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# MKSCAL – SYSTEM FOR LAND CONSOLIDATION PROJECT BASED ON CAD PLATFORM

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**Summary**

Consolidation works are a complicated and lengthy set of legal, technical and administrative operations. IT tools used in this process are developed in many countries, and the scope of their functions is very wide: from a decision-making aid, through support in solving technical aspects, to assisting the evaluation of the effects of consolidation projects. Practically all existing solutions are based on GIS systems, which has many advantages but also imposes some limitations related to supporting typically geodetic aspects of these works. The article presents a different approach to implementing this kind of projects, which is based on CAD platform. It is used as an aid in various stages of land consolidation works in more or less half of the area of Poland.

**Keywords**

land consolidation • land reallotment • expert systems

## 1. Introduction

Land fragmentation is one of the key factors that negatively affect the profitability of agricultural production [King 1982]. Many countries around the world and in Europe, especially those in Central and Eastern Europe, are confronted with this problem, which continues to be the subject of numerous recent studies [Hartvigsen 2014]. The most important aspect of land fragmentation is the division of farms into many small plots scattered on a large area, which often makes farming costs higher than potential profits. To improve this ratio land fragmentation process is most commonly used [Pašakarnis and Maliene 2010]. Its aim is to reorganize the layout of plots on a large area of a whole village or – more rarely – its part, or a compact area covering a few neighbouring villages.

Land consolidation procedure is a complicated and costly operation, and the duration of such projects depends on solutions adopted in a particular country and varies from a few to a dozen or so years [Hartvigsen 2015]. This period includes both the implementation of the land consolidation project and time necessary for carrying out essential accompanying investments, including especially building new agricultural roads. The process has largely administrative and legal character, however due to major share

of typically technical elements, including those related to measurements and calculations, development of information technology has proven effective in aiding specific aspects of these works. The model of consolidation works differs greatly depending on a country where the works are carried out, from highly centralized, based on state or local government units, to a strictly commercial one, with private companies acting as part of public works contracting system. Carrying out land consolidation works is in most cases an element of rural areas development politics implemented in specific countries [van Dijk 2007], or even, as it is in the EU member countries, the politics realized in the whole region [Sonnenberg 1996].

The most popular IT solutions adopted to assist in the land consolidation procedure are based on GIS type platforms [Martínez 2013, Junfang et al. 2006, Tourino et al. 2003, Semlali 2001] and are used as help in typically technical operations, in planning elements of these works [Changjiang 2011], as well as in estimation of their effects [Coelho et al. 2001, Gonzalea et al. 2004], while the project implementation can be supported by propositions of land plots layouts generated by optimizing algorithms [Wang 2010, Demetriou et al. 2014, Cay and Iscan 2011]. More and more often they take the form of integrated systems covering broad scope of operations related to consolidation works [Demetriou 2014].

The paper presents a different approach to aiding consolidation works, based on CAD type platform. It is executed by a software package called MKSCAL, which is widely used in Poland. The approach based on CAD has its origins in the historical aspects of its development. The main task of the early versions of this software was to help to create a consolidation project based on the results of geodetic surveys and available geodetic and cartographic data. However, at the time when the MKSCAL was developed – namely at the beginning of the 21st century – the basic tool used by many firms carrying out consolidation works in Poland was a family of MircoStation software by Bentley. The advantages of CAD-oriented approach to designing consolidation works are still significant, as they give much greater freedom in designing, offer more drawing tools and broader scope of using various data formats than GIS platform. Yet undoubtedly both approaches to storing and processing data are increasingly convergent, also due to the development of conversion methods of these two types of data, especially from CAD to GIS environment [He 2011, Al Rawashdeh 2013]. For this reason, in a dozen or so years a division between tools based on CAD and GIS model may disappear.

## 2. Technical and legal conditions of consolidation works in Poland

IT solutions supporting transformation process of lands spatial structure are largely determined by legal and organizational conditions existing in a specific country. When describing the structure and functionality of the MKSCAL system it seems reasonable to outline the model of how consolidation works are carried out in Poland. Such projects are run by specialized units of voivodeships governments. In almost each of 16 voivodeships in Poland there is usually one geodetic unit which carries out such works and which, in some voivodeships, has its local branches. Only in a few voivode-

ships there are no units of this kind, because of relatively low demand for that kind of works in the area. In such cases consolidation works are done by units from other parts of Poland under agreements of appropriate local governments.

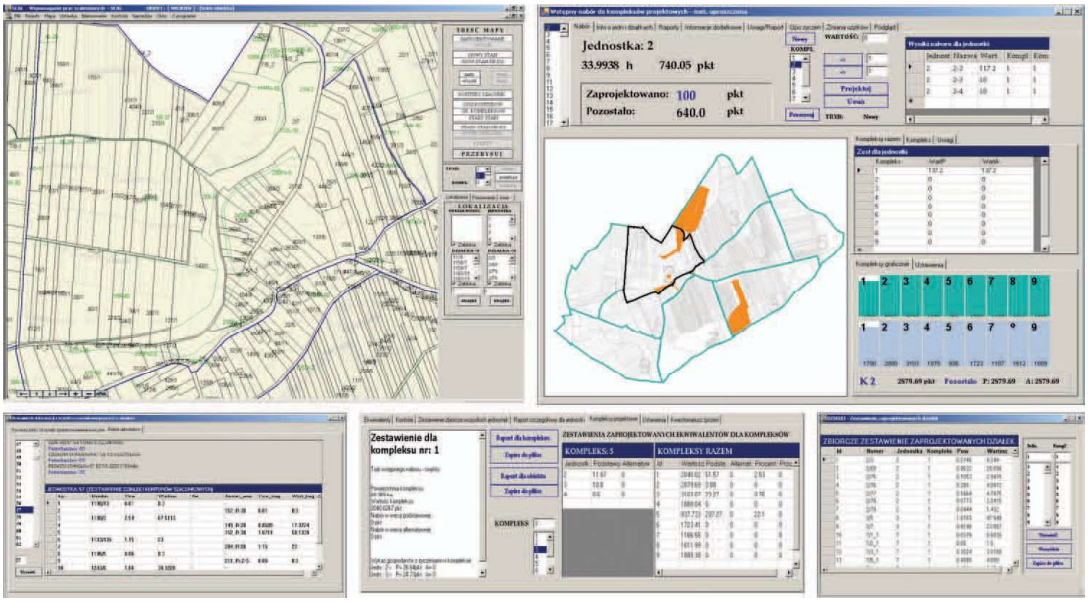
In Poland there are no technical requirements related to IT tools that can be used in land consolidation works. Up until the beginning of the 21st century each institution developed its own IT tools aiding consolidation works, of mostly fragmentary rather than comprehensive character. Of major significance was a choice of a principal IT platform for most geodetic works in a voivodeship. Two types of software dominated and still dominate in this respect: the first one consists mainly of CAD software of Microstation line by Intergraph and by Bentley Systems, the second is based on Polish device integrating functionalities typical of CAD, GIS platforms, complying with the specificity of the Polish cadastral data model and including contents of separate categories of geodetic maps – software package developed by Geobid since the nineties up to this day. Other tools, including those based on typical GIS platforms (and on ArcGIS, MapInfo, Geomedia and others), are in small minority, though recently they are becoming more poplar in some regions of Poland – and a good example of that is a system designed and put into implementation at the beginning of 2016, aiding consolidation works in the Lubelskie voivodeship, based on ESRI ArcGis platform.

## 3. The genesis of MKSCAL system

At the beginning of the 21 century the scale of consolidation works in Poland was relatively low because of two principal reasons. First, there was no effective tools to help their financing. The binding provisions of law limited the ways of financing these works almost exclusively to resources of the Treasury. This apparently safe method was in practice very problematic, as this kind of expenditures was not included in consecutive budget plans, which was the condition for the works to be done. Second reason was a relatively low interest of lands' owners. Negative perception of local communities stemmed from their experiences of consolidation works carried out according to the law of 1969 on consolidation and exchange of lands, which was in force up to 1982. Its provisions allowed for consolidation works to be done regardless of or even against the owners' will (manifested in applications). Moreover, the works often boiled down to approving the project on new layout of plots and to outlining it in the field, while access roads to arable lands were not built for a long time after the consolidation had been completed.

In Poland the consolidation works, in contrast to majority of other categories of geodetic works, were never an element of free market game, and they were reserved, with rare exceptions, first to state units and then, after the reform of 1999, to local government units. The result was a limited number of institutions responsible for consolidation works. Together with an almost total disappearance of consolidation works at the beginning of the 21st century, it diminished the interest of software firms in developing tools for consolidation works. Also, at the level of local and central government, there were no solutions enabling uniform IT standard encompassing common data model, tools and procedures.

The first attempt at comprehensive approach to implementing IT solutions to consolidation works was made in 2001 in the Małopolskie voivodeship on the occasion of resuming, after many years of suspension, consolidation works in Wojków. The works were continued up till 2014 and it was during that period when the MKSCAL system was conceived and implemented. Its first form [Janus and Zygmunt 2005, Litwin et al. 2006] consisted of two elements: project part, integrated with MicroStation graphic platform by Bentley Systems, and a module for assisting the process of balancing consolidation works in accordance with requirements of the law on consolidation and exchange of lands, the software created with the use of Visual Studio package and independently of CAD platform (Figure 1).




Source: author's study

**Fig. 1.** Chosen elements of the first version of MKSCAL system of 2005

The innovativeness and potential of the package were soon noticed by and then implemented in many centres responsible for carrying out consolidation works in Poland. In 2006 the system and its two authors were awarded a prize by the Ministry of Construction in recognition of outstanding achievements in geodesy and cartography that consisted in designing and implementing this system in nearly half of Poland.

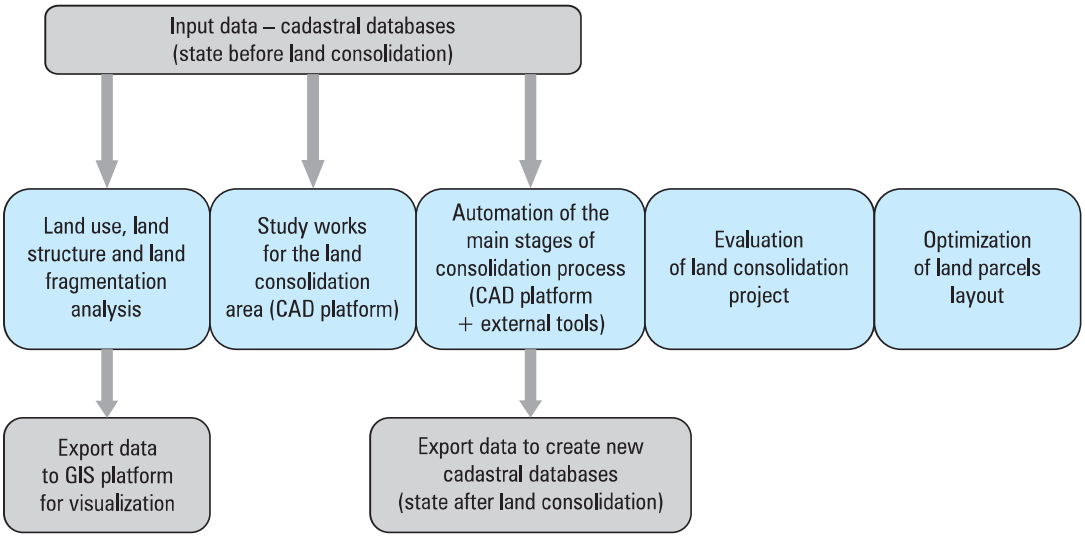
Since its market launch the software package has undergone many changes, related to both the development of original modules and adding new functionalities, including those assisting the study stage and evaluation of consolidation works. Today it can be regarded as a fully integrated system assisting both the decision processes and implementation stages of consolidation works.

## 4. The functional scope of the system – from analysis of the needs to evaluation of results

Today, that is in 2016, the MKSCAL system consists of a number of elements, aiding the following categories of works related to the process of consolidation of lands:

- analysis of land and building register (LBR, in Polish: EGiB) databases in order to identify the areas with unfavourable parameters of lands' spatial structure that qualify them for consolidation works,
- assisting the study works proceeding the proper consolidation works,
- automating appraisal map creation based on LBR data and on comparative estimation of lands,
- automating appraisal registers generation before and after consolidation,
- assisting the creation of transitional register,
- automating the process of designing land plots of intended value, size and width,
- assisting the generation of geodetic documentation,
- assisting the process of balancing and control of the project in accordance with the provisions of the law on consolidation and exchange of lands,
- assisting the process of establishing new land register after consolidation,
- evaluation of effects of completed consolidation works,
- experimental module of optimizing plots layout, based on the methods of linear programming using binary variables and external computational package GLPK [Makhorin 2008].

The functional chart of MKSCAL system is presented in Figure 2.




Source: author's study

**Fig. 2.** Structural chart of MKSCAL system

## 5. Automation of some stages of consolidation process

This article is aimed at presenting these elements of the programme that while using the best aspects of CAD platform can be of help in some technical operations. These elements are presented in consecutive subsections below.

### 5.1. The preparation of land value map

One of the key elements of consolidation procedure is defining the principles of appraising lands intended for consolidation, because in Poland, as a rule, individual owners are allotted the same (with some tolerance) value of lands before and after the consolidation. These principles should than be applied in the process of creating the land appraisal map of the consolidation area. The content of the map is in turn used in the process of generating comparisons defining the value of each participant's lands divided into particular plots.

These operations are usually based on maps of land quality classification and soil and agricultural maps, while the additional aspects taken into account in the appraisal process are records of local development plans, distance zones and local corrections proposed by representatives of local community.

### 5.2. Generating register of comparative appraisal before consolidation

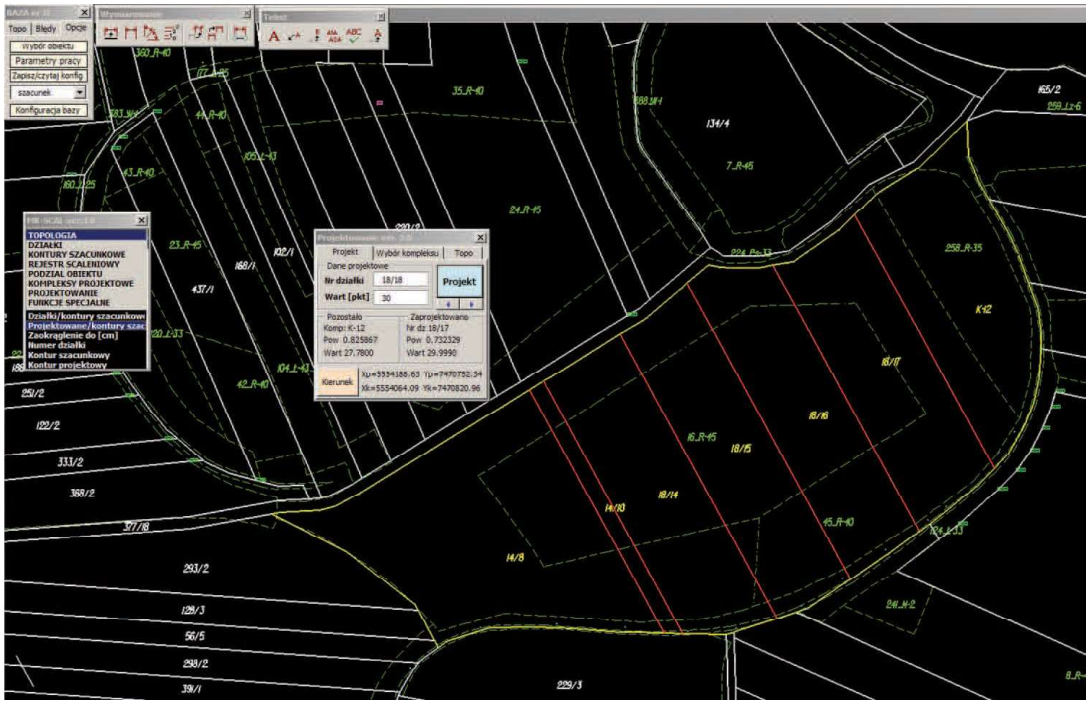
Completed appraisal map, after geometric cutting of a layer which it represents with a layer of plots, enables generation of adequate comparisons, formally called "register of comparative appraisal". This operation is performed in the consolidation procedure twice, at its beginning and at the end, which allows for essential comparisons in the evaluation of consolidation correctness and financial settlements related to enlargement or reduction of farms' areas.

### 5.3. Division of object on project complexes

After the appraisal register is generated, the works on the essential elements of the project can be stared. The design process must be proceeded by a division of a village area into complexes, often limited by existing or newly designed roads, external borders, borders of compact forest areas, built-up areas, rivers, railways and any significant terrain obstacles. The boarders of these areas have their counterparts on the comparative appraisal map, in the form of borders of proper appraisal contours and areas excluded from the appraisal. On this basis, in an automatic or semi-automatic way, a first version of division into project complexes can be created, which then can by an object of further corrections based mainly on data from geodetic measurements taken directly in the field.

## 5.4. Designing plots

Assisting the process of designing plots (Figure 3) is made in many ways: as designing plots of intended value, while taking into consideration the content of appraisal map, as designing plots of intended size or intended width. The algorithms used accept any complexity of appraisal map and any shapes of complexes. The tools to help the designing process are combining the advantages of CAD approach to free creation of vector drawing with requirements of current control of topological correctness of structure of created area spatial objects. To this purpose technology of virtual objects was used [Siejka et al. 2014].




Source: author's study

**Fig. 3.** An example of module of the MKSCAL package, responsible for designing plots

The designing process is enhanced by an information immediately conveyed to the user on a current state of the project for a given farm, on the plots layout before and after consolidation and on comparisons of values and sizes of lands (Figure 4).

Equally important aspect of preparing a consolidation project is a control over its correctness from the point of view of legal provisions regulating this procedure. They impose a number of conditions and limitations on a created project that have to be controlled during outlining the borders of consecutive plots. One of the most important requirements of correctness is the control of size and value divergence of plots in a specific farm, before and after consolidation, and compliance of proposed locations

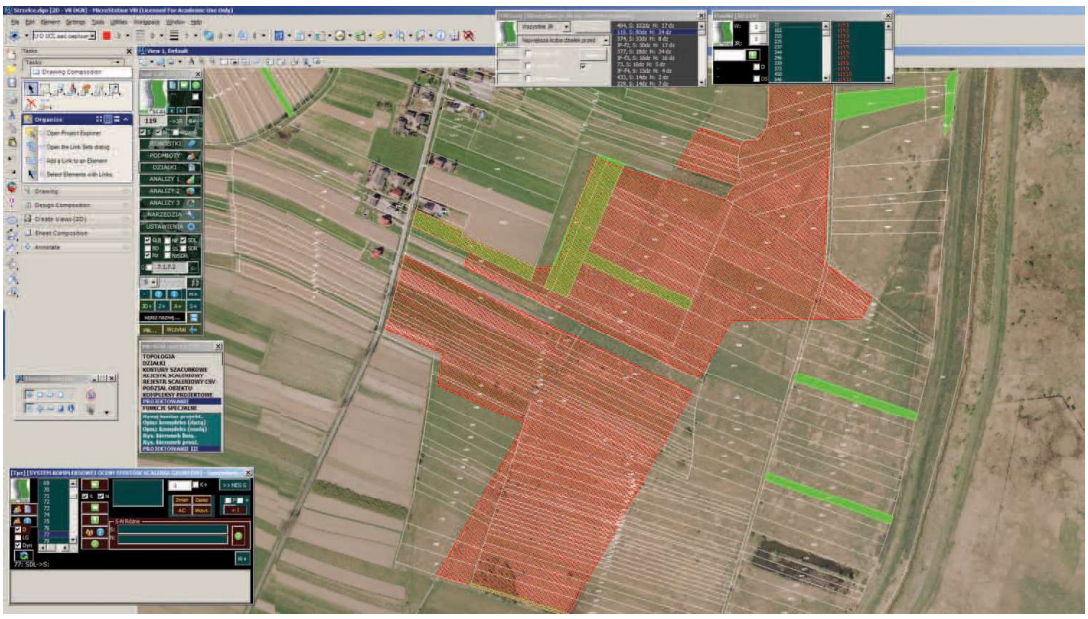


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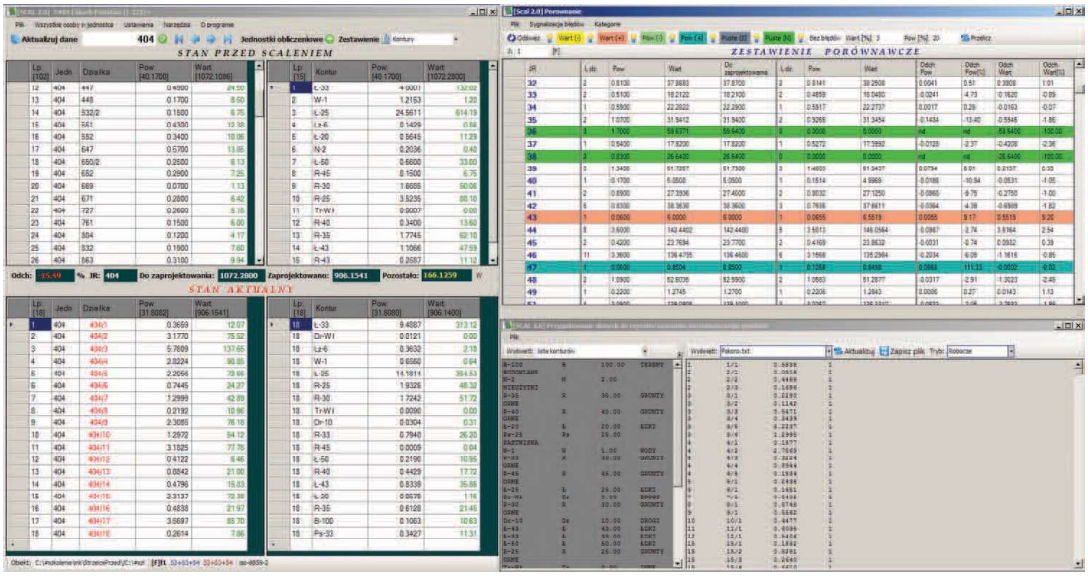
**Fig. 4.** An example of module of the MKSCAL package, responsible for visualizing progress of works in the MicroStation software family




Source: author's study

**Fig. 5.** Some elements of the MKSCAL package, presenting the progress of works over the project of consolidation in a tabular form

with an owner's application. It is verified by a separate group of system's tools, and some elements of them are presented in Figure 5.

The final form of the project is a basis for generating geodetic and cartographic documentation, or lists of coordinates, outlines of plots' layouts and documentation maps. The last stage of works consists in generating digital cadastral databases showing new plots layout and documentation, essential to upgrading land and mortgage register.

## 6. Conclusions

The elements of software package described in the article showed their great potential in assisting the technical aspects of consolidation works procedure, and their usefulness has been confirmed in numerous implementations overseen by appropriate units over the last dozen or so years. It is especially noteworthy that there are actually no limitations as to the size of objects, their number (up to tens of thousands) and area (even a few thousand hectares). By involving CAD platform it is possible to simultaneously use many other dedicated tools and overlays for geodetic design development, including those for creation of situational-elevation layers or related to utility infrastructure. Using the algorithm of virtual topography provides the possibility of taking advantage of object-oriented approach to map development, while keeping the convenience of graphics editing typical of CAD platforms. Among the disadvantages of the presented approach is limited scope of spatial analysis (defined by a user and not explicitly anticipated by the system's developers) and less convenient data exchange with other systems, regarding both geometry and all objects' attributes stored in the system. In the process of its development the presented software has been supplemented with numerous analytical modes related to evaluation and optimization of plots' layout, including algorithms of automatic division. These features make him a comprehensive (though not integrated in one platform) assisting system useful not only in consolidation works but also in analytical and decision processes related with them.

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