ruins of the Church of the Transfiguration of the Savior, in the valley area of the village, and over the Pyskorka river till to the Nikolskaya Church, on the top of Mount Pyskorskaya which dominates the Kama landscape.

Church of St. Nicholas the Wonderworker, or Nikolskaya Church, was built between 1655-1695, probably converted from a refectory and survived to the destroy of the complex as a symbolic remain. It consists of a single monumental block, surrounded by the local cemetery. In the original Pyskorsky complex, it was the church of the male monastery, located in the hermitic area of the mountain and dedicated to the monk Saint Tryphon of Vyatka.

It was built adopting elements of baroque and classicism, financed by the salt owner Grigory Shustov. The monument consists of a one-domed main church developed in double level height and ending in a lower apse, crowned by a decorative cornice and a half dome. The refectory, including a chapel, and the vestibule, with a three-level bell tower, were added in 1837-1838. The bell tower has an octagonal structure on a four sides basement block, decorated with small pilasters.

few remains of the monastery complex are visible: the dilapidated stone Nikolskaya Church and pits on the site of the former building complex. Cf. Bogoslovsky (1915), *Underground passage and archaeological excavations in the village of Pyskor*.



In 1832 the church was rehabilitated for the religious function, but with the Soviet regime it was closed in 1930, reopened in 1943, and closed again in 1962 when it was adapted as a warehouse. In 1960s, the building, recognized as a monument of federal significance, obtained the state protection, but it did not receive conservation and restoration initiatives. Next to Nikolskaya Church, a new wooden church was erected to support the community of Pyskor, and in 2005, the building property was transferred to the Perm Epiphany Monastery of the Perm Diocese<sup>4</sup>.

Above in the village area, the ruins of the Church of the Transfiguration of the Savior originally belong to the former Vvedensky women's monastery, founded in 1782-1808 and rebuilt several times. The actual monument was built between 1830 - 1840, presumably by the architect I. I. Sviyazev.

The architectural general plan consists of a ship temple with apse, refectory and bell tower in Russian classicism style, crowned by a dome. In the original plan, a five-level bell tower was inserted but, when the church was closed in 1930s, it was dismantled, and its bricks were reused for the local school. The building was readapted as a village club and a bakery, and since 1978 it is abandoned. The external walls are crowned by a figurate cornice, and the arched windows are framed with archivolts. In the interiors, profiled casings and individual fragments of vegetable-geometric ornament are preserved. The building is currently in a state of ruin and collapse emergency.



**Fig. 04**  
**Digital data acquisition with TLS survey campaign**  
 Some of the results of a 3D point cloud, describing, from the detail till the general context, geometries and state of conservation of each building.

<sup>4</sup> Cf. Kiselev, Yakina (2011), *Historical and architectural heritage*.

### Digitizing the monumental remains: the Architectural scale of documentation

The implementation of a documentation programme for the historic complex of Pyskor begins with the observation and analysis of the monumental forms that are still preserved and visible, subsequently tracing back from them to the identification and enhancement of the constructive traces dispersed across the landscape. In this way, the cultural imprint of the site is rediscovered and reconnected to local histories and traditions, fully integrating—through its historical identity—into the broader framework of territorial transformations within the Cultural Heritage Route. The survey strategy based on Terrestrial Laser Scanning (TLS) is adopted as a key action for documentation at the architectural scale. Its high sensitivity in both metric and surface measurement of spatial geometries ensures a detailed representation of the existing building solutions. According to a scan network distributed to achieve full coverage of the monumental structures, an initial dataset was obtained, describing the spatial distribution of constructive forms, from architectural spaces to decorative elements. In this way, vaulted halls, building volumes, and roofing systems emerge as polyhedral compositions of the architectural system. At the same time, the external surfaces are characterised by *zakomaras*<sup>5</sup>, figured cornices and *kokoshniks*<sup>6</sup>, whose detailing reflects the cultural tradition of the territory.

The high level of measurement accuracy also enables analyses related to the stability and safety of structural and construction components, which have reached the present in varying conditions of conservation and integrity due to successive historical transformations. The metric knowledge of the architectural system supports both qualitative evaluations—such as deformation and stress affecting original and modified masonry—and quantitative assessments, including the estimation of collapsed ruins or the residual volumes of dismantled structures, thus helping to better target intervention and rehabilitation strategies. The area mapping conducted through UAV-based photogrammetry and Structure from Motion reconstruction of the surrounding context provides an integrative support to the architectural form, particularly for elevated and roofing portions. It establishes a secondary dataset that mediates between the adopted LiDAR-based measurement strategies, creating a level of digital data connection between the architectural and landscape scales.

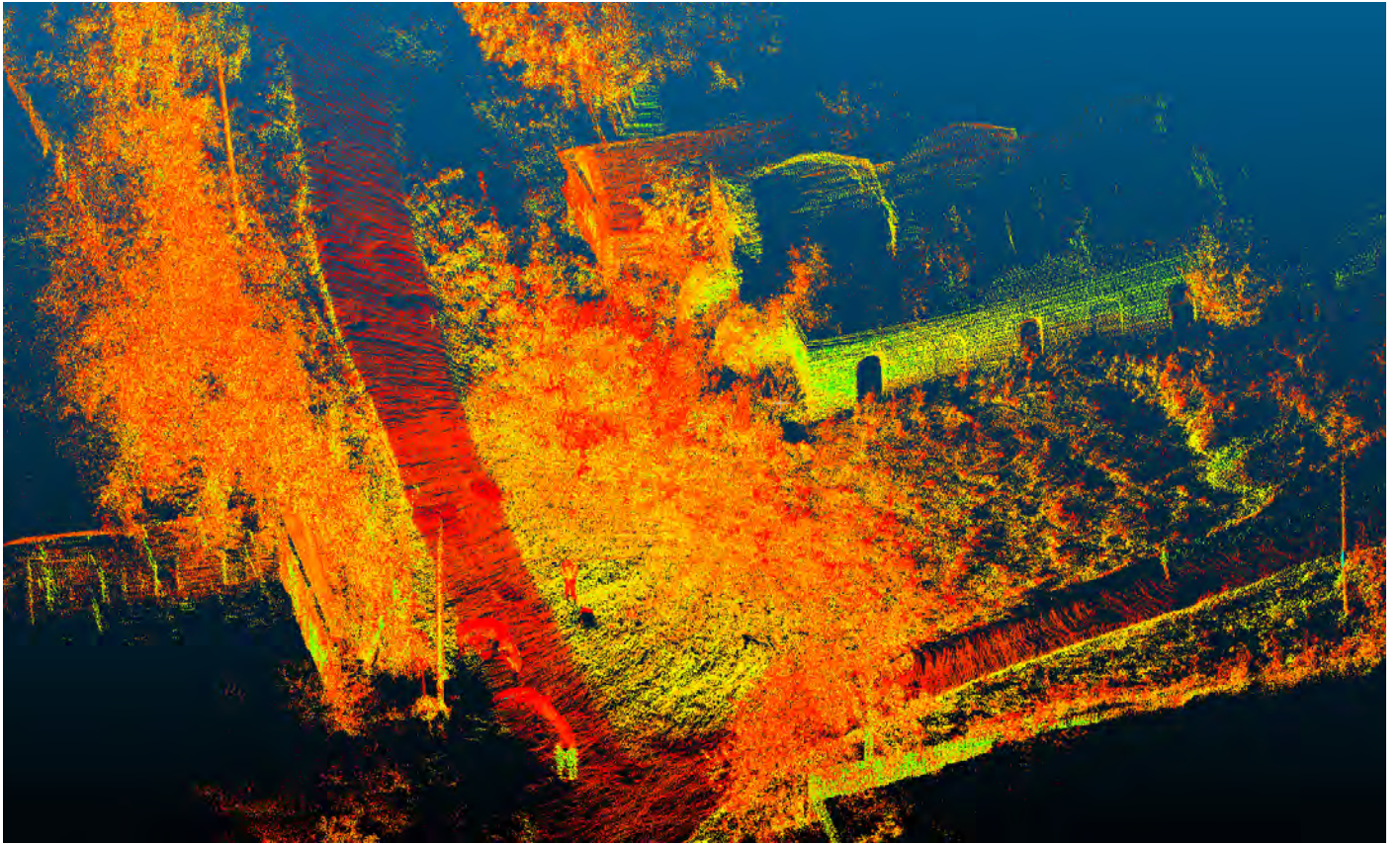
### The Landscape scale of documentation

An extensive survey strategy was adopted to properly contextualize the two monuments within the territory of Usolye as a unified historical and cultural entity, utilizing a mobile laser scanner (KAARTA Stencil). Given the historical link between these sites, this approach allowed for a more integrated

*Side Page Fig. 05*  
**SLAM technology for a landscape documentation**  
 Two views of St. Nicholas Church of Pyskor with its surrounding. The aim of this application is to describe with a rarefied point cloud a geometric representation both natural and architectural elements, in order to underline spatial relations insisting on the hill between built-up area and open spaces.

<sup>5</sup> Zakomar (Russian: Закома́ра): semicircular or keeled completion of a wall (curtain wall) in the Russian architecture, approximately corresponding to the curvature of the closed vault. Cf. Pluzhnikov (1995), *Terms of Russian architectural heritage*.

<sup>6</sup> Kokoshnik (Russian: Кокошник): false zakomar, decorative element behind which there is no vaulted structure corresponding to the outer contour of K.; it has a semicircular, three-centered, keeled or triangular shape. Cf. Pluzhnikov (1995), *Terms of Russian architectural heritage*, cit.



analysis, bridging spatial and contextual gaps. Through advanced three-dimensional scanning, the mobile laser scanner effectively captured the complex morphology of the landscape, extending from the monumental ruins in the village valley to the summit of Mount Pyskorskaya, which dominates the panoramic view of the Kama River. The two key monuments — the Church of the Transfiguration of the Saviour and the Church of Nikolskaya — are connected by a linear path, guiding visitors to the mountain's summit in approximately half an hour.

To ensure a precise and comprehensive digital reconstruction, three distinct surveying routes were meticulously planned: two focused on documenting each monument in detail, while the third followed the linear path that links them.

Acting as a connective tissue between separately acquired datasets, the mobile laser scanner played a pivotal role in unifying different data sources, creating a continuous and cohesive digital representation of the site. This technology significantly enhances the process of digital heritage documentation by bridging gaps between static surveys and ensuring spatial continuity in the reconstruction of the area.

The method captures extensive details, from intricate architectural elements to the vast surrounding landscape. However, despite its advantages, mobile scanning simplifies the resulting point cloud, sometimes leading to a loss of critical architectural details, particularly in the case of the delicate brick masonry unique to these structures. While this reduction in detail presents certain challenges, integrating mobile data remains crucial for completing, linking, and contextualizing the surveys, ultimately providing a more holistic view of the historical and natural environments. Unlike traditional surveying techniques, mobile laser scanning enables the creation of truly continuous digital routes, seamlessly integrating datasets derived from static terrestrial surveys and photogrammetry. This innovation facilitates the development of detailed and comprehensive mappings, not only capturing individual architectural features but also reconstructing an extensive view of the broader monumental and landscape context. By embracing this technology, the digitization of cultural heritage takes a significant step forward, offering powerful new tools for documentation,

conservation, and even potential virtual reconstructions of endangered sites. At the time of the survey, both churches were in an advanced state of deterioration, with severe internal collapses and a clear risk of irreversible loss. Without urgent intervention, these architectural and historical testimonies face the threat of vanishing, taking with them an invaluable part of Usolye's cultural and landscape heritage. Given their structural fragility, using advanced surveying technologies is essential for precise documentation and integrating these findings into long-term conservation and restoration strategies. The mobile laser scanner, therefore, serves as a means of virtually connecting two separate historical sites and as a critical tool for raising awareness, supporting preservation efforts, and safeguarding Pyskor's unique cultural landscape for future generations.

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Temples.ru 2021, available at: <http://www.temples.ru/card.php?ID=17211> (accessed 6 January 2021).



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Taman is a small village in Usolye region of Perm Krai, situated on the bank of the Kama river and in the mouth of the river Tamanka, 23 km far from Usolye and 144 km far from Perm. Till 2006 the village was the center of Taman rural administration, further it found itself as the part of Usolye urban settlement. In 1726 the Stroganovs constructed the copper smeltery on the bank of the river Tamanka which had been closed by 1774 due to the lack of raw material delivered by water way from the Romanovs copper mines. In 1779 the Stroganov raised here a first Petropavlovsk Church. At the beginning of the 20th century the wooden church fall into disrepair condition (it was finally destroyed by the fire of 1981) and the question about the construction of new church came up.

The wooden church was built by the local lumberman and merchant F. Kiryanov who had been impressed by his pilgrim's journey to the Mount Athos in Greece and Jerusalem (Holy City). Perhaps, that long journey in the Holy places was the reason of construction the church on the high right bank of the river Kama with opening river view.

The construction of the church continued for about 10 years, following the project of Alexander Bonaventurovich Tucheich, till it was finished in 1912 and the next years consecrated in the name of Peter and Paul. Two main domes of the church were covered with gold. unfortunately, with the beginning of the war the church underwent some changes of function and substantial changes that conditioned it for almost half a century. In 1934 the Soviet authorities closed the church and up to the end of the 1960s the building was used as the club with the cinema hall. In 1968 the central dome of the church and the tented roof of the bell-tower were destroyed by the thunderbolt, and so it has remained to this day. The church constructed from the solid ceramic brick in the style of architectural eclecticism (retrospective style) combines the typical features of Russian, Gothic and Byzantine architecture. This is an one-storey five-dome church with apse, small refectory and bell-tower. The plan is composed of a cross combined with a rotunda. The second lit is made in form of quadrangular frame in the center of which the tambour is placed. Initially it was crowned with dome, but after the 1968 thunderbolt it is absent. Small domes on the brick necks are placed in the corners, covered with the lead chequer-plates with the joints tin plating. The original crosses have been preserved. Facades of the church are emphasized by avant-corps completed with fastigiums, rich of décor from hewn and circle brick. The walls, internal surfaces of the arches and dome were painted with the sainthood and floral design. In some places these paintings have been preserved.

*Side Page Fig. 01*  
**Overview of Taman settlement from the river**  
The image highlights the relationship of the village of Taman with the river. The church, located at the confluence of two streams, stands high on the right bank of the Kama River with a privileged view from/ onto the river.



Fig. 02

#### Overview of Taman settlement from the land

Decreasing in scale, the feeling is that of a rarefied but well-organised landscape on a regular grid. The green space within the quadrants divided by the streets is a predominant and omnipresent component in the perception of space.

Under the arch abutments between refectory, altar and temple (place of worship) there placed the fret consoles with painting in grisaille technique. Some inscriptions have been preserved on the western wall of refectory.

One-storey brick mortuary chapel situated to the east from the Church of the St. Peter and St. Paul is known as the family mausoleum of the merchants Kiryanovs (1905, the author is unknown). Originally the lantern tower crowned with dome overtopped the crypt. The light drum-octagonal is marked with arched gables.

Side page Fig. 03

#### A description by images

Taman's most characteristic architecture, including the traditional wooden buildings and the brick church of St. Peter and Paul itself, were analysed in their relationship to the landscape context. In the photographic images and sketches, the symbiotic relationship between the architectural element and nature emerges. (Drawings credit: Alexey Leybchik)







**Fig. 04**  
**Church and village from a top view**

The use of the photographic tool to “look up” not only facilitates the understanding of spatial relationships that are not easily understood from the ground, but also helps to better plan acquisition campaigns with digital technologies: it is in fact from these photographs that the subdivisions of areas for drone flight plans were planned.

**Side Page Fig. 05**

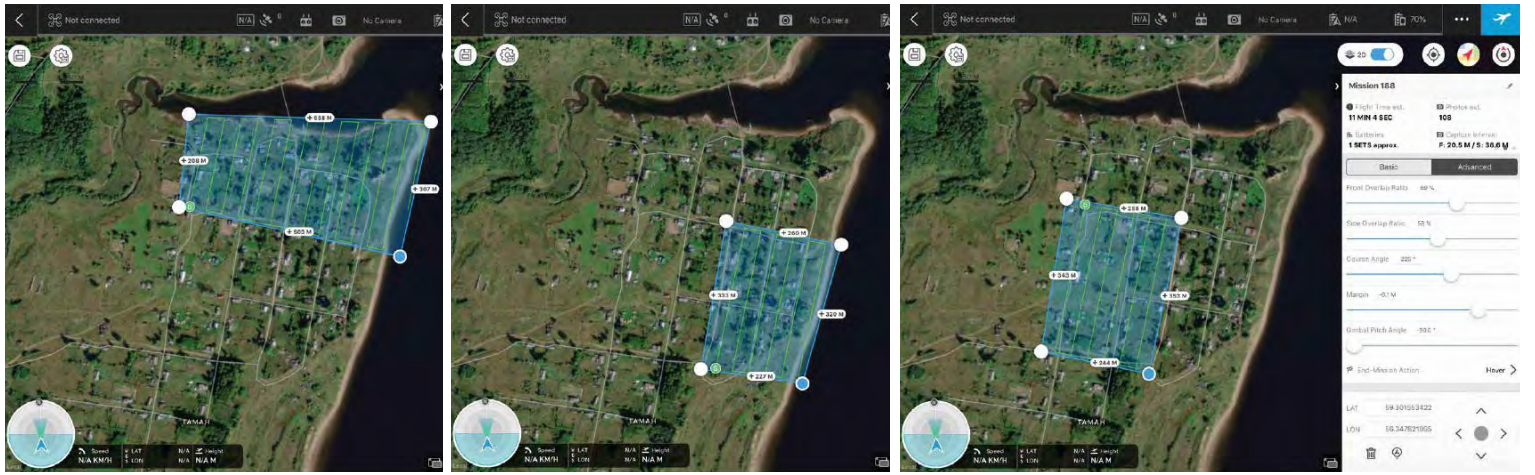
**Data integration between point and extended data acquisition results**

Above, the execution of flight plans at constant altitude to document the territorial extent of the village. Bottom, point acquisition with point of interest around the architectural object. Once processed, the two digital products were integrated within a single system in order to obtain the maximum quality of the data on the church and the minimum quality on the landscape context.

Apertures surrounded by semi-columns with the cubic capitals and knop in the center are covered with castellated archivolts. The corners are decorated with the paneled scarps and corbel arches over them. On the eastern wall the fragments of picturesque Jerusalem panorama have been preserved, while on the western wall we can see the fragment of the inscription about the people buried here.

In the construction of the church and mausoleum new materials and structural elements were used: cement, ceramic floor multicolored tiles. Oak window frames, wrought iron lattices, perfectly smooth floor, winding staircase to the bell-tower, zinc coating of domes gave the magic view to the church. The church is placed on the high basement made from the hewn grey granite. Its internal part is occupied by the deep subbasement. In 2015 the church and the mausoleum of the merchant Kiryanov were given to Perm Eparchy, and the following year they were included in the list of cultural heritage of regional importance. The monumental church has not only value for its historical importance, but also for its identity within the landscape system in which it is located. It appears as a landmark in the linear landscape of the coast of this area of Upper Kama. Its visibility from the Kama River, navigating from Usolye to Taman, gradually appears within progressive panoramic sequences, as revelations of a monumental identity highlighted at each visual frame of the path that leads us to the village.

The visual images and photographs taken to document this aspect of progressive monumentality contribute to increasing the possibility of extending the knowledge of a specific place. The purpose is not only to document the monument and the context in which it is located, but also to understand and codify the landscape system, explaining the relationship between the church and the elements that characterize the village to understand its compositional dynamics. In order to structure an investigation action on the village of Taman, cognitive inspections were carried out to create a multiplicity of heterogeneous sequential images in the visitor’s mind on which to orientate and establish criteria for codify the space.



The village of Taman is spread over a relatively large territorial surface, even if currently few people live there. Distributed on the right and left bank of the inlet, it is divided into a regular grid system, arranged on one level, oriented with respect to the bank of the Kama River. The village is rarefied, with houses distributed mostly along the driveways that separate the rectangular blocks, but always at a defined margin from the road. Even the annexed services (remittances and baths) are located at a distance from the house, often surrounded by tall trees or bushes, configuring each block as a space in which the green of nature is dominant compared to the building. The main road that connects the two banks and that connects the two portions of the village is interposed with the panoramic one that, from the center of the village, leads the visitor to the church of San Pietro and Paolo and to the panoramic view of the river. The buildings near the church that provide the scenic backdrop to this route have maintained their characteristic of traditional wooden houses and emphasize, with the lively coloring and the decorative motifs, the monumentality of this panoramic view. With the exception of some buildings, on which new materials have been used for the recovery of the roofs or the construction of remittances, the village of Taman retains the traditional character of the wooden houses, many of which are abandoned or in poor condition. The dialogue that takes place between the buildings of the village and the religious complex and which has been maintained over the years thanks to the absence of disastrous restoration interventions, has meant that this village assumed a specific historical identity value in this area. The important activities carried out inevitably involved the landscape aspect as the main value to be documented, known and transmitted.

For this reason, campaigns of laser scanner and photogrammetric documentation, from ground and drone, have been planned to obtain metric and colorimetric information from which to highlight aspects to structure a landscape analysis aimed at defining levels of knowledge and explicating the landscape relationship between monument and territorial context. The laser scanner detection activities focused on the acquisition of the religious complex of San Pietro and Paolo and the mausoleum located near the church. In addition to these metric acquisition activities, photogrammetric survey activities were carried out, aimed at describing the material and colorimeter aspect of the monument. In order to relate the building system to that of the village, a major campaign was carried out on the portion of the village on the shore near the monument. The planimetric extension of the village and the reduced time in which the campaign had to be carried out led to prefer a drone photographic shot, the execution mode of which would have produced a point cloud associated with the port cloud produced for the church.

Before embarking the photogrammetric campaign by drone, some inspections were carried out, aimed at defining the best point for the landing and take-off of the aircraft, to establish the good visibility of the drone in flight and to understand the extension and conformation of the area to be acquired. To obtain a good result in terms of metric and, above all, qualitative reliability, i.e. to create a database capable



of containing information related to the site's identity aspects, the photogrammetric acquisition were performed quite close to each object (building or natural elements), all inside the block. The altitude at which the drone would have taken a sufficiently sharp and detailed image was then analyzed. The first operation was to create a general flight plan, from which to extrapolate the metric-dimensional information of each lot. The area of the village was flown over with a drone, placed at a constant height of 50 m from the surface and with the camera shooting in the nadir axis, which covered the surface of the village. This allowed to obtain a general 3D model of the entire village, to understand the mutual position between buildings and the relationship with the natural elements. A second acquisition phase involved the assignment of points of interest with the center of the axis of each block. In this way, the variable altitude also allowed the acquisition of the fronts of the buildings, creating a more detailed database of the architectural elements compared to the green mantle of the block. The integration of these two acquisition methods has allowed to obtain a very detailed colorimetric point cloud of Taman village, thanks to which it is possible to generate SfM models at different levels of geometric details. In particular, this operation was planned with the aim of creating a photogrammetric point cloud of the path inside the village that leads to the church of San Pietro e Paolo, to transfer the considerations



**Fig. 06**  
**Orthoimage of the 3D**  
**photogrammetric model**  
**obtained**

An update photographic map of  
the Taman village.

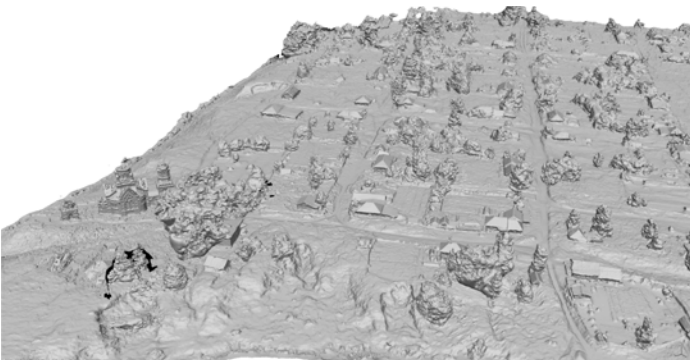


**Fig. 07**  
**3D point cloud visualisation**  
 Visualisation of the dense point cloud obtained by using SfM methodologies from a drone.



**Fig. 08**  
**Photogrammetric model**  
 On the left, a shaded representation of the 3D model, on the right the textured model.

made from a view or photographic images into a virtual space, storage of multiple information. In this way the perceived spatial relationships are compared with metric reliable digital spaces of the point cloud: environmental sections, axonometric and perspective views allow each building to be put into a well-defined spatial relationship, making it part of a known system, the complexity of which is partially organized and codified. The spatial relationship between village and monument becomes easily quantifiable and analyzable, both from a metric and colorimetric point of view. The color of the church acquires its specific value if related to the colors of the other materials present in the context, so as to be able to assess its visual and landscape impact to improve its management and to any restoration activities on external surfaces.



Thanks to the production of two-dimensional drawings consisting of colorimetric information, it is possible to update the existing cartography on these settlements, offering new more detailed images than those provided by the satellite.

The update map allows us to obtain a territory management tool to update information and improve the management of the buildings present, useful to estimate the number of homes destroyed, in a state of neglect or for which programmatic restoration interventions are needed. The creation of a 3D model of the entire village can also respond to the need to make explicit and transmit those identity values of the space that emerged from historical investigations and from an in-depth reading of the landscape system. Thus, through a simultaneous reading of the elements of the space, some new landscape values can emerge and enter to contribute to the formation of the image of the village.

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# MORPHOLOGY AND COMPLEXITY IN THE SURVEY OF TAMAN CATHEDRAL COMPLEX

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The Church of Saints Peter and Paul in Taman develops a unique typological conformation in terms of the characters and forms of the architectural system, constituting one of the most morphologically complex sites in Upper Kama<sup>1</sup>. The complexity of form is evidenced at several levels of the church's design system, which is still well preserved in the general framework of decay<sup>2</sup>, with a modulation of volumes and surfaces observable in both the 'unit-structure' and 'module-structure' relationships.

## **Breakdown by macro-morphologies: the resistant units and the monolithic structure**

According to a formal macro-geometric analysis, the historical complex is composed of several structural bodies and secondary building blocks, corresponding to a functional path developed according to the building's original religious activities. The main blocks of the narthex, bell tower, vestibule and central body define the macro-division by parts: these blocks identify the main structural and volumetric scheme of the work, regulating the reciprocal three-dimensional static interaction in the overall architectural system. They are joined by the independent block of the Chapel-tomb of Kiryanov, which completes the macro-structural composition of the site (in addition to the spiritual symbolic path), but without developing interactions and equilibrium constraints with the main complex.

The building system, apparently perceived as a 'monolithic unit' with domed configuration, is in reality based on a complex and composite structural form, generated by a series of simple 'geometric units' juxtaposed to compose a polyhedral scheme.

*Side Page Fig.01*

### **The St. Peter e Paul Church in Taman**

Monuments such as those at Upper kama are often made up of strong masonry structures, of considerable size, continuous and tightly woven. The use of ephemeral structures, such as those found in Taman Cathedral, is left for functionality to independent secondary systems, such as roofs and ornaments, which are frequently reworked and replaced.

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<sup>1</sup> The changes in the historical conformation of the site, which was once enriched by additional building blocks that have now disappeared, in particular the adjacent wooden Petropavlovsk church of the Kiryanov family (destroyed in 1981), as well as the numerous warehouses and sheds arranged on the slope down to the river bank (which disappeared during the 20th century), lead to a system of morphological relations different from those that can be appreciated today. A similar discourse can be conducted on the shape of the cathedral itself, deprived of its characteristic gilded roofing since 1968, collapsed following a lightning strike as in the Pokcha Cathedral, and altered in the brick decorations of the external surfaces, chromatically altered and eroded in their profiles. The current conformation of the site today is equally complex, with systems of relationships and readings of formal space that differ from the original design of the site, but equally rich in defining local identity. The original morphological matrix of St. Peter and Paul's Cathedral in Taman and its landscape, understood as the configuration at the time of the inauguration of the stone cathedral and the maximum coexistence of original and renovated artefacts, is now irretrievably lost.

<sup>2</sup> The church, although restored to its original religious function, is now used only occasionally, and in any case not affected by restoration and conservation works. The result is a phenomenon of uneven degradation of the building, related to different contextual factors: winds and weathering from the north-east, along the Kama axis, contribute to an erosion phenomenon of the wall surfaces, undermining their morphological reading. The same roofs, originally ephemeral, are now absent, and give an altered image of the factory body proven of the characteristic onion domes and varied in the altimetric profile of the roofs, originally integrated by wooden layers of filling and protection.



Fig.02

**Interiors of the Church**

The 2018 documentation of the complex and its structures sought to highlight the masonry equipment and the state of conservation of the (often illusory) surface finishes.

The linearity of the structural profiles is taken up as much in the construction, in the arches and elevation profiles, as in the volumetric scheme, in the grafting and connection between the blocks. The interior spaces are rhythmic and delimited in a controlled spatial structure, perceptible in the forms and volumes of the layout also outside the complex. The roofing towers, even if now deprived of their onion-shaped wooden tops, contribute to this scansion, outlining an evident variation between empty and full spaces in the distribution of the building blocks. The building nucleus is defined by the main block, set on a central Greek cross plan, and conformed in a monumental vaulted system completed by a series of four angular apses. The entire room is actually composed of a complex frame of arches in a shell-like arrangement: four square section arches, 1.5 metres on a side, intersecting at about two thirds of their total height, delimiting the central space and forming its elevation structure. At the top of this intersection is the box-shaped block of the windowed tambour, culminating in the interior dome. The other vertical and horizontal surfaces have the sole function of completing, welding and consolidating the wall box.

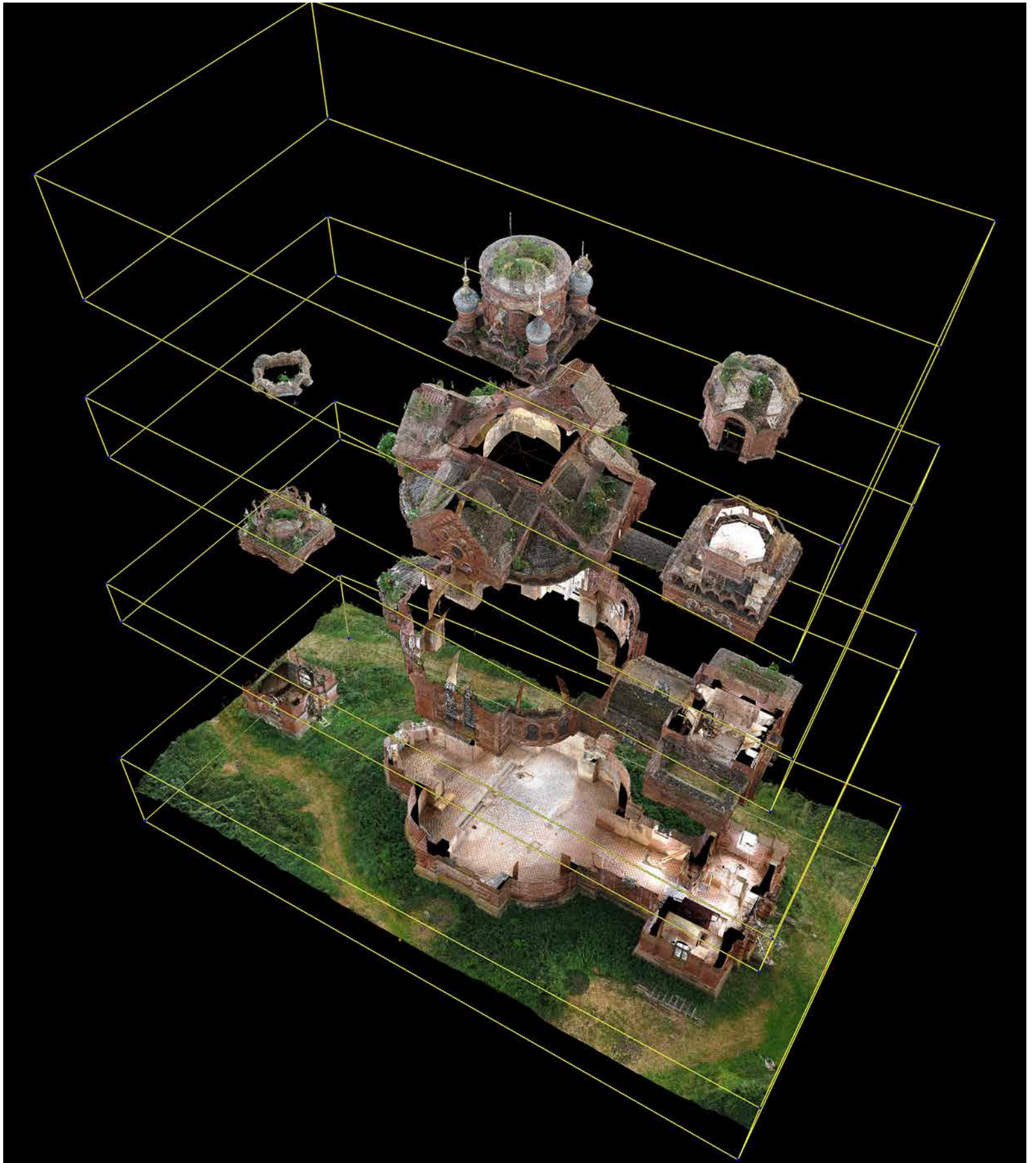
The static support function of the central vault is performed by the twin corner pillars, formed by the main arches themselves, while the secondary apses are configured as self-supporting masonry structures. This structural scheme, only apparently complex, has the property of being particularly solid thanks to the geometric organisation and the massive size of the support points. The intersection of the four arches gives the single arch greater resistance to overturning out of plane, thanks to the support of the other two supports both under load and overturning. Despite the specific conformation, iron chains are inserted to support the counteracting horizontal thrust forces, increased by the weight load of the upper cylinder (drum).

Added to this core are the structural schemes adopted in the other blocks of the complex, mainly consisting of a repertoire of vaulted units adapted to the different perimeter conditions of the narthex, vestibule and apsidal portion.

Side page, Fig.03

**Decomposition by planimetric levels**

the point cloud constitutes a system of spatial information that can be organised by planes or portions in order to obtain specific analyses of the artefact. In order to prepare a detailed and multiscale cognitive system on the artefact, the point cloud of the Taman church was broken down by levels to obtain semantically functional portions to describe the technological, structural and decorative apparatus of the building.



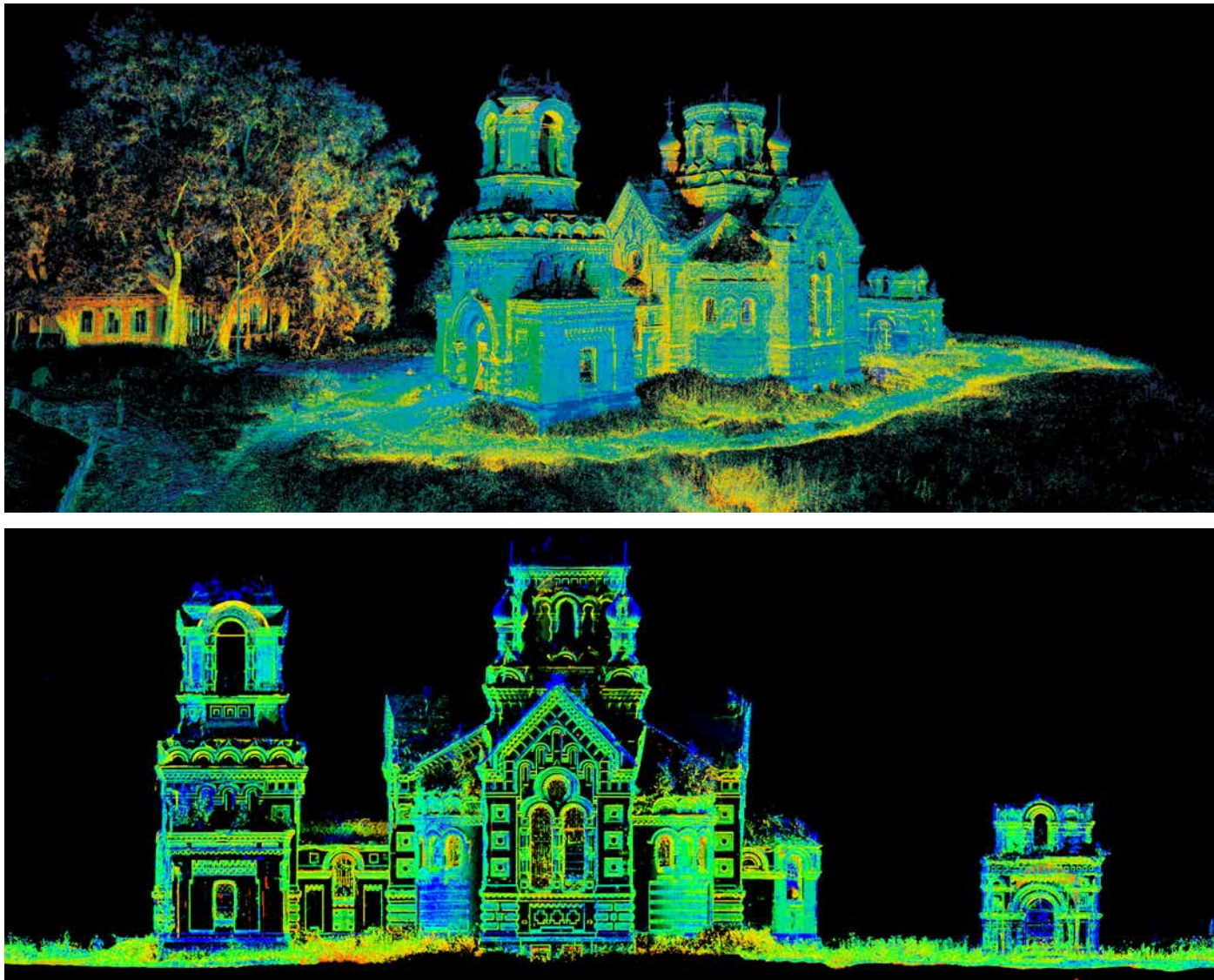


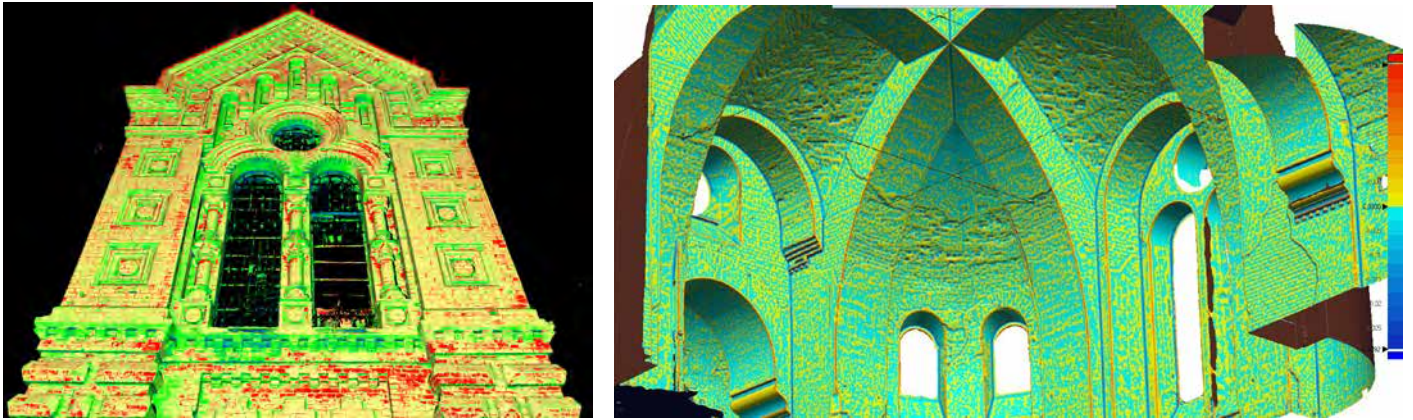
Fig.04

**TLS Point cloud of Taman**

A general view, above, and an elevation, below, of the entire complex.

### Layering by micro-morphologies: decorative modules and the paramental envelope

According to a formal micro-geometric analysis, the complex presents external brick facades organised in several orders and geometric modules, enriching the morphological scansion of the main surfaces with an ornamental character. The building system can thus be broken down according to geometric patterns of the surfaces, following the formal hierarchy of the wall 'decorative modules'. The elements, rendered with shaped bricks and an integral part of the masonry, contribute with their arrangement to the organic design of the church envelope, enhancing the permeability of the architectural work in the landscape. Tongue-and-groove, halo, rhombus, ashlar and corner-column textures sculpt the external surfaces with a rich decoration, which on a constructive level is an integral part of the structure, while on a static level it does not participate in the classification of the equilibrium patterns. The decorative apparatuses with formal three-dimensionality are concentrated on the surfaces of the external façades, giving an intrinsic plasticity to the brickwork

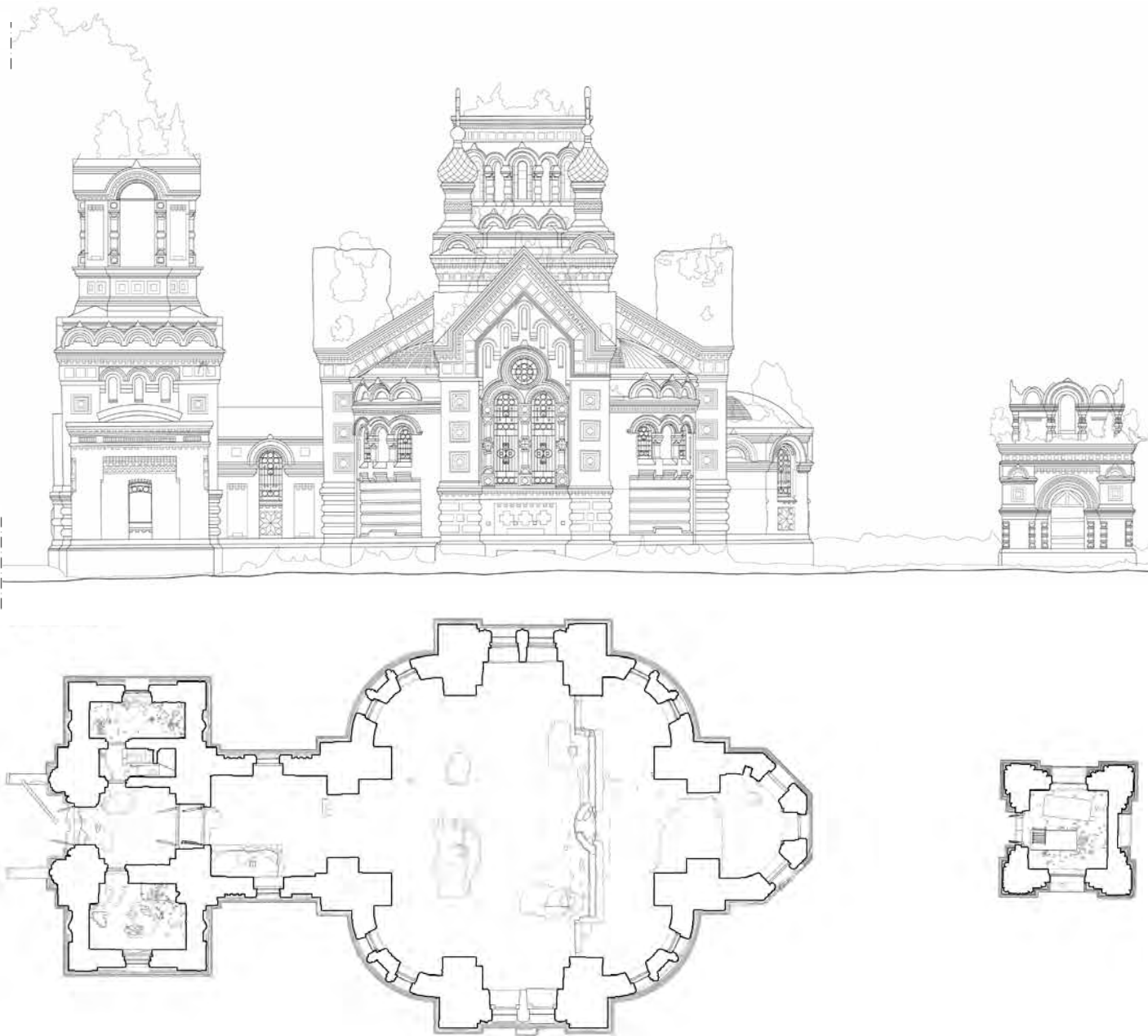


↕  
**Fig.05**  
**Reflectance index on wall surfaces**  
 Structural surface reconstructed with polygonal pattern of the Church: colour map by relative curvature of dense polygonal modules.

and accentuating the play of shadows that these geometric forms generate on the plane from their composition. It is possible to find three hierarchical types of decorative fields: basement apparatuses, crowning apparatuses, composite cornices of the openings and field modules. At the basements, the façades present decorative ‘ashlar’ apparatuses, similar to ‘diamond point’, shaped through courses with different projections of special brick elements. The courses of rustication, concentrated around the corner profiles, are either continuous or interrupted in a geometric rhythm. At the crowning, composite cornice solutions are adopted that follow the course of the upper architectural profiles, either flat or in gabled solutions. In the case of the Church of Saints Peter and Paul in Taman, two types of linear decorative frames are predominantly applied: prismatic module and semicircular module, also known as kokoshnik decoration. Such cornices are worked with several levels of splay, rendered through the “band” arrangement with a centre of curvature of standard bricks or special “scotia” shaped bricks. At the openings, the semicircular kokoshnik module is often taken up, with a greater richness of frames and entablature elements. More complex solutions are added for the composite openings of mullioned windows and upper oculus, combining more articulated geometric frame constructions with relief column supports with simplified components alternating with cruciform modules. In correspondence with the remaining portions of the front, contained between the architectural profiles, variable field-filling solutions are adopted with decorative geometric modules, based on square or rectangular patterns with different splays, combined with circular shapes or star compositions.

### **Digital survey experience for the structuring of a multi-layer database**

The documentation project on the site was organised with this double morphological reading of the surfaces and architectural components on the entire complex in mind. In the external areas, the plasticity of the masonry work was combined with the absence of the external covering or painting layer, which had been altered in its conservation, allowing the design of the masonry texture to emerge as a further factor emphasising the decorative modelling and the 3D character of the surfaces. In the interior rooms, on the other hand, the greater regularity of the masonry finish was contrasted by a figurative richness linked to the design of the surfaces with frescoes and representations, requiring



**Fig. 06**  
**Architectural drawings**  
 Main elevation and planimetry  
 of ground level.


a more sensitive condition of documentation not only spatial-geometric but of 2D mapping of the surfaces. As a supra-system of the two categories, the recognisability of the overall structural layout of the work was placed at the centre of the investigation objectives, defining the hierarchical system of support and connection between the two fields.

The survey activities conducted on the complex included a double morphological data acquisition campaign, conducted in parallel from the ground with Terrestrial Laser Scanner and from above with UAV. The point clouds processed and integrated ensured a detailed reconstruction of the wall surfaces, with a high resolution of points per area, faithfully reproducing the spatial proportion and specific formal arrangement in a digital environment.

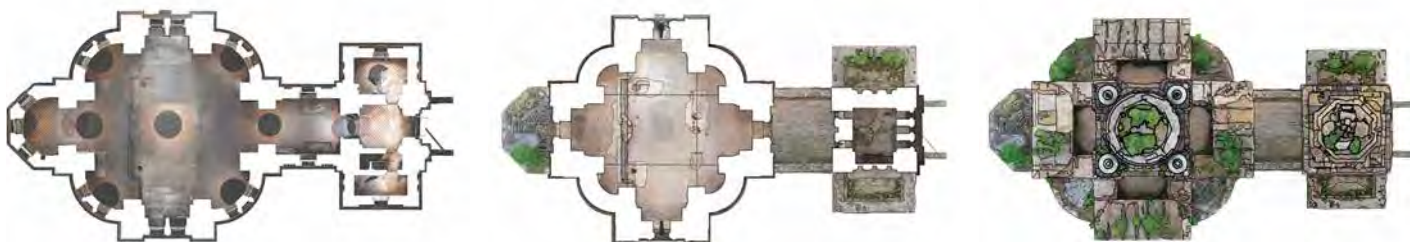


The documentation action developed with a reverse logical process of formal analysis, where from the first perception of the prevailing decorative visual texture it becomes necessary to synthesise and abstract the morphological scheme in order to trace the volumetric primitives underlying the architectural layout. This operation is actually facilitated by the analysis carried out through digital survey products, in particular 3D point clouds from laser scanner or drone, where the naturally three-dimensional character of the database and the direct fruition of the discrete model, which can be orbited and sectioned, support the abstraction and understanding of the hierarchy of components in the morphological system of the wall structures.

The process of analysing St Peter and Paul's Cathedral thus originates from a dynamic relationship between object and acquisition source, where the same operator experiences a 360° discovery of the complex's environments in order to ensure integral coverage of the surfaces and their apparatuses. Finally, we arrive at the processing of a virtual spatial simulation of the real space, on which to operate for the identification of instances, structures and formal hierarchical classes. The morphological reading of the building's apparatuses thus highlights the need to proceed with a specific approach of decomposition and classification of the formal elements observable from the digital database. The objective is to recognise the coexistence of formal relationships between structure and decoration and to differentiate their respective apparatuses. The digital architectural system takes on the character of a multi-layered segmented container, between 'structural form' and 'decorative form', designed to support modelling activities and provide an information link between each component, the semantic structure to which it belongs and the respective thematic map.


**Fig.07**  
**Architectural drawings**  
 Main elevation and planimetry  
 of ground level.

*Next page*  
**Colorimetric technical drawings**  
 Floor plans of the 3 levels,  
 cross sections of the central  
 hall and longitudinal section  
 of the church and bell tower.  
 all drawings are characterised  
 by the texture components,  
 obtained from the application  
 of colour laser scans and the  
 associated photogrammetric  
 campaign.

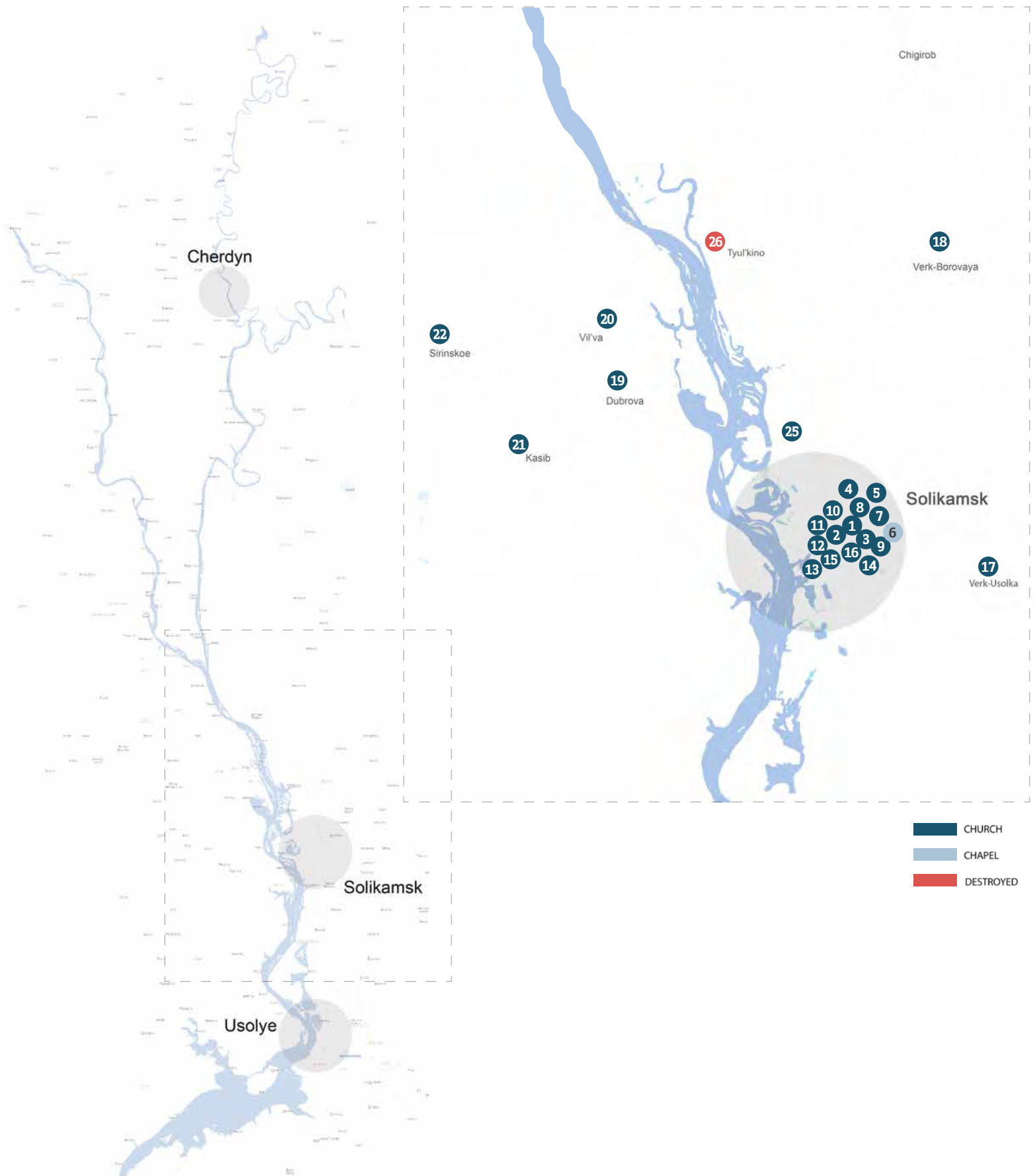


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**Solikamsk: a district between  
preservation and present**



## List of Solikamsk monuments

- 1\_ **The Cathedral of the Trinity**, Solikamsk, 59.650338, 56.771561, Date: 1684 - 1697.
- 2\_ **Church of the Resurrection of Christ**, *Церковь Воскресения Христова*, Solikamsk. 59.650406, 56.770558, Date: 1714 - 1752.
- 3\_ **Bell tower of Trinity Cathedral**, *Соборная колокольня*, Solikamsk, 59.650338, 56.771561, Date: -
- 4\_ **Cathedral of the Exaltation of the Holy Cross**, *Собор Воздвижения Креста Господня*, Solikamsk. 59.651431, 56.769378, Date: 1698 - 1709
- 5\_ **Church of the Epiphany**, *Церковь Богоявления Господня*, Solikamsk. 59.651582, 56.773573, Date: 1687 - 1695.
- 6\_ **Chapel of Peter and Paul**, *Часовня Петра и Павла*, Solikamsk. 59.651815, 56.773903, Date: 1730 - 1770.
- 7\_ **Temple complex. Church of the Transfiguration of the Savior**, *Церковь Спаса Преображения*, Solikamsk. 59.65255, 56.779205, Date: 1683 - 1692.
- 8\_ **Church of the Presentation of the Blessed Virgin**, *Церковь Введения во храм Пресвятой Богородицы*, Solikamsk. 59.65262, 56.778551, Date: 1687 - 1702.
- 9\_ **Church of Myrrh-Bearers**, *Церковь Жен-Мироносиц*, Solikamsk. 59.654623, 56.785562, Date: 1780.
- 10\_ **Church of the Savior Miraculous Image**, *Церковь Спаса Нерукотворного Образа*, Solikamsk. 59.647001, 56.765698, Date: 1689.
- 11\_ **Church of St. Michael the Archangel**, *Церковь Михаила Архангела*, Solikamsk. 59.646961, 56.764963, Date: 1725.
- 12\_ **Ascension Trinity Monastery: Church of the Ascension**, *Вознесенский Троицкий монастырь. Церковь Вознесения Господня*, Solikamsk. 59.646381, 56.761181, Date: 1698 - 1704.
- 13\_ **Ascension Trinity Monastery: Church of Michael Malein**, *Вознесенский Троицкий монастырь. Церковь Михаила Малеина* Solikamsk. 59.646614, 56.761234. Date: 1731 - 1734.
- 14\_ **Solikamsky St. John the Baptist Krasnoselsky Convent. Church of the Nativity of John the Baptist**, *Соликамский Иоанно-Предтеченский Красносельский женский монастырь. Церковь Рождества Иоанна Предтечи*, Solikamsk. 59.638841, 56.738559 Date: 1721 - 1728.
- 15\_ **Church of Simeon of Verkhoturye**, *Церковь Симеона Верхотурского*, Solikamsk. 59.640654, 56.771714, Date: 1900.
- 16\_ **Church of the Icon of the Mother of God "The Sign"**, *Церковь иконы Божией Матери "Знамение"*, Gorodishche. 59.668537, 56.85759, Date: 1750 - 1757.
- 17\_ **Church of the Intercession of the Holy Virgin**, *Часовня Параскевы Пятницы*, Verh-Usolka. 59.583838, 57.011876. Date: 1750
- 18\_ **Verh-Borovaya**, *Церковь Воздвижения Креста Господня*, Verh-Borovaya. 59.813228, 56.88464. Date: 1678.
- 19\_ **Church of Dimitri Solunsky**, *Церковь Димитрия Солунского*, Dubrova. 60.088272, 56.711162, Date: 1773
- 20\_ **Church of the Epiphany**, *Церковь Богоявления Господня*, Vil'va. 59.768043, 56.473503. Date: 1775
- 21\_ **Church of the Intercession of the Holy Virgin**, *Церковь Покрова Пресвятой Богородицы*, Kasib. 59.690768, 56.343042. Date: 1885.
- 22\_ **Church of the Transfiguration of the Savior**, *Церковь Спаса Преображения*, Sirinskoe. 59.762835, 55.930832. Date: 1853.
- 23\_ **Church of St. George**, *Церковь Георгия Победоносца*, Urolka. 59.794803, 55.789579, Date: 1844 - 1855.
- 24\_ **Church of the Epiphany**, *Церковь Богоявления Господня*, Chigiob. 60.026788, 56.795167, Date: 1773.
- 25\_ **Church of the Nativity of the Blessed Virgin in with Solikamsk**. *Церковь Рождества Пресвятой Богородицы в с. Усть-Боровой*, Solikamsk. 59.719023, 56.661387. Date: 1753 - 1758
- 26\_ **Church of the Epiphany**, *Церковь Богоявления Господня*, Tyul'kino. 60.02724845, 56.79452984. Date: 1862.



**Eugene Smirnov**

Public Relations Department Solikamsk Diocese

The ancient Ural city of Solikamsk is located on the upper reaches of the Kama river. A salt gave a life and the name to Solikamsk. The city originated at the salt fields, which was organized by immigrants from Vologda Kalinnikov family. Around 1430 they arranged brine-raising pipes and saltworks on the Bank of the Usolka river, thus marking the beginning of Solikamsk.

In 1472, the lands in the upper reaches of the Kama river together with Perm the Great joined the Moscow state. Favorable geographical location and rich reserves of salt springs attract traders to Solikamsk. The number of saltworks was increasing, and the city is growing. In 1579, during the first census of Perm, Solikamsk was a fortified city with a settlement. It had 190 yards, 16 salt mills, 27 shops. Occasionally the city suffered from the raids of nomadic tribes and the fires, but every time it recovered.

In the XVII century Solikamsk became a major transit and transshipment point on the way to Siberia, an important economic and administrative center. Since 1613 the Voivodship Board (till 1780) was established in the town. By the end of XVII — beginning of XVIII century. Solikamsk was the largest “salt factory” in Russia. “Salt Kama” gave more than half of all sold in the country of salt.

In XVII—XVIII centuries, industrial facilities, residential buildings and temples represented a single ensemble. The leading, organizing role belonged to industrial buildings. Industries were stretched along the river, as this facilitated the extraction, transportation of salt and delivery of firewood. Residential development was located near, parallel to the river. There were also ensembles of monumental buildings built on the site of burned wooden churches, administrative buildings and fortresses.

Solikamsk had a three-part division - the central part and the male and female monasteries on the flanks. The small fortress (the original core of the town) was burned down in 1672.

The center of Solikamsk was determined by the intersection of land and water roads - the main trading place. The Kremlin as a public and administrative center of the old Russian city, surrounded by a fortress wall was not formed. Its role was played by the Cathedral square. Around it were temples and administrative buildings-the center of secular and spiritual power.

There are several main ensembles in the architectural structure of Solikamsk: the Central one, the ensemble of the former convent (summer Transfiguration church (1683-1690) and winter

*Side Page Fig. 01*

**Historical picture of Solikamsk**

Photograph from the first half of the 20th century showing the monumental complex of the old town of Solikamsk and the urban layout of the city. Emerging in the foreground are the roofs of the traditional wooden houses, which have now been incorporated and almost completely disappeared from post-war housing.



*Above-next pages Figs. 02-06*  
**Postcards of 20th century**

**Solikamsk**

The image above and those on the following pages depict different views of the historic city centre, in which the monumental complex of the cathedral and bell tower is always framed.

church of the introduction of the Blessed Virgin (1687-1702)); the ensemble on the place of the burnt fortress (summer church of the Saviour (1689), winter archangel church (1712-1725)). There are buildings of the monastery Ascension Church (1704) and the Church of Michael Malein (1731) on the steep bank of the river.

Salt mines occupied the entire low right-bank part of the town. This was the main ensemble of Solikamsk. The impressive buildings of salt barns completed the ensemble were located opposite the monastery. Here salt was loaded on barges for shipping to Nizhny Novgorod's fair. Unlike Cherdyn and Usolye having a "river faces", Solikamsk ensemble was focused to the land road. Most of the buildings were located between the river gate of the town and the intersection of the water road with the land road. The buildings of other ensembles are oriented to the town center and form an entire spatial composition with it. Architectural images of Solikamsk ensembles become more complicated in the center. The number of structures in each ensemble increases. There are single temples on the outskirts of the town; monasteries with two high-rise buildings are located closer to the center. The triad of temples and the constellation of the Central ensemble rises at the Cathedral square.

The architectural ensemble of the center has the shape of a horseshoe. There are all the most important buildings: the majestic Trinity Cathedral (1684-1697), its marvelous stone carving Epiphany Church (1687-1695), the Governor's house (1688), rare decorative decoration Holy



cross Cathedral (1698-1709), a clear vertical Cathedral bell tower (1713), modest, but appropriate here Christmas Church (1714, the chapel of the Resurrection Church later).

Solikamsk is characterized by the construction of paired (winter and summer) churches, which makes it related to other ancient Russian cities. Although this compositional technique was caused by local climatic conditions, it also played an artistic role. It turned out a kind of rhythmic repetition, because all the summer churches are five-headed, and the winter ones are one-headed. Sometimes winter churches were attached to the summer ones in the form of chapels, for example, in the Epiphany Church and the Resurrection church.

The noted compositional features of the ensemble are not accidental. They were developed by different generations of masters in the period from 1683 to 1780, and each master built his building so that it sounded in “unison” with others.

Another feature attracts attention in the urban ensemble. This is the repeatability of architectural details. This binds the individual parts of intricate architectural image together. Thus, the richest decoration of the facades is made of the identical shaped bricks. Individual buildings and ensembles have always a recurring motif. The overarching theme of Solikamsk is a “beetle” ornament.

In the design of the facades, the influence of wooden architecture is noticeable. Ural “master of stone” had centuries-old carpentry school behind shoulders. While working with a new materials



and bricks the master thought of images of wood (barrel, columns of the Western porch of the Trinity Cathedral, balusters). Color was originally applied in Solikamsk ensemble. The decor of facades remained without painting or was painted under color of a brick. The center of the town is highlighted in the most color. The white walls were decorated with terracotta color patterns. Colored spots of icons and belts of tiles enlivened facades. Cathedral bell tower - the main belfry of the town, was painted the brightest color.

In the second half of the XVIII century Solikamsk lost the importance of the trade center in connection with the emergence of a new Siberian route Perm - Kungur - Yekaterinburg. Its economic importance is also falling. In 1781 Solikamsk became a County town of the Perm governorate (since 1797 the province). In 1781 architect Ivan Lem replaced the medieval planning structure with a geometric rectangular grid. This project served as the basis for all subsequent development of the town. The layout of the quarters, planned by I. Lem, has mostly survived to the present day. In the XIX century, the remodeling of old buildings began. Significant damage was caused by the desire of churchmen to increase the useful area of the temples. Magnificent porch of the Trinity Cathedral were glazed, the top of the cupolas, roofs were converted (plank cover was replaced by iron), even bearing structures were replaced.

Before the First World War Solikamsk was a County town with a population of a little more than 3 thousand people. During the years of Soviet period the town has grown into a major industrial center of the Urals.

На Уралѣ

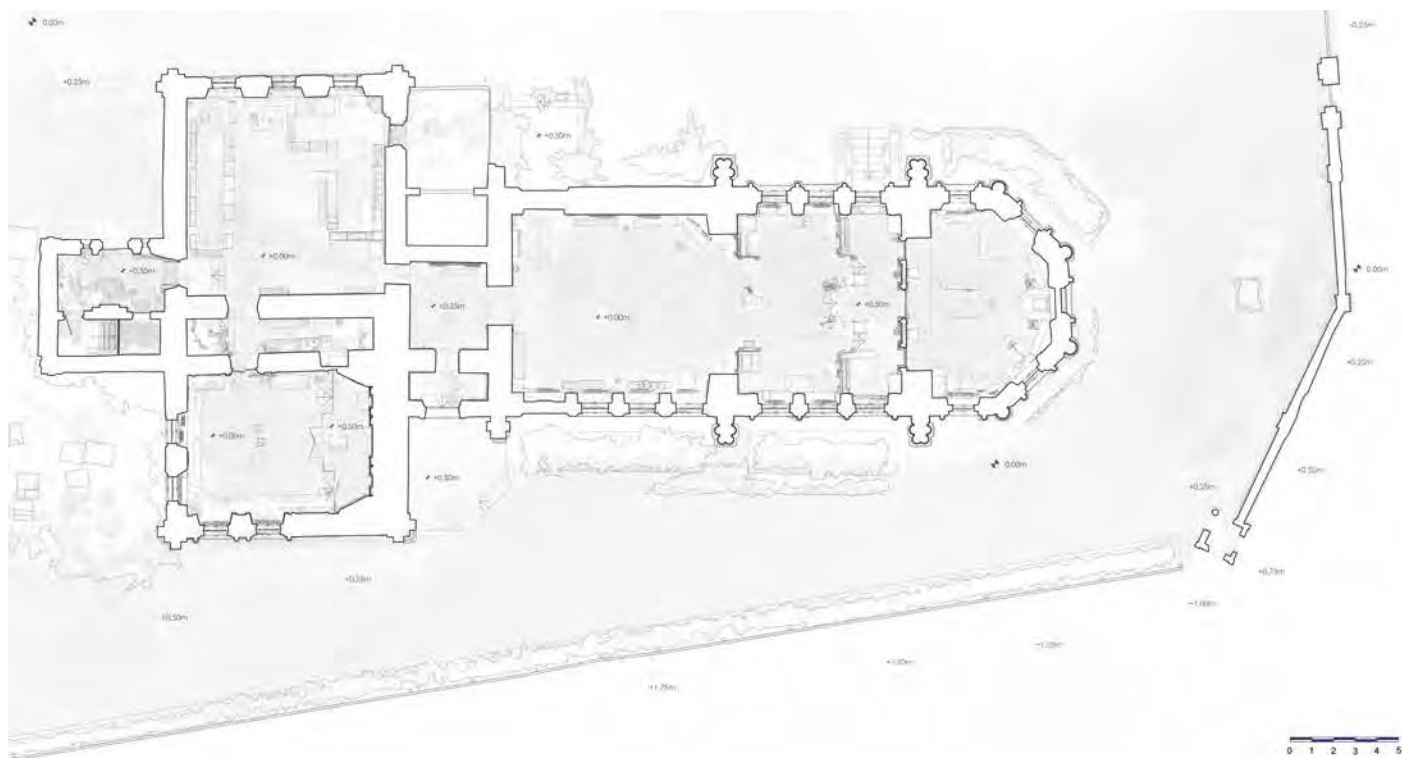
№ 229. Соликамскъ. Видъ на колокольню и зимній соборъ.



На Уралѣ

№ 230. Соликамскъ. Видъ на лѣтній соборъ.





In 1925, the world's largest potash deposit was discovered near the city. In 1927 a potash mine was laid three kilometers from the town. The launch of the plant was the impetus for the further development of the city. At this time, the railway line connected Solikamsk with Perm and the railway network of the Soviet Union. Construction of a magnesium plant began in 1933.

In 1941, Solikamsk pulp and paper mill entered into operation of existing enterprises. In 1970, Solikamsk was elevated to the rank of a historical city with an appropriate regime of protection of monuments. The historical heart with the architectural ensemble remains the center of Solikamsk to this day.

The existing Solikamsk's stone churches built between 1684 and 1714, except the cemetery Church of the Holy Myrrh-bearing Women. Probably all these churches constructed by the same masters because the general methods of the construction and even architectural decoration of all churches are almost the same.



*Here-previous page Figs. 07, 08*  
**Drawings of the Monastery of the Women**

Thanks to the laser scanner and photogrammetric survey, a series of drawings were produced to update the existing documentation on this building. General plans and indicative sections make it possible to narrate the complexity and richness of this building.





Here-next page Figs. 09-11  
Textured drawings

Images of the two main external fronts of the Women's Monastery, obtained from ground and drone photogrammetry processing. Fig. 11 shows the interior with the laser scanner point cloud superimposed.

There was the ancient tradition to build warm churches separately from cold ones. This is seen in the existing Solikamsk churches. The current cold Cathedral of the Holy Trinity and warm Cross Exaltation Church, the cold Transfiguration Church and warm Introduction of the Blessed Virgin Church, the cold Saviour Church and the warm Archangel church make up separate buildings with one common church property and even with some common local icons.

Bell towers of both cathedrals (the Savior and the Archangel churches) stand apart from temples, on special foundations. Cathedral bell tower was built on two-storey building with cellars. The monastery bell tower was built on the top of ancient two-storey temple.



All churches were built on foundations of calcareous stone, uncouth, and quite large. The walls are constructed of strong burnt, strongly red brick 30 x 15x7 cm.

Layer of lime between the individual bricks is not smooth everywhere, thickness from 2 to 4 centimeters. Masonry is named “Polish”, which means that one bricks are put along, another one across in each row. External, larger decorations, such as large columns, are made of brick and hewn along architectural lines. Small decorations are not hewn, but are made of bricks, which were given a well-known figured shape during molding. All the churches are not plastered, but are covered with such a thick layer of lime that it is almost impossible to distinguish the outlines of the masonry.





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### Changes and transformations of built shapes in the historical center

The historical transformations that affected the Upper Kama area have brought characters of social and productive change, with inevitable reflections on the identity image of the urban landscape and cities. The industrial adaptation and the infrastructure of the territory, to optimise resources and exchange flows, have profoundly influenced the arrangement of settlements along the route, as well as the formal reference systems of monuments at different scales: architectural, urban and landscape.

The historic center of Solikamsk bears witness to a complex building history, developed in each architecture within singular events of transformation. The ensemble consists of two cathedrals, a bell tower, two churches, and one chapel: they present different states of preservation, between abandonment and musealisation, which can be related to the historical documentation on the functional uses, landscape conformations, and formal characterizations undergone by the building apparatuses of each site.

The Cathedral of the Exaltation of the Holy Cross was built between 1698-1709 on the embankment of the Usolka River, but in 1741 a fire event caused its partial reconstruction<sup>1</sup>.

Industrial uses during the Soviet period - since 1929 it was also a brewery - caused invasive and destructive interventions in the building's interiors. The masonry structures were demolished, changing the planning and symbolic design of the building to accommodate industrial machinery structures. As a result, the distributional arrangement and the spatial perception of the religious environments were compromised.

By contrast, the outer wall envelope and its decorative brickwork apparatus remained almost intact, preserving the main volumes and the rich design of the facade decorations<sup>2</sup>. Even though the abandoned building is repeatedly affected by Usolka overflows and flooding, as well as a cyclical painting of the exterior, it preserves a monumental historical image in the urban landscape.

Side Page Fig. 01  
Solikamsk's bird view  
Aerial view of the historic core  
of the center of Solikamsk (2019)

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<sup>1</sup> During the city fires of 1741 and 1743 the cathedral was severely damaged and rebuilt at the expense of the Solikamsk merchant Surovtsev, with a profound variation of the original architectural and stylistic features. Cfr. E. N. Gontsov (eds.) (2011) Historical and architectural heritage of the Perm region: catalog-reference. Perm: Reykjavik Design Bureau, p. 210.

<sup>2</sup> The outer shell of the Cathedral features a rich decorative apparatus in the Russian Baroque style, with a composition of cornices, coupled columns and corbels with *sekirovidnymi* motifs that frame the fronts of the main block above. The platbands of the windows of the temple part are similar to the windows of the refectory. The upper part is framed to the full height with an arcature-columnar belt resting on bundles of hanging three-quarter columns. In the center of the southern and northern façades, there are large icon cases framed by columns with a *kokoshnik* decoration.



**Fig. 02**  
**A transforming landscape**  
Comparison between the photographic survey of the historic center of Solikamsk between the 20th century and 2019. The change in the surrounding urban asset is clearly visible.

**Next page Fig. 04**  
**Cathedral of the Exaltation of the Holy Cross and Church of the Epiphany**

General view of the architectural complexes and detail of the constructive and decorative apparatus of the windows. In the second one, the crack due to the structural assessment of the church is clearly visible.



**Fig. 03**  
**Historical photogallery**  
Gallery of historical pictures between the 19th and 20th century documenting the architectural development of the historic center of Solikamsk and the urban and social context of its monuments.

The Church of the Resurrection of Christ, or Voskresenskaya Church, was built between 1714-1752 as a five-domed temple with a central bell tower, for winter religious services. Due to later interventions, the domes were demolished, and the central body lowered, losing the stylistic features associated with the church type and its perception in the urban skyline. The site has undergone an altered cultural role within the Solikamsk ensemble, and today serves as an exhibition hall and local history museum.

The Bell tower of the Trinity Cathedral represents the most noticeable and symbolic monument of the Solikamsk ensemble. Built in 1713 starting from the basement block of the mercantile rooms, the bell tower features an octagonal plan body developed on three orders with kokoshnik exterior decorations. The formal structure has remained untouched during the cyclical transformations of the Old Town. Still, the monument is frequently affected by repainting according to different colour palettes, which characterise an incongruent perception in its chromatic relationship with the surrounding monuments and the landscape.

The Trinity Cathedral was built between 1684-1697 in the Moscow Baroque style<sup>3</sup>, envisaging from the original design a five-domed double-height body. The theme of the “gallery” distinguishes the stylistic design of the monument, repeating itself both three-dimensionally in the external porch of access and in the flat decoration developed on the facades of the main body, made with modules and profiles obtained through shaped bricks.

<sup>3</sup> The main church of Solikamsk was built on the model of the Kazan Church in the royal estate Kolomenskoye, near Moscow. The tsars John and Peter Alekseevich partially funded the construction of the cathedral and, in honour of this, the imperial crown was laid out on the cathedral.







Fig. 05

**Color palette analysis**

This study has been applied on the photographic documentation available on the Bell Tower from the 20th century, 2019 and 2020. It is clear the effect of restoration activities on the architectural and landscape perception of the urban context around the main building.

The Church of the Epiphany, built between 1687-1695, was planned with a five-domed double-nave body. The bell tower was added to the main front of the complex in the 18th century, with later intervention in the original design. The building addition caused a subsidence of the foundation structures, and during the Soviet period part of the new structure was removed, lowering the body of the bell tower to its present configuration. The rich exterior decoration consists of corbels, cornices, gables and platues of elementary geometric modules and kokoshnik, composed in multiple and unique solutions that frame the openings and fronts. Stylistically adherent to the main church, the Chapel of St. Peter and Paul is located on the perimeter of the site area. Today the church hosts the Museum of Old Russian Art.

**Solikamks: objectives and targets for an urban representation**

The process of analysis for the study of Solikamsk's urban context, treated as a unified documentation program on its monuments, started by identifying the main characters of urban image influence and variation, and the visual perception of architecture in the contemporary landscape.

Formal building geometries, shaping of urban space, and variation in their chromatic features emerged as the main aspects for evaluating the effectiveness of conservation and restoration strategies. The preservation of the cultural relationship between the history of the historic center and its management in the administration of the area is directly reflected in the perspectives of the attraction and enjoyment of visitor flows in Upper Kama.

In this sense, the “instant capture” of the image of urban landscape becomes central to the incessant dynamics of city transformation, and it values the integration of multi-source data to produce a reliable and comprehensive database as a basis for knowledge, analysis, and communication of diffuse heritage in the Cultural Heritage Route dimension.

The information contained in the historic center, which image turns out to be the result of multiple events over the years, constitutes a heterogeneous and complex data set of geometric and colourimetric nature, including compositional modules of the landscape.

The visual transformations of the urban system testify to the impacts of a social and economic nature as well as purely stylistic and formal changes. At the same time, these changes have obvious repercussions in the spatial conformation of sites, concerning urban infrastructure, road routes and the preservation of basins directly connected to waterways of the Kama network. Therefore, the visual documentation itself returns a complex landscape, reflecting a specific cultural identity defined through history and spread today within the contemporary pattern of expansion.

Documenting the formal qualities and relationship characters between monuments and urban compartments recalls the adoption of digital entities and virtual environments extended to both architectural and landscape dimensions to produce a catalogue of forms and patterns that condense the cultural and social narrative dimensions of place.

The goal for the digitization of the historic centre of Solikamsk is to compare forms and models to establish a network of information that qualifies the complex space, envisioning in the descriptive values aspects useful for the preservation, management, control and even development of the city in respect of its cultural heritage.

The database aims to define an associative structure between the image of urban form and the organisation of data in the digital database. It does not only reproduce the morphology of the context, by following the different instrumental applications, but intends to thematise the analysis of urban configuration as a projection of the image of the historic city into the future.

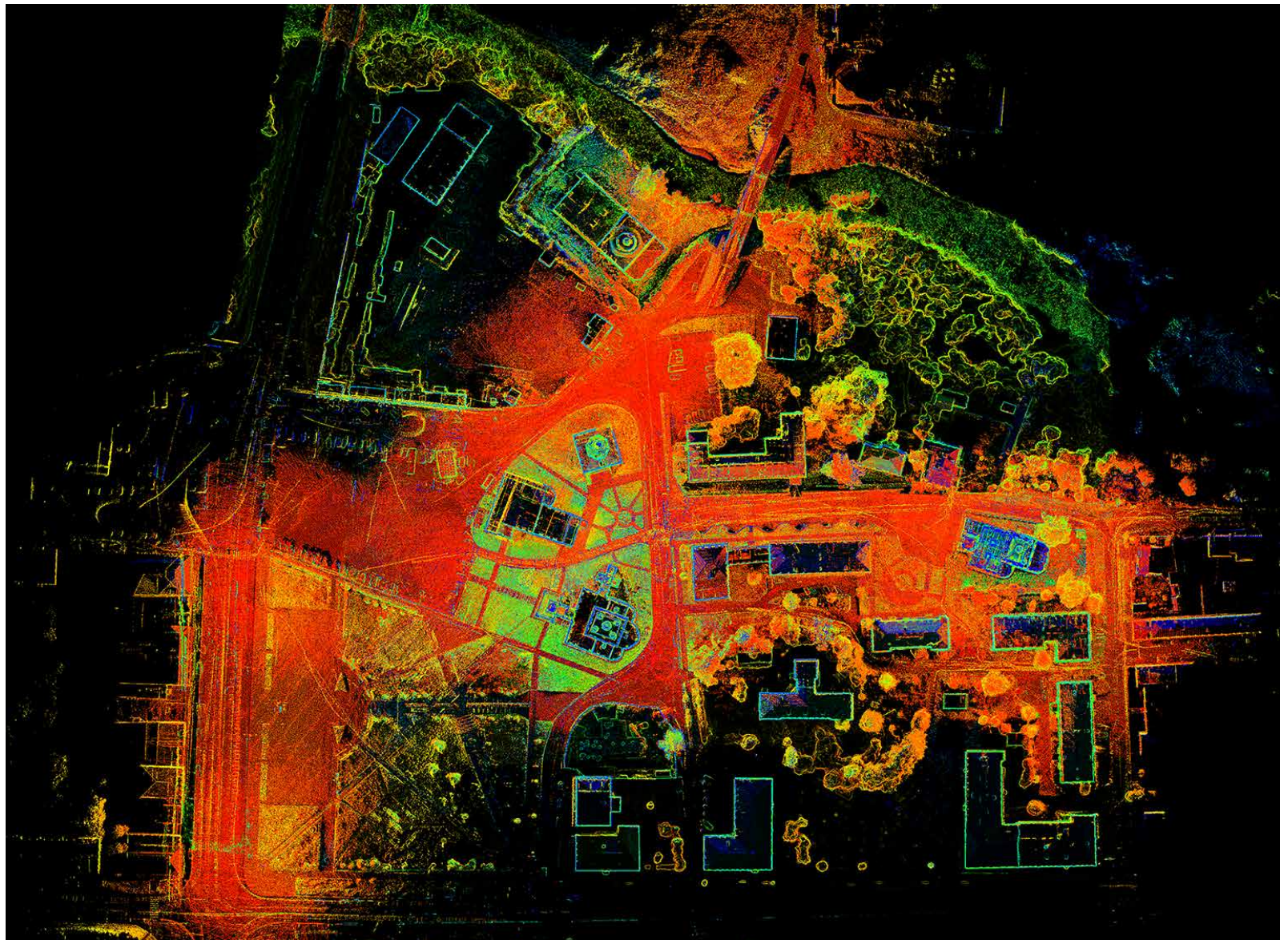
### **On-site documentation activities: ground scanning and aerial mapping systems**

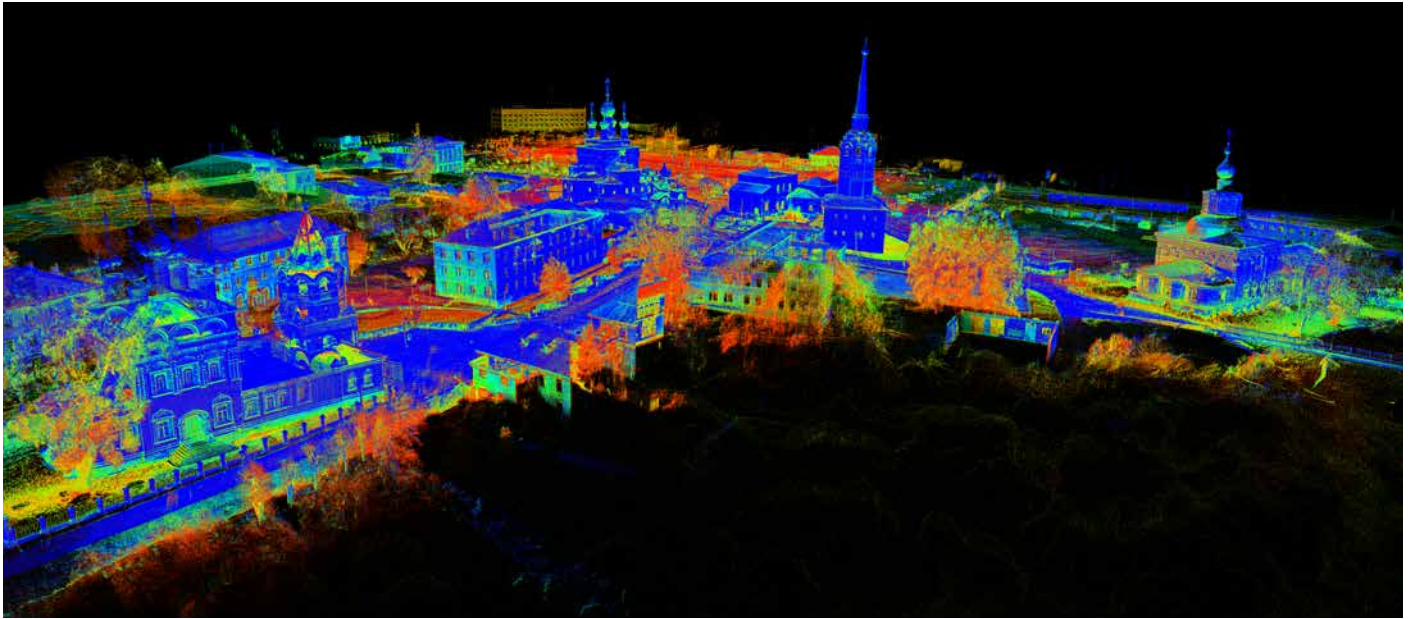
The morphological complexity of the area, combined with the need of a fast planning of the survey campaign<sup>4</sup>, led to the development of a rigorous acquisition strategy aimed at ensuring consistent and high metric quality of the architectural data. This approach enabled a comprehensive and homogeneous understanding of the surveyed space through the integration of multiple digital survey and mapping technologies, including TLS (Terrestrial Laser Scanner), MLS (Mobile Laser Scanner), and UAV (Unmanned Aerial Vehicle).

The TLS-based survey campaign required the adoption of a dual acquisition strategy. In addition to a *distributed* acquisition along polygonal paths parallel to secondary urban fronts, a *targeted* acquisition was carried out for significant elements of the urban landscape, namely the main monuments. Large overlap margins (5–50 m) were ensured between datasets, allowing the survey to be conducted over multiple days while maintaining accurate registration and a uniform metric reliability (1–2 cm) in the final point cloud. Targeted acquisitions focused on buildings of highest historical and architectural relevance, primarily identifiable within the religious architecture of the historic centre.

<sup>4</sup> Survey activities focused on testing fast survey strategies, following a strategy of documenting the route in a timeframe useful for data processing and intervention. In that regard, digital documentation of the Solikamsk ensemble was comprised of 4 days of fieldwork, during which operators conducted simultaneous multi-instrumental mapping of the area.

*Next page, Figs. 06-07*  
**Integration of LiDAR acquisition databases on the historic center of Solikamsk**  
 RGB point cloud from Terrestrial Laser Scanner and red-grade point cloud from Mobile Laser Scanner.





The use of closed polygonal trajectories to support TLS sensors during the acquisition phase, together with the predominant adoption of cloud-to-cloud registration methods in the post-processing phase, enabled effective error compensation without the need for ground control targets, thus facilitating the rapid execution of the survey. The metric accuracy and resolution of TLS data proved suitable for documentation purposes, supporting the analysis of architectural features from both geometric and chromatic perspectives<sup>5</sup>. These aspects are particularly relevant in the investigation of decorative elements on church façades, as well as in the mapping of decay phenomena and conservation conditions.

However, TLS acquisition presented some operational limitations. The duration of individual scans (3–8 minutes), combined with the time required for instrument repositioning (1–3 minutes), partially constrained the efficiency of rapid survey workflows.

Furthermore, TLS systems are limited in capturing inaccessible areas, such as elevated architectural components (roofs, domes, decorative elements) and densely vegetated zones, necessitating the integration of aerial photogrammetry.

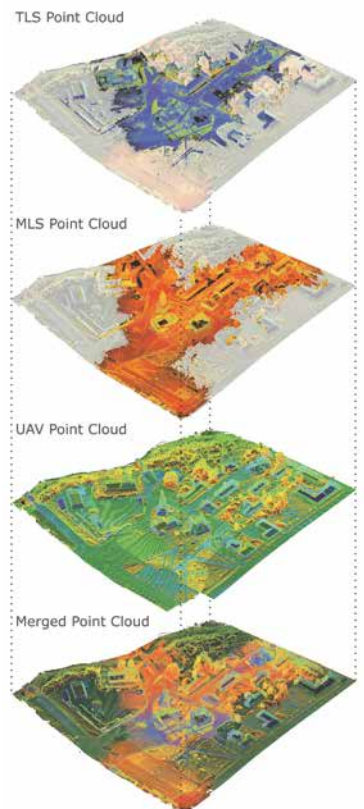
The SfM acquisition process was structured into multiple flight plans<sup>6</sup>. An initial phase involved planar mapping flights covering the entire urban area, providing a comprehensive overview of the site. The resulting data proved effective for large-scale spatial analysis, offering a coherent representation of landscape morphology enriched by colour information. However, due to the distance between the UAV and individual buildings, the morphological resolution of specific architectural elements remained limited.

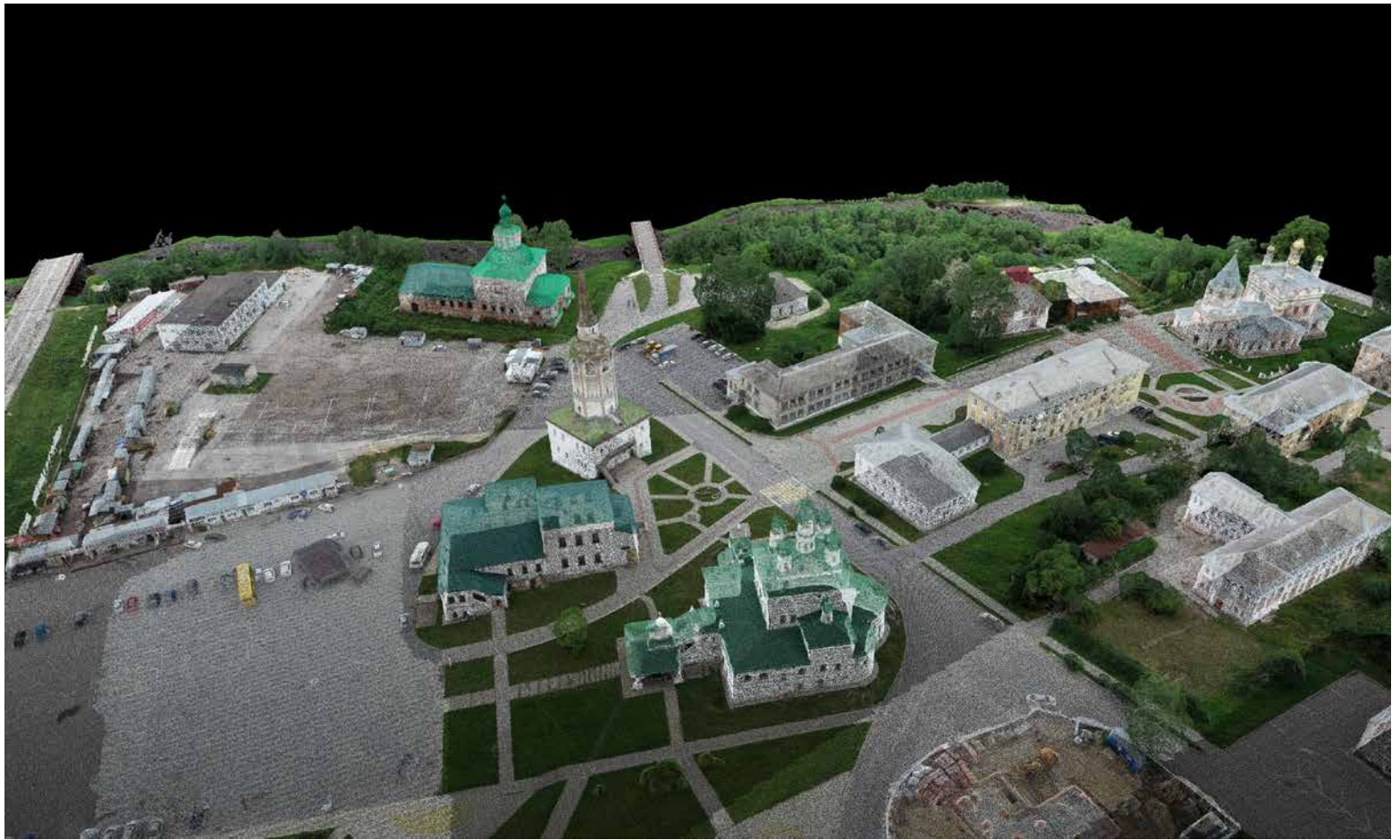
<sup>5</sup> The scans using TLS instrumentation were set up with colorimetric data capturing, this extends the acquisition time however allows for a better understanding of the elements and context.

<sup>6</sup> For each flight plan, it was chosen a favourable viewpoint to control the drone, in order to ensure complete and constant visibility, to be constantly in control over the drone's trajectory and to modify it in case of malfunction.

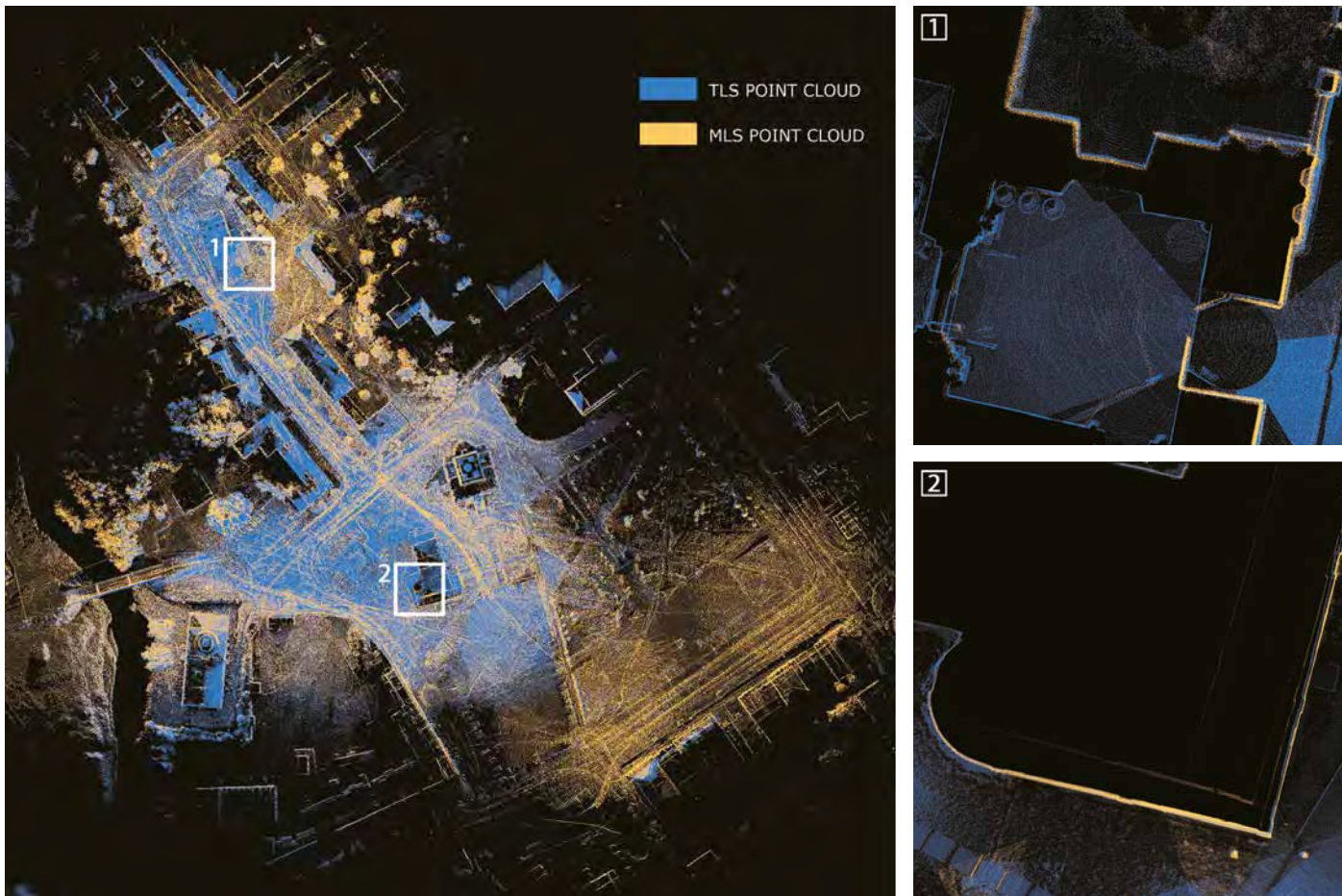


**Fig. 08**  
**Overlapping scheme**  
Integration and complementarity between the databases of point clouds acquired by multiple instrumental applications of digital survey.









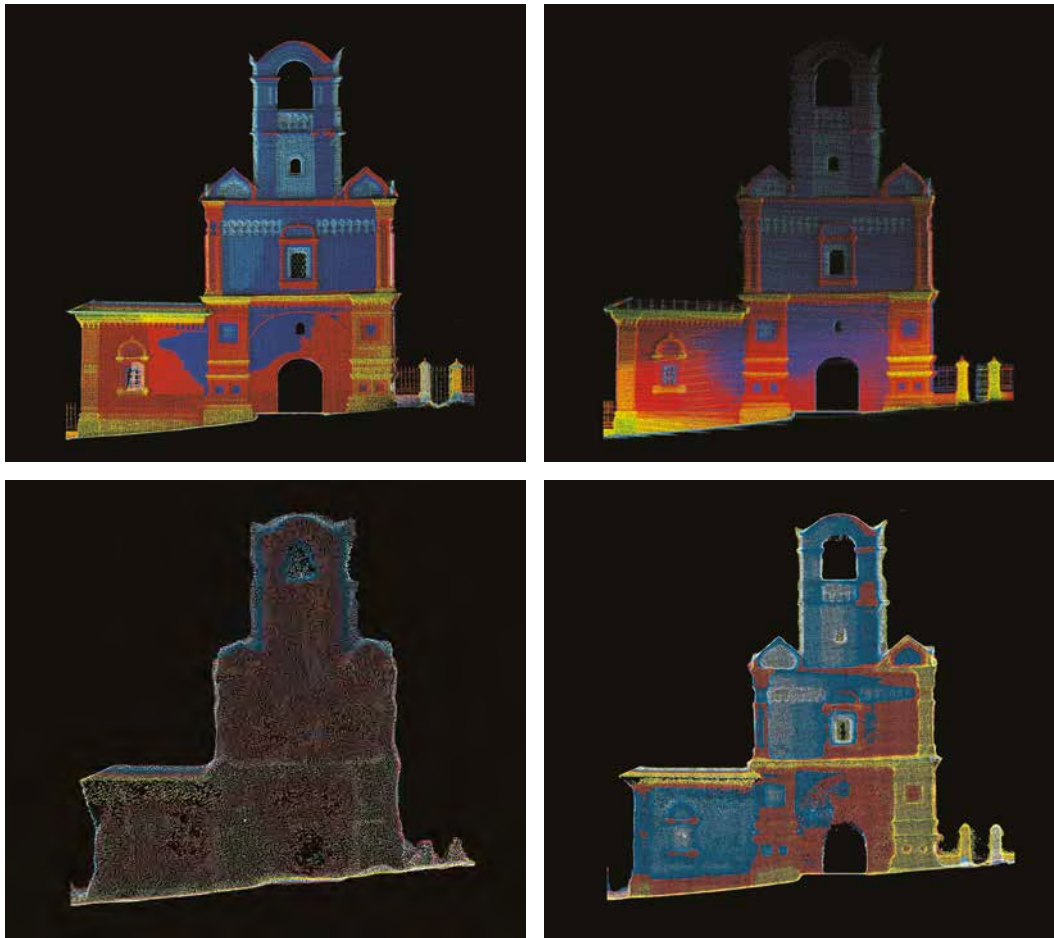
↑  
**Fig. 11**  
**TLS and MLS point clouds**  
 Overlapping and  
 complementarity between  
 TLS and MLS point clouds (left)  
 and morphometric comparison  
 of data obtained from the  
 measurement systems across  
 two specific sections of the  
 churches (right).

To address this, a second phase focused on detailed acquisition through point-of-interest-based flight plans. These involved concentric, multi-altitude trajectories around individual buildings, significantly improving the geometric definition and clarity of the resulting models.

The use of Mobile Laser Scanner (MLS) systems based on SLAM technology enabled rapid data acquisition over extensive areas. Each acquisition generated point cloud datasets within a radius of approximately 50 m, covering segments between 150 and 500 m along the operator's trajectory. Point density and resolution were influenced by movement speed and by the system's ability to recognise stable morphological features within the urban environment. The resulting datasets include reflectance-based colour information but may exhibit geometric distortions (e.g., drift or mirroring effects), requiring post-processing corrections.

### Processing of digital data and final 3D products

During post-processing, TLS and MLS datasets were aligned to produce two comparable 3D point clouds. This enabled a comparative evaluation of the morphometric data at both urban and territorial scales, allowing an overall assessment of the documentation quality achieved through the two acquisition systems. The data registration process from the TLS survey was carried out by using visual



matching systems based on cloud-to-cloud calculation algorithms, which allowed a registration match between data without the need of control targets. Monumental buildings, surveyed through closed polygonal scans, were processed as independent clusters (FARO Scene software) to ensure reliable cloud-to-cloud registration.

The integration of MLS datasets was carried out through the identification of homologous points within the urban morphology, which were subsequently used to merge TLS and MLS point clouds. Within the registration framework (Leica Cyclone software), these homologous targets were distributed to form a network of triangulated control geometries, ensuring a balanced and homogeneous error compensation across the dataset.<sup>7</sup>

The result is a point cloud with high metric reliability and resolution of the street level, whose missing portions of data are integrated with the aerial SfM data. The resulting integrated point cloud achieves high metric reliability and resolution at street level, while missing portions of data are supplemented through SfM photogrammetric acquisition. The photogrammetric point cloud was elaborated in Agisoft Metashape following image alignment and dense reconstruction processes.

<sup>7</sup> Due to the size of the area and in order to have as little overlapping error as possible, there were identified approximately 90 morphological targets.

↑  
**Fig. 12**  
**Comparison of point clouds**  
**quality adopting elevation**  
**maps**

The difference in resolution and geometric quality of the dataset is visible, considering the TLS density (above, left), the MLS vertical limit (above, right), the UAV resolution (below, left) and the terrestrial photogrammetric resolution (below, right).

The dataset was organised into separate chunks corresponding to the distributed survey and to targeted acquisitions on specific architectural elements; these were subsequently aligned and merged into a unified model. The resulting point cloud was then exported and aligned within a common coordinate framework derived from TLS data by identifying morphological reference points and assigning their coordinates accordingly.

Starting from the TLS point cloud, which was assumed as most reliable basis, a comparative analysis of the global data obtained from the union was developed.

The SfM-derived point cloud provides extensive coverage and high overall overlap; however, it exhibits geometric inaccuracies near building edges, where volumes tend to appear smoothed or rounded, reducing the fidelity of architectural representation.

The MLS-derived point cloud, while characterised by lower geometric resolution and the absence of true colour information, offers acceptable morphological readability and efficient spatial coverage, with deviations (3–10 cm) compared to TLS data.

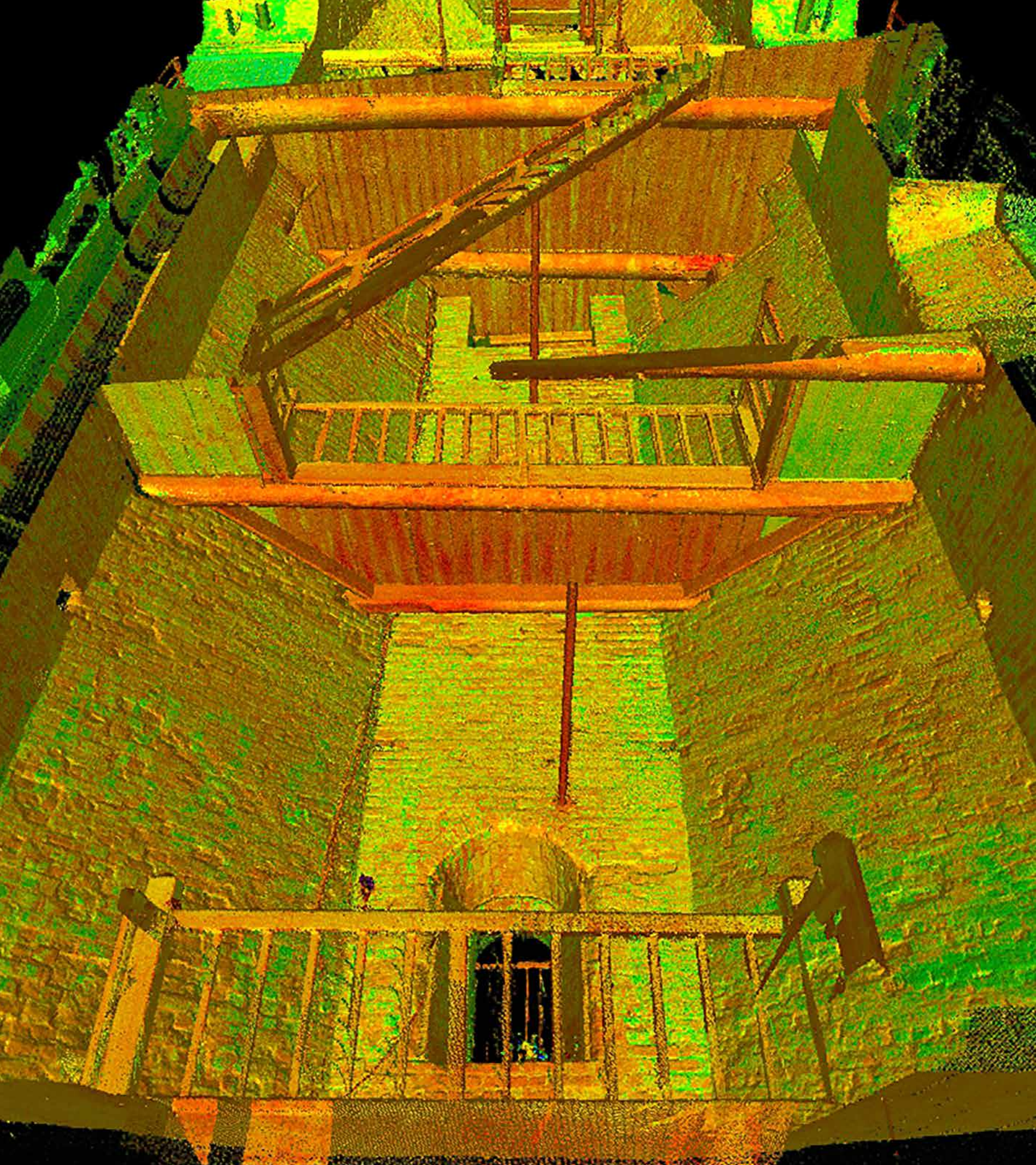
From a descriptive perspective, TLS data was prioritised for the representation of architectural morphology due to its superior resolution and metric precision. Conversely, SfM photogrammetry proved more effective at the urban and landscape scales, providing broader spatial coverage and enhanced colour information. MLS data, despite its lower precision, remains highly competitive in terms of acquisition speed, particularly for large-scale and time-sensitive survey scenarios.

The integrated dataset constitutes a comprehensive digital documentation system of the Solikamsk urban ensemble e from a morphometric perspective, supporting both detailed analysis of monumental architecture and broader investigations of urban structure, spatial organisation, and service networks.

The adoption of semi-automated semantic segmentation and annotation strategies further enables advanced interpretation of survey data, extending its application beyond conservation towards urban accessibility analysis and spatial redevelopment strategies within the framework of Cultural Heritage Routes.

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### Historical and architectural research

Crowned with a spire, the free-standing bell tower “on the chambers” - the octagon on the quadruple - was founded in 1713 as a common belfry for the Trinity Cathedral (summer) and Holy Cross Cathedral (winter). The construction was conducted with a part of the state funds allocated to the Trinity Cathedral by a royal decree.

The "chambers" on which the bell tower was located also belonged to the cathedral. The basement was used to store merchandise goods, the upper floors were occupied by city and county institutions, transferred here from old wooden buildings: the magistrate, the court, the school, the city council, and the spiritual government. In 1819 and 1726 the Doctor of Medicine D. G. Messerschmidt, who headed an expedition to Siberia on the instructions of Peter the Great, stopped here. In 1725 Vitus Bering clarified his further path through the Urals. In 1742 the famous historian of Siberia G.F. Miller studied the local archives here on the instructions of the Academy of Sciences. The bell tower building repeatedly suffered from fires but was restored every time.

In 1848, at the expense of the churchwarden Semen Patrushev, the restoration of the destroyed zakomars was carried out and the painting was resumed according to the old model (in the "Asian style"). In the late 19 century the colouring changed. In the middle of the 18th century on the south facade a two-story annexe was built on the basement, which was dismantled in the 1930s.

At the beginning of the 20th century in the southeast corner a buttress was erected. There was a quadruple on a sub-base passing to the floor by lowering the relief and windows with jumpers in the form of box arches placed in rectangular niches. Doorways are located on each floor: in the basement - on the eastern, northern and western facades; on the first floor - on the southern facade (two), eastern and western facades (the last two are not used – they are currently windows); on the second floor - on the south facade (two), the entrance is via an external wooden staircase.

The three-tier octagon is completed by the arcade of the ringing tier, passing into three tapering tiers of kokoshniks. Initially, the bell tower ended with a wooden chapter. After damage of the bell tower by a storm in 1836, in 1837 it was replaced by a high spire with a small dome.

In 1943, during a severe storm, a wooden spire collapsed. In 1957, it was reinstalled from metal structures (the restoration was authored by F. M. Tolziner). The octal ribs at the level of the 2nd and 3rd tiers are distinguished by half-columns with four reeds in the capitals.

*Side Page Fig. 01*  
**Bell Tower point cloud**  
An image of the 3D point cloud  
obtained by TLS instrument.



*Fig. 02*  
**Historical image of Solikamsk**  
 Solikamsk from a west view, the 80-ies of the XIX century, Holy Crosses Cathedral, the Cathedral bell tower, Church of the Resurrection, a prison, a district council.



*Fig. 03*  
**The Bell Tower**  
 View across the river Usolka, 1896.



In terms of the quadruple, the cross is divided into 4 equal sections communicating with each other; in the sub-base, each section is divided in half with a separate entrance and is blocked by a cylindrical arch. The tower design is original and has no direct analogues in Russian architecture. The classical “octagon on quadruple” scheme is not applicable here, since the diameter of the tower is significantly smaller than the size of the base. In Solikamsk, a much more complicated construction technique was used. The lower volume of the building is divided into four equal squares, powerful cruciform walls in terms of the plan, a vaulted room is arranged in each square. Above the arches, diagonal arches are arranged, on them, as well as on the cross-shaped walls, the tower is supported.

In the 1930s- 40s various organizations were located in the building: Usollag printing house, Glavmoloko (warehouse), match factory, Union of Polish patriots, potash factory archive, Solikamsk branch of the inter-trade (carpentry workshops), Gorpromkombinat (shoe workshop), etc. From the beginning of 1951 to 1987, the building was used by Perm special scientific and restoration production workshop for the office, housing and warehouses. By decision of the Solikamsk City Executive Committee in 1986, the bell tower was occupied by the Solikamsk Museum of Local History.

### **Digital Survey for Heritage Documentation and Religious Complex Analysis**

The documentation campaign conducted on the Trinity Church Bell Tower aimed to support the knowledge and enhancement of the artefact through the analysis of its compositional and morphometric characteristics. This cognitive phase benefited from the adoption of integrated digital surveying technologies for the documentation of historical-architectural heritage. These technologies, constantly



evolving, reinforce consolidated methodological approaches for conducting up-to-date surveys of the mensural, geometric, morphological, and material characteristics of existing heritage. These integrated survey procedures were carried out using TLS (Terrestrial Laser Scanning) instrumentation alongside Image-Based technologies for photogrammetric restitution.

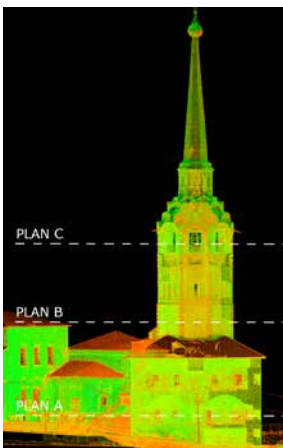
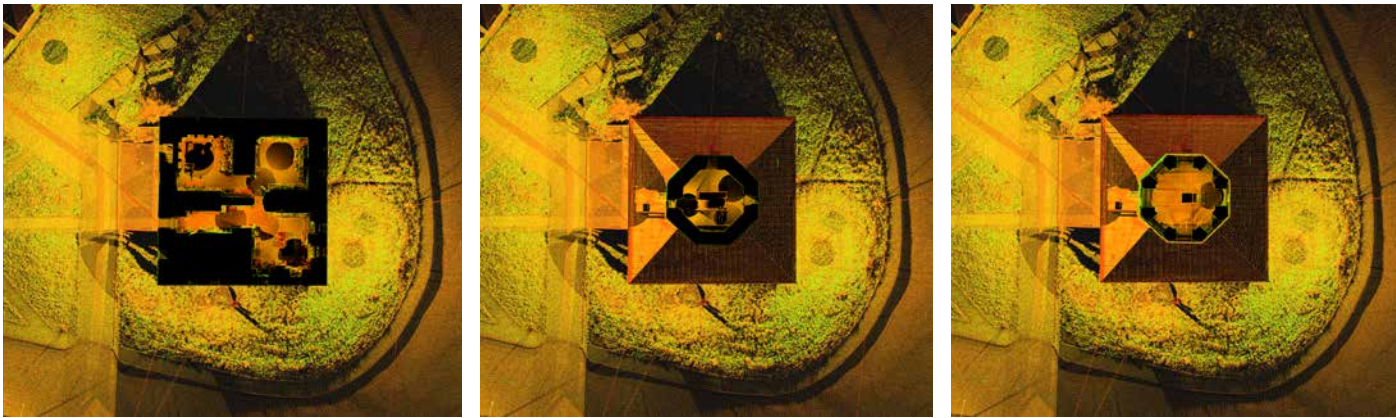
The initial phase of field operations was characterised by a visual survey, where drawing serves as an effective tool for representing the complexities of the bell tower's architecture and schematising the structure of the built environment, simplifying the planning of documentation activities. The comprehension of the structure was performed in preparation for the digital survey activities, developing a useful process for identifying possible challenges in achieving the expected goals and planning analytical systems to overcome these obstacles. The architectural object consists of a lower square-plan volume, articulated over three levels and composed of a system of interconnected rooms, surmounted by the octagonal bell tower structure. The bell tower connects to the lower volume through an opening at its base, accessible from the roof of the underlying structure.

To facilitate the digital survey activities, the building was subdivided morphologically into different spatial units: the octagonal bell tower and the lower quadrangular structure. This also allowed the organisation of the work into several phases divided by days. The TLS survey campaign, carried out using a Leica C10 laser scanner<sup>1</sup>, was planned by arranging acquisition stations along closed polygonal



**Fig. 04**  
**Pictures from the interior**  
 photographic images are fundamental documents of a survey campaign. On multilevel buildings, such as the bell tower, they help in the recording phase of laser scans and in data post-production for the discretization of the data.

<sup>1</sup> Specifically, the Leica ScanStation C10 laser scanner has the following specifications: scan rate up to 50,000 points/sec, maximum instantaneous rate; Range 300 meters; Field of view 360° on the horizontal and 270° on vertical; Accuracy of single measurement 6mm (position) and 4mm (distance).



↑  
**Fig. 05**  
**Cross-sections and plan view**  
 The articulation of the interior spaces of the lower volume and the development of the vertical connections of the bell tower can be appreciated. Below, a scheme of the section plans.

paths, starting from the upper portion of the bell tower and progressing down to the ground-level rooms, followed by the acquisition of the exterior façades. To ensure accurate alignment during post-processing, on-site targets of different types and sizes were employed, including 2D B/W targets, tilting targets, and spherical targets.

The TLS acquisition process began from the tower structure, consisting of several levels connected by wooden stairs with a single ramp. Starting from the top level of the bell structure and proceeding towards the lower floors, the scans were set up in such a way as to have sufficient data overlap (70–80%).

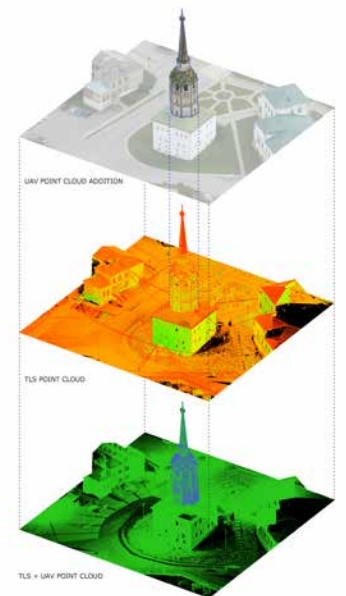
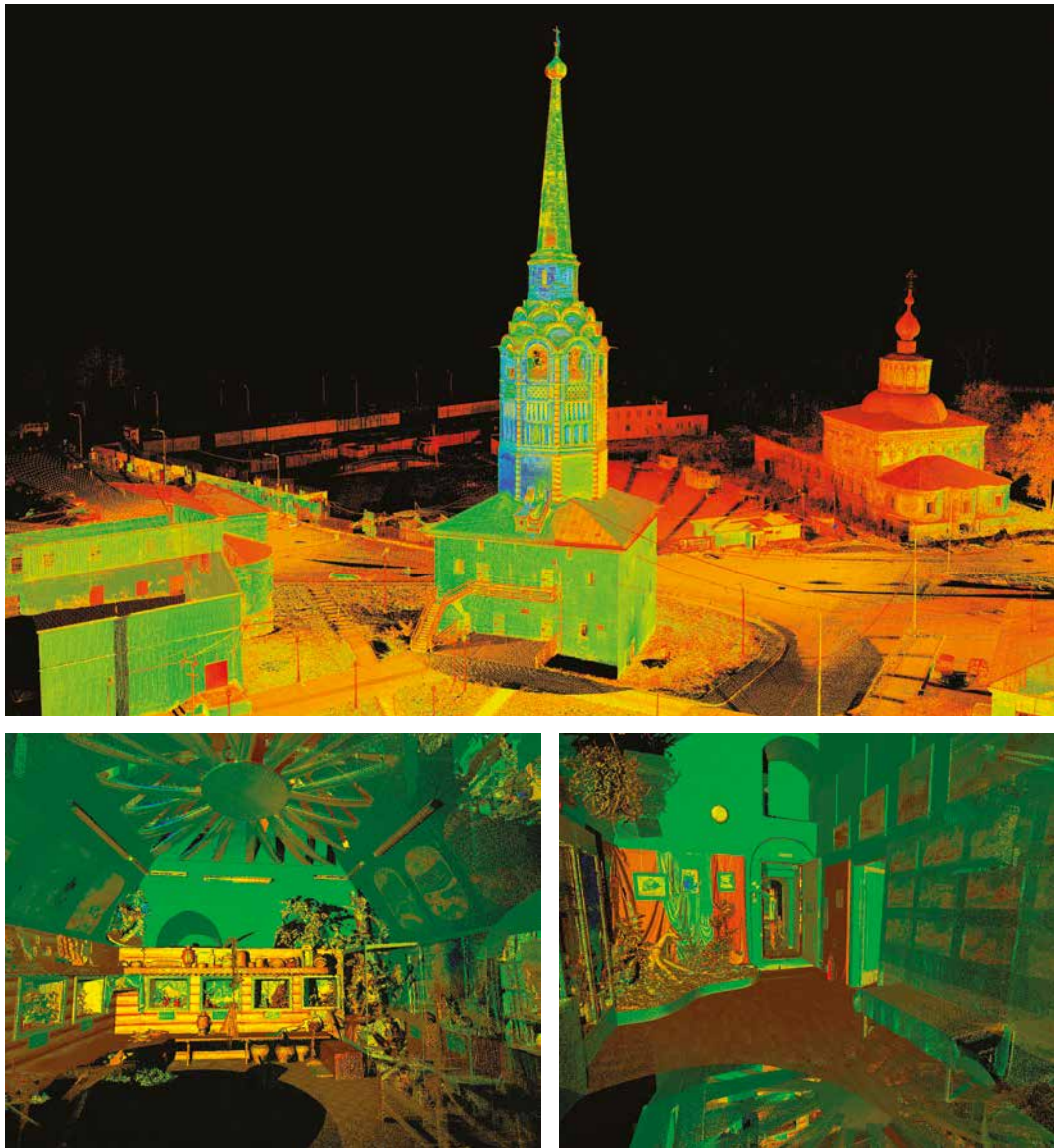
Three scans per floor were planned for the entire acquisition of each level, complemented by two additional stations positioned at the lower and upper ends of each stair ramp to ensure continuity between environments.

The acquisition of the interior spaces within the lower structure followed a similar top-down approach. Due to the morphological configuration of the building, access to the first floor, housing a museum, is at ground level. This level, as well as the one above, consists of four interconnected rooms. One of the main challenges encountered during data acquisition in these spaces was the presence of glass display cases<sup>2</sup>. This triple-height building is connected by a narrow and steep staircase, with a curved ramp in the final steps. This spatial conformation required several close-up scan stations and, consequently, an increase in the number of targets in the scene. On the ground floor, there are small independent rooms that do not allow for a single acquisition path and were surveyed individually. The use of tilting targets in this situation was effective as it allowed for common points between scans conducted inside the rooms and those performed outside. Due to their distance, it was not possible to apply 2D B/W targets on surrounding building façades.

In the last phase, the external part of the structure was acquired by planning stations and setting the instrument at a regular spacing along closed polygonal scan paths. For the exterior portions of the bell tower, a photogrammetric acquisition campaign was carried out using UAV instrumentation. The close-range photogrammetric acquisition was conducted with a DJI Phantom 4 Pro drone<sup>3</sup> and

<sup>2</sup> During acquisition, the instrument stores, for each detected point, not only the computed distance but also the reflectance value of the surface. Glass, by its very nature, has a low refractive index, which results in a low reflectance value, and this can create distortions and inaccuracies in the point cloud.


<sup>3</sup> DJI Phantom 4 Pro camera technical sheet: camera sensor: CMOS 1", pixel: 20M, focus: 8,8 mm/24 mm (format 35 mm) f/2.8.



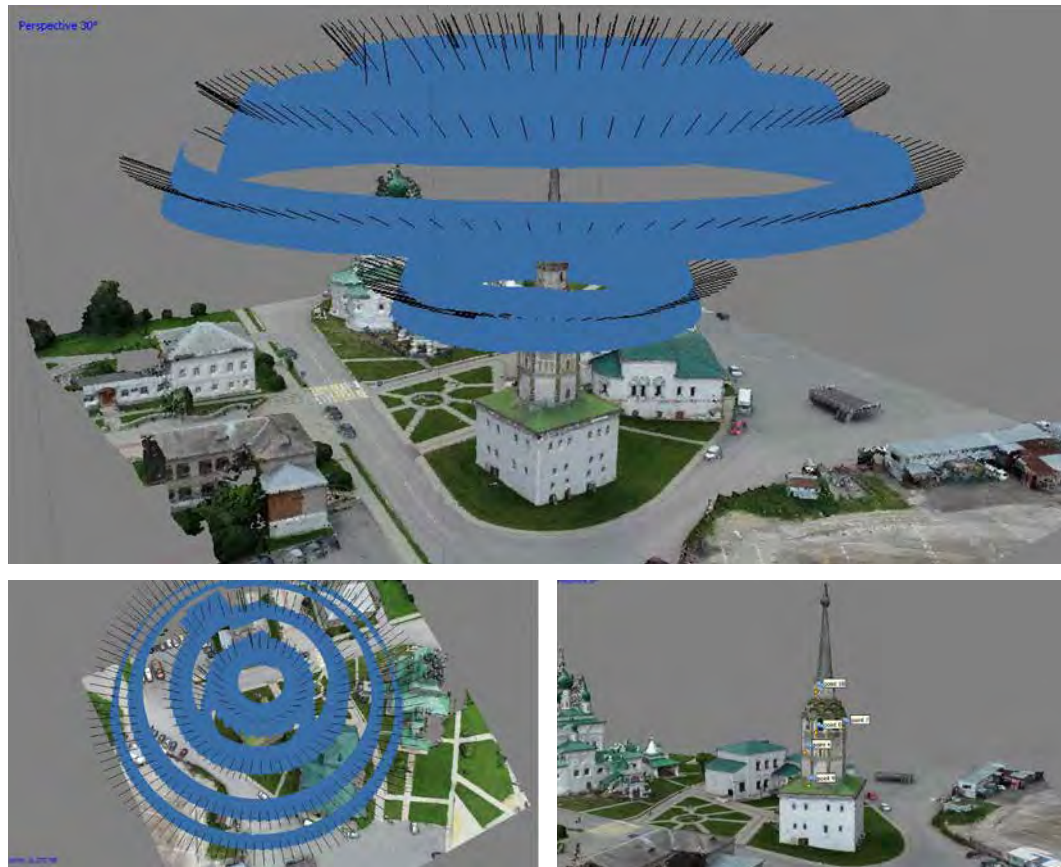
involved flight plans organised by points of interest, in which the documentation was performed with concentric trajectories set at different altitudes from the monument's position. The flight and shooting modes were planned to structure a 3D dataset to integrate the missing parts of the laser scanner point cloud<sup>4</sup>.

### Post-production process and digital restitution of the bell tower

The TLS data registration process ensured the validation and reliability of the dataset, supporting spatial analysis and the interpretation of the building's geometric complexity. During post-processing, individual scans were aligned by matching homologous targets using Leica Cyclone


**Figs. 06-07**  
**Multisource data integration**  
 Left, some images from the point cloud. Right, a schematic representation of the overlay and matching of data from TLS and UAV.

<sup>4</sup>The inability of the operator to reach and place scanning stations close to the decorative apparatus of belfry top structure required the integration of UAV data.

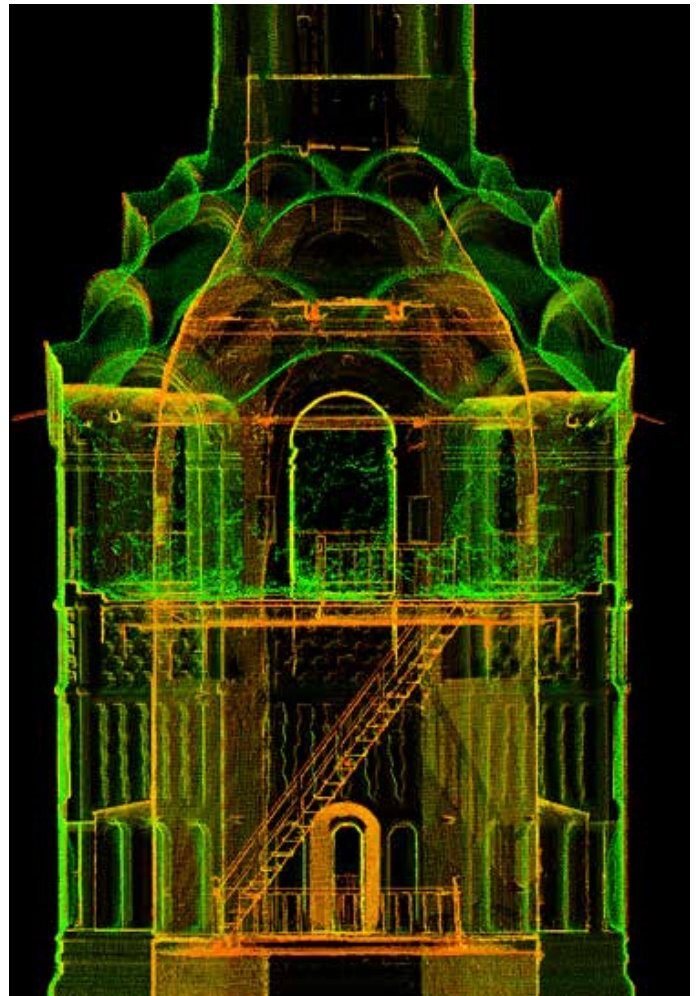
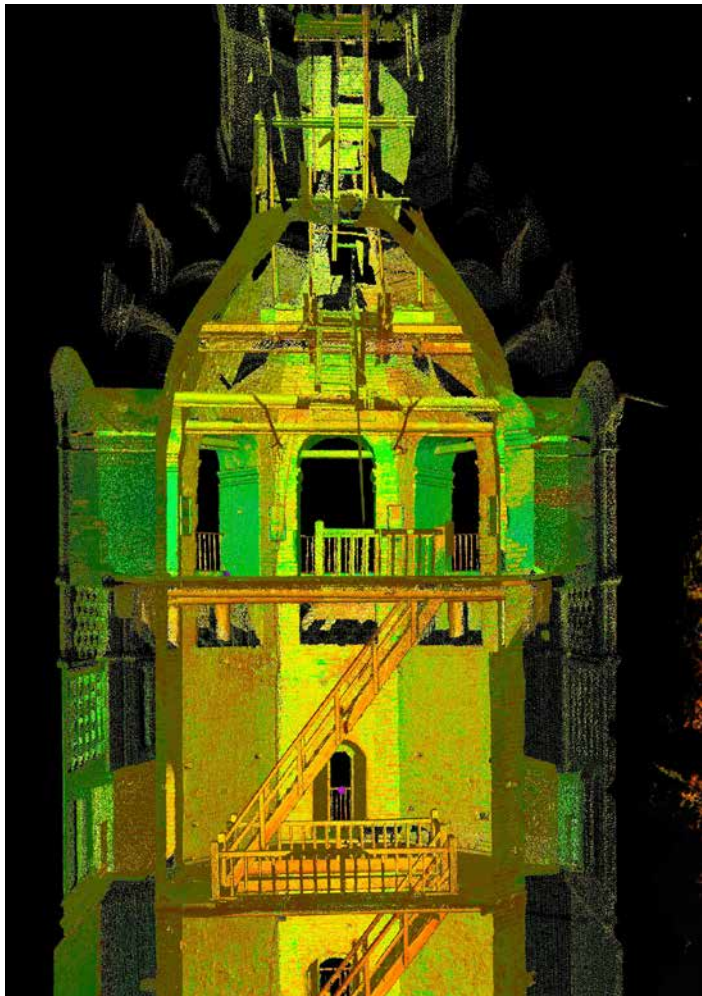


**Fig. 08**  
**UAV acquisition**  
Acquisition paths with UAV operated in circular flights with varying altitude around the building.

point cloud processing software. The registration process involved the creation of two separate scanworlds (exterior and interior) that were subsequently aligned by homologous points. The applied registration tolerance (1-2 mm) also set up the database for possible structural analysis, considering the lability and deformation of wall faces. The point cloud acquired with UAV instrumentation was processed through Agisoft Metashape software and referenced, also by homologous points, based on TLS data.

The overall post-processing workflow included the alignment of all datasets within a shared UCS, defined through common morphological reference points identified across TLS and UAV data. The TLS spatial data ensured accurate referencing and uniform metric reliability (1-2 cm) in the final point cloud. The UAV point cloud presented a metric variance of 2-3 cm compared with the TLS discrete surfaces. From the dense photogrammetric point cloud, only the upper portion, which corresponds to the roofs of the building, was exported, enabling the integration of the missing TLS parts. The result is a three-dimensional digital database that allows the understanding of the building in its entirety. It constitutes a knowledge base enabling multiple evaluations and applications across 2D technical documentation and 3D virtual environments, supporting restoration and renovation interventions at both the level of individual architectural elements and the building as a whole.

**Next page, Fig. 09**  
**Data integration**  
Overlay of UAV data on the TLS point cloud. Below, two images of interior-exterior facades with complete 3D data.



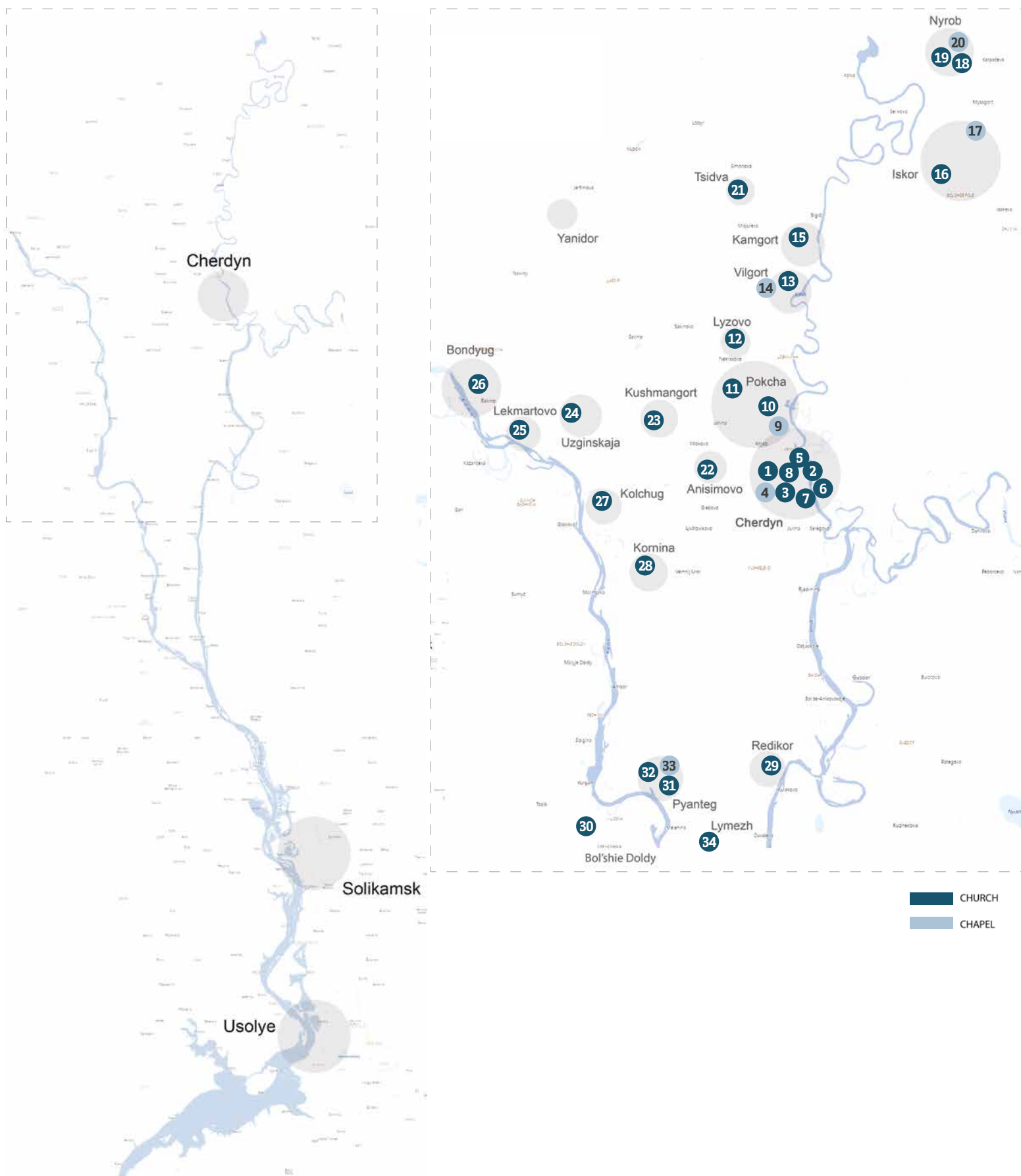
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**Cherdyn: Northern district  
and widespread heritage**



## List of Cherdyn monuments

- 1\_the Cathedral of the Resurrection of Christ Собор Воскресения Христова, Cherdyn. 60.402568, 56.486881, Date: 1754/1911 (bell tower).
- 2\_ Church of the Transfiguration of the Savior, Церковь Спаса Преображения, Cherdyn. 60.402213, 56.485953, Date: 1756.
- 3\_ Church of the assumption of the Blessed Virgin, Церковь Успения Пресвятой Богородицы, Cherdyn. 60.401119, 56.483726, Date: 1784.
- 4\_ Chapel of Savior, Часовня Спаса Нерукотворного Образа, Cherdyn. 60.400893, 56.485546, Date: 2005/2007.
- 5\_ Church of the Epiphany, Церковь Богоявления Господня, Cherdyn. 60.405512, 56.486237, Date: 1751.
- 6\_ Church of Elijah the Prophet, Церковь Илии Пророка из с. Бигичи, Cherdyn. 60.400074, 56.488443, Date: 2013.
- 7\_ Cherdynsky Monastery of St. John the Theologian. Church of St. John the Divine. Чердынский Иоанно-Богословский мужской монастырь. Церковь Иоанна Богослова, Cherdyn. 60.408365, 56.487836, Date: 1718.
- 8\_All Saints Church, Церковь Всех Святых, Cherdyn. 60.415974, 56.478334, Date: 1817.
- 9\_Chapel of the Kazan Icon of the Mother of God, Часовня Казанской иконы Божией Матери, Pokcha. 60.450044, 56.456964, Date: 1913.
- 10\_Church of the Annunciation of the Blessed Virgin, Церковь Благовещения Пресвятой Богородицы, Pokcha. 60.457602, 56.459678, Date: 1785. 1910.
- 11\_Paraskeva Friday Church, Церковь Параскевы Пятницы, Saltanovo. 60.490246, 56.364268, Date: 1838.
- 12\_Unknown Church, Неизвестная церковь, Lyzovo. 60.525806, 56.360115, Date: Unknown.
- 13\_ Church of the Trinity, Церковь Троицы Живоначальной, Vilgort. 60.564979, 56.467151, Date: 1779 - 1902.
- 14\_ Unknown Chapel, Неизвестная часовня, Vilgort. 60.557797, 56.462346, Date: Unknown.
- 15\_ Church of the Presentation of the Blessed Virgin, Церковь Введения во храм Пресвятой Богородицы, Kamgort. 60.580101, 56.494788, Date: 1915.
- 16\_ Church of the Nativity, Церковь Рождества Христова, Iskor. 60.65122, 56.705846, Date: 1793 - 1803.
- 17\_ Chapel Paraskeva Friday, Часовня Параскевы Пятницы, Iskor. 60.685922, 56.763524. Date: 1891.
- 18\_ Church of St. Nicholas, Церковь Николая Чудотворца, Nyrob. 60.734114, 56.720866, Date: 1704 - 1705.
- 19\_ Church of the Epiphany, Церковь Богоявления Господня, Cherdyn. 60.734395, 56.719579, Date: 1736.
- 20\_ Chapel of the Archangel Michael, Часовня Михаила Архангела, Nyrob. 60.402213, 56.485953, Date: 1756.
- 21\_ Church of St. Michael the Archangel, Церковь Михаила Архангела, Cydva. 60.620859, 56.391812, Date: 1771.
- 22\_ Church of Elijah the Prophet, Церковь Илии Пророка, Anisimovo. 60.423619, 56.342, Date: 1773.
- 23\_ Church of the Tikhvin Icon of the Mother of God, Церковь Тихвинской иконы Божией Матери, Kushmangort. 60.458855, 56.246781, Date: 1779.
- 24\_ Church of St. Nicholas, Церковь Николая Чудотворца, Uzhginskaya. 60.469357, 56.059371, Date: 1897.
- 25\_ Church of St. George, Церковь Георгия Победоносца, Lekmartovo. 60.460751, 56.032679, Date: 2013.
- 26\_ Church of the Exaltation of the Holy Cross, Церковь Воздвижения Креста Господня, Bondyug. 60.408365, 56.487836, Date: 1858.
- 27\_ Church of the Savior Miraculous Image, Церковь Спаса Нерукотворного Образа, Kolchug. 60.401773, 56.159105, Date: 1791.
- 28\_ Church of the Nativity, Церковь Рождества Христова, Kopino. 60.339837, 56.223179, Date: 1890.
- 29\_ Church of St. Nicholas, Церковь Николая Чудотворца, Redikor. 60.185911, 56.459771, Date: 1838.
- 30\_ Church of St. John the Baptist, Церковь Иоанна Предтечи, Bol'shie Doldy. 60.278354, 56.122674, Date: 1913.
- 31\_ Church of the Epiphany, Церковь Богоявления Господня, Pyanteg. 60.155226, 56.245, Date: 1612.
- 32\_ Church of Elijah the Prophet, Церковь Илии Пророка, Pyanteg. 60.155568, 56.251887, Date: 1768 - 1779.
- 33\_ Unknown Chapel, Неизвестная часовня, Pyanteg. 60.160853, 56.244764, Date: 1800 - 1900.
- 34\_ Church of the Savior, Limezh. 60.078801, 56.329908, Date: 1778.



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The first mentioning of Cherdyn is met in Vychegodsko-Vymskaya chronicle of 1451. Cherdyn was originated from the Troitsky hill where the Russians constructed the wooden fortress-kremlin.

Becoming the utmost north-east fortification (outpost) of Moscow State the settlement began to be built with the wooden fortress structures. In 1472 the construction of Kremlin started in Cherdyn. Namely this fortress was destined to become the first Kremlin in the Urals. Today it is known only the description of the wooden Kremlin of 1535 constructed under the direction of boyar Kurchev. That kremlin was built on the place of the previous one burned out in 1504. There were six towers (Spasskaya, Srednyaya, Knyazhaya, Glukhaya, Naugolnaya, over “the hiding place”), four gates, other buildings and a subway to the river. Due to the historical reconstruction the employees of PSNRU made three-dimensional model of this Kremlin in 2017-2018.

The perimeter of Cherdyn wall replicated the contour of the upper ground of the Troitsky hill which was the part of the coast rising over the level of Kolvs River up to 50 meters. The Kremlin had the form of trapezium extended from the west to the east and having the smaller eastern side.

Defensive quality of the fortress was enlarged by Pryamitsa ravine from the north, “Romanov bayarak” from the south and the bluff coast of Kolva from the east.

In the west there were no natural obstacles, so it was constructed the mound of earth the remains of which can be observed up to now.

Later the Trinity Church was built within the Kremlin. Firstly it was a wooden construction, later - the stone one. The wooden Church was burned in the fire while the stone one was destroyed in the Soviet times. Now the wooden church of Elijah the Prophet transported from the settlement Bigichi of Cherdyn region in 2012 has been placed instead of it.

In XV-XVI centuries there were two monasteries, 14 churches, the house of voivode, custom house and other buildings in this town.

Numerous fires destroyed the wooden architecture of Cherdyn. In the fire of 1638 all churches, 99 houses, 5 landless peasants' yards and all shops burned away. Reconstruction of the town was being made by carpenters. From the 18th century new stone mansions began to appear in Cherdyn. They formed the architectural image of the town: stone Church of St. John the Theologian (1704-1718), The Host Resurrection Cathedral (1750-1754), Church of the Epiphany (1751-1893), Church of the Transfiguration (1756, 1852), the Dormitory Church (1784), All Hallows Church (1817).

Side Page Fig. 01

### Bell Tower point cloud

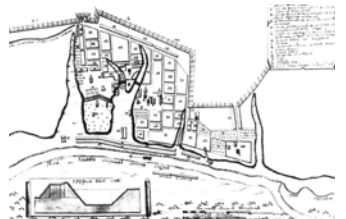
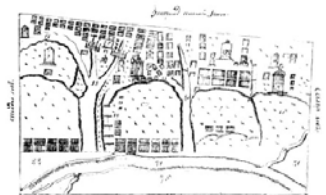
An image of the 3D point cloud obtained by TLS instrument.



Figs. 02-03-04

### Historical maps of development plan for Cherdyn

From the top, the plan of Cherdyn before 1792; a plan with the orography of the land; the original settlement compared to the 20th century city grid.





↑  
**Fig. 05**  
**Troitskoe Gorodoshche –**  
**Cherdyn**  
 Three-dimensional model of  
 Cherdyn Kremlin of 1624. Digital  
 reconstruction by PNRPU.

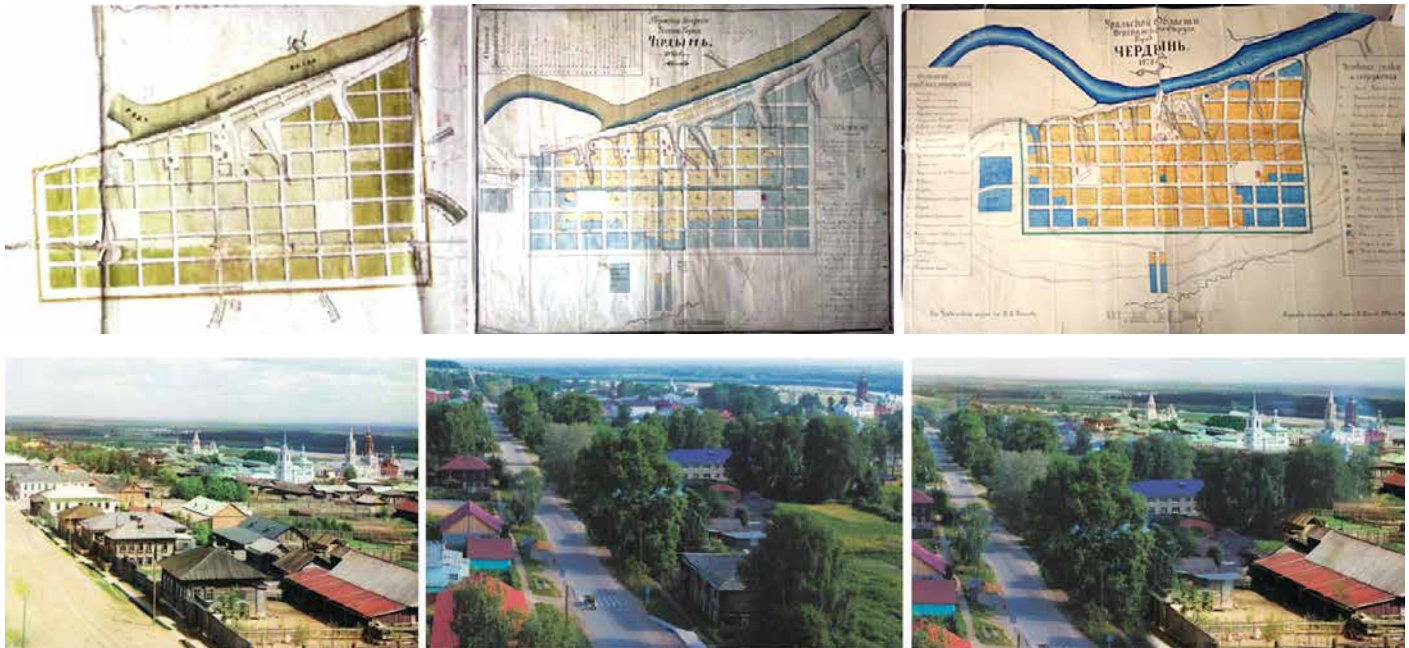
Considerable influence of the town planning was made by the fire of 1792 when the entire center burned out. Together with the wooden citizens' houses the fire swept away irregular squares of different size which were situated along the curved streets gravitated towards Kolva since the river was the basis of the citizens' well-being in that primeval place.

From 1792 in Cherdyn there were mainly constructed stone buildings and two-storied domestic houses. It was used the linear construction along the new streets according to the new geometrical planning of 1806 approved after the governmental decree of 1763 about the urban development plans for all provincial towns.

The modern urban area development of Cherdyn has preserved the planning features formed after the fire of 1792. The lack of fundamental planning changes was confirmed by the panoramic exposure of the well-known Russian photographer M. Prokudin-Gorsky made in 1913 and the photo from DJi Spark dron of 2018.

In the process of town examination in 2018 the modern photo and historical S.M. Prokudin-Gorsky's photos were overlapped. The photo of 2018 was succeeded making by DJiSpark drone, since the historical view which was photographed by Prokudin-Gorsky had been removed due to catastrophic condition of the water tower and destruction of the internal staircase.

As the modern photo shows the central part of Cherdyn has practically not been changed for 105 years in the architectural planning. It happened to a large extent due to the town remoteness and the status of historical settlement assigned in 1990. Architectural urban dominants were considerably modified by the reason of bell-towers destruction. In the picture of 1912 we see small town with the net of perpendicular streets built with two-storey wooden and stone houses. According to the words of V.V. Kostochkin, the architect and researcher of the Upper Kama architecture, "long-standing churches rise over them as the obelisks". The picture made from the bird's-eye-view confirms this fact.



Five churches and two chapels can be observed in the picture. All of them are located along the high bank of Kolva and have the uniform image in style. At that moment and today there were seven churches in the town: six of them – in the center and one – in the graveyard (All Hallows Church)<sup>1</sup>. In the right edge of the picture there is the Host Resurrection Cathedral. Its view has been formed for a long period of time. The main building of Cathedral was constructed in 1751-1754. In 1908-1911 (shortly before this picture was made) from the west side it was constructed a large additional building from the red brick – refectory \and a high bell-tower which now is the part and parcel of Cherdyn panoramas. At the beginning of the 1930s the Cathedrals was closed, but the building has preserved its appearance. For a long period of time it has been used as the cultural center. Several years ago the building was given back to the Russian Orthodox Church.

More to the left and slightly nearer is the Church of the Transfiguration covering partly the view of the Host Resurrection Cathedral. The Church was built in 1756. In 1853 it was added by two-storey porch with high bell-tower which changed the old ramshackle one. The Church was closed at the beginning of the 1930s. The crown of the main building has been completely destroyed (instead there is a gabled roof now). Bell-tower was finally destroyed at the beginning of the 1950s.

Against the background of the Church of the Transfiguration we can see the dome of the Savior Chapel constructed by the grave of 85 killed soldiers.

This historical and architectural monument was destroyed in the Soviet time but in 2005-2007 the Chapel was rebuilt. More to the left and more nearer is the Dormitory Church. It was constructed in



Fig. 06

#### Urban changes

Above, plans of Cherdyn (1828); below, View of Cherdyn from the water tower. 1910. Photo of S. Prokudin-Gorsky (source:[http://ps-spb2008.narod.ru/ur\\_cherdyn1.htm](http://ps-spb2008.narod.ru/ur_cherdyn1.htm))

<sup>1</sup> The Trinity Church is not seen in the right side of the shot. The Church was blown up in the Soviet time. In 2012 the local authorities decided to reconstruct the wooden Kremlin on the Troitsky Hill, so the Church would be wooden but not the stone as well. Supposedly, the Church of the Prophet Elijah (1913-1917) from Bigichi settlement is similar to the removed wooden church. Therefore, it has been transformed from Bigichi settlement to the Troitsky Hill and mounted over again in 2010-2012.



**Fig. 07**  
**Cherdyn settlement, historical**  
**houses and monumental**  
**churches**

Photo from the archive of  
 Cherdyn local history museum  
 by the name of A.S. Pushkin

1784 and later the bell-tower with spire was built on (In all known sources the bell-tower is dated to 1884, but this date seems to be questionable: the architecture of the bell-tower is similar to the Empire style of the first half of the 19th century).

Farther to the left it is seen the Epiphany Cathedral constructed in 1752 - 1761, with the bell-tower of the end of the 19th century. The placing of the side domes of the five-domed Cathedral is somehow unusual – not in the angles of the main cubic content but along the axes of elevation. The Cathedral finished his existence not later than 1930s. The dooms and the top tiers of the bell-tower have been destroyed. Today a bakery plant is located in this building.

In the picture the bottom part of the Epiphany Cathedral is covered by Gostiny Dvor (shopping arcade). The building was constructed in 1857 but its architecture is similar to the building traditions of the previous epoch of classicism. It is seen the arcade traditional for the Russian trade constructions. In the Soviet time the arcade was bricked up and now different shops and the House of Sport are situated in this building. Close to Gostiny Dvor there is a chapel surrounded by the greenery. Picturesque five-domed crown of the chapel is noticeable. This chapel was destroyed only in 2007.

And at last, more left and farther the Epiphany Cathedral we can see the top of one more Church – the Church of the St. John the Theologian (1704-1718). It is one of the first stone buildings in Prikamye. The Church has been preserved and works today. The appearance of two Churches – the



Host Resurrection Cathedral and the Church of the St. John the Theologian - is now similar to that imprinted by S. Prokudin-Gorsky in 1912. All the other churches require considerable reconstruction of their appearance with the aim to be included in the modern panorama of the town.

Monuments of cultic architecture suffered not only from fires and the Soviet antireligious policy but from continuous reconstructions by the Church, bureaucracy and local aristocracy. These reconstructions were explained by the fact that the attitude to churches was not the same as to the pieces of art but as to the houses of persistent divine service. It is interesting to mention the fact, as A.I.Makovetsky noted that churches have always been built in the place of the burnt or destroyed old ones. It is existed the hypothesis that initially there placed the pagan temples (pre-Christian religious buildings). In traditions of religious construction of Russia the order of the churches building was supported by the Russian regulations of 1551 (The Council of the Hundred Chapters of 1551), 1716 and 1826 (The Laws of the Russian Empire) and 1901 (Building Acts). Dynamics of the church development was represented in the following way: parish allocation, construction of chapel, further – of the wooden church, building of the stone church, development of church, development till the limited size, allocation of new parishes [E.P. Voznyak, E.S.Goryunov, S.V. Semetsov. Architecture of the Orthodox Churches by the example of churches of St.-Petersburg.



**Fig. 08**  
**View of the monumental complex from the river**  
 Historical image underlines the relations between the houses along the river and those at a higher level. The Cathedral of the Resurrection of Christ and the Church of the Transfiguration of the Savior appeared as landmarks from the top of the hill.



**Fig. 09**  
**A current image of Cherdyn**  
Drone image of the city towards the Cathedral of the Resurrection of Christ and the river landscape behind it.




**Fig. 10**  
**Cherdynsky Monastery of St. John the Theologian**  
the religious monument in an image from the early 1970s, on the left, and from 2017, on the right.

Today in the territory of Cherdyn the law of historical-cultural monuments conservation is being in force. The most valuable building from the point of view of the Russian state is the Church of the St. John the Theologian which has the Federal status, all the rest churches have the territorial status. The restored objects are not the official architectural monuments: the Chapel of Protection of the Blessed Virgin and the Chapel of the Holy Savior's image destroyed in the Soviet period of time.

Cherdyn is characterized not only by the objects of cultural heritage. From 104 guarded buildings there are 10 churches and chapels, 94 monuments of civil engineering construction. These are mainly the merchants' houses.






**Fig. 11**  
**A the Cathedral of the Resurrection of Christ**  
 Historical image and current, post-restoration image compared.

Every building has its individual architectural features, and this fact will make possible to compile the catalogue of unique details of civic buildings décor. These objects include stone, constructed partially of stone and wooden houses.

The heritage of Cherdyn involves not only well preserved historical planning and the number of the monuments of the past but the unique landscape and views. This is the City of Seven Hills on the high bank of Kolva (Taiga, Vyatsky, Troitsky, Voskresensky, Bogoyavlensky, Monastyrsky, Posadsky-Vsesvyatsky). The Hills separated from each other by coulees create the united rhythmical row repeated in architectural structures.

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Understanding an urban space or a complex territorial system depends on the implementation of several analytical activities that produce different phases. Each of these phases relies on the use of new digital technologies to produce descriptive outputs of a specific context, organized hierarchically across different levels of knowledge. It is important to emphasize that each new form of technology deployed is capable of configuring a specific digitalized scenario of that context, and that it will be the individual or public opinion itself that establishes the logic of understanding and codification of the space. The choice of technology is therefore extremely important in the process of building shared knowledge of a specific territory and in the creation of a descriptive system that can be implemented over time. The quantity and type of data produced in each phase and by each tool will be appropriately processed and managed to ensure that each output is transversal, breaking down the communication boundaries within which "representation" and the "documentation" process are typically confined.

To initiate descriptive processes for decoding Cherdyn's urban system using digital tools that approximate the mental images produced by sensory perceptual systems, photography was chosen. The complexities of the system were divided into levels of investigation, and photographic and photogrammetric survey campaigns were planned to describe the characteristics of the urban space.

The documentation of this site is of interest due to its historical and geographical importance in the Upper Kama. The aim is to clarify, through digital access systems, the presence of non-mental buildings and the settlement's structure as a nerve center of the history of urbanization along the Kolva River. Near the confluence with the Vischera River, the strategic settlement of Cherdyn controlled river passage in several directions: to the north, navigating the Kolva towards the Pechora Basin; to the south, navigating the Kama towards Moscow; and to the east, navigating the Vischera towards Siberia. Having become the administrative center of the Perm Krai following the fire that destroyed the village of Pokcha in 1535, its importance over the vast territory of the Perm Krai grew significantly, maintaining its leading role throughout the second half of the 16th century. The closure of the road to Siberia and the subsequent administrative shift from Cherdyn to Solikamsk at the end of the 17th century gradually slowed its construction and urban development.

Comparison with historical maps and city maps revealed the current layout of the streets and grids that make up the rectangular blocks of the historic center. The flatness of much of the settlement's surface and the lack of landmarks in the surrounding area make it difficult to understand the distances between

*Side Page Fig. 01*  
**Drone data acquisition**  
A view from the SfM software  
of a flight plan data acquisition  
above Cherdynsky Monastery of  
St. John the Theologian.



↑  
 Fig. 02  
 Top view of Cherdyn  
 monuments and urban  
 landscape.




the various buildings, often hidden behind tall trees. Walking through the village, the view is distorted by expanses that the eye can't see and by depth levels that aren't clearly delineated by the progression of buildings across the various depth levels. From above, this system appears much clearer, and the relationships between landscape elements are expressed in specific dimensional relationships thanks to panoramic images and descriptive videos from drone flights. These images and videos were created both to provide a general descriptive framework to highlight the general characteristics of the Cherdyn landscape, and to carry out a preliminary reconnaissance, an initial "survey from above", from which to understand the most favorable points for piloting the aircraft and the complexities and critical issues of the urban fabric, which cannot be understood from a ground survey.

These preliminary site surveys revealed the richness of the structures and organization of the agricultural space concealed behind the buildings that surround each block. Agricultural structures, sheds, or simply the network of green spaces and cultivated gardens characterize each block. Comprehensive



documentation of these structures is essential for updating the number and function of the existing structures, but also for building a database of the elements and relationships that define Cherdyn's urban landscape. These analyses of the blocks' internal structure will then be combined with those conducted on the monuments' surroundings, creating a heterogeneous system of information. Organized hierarchically, from the monumental-landscape scale to the specific scale, they will provide a framework for understanding and managing activities on the territory.

The preliminary flights also allowed us to plan the subdivision of the site and execute flight plans for different portions, which, once combined, will form a comprehensive point cloud of Cherdyn. Specifically, the drone photogrammetric acquisition activity focused on two portions of the Cherdyn area: the first included six of the blocks of the historic center; the second concerned the waterfront, including a series of monuments distributed along the road that runs alongside the river. The objective of both these systems was to analyze the 3D database to extract specific information on the conformation


**Fig. 03**  
**A construction of a digital Landscape**  
 From the top, the camera position of several drones flight plans conducted upon Cherdyn district. Below, from the point cloud to a digital modelling of the urban territory.



**Fig. 04**  
**Comparison of images from the Cathedral's bell tower**  
 On the left, an image from the early 1900s, on the right, the corresponding view of the current landscape, elaborated from the photogrammetric model obtained by a drone.

of the blocks and the relationship between public and private space (in the first case) and on the value of the relationship between the monuments and their context (in the second case).

For the first case, flight plans were produced for each of the analyzed blocks, carefully evaluating the camera's distance from the shooting surface at which the spatial details could be easily understood. Subsequently, the acquisition perimeter was prepared for each block, ensuring sufficient data overlap between them to allow for alignment in post-production. Specifically, the roads were considered as the block's perimeter boundary, taking care to also include the edge of the road forming part of the adjacent block's perimeter within each shooting set. For each block, the take-off and landing positions were carefully evaluated, a not particularly problematic aspect in uncrowded contexts such as these Upper Kama villages. For each block, the drone performed five paths at a constant altitude and with variable camera angles relative to the nadir axis, to obtain complete coverage of the four fronts of each building and the roof. Obviously, the constant elevation does not allow for close-up imaging of the building or detailed acquisition of the most hidden or hard-to-reach surfaces (the ground connection, some interstices, some details), but it does allow for a comprehensive point cloud capable of describing the general orientation and the macrosystems that constitute each block. The colorimetric aspect is also important for this type of investigation: non-uniform colors or structures constructed with materials inconsistent with traditional ones constitute critical points in preserving the landscape's identity. Often, when walking along the streets, these features are not immediately visible (because they are located on roofs or within the home's garden or vegetable patch). For this reason, monitoring and documentation from above can also aid in census procedures.

Regarding the landscape analysis of the Cherdyn waterfront, sections connecting the Church of Elijah the Prophet to the Monastery of St. John the Theologian were analyzed. These include monuments important to Cherdyn, as they defined the identity of the settlement and have served as landmarks for the community over the centuries. For this area, whose irregular shape lies on a significant slope from



the riverbank to the village, flight plans were prepared using the same methods and characteristics as those for the village, in order to obtain the conformation of the terrain and a general system of the analyzed portion. Furthermore, specific acquisition campaigns were conducted for each of the monuments present, organized by points of interest around the various complexes. These campaigns, involving variable elevations and multiple inclinations of the camera axis, allowed for greater coverage of the analyzed object. The individually generated models were subsequently merged, in the post-production phase, with the general model of the portion acquired with the flight plans, in order to produce a system differentiated by quantity and quality of information.

In this way, the digitization of the landscape allows for a hierarchical reading of the acquired elements, but also at different levels of detail: the building and its conformation can be examined down to a specific level of investigation, evaluating the multiplicity of aspects that contribute to defining its architectural value. The space in which it is immersed is deliberately left at a lower level of definition, since it itself represents, in its complexity, in its relationship between buildings and open space, the landscape value that must dialogue with that of the monument. The colorimetric database thus allows for a system manageable across various platforms and accessible at multiple levels of analysis, aimed at emphasizing the territorial connection of the scattered linear system of churches on the Cherdyn waterfront with the structure of the historic center.

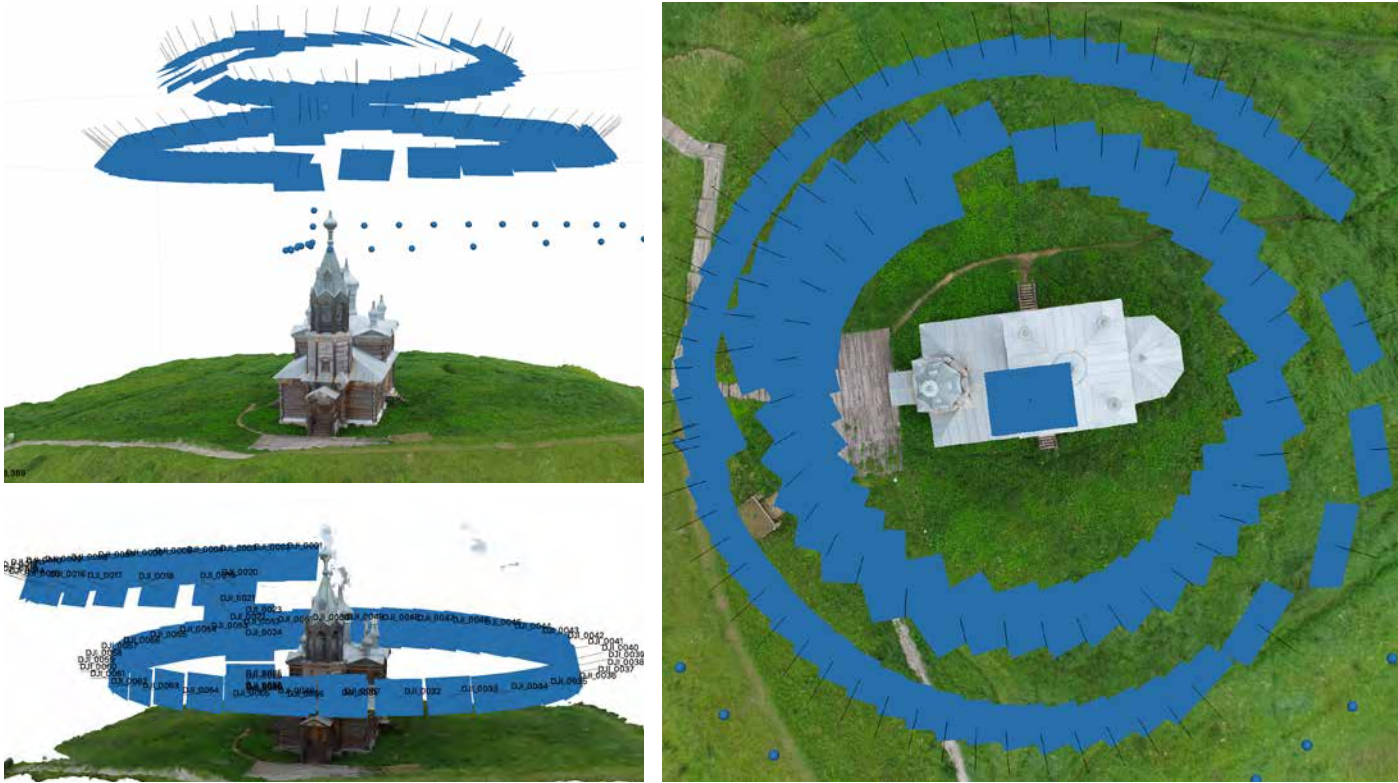


**Fig. 05**  
**Landscape representation by the model**  
The resulting photogrammetric model allows for the correlation of the terrain's orography, road networks, monuments, and monumental cores of the riverside system.



**Fig. 06**  
**Environmental sections**  
transverse and longitudinal (riverside) view of the photogrammetric model.





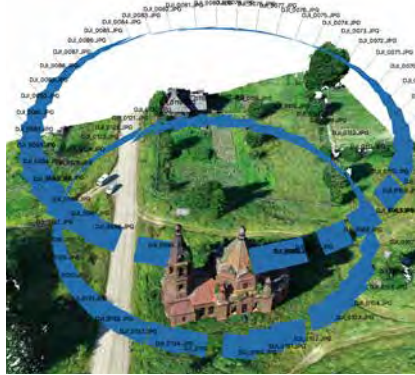
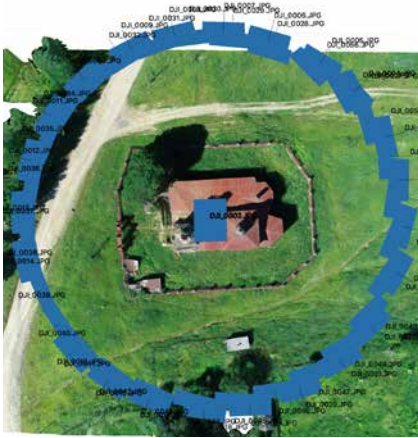
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**Fig. 07**  
**Points of interest**  
 Data acquisition in automatic flight mode, using a point of interest around a specific object. Above, different round circles for the complete acquisition of the Church of Elijah the Prophet.

→  
**Fig. 08**  
**Data acquisition of the Church of St. Nicholas, Myrob**  
 A view from the dense point cloud generated using SfM software data processing.

The two systems analyzed—the "urban" system of Cherdyn's historic center and the "landscape-monumental" system of the waterfront near the city's main monuments—can be analyzed individually, as parts of autonomous landscape systems, since they contain relationships established between each of the involved parties. However, they can also be interpreted as part of a larger system. The two databases, merged into a single database, allow for the analysis of the urban phenomenon as a whole, assessing the shift in scale from the diffuse, linear scale of city blocks to the vertical, episodic scale of the riverfront, and how this affects not only the perception of space but also the systems for its management, maintenance, and enhancement over time.



Next page, Fig. 09  
**Uavs for the definition of punctual database complexes**  
 All the monuments had been acquired thanks to a "point of interest" mode set on the drone. The goal is to obtain a better quality data of the building and then integrated these digital output with the general point cloud of the terrain.



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Due to the preserved planning structure and historical atmosphere Cherdyn represents special interest for investigation. Streets and planning of Cherdyn have changed a little since the 19th century, the golden age of the city. The structure of the regular plan of 1828 has kept the reticulation of the streets proportional to the scale of the town and built-up with the mansion houses.

Many stone buildings with expressive architecture and being not the religious objects have reserved here. There is a considerable still library of the town. So, on the base of collage technique buildings in their modern appearance could be supplemented with the lost architectural and ornamental elements. Cherdyn is the city of the Seven Hills on the banks of the river Kolva which makes the landscapes around the city even more picturesque. The task of the landscape-visual analysis is to reveal both the city architecture rich of historical details and its interaction with the interesting surrounding landscape, to find the best views of Polud and Vetlan mountains rising on the horizon.

In 2018 in the process of investigating Cherdyn it was made the first stages of the landscape-visual analysis, namely the determination of specific points in the central part of the city. There were find the views “saturated” with historical architecture and landscapes interesting for pedestrian routes development. The connection of the center with the river was studied as well.

As it has historically formed Yurganovskaya and Uspenskaya are the main streets of the city. At the beginning of the 19th century there was the market place in Uspenskaya Street which made it the most active. Nowadays the importance of Urganovskaya Street is growing since the municipal administrative institutions are situated here. So, its improvement is made at the expense of municipal funds.

Methodology and tools of the landscape-visual analysis applied in the research of the central part of the city were similar to those described in other case studies of this research project.

### **Analysis of the planning structure and typology of development**

The analysis of the real land use has shown that in the center there are undeveloped sites appeared as a result of modification of the estates' limits. Due to such modification the integrity of the planning structure was lost.

The destroyed reticulation inside the square is obviously leads to the worsening of architecture and landscape perception. In the central part of the city 1-2 storied stone buildings for public, cultural, trade and residential needs are situated. The analysis of the central part development typology made

*Side Page Fig. 01*

#### **Cherdyn urban settlement**

A view above the main access road that divides the monumental area that overlooks the river, from the grid of the urban fabric.

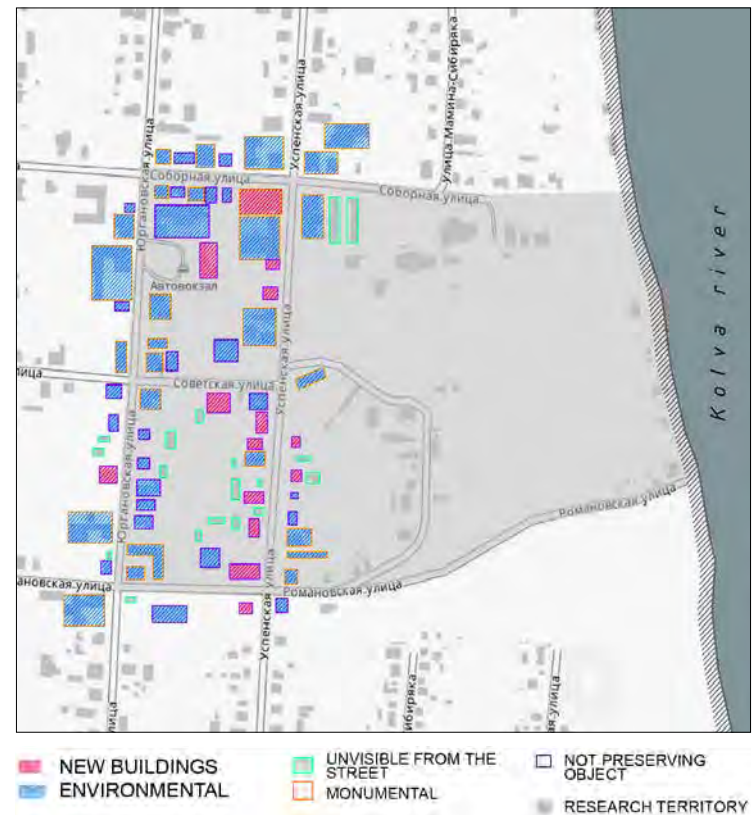
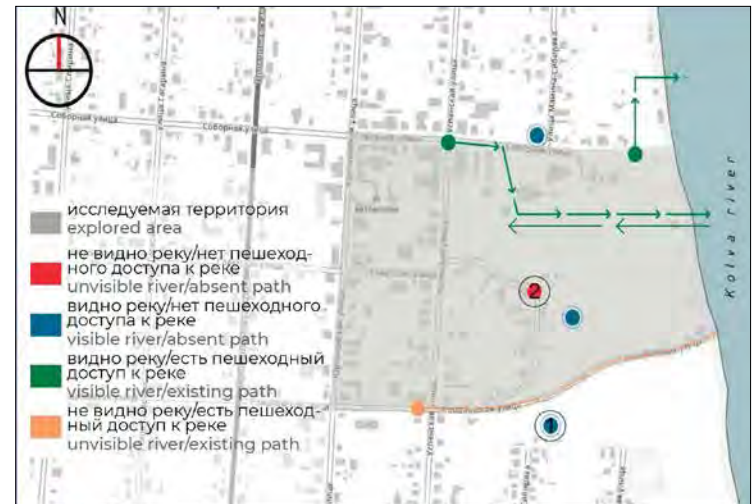
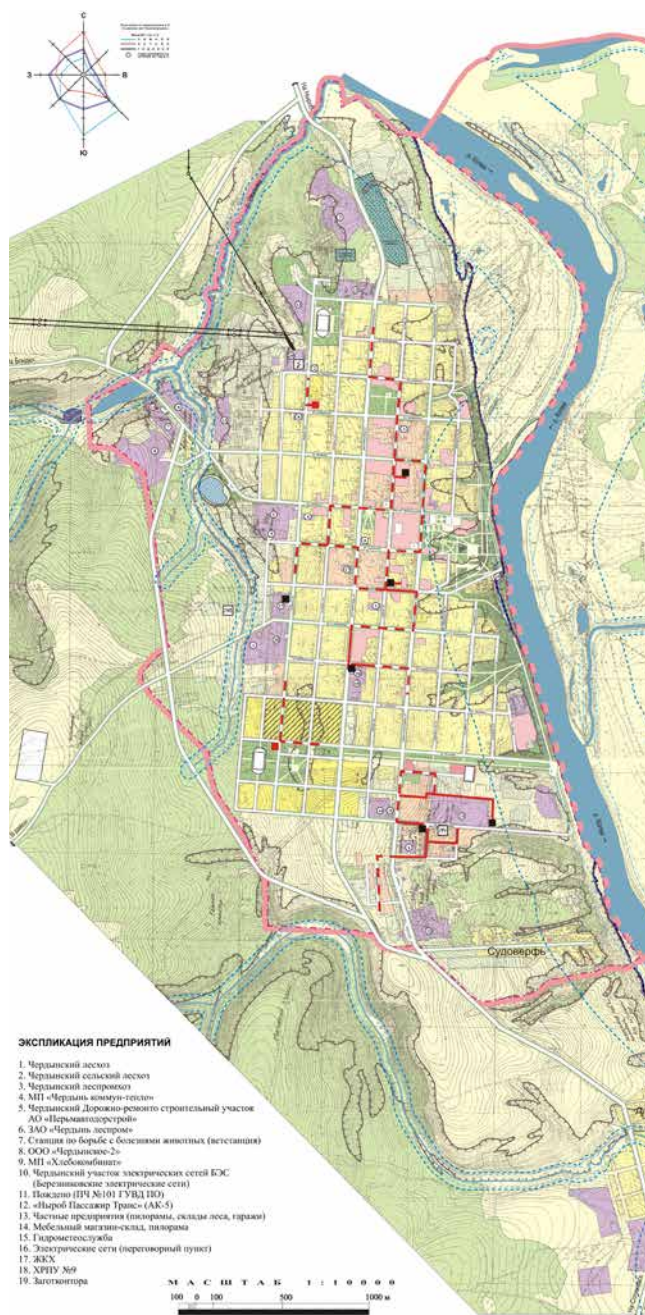


**Fig. 02**  
**Matched collages of the modern and historical photos**  
 The superimposition of portions of buildings in historical images with those of the same buildings in current images serves to emphasize characteristics that remain in the urban landscape, landscape invariants that contribute to maintaining the identity of the place.

possible to single out nine typical buildings different in material, arrangement of the main entrance, position of the yard: wooden, stone, combined stone-wooden, single-family houses, etc. Typology of buildings is shown in the figures.

In the process of the landscape-visual analysis these buildings were classified according their composition place in the environment: town-planning and local dominants, environmental objects, objects with architectural (silhouette, plastic and coloring) accents.

In the process of visual analysis it was mentioned the screaming collision of the modern urban design



and historical environment. Location of uncoordinated in style advertising and chaotically spaced signboards on the panes of buildings is typical for Cherdyn as for the other provincial towns of Russia. They prevent from perception of definite buildings and of the street in whole, disturb the rhythm and scale of ornamental elements creating visual noise.

The examples presented show the easiness of historical context disturbance by the signboards. But at the same time they make possible to understand how the municipal regulation of the urban design can easily and quickly assist the renewal of small historical towns' authenticity.

**Fig. 03**  
**The maps with the real land and blocks use**  
Above on the right, the block in the limits of Urganovskaya, Sovetskaya, Uspenskaya, Romanovskaya streets. Below, Distribution of buildings according to the composition place in urban environment.



↑

**Fig. 04**  
**Buildings typologies in Cherdyn**  
 Brick buildings for stately homes alternate with wooden or mixed wood-brick structures for residential spaces. Both solutions feature notable decorative features.

**Analysis of specific points**

Cherdyn is remarkable for the landscapes and picturesque views which together with its architecture create the unique atmosphere of the place. The most “saturated” viewing areas are based on the hills raised over the Colva River. However, pedestrian infrastructure providing the accessibility of specific viewing points is absent. Neither the River nor the landscapes can be seen already from Uspenskaya street which the nearest to the River and is parallel to it.

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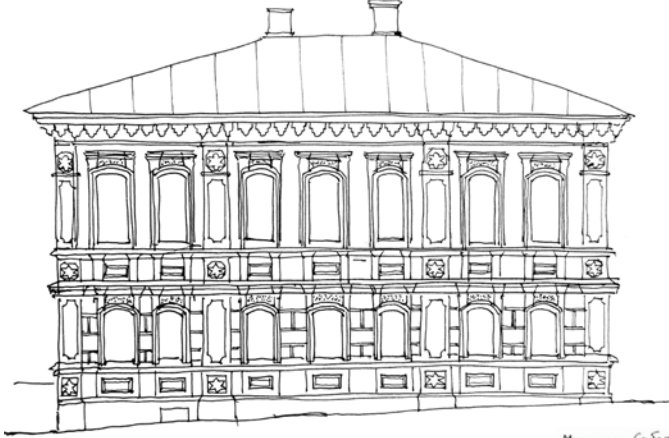
**Fig. 05**  
**Historical context disturbance by the signboards**



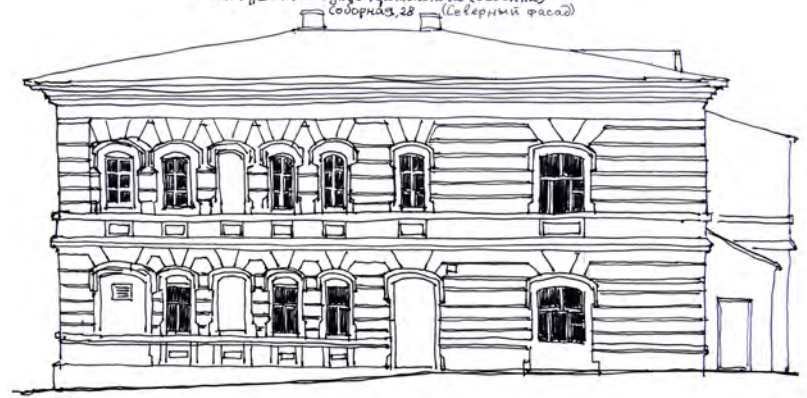
*Next page Fig. 06*  
**explanation of the construction and technological characteristics of the fronts**  
 hand-drawn sketches of the main street fronts, in which the material and decorative apparatus present are highlighted. (Drawings credit: Alexey Leybchik)



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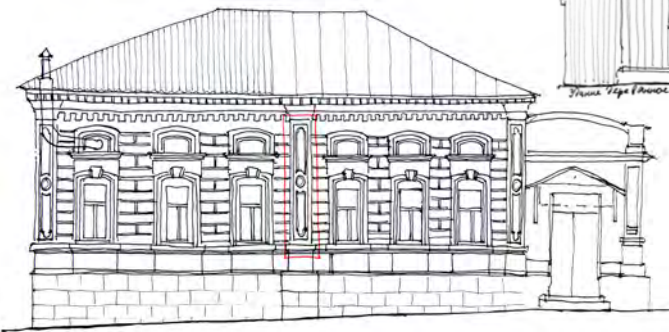
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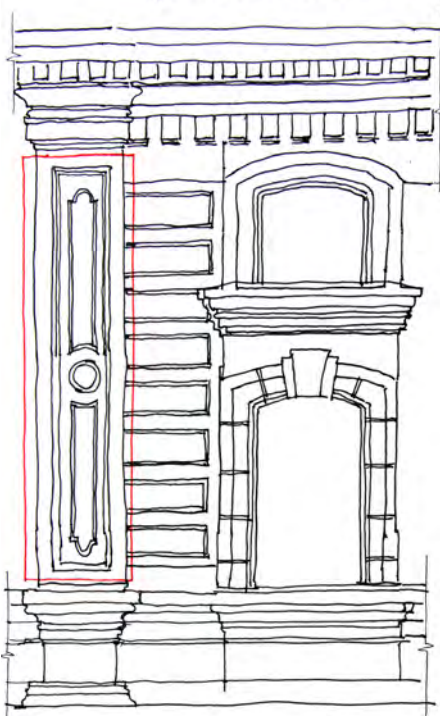


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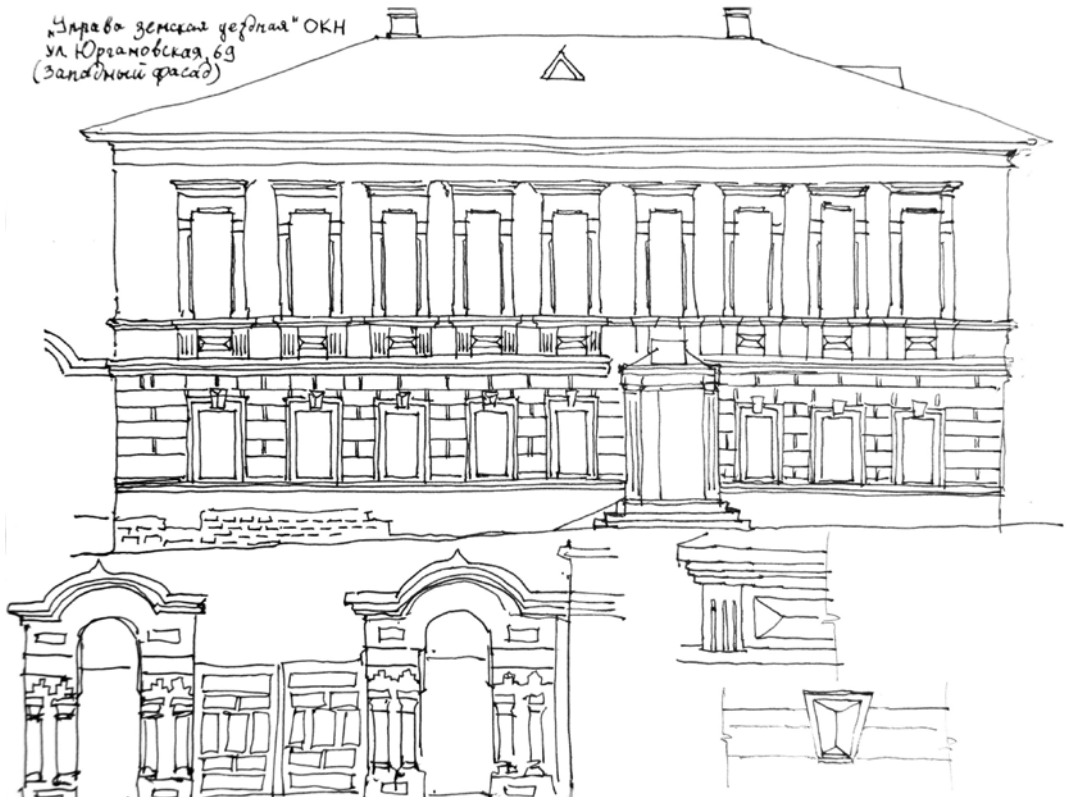
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### Analysis of coastal territories

The bond with the River is described by visual and physical connectivity. Visual bond means that we can observe and see the River from the definite points; physical one means that we can come to the river and even touch it.

As for the most cities of Verkhnekamye the connection of Cherdyn with the River was very important during a hundred of years. The river was a trade route and the life of citizens went by the bank of the River. Many buildings of Cherdyn were situated on the bank between Troitsky and Vsesvyatsky hills. There was a straight road from the river upwards the rest part of the city. The road was called “pyamitsa”. It has been kept safe and today it connects “Staraya pristan” hotel and residential zone on the hills.

Visual and physical bonds are present in the central part of the town with the River. It is obvious that the access to the River is limited; however, there are many places with visual connectivity.

The important result of the landscape-visual analysis is the obtained Atlas of ornamentation of the central part of the city. Ornamental elements reflect the architectural style of Cherdyn buildings and allow investigating the technique of the local architectural forms’ production and the ways of their interaction with architectural traditions and life of that time.

In whole, the initial stage of the landscape-visual analysis has demonstrated the inseparable connection of Cherdyn’s architecture and nature which is now unappreciated. Further landscape-visual research will be directed to the transformation of the urban environment and renewing of the tourist routes which make possible to estimate this unique interaction to the full extent.



**Fig. 07**  
**The monumental area of Cherdyn, always connected with Kolva river**  
View of the hill where the Church of Elijah the Prophet (2013) has been built.



### Territorial descriptors and census methodology

Cherdyn region has an unique territorial descriptors. A town which is the capital of the region has population 4687 people and saturated history since 1451. In fact, Cherdyn looks like an encrypted message understood by everyone in their own way.

Town territory has a heterogeneous planning structure with run-down areas and wasteland. Bird's-eye view of town center like a compact grid with good connectivity, worth noting the relief features and set of potential view points. If we pay attention to the historical plans of XVIII-XIX we'll see that it isn't deformed into quarterly grid, but changes in the structure of intra-quarter development are noticeable. Due to these transformations, the urban planner faces a dilemma - is the modern urban structure fulfilling the necessary social functions? Have urban senses survived in the interweaving of streets and squares?

Thus, architectural and urban studies became for us as researchers inseparable from social studies. First method we use was the cognitive mapping of the town territory by K. Lynch's methodology. Mental maps are provoked documents allowing to learn the experience of the city through informants. In essence, this is a standalone visualized empirical material which captures the way people think about the area. Mental maps in our study drawn by the locals and fixed their lovely walking routes, best places for enjoying city views, must-see attractions for tourists.

An analysis of these material allowed us to determine "key planning mistakes" in modern city structure. First "mistake" is the urban planning neglect of the historical streets and squares status. Nowadays local government unilaterally granted the main street status to Yurganovskaya street. Here are the municipal offices, elk monument as a symbol of the city, sports institutions, bus station, tourist signs, information boards. In accordance with the mapping results of citizens, this street has the status of "unnamed path." None of the 10 respondents indicated the name of the street in the figures and in the oral comments to them.

We were especially interested in the phenomenon of landmarks and city symbols substitution. Thus, the symbol of the city - the elk, depicted on the monument, corresponds to the accepted brand of the city. The development of the brand was carried out by order of the Government of the Perm Territory. It was a decision that fully complied with the policy of higher authorities, but didn't correspond to the local's vision. So, the main symbol of the city, placed on the station square, isn't a landmark, not mentioned in the comments of the informants. After conversations with respondents and visual analysis of maps, we had the hypothesis that, new trends are categorically not prevailed in Cherdyn. Another example is a fresco created several years ago that adorns the walls with a city clock. Neither the clock itself, nor the fresco, which we noticed as tourists aren't landmark for locals. None of the respondents didn't indicate them in mental maps, identifying this place as a square with a fountain. Thus, a fairly ordinary fountain is an urban symbol of greater strength than the city clock and fresco.

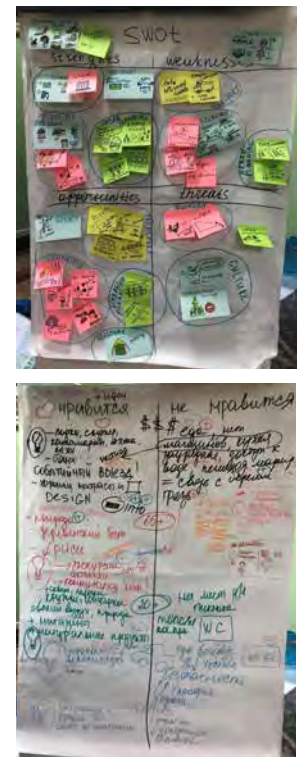


Fig. 08  
SWOT analysis  
Images of the analysis  
conducted during on field  
survey in Cherdyn district.



Here and next page Figs. 09-10  
**Monuments and Landscape as  
 part of a homogeneous system**  
 Panoramic views to the Kolva  
 river.

Another “key planning mistake” is the bus station status. First, respondents didn’t determine it as the main city square although it is located in the center place. Second, respondents mark it as a transit area, the shortest way to the square with fountain and other signs. Archival materials indicate that this area was previously used as an open-space trade square. The trading functions have been partially preserved, but now they are represented by straight-line trading pavilions, separated from the station space by a metal fence. The city authorities are trying to restore the appeal of this space by planning graffiti with a map of Cherdyn region on a firewall. We cannot assert that this idea is unsuccessful, but mental maps speak of a new trend “harsh future” in the city.

Third amazing fact revealed by mental maps is false identification of the main urban resting place. As we wrote earlier, informants drew plaza with fountain as a landmark and said that it is the central place for rest. Town holidays are held here, young mothers walk with strollers, locals sit on the benches. However, official events are held at another point - the square opposite the city authorities at the intersection of Yurganovskaya and Sobornaya streets. Turning to the archival maps, it becomes clear that the mental inhabitant’s representation of the central place with the historically established tradition. Thus, the social functions of the city square are “brought down” by administrative convenience. Mental maps also revealed another urban problem – the devaluation of the Kolva river. River has a recreational value, it is the place for rest and fishing. There is also a view of the Ural mountains and the valuable natural monument Polyud mountain from the shore. Only 2 of 10 informants drew river in mental map. Thus, mental maps revealed inconsistencies between planning decisions and social functions carried by the territory. We discovered the deep tradition of local people, patterns of movement and thinking.

After the work with mental maps we use a focus group method. The aim was to correlate the current image of the city with the needs of target groups: tourists, potential residents, workers. First we organized the role game which was attended by 32 non-resident in age from 17 to 55. We divided roles and offered respondents marked what was the strengths of the Cherdyn, what weaknesses they saw and what activities should be organize local government in the nearest future to attract different target groups. After the inside discussion we highlighted common items and fixed it on the flipchart. Respondents noted that the strengths of the Cherdyn are the possibility of unity with nature, low level of prices. Residents of large cities talked about peace and return to rural life.



All respondents inspired architectural heritage of Cherdyn region. In weaknesses respondents allocated fact that there are no activities for tourists and town is “blah and boring”, there is no connections with the river, no opportunities for sailing, catamaran ride, horse riding and another activities. Negatively reflected on the territory’s value for respondents’ low level of urban improvement, the absence of local food market and craft workshops.

After the focus groups method we used also the interview with local authorities which approve the results of our social studies.

Thus, the main value of Cherdyn region is the architectural and historical heritage. The existent system of churches should be the fundamental tradition basis for urban planning.

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Due to the Stone building of the Church of the Assumption was constructed in 1784 instead of earlier existed wooden church with the same denomination. The first mentioning of the wooden Church of the Assumption of the Blessed Virgin Mary as a part of Nunnery is dated to 1624. In 1764 the Uspensky Convent of the Dormition was abolished and the Church of the Assumption became the parish church [11]. The bell-tower and the antechurch were constructed later, in 1845-1856. Subsequently, in 1884 the bell-tower was reconstructed. In the 1930's the church lost the dome and the bell-tower. From the beginning of the 60's the building was transferred to the Cherdyn local history museum and from 1976 the archive and the library were functioning there. In 2000 the Church of the Assumption was included in the list of the cultural heritage objects of the regional importance and there was located the Museum of the Orthodox faith History. In 2005 there were partly reconstructed the roof of the building and restored the octagonal structure and the dome of the church.

The Church of the Assumption differs from the other churches of Cherdyn by the richness of cases' design, by Corinthian semi-columns and picturesque entablement. This church was constructed in 1784 instead of the wooden church existed from 1757.

The concept of its plan is traditional for the Russian church: little extended two-colored single-dome quadrangle with high fivefold apse and large refectory. Refectory, church and apse are covered with cloistered vaults and connected by wide stilted arches. In 1930 the vault over the antechurch was removed.

The church is divided into two levels: the bottom and the upper. In the façade it is underlined by the intermediate cornice with a number of sculptural consoles. Cases in the bottom level are simple framed, the upper ones are decorated with typical for the Cherdyn churches helixes turned to each other. Axial windows of the sanctuary part have the ordered framing with Corinthian semi-columns with the rounds (Fig.3), with supporting brackets, with the wide picturesque entablements and baroque helixes with fillet. All picturesque elements are made of the circle brick.


External decoration includes the typical features of the Russian baroque. The elements of the Peter's style are the following: small octagonal structure, one dome, flat making of scrolls over the upper floor windows.

Roomy scrolls over the bottom floor windows, pilaster side of the "beetle" entablement and columns are the traditional features of Moscow baroque, according to Solikamsk school.

*Side page Fig.01*  
**Bird view of the Church and its context**

The current state of the Church of the Assumption of the Blessed Virgin Mary.



 **Fig.02**  
**Windows decoration**  
The apse church of the Assumption.



**Fig.03**  
**Volumes transformations of the building**

The Church of Assumption with the bell-tower in 1901, 1995, 2018. (Source: <https://pamaday.ru/starinnygoroda/cherdyn/uspenskaya-cerkov>).

In 1845-1856 (according to the other information - 1884.) it was made the reconstruction of the Church and the bell-tower was built. It had four tiers: the first (is preserved) had two floors, its height was equal to two stories of the church.

The façade of the bell-tower is presented in the style of “high classicism”. The first floor is separated from the second one by the over sailed triple brick fillet. From the west along the main axes there is a large orthogonal door aperture of the main entrance which has the placed over it the framing case with the supported fascia. From the north and south along the axes of the bell-tower facades there constructed the orthogonal apertures in the form of the right-angled niches with fascias.

The second tier (today is lost) was equal to the third floor of the bell-tower, the wall was slightly shifted inwards.

The third tier (today is lost), as the previous one, corresponded a quadrangle and was shifted noticeably with respect to the second tier. The corners of quadrangle as well as the corners of the church were framed with wide pilaster-strips. Apertures were fenced by balustrades. The construction was completed by the dome with the cross on the top of the spire which was placed on the low octagonal structure having eight archways.



**Fig.04**  
**Reconstruction of the octagonal structure and dome**

On the left, view from the south-west (the date of taking pictures - July, 2005.) (<http://sobory.ru/photo/10486>); on the right, view from the north-west. Current state (the date of taking pictures: July, 2018).





*Fig.05*

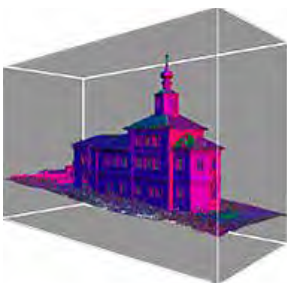
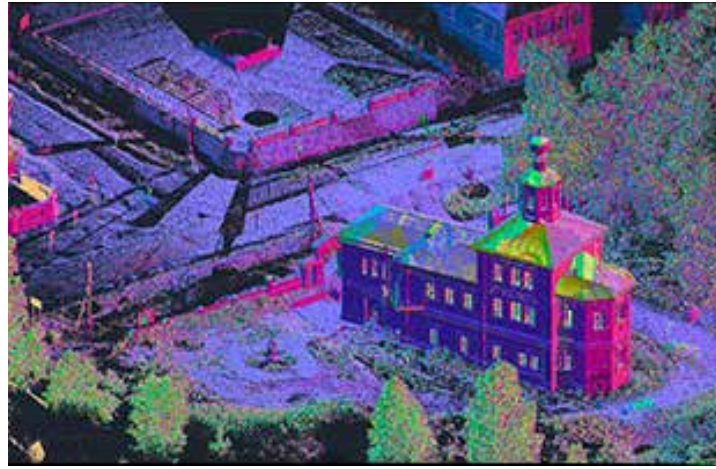
**Photo fixation of defects and damage:**

- a) the crack between the antechurch and refectory;
- b) penetration corrosion of the basement steel door;
- c) wetting of the plaster and brick bed, destruction of the plaster layer;
- d) wetting of the plaster and brick bed in the level of the first floor, the lack of drainage;
- e) the damage of the base brick bed, the lack of covering.

Today the Church is the object of historical-cultural heritage of the regional importance. There is the permanent exposition of the museum of the truth history. In the time of the Orthodox feasts public liturgies take place in this church.

Architectural survey of the Church of Dormition of the Mather of God was carried out with aim to obtain the initial data for the bell-tower reconstruction project. Leica Scan Station C10 Scanner was used in the process of survey.

To scan the monument it was chosen 39 points for scanner standing. Such method made possible to obtain the point cloud with the spatial-geometrical characteristics.



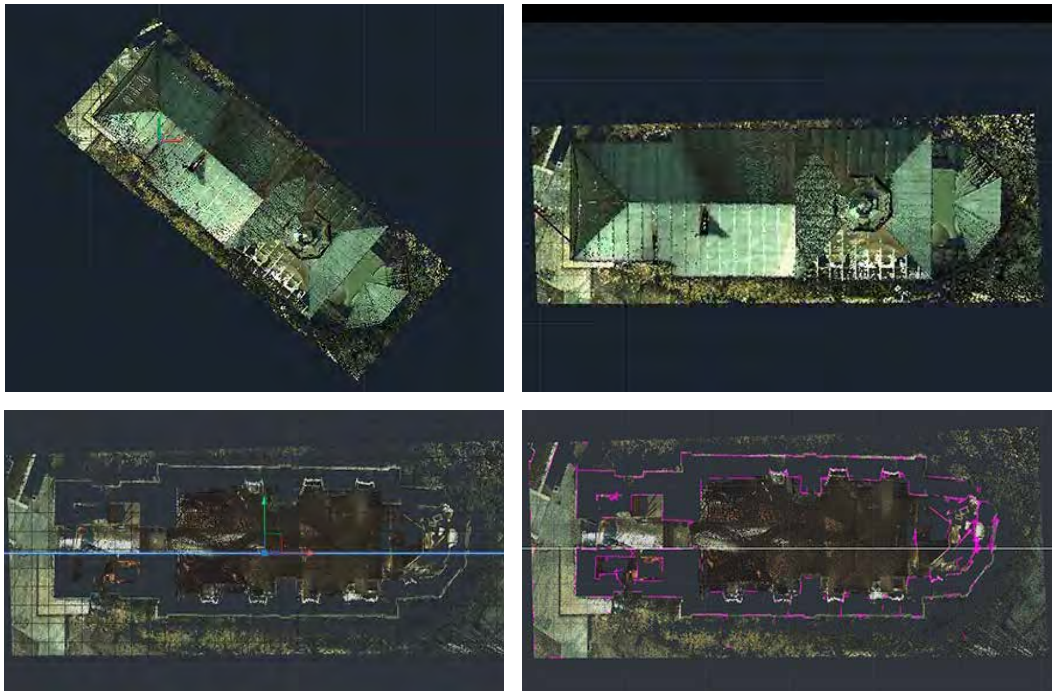
Scan processing and stitching in 3D model was made in Leica Cyclone program. Cloud point file in PTX format taken from Leica Cyclone was converted into RCP AutodeskReCap format and further – into AutoCAD. DWG format was used in the consequential work of the cloud geometry extraction and making 2D vector graphics on its basis


Floor plan of the Church gained by the laser scanning is given in following images.

The exact geometrical characteristics of the building were supplemented by the data of visual examination of constructions and calculation of the antechurch bearing walls strength.

The wet condition of the brick walls, local plaster damage, corrosion of metallic components have been caused by the capillary moisture suction effect due to the disorganized water course from the roof and adjacent territory. And with it, the calculated bearing capacity of the antechurch brick walls taking into consideration the reconstructed bell-tower is provided. The reserve of the bearing capacity is amounted to 56,5%. Subsoil bearing capacity at the complete calculated loading has also been provided with the reserve of the bearing capacity amounted to 72%.

In future the results of the surface laser scanning is planned to use as the underlay for the information modeling of the reconstructed bell-tower of the Church in AutodeskRevit.

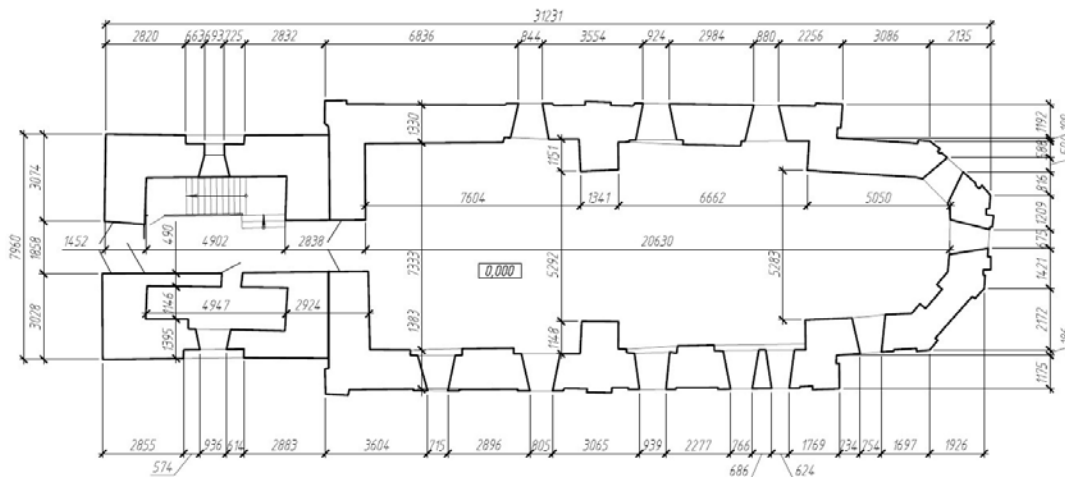




**Fig.07**  
**Extraction of 2D-cloud point geometry:**  
 a) cloud point trimming; b) rotation of the trimmed cloud;  
 c) cross-section of the first storey; d) extraction of truncated segment geometry

*Previous page Fig. 06*  
**Visual presentation of the point model in Recap:**

On the left, the map of scan standing points; on the right the overview of the point model; below, a photorealistic picture of Cathedral with the marked dimensions and notes.

On the boxes below, a trimming of cloud by Limit Box tool.




**Fig.08**  
**2D drawing**  
 The plan of the first floor of the building derived from the point cloud model.

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## ARCHITECTURAL SETTLEMENTS AND WISPERED RELIGIOUS COMPLEXES ALONG CHERDYN TERRITORY

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### From Cherdyn to Nyrob: Monumental Features Along the Kolva

The territory surrounding Cherdyn is characterized by numerous monuments and churches located within small, rural settlements. Historically, Cherdyn has been, and still remains, one of the main settlements in the Upper Kama region. The small centers surrounding it, both those along the Kolva River and those further inland, connecting the banks of the Kolva to those of the Kama, are marked by the presence of relatively small, low-density settlements. Within these semi-abandoned villages lie the remnants of religious monumental buildings that define the area—a landscape in which the bell towers of the principal churches rise as landmarks in the rural scenery of the Upper Kama.

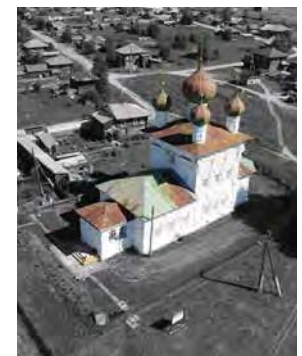
Dominating the route that connects Cherdyn to Nyrob, the northernmost center along the Kolva, is a series of brick churches, often in vivid red hues or, at times, a faded yellow brick partially covered by plaster. This contrast highlights the fact that, outside Cherdyn, these structures did not benefit from the same fortune of being rebuilt. This, however, enhances the evocative nature of these buildings, set within the natural landscape that surrounds them. The allure of ruins, celebrated by Ruskin, finds excellent examples in places like Pokcha or Iskor, where efforts to preserve this heritage aim to maintain the original image of the churches without altering their essence through invasive restoration. The grand Church of the Annunciation in Pokcha and the nearby Paraskeva Friday Church are two notable examples of monumental ruins. The former, situated close to the river, remains unchanged and static against the flow of the water, while the latter exudes a romantic charm, blending seamlessly with the natural environment to become one with it.

Some of these village churches appear almost like apparitions atop hills or at bends in the road, as is the case with the Trinity Church in Vilgort. Its original structure, built in 1779 and later expanded with a brick addition in 1902, culminates in a unique cornice adorned with archaic decorative motifs originating from the Solikamsk area, with influences from central Siberia. The Presentation Church in Kamgort is situated within a flat landscape, isolated from the main settlement, yet possessing a monumental character due to its compact design. The eclectic and austere style in which it was built at the end of the 18th century is evident in the brick arches supporting the façade's bell tower, as well as in the octagonal drum with a pavilion roof crowned by an onion-shaped metal dome. Continuing north along the right bank of the Kolva River, one encounters the village of Iskor and the Church of the Nativity. This church, located at the intersection of the village's only two main roads, serves as a significant reference point for travelers approaching from different directions.

Side page Fig.01  
**Nyrob monuments**  
The church of St. Nicholas, built  
in 1704-1705.



Fig. 02  
**A picture from above**  
A general view of the  
monumental complex.



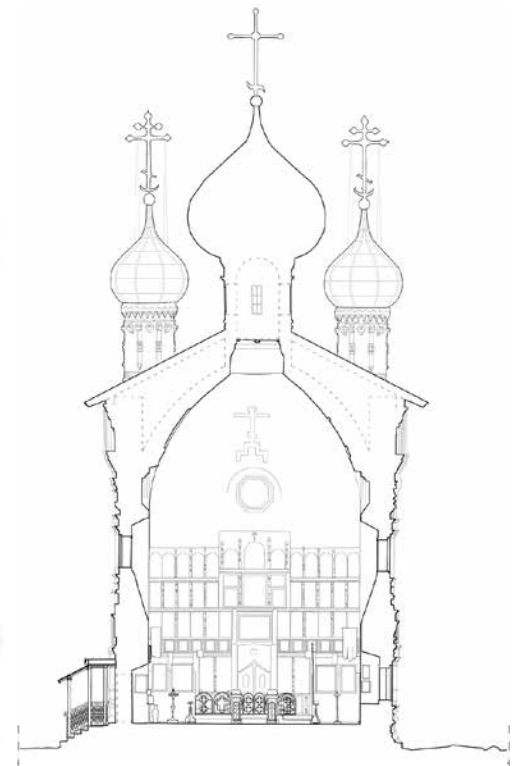
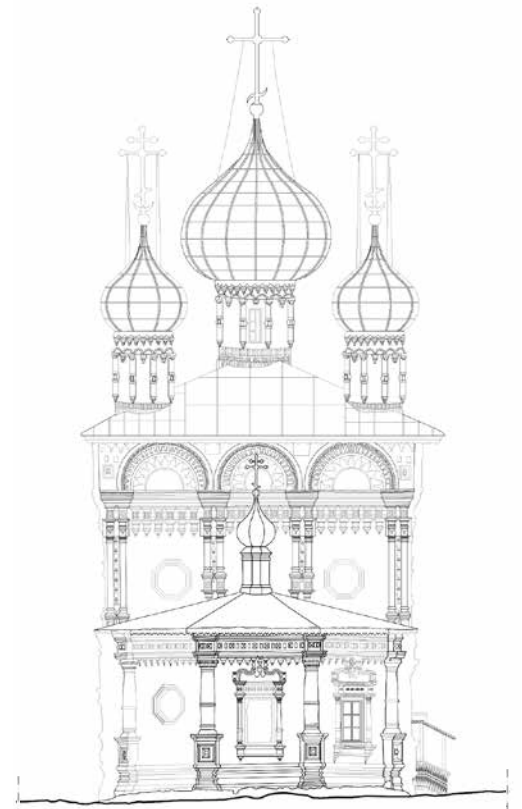
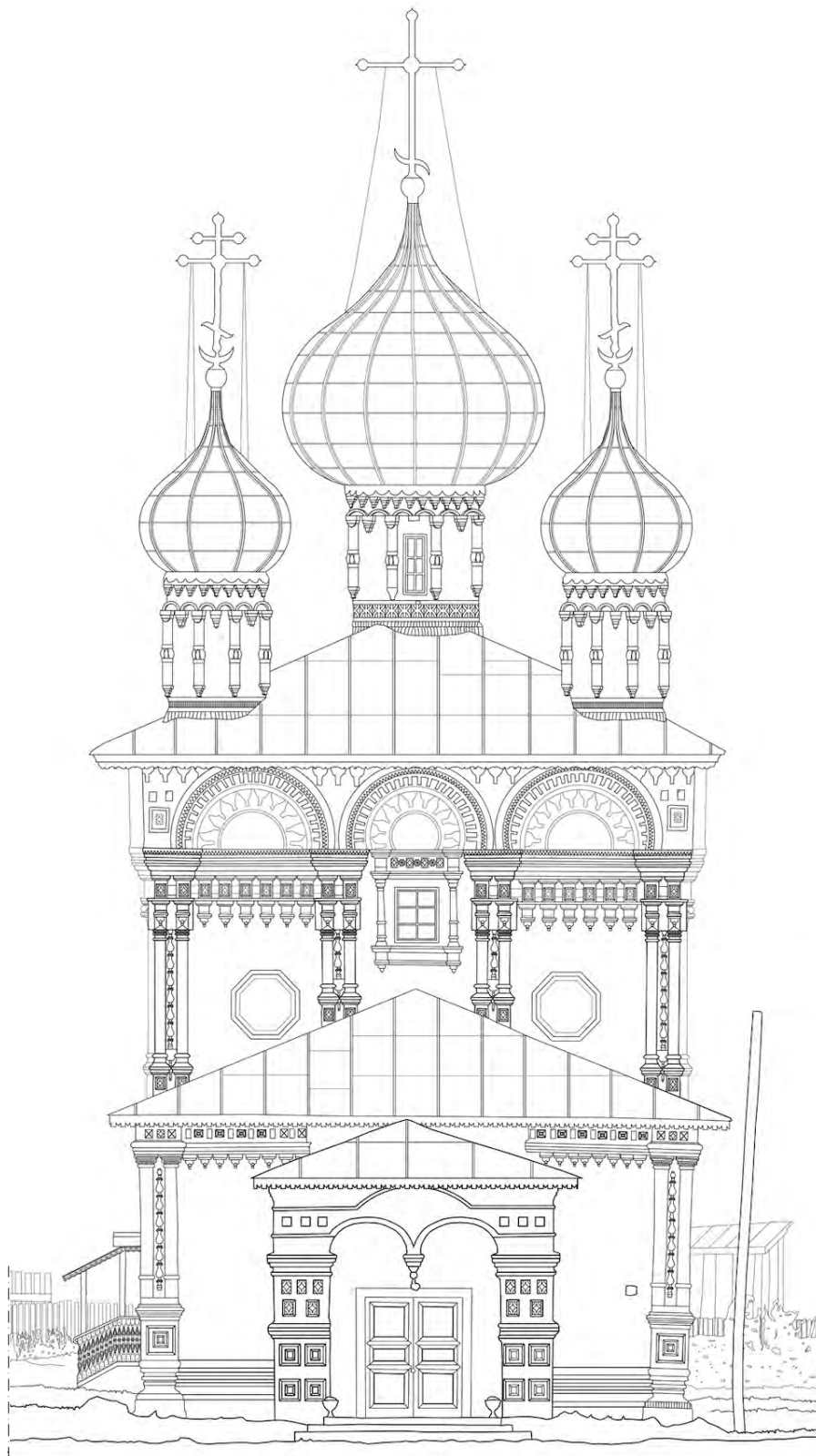


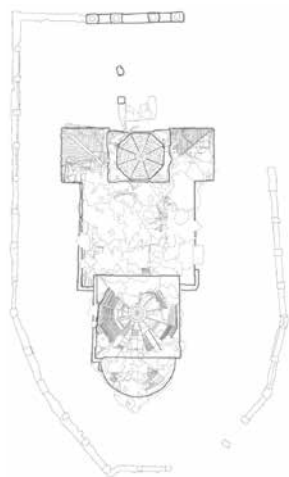
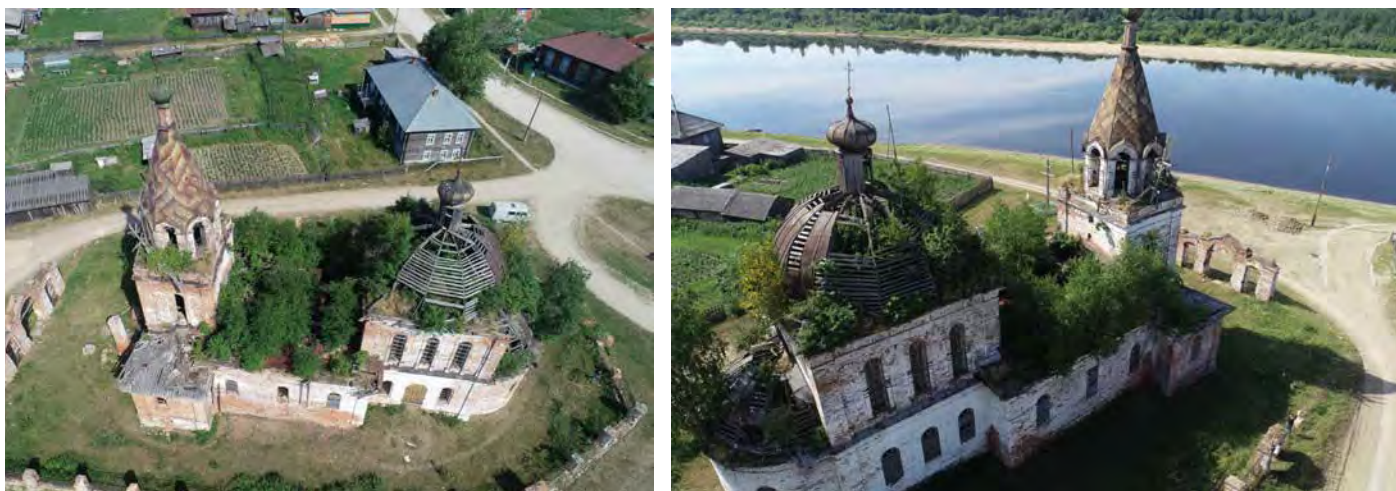
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 Here and next page, Figs. 03-04  
**Architectural drawings**

General plan and elevations of the Nikolskaya church, 1705. It is the double-height five-dome quadrangle with fivefold altar and small refectory, with rich décor of the end of the 17th century architecture. In 1930s it was closed and began to be used in household needs. At the beginning of the 1960s the building was restored but used as the post office. In 1991 the church was given back to believers and regular public worships have been performed since 1995. Nikolskaya church is the part of the temple ensemble of the settlement the parts of which are the Church of Epiphany and separately standing (not preserved today) the bell-tower.

The last and most prominent monument found in the Upper Kama region as one moves upriver is St. Nicholas Church in the village of Nyrob. Approximately 40 kilometers from Cherdyn, Nyrob is one of the district's most important centers, mentioned as early as the 16th century. Its Nikolskaya Church, part of a religious-monumental complex, holds significant historical, architectural, and symbolic value for the area. It combines Western Russian Baroque decorative styles with distinctive elements of local tradition, exhibiting a quality comparable to the churches in central Solikamsk.

Dating back to 1705, the building was restored between 1991 and 1995, preserving its fine architectural features from the 17th and 18th centuries. Fully constructed in brick, the church now boasts a gleaming white plaster finish that accentuates the shadows cast by the decorative elements on all four façades. This gives the structure a highly refined sculptural plasticity, with scarab-like ornaments and serrated geometric motifs. The double-height quadrilateral structure is crowned with a roof featuring five onion domes. Having been closed and repurposed multiple times over the years, it was restored to its original function during the most recent renovation and now hosts regular public worship services. The religious complex also included the Church of the Epiphany and a bell tower, though the latter no longer exists.





### Towards Bondyug: exploring a dispersed architectural heritage

The road connecting Cherdyn to the center of Bondyug traverses a territory immersed in taiga, characterized by dense forests and wide clearings where, over centuries, small rural settlements have developed. These clusters of houses often arise near modest religious buildings, almost completely abandoned, capable of evoking emotion and interest as soon as, unexpectedly, a part of the church comes into view while crossing the village road. In some cases, these sites are hidden deep within the forest, invisible from the road, requiring a walk to reach the church.

The Church of Elijah the Prophet in Anisimovo and the Church of the Savior Miraculous Image in Kolchug are visible from the main village road.



Fig. 05

#### Architecture of Bondyug

Church of the Exaltation of the Holy Cross; above, images from the drone, up and on the right, plan and elevation. Funded not later than the 1630s, the brick church was constructed according to the original project in 1846-1853. The quadrangular with two tiers of windows is covered by domed roof, with refectory and tree-level bell-tower under the hipped roof of frame construction. It was covered in the 1930s. For a long time it had been used as the storehouse but nowadays it is empty.



Side page, Fig. 06

#### Architecture of Kamgort

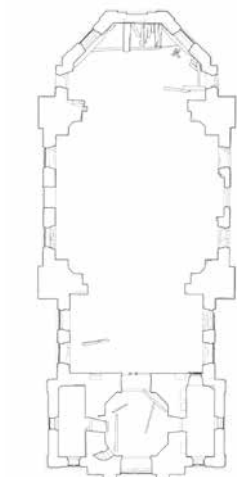
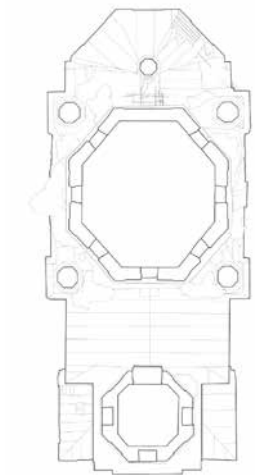
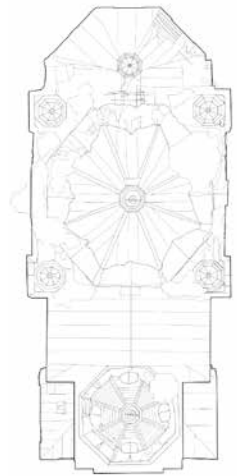
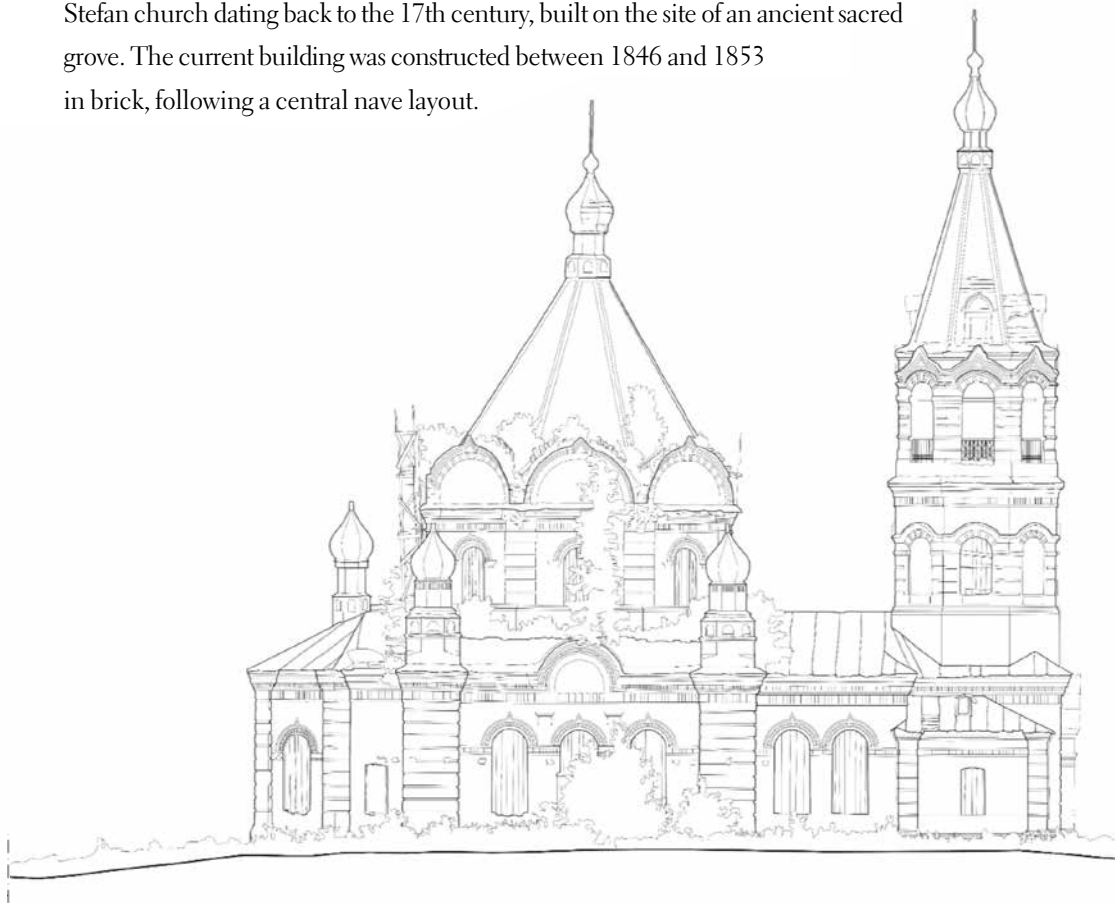
Architectural drawings of the Church of the Presentation of the Blessed Virgin, plans and elevation.

However, the deteriorated state of their exteriors and the neglect of their surroundings make them less appealing to visitors, despite decorative elements that hint at the prestige and importance these buildings must have once held in the region.

Further north, the Tikhvinskaya Church in Kushmangort is entirely engulfed by the forest, surrounded by tall trees that render it visible only during winter when the yellow-red bricks contrast with the snowy landscape. Heading westward, towards the right bank of the Kama River, stands a small wooden building, the St. Nicholas Church in the village of Uzhginskay. This wooden church, encased with planks, was built between 1874 and 1878. It features a rectangular layout with one tier of windows and is crowned by a small dome, with a sanctuary and an antechurch above which a bell tower with a pavilion was placed. The church was closed in the early 1900s and fell into a progressive and inexorable state of abandonment and decay, culminating in the winter of 2013-2014 when the roof collapsed.

The village of Bondyug is situated at the mouth of the Bondyuzhanka River, a left tributary of the Kama River, about 36 km northwest of the city of Cherdyn. Once considered one of the largest rural settlements in the Cherdyn district, it was originally known as the village of Harino.

The original site of the Church of the Exaltation of the Holy Cross was home to a wooden Orthodox Stefan church dating back to the 17th century, built on the site of an ancient sacred grove. The current building was constructed between 1846 and 1853 in brick, following a central nave layout.



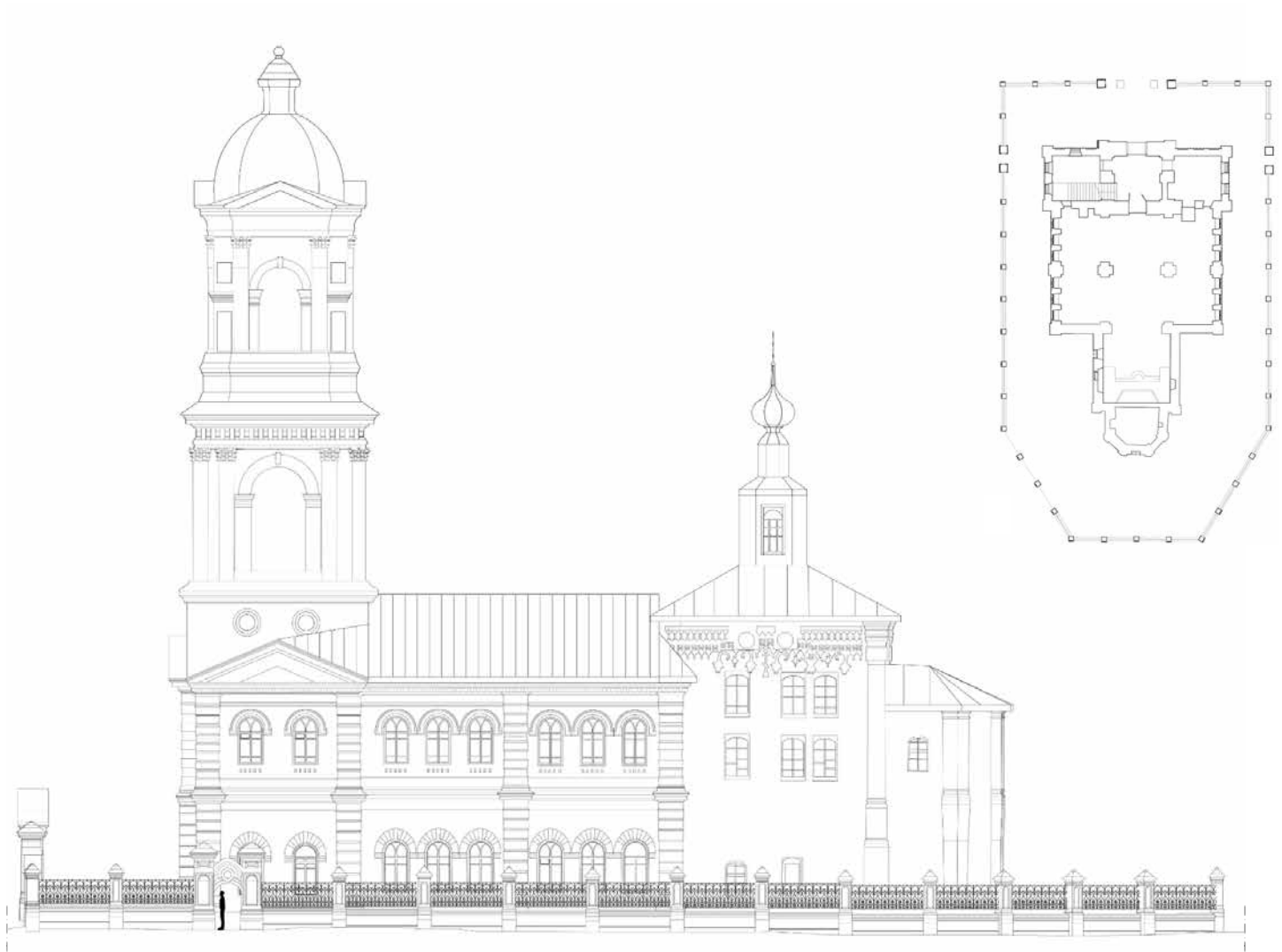


**Fig. 07**  
**Architecture of Vilgort**  
 the Church of the Trinity, views from the top, with bell tower and apse details. Funded not later than the middle of the 16th century, it was built in 1779-1810. It was constructed instead of two wooden temples (The Holy Trinity and the St. John the Baptist). In 1902 the refectory and the bell-tower, built in red bricks in pseudo-Russian style, were attached to the main building. In 1937 the church was closed and then the House of Culture were located in that building.

With two tiers of windows, it is covered by a domed roof and features a refectory and a three-level bell tower with a hipped roof of frame construction. For a long time, the church served as a warehouse due to its proximity to the river and related fluvial activities. Today, it stands empty.

The structure reveals its wooden framework in the dome and the semi-dome of the apse, from which shrubs and branches sprout, lending it a highly evocative appearance.

Each of these sites offers a series of images that uniquely highlight architectural characteristics and their relationship to the landscape. Among the districts analyzed, the territory of Cherdyn undoubtedly offers the most diversity and stylistic variety in its architecture, uncompromised by often invasive restoration interventions. There are formal, stylistic, and typological relationships among many of these sites that can be compared and studied. Additionally, certain examples display stylistic influences from other districts or geographic regions, providing valuable insights for the study of Upper Kama architecture and proposals for the conscious management of this heritage. Digital technologies open up vast opportunities for the exploration and preservation of the lost architectural heritage of Upper Kama's rural settlements, a unique historical and cultural phenomenon.



### The need for a fast survey to analyze and compare sites

Documenting such a vast and heterogeneous system to integrate it into a database capable of simultaneously containing this dispersed heritage across the territory requires careful planning and the development of strategies for data acquisition and processing. The models of individual buildings and monuments in the Cherdyn district must include information that describes their main spatial and architectural components, as well as their relationship with the surrounding landscape. Incorporating this data into a unified system for consultation and analysis will enable comparisons based on predefined categories, providing a foundation for conducting analyses and establishing relationships that support proper heritage management.

The data acquisition campaign utilized integrated survey methodologies, including photogrammetry, traditional surveys, drone-based mapping, mobile laser scanning, and, in select cases, fixed laser scanning. The planning of fast survey operations allowed for quicker documentation of various sites while leveraging advanced technologies to capture not only the individual monuments but also portions of the surrounding landscape. This protocol enabled researchers to relate each monument to



*Fig. 08*  
**Vilgort 2D representation**  
 Architectural drawings of the Church of the Trinity, plan and elevation.

its context and analyze relationships at the landscape, architectural, and detail levels. In many cases, data integration was necessary—such as for sites where rooftops were not visible from the ground or where drone operations were restricted due to obstacles along its flight path.

One of the most compelling aspects of the Upper Kama's heritage is the relationship between its monuments and their surrounding landscapes. Churches such as the Presentation Church in Kamgort, isolated yet monumental in their flat surroundings, or the Tikhvinskaya Church in Kushmangort, engulfed by forest, derive much of their significance from their settings. Expeditive surveying allows for the simultaneous documentation of both the architectural elements and the broader context, enabling a comprehensive understanding of how these sites interact with their environment.

By capturing data on the spatial relationships, topographical features, and visual connections between monuments and landscapes, expeditive surveys contribute to preserving the intangible aspects of heritage. This approach ensures that any future conservation or restoration efforts respect the original character and significance of these sites.

The creation of a centralized database is essential for managing the wealth of information collected through expeditive surveys. Such a database would include 3D models, spatial analyses, and metadata for each site, allowing researchers and policymakers to compare and analyze architectural styles, structural typologies, and landscape relationships. For example, the database could reveal stylistic connections between the baroque elements of the Nikolskaya Church and other regional influences, or it could highlight patterns of deterioration that inform targeted restoration strategies.

Moreover, the database serves as a tool for public engagement and education. Virtual reconstructions and interactive maps can bring these remote and often inaccessible sites to a global audience, raising awareness of their value and the need for their preservation.

Expeditive surveying not only aids in documentation but also plays a critical role in conservation planning. By providing detailed and accurate data on the current condition of structures, it enables the prioritization of interventions based on urgency and significance. For instance, a structure with a collapsing roof, like the Church of St. Nicholas in Uzhginskay, would be flagged for immediate stabilization, while others with less critical issues could be scheduled for later restoration.

Additionally, the integration of expeditive survey data with advanced analytical tools, such as structural simulations and environmental impact assessments, can inform decisions on how to best preserve these sites. This approach minimizes the risk of invasive or inappropriate restoration techniques that might alter the original character of the monuments.

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### **Blagoveshchenskaya Church: shape, history and ruins**

The case of Blagoveshchenskaya Church, or Church of the Annunciation in the village of Pokcha consolidates a central historical-architectural phase characteristic of Cherdyn district, synthesizing the value of historical evolutionary urban events in the stratification of its structures and walls, today abandoned in a state of ruin. The first information about the church<sup>1</sup> identify the existence of a previous double wooden complex<sup>2</sup> starting from 1481, at the behest of the Grand Duchy Yermolich family, used for the conservation of the relic of the Annunciation sent by Perm in 1451.

The original wooden complex was replaced in 1785 with a new one in stone and brick masonry<sup>3</sup>, subdivided in multiple environments: the main body, with a quadrilateral planimetry, constituting a nucleus for the refectory, the chapels of St. George (southern) and St. Nicholas (northern), the bell tower and the entrance narthex.

In 1910, a reconstruction intervention has modified structurally and morphologically large portions, in particular the bell tower, entirely replaced, and the eastern section of the central vault and the altar, reconstructed with the insertion of a 5-headed chapter; the interiors in plastered stone, with paintings and ornaments from 1870, are preserved instead. The general coat of the building with an additional red brick facing contributes to the strengthening of the external envelope and gives the possibility of inserting additional devices of tension resistance into the stratified walls.

The eclectic style with a strong Renovatoinist character is expressed in the ashlar, smooth and pyramidal apparatuses, for the basement, in addition to the crowning of the profile of windows and openings with splayed cornices and coupled columns. The history of the site goes through restoration works attempted from 1920, until the complete abandonment in 1940 and the re-conversion into a

*Side page Fig.01*

#### **The Curch of Pokcha**

Founded in the late 14th century, the last building was constructed in 1785. This image show the ruin of brick quadrilater of the church, originally with five domes. This structure remained intact even after the restoration of 1910, when a new bell tower was erected. From the 1940s onwards, it was closed and further neglected, until it fell into ruin.

*Next pages Figs.02-03*

#### **Documenting the transformation**

Blagoveshchenskaya Church, or Church of the Annunciation in the village of Pokcha.

On the left pages, historical photographic documentation (before 1917), on the right page, photographic campaign for the documentation of the state of conservation of interior and external facades, conducted in 2018.

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<sup>1</sup> Information on the development of the Pokcha settlement only begins from 1472 in correspondence with the first architectural documentation of the wooden Kremlin, the identity of the local territorial governorate. Political decentralisation following the great fire of 1535, with the transfer of the local representative seat to the city of Cherdyn, led the settlement to focus its development on trade. In the 17th century, Pokcha became an important barge-building centre of the Upper Kama until the beginning of the 20th century, with the private shipping company of the merchant S. V. Chernykh, and obtaining an independent administrative role as the Pokchinsky rural settlement of the Cherdyn district.

<sup>2</sup> The stone church in the name of the Blessed Virgin Mary was erected in place of two dilapidated 16th century wooden churches, Blagoveshchenskaya Church and Georgievskaya, in 1579. Cf. Shumilov (2003), *Orthodox churches and temples of common faith in Perm Krai: short historical guide*.

<sup>3</sup> At the end of the 18th century, the widespread use of bricks and the renewed administrative role of Pokcha led to the appearance of numerous brick houses and the rebuilding of the main religious site, the Church of the Annunciation of the Blessed Virgin, with a new stone and brick building constructed in 1785 and consecrated in 1794. Cf. Shumilov (2003), *Orthodox churches, cit.*



power central by Cherdyn MTS: the energy issues linked to the new function led in the 90s to the partial collapse of the main pavilion vault and of the bell tower roof, after repeated flashes attracted by the electrical system. As result of the extensive damage, the church was excluded from the list of architectural monuments of interest, precluding any new intervention and restoration initiative, and leaving the site to its collapse<sup>4</sup>.

In 2018 the architectural complex was found in an evident state of neglected conservation. The wooden roofs are almost entirely destroyed, and the main structural building is also damaged in several portions, particularly in the main block of the vaulted system of the church.

The debris have submerged part of the loading pilasters of the vaults, which cannot be inspected in their ground basement, and have been covered by soil and vegetation creating a natural hill that reduces the access to the narthex and apse rooms, as well as being the cause of degradation of the preserved supports. The connection with the bell tower, once allowed by the central nave through the gallery and the refectory, has been demolished and prevents from the direct documentation of the state of conservation of the elevated structures.

Following the collapse of the roof, the complex is deprived of the main factors of protection from atmospheric agents, in particularly during the winter season, and it is therefore subjected to a rapid degradation of the remaining portions, affected each year by localized collapses. The site is also totally devoid of control services for the access of people and animals, who often occupy it and damage the spaces and their structures. In particular, the narthex environments are deteriorated by the frequent presence of herds in transhumance, housed by the shepherds inside the church during the summer season.

<sup>4</sup> Local church services are held inside the Kazan Chapel, built in 1913 and now returned to its original function after being converted into a grain warehouse in 1951.





**Fig. 04**  
**Point cloud from TLS data acquisition**

A general view of the point cloud acquired with a Terrestrial Laser Scanner. The range-based survey campaign was conducted for the internal and external environments.

### **A documentation approach for digitizing the conserved shape**

In relation to the current state of the monument, the documentation of the Blagoveshchenskaya Church in Pokcha has highlighted the need to experiment with integrated approaches to representing the “present form” in order to understand the preserved architectural “ruin.” The analysis focuses on the primary structural components of the building and their stabilization for future interventions. The morphological study of the masonry structures was organized and simplified through a breakdown of the spatial construction units. The architectural elements of the spaces, semantically detailed but always connected to the overall volumetric system, propose a critical analysis of the Blagoveshchenskaya Church complex: its current fragmented and incomplete form is observed through the imperfections of documented signs and geometries and interpreted within a knowledge framework composed of morphological, constructive, technological, and conservation data.

In particular, the internal inspection of wall sections encourages the implementation of a reliable and comprehensive 3D graphic support for reconstructing the architectural “skin,” which serves as a reference for technical insights into materials and construction components. The “form of the ruin,” a central element in the cognitive process achieved through representation, thus becomes a fundamental tool both for direct knowledge and for future technical implementation. This tool integrates repositories and historical-constructive analysis data (archives, photographic details, thermal maps), with the dual aim of completing the technical stratigraphic knowledge framework and revising, through an integrated instrumental and disciplinary approach, the behavioral diagnosis of structural components.



The ruined complex of the Blagoveshchenskaya Church, due to structural collapse and the lack of site regulation, has lost the original spatial design that the masonry envelope once revealed. The constructive and functional principles that guided its design now appear compromised or missing. The absence of the main wall sections of the roofing system deprives the current analysis of a necessary treatise on the formal and material typologies of the internal vaulted systems, which played a critical role in the structural balance of the nave and presbytery. Additionally, the absence of the corresponding external elevation structures, originally consisting of small towers with ephemeral domes, alters both the historical building's visual impact on the landscape and the static reference for the structural resistance schemes of the entire edifice.



Fig.05

**Data acquisition by UAVs.**

Two acquisition campaigns with mini UAVs were conducted on the monument: the first, with a point of interest, acquired general information about the monument; the second campaign involved the bell tower and some inaccessible areas and surfaces, using a smaller drone capable of getting closer to the surfaces and capture more detailed elements.



Fig.06

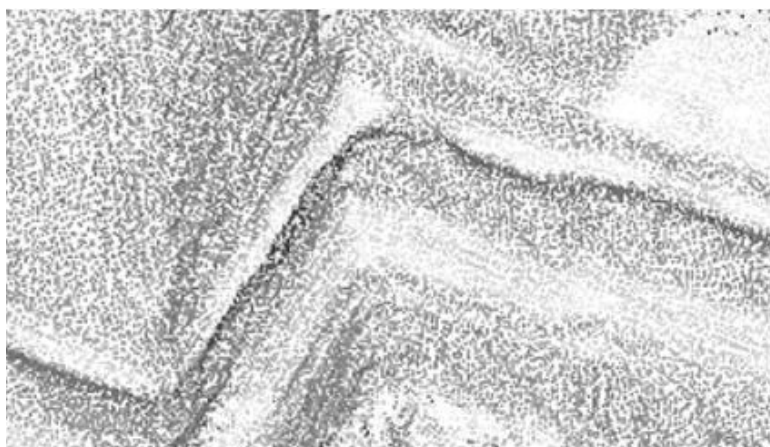
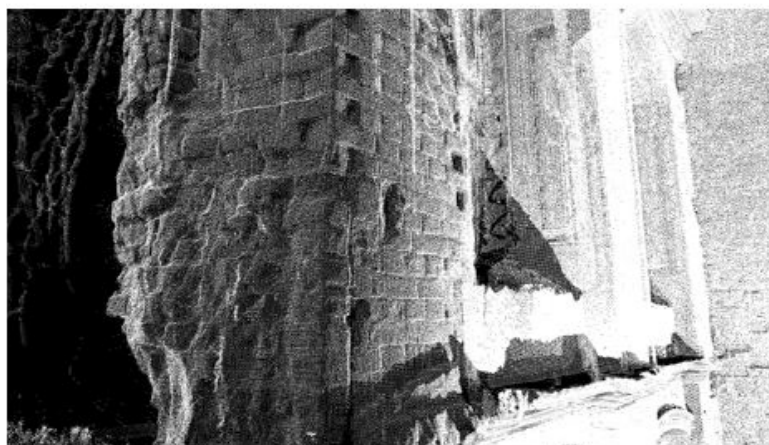
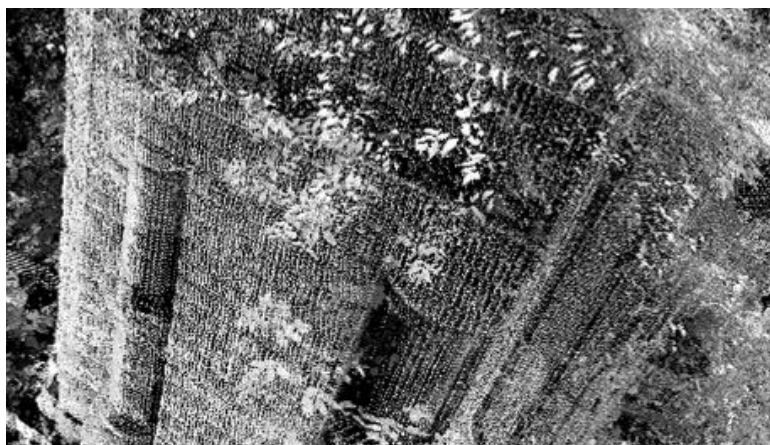
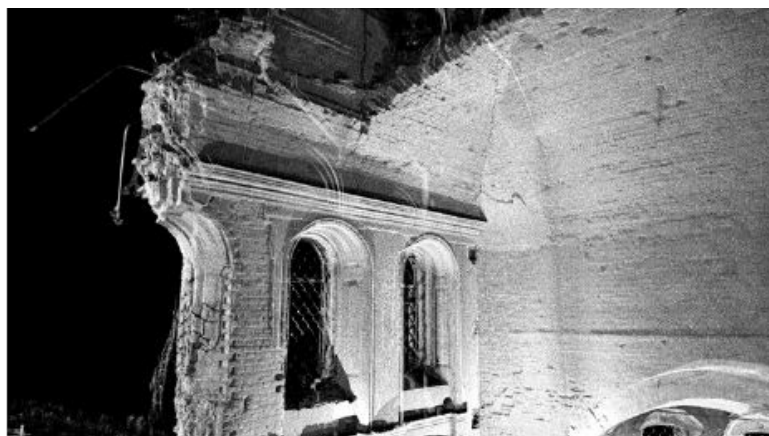
**Dense point cloud**

View of the model obtained with SfM data processing.

Next page, Fig.07

**Views of the registered point cloud by TLS and by UAVs**

Details of the two point clouds obtained (above TLS, below UAVs).





↑  
**Fig.08**  
**2D drawing elaborated from**  
**point clouds by TLS and UAVs**  
 Vectorial and materic plans and  
 ections of Blagoveshchenskaya  
 Church.





The documentation approach underscores the need for renewed attention to the methodologies of acquisition and representation of the building's formal properties, particularly in terms of their correspondence and integration. It also emphasizes the opportunities offered by digital transposition as an enhanced means of reconstructing and utilizing archaeological and architectural data. The loss of critical portions of the masonry environment—both vertical delimitations and the upper closures of the construction envelope—leads to reflections on the structural form and the optimization of metric-spatial information acquisition from the remaining ruins.

The digital morphological detail of the “present” plays a strategic role in understanding the “absent” elements, facilitating the reconstruction of the building layout by transferring diagnoses and hypotheses on the mechanisms of structural decline. This serves to propose ideas and guidelines for the conservation and reconstruction of the building.



*Fig. 09*  
**Point cloud and materic orthoimage of the bell tower**  
comparison of the processing between orthoimage of the laser scanner point cloud and orthoimage from the photogrammetric model.



*Fig. 10*  
**Mixed elaboration sections**  
Vectorial and materic sections of Blagoveshchenskaya Church.

### 3D integrated modelling opportunities for structural apparatus reconstruction

The inevitability of a formal approach to the re-design analysis of the historic building directs the operational experimentation of morphological-structural representation toward two research targets:

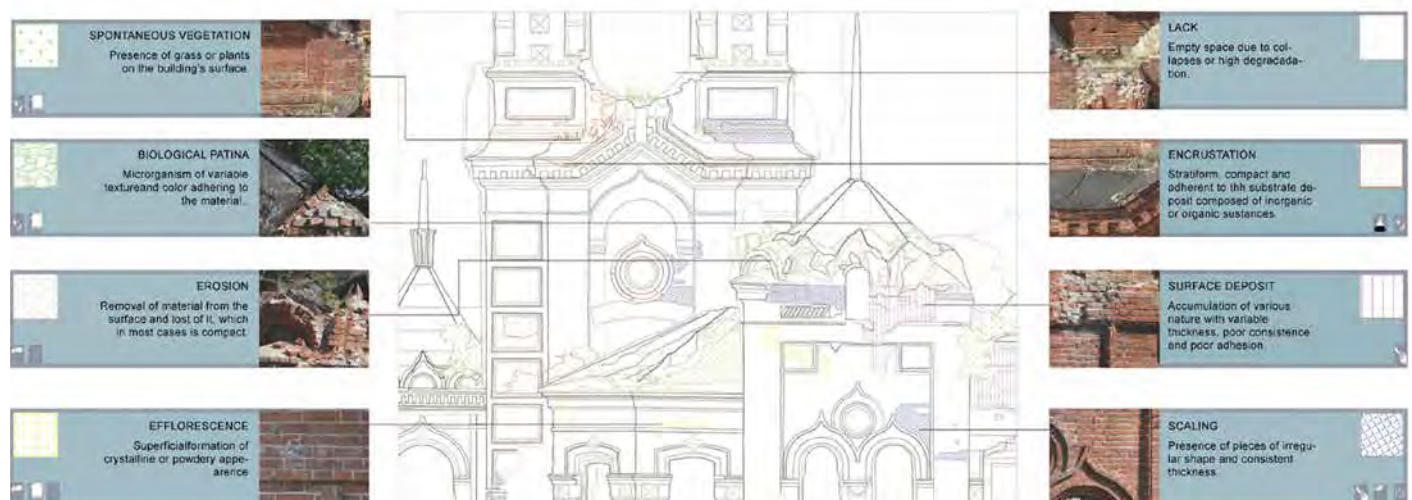
1- The planning of a documentation strategy capable of capturing both the entirety and the specificity of the architectural details of the Blagoveshchenskaya Church, encompassing all its typological variations (masonry, metal parts, wall finishes, vegetation components) and locations (main spaces, underground areas, elevated sections, roof levels).

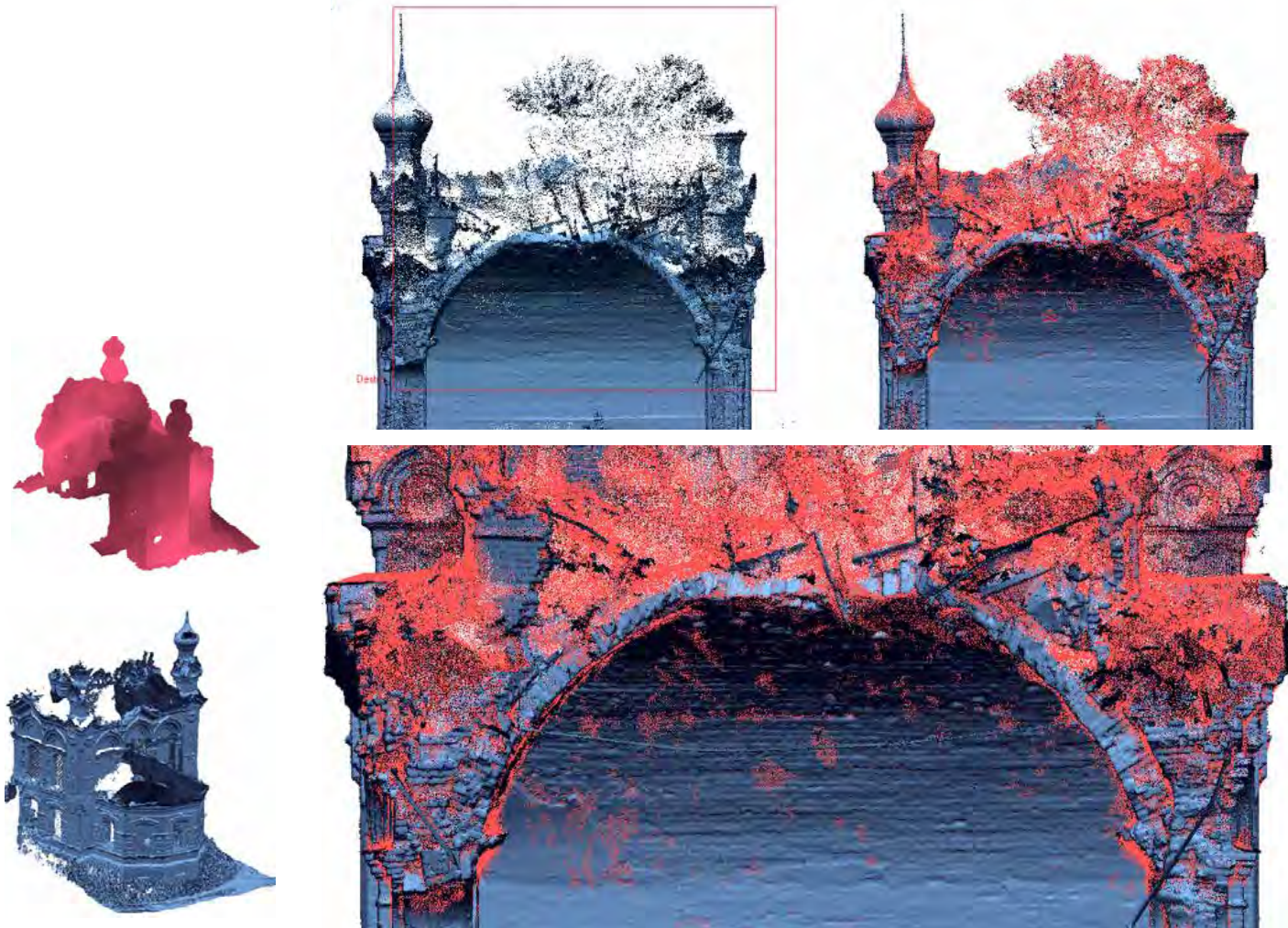
2- The suitability of transferring these detailed systems into appropriate morpho-metric products that, through the language of graphic representation, convey the richness of information and the analytical opportunities provided by the historic masonry. This objective guides methodologies and tools to prioritize a three-dimensional documentation approach using digital surveying. Interactive orbiting thus becomes the medium for conducting qualitative and quantitative evaluations of the databases and point clouds generated by instrumental applications, fully acknowledging the interactions the historic structure of the Pokcha church can establish between its individual preserved components and, in the context of a restorative intervention, its design potential.

The integration of digital survey products, gathered through terrestrial and aerial acquisition tools, achieves completeness and complementarity based on differentiated visual positions, ensuring data capture of ground connections, external and internal envelope surfaces, and monitoring information on roof units and elevation components. The finalization of the complete database for the Pokcha complex establishes a virtual system of the preserved form, focusing attention on the metric-spatial correspondence of the data obtained from Terrestrial Laser Scanning (TLS) and UAV photogrammetry, while considering the varying reliability of capture and spatial reconstruction.



**Fig.11**  
**Decay analysis**  
mapping of the main degradations present on the external fronts, processed according to the NorMaL standard.





**Fig. 12**  
**Decay analysis on 3D model**  
 Integration between TLS and UAV point cloud and management of alignment reliability, optimizing the final integrated database to derive the HD mesh model. The test had been made on the vaulted central environment.

*Next page, Fig. 13*

**Hypothesis of the reconstruction of the vault**  
 From the slices of the final mesh model, it was possible to reconstruct a geometric design version of the original "a schifo" vault of the central nave. By comparing it with the geometric module, it was possible to identify the instability areas present on the resistant unit and derive diagnostic considerations.

Subsequent modeling actions follow the integration and study of a mesh triangulation strategy for the combined data, producing reality-based models capable of preserving architectural irregularities as a structural identity component, mediated through numerical polygonal surfaces.

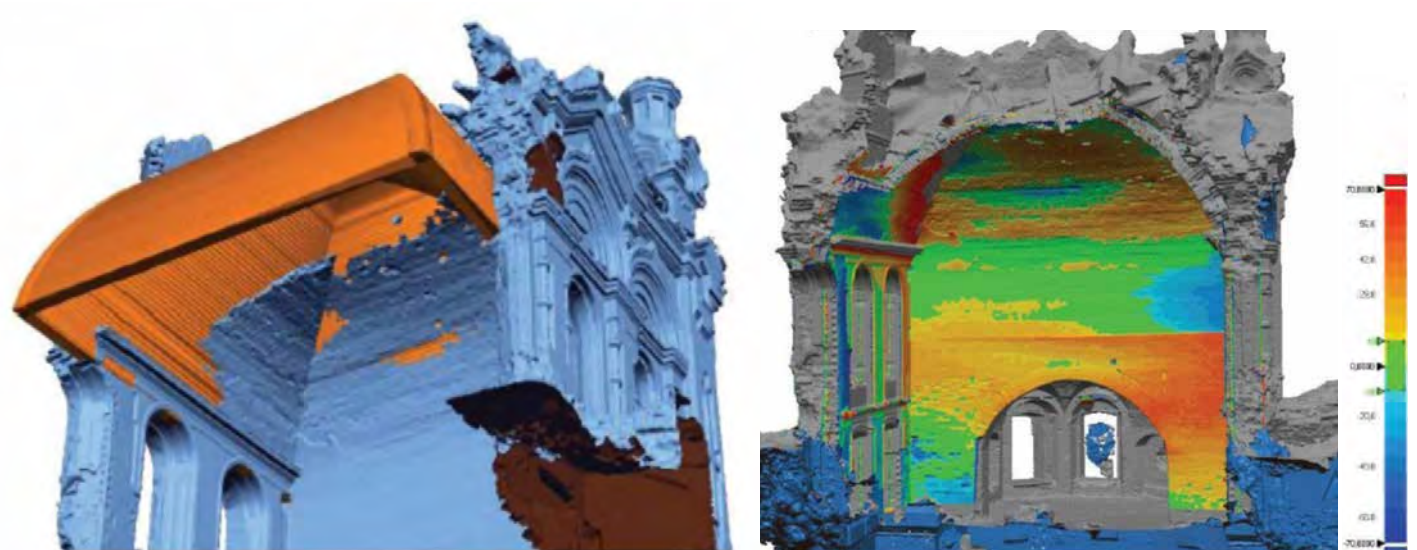
The generation of a comprehensive model of the Blagoveshchenskaya Church is conducted through a strategy of decomposition and meshing based on "structural cells," defined as minimal spatially identifiable and statically determined units into which the architectural fabric can be divided.

This decomposition, besides providing specific support for data processing in software, closely links the modeling process to the typological understanding of architectural space. In this way, reality-based modeling methodologically directs its outcomes toward automation only after a segmentation process of the scattered database. The resulting process of ordering and critical understanding of the monument is thus equivalent to the experience of a geometric or parametric modeling process.

The applied research aims to develop optimized 3D knowledge products, even in the presence of complex, ruined, or incomplete structures that no longer retain their original form. This is intended to promote intervention systems for the restoration of structural components and to foster renewed awareness of their valorization.

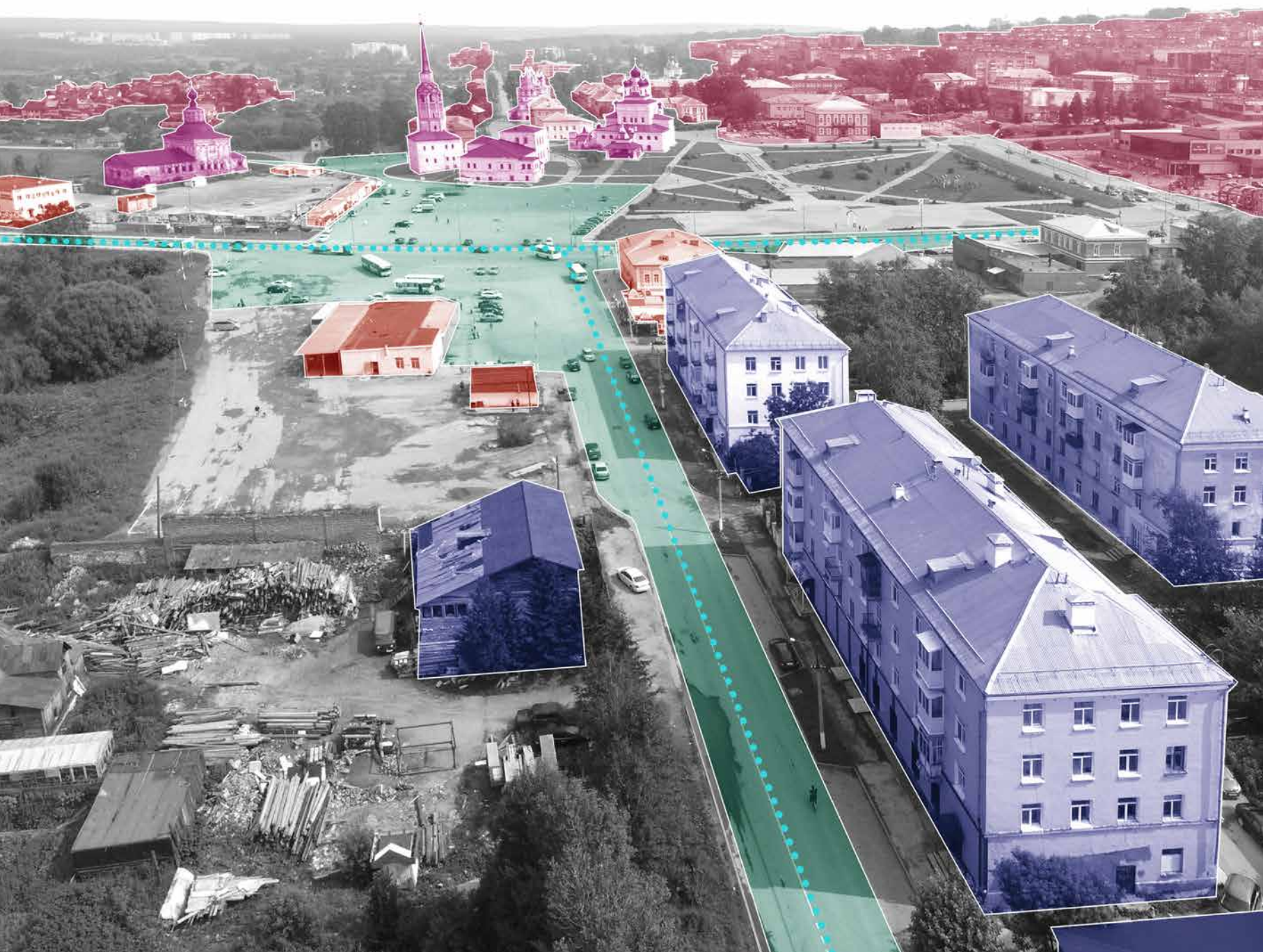
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## **Inventory and modelling buildings and structures**



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Today's vision of cultural heritage reflects a process of semantic expansion that from the size of the monument has reached the size of the landscape. The landscape has been identified as a fundamental importance system as a connector and element of integration between the monument and the territorial system. International organizations such as ICOMOS, UNESCO, IUCN, and the European Council have recognized landscapes as symbols of representation of their cultural identity. To this end, management policies require tools for an integrative vision of landscape inclusion in spatial planning of the territory.

The definition of an effective method for assessing the landscape, capable of establishing a relationship between its characteristics and its potential as an active resource for society in an interdisciplinary framework and through quantitative and qualitative techniques, represents a tool of fundamental importance for the territorial, cultural heritage management scenario.

The concept of landscape has always been linked to the image, being a critical representation of the real environment. The translation of the landscape in the digital environment into a new form of representation of the landscape implies a transposition of the image that is no longer a static form of simulation and critical representation but becomes a three-dimensional model structured by topological or parametric geometries, information, and dynamic interconnections.

The digital representation of the elements characterizes the territorial landscape within a simulation of the complexity of artificial and natural elements' relationships. The architectural and territorial systems intertwine within a dynamic network of combinations and flows define a new multidimensional representation of the landscape. In which the model is not a mere simulation of the form of the architecture but becomes an expression of the will to be a tool for reading and representing specific aspects.

To structure this information investigation system, it is necessary to define an environmental and architectural structure that evokes landscape and nature's formative rules and proposes qualitative aspects capable of interaction and modification based on defined parameters.

In this context, the architect becomes a designer of information spaces, spaces whose boundaries are lost within a fluid space of navigable hypertexts. Information architecture thus stands as a collective intelligence tool within which, through the virtualization of shared concepts, each territory, architecture, environment is mandatory through heterogeneous links that become filters for reading reality.

*Side page Fig.01*

**Preparation of a Solikamsk information model**

An illustrative image in which the elements that contribute to defining the urban landscape, including buildings, paths, road networks and monuments, are classified and categorised according to what will then become a semantic model.

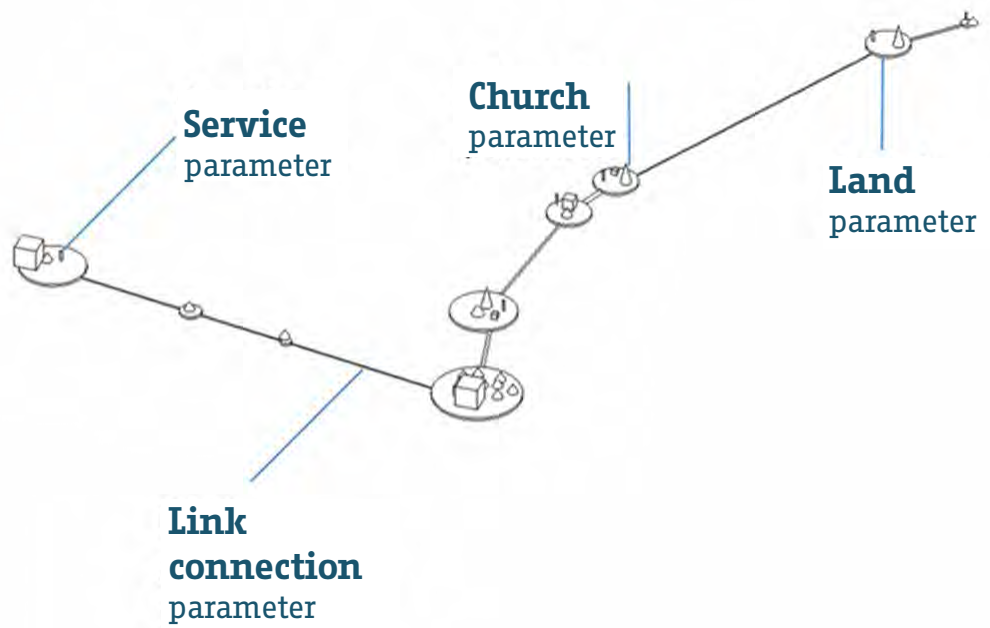
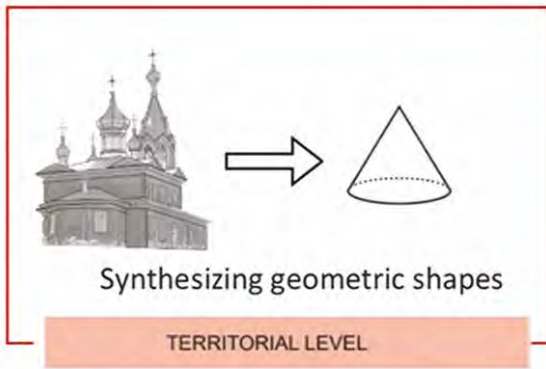


**Fig. 02**  
**Classification of monumental complexes**  
 within the macro-categories the architectural elements are then further subdivided to define a hierarchical levels structure from the general (monumental area) to the detail (single building).

In applying this representation filter, the landscape is analyzed not only in its scenario but also as a social product as a result of the relationships and interconnections between users and the different elements that compose it. The operations to accomplish this synthetic representation can be summarized in knowledge, identification of variables, structuring of dynamic and interactive interconnection systems. These reflections are the concepts underlying the design of a responsive model, capable of describing quantitative and descriptive aspects of the Upper Kama territory through the definition of sub-models, which, qualified in the form of an abstract symbol, are descriptors of specific qualitative values. The project aims to structure an accessible and interoperable virtual platform structured on different levels of information detail.

The first reflection on the structuring of an information model of a widespread architectural heritage as the three districts under analysis lies in the definition of a language grammar based on specific taxonomies of representation. The territorial characters are thus hierarchized and translated into specific symbols of representation.

To this end, a process of analysis and identification of different interpretation levels of the territory is necessary. Characterized by a type of funnel analysis that from the narration of the territorial system goes into deepening the scale of analysis of urban characters to arrive at a type of narration more specific, including the individual monuments' technological characteristics.



PARAMETRI

LAND

- 0 0 houses
- 1 1-15 houses
- 2 15-50 houses
- 3 50-100 houses
- 4 over 100 houses



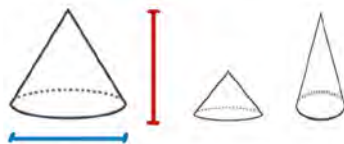
LINK

- 0 0 connection
- 1 car
- 2 car bus
- 3 Car bus feet
- 4 Car bus feet boat



SERVICES

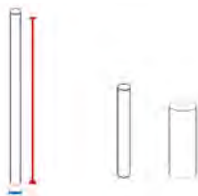
- 0 No
- 1 bad
- 2 few
- 3 good
- 4 very good



**Church Parameter**

The geometric shape changes by inserting the two:

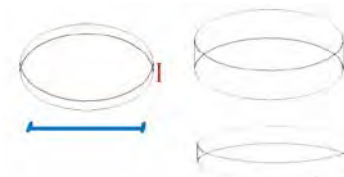
- **Height** parameters matched to a value chosen from a scale of values defined to indicate the importance of the church.
- **Diameter** that indicates the conservative state in which you reverence the church.



**Link connection Parameter**

The geometric shape changes by inserting the two parameters:

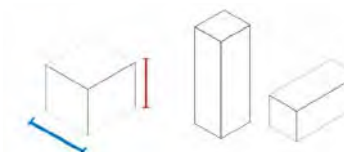
- **Length** that indicate the distance between the two center
- **Diameter** that change which changes according to the number of transport services are available to reach the center



**Land Parameter**

The geometric shape changes by inserting the two parameters:

- **Height** that indicate the number of inhabitants.
- **Diameter** that change which changes according to territorial estension (Km2)



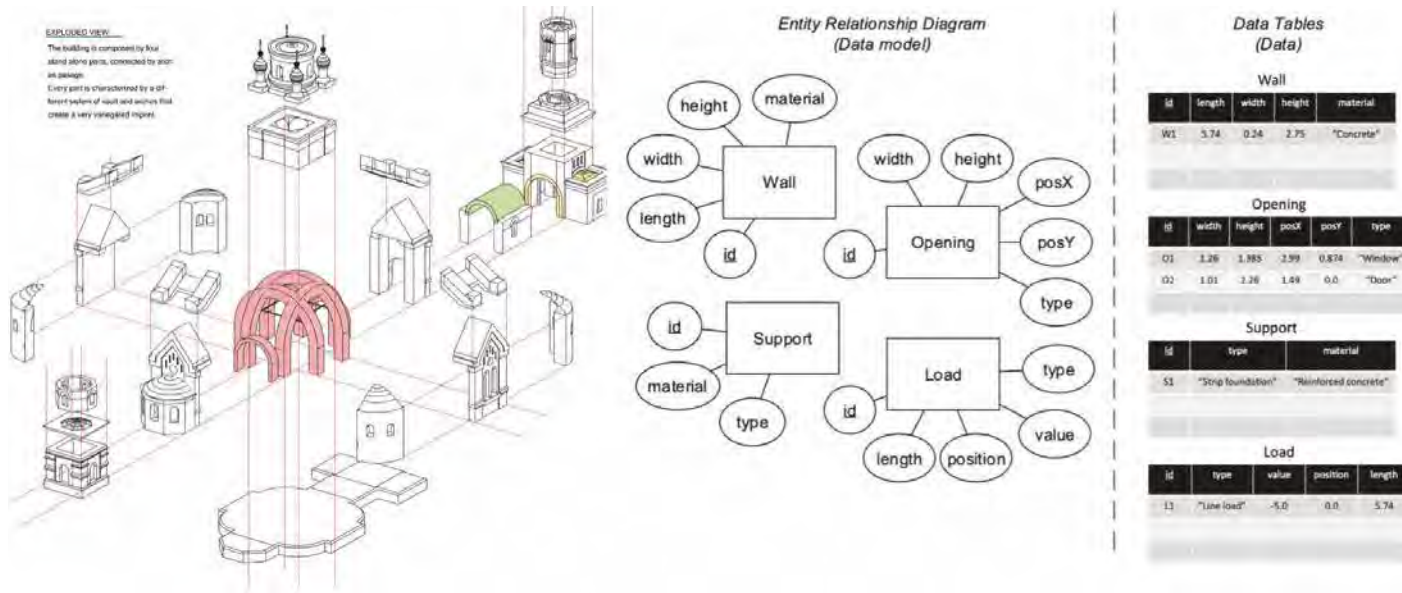
**Service Parameter**

The geometric shape changes by inserting the two parameters:

- **Height** that indicate the number of the service.
- **Length** that change which changes according to the use of it.

*Fig.03*  
**First considerations made on the construction of a simplified informative model of the territory**

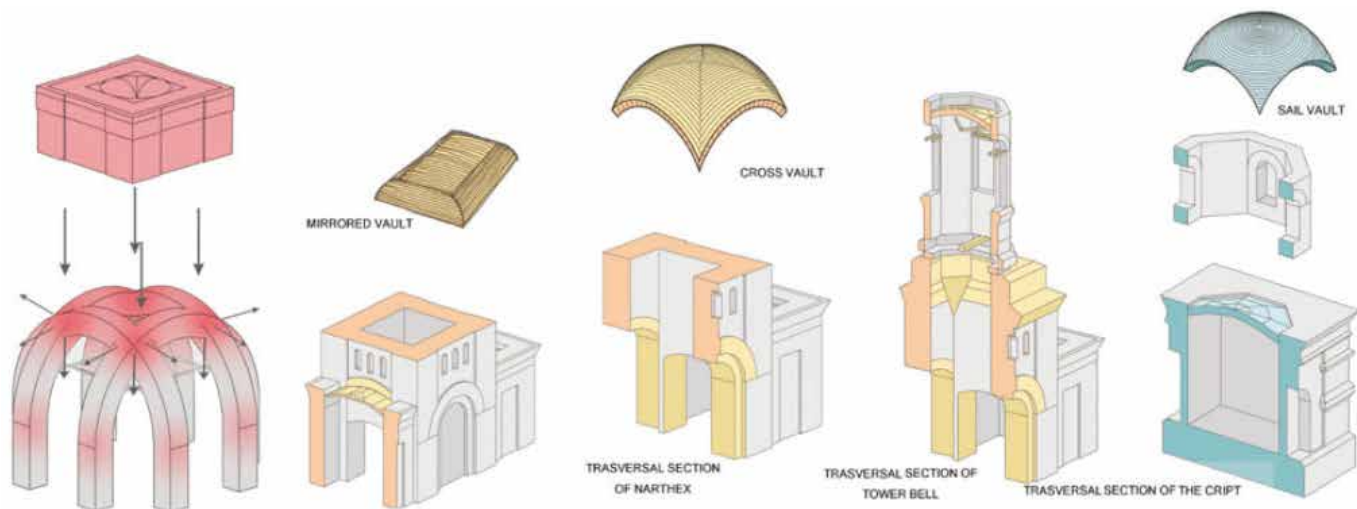
The simplified three-dimensional geometric forms define and describe the characteristics of the territory through the insertion of specific parameters. Each simplified model of church is expected to connect a more detailed model that describes the different technological elements in detail. On bottom right the parametric structure of a model of connections that explicates the possibilities of remote interaction between the different elements present on a widespread territory.

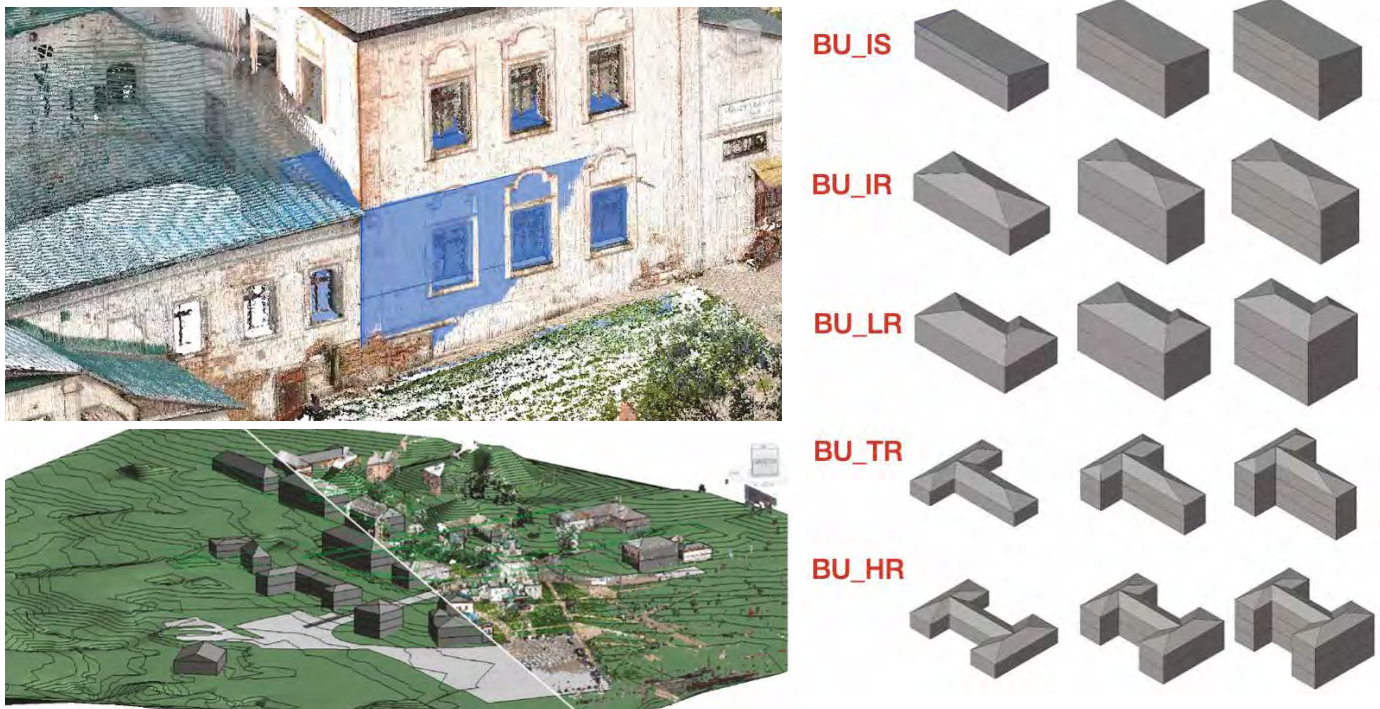


↑  
Here and below, Figs. 04-05  
**Complexity of parameters and links between information system and architectural features**  
The different levels of graphic interaction and implementation conduct to deeper levels of knowledge and morphological detail of churches.

Four levels of reading have been defined:

- **Territorial Level:** in which the different centers present within the districts are identified through a hypergeometric simplification model. This model will describe the connection and accessibility characteristics of the individual monuments, explaining the possible paths of connection between the religious complexes.
- **Urban Level:** in this model, all the different activities and services present within the single-center will be identified.
- **Monumental Area Level:** within the single urban center, the monumental area model will be studied in depth to identify the different areas for safeguarding the historical character of the individual





territorial centers. To this end, the identified area's landscape features will be described in a single model concerning the monumental aesthetic qualities. It will be possible to identify the typological features of the monumental structures present in the area.

- **Monumental Building Level:** the different buildings present in the monumental areas, identified by the previous level of analysis, will be investigated, where a specific HBIM information model will be described individually through the construction decorative and technological characteristics of the whole building.

In the design phase, the modeling protocol becomes the tool for specifying the guidelines to support the modeling phases of the different levels of investigation. This protocol provides as a first action the preparation of a shared diversified abacus based on the definition of different LODs (Level of detail) of representation of the model for the differentiation of the different levels of investigation through the coding of each element in specific model categories.

The project, following the LOD definition criteria, provides for modeling to a LOD 100 detail for the description of the territorial, landscape, and urban levels, in which the volumes and dimensions of the buildings will be modeled in a conceptual form of useful mass to define the dimensional characteristics of the overall dimensions and orientation. The churches' technological and decorative characters will then be explored in the second level of modeling based on the LOD 200 criterion. The idea is to structure a chinese box system in which the models are connected together in a branched structure. Each model specifies certain elements identified in the previous one. The methodological choice was made with the awareness of structuring a system that can be easy to read, adaptable, and descriptor of the large catalog's different spatial and morphological characters.



Fig. 06

**Scan-to-BIM process**

A 3D semantic modelling of the landscape starting from the acquired point cloud. For the description of the urban levels, the terrain had been decoded in curves interpolated; and building units had been simplified in volumes.

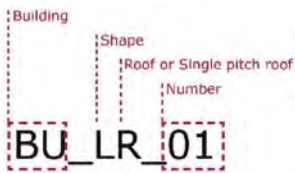
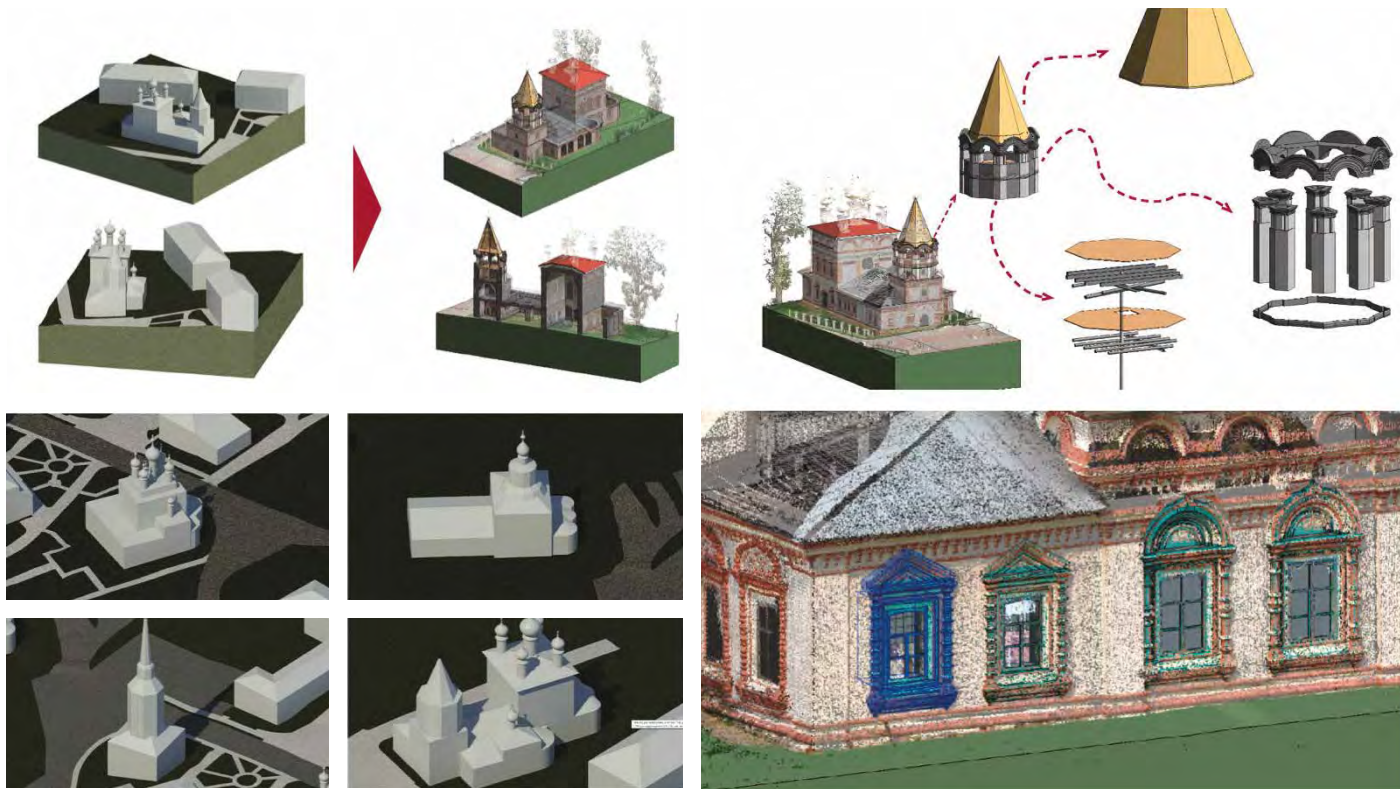


Fig. 07  
**Codification of buildings within the landscape model**  
 From the top: hierarchical decomposition of monumental landscape levels and the results of the architectural level modeling of the Epiphany church in Solikamsk district. Below, Building Units (BU), type of building (L-shaped, I-shaped, T-shaped or H-shaped), type of roof, number of building typology.

Next page Fig. 08  
**Definition of built and empty space**  
 Placement of buildings and urban furnitures into the parametric landscape. Below, list of codes and simplified models for defining the semantic model of the Solikamsk center.

A catalog of model indicators is being developed, resulting from the combination of landscape analysis data and instrumental acquisition data from the metric survey.

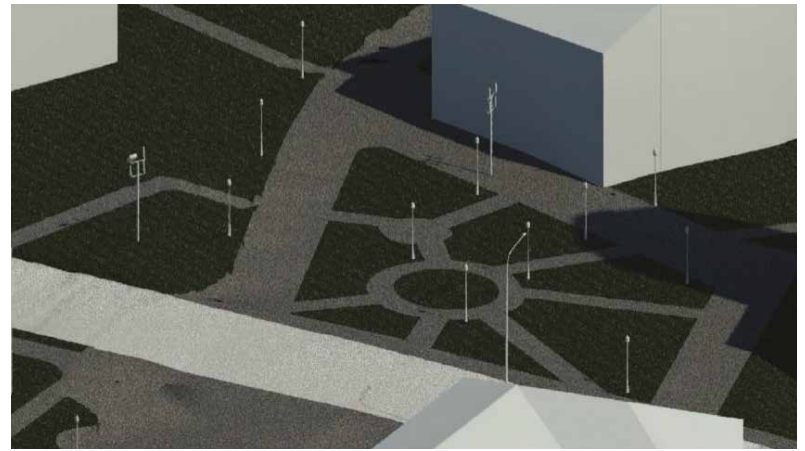
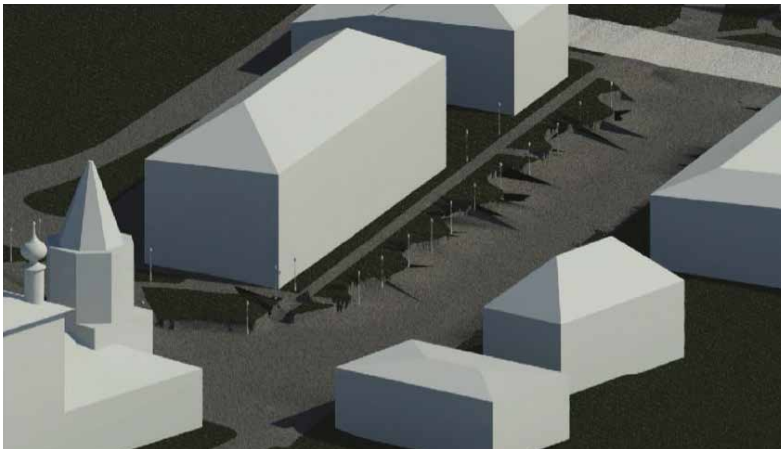
The structuring of a catalog of indicators represents a fundamental action for structuring the information network that will enrich the territorial survey's virtual model.

Within the model, the data will be distinguishable through a diversification between model components and information components.

Tangible functions will represent the model components, added to the model as a line-surface-solid shape. The natural physical (territorial morphology, hydrology, vegetation), anthropogenetic-natural (agricultural areas) characteristics will be distinguished through a specific symbol, plantations), and anthropogenetic (urban settlements, road network, infrastructure, cultural heritage, buildings, urban furniture). Such model components provide a representation vector for reading the various information levels associated with them.

The information components that will qualify the models will be the outcome of the analysis surveys, an instrumental acquisition of the survey activities, and the structured census action through the compilation of information sheets to collect data based on specific indicators at the landscape level, urban and architectural-technological. These indicators will be translated into compile-able model categories to structure model properties where alphanumeric, vector, and raster data can be stored, making it possible to query and analyze the components of the modeled system.

The catalog of indicators will be the initial step to highlight the possibilities of combining the different levels of model analysis to achieve an integrative systematic vision aimed at extra utilities from



Level	Category	Elements	ID	LOD	Parameters	Image Shape	File name	Extension	Drive Folder
LS	Buildings		BU_IS_01	100	L;W Roof H Floor H		BU_type0_I_1Floor_SinglePitchRoof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_IS_02	100	L;W Roof H Floor H		BU_type0_I_2Floor_SinglePitchRoof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_IS_03	100	L;W Roof H Floor H		BU_type0_I_3Floor_SinglePitchRoof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_IR_01	100	L;W Roof H Floor H		BU_type1_I_1Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_IR_02	100	L;W Roof H Floor H		BU_type1_I_2Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_IR_03	100	L;W Roof H Floor H		BU_type1_I_3Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_LR_01	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type2_L_1Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_LR_02	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type2_L_2Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_LR_03	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type2_L_3Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_HR_01	100	3 Sides L;W Roof H; Ridge L Floor H		BU_type3_H_1Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_HR_02	100	3 Sides L;W Roof H; Ridge L Floor H		BU_type3_H_2Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_HR_03	100	3 Sides L;W Roof H; Ridge L Floor H		BU_type3_H_3Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_TR_01	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type4_T_1Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_TR_02	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type4_T_2Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>
LS	Buildings		BU_TR_03	100	2 Sides L;W Roof H; Ridge L Floor H		BU_type4_T_3Floor_Roof	.rfa	<a href="https://drive.google.com/ops">https://drive.google.com/ops</a>



**Fig. 09**  
**Urban furniture list**

The importance of formalizing a standard modeling protocol for an organic result of the model design activities, in which the application aspects of the model and the information it must contain are decided.

In the image, typologies of public space furniture (es: street lamp).

territorial management to promoting the tourist offer. Through the connection of hyperlink structures, this multiscale reading system allows the description of a multidimensional landscape. It offers tangible quantitative results through the ability to use facilitated through the information transmission networks. The categories of indicators correspond to the landscape values strongly linked to their spatial and functional interrelationships. This structured system of models offers a valid alternative to traditional cataloging systems that see the different aspects disjoint from each other, without considering those characteristics or dynamics of the territory and the landscape that inevitably influence the services and characteristics that inevitably affect the spatial qualities of the place. To make a model structure easy to read, each feature takes the form of a specific modeling level, thus creating a set of values for evaluating the landscape as a resource.

The application of the methodological approach of Information Modeling to the Cultural Heritage sector opens up a potential range of applications. It gives the possibility of transmitting different quantities of data and the possibility of management thanks to integrating data on a territorial scale to that of the single building, extending from the architectural analysis to that of urban, territorial, and above all infrastructural planning. A context in which this strategy can represent a paradigm shift aimed at managing the complexity of the territorial structure more effectively.

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*The inhabitants of a territory never stop erasing the old book from the ground<sup>1</sup>.*  
A. Corboz

### Technological analysis and reading of Upper Kama monuments

The relationship between architecture and place could excite us to analyze and respond to physical-environmental aspects. Nature, understood as landscape, climate, orography, urban environment, architecture, urban planning, should be a constant source of architectural reflection and has been in the small towns we have visited along the Upper Kama river. The site has been well chosen. Full of open secrets, it is an open, friendly city that immediately invites visitors to want to know more about what they are seeing, rather than what they are feeling. The incomparable landscape of Kama river region does not leave anyone indifferent, especially if the visitor has a pencil in his hand, a heart that feels strong and the urgency to express himself, to make himself felt, before the constant signals he receives. And all this because architecture, in this case, has a voice and speaks to us, from the humble church to the renovated palace.

### Architecture as a point of reflection. project and memory

The built heritage constitutes not only a cultural heritage, but also a frame of reference of a disciplinary tradition inescapable for the architect. Let's start from a principle, for the case at hand, which will be "obligatory" for other similar ones: respect for pre-existences.

Knowing what exists includes knowledge of compositional knowledge, a historical analysis and therefore obtaining first-hand elements such as scale, proportion, rhythm, instruments that were originally in charge of formal and spatial design.

The architect can incorporate history into his memory, but not only by knowing it through specific references, or through certain anecdotes of the built past. Only when he is able to "metabolize" it in his memory, will he be able to give meaning to it and will have to rely on "epithelial"<sup>1</sup> level reaction. It will not be enough to be able to know with a glance the passage of time on the silent stones, the demolished and discolored walls, the missing elements but must be attentive to the voices of those who entered through the door, the noise they made as they sat moving the primitive seats or even try

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<sup>1</sup> Corboz (1985), *Il territorio come palinsesto*.

Side page Fig.01  
**Restoration of the Cathedral of the Trinity in Solikamsk**  
Construction sites highlight the structures and technologies associated with the construction of monumental complexes.



Figs. 02-03  
**Brick structure decay**  
collapse and superficial detachment from resistant masonry structures.





Figs. 04

#### Restoration activities

Replacement of the domes and preparation of the renovation of the facades of the central quadrilateral of the Cathedral of the Trinity in Solikamsk.

to imagine the smells of the stews they cooked, only in this way, permuted in time, will we be able to understand the function of the place, the habitat and the relationship of space with those who were its inhabitants. From that point of the interpretation of the facts, we will be able to arrive at alternative of intervention proposals. Let us say that we must know in order to create. And in Upper Kama, the proposals, the intervention project, is framed in a historical continuity that respects the past and with renewed freshness will present current, imaginative proposals, and hopefully, in most cases, will be useful.

An analysis of the particular formal language shown by the work, (the place, the churches), will give appropriate results, without great distensions or erroneous approaches. The project, in this case, will have an idea of historical continuity from which positive and novel experiences are extracted that must coexist with the weight of the past, to be concise with the weight of history. Therefore, will have to reflect on function, place, technique and culture and also respond to new challenges, such as the integration of environmental and sustainable concepts that will undoubtedly be part of our legacy in the future. From these assumptions where the past of place persists.

#### So, what's the starting point?

The answer is concrete: history, culture and heritage. Which teaches us almost everything, history that translates into the interpretation of the habitat. Therefore, one of the objectives of the project will be



↕  
**Fig. 05**  
**Restoration activities**  
 Interiors of the church of the  
 Transfiguration of the Savior in  
 Pyskor. On the right, details of  
 the stratification of the brick  
 wall and the plaster.

to have as a base a historical reference of the place and of the built heritage. Because without this, the arguments put forward may suffer from a certain logic, even being incompatible with the environment. That is why it is important not to lose the criterion that things do not only exist, they also have a meaning. There is a perfectly codified language in the architecture of the place and this, without a doubt, the interpretation of: where I am and what the place transmits to me... it would be a mistake, (unfortunately too frequent), to think: "This for me, means...". Therefore, let us fix the idea of: observation, thought and action.

Action without rivalry, without unfortunate encounters, between the existing, from a basic and primitive style to a more elaborate style, (or innovative), both are necessary in architecture. In this way, we will be able to create a hierarchy in the use of architectural elements for the future, with a defined reading for all the elements from the originals (what they were, mobile or not) and the conventional and ordinary ones, the important thing will be to apply them with order and sense. Here we will focus our attention on what I personally refer to as the specificity of construction and architectural technique. The technical dimension of architecture presents, compared to other artistic disciplines, a series of different features derived, fundamentally, from the determining and complex role that construction plays in this aesthetic field. Technique and architecture have always established a complex relationship in which both struggle for supremacy depending on the role assigned to each of them, in accordance with the different and varied architectural conceptions formulated throughout history. The importance

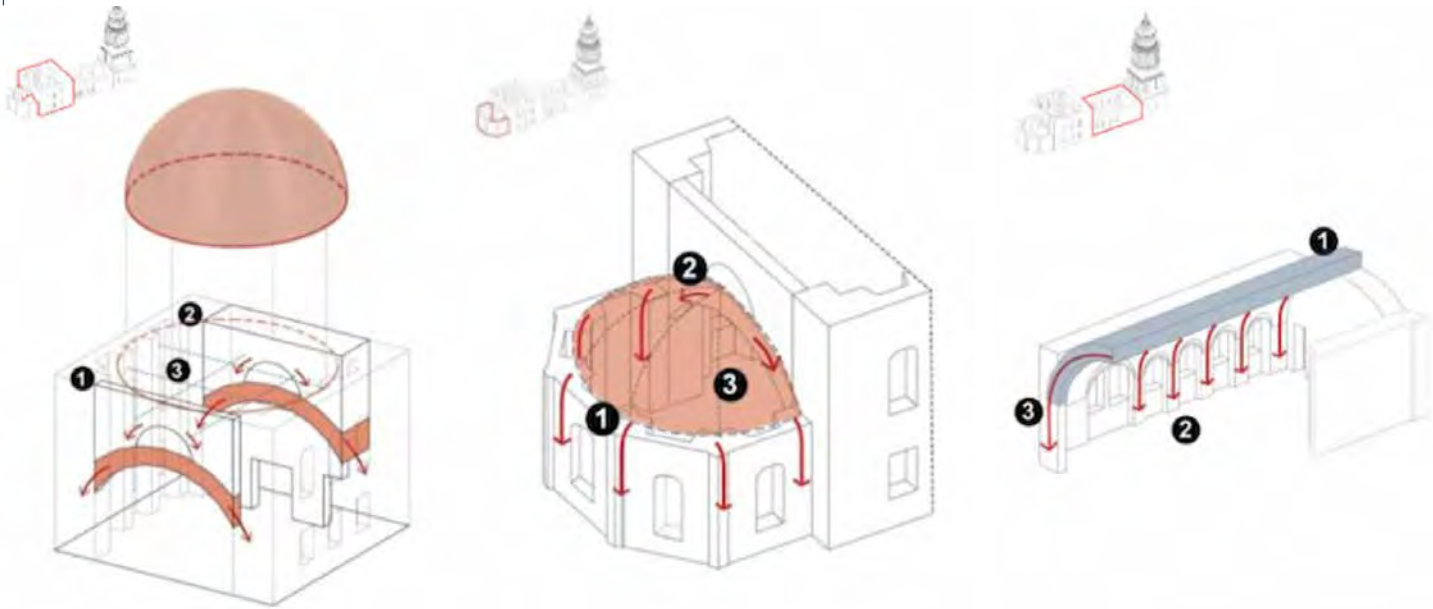


Fig.06

#### Overview of Load-Bearing Elements

The large dome rests on four walls; for the external ones, the walls between the windows are able to support the load. In the apse, the roof is semi-spherical, with the forces being transferred onto the pillars positioned between the windows. The vault of the central nave rests on two parallel walls running along the length of the structure.

of technique in architecture, making the materialization of the spatial idea possible, marks one of the first traits of its specificity and the singular character of construction. Others will be the capacity of architecture to enhance and transform technique, the value of the cultural meaning of the processes of materialization summed up in the ideas of stability, linkage to place and permanence.

#### Construction techniques and materials

The first characteristic we encounter when analyzing “material” culture is its universal presence in both space and time. The material remains therefore provide us with a chronological account of a place and a time directly related to historical memory and events. Likewise, these findings refer us not only to the object itself, but also to a group of social groups that placed their expertise at the service of society, in many cases with multipurpose and rich readings, as in the case in question.

Understanding the building as a context means having a unique reading of it, including the construction process, with all the elements involved, without setting aside others that do not apparently have a descriptive reason. This reading is based on criteria that are usually those relating to its use, to the space or architectural type and to the construction technique. This technique, whose most immediate definition could be the forms or ways of using the materials to make the structures, change over time depending on the training of the craftsmen, the geographical areas where they are located, as well as the use they are going to be put to. And it is here where we must deal with the architectural style of the construction. In our case study, it is a religious style, where large masses, great lights and monumental aspects predominate insofar as the building itself represents a religious and therefore social icon. These aspects are to some extent invariant to other European constructions, even though the Russian objects of study present very diverse and attractive particularities, but, in short, the structures of mass, the composition of arches and vaults and the unloading of weights on them make the solutions somewhat familiar to us. The use of materials, predominantly brick and stone as inert elements or wood for the structures make it possible to identify a constructive and rational style in accordance with the technology of the time, which crossed frontiers with a common and identifying language. On the other

hand, the tradition of what we know as the trades, those referring to other constituent materials of the complex, but without a structural function, also represent very rich aspects of local craft production. Therefore, if in terms of construction technique the basic elements are two: material and technique, the latter in terms of the way it is built, which is summed up in the Italian term *tecnica edilicia*, two other terms are also basic: the use, where these materials make up an architectural space with a specific purpose and which will define a specific construction technique, for example, the arches that make up a Renaissance cloister which in turn formalizes an architectural style and the other use refers to the social use of the space: a wall can first be the façade of a convent, and then become an interior corridor of a habitat of baroque cells, or as happens in many other monasteries, the space was first a chapter house and then became a stairwell. This reading, without being particularly related to the technological issue of the building in question, has an important impact and explains in many cases how the building has worked.

Likewise, knowing the production process of the buildings, i.e. the order in which they were constructed, offers the researcher a reading that serves as a visual guide (and on a natural scale), in order to be able to interpret a logical and effective conceptual succession. Thus, we will get to know each material element that occupies a place and what use it will support, giving information on the intentions of the builder, the way of understanding the building, as well as understanding the forms that act on it and how these interrelate between the parts.

The reading and interpretation presented by the religious style buildings on our route represent a very well-defined functional typology which we must analyze from the point of view of its importance as a “document” of the material and therefore constructive culture, to which we must show the utmost respect when intervening and conserving the remains that have come down to us. By respect we mean both the non-destruction and the non-imitation of certain elements that are susceptible to this question. In both cases, the study of material culture requires: that this legacy, which has come down to us today, be maintained and passed on to the future, even though in some cases we may be critical and think that some of the samples we might say represent are of little value. We must also ensure that the remains are kept in their original contextual unity, without breaking the material relationships that exist between them, in order to safeguard what has been found and, lastly, bear in mind that, if in any way a substantial loss of any element should be made, it should be dated and documented in order to preserve the memory of the place and of what was once there.

We have mentioned that the churches under study in our project already have constructive connotations very similar to those we know, their materials being stone, brick and wood, the former for the massive vertical structures and wood, which is very commonly used for floors, horizontal and inclined elements as trusses, as well as to form the supporting structures of the vaults, which deserve our attention in more detail.

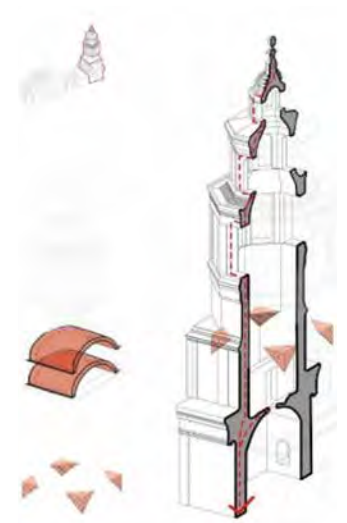


Fig. 07

**Force Distribution and Structural Analysis of Rubeskaya Church**

The structural system originates with a small masonry vault, above which rises the tower's upper section, composed of a timber-framed structure and a metal spire. The vertical and lateral loads from these elements are transferred through the vault to the underlying brick corbel (1). This corbel effectively redistributes the thrust forces downwards in a controlled manner. Three brick corbels are integrated at different elevations within the tower. Two of these are of a similar design, generating a stepped setback profile as the masonry walls recede progressively level by level. The third corbel (2') is unique, incorporating a complex geometrical transition from a rectangular to an octagonal plan, a key feature in this type of construction. (3) Below, a brick barrel vault forms the support for the first floor, further stabilising the load paths and contributing to the tower's overall structural integrity.



Fig. 08

**Condition of structures**

The photographs capture the present condition of the brick church structures, where crumbling masonry, exposed elements and collapsing sections testify to their long period of abandonment.

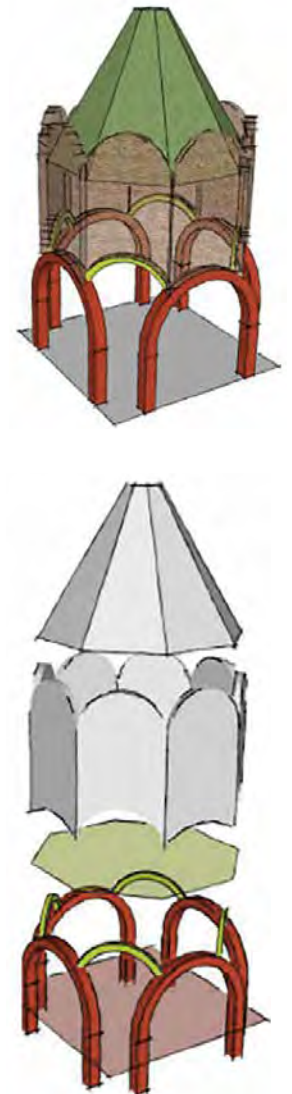
Choisy, in his *History of Architecture* of 1903, already said that the Roman vault is “moulded”, while the Byzantine vault is “built”, that is to say that it reaches its own stability through the use of the materials that compose it: the brick and by the action of these, one supported on the other, without the use of falsework.

This construction, which we have come across, is reminiscent of the Catalan vault construction system, which gives a plastic value and extreme lightness to the constructions. But going back to the cases we have found, we have analyzed that the stability was entrusted to the main brickwork, sometimes with a certain partial combination of stone, especially in the pillars of the vaulted structures, with joints where sometimes, instead of mortar, lead joints were used. Brick vaults were made by means of several “threads” which had additions to the mass of lime mortar to improve their adherence, an important issue as they were self-supporting elements that had to withstand great thrusts and tensions between them. Once they were finished, they were covered, depending on where they were located, with layers of lime mortar and then painted or with mortar that was then used for the varied and colourful decorations.

Our churches have been visited individually with the analysis and precise considerations to obtain data that, once converted into results, will give a new consideration of a very important social and popular aspect. The idea of defining a heritage, historical and architectural catalogue is something that gives us pride and satisfaction and makes our work beautiful and useful, but I would like to draw attention to a significant point: in many occasions the object of study attracts our attention and we go to it attracted like a magnet, without falling into the richness of the environment itself, since the monuments correspond to open spaces that dignify the object of study itself, the volume itself, in the considered project since, the landscape and nature in relation to sustainability and access for all people is an obligation for all in the management not only patrimonial but also neighbourhood and urban management.

The word volume refers to what we see from the outside, from the outside, while the word space is what we use when we refer to closed confined or simply interior places. Today, fashions have made these concepts unwise etymological changes of dubious taste, so we have: content and container, words used frequently and with little or no definition of what they intend to show. Undoubtedly, the spatial sensation is not only that corresponding to what we understand as closed, (we don't need a roof to confine the space), a square is a space closed by buildings...and by the sky as a roof. In this case, we perceive a continuity with the urban fabric, the streets adjacent to the square are like natural corridors, open, that let you glimpse the sky, nothing oppressive, nothing claustrophobic, the streets make natural distributors and exits. The word space presents many meanings, but in the case that interests us, it will always be linked to the dimensions of the same one and to the position in which one is, it is from here that we can use the term of compound form, that is to say, space-time. Our open space is the district of the different places visited. It is presented with established conditions, (morphologically speaking), which we will know how to value by our role of observers. The position will not be able to mutate, and therefore and for this case, we save assumptions, among others, of orientation or in preference location. Carvajal speaks of the disciplinary conditions of form, space, construction and order. They are dimensions of the project that the architect qualifies through his action. According to Carvajal, extradisciplinary conditions are those that affect the project from the outside. Because they are alien to a first intervention, they demand recognition before any mental or physical impulse about what we see or perceive. There is no choice, it is what is presented, it is what we have, it is what there is. We could classify these conditioning factors in function, place, technique and culture. Without entering into other suppositions, we will put our attention on the possible analysis of the enunciated concepts. It will also be useful for us as an initial guide, as a starting point, the possibility of pairing, this type of conditioners: Thus, almost unintentionally, we have the tandem: form-function, space-place, construction-technique and finally order with culture and heritage. These reflections, (always from the theoretical plane), do not solve the problem of creativity, (fundamental aspect without which there is no discourse), but at least point to a path of beginning in which the interrelations will gradually be adjusted. The approach towards the virtual materialization of the project idea. The knowledge and identification of what we have, helps to synthesize the project idea in an objective way, at the same time that we can have an argued criticism. This whole process of spatial and mental "location" will allow us to insist on the rational aspects of the project.

One of the most important issues when undertaking the study for possible intervention and recovery of a building is to know as accurately as possible all the parts that make it up, which will make the intervention, maintenance, and recovery tasks much more effective. In recent years, the possibility of using specific instrumentation and software is becoming essential in what we call the recovery and enhancement of architectural heritage.



**Fig.09**  
**Simplified structures diagram**  
 The image illustrating the structural decomposition of Kamgort Church, developed to guide the creation of parametric elements in line with the building's construction logic and load-bearing system.



**Fig. 10**  
**Structural Insights from Point Clouds**

The point cloud surveys made it possible to observe and measure even the smallest structural details, shedding light on the traditional construction techniques used in each church. To illustrate and interpret this information, a set of simplified structural diagrams was created for each building, highlighting the main load-bearing elements and construction methods.

The BIM methodology (Building Information Modeling) applied to heritage, already recognized globally by H-BIM, will be a fundamental help for the tasks and objectives that are addressed in the project, this, in turn, means the realization that carrying out a work of heritage enhancement, can not be understood without a multidisciplinary collaboration through which to combine efforts to achieve an optimal result.

Thus, on the one hand, we have a methodology (instrumentation and application software) with which to show results never thought of before, with advantages of easy interpretation, mainly because it presents a direct “visibility” of the object of study, but of equal importance is the field data collection, because it allows the knowledge of the “placement” or arrangement of the materials involved, their relationship with each other and compatibility with the construction system used, in short, an architectural-structural-technological relationship of the object, without which the above-mentioned visualization would not be possible. These data and information introduced to the model will guarantee adequate management and prudent and knowledgeable maintenance. Therefore, it is necessary to look for recognition towards what we could call a constructive retrospective, an as-built to know all the specific quantitative and qualitative characteristics of the object in question.

However, the “reading” of the building can not only accumulate a series of geometric data, i.e. constructive, but must also be reinforced with a historical background that serves as a premise for the future visualization has the most faithful character to its original state, therefore, should be taken into consideration as the ideal state would be one that not only represents the model under study in terms of a geometry say, “recovered”, but the realization of a database that accompanies the building should be another object inseparable from the first. Especially because in matters of future intervention and maintenance protocols, this information would be very important as much or almost more important than the attractive visual state that we are all accustomed to seeing.

### A case study of constructive knowledge

As we can see, one of the case studies can be the Church of Vladimir Icon Mother of God in Rubezhskaya in the locality of Usolye, which offers us the possibilities to be studied and analyzed on its architectural and constructive peculiarities. The monument is located in the north of the island of Usolye, in the vicinity of the Kama river itself. This small town was founded around 1606 as a salt-mining settlement of Novoye Usolye of the early 19th century, where there were more than forty salt wells. The Rubezhskaya church is part of the Usolye cathedral complex; it presents a dominant profile of the historical-architectural ensemble due to the relief and the surrounding landscape.

The Rubezhskaya church was built at the expense of Usolye clergymen Fyodor Korovin and Jacob Dyachkov in place of the wooden church that burned down on February 20, 1756, because of them. During the great fire of June 6, 1809, which devastated the town of New Usolye, the Vladimir church

again suffered a fire, after which it was restored and re-consecrated: Stephanovsky Chapel - September 13, 1809, Vladimir Church - May 28, 1812.

Rubezhskaya is a single-story church with a side altar, a two-light main temple, a pentagonal apse, refectory, and portico. In 1971 a seven-story bell tower was built, in the manner characteristic of Kama temples: three octagons of decreasing height were placed at the base of the square. Its construction dates back to the 1760s and its style is somewhat eclectic but corresponding to the Pseudo-Russian Orthodox style.

The composition of the church has a main nave with a barrel vault system. Adjacent there is a large dome and an apse that has a hemispherical vault. Finally, attached to the main nave there is a bell tower. Therefore, simply with these basic data taken in situ, we can get a fairly approximate idea of, for example, the architectural style to which it belongs by identifying it with the churches in the area and with the historical and documentary background that the researcher has previously obtained from reliable sources. Once this step is completed, and shifting the focus to the direct observation of the monument, the analysis moves towards understanding its construction. In this case, the constructive layout can be interpreted in terms of its load-bearing system, characterised by a vaulted structure with semicircular arches that transfer loads onto massive, thick walls capable of absorbing the structural forces, which remain relatively limited due to the modest scale of the monument. However, the stresses are distributed spatially in the case of vaults and semi-vaults, and oblique loads are distributed on walls. Likewise, if we observe the bell tower, it presents a constructive scheme of load distribution, which are dissipating along with its height, through thick walls, but distributing the loads employing vault pendentives that help and improve the mechanical behavior of the element as a whole until reaching the meeting point of the foundations. The supporting walls, in turn, present a studied mechanics where the resultant is coincident with the central third of its thickness, a question that makes the researcher think that the criteria of stability and mechanical behavior of the time were identical to those used in Western Europe.

Once we have reached the interpretation of the constructive language used, we continue with the reading of the state of the same; in terms of the materials that were used, their arrangement, or their current state. This last observation can be decisive given that due to the lesions, fissures, cracks, and pathologies we can obtain in terms of the physical-chemical properties will also provide a series of very valuable data to be able to specify definitive aspects for its later reconstruction a fairly faithful idea of what was the background of the building before its immediate ruin. The study of the materials will provide very important data, always distinguishing the function of the same, that is to say, those that have a purely structural mission of support and bearing and on the other hand those that depending on their disposition can provide data possibly not taken into account in a first formal revision. Thus, the case of the rigging can define its style, as well as certain formal and representational references from



**Fig. 11**  
**Structural analysis of Bondyug Church**  
 the building is constructed almost entirely as a traditional timber-frame structure. Using advanced 3D modelling techniques, a virtual reconstruction of the roof assembly has been developed, allowing the hypothesised geometry, joinery details and load-bearing behaviour of the original covering system to be studied and visualised.

other places where the tradition of its implementation may even have been “exported” to the current place of origin. Likewise, the reading of the central part of the keystone of an arch can provide data on its state of loads, the stresses it has undergone, or even on the constructive quality of its execution.

The case presented shows the possibility of analyzing the cladding, as well as the support of the cladding by looking at all the sores and tendrils of the bricks and therefore their arrangement, as well as the connections of the slabs which, as in the previous case, present a formal execution in a European style. Finally, the last photo shows the different brick threads that formalized the arch, giving thickness to the arch and with the bricks alternating with ropes in the function of the connections with the walls, taken with bastard mortars. All this is reflected in the various technical datasheets which can summarize the most important aspects of this data collection.

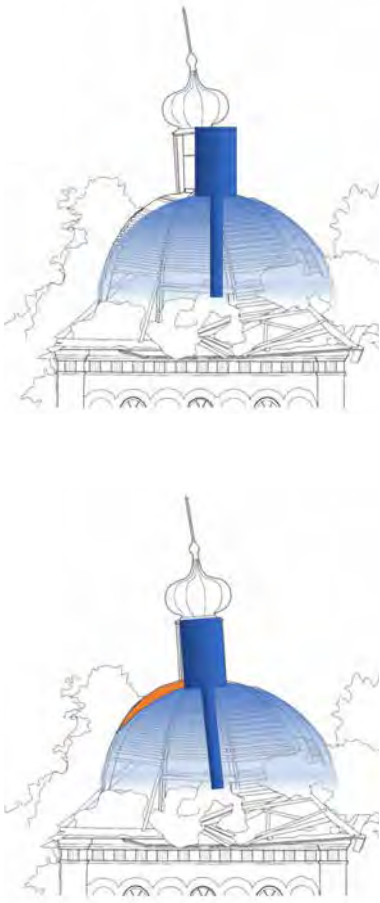
### Conclusion

For the training of an architect, Vitruvio’s thousand-year-old phrase would still be valid, which alludes to the experience of the work, as the rational thought of the project, which has to do with the constructive process itself, with the materials and the know-how when designing (*architectura nascitur ex fabrica et ratiocinatione*). Although in such a definition, it is not true that Vitruvio prefers the factory, the quarry, the obtaining of materials, their treatment, water, sand, etc., it is necessary not to forget for future actions in the place, to understand the existing mechanisms themselves, that is to say, the constructive and constitutive, (massive) and material systems. It will be essential to guarantee the permanence of the material authenticity referring to the collective patrimony of the place. The fact is that architecture, like us, has its own individual body that develops over time in a continuous process of accumulation and subtraction (wear and tear), generated by society and the culture that goes through it, leaving permanent signs of its own pace. Architecture, Vitruvio continues, has two fundamental elements, the signifier and the signified, that is, what the work means, and how it is received.

They are ideas for reflection. From the famous vitruvian triad, for more than 150 years that the third term, (*utilitas, firmitas, venustas*), has been losing, in a certain way, its identity, and more, since when Rosenkratz, (philosopher and disciple of Hegel), in his praise to the “Aesthetics of the ugly” raises an important controversy and reflection to bring the ugly to the center of the discussion. His discourse is not banal, nor autonomous, because it shows that the beautiful is related to the good, when the ugly does not have to be bad.

All these questions are the effects of epidermis, of feeling before acting, of knowing before deciding, they are only observations, to be able to reflect and to be able to find solutions according to our most personal concerns.

Finally, a consideration-reflection to take into account and which will undoubtedly be valid: the tourism of the architectural heritage. In the midst of the democratization and integration of heritage,



**Fig.12**  
**Structural analysis of Bondyug Church**

The digital model allowed the assessment and formulation of hypotheses on potential structural instabilities, including crack propagation, differential settlements, and load redistribution mechanisms affecting the dome.

conservation has collaterally provoked a social-spatial displacement of the most vulnerable social strata. Mass tourism “consumes” heritage, whose values and meanings are not understood by visitors, who only consider the idea of monument and stage. Although on the other hand, this idea is also changing because it is true that the importance of tourism is an added value, which has served for the rehabilitation of historic centers, or historical monuments like our precious churches of Upper and for the social and economic improvement of the place.

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### **The analysis of construction and technological features from the historical apparatuses of Upper Kama**

The research experience in Upper Kama has foreseen the creation of a system of analysis for damages and conservation conditions of buildings belonging to the traditional architecture of the route. The purpose of collecting and interpreting the constructive characters of monumental churches has been assumed as preliminary action to the definition of descriptors about architectural features, and to the wider creation of digital census cards for a database management of Upper Kama heritage.

Concerning the overall purpose of the international collaboration project, the contribution apported by the experience in historical building construction has characterized the field of technological and constructive analysis of architectural heritage.

Regarding the preliminary analyses conducted on site, observations and critical reflections have been made on the material relationship between monuments, constructive traditions, and environmental context.

In this way, a first relevant background of direct knowledge has been established to direct the analysis on the historical documentation archives, towards the identification and selection of those construction events of monuments which have more characterized their evolution in the territorial administration. From these preliminary actions, it has been possible to develop a first technical report on the most suitable typological descriptors for the characterization of the specific cultural route. This action has taken place in parallel with the identification of the boundaries of the Upper Kama pilot area. Also, at the same time, it has delimited and focused the objectives of research and classification of the documented site along the route.

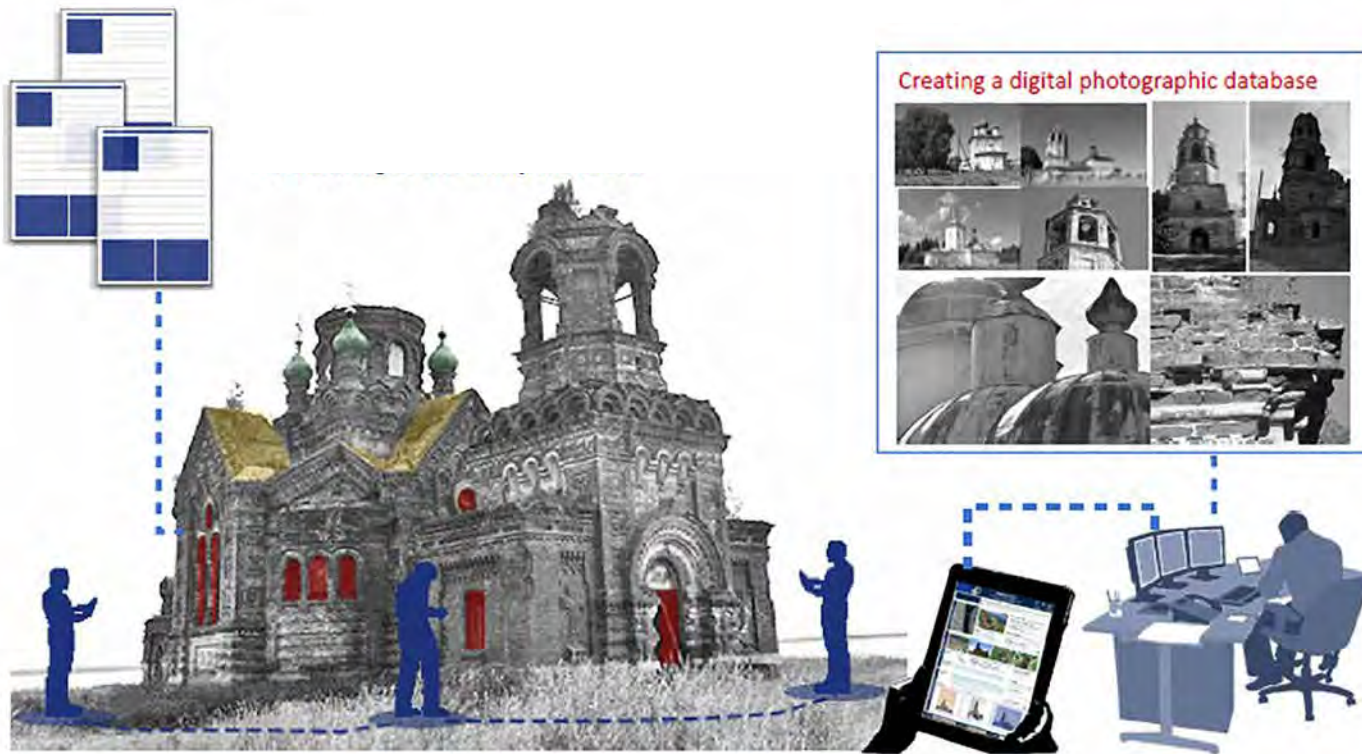
In this perspective, the constructive and technological analysis has been developed starting from a structured knowledge program. Then, it has been detailed and declined in a more specific way, both in relation to the chosen case study and to the specific extended territorial dimension of the Cultural Heritage Route.


In order to set a cutting-edge knowledge on the territorial pre-existence of the religious sites, different factors have been studied, with direct and determining influence on the architectural phases and features of the monumental churches.

*Side page Fig.01*

#### **Façade detail and material decay**

Detail of the façade of the Church of the Nativity of John the Baptist (St. John the Baptist Krasnoselsky Convent), showing material degradation, plaster detachment, and exposed brickwork.




**Fig. 02**  
**Structural analysis of the Church**  
 The digital model allows the assessment and formulation of hypotheses on potential structural instabilities, including crack propagation, differential settlements, and load redistribution mechanisms affecting the dome.

These factors have dealt with various issues, such as:

- Historical context, considered both in its Social, Political, Cultural, Artistic, and Economic aspects.
- Constructive technology, referring to the technical knowledge of architectural periods related to the art of construction (technical needs and limitations).

In general, the following questions have been answered with their respective information:

- **Who is it?** Given answer in here to the chronology or the date about when the monument has been built.
- **Why?** Concerning to the functional needs of the period that have supported the foundation and development of the building, till to the conclusion of its construction site.
- **What?** Referring to the architectural typology and the composition of its design among centuries and reference constructors or architects.
- **How?** About the applied constructive solutions and their correlation with architectural value and typological assumption.

Finally, at the end of this preliminary report, it has been possible to recognize architectural forms and associated structural systems.


### **The on-site experience as preliminary survey of historical apparatuses for conservation interventions**

When considering the aims and purposes of constructive analysis, it is relevant to assume that a building is something “alive”. Besides each building, there is the result of a balanced consideration between architectural and constructive aspects, that have also been stratified and adopted in different arrangements in the case of historical buildings that have developed among 2-3 centuries.



Therefore, it is important to know, first, the main aesthetic trends of the period, and, secondary but not least, the characteristics of Upper Kama dominant typological models and their conditioning factors.

Therefore, the main objectives of constructive analysis have been established:  
 the specific analysis of different constructive elements located in the building.  
 the identification of the overall construction systems involved in the materialisation and execution of these construction elements (construction techniques, materials, auxiliary equipment and the process followed in the execution).


**Fig. 03**  
**On-site survey and documentation activities**  
 Fieldwork operations including laser scanning, photographic acquisition, and direct inspection, supporting the technological and constructive analysis of architectural heritage.

## Materials



↑  
**Fig. 04**  
**Materials and construction techniques**  
 Overview of construction materials and masonry techniques.

In support of the traditional processes of documentation of architecture and territory, the knowledge on the relationship between construction systems and cultural traditions of Upper Kama has oriented the on-site investigations. The joint activities of research have been managed to derive a correct evaluation of the technological design characteristics, addressing their influence in the current state of conservation of monuments.

The on-site research activities have been conducted as first task of a direct census campaign in the sites of the cultural route, with both external and internal inspections of individual monuments and ruins, in collaboration with local administrations. The exchange of knowledge between Architectural, Constructive and Route scales of documentation has made it possible to integrate competences in the calibration of digital and territorial documentation systems, contributing to these processes in the acquisition of specific information necessary for technological and constructive analysis.

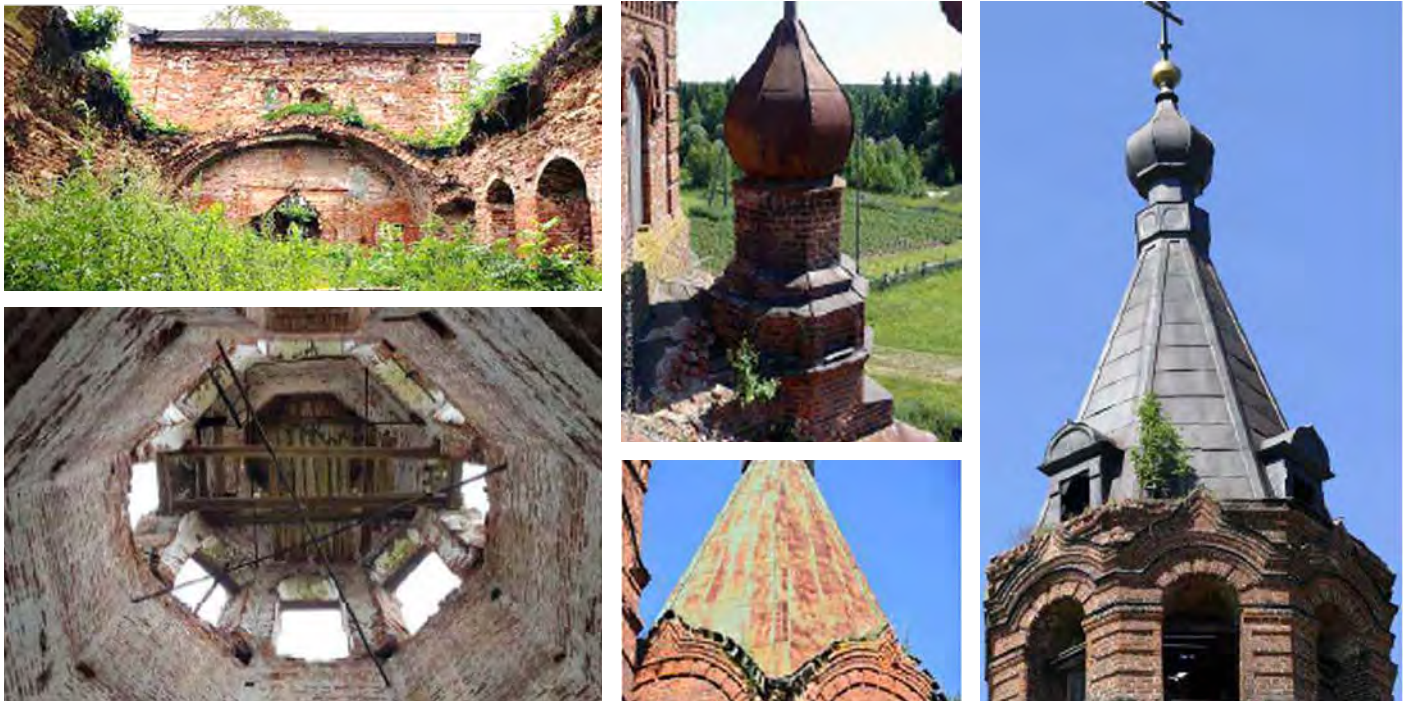
The research conducted during the on-site documentation campaign has allowed the collection of architectural and territorial data, defining an inventory of technological and constructive characteristics on buildings and materials.

Basing on a critical orientation on the historical evolution of the sites, and within a preliminary assessment of damage patterns and archaeological classification, the first phase of research has reconstructed a database of technological characteristics, and building modules found on the Cultural Heritage Route of Upper Kama. This archive has been digitally structured, with the support of census layouts specifically developed for the European project, as result of the exchange of skills and specializations within the field of Heritage Databases.

Within this archive, the technological analysis has been structured for church set analysis, typological analysis, technological description, and pathology analysis, including:

- analysis of the different materials found in the building;

## Roof



- analysis of the different typologies of horizontal structure, vaulted system, roof, domes, such as the typical Russian onion dome, stairs, and opening arches;
- analysis of the different openings, and carpentry;
- finishings/coverings, decorative elements, and singular elements;
- pathological analysis, not only external, but also internal.

In the mapping, all pathologies affecting mechanical and environmental effects have been covered, considering how the evaluation of the technological aspect of historical heritage is deeply affected in the overall construction system by its lack of permanence over time.

The summary of considerations on the constructive knowledge dedicated for buildings and site of Upper Kama Route has included different constructive aspects for the census. Three categories have been established according to their relevance degree within the building itself, integrated with an overall consideration on the conservation and decay conditions:

Primary System, which includes the structural elements that provide stability to the building and protection from nature actions.

Secondary System, which includes those elements that are generally contained in the building, necessary to its constructive unity, such as those that contribute to protect from external agents, communicate vertically, provide lighting, provide durability, etc.

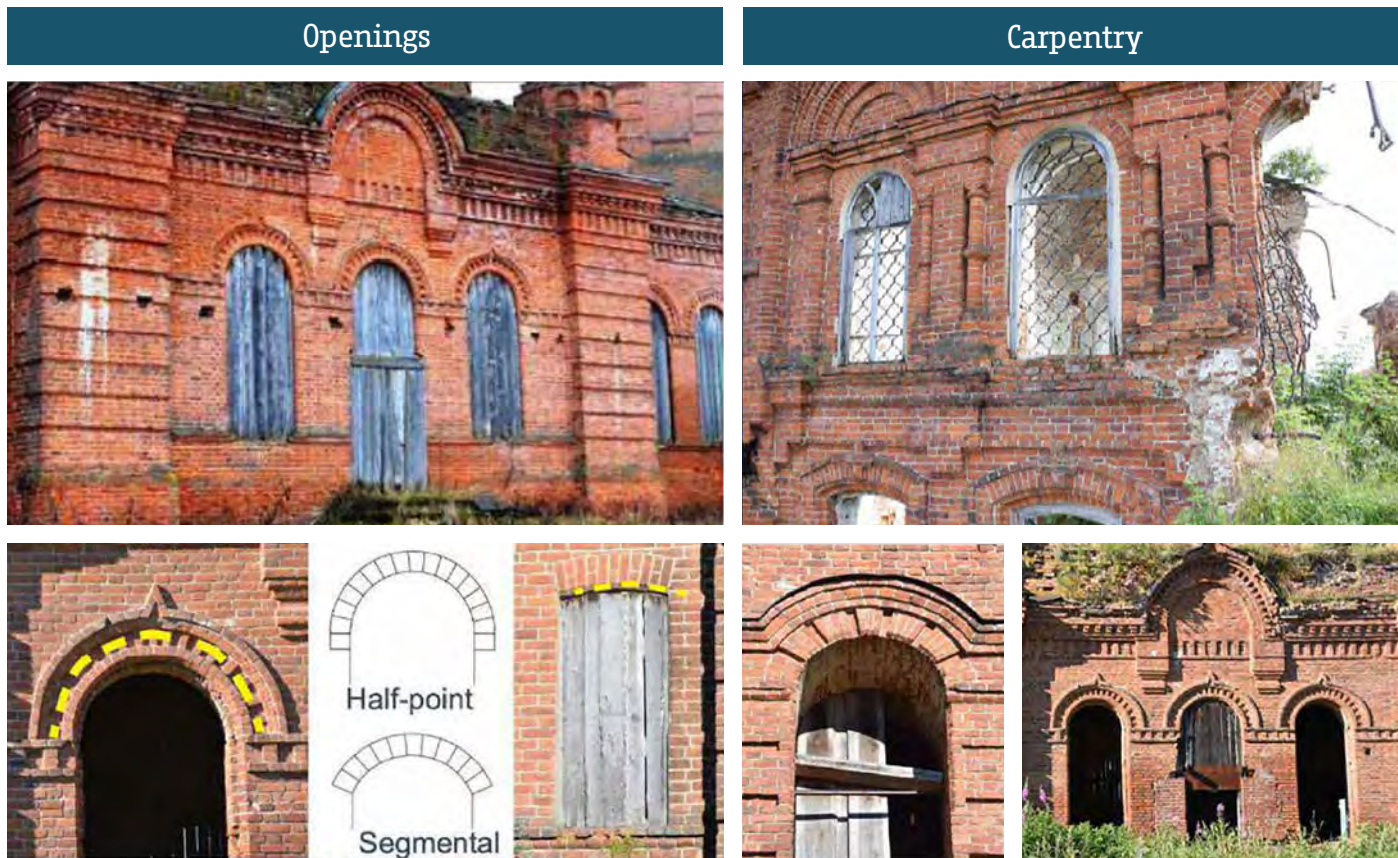
Complementary Elements, considering in this case those that would not be strictly necessary, such as the decorative ones, or those that offer security protection. Singular elements of the building are included in this point as well.



*Fig. 05*

### **Roof systems and dome structures**

Examples of roofing systems and domes, including traditional Russian onion domes, illustrating structural configurations and their conservation conditions.



**Fig. 06**  
**Openings and carpentry systems**

Analysis of openings, arches and carpentry elements, highlighting typological variations and construction solutions within the architectural system.

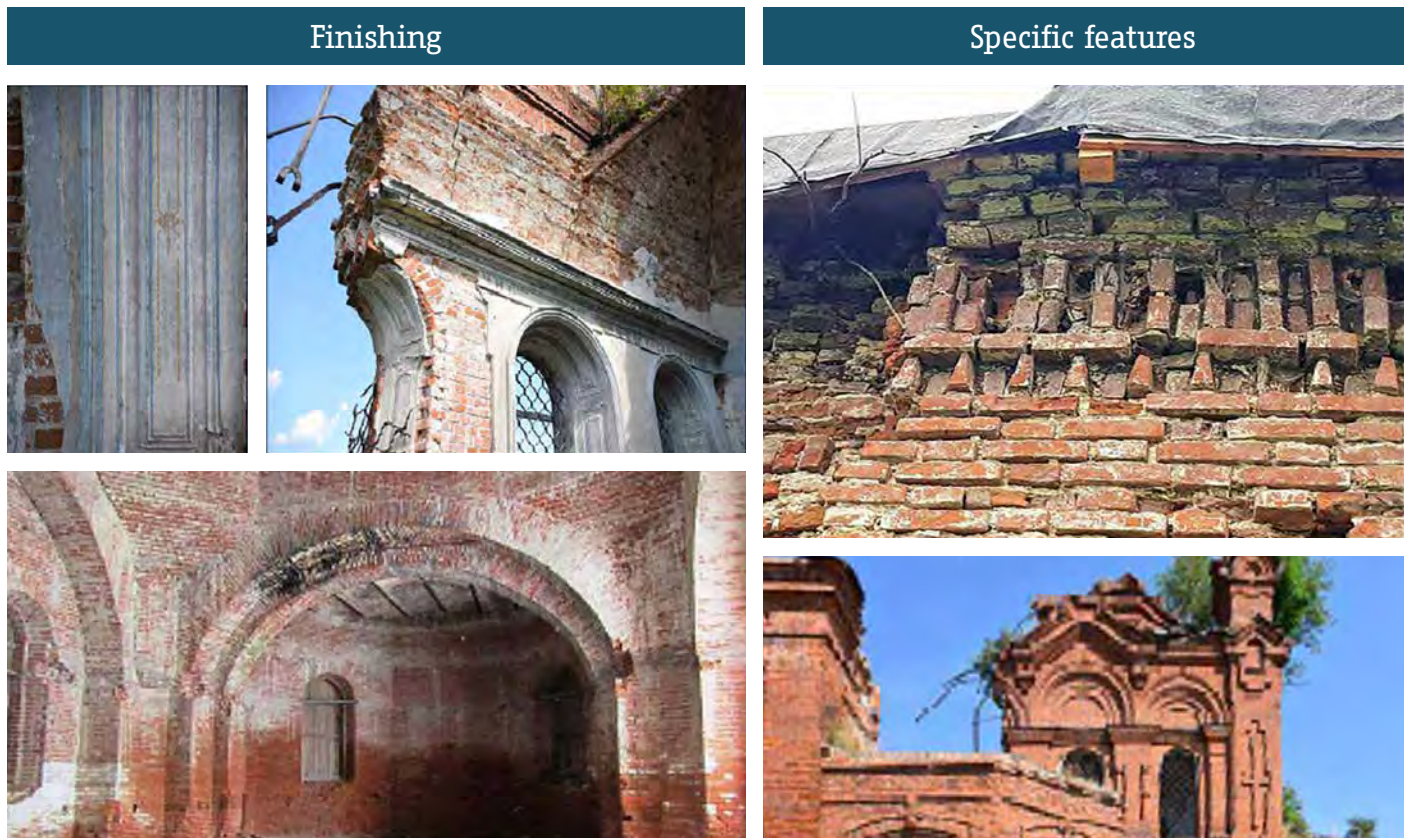
In addition, the Pathological Study of these constructions over time is seen not only from the external manifestations, visible and easy to understand, but also considering the result of the compatibility of materials. Those conservation pathologies inherent to the construction systems have been listed, from the information collected to the rigorous “in situ” visual analysis. In this way, the different types of pathologies have been determined, both typologically and considering their specific location, to deeply understand the reasons of exposure to natural and biological environments and their increase in time.

The structure of the pathological analysis census template has been developed in according to the terminology and European Heritage References presented by ICOMOS Guidelines, and it is proposed basically with the following information:

General Diagnosis, with the content of general schemes or drawings and a list of pathologies that globally cover the monument or building site.

Specific Analysis, where each pathology is developed in a graphical and visual way, using schemes or drawings and photographs.

Pathologies of degradation and damage characters have provided for a careful coding and schematization conducted on each monument. This task has developed a first stage of information linked to 2D classification elaborates for the sites of the Cultural Heritage Route.



### Database applications for an extended census campaign: towards an informative system

The joint research, developed by the interdisciplinary team, has led to the preliminary definition of an extremely heterogeneous and complex data flowchart for analysis. Starting from the interdisciplinary approach between technology, history, conservation and legislation of architecture, the research objective of the PROMETHEUS group has been to develop a unified strategy for site evaluation, preservation, and involvement of stakeholders, aimed to reach the implication of administrators and local heritage premises. The adoption of a digital database for the management of information flows has been evaluated to set an on-site collection of direct data (texts and images) in a more immediate and structured way. The objectives of knowledge and direct documentation of the relevant components for the technological and construction system of the historic buildings have been managed similarly to the growth and structuring of a “cognitive map” on the monument-site architectural systems. In this system, conceived in terms of a digital “information system”, data are automatically and immediately revised in a query grammar which is the basic workflow both to the achievement of logical results and to the development of collaborative deductions and transfer of knowledge between researchers.

In this sense, the observations and notes directly collected and archived during on-site activities in Upper Kama are subjected to an immediate aggregation, grouping and filtering as set by the census layout. Furthermore, automatic data flows are created, that influence the generation of new knowledge and

Fig. 07  
**Surface finishes and decorative elements**  
 Documentation of finishing layers and decorative brickwork, supporting the identification of construction phases and material decay patterns.

**PROMETHEUS**  
PROMETHEUS for information Models Libraries Tested on HEritage of Upper Kama Sites

District: [Dropdown] Local Name: [Text]  
Name: [Text]

**GENERAL INFORMATION**

Map [Image]  
Settlement: [Text]  
GPS Lat.: [Text] Lon.: [Text]

Date of construction: [Text]  
UNESCO affiliation: [yes] [no]  
State registry n°: [Text]  
Buffer Zone presence: [yes] [no]  
Category: [Dropdown]  
Legal status of protection: [Dropdown]

**VISUAL DESCRIPTION**

Fields: [Image] [Image] [Image] [Image]  
Volume: [Simplex] [Complex] [Undefinable]  
Compositional role within the ensemble: [Primary] [Secondary] [Facility] [Altro...]  
Visibility: [Dropdown]  
Surroundings description: [Text]

**HISTORIC INFORMATION**

Architect: [Text] Customer: [Text]  
Historical main notes: [Text]  
Changes of function: [Museum] [Commercial] [Industrial] [Residential] [Storage] [Administrative] [Medical] [Cultural] [Educational] [Altro...]  
Current function: [Dropdown]  
Ownership: [Dropdown] User: [Text]

Compiler: [Text] Survey date: [Text] Update date: [Text]

### Classes of census information data

#### FREE TEXT FIELDS

**Historical main notes**

.....  
.....  
.....  
.....

#### OPTION FIELDS

**Settlement** [Text]  
**GPS** Lat. [Text]  
Lon. [Text]

**ORIENTED ON CONTENTS**  
Define THEMES and KEYWORDS that can guide the QUALITATIVE COHERENCE of the information

**Changes of function**

Museum Commercial  
Industrial Residential  
Storage Administrative  
Medical Cultural  
Educational Altro...

**Visibility**

Wide  from river  
Partial  from hill  
Hidden  from main road  
 from secondary road

**Legal status of protection**

[Dropdown]  
Federal significance  
Regional significance  
Municipal significance  
no status  
Modifica...

**ORIENTED ON VALUES**  
Define PARAMETERS and WEIGHTS that can compose the QUANTITATIVE EVALUATION of the information

↑  
**Fig. 08**  
**Census data structure and information classes**  
Structure of the digital census system, defining data fields, descriptors and classification criteria for the management and querying of heritage information.

relationships between information. As qualitative data are properly inserted in flow grids and weight algorithms, they can be translated into quantitative parameters and generate evaluation criteria as well as identifying classes for intervention and emergency assets.

The design of an ad-hoc census database for the Upper Kama assets aims to make the information produced more accessible. This task is based on the principles of “sharing” and “connection” of data in post-production between multiple users, such as, primarily, the working groups involved in the international project. But the application is also designed in the dimension of users external to the network and in the aim of future reapplications on Cultural Heritage Routes. International protocols are called to involve personnel and collaborators that are distributed not only among sectors and professionally, but also geographically, and often unable to directly verify the conditions of built heritage.

The layout adopted for the census system defines a basis for the methods of viewing and querying of the archive, in the format of a card with sections and fields for further information. At the same time, its semantic structure is based on a digital cognitive map stored in the database, introducing development opportunities such as the integration of Geographic Information platforms to build thematic maps for typological and emergency intervention on the territory. In order to collect the data, sections and fields have been structured in query format, with descriptors and value lists, as well as fields for storing graphic and photographic contents.

## Cultural Heritage Route Cataloguing System

# PROMETHEUS

PROtocols for information Models librariEs Tested  
on HEritage of Upper Kama Sites

CH – 001

District Cherdyn
Local Name Церковь Всех Святых

Name Church of All Saints

**UPPER KAMA CULTURAL HERITAGE ROUTE**  
Documentation of monumental religious complexes in Cherdyn district

SITE	PHOTO	PHOTO	PHOTO	PHOTO	PHOTO
1. CHURCH OF THE RESURRECTION OF CHRIST (Church of the Resurrection of Christ) (1860-1865, 1870-1875) (1870-1875)					
2. CHURCH OF THE PROCESSION OF THE HOLY SPIRIT (Church of the Holy Spirit) (1870-1875)					
3. CHURCH OF THE ASSUMPTION OF THE HOLY VIRGIN (Church of the Assumption of the Holy Virgin) (1870-1875)					
4. CHURCH OF SAINTS (Church of Saints) (1870-1875)					
5. CHURCH OF THE BIRTH OF CHRIST (Church of the Birth of Christ) (1870-1875)					
6. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
7. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
8. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
9. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
10. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
11. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
12. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
13. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
14. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
15. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
16. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
17. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
18. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
19. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					
20. CHURCH OF THE BIRTH OF THE HOLY KING (Church of the Birth of the Holy King) (1870-1875)					

### Conclusions

The joint international research has expressed on sharing points and barriers to common languages for the use of “smart environments” as a support to the evolution of processes for the documentation, management and monitoring of the historical heritage of Upper Kama. The objectives of non-destructive diagnostics and improvement of safety and accessibility on the territory have been considered.

The cooperation within the international research team has supported the identification of correspondences between construction materials and damage mechanisms within the conservation status of the monuments. This collaboration has been also extended to an in-depth research on the most appropriate cognitive-graphic representation codes for the synthesis of the information collected, and to their referencing in the technical documents developed on the sites. The search for the overall typological classification of the route has proved to be a prerequisite for setting up targeted diagnostic investigations, and to establish the basis of the 3D Modelling information system.

Furthermore, specific analysis has been planned to integrate the on-site census, with more advanced research processes on the digital data directly acquired, such as metric and shape information from architectural survey, structural behaviour of monuments and historical ruins.

**Fig. 09**  
**Cultural Heritage Route cataloguing system**  
Integrated system for cataloguing heritage sites along the Upper Kama route, combining geographic mapping and database information for analysis and management.

The features of Data Visualization adopted to collect and preserve the heterogeneity of data and their critical interactions introduce a reflection on the opportunities of “design” of the database to support such data, and on the development of more or less abstract models and information systems that will collect and finalize such management systems.

The objective of development for the census system is to improve the representation of such transversal knowledge and their interconnection, from the technological-constructive system to the historical and architectural sectors involved, reducing the cognitive efforts of the participants, as well as of the users, in the process of integration and exchange. The appropriate representation of the knowledge collected on the Upper Kama Cultural Heritage Route is part of the optimization and impact solution of the data stored within the census towards users.

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The objective of the research conducted by the authors of this contribution for SISMA is to design a typological classification system for the churches of the Upper Kama region. The starting point for this classification was the study of the methods theorized and utilized by Francesco Doglioni, later revisited by Antonio Giuffrè, which are based on successive phases of in-depth analysis. The process begins with studying the layout of the building, followed by an analysis of macro-elements, and concludes with an in-depth examination of the individual technological elements that compose them.

The “material history of the built environment” studies and investigates buildings as physical sources but also utilizes documentary sources to clarify the production relationships and usage modes as historically determined in the societies where the buildings were erected, used, and modified. This contribution aims to provide guidelines for developing a knowledge-based process for analyzing the churches under study, with particular attention to identifying the construction elements to determine the primary structural macro-elements.

The methodological process for understanding the general characteristics of the structural organism responsible for static and seismic resistance, including non-structural components, involves a well-defined analysis of the conservation state of the buildings examined. The evaluations proposed in this contribution aim to highlight the main characteristics of the structures, specifically the degree of uniformity of deformations and their magnitude, as well as the static regime under vertical loads.

The first part of this knowledge acquisition process involves developing:

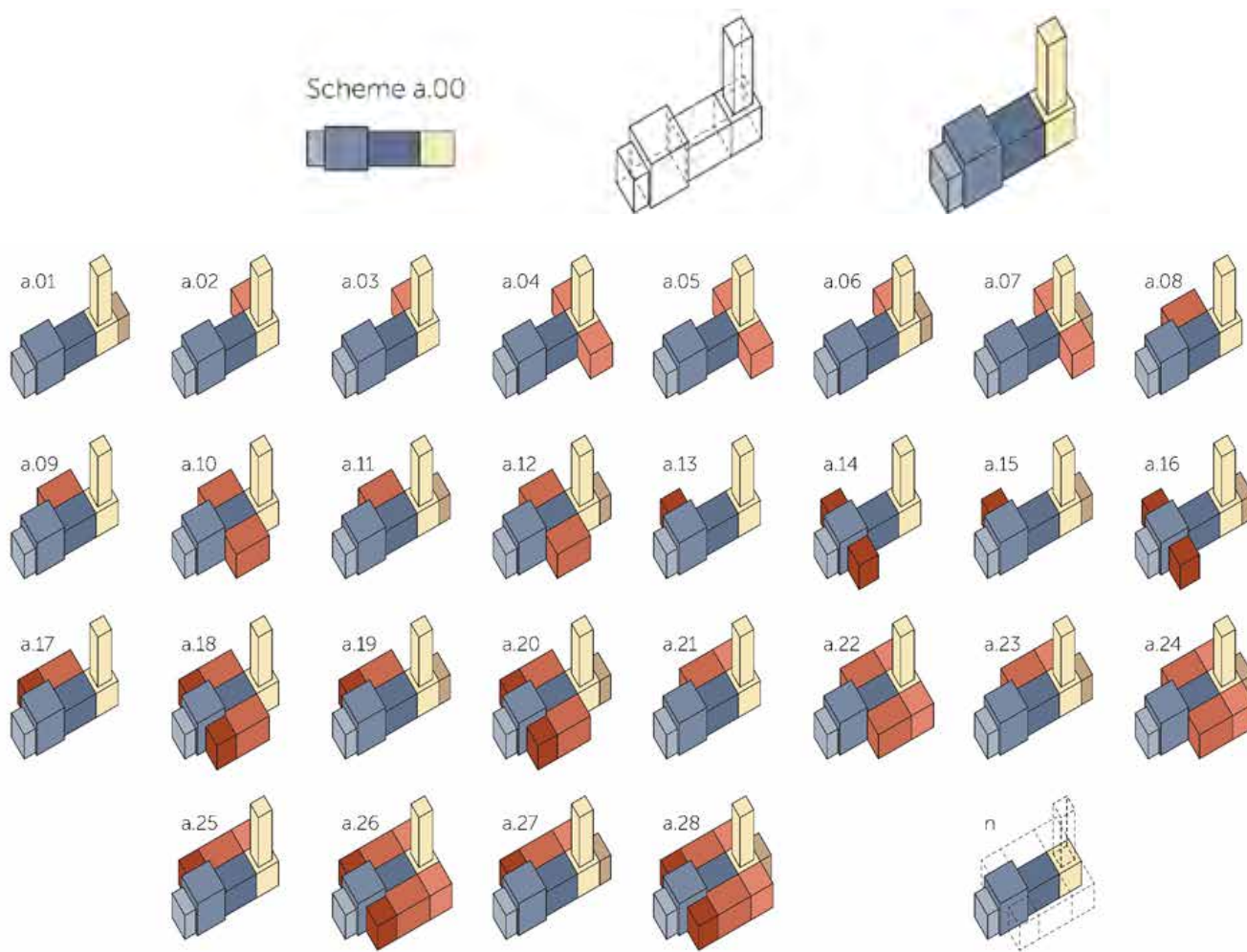
- *a thorough historical-documentary research* aimed at reconstructing the architectural and structural design process, the construction aspects during its realization, and the subsequent modifications over time. In this phase, particular importance is given to events (static and seismic damage) that have affected the structure.
- architectural and structural surveys accompanied by detailed analyses of the construction elements and assessments of the mechanical properties of materials.

These initial two phases are complemented by analyses of materials and their architectural degradation, construction techniques, and their structural degradation state. Based on this information, indications are provided on which elements to focus investigations and testing. These initial phases of work have been largely developed by the interdisciplinary research group carrying out this project.

*Side page Fig.01*

**State of conservation**

View of the Church of the Blessed Virgin of Kamgort, showing advanced decay conditions, with material deterioration and structural instability affecting masonry walls, roofing systems, and vertical elements.



↑  
Above and next Pages Fig. 02-05  
**Typological abacus of macro-elements**

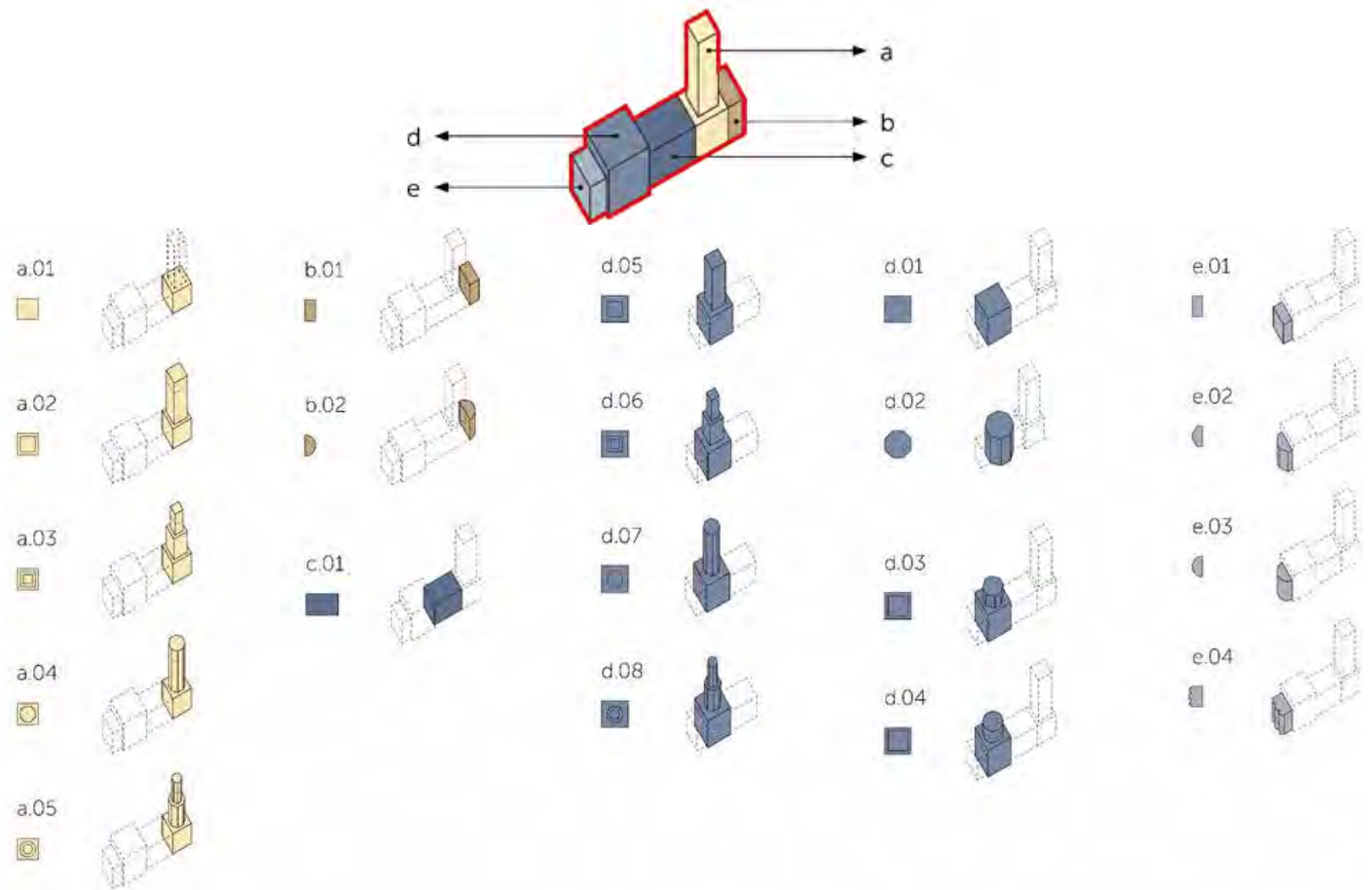
Abacus of structural macro-elements and their configurational variations, supporting the identification of recurring typological patterns in Upper Kama church architecture.

The choice of models for conducting structural verifications presupposes a deep understanding of the construction, not only geometric but also technological and structural. By examining the construction phases, transformations, interlocking, connections, and the characteristics of horizontal elements, it is possible to identify the main local mechanisms to consider when evaluating safety and conservation status. The global model also requires choices that involve diagnostic investigations, both for a proper definition of geometry and constraints and for assigning the mechanical properties of materials, specifically the stress performances used in static and seismic verifications.

In the preliminary phase, the analysis of damage is particularly significant:

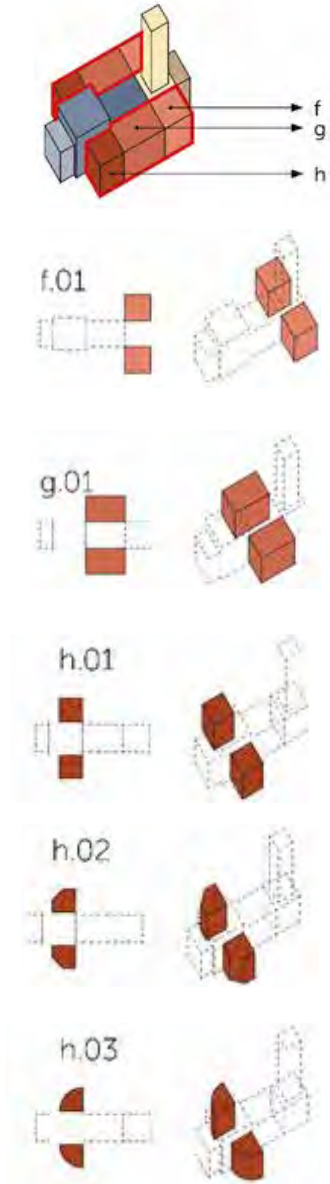
- Cracks
- Deformations: these must also be assessed in light of the quality and conservation state of the materials and the architectural and structural elements. Identifying the characteristics of structural nodes—corner, T, and cross connections, and those in elevation; wall-to-floor joints—is crucial for evaluating box behavior and structural regularity.

In this specific case, exploratory tests to verify the dimensions and characteristics of non-visible structures (foundations, floors, and masonry covered by plaster) were not necessary since some of the buildings analyzed are in a state of ruin, and the construction type is repetitive.



When constructing the structural survey and the corresponding structural model, the following construction details must be carefully evaluated:

- Types of horizontal elements: construction technology, orientation of beams, flooring stratigraphy; in the case of vaults, thickness at the crown and spring, presence of reinforcements or fillings.
- Vertical connection systems (e.g., staircases), focusing on their in-plane rigidity.
- Roof types: connections, thrusting or non-thrusting systems.
- Presence of niches, cavities, or blocked openings in the walls.
- Quality of connections between vertical walls.
- Quality of connections between horizontal elements and walls, and any presence and effectiveness of floor girders or other connecting devices.
- Existence of structurally efficient lintels above openings.
- Presence of structurally efficient elements designed to eliminate potential thrust forces.
- Presence of highly vulnerable elements (e.g., tall partitions, heavy suspended ceilings).
- Presence and structural efficiency of tie rods.
- Masonry type (single-layer, multi-layer with or without core infill, with or without transverse connections, etc.) and its construction characteristics (made of artificial elements or stone, regular or irregular, etc.).
- Foundation types and dimensions.



The mechanical characterization of materials aims to determine deformability and resistance parameters necessary for modeling structural behavior. For masonry structures, this aspect is closely tied to material surveys and specific diagnostic investigations. Recognizing the construction characteristics of the masonry can aid in assigning an appropriate typological class, based on which reference values for mechanical properties can be assumed, as provided in literature or normative documents for similar types. Mechanical property characterization should be investigated for at least one representative wall panel of each masonry type. Reliable characterization of resistance and stiffness properties is generally achievable through destructive experimental tests (compression, shear-compression, diagonal shear), which provide direct characterization.

In identifying possible sacrificial areas for destructive analyses, the outcomes of historical research and transformations of the structure can be taken into account.

Italian regulations emphasize the importance of the diagnostic phase by defining levels of knowledge. This regulatory approach, however, can become part of good practices internationally for analyzing historic structures. The quality of investigations determines the levels of knowledge:

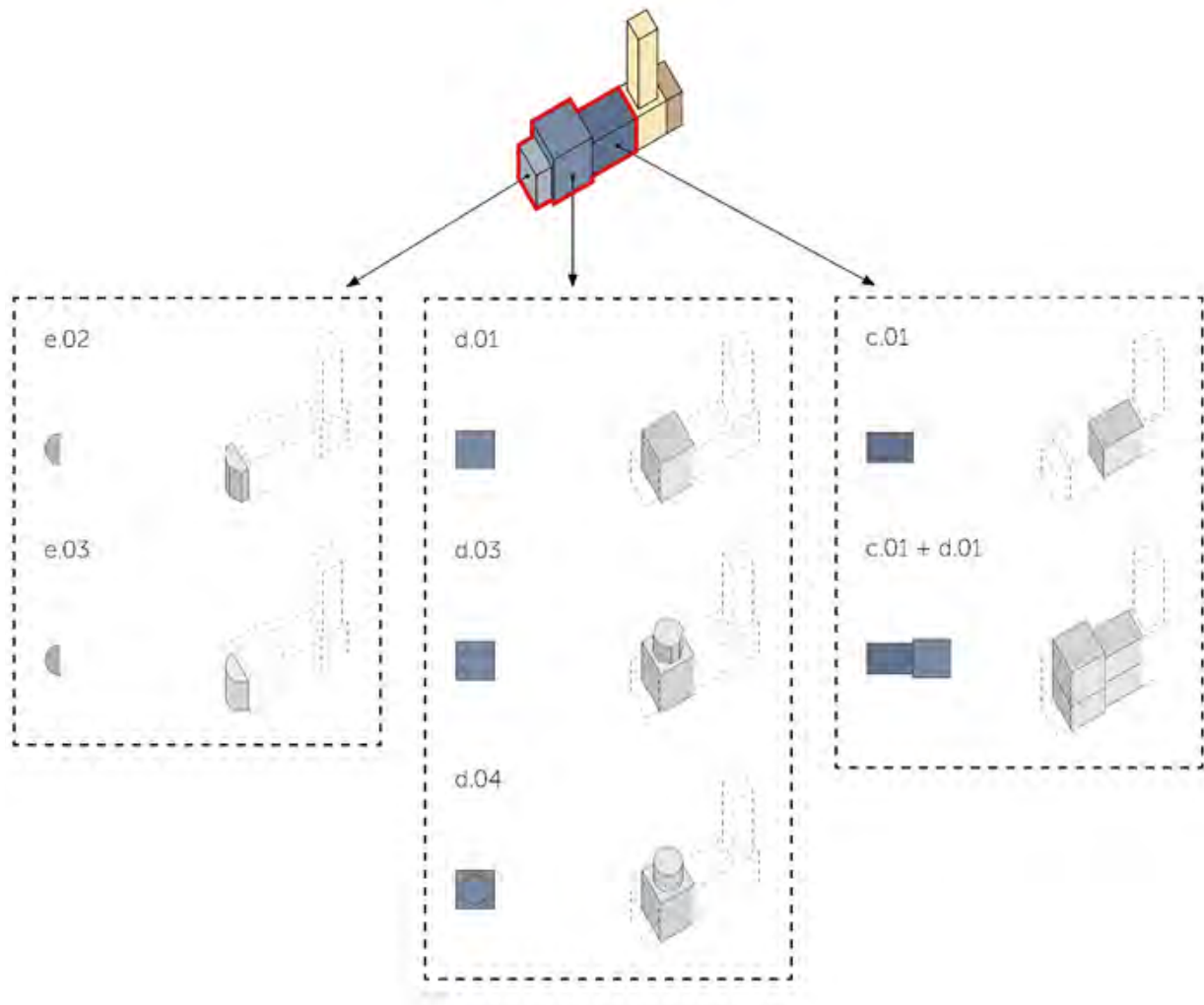
- **LC1 – Limited Knowledge:** characterized by poor quality of documentary investigation, architectural and structural surveys carried out in a non-detailed manner, and the inability to conduct tests and trials on structures.
- **LC2 – Adequate Knowledge:** characterized by high-quality documentary investigations, detailed and complete architectural and structural surveys, with the possibility of conducting exploratory tests and non-destructive testing on structures and materials (e.g., rebar locators, sclerometers, infrared investigations, sonic tests).
- **LC3 – Accurate Knowledge:** characterized by extensive investigation quality and, in a number determined by regional seismic services, mechanical testing of materials in situ and in laboratories for material mechanical characterization.

The importance of knowledge levels lies in their determination of confidence factors, which are numerical parameters penalizing material stress values (as well as their age) used in structural safety verifications for static loads (vertical loads) and dynamic loads (depending on the seismic acceleration forecast for that site).

- For LC1 (limited knowledge), the confidence factor (CF) = 1.35.
- For LC2 (adequate knowledge), the confidence factor (CF) = 1.20.
- For LC3 (accurate knowledge), the confidence factor (CF) = 1.00.

The study of the Upper Kama churches consists of three main macro-phases:

- 1 - Typological and planimetric study of the buildings, focusing on the building layouts.
- 2 - Macro-element analysis, concluding with the study of technological elements.
- 3 - These phases are understood as “layers” of information characterizing each building.

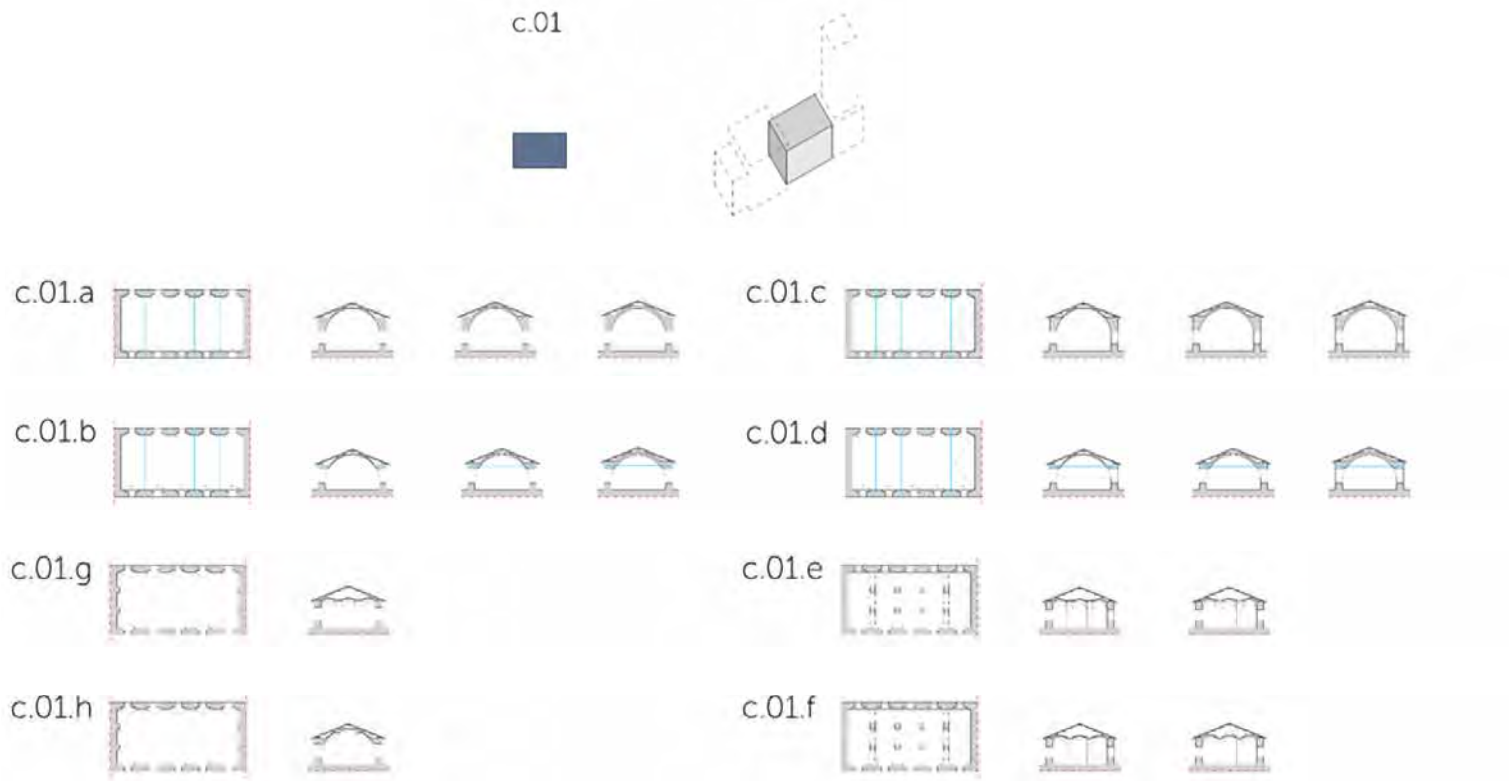


The first layer of information describes and classifies the layout. Six recurring patterns composed of simpler “blocks” were identified. These patterns were further analyzed, identifying numerous sub-patterns. This dual classification allows for identifying churches based on their general layout and a more detailed, specific schema.

The second layer analyzes the macro-elements. Each layout pattern consists of colored blocks, each representing a single macro-element of the building. These blocks were identified based on their structural behavior rather than their function. As with the layout analysis, each macro-element is then studied in greater detail, defining different sub-macro-elements.

The final phase (third layer) is the analysis of technological elements. By studying 19th-century construction manuals and comparing them with photographs and surveys, an abacus of cases was defined. The result is a series of plans and sections highlighting the salient features of the walls, vaults, and roof.

The next step in our analysis is to field-test the results obtained through the described analysis. We must compare the proposed models with the churches of the Upper Kama and understand in detail how the proposed macro-elements relate to existing damage mechanisms.



#### Technological elements

Comparative abacus of construction solutions derived from historical manuals and survey data, highlighting wall sections, vault systems, and roof configurations.

This analysis allows for obtaining a set of overlapping, comparable, and applicable information for many buildings, not just the roughly 100 churches analyzed. The choice to use a typological classification aims to create a repeatable and consistently valid tool that allows for comparing a large number of buildings.

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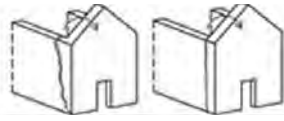
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Side page, Fig. 06

#### Damage mechanisms and structural behaviour

Representation of local damage mechanisms and their correspondence with simplified 3D models of the Church of the Blessed Virgin of Kamgort, supporting the interpretation of structural behaviour and vulnerability patterns.



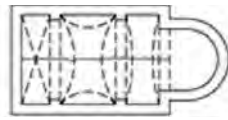
Façade overturning



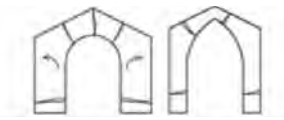
Tympanum hammering



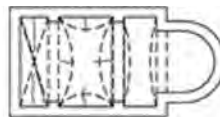
In-plane façade mechanisms



Transverse response of the nave



Triumphal arch



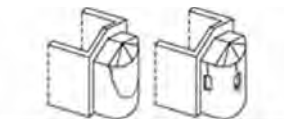
Nave vaults



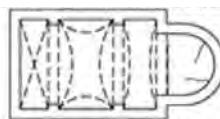
Roof hammering mechanisms



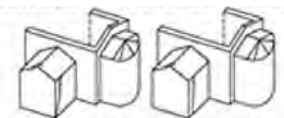
Dome or drum



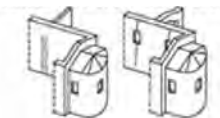
Apse overturning



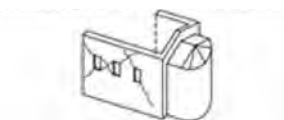
Vaults in the presbytery and apse



Overturning of other walls



Interactions between adjacent bodies



Shear failure of walls



Bell tower

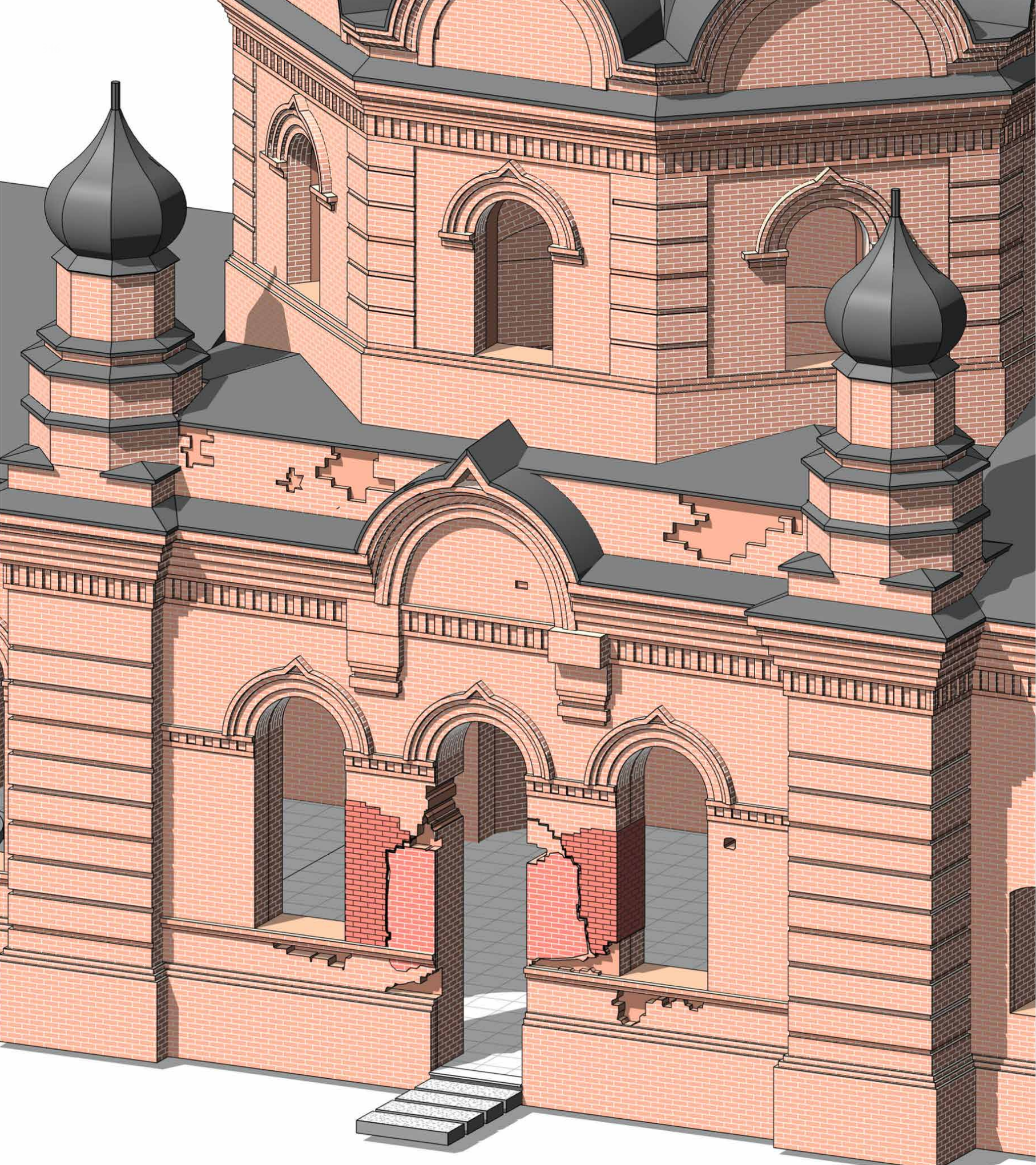


Belfry cell



Collapse of vaults and spires





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## FOR THE DEVELOPMENT OF BIM SYSTEMS ON THE MANAGEMENT OF MONUMENTAL HERITAGE

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Currently, there are various lines of research on the management of architectural heritage, aimed at identifying reliable tools and processes to efficiently manage the information gathered from monuments with historical value. The main challenge when carrying out interventions or revaluation efforts lies precisely in this aspect, as organizations and professionals often work in isolation, frequently overlooking work already conducted by other stakeholders, which leads to duplicated or inconsistent information.

Based on this premise, the most important aspect of the project is the management of such information, creating the need for a methodology that addresses these concerns. BIM (Building Information Modeling) allows the creation of three-dimensional models collaboratively, integrating all the necessary data for building management, with the ultimate goal of achieving a “Digital Twin.”

This methodology, when applied to the management of heritage assets, is known as HBIM (Historic Building Information Modeling), which is currently under study and development at a global level<sup>1</sup>. For this reason, implementation processes are not yet fully defined, highlighting the need to test proposals developed in other research lines in order to generate a protocol that could be applied to all the churches in the ensemble.

### Methodology

First of all, before starting the modeling of the corresponding church, a series of guidelines are proposed for the creation of an HBIM Protocol in order to provide a working methodology that can be adopted for the practical application in generating future cultural heritage models within the H2020 Prometheus project.

The goal of this protocol is to create a parametric model that gathers all the historical and construction-related information for each monument cataloged within the study area<sup>2</sup>. For this purpose, it is essential to define a guide and specify the information to be provided at each stage.

The methodology is proposed to be applied in three stages:

**1 - Collection of Information and Analysis of the Monument:** in this stage, we focus on the study and organization of the information provided by the team in order to identify the context of the monument's location and its current conservation status.

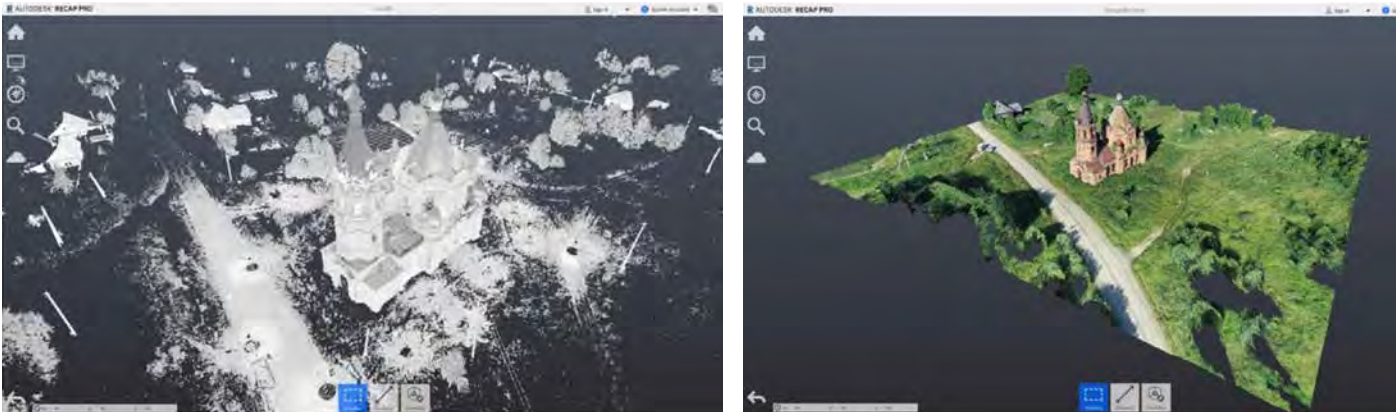
### Side page Fig. 01 Heritage Building Information Modelling (H-BIM) of Kamgort Church

The digital model was meticulously developed and employed as a key analytical tool to accurately identify, document and visually highlight the various forms of deterioration and damage affecting the building's surfaces, enabling a deeper understanding of its current conservation needs.

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<sup>1</sup> Murphy et al. (2009), *Historic building information modelling*.

<sup>2</sup> Jordan-Palomar et al. (2018), *Protocol to manage heritage-building interventions*.



**Fig. 02**  
**Point Cloud Optimisation Process**

The point cloud was carefully imported into Autodesk ReCap and organised into two distinct layers: one dedicated to the laser scanner acquisition (on the right) and the other to the photogrammetric data collected via drone (left). This structured approach ensured a clearer, more accurate integration of the two datasets, enhancing the overall quality and precision of the final model.

The objective of this stage is to conduct a general analysis, for which a series of data sheets are proposed:

- General Information Sheet
- Accessibility Information Sheet
- Technological-Constructive Analysis Information Sheet
- Pathological Analysis Information Sheet

**2 - Modeling Organization:** at this stage, the guidelines related to the processes and roles of those involved in the parametric virtual construction of the building are defined.

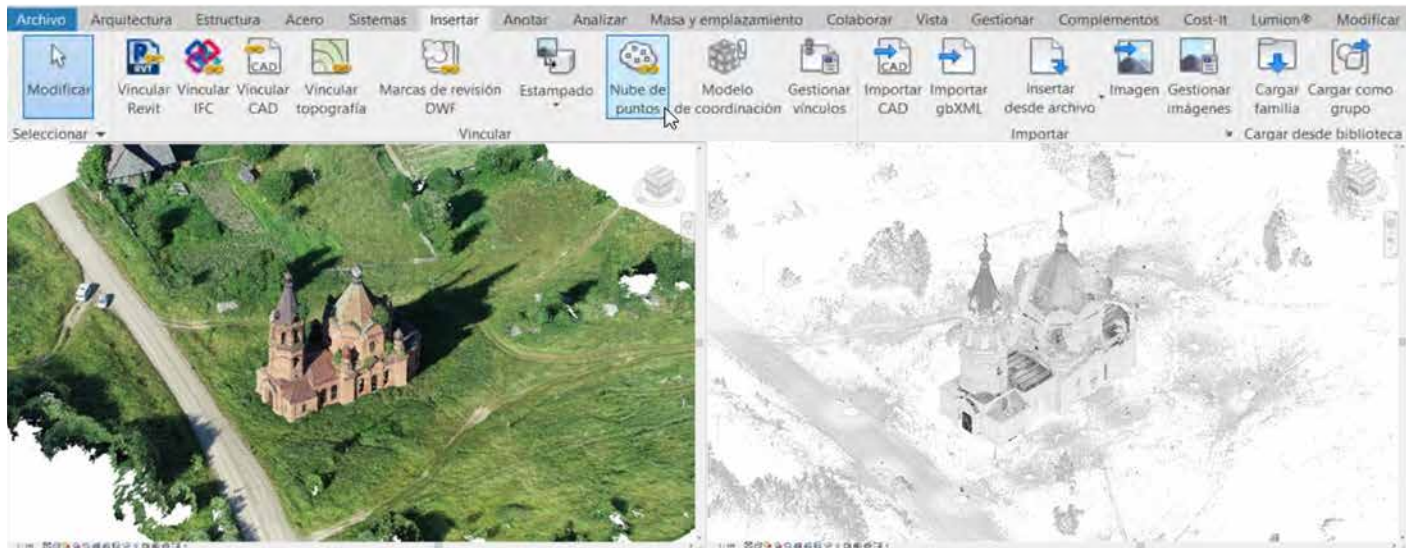
It is important to clearly define the purpose of the model in order to avoid unnecessary work or an overload of information that does not add value at the current development stage. Furthermore, since this is a collaborative effort, it is crucial to clarify the criteria and development of the modeling process. For this purpose, a BEP (BIM Execution Plan) is proposed.

**3 - Generation of HBIM Model:** after completing the previous stages of information analysis and modeling organization, we proceed to the generation of the HBIM model using the Autodesk Revit platform, following the established guidelines.

As this is a research project and the application of HBIM in architectural heritage is still in the study phase, two lines of action are evident from the perspective of the model's contribution:

- The complete modeling or partial modeling of the monument according to its different historical-constructive phases and the identification of pathologies contributes to the dissemination of the technological innovation represented by the application of BIM in historic buildings. This results in the creation of a three-dimensional catalog that includes the information gathered from the construction systems used at that time and the current conservation status<sup>3</sup>.
- The virtual restitution of the monument, thanks to the modeling based on hypotheses of its original state, serves as the foundation for the generation, using the Lumion software, of photorealistic images and virtual tours through the building. In this way, it contributes to the dissemination of the architectural cultural heritage of the area. The possibility of combining both approaches demonstrates the great potential of this methodology to simulate reality through a virtual model and, furthermore, to incorporate the gathered information in a parametric way.

<sup>3</sup> Cos-Gayón et al. (2016), *Aplicaciones de la realidad virtual*.



In order to efficiently manage all the documentation inherent to the project, it is essential to create a shared space through a cloud platform, such as Google Drive, where basic information about each monument can be found.

### Model Organization

The goal of implementing HBIM in the set of Orthodox Churches belonging to the Cultural Heritage Routes of the Upper Kama River is to promote the dissemination of this heritage through the consolidation of a digital catalog for its preservation. This will be achieved by generating three-dimensional databases with parametrized information for each church. The HBIM models created in this context will be managed by the PROMETHEUS team to fulfill the project's mission. Furthermore, this research project also contributes to the dissemination of the scientific contribution of cultural heritage digitization. In this stage, we focus on generating a model of the hypothetical original state, which will also include the technical-construction information gathered and the identified pathologies. Finally, a 3D animation will be created to fulfill the goal of providing a virtual reconstruction of the church in question.

Subsequently, the generated model can be completed as needed, for efficient dissemination and promotion of the architectural heritage present in the Upper Kama River region.

In addition to identifying and defining the purpose for which each building will be modeled, we must adhere to a guide or a BIM Execution Plan, also known as BEP (BIM Execution Plan), which details all the basic information related to the project. This includes its members/collaborators and their respective roles, as well as the level of development or LOD<sup>4</sup> with which each element will be modeled. For this reason, a tentative BEP is proposed to serve as a foundation for the generation of future models within the project. The particular case study for this work is the building: Church of Presentation of the Blessed Virgin in Kamgort, to which the methodology defined in the HBIM Protocol will be applied.

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**Fig. 03**  
**Point Cloud Visualisation Process**

The point cloud, once divided into distinct layers, was then seamlessly linked to Autodesk Revit for visualisation within the modelling engine. This integration allowed for precise alignment and an efficient workflow between the survey data and the modelling environment.

<sup>4</sup> AIA (2008), *AIA Document E202*.

### **Structure of the BEP (BIM Execution Plan)**

The purpose of the BEP is to define the BIM methodology that will be used to carry out all the necessary tasks for the proper documentation of the architectural heritage located along the Cultural Heritage Routes of the Upper Kama River in Russia. This execution plan establishes a regulatory framework where stakeholders and collaborators will be recorded, with their respective roles, scopes, and responsibilities, structure and strategies for information exchange, and all the processes necessary for the proper implementation of BIM in the Project. The proposed BEP index is as follows:

- Introduction
- Access to information
- Actors involved
- Organisation PROMETHEUS team
- Project information
- BIM uses
- LOD criteria
- Platforms and requirements
- Organisation of the HBIM project
- Table of tasks
- Deliverables
- Submission of documentation

### **HBIM model generation**

Insertion of point cloud and photogrammetry in Revit A part of the team was responsible for the survey of the catalogued churches with different tools. The information obtained was managed and made available to continue with the research in the analysis stage and the corresponding modelling of each church. To begin with the task of modelling the selected church, the first step was to adapt the files so that they could be inserted into Revit, for which we used Autodesk ReCap Pro software.

In this platform we import the point cloud in .pts and the photogrammetry in .e57, and then export both elements in .rcp.

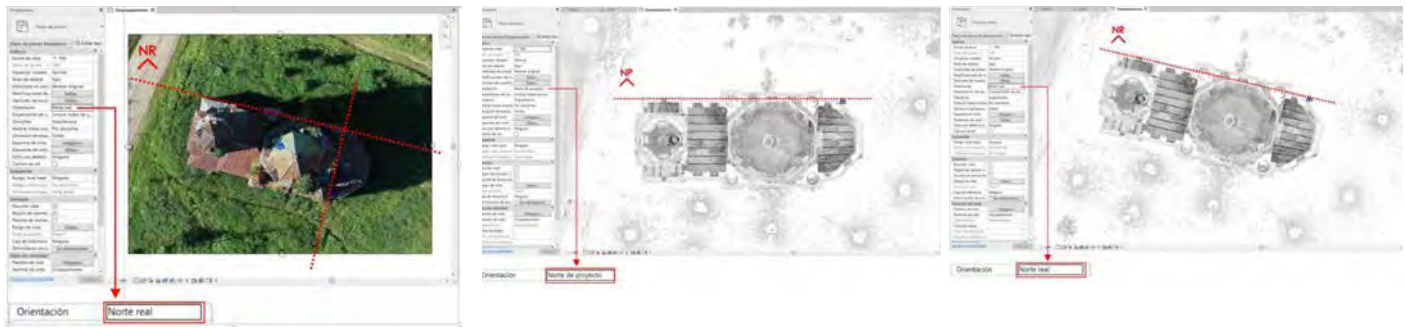
Within the ReCap platform we create a new project and select the element to import, repeating this process in both cases.

1) Photogrammetry:

- a. Import photogrammetry with extension .e57
- b. Export to .rcp

2) Point clouds:

- a. Import point cloud with extension .pts
- b. Export to .rcp



And so we obtain the elements with the appropriate extension for their insertion in Revit. In a new Revit project, we insert both elements that will serve as a basis to start the modelling task. The point cloud provides geometric accuracy and the photogrammetry helps to understand the volume in an easier way thanks to the visualisation of the different textures. By superimposing the two elements, it can be seen that the inclination of the photogrammetry does not correspond to the point cloud. In order to define the real orientation of the building, we used Google Maps. After this check, we can see that the real north corresponds to the position of the church in the photogrammetry. We dump this information in the Orientation parameter of the view properties. The platform facilitates the modelling of any element, preserving the information of its real orientation and at the same time allowing to rotate the whole building with respect to the orthogonal axes of the project. In this way the real north is differentiated from the project north. In the Manage tab we find the Position tool and from the longitudinal axis created we align the north of the project. We import the point cloud again in a 3D view and observe that it respects the orientation of the church with respect to the real north and the project north previously defined.

### Original state hypothesis modelling

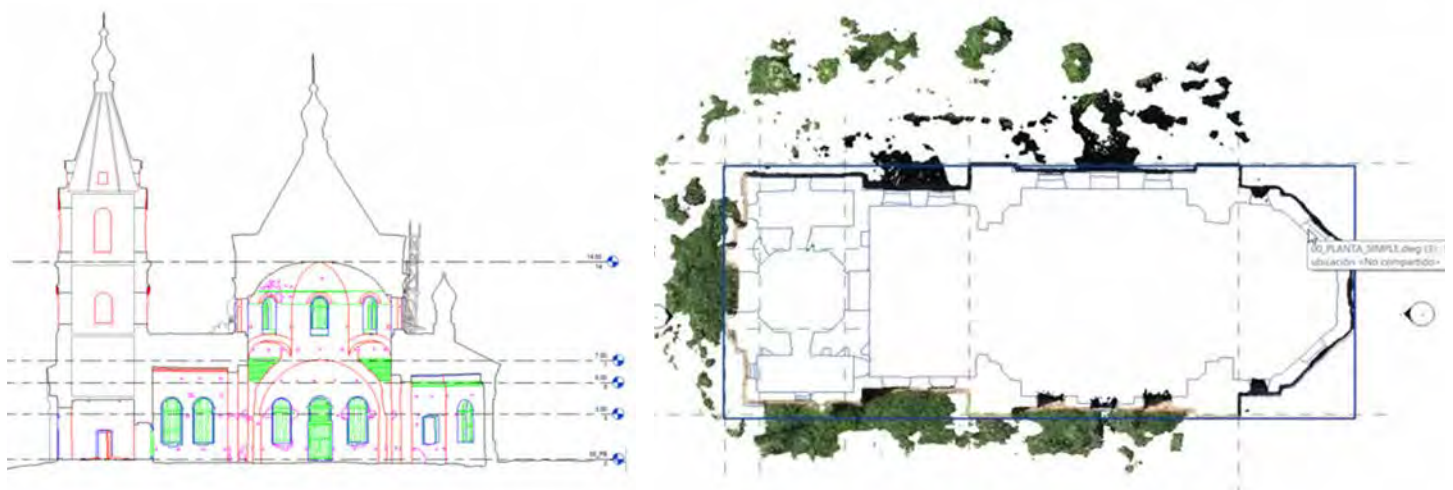
The approach adopted is to obtain a 'Digital Twin' of the initial hypothesis, i.e. of the Church that was originally built. Within the shared space of Google Drive, .dwg files have been generated by the Prometheus team, from sections in the point clouds. To start modelling the church, we defined the project levels in an elevation, taking an existing CAD section as a reference.

#### Fig. 04 Point Cloud Visualisation Process

As a first step, the visualisation was configured in relation to both the project north and the true (system) north. This initial alignment ensured proper orientation of the point cloud within the modelling environment, providing a reliable reference for all subsequent modelling operations.

#### Fig. 05 H-BIM Model Structuring

The H-BIM model was organised starting from the definition of reference levels for both horizontal and vertical planes. This foundational step ensured a clear and accurate framework on which to build the subsequent elements of the digital model.



In a first stage, several levels are created in order to be able to model little by little in the successive plan views, using the CAD point cloud and planimetry as a guide. We insert the existing CAD planimetry in the different plan views to define a series of reference planes that will facilitate the modelling, as they are orthogonal planes visible in all the elevation, section and plan views of the project. In addition, these reference planes can be used to define certain constraints on the project elements. We start by using the family of generic basic walls of different thicknesses, which will later be replaced by the family defined according to the corresponding structure and composition parameters, as this is a modelling with construction elements that simulate reality. As we build up the model, it is necessary to edit/create different families, which can be:

- a. System families: these are the construction elements that define the building itself and are created within the drawing itself by duplicating existing types, such as walls, floors, ceilings, roofs or stairs<sup>5</sup>.
- b. In-situ families: these are elements created by the user within Revit, they are not loaded from external files as they are modelled within the project from a mass or family editor.
- c. Loadable families: these are elements that are imported into Revit from external files created by ourselves or third parties, they can be edited within the family editing environment.

#### a. *System families*

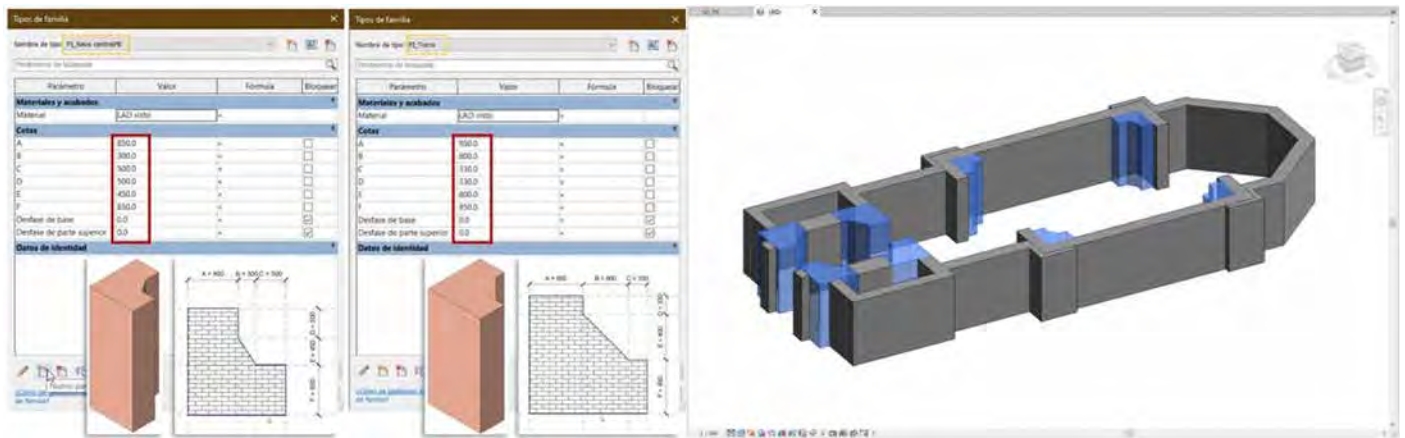
The next step, once the building container has been created, will be to include the different elements, which we will do by creating specific ‘families’ for this building typology: Walls: From a family of generic walls we create the corresponding one to represent the walls of the church with the definition of its internal structure and materials, thus going from a conceptual model to a schematic model with the objective of reaching a LOD 200 as indicated in the BEP of the project. In the materials editor we define the characteristics of the material ‘exposed brick’, which will be applied to the corresponding construction elements.

#### b. *In-situ families*

Pillars: From the technological-constructive analysis we define the basic structure of the building and create a new family using a template of pillars. Next, we define certain parameters of this new ‘PILLARS’ family with the help of reference plans to create the necessary restrictions and thus be able to modify the dimensions according to the different types of pillars to be used in this family. Beams: To continue with the modelling of the main structure of the church, the same process as for the pillars is repeated, creating a family of rectangular section beams with different base and height averages. Revit allows the beams to be drawn with a curved development, making it possible to model the round arches. For the modelling of the ‘bulbous’ domes, we used the method of creating families in situ through the tool Components/Model in situ.

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<sup>5</sup> Moret Colomer (2020), *Guía práctica de Revit*.



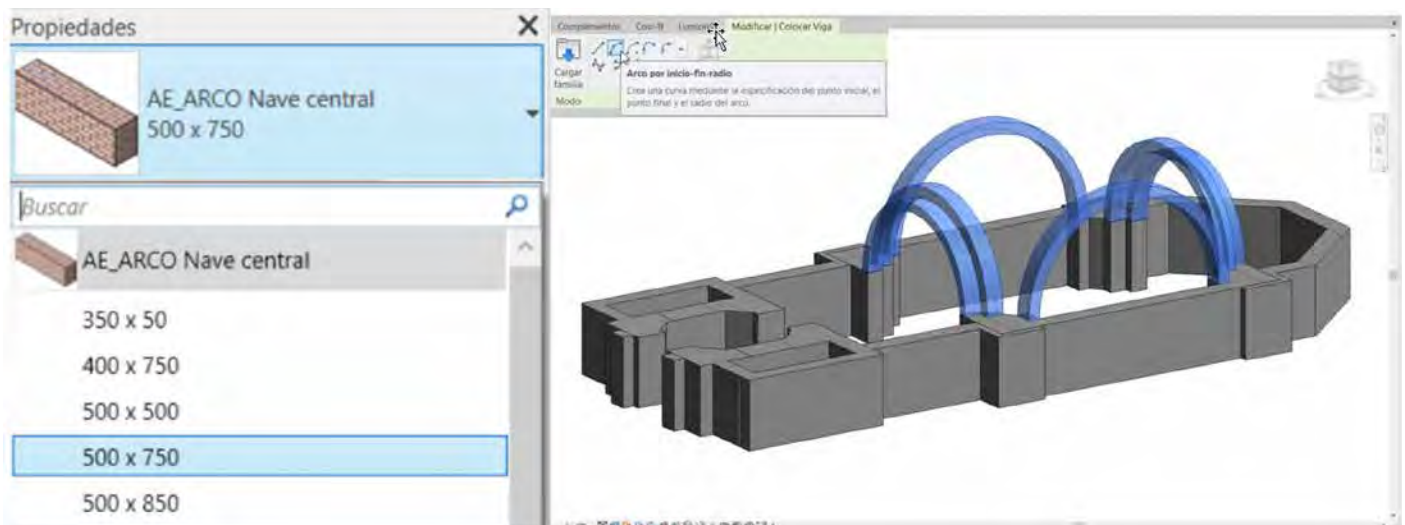
This type of families are modelled within the project environment in Revit and do not have a base template as in previous examples; therefore we use the option Create/Sketch and define a path and the profile of the sketch.

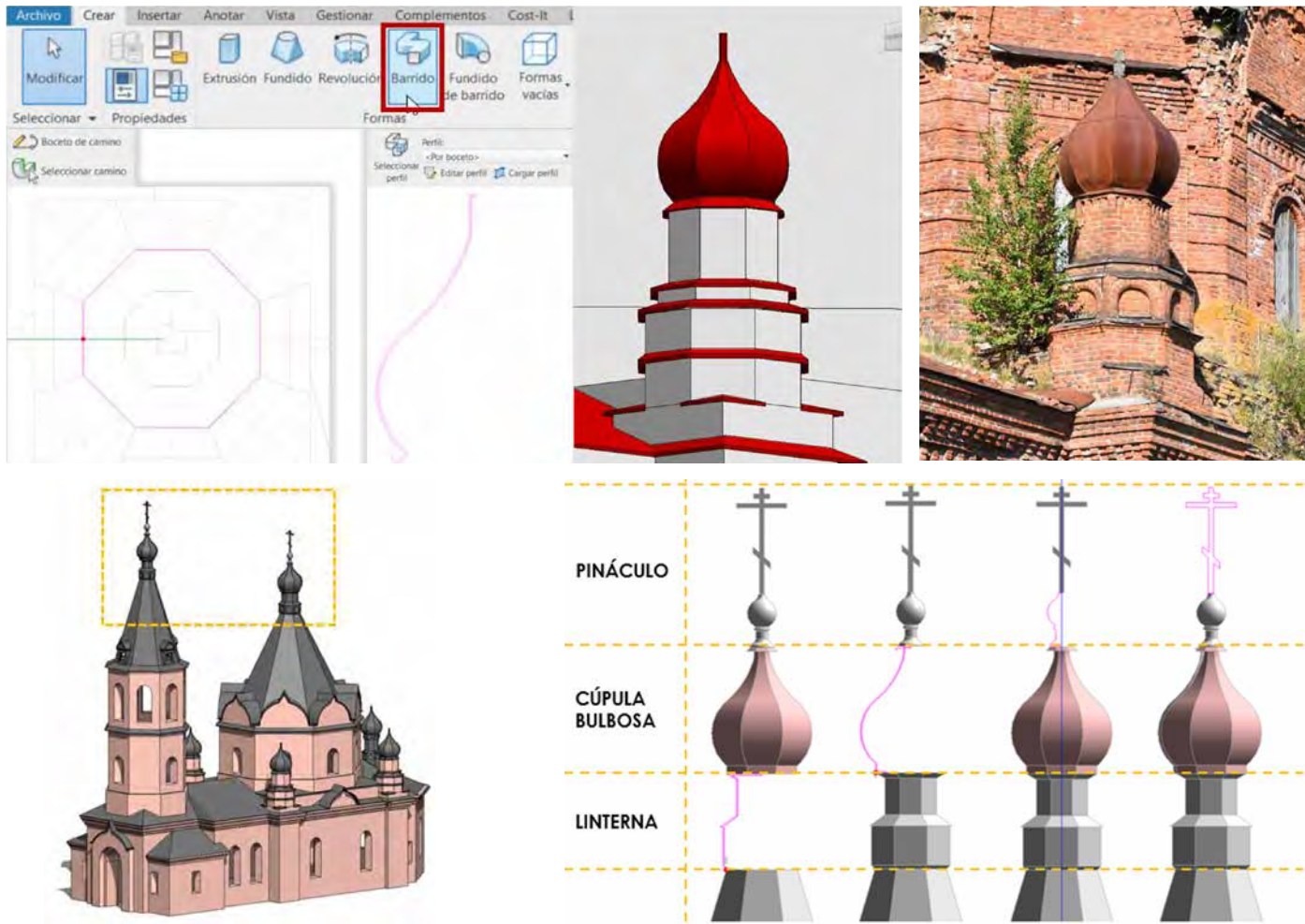
### c. Loadable families

Doors and windows: To define the doors and windows of the project we used the carpentry of another church in the area as an example, as there are no records of what the original ones were like. Within the Revit library of loadable families we find elements that can be adjusted to the needs of the project, as is the case of doors and windows.

We start with a family of two-leaf windows with a round arch lintel, which is similar to the example mentioned above. Within the family editing environment, we modified some parameters to adjust the measurements to the church's openings. In addition, we edited the design of the leaves to simulate the distributed glass that characterises the carpentry of the area. To define the doors, we saved a copy of the window family and modified its category from the option Parameters and family category.

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**H-BIM Model Structuring**  
The various components of the architectural model have been modelled as element families, setting the parameters according to the dimensions provided by the metric data.





**Fig. 08**  
**H-BIM Model Structuring**  
For the domes, the modelling was divided into three parts: the cross, the dome structure, and the lantern.

Then, we adapt the model by editing its measurements and design. Once the modelling is complete, the pathologies are characterised and documented parametrically, using stratification techniques.

Finally, the Revit model is exported to the Lumion software, which makes it possible to generate a virtual image that recreates the reality of the initial hypothesis, allowing images and video to be obtained for dissemination, cultural and scientific use.

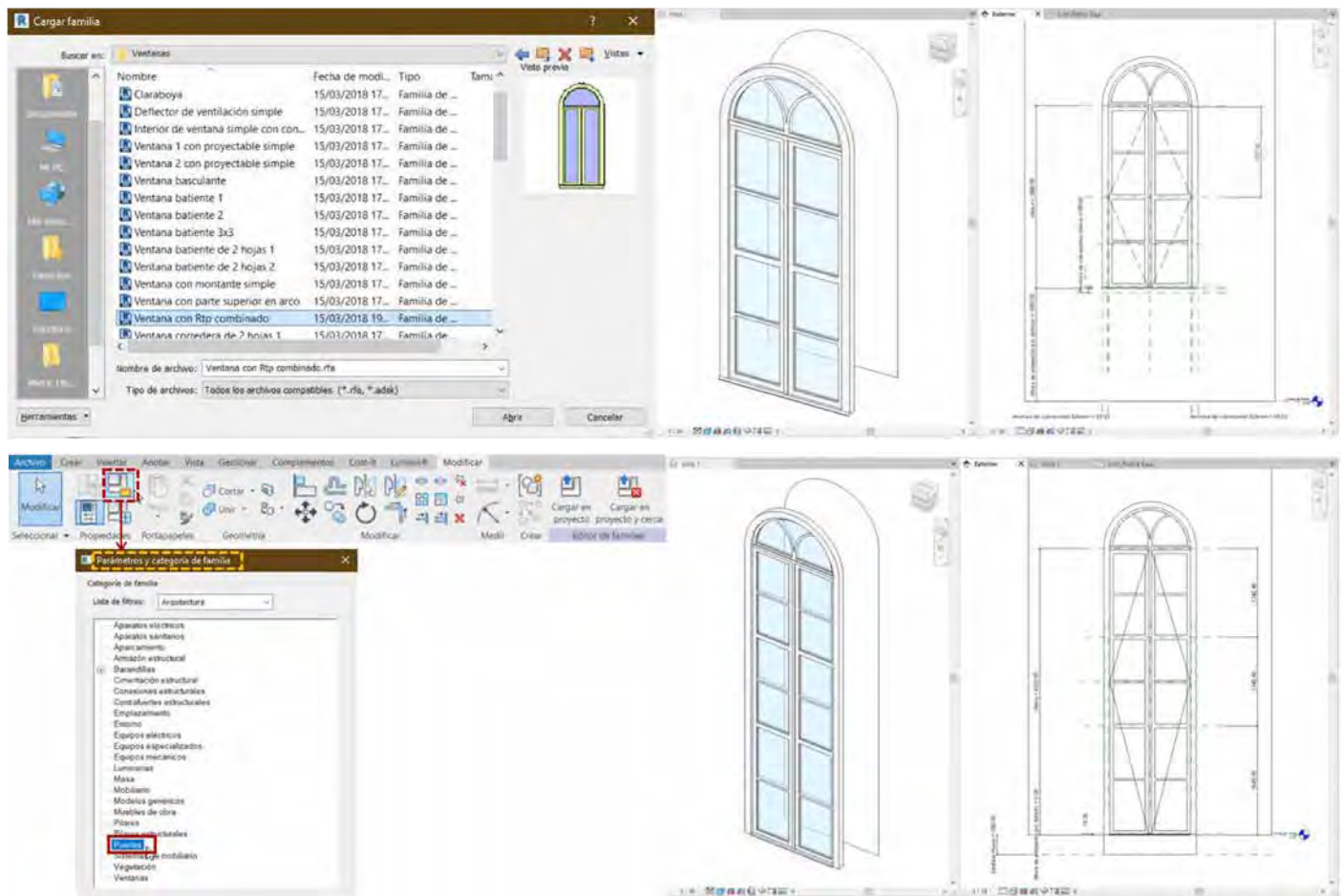
*Next page, Fig. 09*

**H-BIM Model Structuring**  
the architectural components were modelled as parametric element families, with constraints and dimensional parameters defined according to the metric survey data. The windows were also developed as fully parametric families, with adjustable parameters (height, width, curvature and depth) to allow flexible adaptation to the variable geometry of the building's façades and wall thicknesses.

### Application of an Informative Model

The application of HBIM in the management and preservation of architectural heritage represents a significant leap toward integrating advanced digital tools into cultural heritage projects. This research highlights the potential of HBIM to create highly detailed and accurate parametric models that consolidate historical, technical, and pathological information for monuments like the Church of the Presentation of the Blessed Virgin in Kamgort. By employing a structured methodology that includes information collection, modeling organization, and HBIM generation, the project establishes a comprehensive approach to documenting and preserving cultural assets.

One of the key contributions of this research is the development of a tentative HBIM protocol and

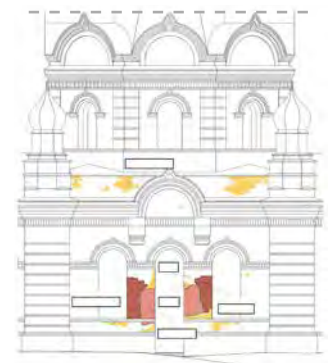


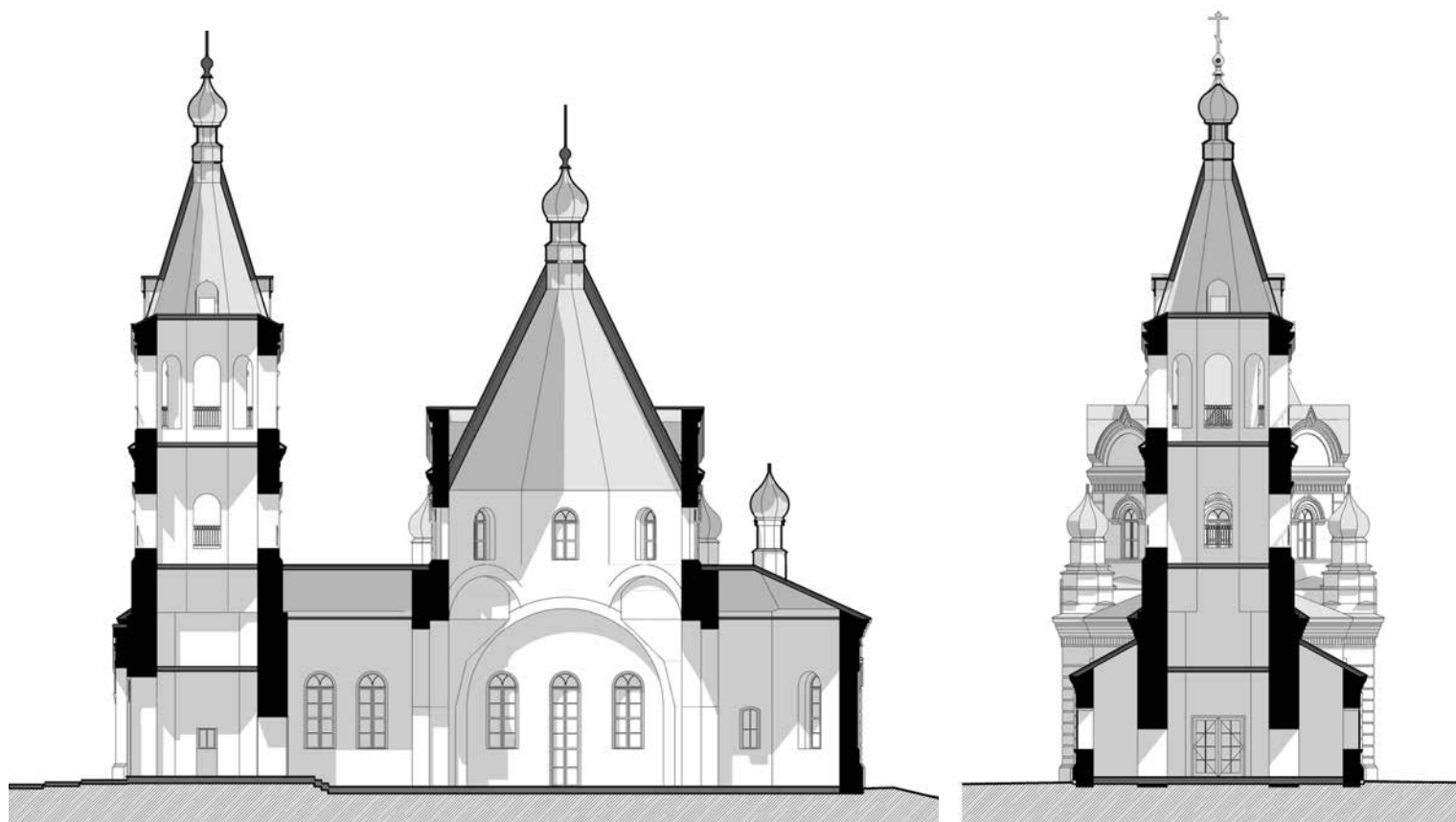
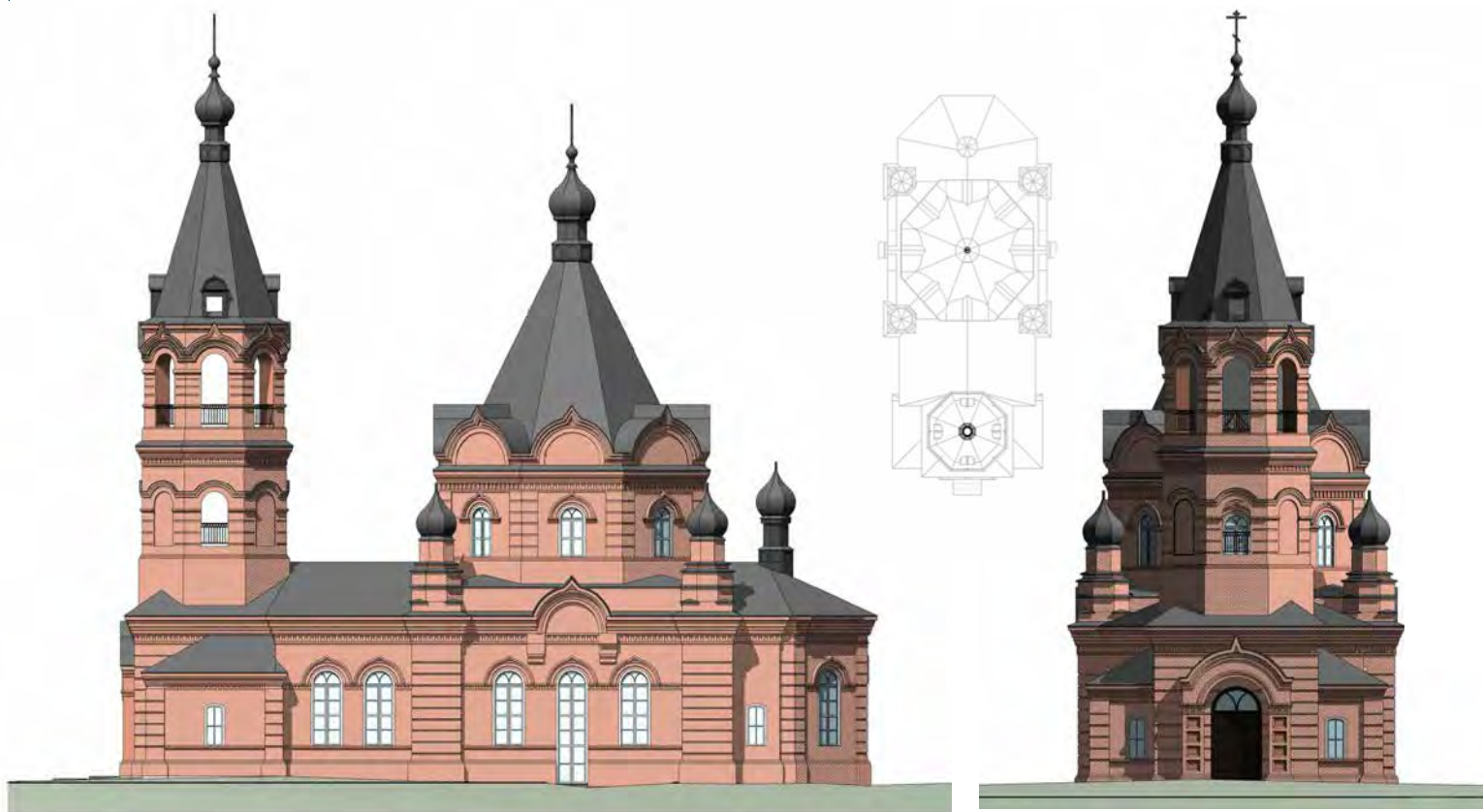
a BIM Execution Plan (BEP), which not only define the technical parameters for modeling but also facilitate collaboration among stakeholders. These tools ensure that the information gathered is accurate, consistent, and efficiently organized, avoiding redundancies and inconsistencies that often arise in isolated efforts. The integration of point cloud data and photogrammetry into Autodesk Revit provides a robust foundation for achieving a “Digital Twin,” offering insights into the original state of the monument while preserving its current condition.

Furthermore, the research underscores the importance of virtual restitution as a tool for dissemination and education. By generating photorealistic images and immersive virtual tours using software like Lumion, the project enhances public engagement and raises awareness about the value of architectural heritage. This dual approach—scientific documentation and public dissemination—demonstrates the transformative impact of HBIM on cultural heritage management.

In conclusion, this study not only advances the application of HBIM for historic buildings but also provides a replicable framework for future projects within the H2020 Prometheus initiative. By addressing the challenges of information management and promoting innovative uses of technology, the research sets a new benchmark for the preservation and promotion of cultural heritage.

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**Fig. 10**  
**H-BIM Model Annotation**  
 degradation mapping has been implemented on the architectural surfaces using hatch-based indicators to represent the morphological extent and typology of deterioration observed on the church façade.







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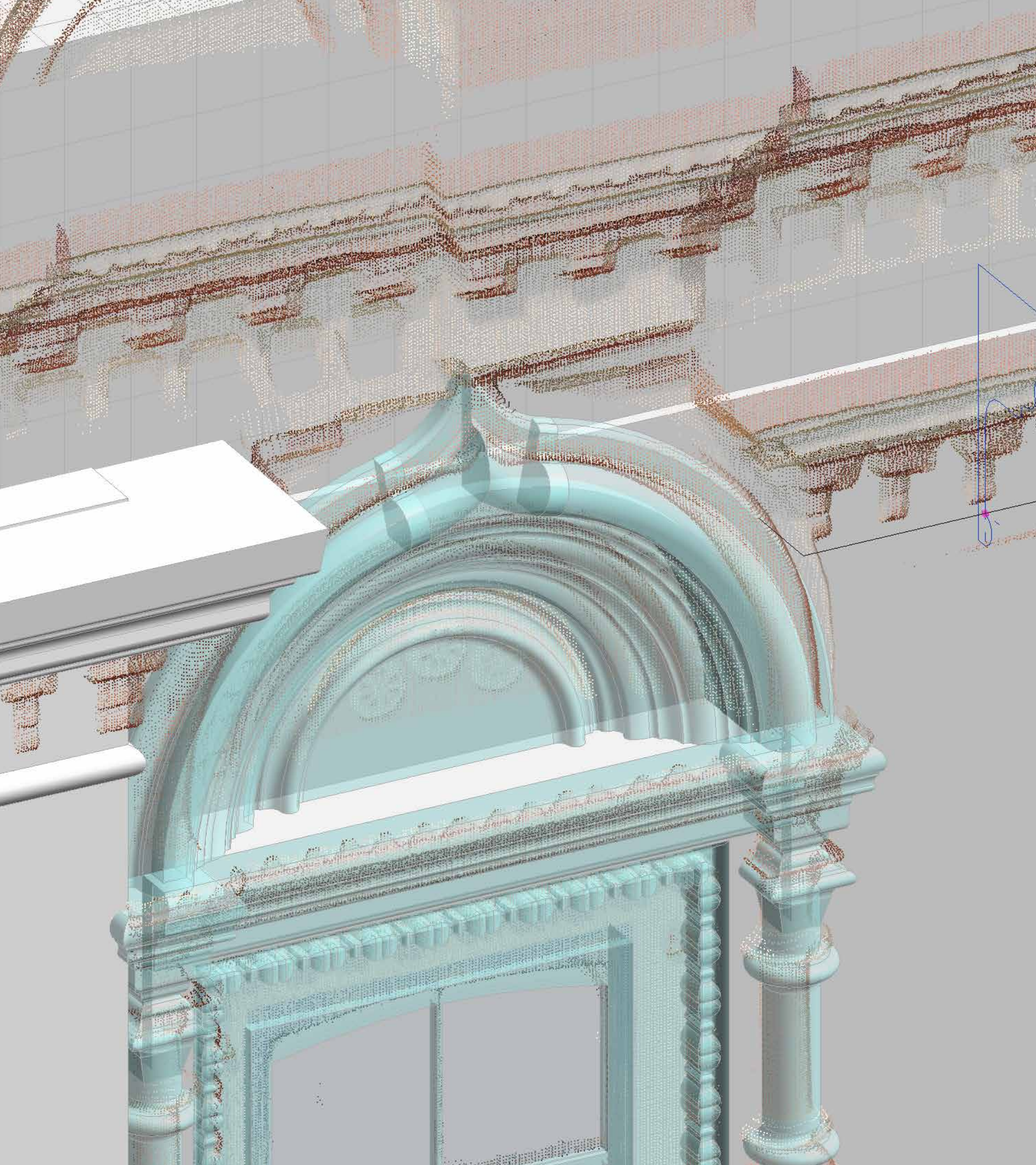
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### H-BIM Model views

A set of images illustrating the H-BIM model, including sectional and perspective views that highlight the modelling results, together with photorealistic renderings showing the digitally reconstructed church in different seasonal settings.



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### The analysis of construction and technological features from the historical apparatuses of Upper Kama

In accordance with European 2020 guidelines<sup>1</sup>, research in the preservation and enhancement of cultural heritage has emphasized the development of open, flexible, and scalable systems that can adapt to various preservation and accessibility needs. This approach involves creating open-ended solutions—those are designed for future development—and dynamic systems that can evolve over time through progressive implementation phases.

The objective is to establish operational protocols that facilitate the digitization of cultural heritage while ensuring long-term interoperability and technological sustainability. The methodological research activities conducted within the Prometheus project align with this innovative perspective, aiming to standardize digitization processes through shared and internationally recognized protocols. Specifically, the project promotes the adoption of the IFC (Industry Foundation Classes) format, which allows for the creation of interoperable models for the digital representation of cultural heritage. The goal is to establish a standardized modelling language that facilitates the efficient and structured exchange of information among various expertise involved in the management, restoration, and enhancement of cultural heritage. This approach encourages the integration of contributions from experts across different disciplines, fostering a collaborative ecosystem that prioritizes data sharing, operational transparency, and the optimization of resources.

In the context of cultural heritage management and digitization, “optimizing modelling” processes are a key objective, particularly in the implementation of H-BIM protocols. This innovative method aims to reduce management time and costs while promoting greater efficiency through the sharing of technical decisions, early identification of inconsistencies, and minimization of errors. All of this occurs within a multidisciplinary framework that integrates the necessary skills, recognizing and enhancing the interconnections between fields such as drawing, restoration, engineering, cultural heritage conservation, and applied information technology. A distinctive aspect of this approach is the division of the project into progressive phases, where the system adopts a defined configuration at each stage but remains open to future implementations and revisions as needed.

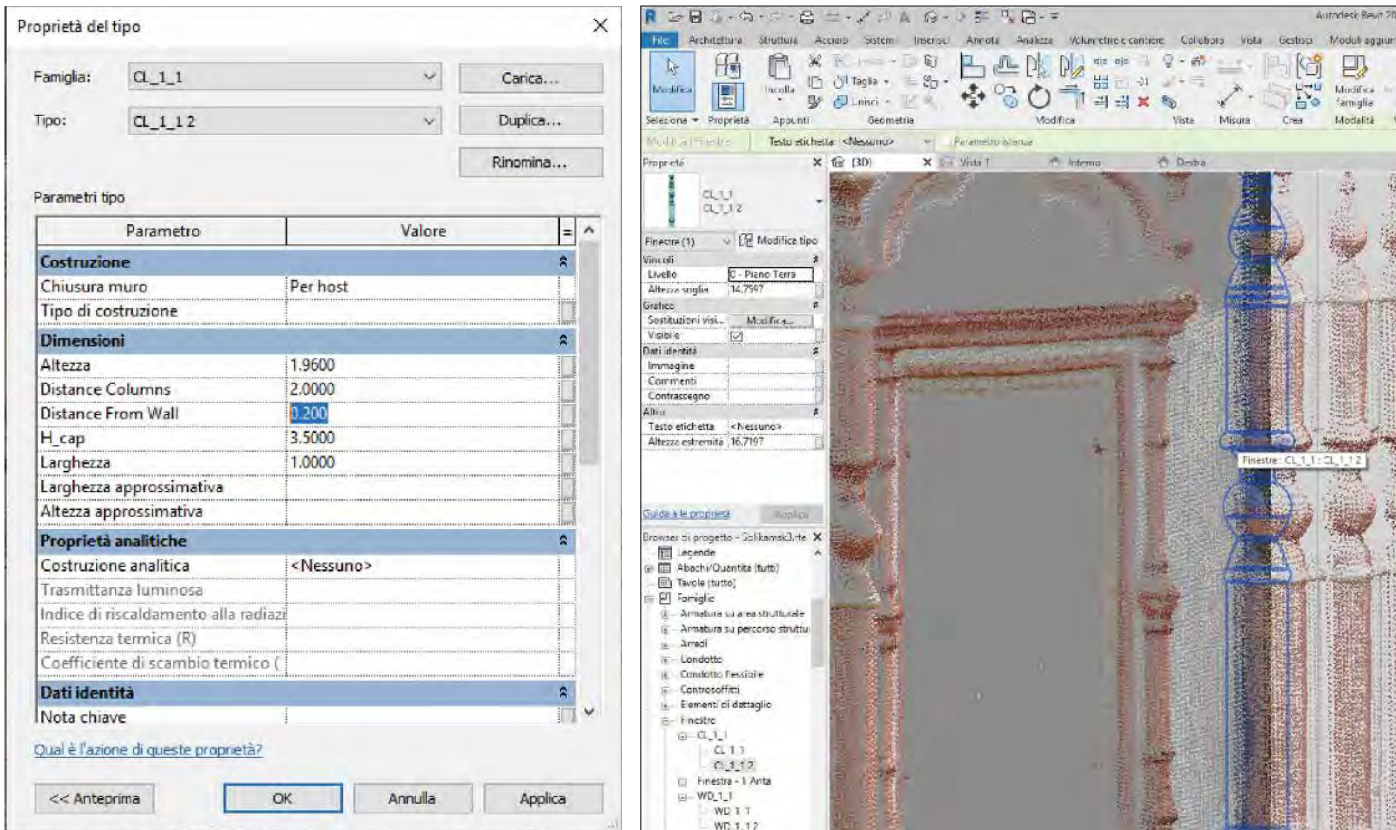
Side and next page Figs. 01-02  
**The modelling of the windows of the Church of the Epiphany in Solikamsk**

It has highlighted an interesting and complex issue. At first glance, the decorative patterns of the wall surfaces, the window frames, and the ornamental elements surrounding the openings seem to follow precise and repetitive compositional rules. However, a more in-depth analysis reveals that no two windows – nor their decorative components – are designed according to the same set of rules.

This variability applies not only to the proportions and profiles of the windows themselves but also to the mouldings, cornices, and carved decorative details that frame them. Consequently, the definition of adaptable parametric families for these elements has proven to be highly complex and, in certain cases, unnecessary.

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<sup>1</sup> Europeana Data Model – Mapping Guidelines v2.4 <http://pro.europeana.eu/edm-documentation>

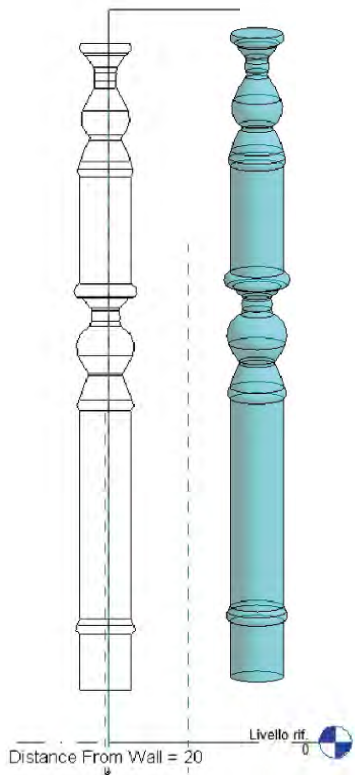


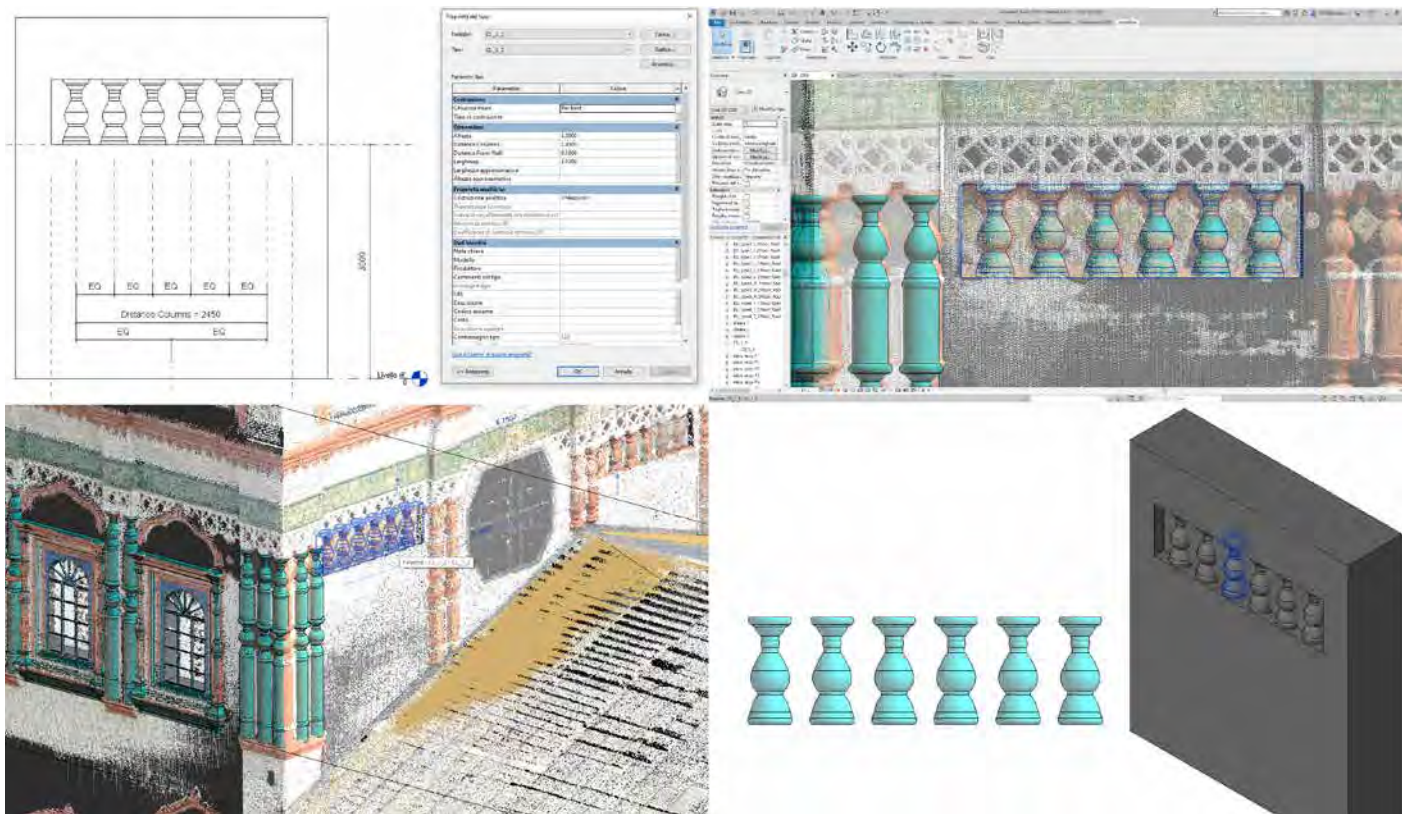
This flexible working model enables an organic and coherent outcome in the design and construction of the digital model, ensuring structured and adaptable management. The formalization of a common protocol is vital, as it establishes clear and shared application criteria for the model and integrates essential information needed to create an effective and interoperable modelling protocol.

### The Prometheus Scan to H-BIM procedure

Applying Information Modelling methodology to the Cultural Heritage sector opens new perspectives and opportunities, enabling the integrated management of a wide range of data. This approach makes it possible to operate on different scales of analysis, from the territorial dimension down to the individual building, extending the field of action from architectural analysis to urban and territorial design and planning. Integrating data from digital surveys, cognitive investigations and diagnostic analyses enables the construction of detailed information models, improving the understanding and conservation of cultural heritage.

The different phases of the workflow involve active coordination between the various researchers, made possible through a set of rules useful for the management of processes and shared files of the digital model. These rules are defined within the BEP (BIM Execution Plan). This operational document was made available in the shared project drive, which serves as a methodological guide to guarantee the consistency and quality of the modelling process. Adopting a structured framework for sharing information on the cloud proved to be an effective strategy for optimising data exchange, improving





collaboration between interdisciplinary teams and reducing redundancies and operational errors. The study of modelling procedures raised fundamental questions about the structuring and sharing of a unified language based on standardised signs and symbols capable of translating the spatial interconnection system into a generalisable formal scheme. To meet this need, a single, centralised 3D model was deemed indispensable to collect, implement and parameterise the data related to the cultural assets analysed.

This approach represents a significant step towards constructing a shared digital ecosystem to protect and enhance cultural heritage, in which technological innovation becomes an essential means of preserving historical memory and making it accessible for years to come.

The research group's methodology is based on structuring an information model resulting from the integration of two types of data: the geometric-spatial description derived from the 3D digital survey and the set of information derived from the cognitive and diagnostic surveys, collected within structured census sheets. This approach makes it possible to obtain a complete and multidimensional representation of the architectural heritage, facilitating the management and sharing of information between the actors involved.

A central aspect of the project was the use of symbolic modelling to represent the spatial scale. Starting from this basis, the realisation of H-BIM models related to specific case studies, selected for their relevance in defining the historical and cultural identity of the territory, was initiated.

↑  
**Fig. 03**  
**The model elements are composed through the combination of different families of elements**  
 Each component was individually modelled and subsequently integrated into the overall model, then compared with the point cloud data to assess its accuracy and refine its dimensions through the adjustment of parameters.

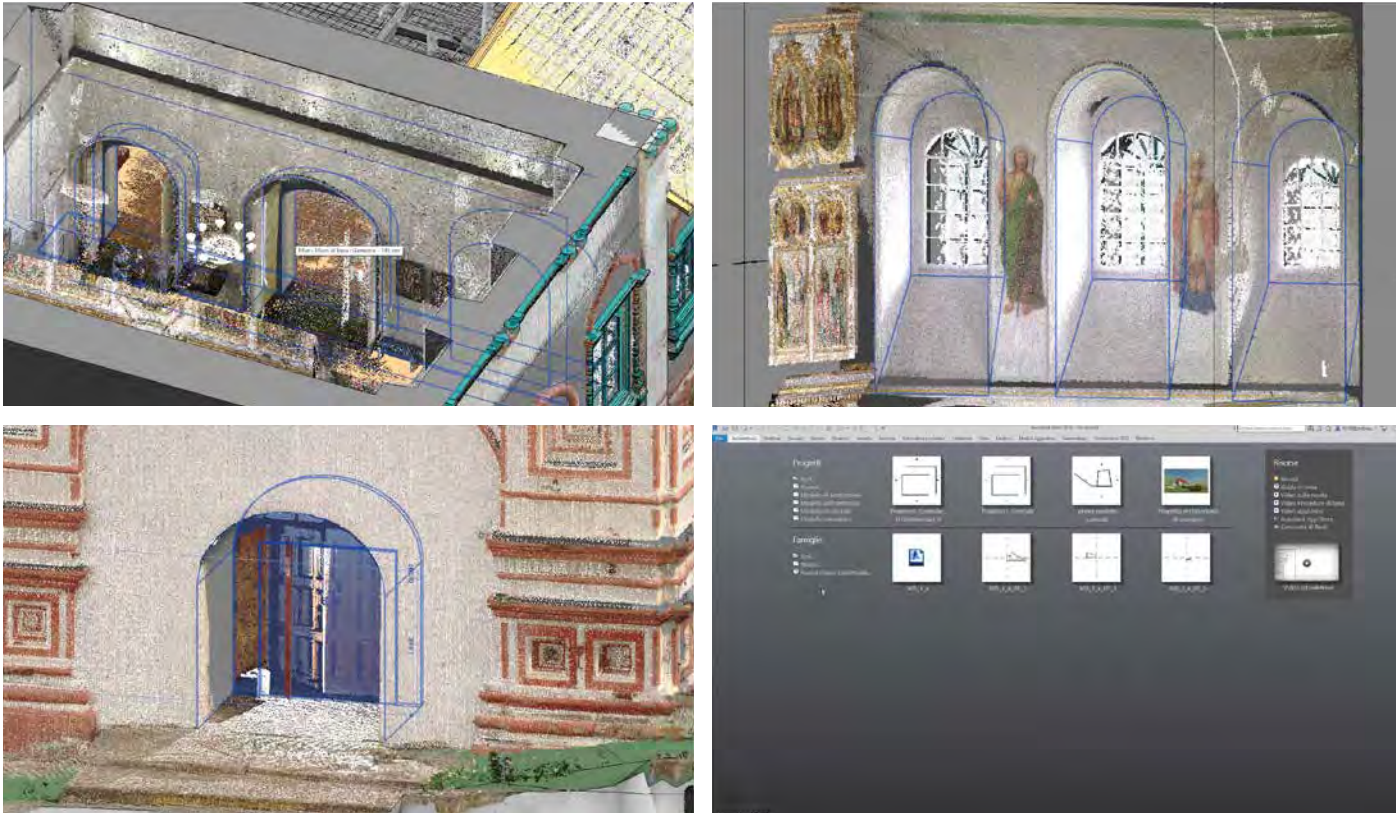


Fig. 04

#### H-BIM model development

A direct comparison between the point cloud data and the model makes it possible to develop modelling strategies that are consistent with the acquired data. In particular, the openings in the masonry walls were modelled using system voids within the in-place model through the use of control points, specifically to ensure correspondence with the metric data.

The buildings analysed include:

- Solikamsk District: Epiphany Church, Monastery of the Women;
- Cherdyn District: The Cathedral, Vilgort Church, St. Nikola and Kamgort's church;
- Monumental Complex of the Island of Usolye.

The first phase of this work involved the definition of a shared language grammar based on specific taxonomies for representing architectural and spatial elements. This process made it possible to hierarchise and translate the territory's distinctive features into representation symbols, thus creating a structured basis for analysis and modelling.

The models created for the route study were developed by adopting an advanced cloud-sharing protocol, which enabled collaborative project management and workflow optimisation. The integration of cloud platforms enabled distributed modelling, facilitating the simultaneous sharing of information between multiple users and ensuring a dynamic update of the digital model.

A collector Excel file was created for structured and systematic data management, which serves as an organisational database of the modelled elements. Within this file, several fundamental parameters for controlling and storing the objects were catalogued, including:

- Element category (AR - Architectural, LS - Landscape);
- Type of element (structural, decorative, plant engineering, etc.);
- Standardised nomenclature code for correct identification;
- Level of detail (LOD) according to BIM standards, specifying the degree of depth of modelling;



- Editable parameters, where available, for advanced parametric management;
- Graphic representation with descriptive images of the modelled object;
- File metadata, including name, extension and location within the storage system;
- Modelling manager to track the contribution of each user.

Following the definition of operational logistics and coordination between team members, a shared central model was established and stored on a dedicated cloud platform. This approach made it possible to simulate the collaborative methodologies typical of Building Information Modelling (BIM) applied to historical heritage in academic research.

The central model serves as the primary reference for all users, but no one works directly on it. Instead, each modeller worked on a local copy of the model, synchronising changes with the central file only at the end of the element construction phase. This method ensured greater security, avoiding the risk of accidental overwriting or version conflicts, and facilitated structured control over the changes made.



Fig. 05

#### Decorative modelling in BIM

In the analysis of the architectural decoration elements, it was found that if, at first glance, the decoration of the wall surfaces and window frames seems to repeat itself according to precise rules, no window is composed with the same rule as the other. In this sense, the generation of adjustable parameters is complex and, in some cases, redundant.

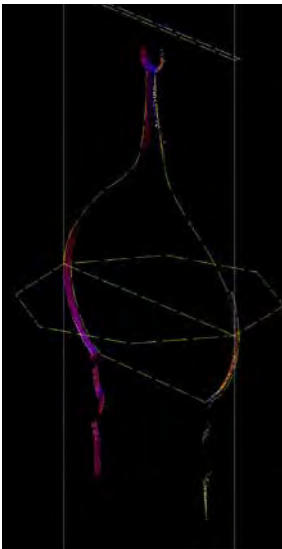
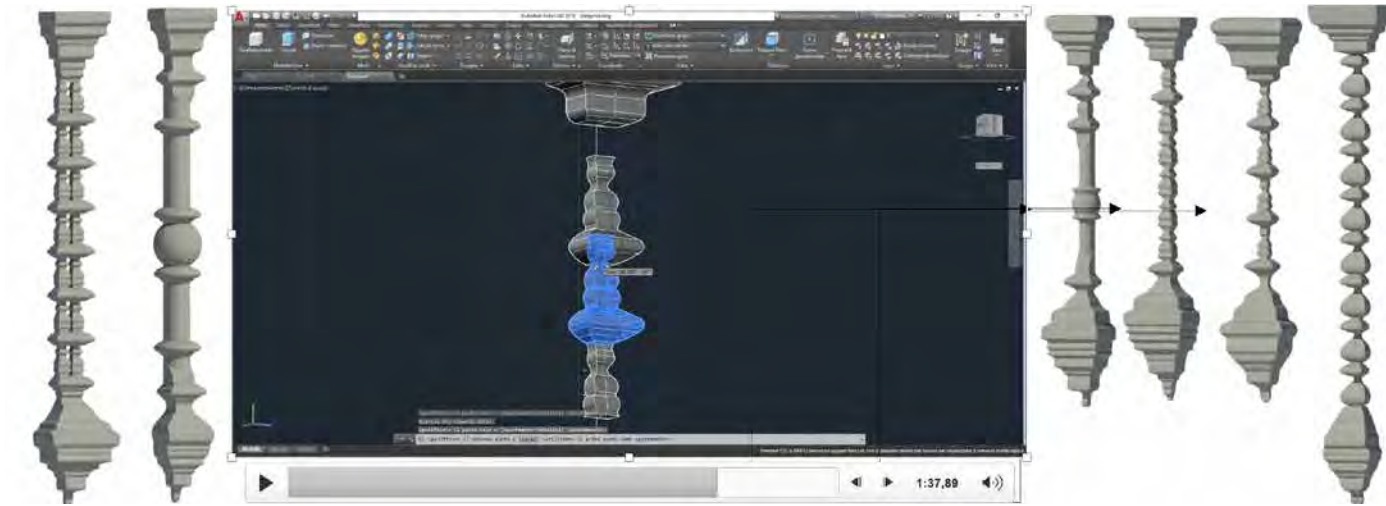


Fig. 06

#### H-BIM model window.

Window model is composed through the combination of different families of elements. Diagram showing the semantic breakdown of the components.

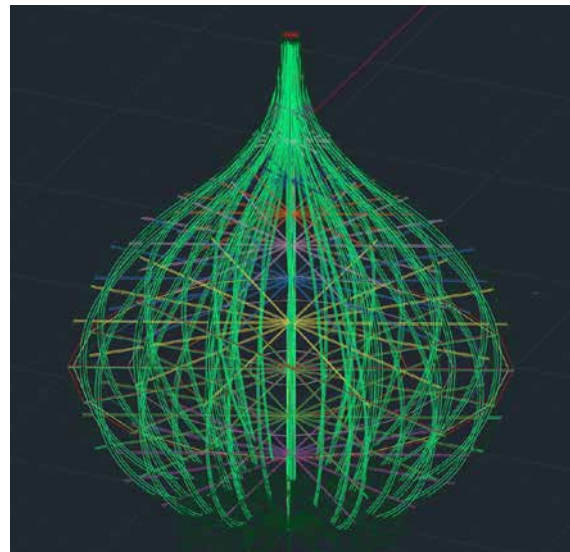
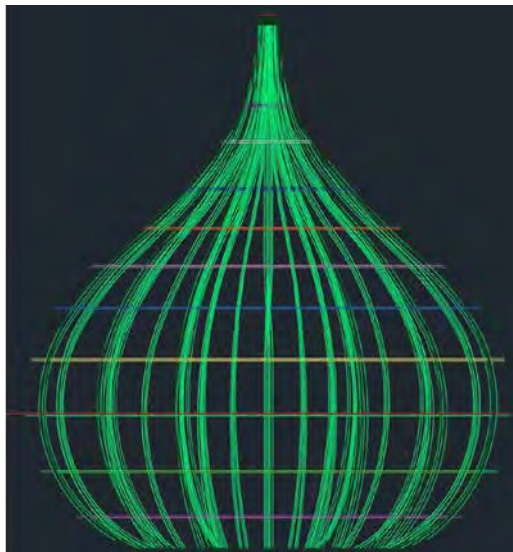


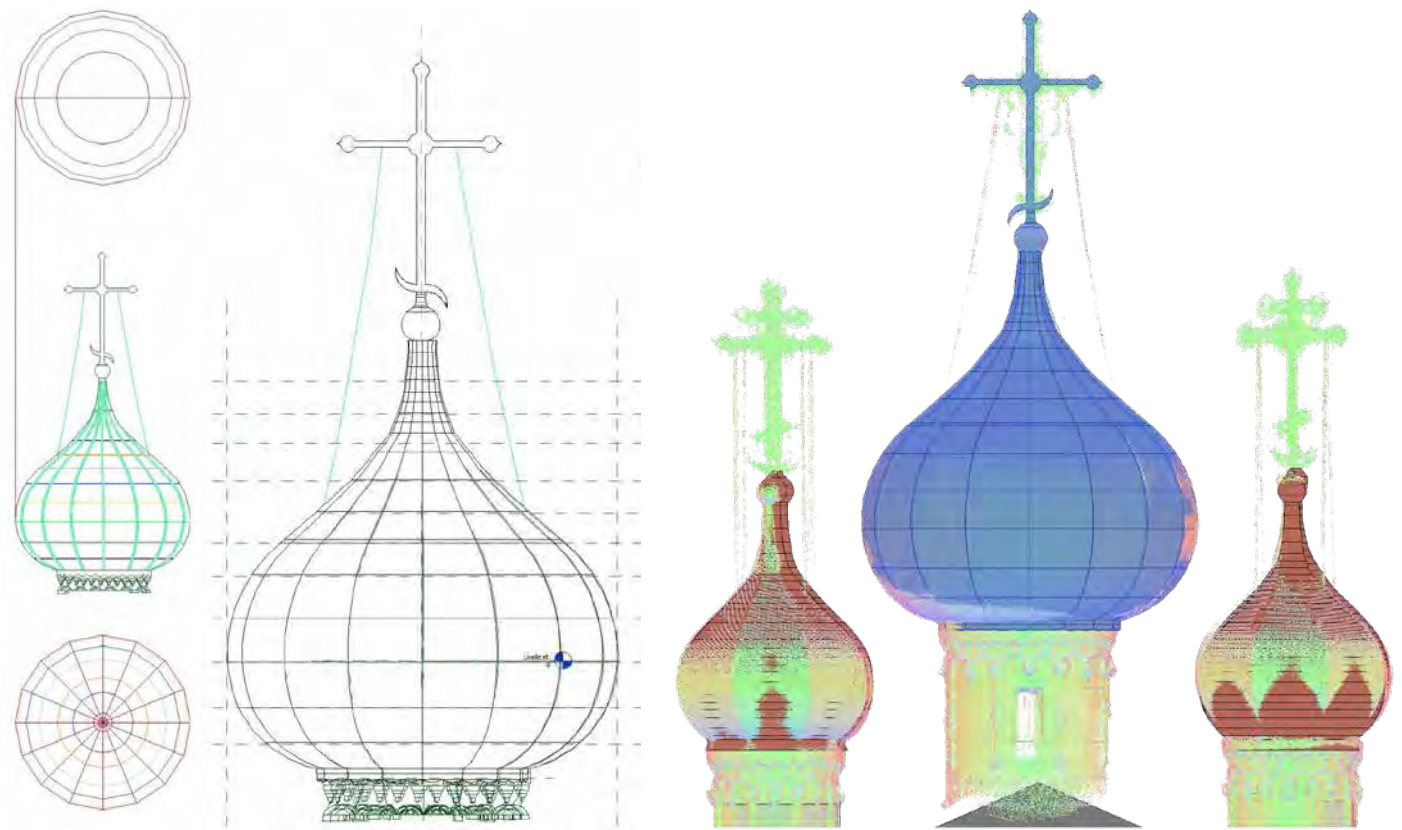


A crucial aspect of the cloud-sharing system was the creation of a shared data repository, organised hierarchically and accompanied by a unified technical glossary. The standardisation of nomenclature and element categorisation improved the model's interoperability, facilitating communication between researchers and ensuring information consistency between the different components of the system.

The effectiveness of the H-BIM modelling process was closely linked to the linearity of information flows and the clarity of communication between participants. The sharing protocol adopted made it possible to simulate real information management scenarios in architectural conservation and restoration, providing a solid basis for future applications on historic buildings.

All the modelled elements flow into a shared abacus on the cloud, contributing to the construction of a digital library dedicated to cataloguing the architectural elements of the Upper Kama monuments. The aim is to create a structured database that can serve as a reference for heritage conservation, research, and enhancement, allowing the modelled elements to be archived and reused in other study contexts.





### From point cloud to H-BIM model

The modelling phase of the monuments was set in work sharing mode, using Scan to H-BIM techniques to convert digital metric surveys into information models. The process is developed through a preliminary phase of recognition and decomposition of the different hierarchical components that constitute the building. A critical aspect that emerged during this phase concerns the perception of certain architectural elements that, although they seem to repeat themselves with regularity along the façades, are unique, presenting minimal but significant differences. Parametric modelling of such elements could be inefficient in terms of time and resources, especially if the objective is to ensure historical and geometric accuracy without compromising the consistency of the model.

In many cases, creating a non-parametrised family model has proved more convenient, which nonetheless allows the association of descriptive information and can be integrated into the library of architectural elements. This choice makes it possible to optimise the modelling process, while maintaining the flexibility required for project management.

The architectural models were developed by defining strategic level references, guiding the vertical elements' extrusion. This approach made it possible to establish a consistent system of vertical references, which was essential to ensure accuracy in the three-dimensional modelling of the buildings. The levels were set to reflect the actual inclinations and heights of structural elements, such as walls, columns and pillars, about the building's original architectural features. This method made it possible to obtain an accurate representation of the dimensions and proportions of the vertical elements, which is essential for creating a reliable H-BIM model consistent with the reality of the building.



Fig. 09

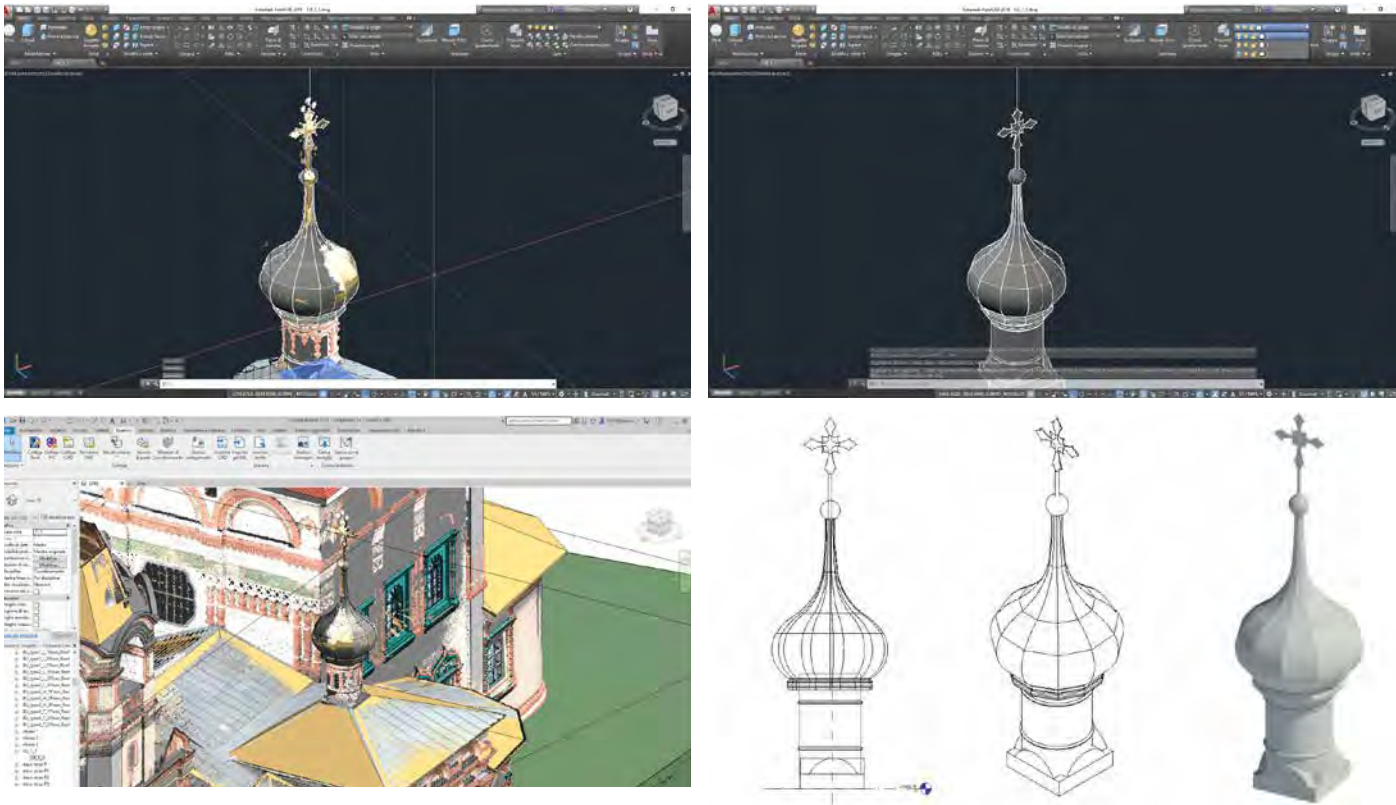
#### The development of specific families of domes

A first step of drawing the dome's skeleton; a second step involves importing the drawing into the modeling environment, where the individual elements are generated based on the drawn profiles, and a final phase of insertion and validation.

Side page, Fig. 07, 08

#### H-BIM Model elements

Architectural components were modelled as parametric families, with constraints and dimensional parameters informed by metric survey data.



**Fig. 10**

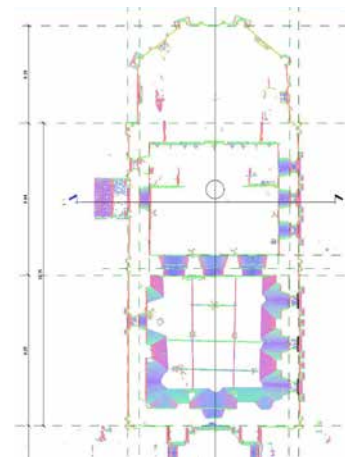
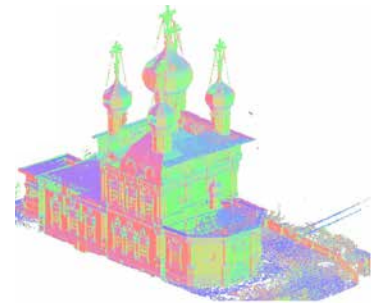
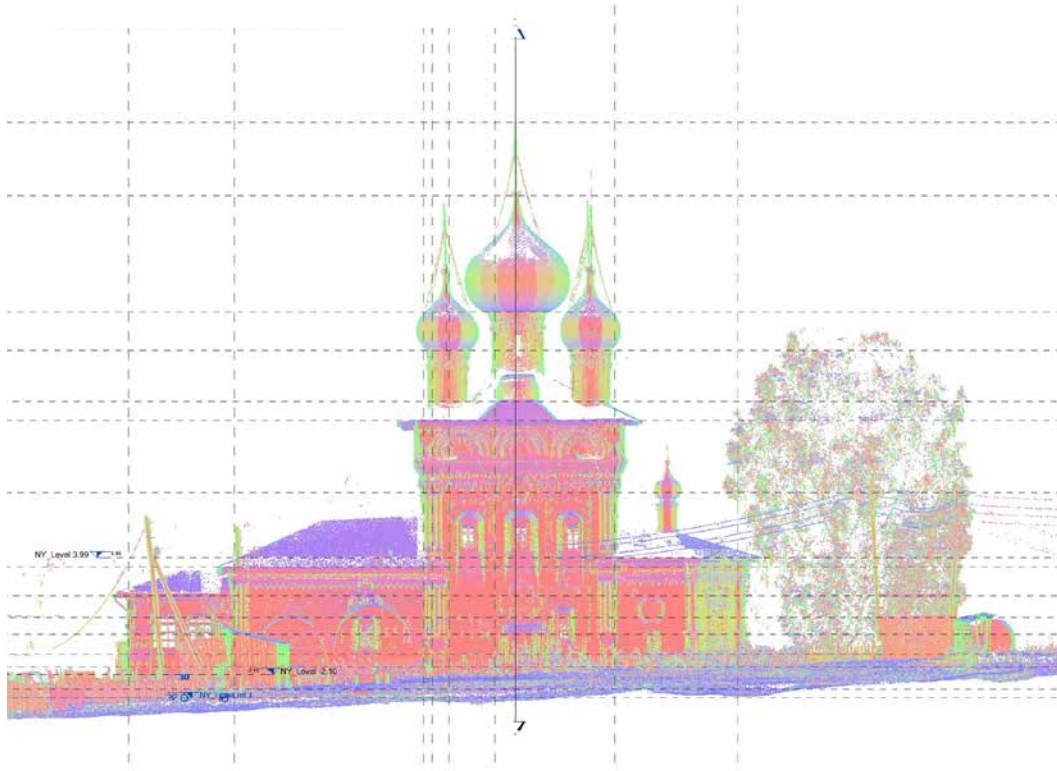
**Domes modelling in HBIM**

For some domes, such as those of the Church of the Epiphany in Solikamsk, a modelling method was tested directly in AutoCAD 3D in order to verify the compatibility between the models and the Revit environment. These domes were therefore modelled directly in AutoCAD and subsequently imported into Revit, ensuring a coherent integration between the two modelling workflows.

In addition, specific families were developed for the most relevant architectural elements, such as windows and vaults, to ensure precise and detailed modelling. Windows were modelled to reflect the various types and configurations, with attention to the building's own historical and stylistic characteristics. With their geometric complexity, the vaults were treated in a special way, using advanced modelling techniques to obtain a precise representation of their structure and curvatures. The creation of these specific families allowed advanced parametric management, facilitating any modifications and ensuring consistency with the original architectural features.

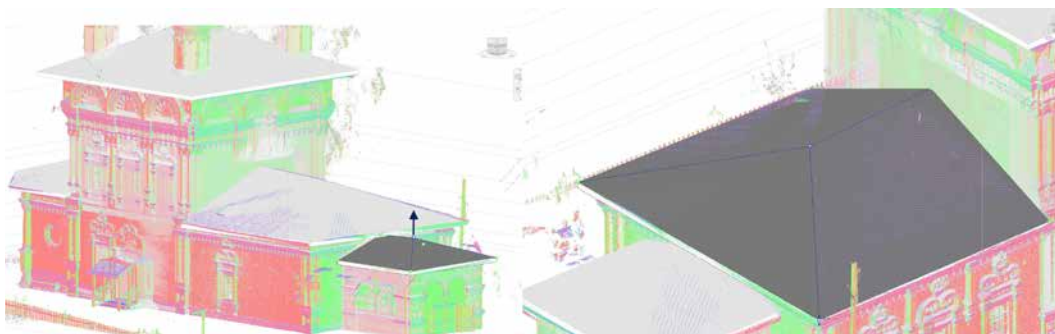
One of the most complex aspects addressed in the project concerns the modelling of the decorative apparatuses, which often display considerable geometric irregularity and an extraordinary wealth of ornamental detail, making accurate digital representation difficult. This aspect is particularly evident in the Stroganov Baroque architecture, characterised by a complex decorative repertoire combining finely carved sculptural elements, articulated surfaces and a strong plastic expressiveness, distinctive elements of this architectural style developed between the 17th and 18th centuries in northern Russia. The project adopted an advanced methodological approach based on semantic decomposition criteria, supported by model exploded views. This method allows each decorative element to be segmented and analysed in detail, facilitating the identification of recurring or similar components and improving the understanding of their complex geometry.

A fundamental step was the integration of point clouds acquired by laser scanner survey and advanced photogrammetry. These datasets, segmented and organised by level of detail, were used as a reference basis for interpreting and modelling the architectural decorations.



The data acquired by mobile laser scanners and drones were used to model the surrounding environment, as they allowed for a precise and detailed reconstruction of the characteristics of the landscape and non-architectural elements, such as roads, vegetation, and street furniture. These data, acquired from a high altitude and in motion, provided a global view of the area, which was helpful in contextualising the architectural modelling within the surrounding environment.

Data derived from the terrestrial laser scanner and photogrammetry performed with digital cameras were used to model the architectural volumes. Thanks to its ability to acquire geometric details with high precision at the level of individual elements, the terrestrial laser scanner allowed for an accurate reconstruction of architectural surfaces, such as façades, arches, columns and other relief structures. Photogrammetry integrated geometric data with visual information, providing details of structures' texture and surface characteristics.



**Fig. 11**  
**Setting up a modelling workflow based on point cloud**  
 The first step is to orient the model and define the reference planes. For orientation, it is possible to align the model according to real-world geographic coordinates, which can then be associated with the "True North" view setting. To facilitate modelling operations, an additional view can be configured using an arbitrary "Project North", which can be toggled in the view settings. Secondly, a structured grid of levels, both in elevation and plan, is defined to establish the framework of the model. This operation can be compared to the erection of scaffolding during a construction phase, as the reference levels form the structural skeleton that supports the construction of the digital model.

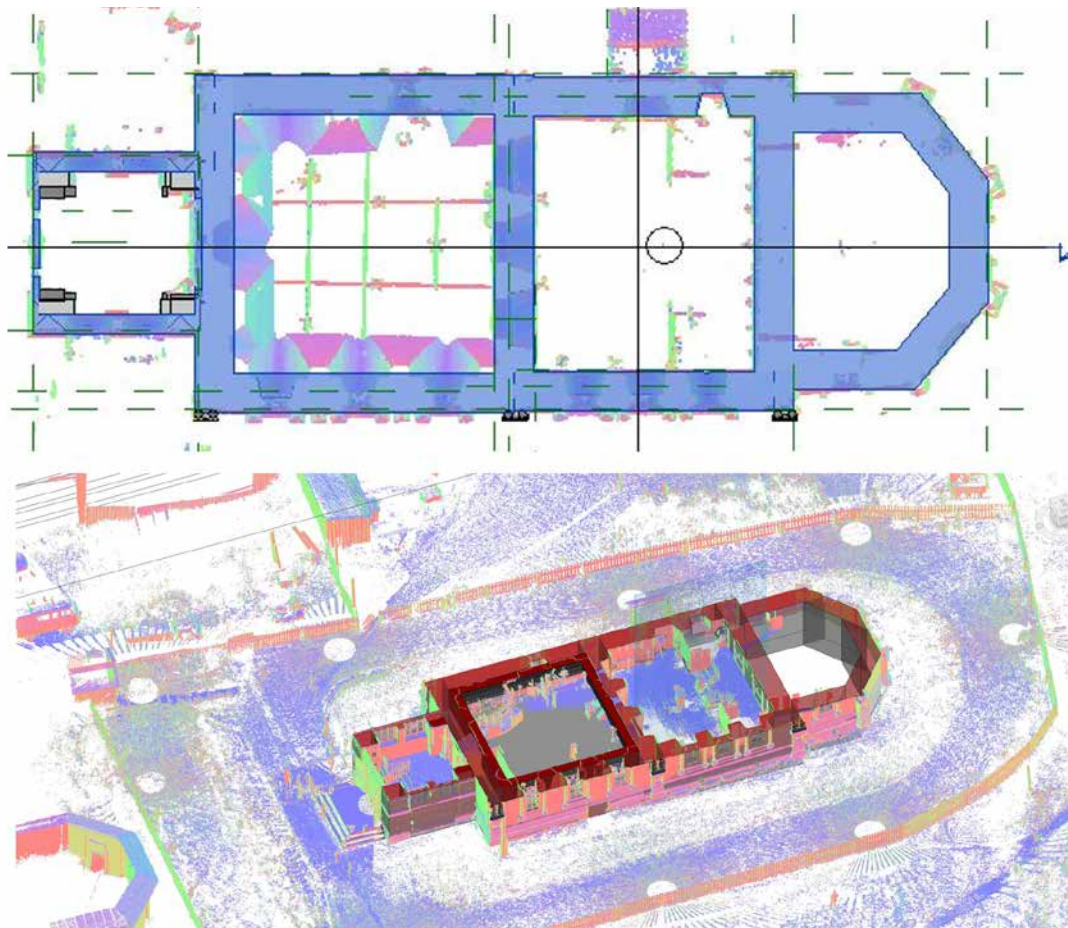
During the modelling phases, the point cloud data were constantly compared with the available photo archives. This cross-checking allowed the data to be interpreted correctly, ensuring greater reliability and accuracy in the model. The photographic images offered an immediate visual reference, which was useful to resolve any ambiguities in the data and better understand the case study's architectural features.

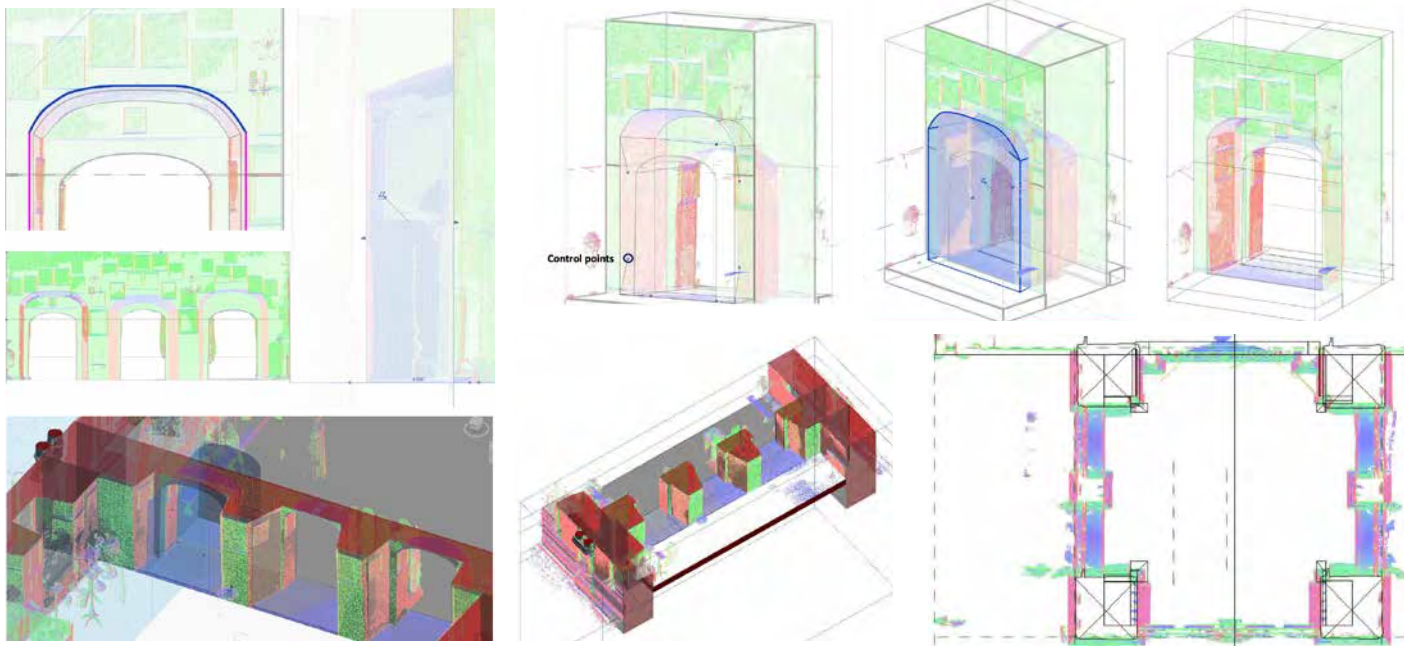
The accurate segmentation of the point clouds isolated the onion-shaped structures of the roofs, volutes, mouldings, friezes, and bas-reliefs, enabling comparative analysis between elements with similar geometries and facilitating their digital reconstruction.

One of the main limitations of traditional modelling, the difficulty of representing unique decorative details without compromising geometric accuracy, was overcome by this approach. By breaking down elements into simpler sub-units, it was possible to classify and organise decorations in a structured manner, facilitating their digitisation and subsequent integration into H-BIM models.



**Fig. 12**  
**Structuring of masonry walls**  
It was carried out on the basis of the point cloud data. Starting from a generic wall family, the walls were then characterised as specific model components and renamed according to an internal project coding system.



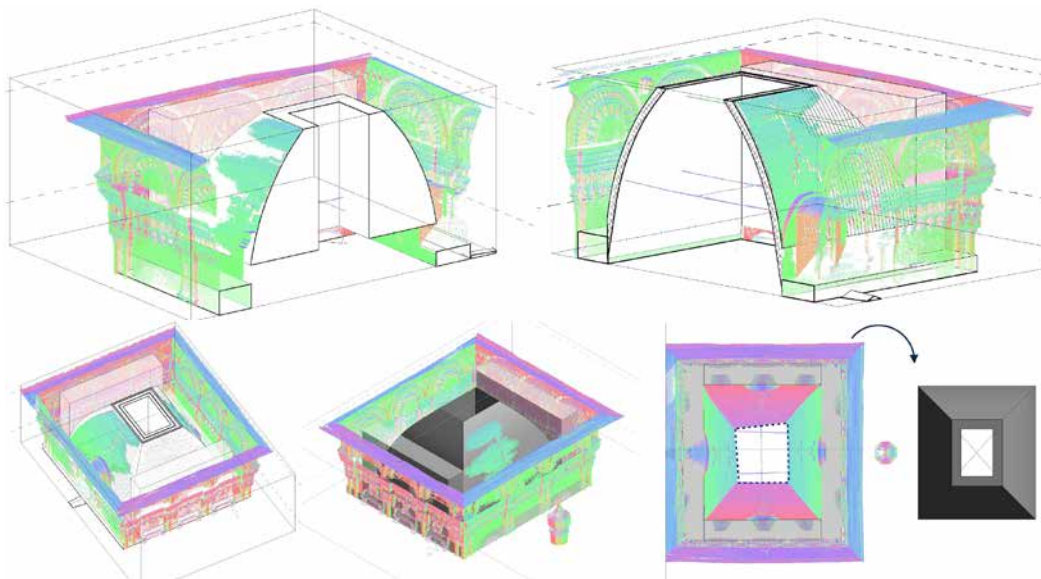


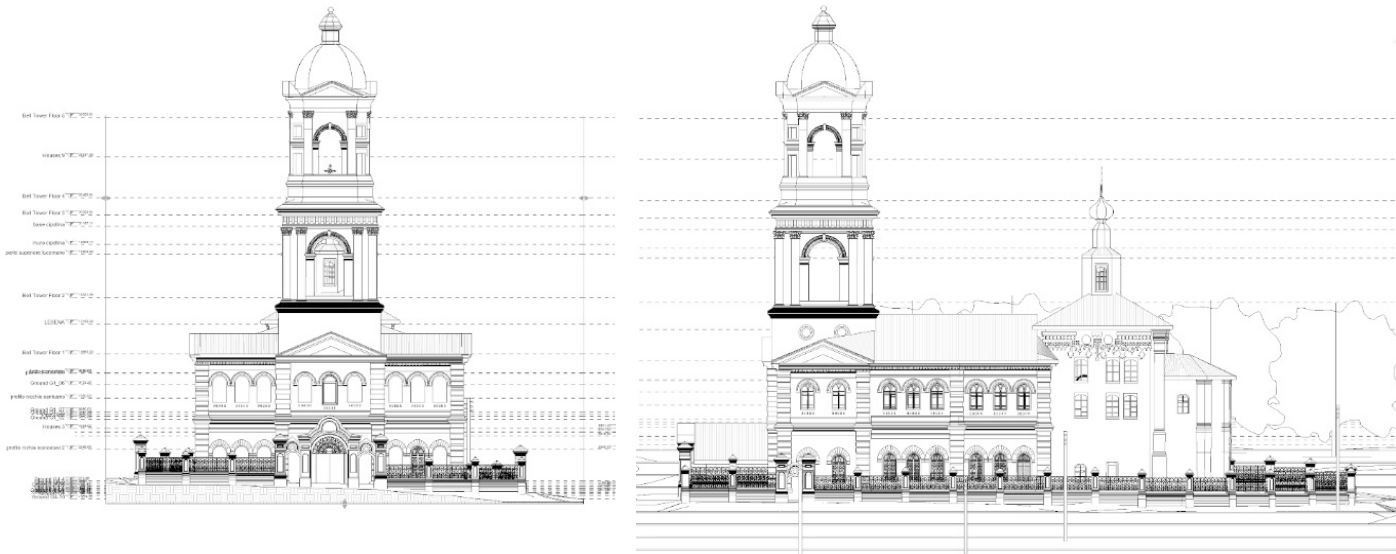
The goal of this methodology is not only the faithful digital representation of the Stroganov Baroque architecture, but also the creation of a library of decorative elements that can be reused for future studies and restoration, ensuring a structured digital archive for the preservation and enhancement of the region's architectural heritage.

Each identified element is encoded with an alphanumeric identifier and placed within a shared digital library on the cloud, accessible to the different research groups involved. This archiving system guarantees the preservation and organisation of information and the possibility of implementing and reusing the modelled data in future projects, contributing to a broader vision of the digital management of cultural heritage.

⬇️  
**Above and below, Fig. 13, 14  
HBIM Verification**

The verification of the adherence between the point cloud and the model was carried out by superimposing the two datasets and evaluating the deviations through dedicated analysis tools. This process ensured the geometric accuracy of the model and allowed for the refinement of individual components where discrepancies were detected.



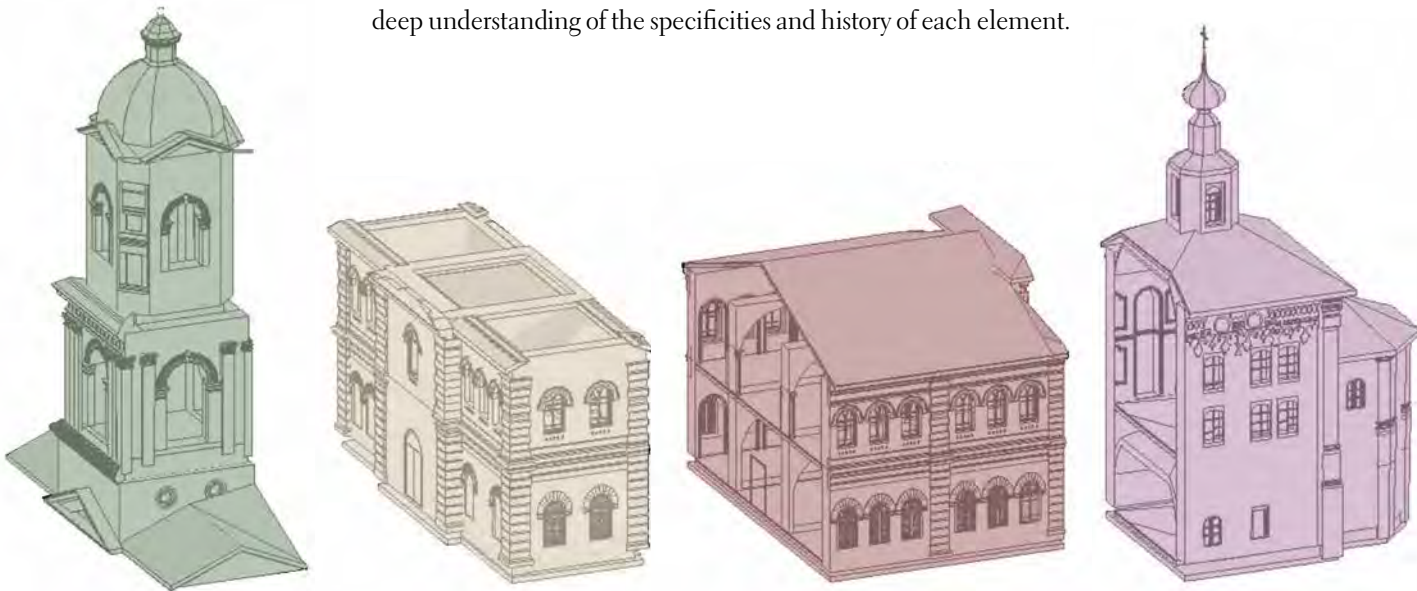


Above, below and next page  
Figs. 15-17

**A 3D semantic representation**  
The following images illustrate  
the outcomes of the 3D  
modelling process of the Trinity  
Church of Vilgort.

The PROMETHEUS project is charting a new direction in the digitisation of diffuse historical heritage, experimenting with advanced H-BIM methodologies for representing and managing cultural heritage. The integration of innovative technologies, collaborative models and data sharing systems is laying the foundations for a new operational practice in protecting and enhancing architectural heritage, fostering a more systematic, scientific and accessible approach to the knowledge and preservation of historical memory.

Research in the field of H-BIM is a constantly evolving topic, open to criticism and new developments. A central and problematic aspect that emerges is the relationship between data acquired through reality-based technologies and the intrinsic nature of historical heritage, which is characterised by the identity and uniqueness of its component elements. This contrast manifests itself in the difficulty of applying a standardised approach, typical of BIM modelling, to historical heritage, which requires a deep understanding of the specificities and history of each element.





*Next pages Figs. 18-20*  
**A 3D semantic representaiton**  
 Views of the Usolye territory  
 modelled according to  
 cartographic data, with the  
 individual building models  
 generated in Archicad integrated  
 into the broader landscape.

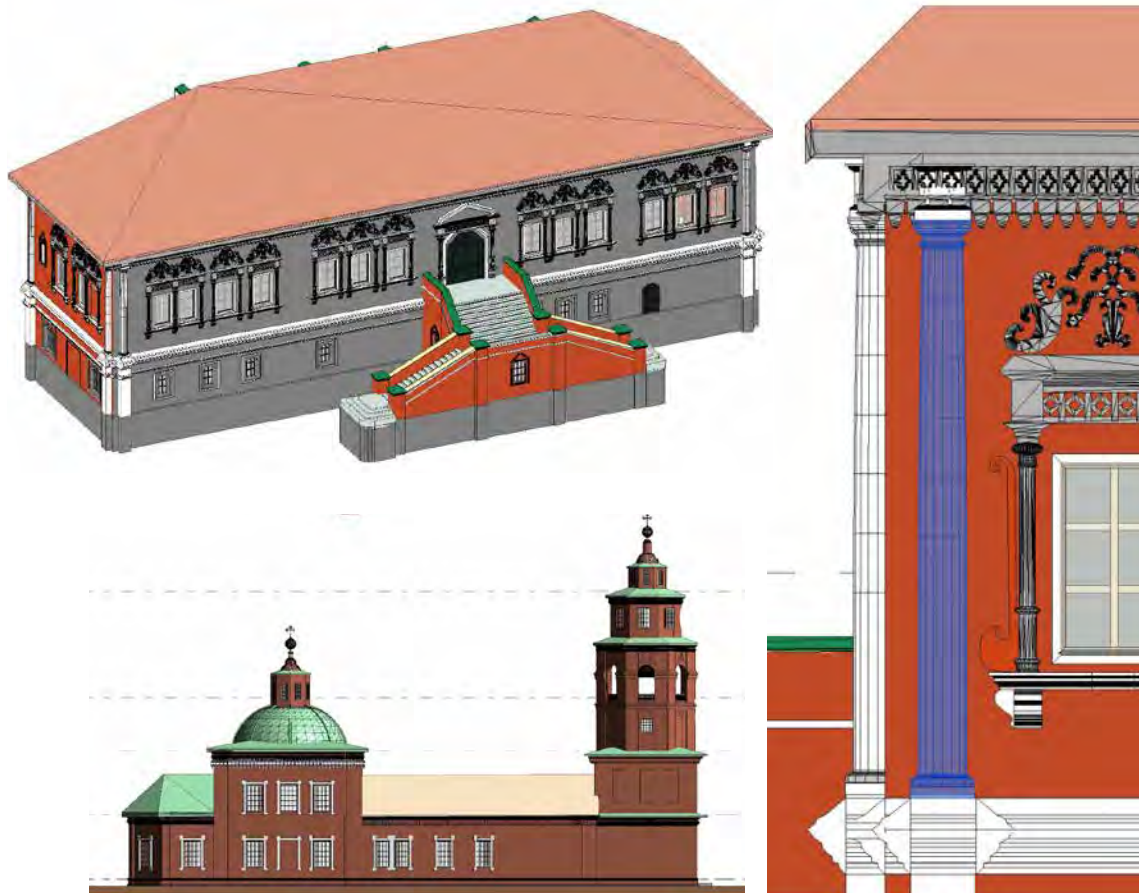






The H-BIM model, if not developed through careful and critical reflection, may end up being a superficial and uncritical replication of spaces. To prevent this, it is essential that the model is constructed based on a precise reworking of the metric data obtained from a thorough survey acquisition project. This approach ensures an accurate representation of the built environment. Additionally, it requires a detailed semantic analysis of the elements, where each component that defines the structure and appearance of the building must be identified and represented in the context of its historical and architectural characteristics.

Without critical reflection, the H-BIM model risks becoming an anonymous and standardized reproduction, which lacks the unique identity essential for the conservation and valorisation of heritage. As a result, a model that does not fully consider the uniqueness of its elements may prove to be of limited use in applications related to restoration and management of architectural heritage. If the forms represented do not align with the actual built environment, it can compromise the quality and effectiveness of interventions.



←  
 Here and in next pages Figs. 21-23  
**Detailed Architectural  
 Modelling of Individual  
 Buildings within the Usolye  
 Territorial Framework**

The following images present the individual building models developed within the project, showcasing the level of geometric and semantic detail achieved. Each model integrates architectural components such as walls, roofs, openings, and decorative features, faithfully reconstructed from point cloud data. These models are designed to be fully integrated within the broader territorial model, allowing for a comprehensive reading of the urban and landscape context.



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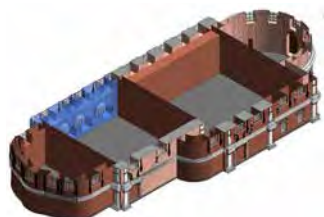
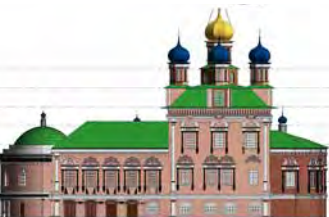
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## Credits



### Research Project

PROMETHEUS – *PRO*TOCOLS for *IN*formation *MO*dels *LIB*rary*ES* *TE*sted on *HE*ritage of *UP*per *K*ama *S*ites – is funded by the European programme Horizon 2020-R&I-RISE – Research & Innovation Staff Exchange Marie Skłodowska-Curie, Proposal Number: 821870.

The scientific coordinator of the project is Prof. Sandro Parrinello.

The project involved collaboration among academic and non academic partners.

#### List of the academic partners:

University of Pavia (Italy)  
 Polytechnic University of Valencia (Spain)  
 Perm National Research Polytechnic University - until 2022 (Russia)  
 Gdańsk University of Technology - since 2022 (Poland)  
 University of Florence - since 2023 (Italy)

#### List of the non academic partners:

SISMA srl (Italy)  
 Ebime srl (Spain)  
 MetaHeritage srl - since 2022 (Italy)  
 Blesarq - since 2022 (Spain)  
 CTA srl - since 2022 (Poland)

### Project Coordinators

**Sandro Parrinello** (from January 2019 to May 2023)

**Francesca Picchio** (since May 2023)

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Archive details: State Regional Budgetary Institution “State Archive of the Perm Krai” — GKBU “GAPK”, 36 Studencheskaya Str., Perm, Perm Krai, Russia.

A selection of the research outputs presented in this volume was developed through educational activities, including master and PhD thesis, academic courses, workshops, and international summer schools. These initiatives engaged students from the universities participating in the research programme and were conducted under the supervision and support of the project's researchers. The resulting materials, such as drawings, survey documents, and digital models, constitute an integral component of the scientific contributions published in this volume.

### **Architectural Survey and Restoration Course**

DICAr, University of Pavia

Academic Year 2018/2019

Course Coordinator: Sandro Parrinello, Giovanni Minutoli

Course Assistant: Anna Dell'Amico, Matteo Bigongiari

**Rubezhskaya Church (Cherdyn)**, pp. 169, 172: Martina Frazzica, Yafei Liu, Elif Yamaç, Linling Zhang

**Church of Saints Peter and Paul, Taman (Usolye)**, pp. 198–200: Francesca Alberici, Neslisah

Mamati, Gang Jin, Xiafei Wang, Bingjie Zhu

**Church of St. Nicholas, Nyrob (Cherdyn)**, pp. 282–283: Antonio Nuccio, Paulina Pawlata, Chenhong Xie.

**Church of the Exaltation of the Holy Cross, Bondyug (Cherdyn)**, p. 284: Anna Barancewicz, Jiachen

Fei, Francesco Grugni, Run He

**Church of the Presentation of the Blessed Virgin, Kamgort (Cherdyn)**, p. 285: Anna Barancewicz,

Jiachen Fei, Francesco Grugni, Run He

**Church of the Annunciation, Pokcha (Cherdyn)**, pp. 297–299: Rukiye Calikoglu, Giulia

Montanaro, Martina Lommano, Xiaoxi Guo, Jingyi Ying

### **Architectural Survey Course**

DICAr, University of Pavia

Academic Year 2020/2021

Course Coordinator: Sandro Parrinello

Course Assistant: Anna Dell'Amico, Elisabetta Doria, Francesca Galasso, Hangjun Fu, Anna Turrina

**Trinity Church, Vilgort (Cherdyn)**, pp. 287: Julia Attia, Ledio Bare, Noemi Fregonara, Strilchuk Dia-

na, Ilaria Benzoni, Miriana Luciani, Erika Maina, Alice Antignano, Giacomo Tosini, Marco Dell'Orto,

Mark Basaly, Vadim Pascaru, Mattia Lombardi, Andrea Pellegatta.

**Cathedral of the Resurrection of Christ, Cherdyn:** Giorgia Calabretta, Caterina Comi, Leonardo

Mattiolo, Alice Sivelli, Maty Oyeronbi, Alessandra Travasso, Pacifica Arianna Lavia, Valeria Maria

Ranieri, Beatrice Zanetti

### **Architectural Survey Course**

DICAr, University of Pavia

Academic Year 2021/2022

Course Coordinator: Sandro Parrinello

Course Assistant: Anna Dell'Amico, Elisabetta Doria, Francesca Galasso, Hangjun Fu, Anna Sanseverino

**Church of Nativity of John the Baptist (Solikamsk)**, pp. 212–216: Andrea Abba, Abderrahman

Benkhadra, Marika Franchini, Rafael Geci, Federica Guarnaccia, Maria Sofia Medda, Laura

Miculi, Letizia Montagna, Martina Pizzo

**International Summer School 2015**

**Vanishing heritage of prikamyé: Usolye. Advanced approaches to preservation of the Stroganov architectural ensemble (7-11 July 2015)**

Scientific Responsible: Sandro Parrinello, Svetlana Maksimova

Scientific Committee: Sandro Parrinello, Svetlana Maksimova, Roberto De Lotto, Piotr Lorens, Kseniia Chmutina, Aleksandr Metelev, Andrey Zhukovsky, Stefano Bertocci

Organising Committee: Svetlana Maksimova, Sandro Parrinello, Lubuov Sosnovskih, Stanislav Horobryh  
Tutors: Anna Shamarina, Kseniia Mezenina, Francesca Picchio, Vladimir Korotaev, Julia Bushmakova, Stanislav Horobryh, Victor Golubev, Ekaterina Melcova

Participants: Elizaveta Nizhelskaya, Iuliia Pavlova, Elina Falakhova, Deena Mohamed Elmahdi Ahmed Hassanin, Rawda Emadeldin Aziz Abdelaziz, Julia Bushmakina, Anna Kalitina, Valeriya Kashevarova, Alena Pirutskaya, Iuliia Shorkina, Iuliia Kazakova, Raisa Nigmatullina, Catherine Shaidurova, Iuliia Shayhislamova, Elmogy Omneya Abdelhamid Taher, Shehata Waled Tarek Aly, Kareem Mohamed Ayman Abdelmajeed Daef, Alexey Leybchik, Iuliia Ryzhkova, Giulia Porkeddu, Alexey Zaitsev, Artem Maximovskiy, Federico Cioli, Anna Abramova, Olga Iscelimova, Pavel Khryashchikov, Iuliia Lapitskaya, Ekaterina Morar, Tanya Adamenko

**International Summer School 2016**

**Vanishing Heritage of Upper Kama: Usolye. Architectural Heritage in digital era (19-28 July 2016)**

Scientific Responsible: Sandro Parrinello, Svetlana Maksimova

Scientific Committee: Sandro Parrinello, Svetlana Maksimova, Piotr Lorens, Kseniia Chmutina, Aleksandr Metelev, Andrey Zhukovsky, Stefano Bertocci, Roberto De Lotto

Organising Committee: Svetlana Maksimova, Sandro Parrinello, Stanislav Horobryh

Tutors: Anna Shamarina, Kseniia Mezenina, Francesca Picchio

Participants: Andrea Campotaro, Federico Cioli, Federico Gugliotta, Giulia Montanaro, Luca Frigerio, Daria Davydova, Maria Merkusheva, Ekaterina Morar, Anastasia Kuznetsova, Raisa Nigmatullina, Iuliia Pavlova, Anastasia Parfievich, Alena Pirutskaya, Alfa Sadykova, Paulina Surina, Elena Tokareva, Iuliia Shaikhislamova, Svetlana Maksimova, Maxim Androsov, Mariya Malinskaya, Alexander Solopov

**International Summer School 2018**

**"CHR DATE - DocumentAtion in digiTal Era" Survey and analysis for an architectural Experiment-Evolution of Cultural Heritage Routes' knowledge. (23 July - 4 August 2018)**

Scientific Responsible: Sandro Parrinello, Svetlana Maksimova

Scientific Committee: Quiteria Angulo-Ibáñez, Andrea Arrighetti, Galina Batrakova, Joaquina García Sentamans, Antonio Gómez-Blanco Pontes, Tatiana Gudz, Vladimir Korotaev, Svetlana Maksimova, Giovanni Minutoli, Sibel Onat Hattap, Luis Manuel Palmero Iglesias, Sandro Parrinello, Francesca Picchio, Esteban Rivas, Petri Vuojala, Andrej Zhukovskij

Organising Committee: Sandro Parrinello, Svetlana Maksimova, Francesca Picchio, Anna Shamarina

Tutors: Raffaella De Marco, Anna Dell'Amico

Participants: Alberto Pettineo, Chekletsova Irina, Ksenia Koryakova, Alexey Leybchik, Anna Shamarina, Aleksandra Kitelyova, Iuliia Bushmakina, Anastasia Semina

### **International Summer School 2019**

#### **PROMETHEUS - PROtocols for information Models librariEs Tested on HEritage of Upper Kama Sites**

(22 July - 4 August 2019)

Scientific Responsible: Sandro Parrinello, Svetlana Maksimova

Scientific Committee: Quiteria Angulo-Ibáñez, Andrea Arrighetti, Galina Batrakova, Joaquina García Sentamans, Antonio Gómez-Blanco Pontes, Tatiana Gudz, Vladimir Korotaev, Svetlana Maksimova, Giovanni Minutoli, Sibel Onat Hattap, Luis Manuel Palmero Iglesias, Sandro Parrinello, Francesca Picchio, Esteban Rivas, Petri Vuojala, Andrej Zhukovskij

Organising Committee: Sandro Parrinello, Svetlana Maksimova, Francesca Picchio, Anna Shamarina

Tutors: Raffaella De Marco, Anna Dell'Amico

Participants: Alberto Pettineo, Giacomo Tortorella

### **3D Models and Fabrication**

All 3D models are authored by the contributors of the respective chapters, except for the model of **Church of the Exaltation of the Holy Cross, Bondyug (Cherdyn)**, which was developed within the framework of Architectural Survey and Restoration Course 2018/2019; **Trinity Church, Vilgort (Cherdyn)**, **Cathedral of the Resurrection of Christ, Cherdyn**: the Architectural Survey Course 2020-2021 and **Church of Nativity of John the Baptist (Solikamsk)** Architectural Survey Course 2021-2022; it is due to Anna Shamarina the develop of 3D model of Buildings within the Usolye Territorial Framework.

3D printing models were produced at:

DAda-LAB, University of Pavia Prototyping and processing of 3D printing models:

Prototyping and processing of 3D printing models: Hangjun Fu, Dante Certomà

## Titoli pubblicati

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The project involved lecturers, researchers and students from different disciplinary fields and proposed an integrated approach to historical and architectural heritage, combining critical interpretation, digital survey, 3D modelling and information systems. Within this framework, PROMETHEUS investigated the application of BIM to heritage contexts, testing digital and cognitive protocols for the representation, management and enhancement of European cultural heritage.

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