GEODETIC INSTRUMENT CALIBRATION POLYGON ELEMENT STRUCTURE AND CONSTRUCTION

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ABSTRACT

Geodetic instrument calibration polygon major components, elements structure and constructions of corresponding to different meanings, configuration and objectives of geodetic instruments calibration polygons establishments and exploitation, they are complex elements and elements that are tailored to the practical tasks of the user. Most important role of elements is support to ensure that the measurement results comply with the requirements. It is also associated with certain elements design and construction, as well as their mutual combination, which provide the best and most reliable measurements performance and stability.
Research task was to prepare the initial theoretical justification for geodetic instruments calibration of polygon project to build a sound information base for elements creation, selection, design and structure. In Latvia is currently not available in full study, which covers of calibration polygon design and choice of element, which can be adapted to the local situation in Latvian, as here, there is not functional or maintained calibration polygon elements.
Result of the study is defined in the basic principles of polygon structure and design elements for selecting the future course of study. It is prescribed the basic positions of polygon development and gives insight into the content for further research and for filing in accordance with the objectives and quality requirements (including accuracy, stability and utilization). The proposed polygon structures comparison in accordance with the polygons of uses and construction elements of choice positions and justifications.
The study results include recommendations and conditions for use of the state geodetic grid of elements (centers), the adaptation and development of developing a new model of polygon.
Main objective of the study is to provide preliminary information and conditions to continue to organize the research and development to create project of new geodetic instrument calibration polygons elements structure and built it for use of the Latvia conditions.

Key words: geodetic instrument calibration polygon design elements, construction elements, geodetic quality laboratory's.

INTRODUCTION

In any type of technical operations - where are used measuring devices or technical equipment is always confronted with two major problems:
1. Is instrument correctly/accurately and credibly presented measured variables?
2. How reliable the measurement results are from used instruments?
Also, to the geodetic instruments application scope of fully attributable this essential problem effect when need find the answers to this questions – whether in surveying used instrument properly and accurately (according to the criteria set) be able to show the measured parameters and how relevant of importance to obtained measurement results with this specific instrument.
In addition to these classical criteria, which apply only to a particular instrument and its technical peculiarities, there are other effects of the factors who also have influence to obtained measurement results – for example for certain works (expected results) selected instruments usage and technologies together with measurer qualifications or training level as a specific instrument proper for user operation and correct selected technology of work application. Here already more emphasis is placed on human factors – such as specialist training and experience.
Geodetic instrument quality indicators response is usually given of the instrument technical documentation - which provides the instrument manufacturer. Traditionally, in order quality determine manufactured instruments depending on requirements, appliances manufacturers use:
• Different types of tests (calibration) stands.
• In Quality laboratories – by instrument manufacturing which checks can be carried out both

on specially constructed stands checks and without them.

- In Quality or control polygons.

Instrument manufacturers choose a specific product quality necessary testing procedures and sites for using all procedures fully or partially (at the specific need).

In special cases, manufacturers can be ordered, regardless of their own internal testing procedure, quality of research or calibration services (where need for an external instrument quality certificate - mandatory) which lead to an independent quality assurance.

Users of instruments answers to these questions are usually obtained by relying on the information provided by the manufacturer, or applying to institutions/authorities - whose behavior is equipped inspection/calibration stands, laboratories, etc., with available appropriate training staff. But despite the above-mentioned user's expectations against the manufacturer, however situation is often formed, which indicates that user need to be carried out in the same instrument or instrument measuring results checks of evaluations finished or performed works. In this case, instrument user requires access to take measurements or appropriate control or test, to polygon or in laboratory calibration stands. With the need for clear and some form of independent from manufacturers answers on the above lists of the geodetic instrument major problems need to face practical use of the most direct tool users as well – of the results measuring the work principles.

The probability of necessary begins with purchasing the instrument, continues with starting new jobs and ends with the discontinuation of the instrument. The instrument often can be discontinued after founding the facts about impossibility to obtain results with satisfactory answers in future exploitation of the instrument. The finding of this fact can be obtained while using all available **options of quality testing – available polygons, benchmarks, etc. services.**

The specification of instrument manufacturer may prove to be inadequate after obtaining highly accurate measurements, because the carefulness of how the technology of serial manufacturing in a highly precise measuring instrument should be developed and implemented doesn’t matter. Each instrument, however, has its own unique, individual /different qualities where every of them alone or in various combinations can affect the accuracy of results differently.

When we speak of the measurements of high accuracy, it is considered that each individual instrument has its own only and unique properties which are formed from the impact of several elements, for example:

- the each different manufactured indicator of accuracy differs from the same indicators in other similarly manufactured products (instruments);
- the assembly or the adjustment and the calibration of components also has the potential to affect obtained results differently;
- during the operations of each individual instrument there are many different external and internal factors which, in general, creates different and individual changes in the sizes of calibration, accuracy and stability.

The fact that during each operation of instrument may change its basic attributes differently has to be taken into account as well. These attributes are, for example:

- the interval between divisions in cylindrical bubble (level) tube;
- optical properties of telescope;
- operation parameters of compensator/s;
- the mutual position between axis of rotation and properties of rotation/aiming mechanisms;
- unit values of reference system or parameters of electronic systems measurement;
- the relationship of angles between the telescope optical axis and the axis of cylindrical bubble (level) tube (angle „i”);
- and others.

The overall quality of instrument operation also may affect equipment elements which are used along with instrument. For example, these are elements, such as – rods, tripods and connection quality to them, quality of distance measuring, the relationship between pins and pads with the placement on surface structure. And at the end there is the human factor – with all the individual characteristics, which can affect the quality of measurement results directly.

The influence of above mentioned facts provides that every surveying instrument (or a set of equipment) for high precision measurement requires careful and detailed inspection, research, examination, but not only prior the operation, but also systematically throughout the work process.

The research and testing of surveying instruments divides into laboratory trials/tests and field tests. Laboratory trials/tests are considered to be with the most quality and the most valuable, but they are more expensive and more complex, because contrary the organization of field testing methods they require more funds for investment in technical equipment, exploitation and maintenance of personnel, facility and premise. But need to be aware that these tests have good quality only to determine technical parameters, but they do not provide the quality assessments of instrument in a real work environment, they have limited application for evaluation of various technological solutions and from experience and training of personnel and its skills to evaluate the individual measuring acquirement.

Field tests can be simplified performed or performed in special dedicated geodetic instrument fields (polygons) of testing and calibration.

The performers of simplified performance usually can do it in any work area – in the territory without specially prepared and tested workplace. They are widely used when it is suspected to receive the loss of measuring quality with any of operational factors or in order to ensure about the functional adequacy of the instrument or the whole equipment set before, during or after the work (the performance often is governed by the requirements of chosen measurement technological cycle). These tests are called self–calibration or self–control.

The field tests of geodetic instruments or set are completed in the specially formed geodetic instrument calibration and test polygons. Tests in polygons are performed in specially designed topical fields (according to the specifics of instruments or sets or their technical or technological methods of usage), which are equipped with a set of specific structural elements (pylons, centers, tripods, racks, benchmarks, objectives, supports etc.), which have interconnected high precision measurement that are completed, verified and documented multiple times. Also, tests in polygons are performed when an authoritative high precision and verification of compliance with the prescribed measuring instrument is necessary (regardless of the manufacturer guarantees), the adequacy assessment of the chosen instrument and the chosen measurement technology to raised quality requirements and the work quality assessments of specialists that are to be or already are involved in the work.

In this kind of polygons new technological and technical solutions for development testing and adaptation work are performed, to ensure that instrument is capable to accomplish raised quality requirements, as well as for technical documentation and recommendation processes. They also serve as scientific research and development or practical examination workplace and as a highly qualified specialist field of training and testing skills.

It is considered that a field calibration and testing polygons do not provide the sterility of precise geodetic instrument and geodetic grid calibration processes – which are performed in laboratories on special precision stands or other specialized equipment for detecting accuracy, but the advantages of field testing polygons are related with instruments, instrument sets and their use in quality tests with selected technological solutions in regions with real conditions and scales that are close to the maximum with environment for practical application of work. Considering that field testing and calibration polygons are not the best substitute of opportunities in laboratories, but they are good to continue unfinished tests and examinations from there in a real work environment, where at the same time ensures the options of high quality and accurate instrument parameters and their examination of used technologies and calibration.

In order to provide the options of checking the instrument and calibration capability processes, it is necessary to build special peculiar benchmarks or measuring devices for calibration or measurement, which at the same time cannot be special laboratory work tables or stands. Then forms a situation in which the polygon with the established elements serve as the benchmark (or its substitute) of calibration or testing. Solutions can be achieved with building installation site (pylons, work tables, poles, circles, stands, tripods, etc.) elements for each group of instruments or for appropriate end-use measuring location. They need to be able to alter long /save their individual spatial position and the position of mathematical relationships to other similar elements that are contained in the usage target system of polygon. The construction of malleable elements is attributable with the deployment of specific instruments and the measuring process specifics of usage, as well as with the quality of calibration and test processes. However, the amount of elements, mutual spatial arrangement and the sequence of deployment depends on the intended/desired technology specific instruments of field test or calibration, as well as the practical application of the technology requirements of work performance standards – this position can be called a polygon element structure. An important condition – that all elements created and involved in the process must be surveyed with precision that exceeds the planned accuracy of calibrated test instrument.

Both polygon element construction and element structure are directly attributable to the specific instrument and its application technologies. That is why the same polygon may consist of one or more topical polygons or polygon groups. They can be made only for purposes of some specific instruments or groups of calibration and test, but also may be combined in groups of various instruments or in systems of various test or calibration elements and structures. Multi-functional test and calibration polygons are also possible.

In geodesy industry most often are found polygons with individual instruments or their systems for field tests and calibration – for example: gravimetric polygons, magnometric polygons, distance measuring polygons, Invar wire calibration polygons (comparators), levelling instrument or elevation measuring polygons, angle measuring instrument (theodolite, tacheometer, etc.) polygons, GNSS receiver test polygons (Fig. 1.), photogrammetry (aerotriangulation) polygons, etc. Polygons with two or three instruments and performance technologies are frequent, but multi-fuctional or nearly full profile geodetic instrument an technology calibration and test polygons are very rare.

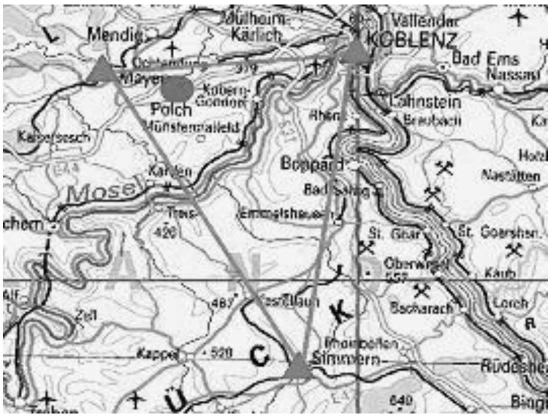

Figure 1. The scheme/structure of GPS instrument test polygon in Germany, Landesvermessung Rheinland-Pfalz

Despite the above discussed field polygon functionality association with instruments and technologies in all cases as option is considered to use polygons for training specialists, for determining and improving qualification and for a realization of scientific research process and events.

MATERIALS AND METHODS

Within the set research tasks were researched documents and information about existing and functioning geodetic instrument calibration and test polygons in the Baltic States and in the region of the Baltic Sea countries. As well, within the set tasks were researched publications related to the questions about geodetic instrument calibration.

Particular attention was paid to the polygons established in Finland and to some polygons established in Estonia. In addition to those, experience of Poland and Sweden was studied as well. Experience in other countries has been reviewed with a relatively generalized view just to complement and confirm the results of analyzes of the polygon element structures and the practice of elements structure.

In parallel were evaluated the designs of geodetic reference grid elements (centers) used in territory of Latvia, their solutions in different periods of history, the guidelines to design construction, to its stability and spatial positions for the interest of preservation. As a special position is reviewed view of practical use and suitability of national geodetic reference points for equipping geodetic calibration and test fields. (National Geodetic Reference Grid classifier)

As good example connected with field calibration polygons, can be mentioned The Finnish Geodetic Institute: In Geodetic metrology – The Finnish Geodetic Institute maintains standards for geodetic and photogrammetric measurements and acts as a National Standards Laboratory of length and acceleration of free fall (Law no. 581/2000). Standards in geodetic measurements include quartz meters, geodetic baselines, precision tacheometers and other high precision electronic distance measurement (EDM) instruments, laser interferometers and comparators for levelling rods. They take care of the traceability of these, and perform high precision measurements and calibrations in various geodetic applications. In 2002 the Finnish Geodetic Institute joined the Mutual Recognition Arrangement (MRA) of national measurement standards and of calibration and measurement certificates issued by national metrology institutes. New quality system meets the requirements of the standards ISO/IEC 17025 and ISO 9001 (Jokela J., 2014).

In the 21st century the Väisälä interference comparator is the most accurate instrument to measure lengths less than 1 km. The Nummela Standard Baseline (Fig. 2.), 40 km north-west of Helsinki, is the most famous baseline measured with the method developed by the academician Yrjö Väisälä in the 1920s. Use Standard and calibration baselines. A baseline is a permanently marked distance, the length of which is known and traceable to the definition of the meter with a known (small) uncertainty. Baselines are used as measurement standards e.g. in length transfer to electronic distance measurement (EDM) instruments and measurement wires and tapes. Standard baselines are established as national or international length standards. These and other calibration baselines serve in various tasks of geodetic metrology (Jokela J., 2014).

Figure 2. The Nummela standart baseline elements

Baselines in Finland: Nummela Standard Baseline (Fig. 2.), Nummela Calibration Baseline, Jämijärvi Calibration Baseline, HUT Väisälä Baseline. Similares Baselines around the world: Since 1947 the FGI has measured standard and calibration baselines around the world. Many of them now belong to the history of geodesy; some of them still are of great importance in maintaining and developing national measurement standards. (Poutanen M., Rouhiainen, P., 2014). The Gödöllö Standard Baseline in Hungary (Fig. 3.), 30 km north-east of Budapest, was founded in 1938.

Figure 3. Sight on base line in polygon at Godollo (Hungary)

The Chengdu Standard Baseline in Sichuan, China, was founded in 1998. This old calibration baseline was measured The Chang Yang Standard Baseline in China (Fig. 4.), 35 km south-west of Beijing was constructed in 1984. The Taoyuan Standard Baseline in Hsinchu, Taiwan, China.

Figure 4. The look of calibration base pylon in China

Since then seismic activity has caused deformations. The high precision EDM instruments used in the monitoring of stability were calibrated at the Nummela Standard Baseline in 1997 by the Center for Measurement Standards of the Industrial Technology Research Institute. High precision EDM is a much simpler method to measure baselines than the interference measurements. The 1320-m Kyviskes Calibration Baseline, 25 km east of Vilnius, Lithuania, was established for calibration of EDM instruments in 1996. The baseline was extended to a triangle-shaped test field in 2000, and remeasured in 2001. The results confirm the good stability of the baseline, which now can be used in calibration of EDM instruments and testing of tacheometer and GPS measurement equipment. A similar scale transfer project was performed in 2000 to the old Vääna baseline (1728 m) in Estonia, in co-operation with the Maa-amet, Estonian Land Survey (Jokela J., 2014).

The calibration of a measurement instrument in Finland compare the results given by the instrument with the more accurate values represented by the measurement standard. In geodesy the measurement standards include e.g. baselines (for EDM instruments) and laser interferometers (for levelling rods). Angle measurement instruments are not calibrated in the FGI. Facts related in calibrations in gravimetry can be found at the web-site of our National Standards Laboratory of acceleration of free-fall. In the calibration of EDM instruments the observed values are compared with the known values. Refraction and geometric corrections are needed before further computation. Adjustments of observations produce the instrument errors, necessary corrections and accuracy estimates. (Poutanen M., Rouhiainen P., 2014)

The Nummela Standard Baseline (Fig. 2.) is the right place for calibration of high precision EDM instruments and for scientific research. As actual measurements are usually performed in field conditions, instruments should be calibrated in real field conditions, too. The medium always have an impact on the propagation of measurement signal. Correct air temperature, pressure and humidity values are of great importance, and must be determined with calibrated weather observation instruments. Self–service calibration facilities are available at the Nummela Calibration Baseline and at the Jämijärvi Calibration Baseline. National Standards Laboratory of acceleration of free-fall serves in the calibration of gravimeters too (Jokela J., 2014).

Exploitation of electronic distance meters (EDM) in surveying practice, their rapid development in terms of construction, especially to range and accuracy of measured distance, brings a solution of new tasks in the area of measurement processing. One of the main characteristics is accuracy parameters of EDM. Low variance of the measurements when using EDM can often lead to a deep trust in the measurement results and factor of change of EDM parameters is often neglected. To the fore appears the reproducibility of distances when repeating measurement at different time intervals (Jezko J., 2012) (Micuda J., Korcik P., 2001).

During the long-term exploitation is necessary to verify stated parameters in the field conditions. EDM user role is therefore check the reliability and accuracy of EDM before its exploitation, what should become the norm when using all instruments in surveying practice. One of the possibilities of verification of the EDM parameters is hence its calibration on the field length baseline. Such length comparative baseline – baseline Hlohovec, was built by the Department of Theoretical Geodesy of Faculty of Civil Engineering in collaboration with then IGHP n.p. Žilina, plant Bratislava in 1978 (Jezko J., 2012) (Micuda J., Korcik P., 2001).

RESULTS AND DISCUSSION

The main components of geodetic instrument calibration polygon element structure and construction correspond to different meaning, configuration and target calibration instrument polygon designing and exploiting, they are elements and element complexes, which are formed in accordance with clearly defined tasks and role of practical use.

The most important role of polygon elements is to ensure that the measurement results comply with the requirements and are attributable with design and construction of certain elements and their mutual layout – structure, which provides the best and the most reliable adequacy with the high precision measurement tasks and stability.

Geodetic polygon element structure usually is adjusted to either a specific instrument or group of instruments to perform field tests or to perform standardize measurement procedures for interests of technological cycle performed activities within planned targeted tasks in firmly modeled/designed and prepared polygon system.

With the purpose to accomplish each technological cycle of instruments or works there can be made multiple separate and independent polygons. For example, the distance measuring instruments and their application technologies (laser rangefinder and similar instruments are usually different from the measuring tapes, measuring wires or optical rangefinder systems) may be formed its own polygon (Fig. 3. sight on base line in polygon at Godollo (Hungary)). Levelers and levelling equipment sets have completely different polygons, etc.

The structure of polygon (Fig. 1.) usually forms from the polygon elements that are accordingly to the specificity of the task constructed and arranged in strictly deliberated, reasoned order or shapes which provide that scheduled calibration or test task results are obtained when measuring with the instrument.

For example, in polygons designed for rangefinders (Fig. 3.; Fig. 4.) the most common structure consists of elements which are located in one or more straight lines formed in strict order and distances between them. Line or line lengths (between the furthest line elements) usually reaches the distance that is maximal possible for rangefinder to reach, in some cases it may be less, but then there is an adequate justification.

Elements in levelling polygon structure can be arranged either on the same straight line or on broken ones, where the total length of polygon often corresponds to one complete cycle (loop) of levelling measurement line length.

The next question is – how many and what design elements are placed in each individual polygon – but always need to remember that even polygon of one type and task can be supplied and equipped with elements of various difficulties.

In dealing with geodetic polygon element structures – as the first raises the question of the stability of the spatial structure. Position to preserve the stability is achieved by considering a number of engineering-kind conditions – the first one is the importance about the placement of the polygon and elements, in geological meaning. For example, if the selected polygon's placement is in Finland and Sweden on the bedrock of granite (Fig. 5.) and other continental plates of solid rock where in some places they reach the earth's surface – the polygon element construction can be easily created without complex and massive additional buildings, deeply immersed pylons, etc. – here the main guarantor of stability is the base.

If the stable bedrock is deeper – then when designing elements in most occasions need to sustain it (link) to the bedrock with constructing pylons – whose base is based on the bedrock and the upper part is at least at same level as earth's surface (Fig. 2.; Fig. 3.; Fig. 4.; Fig. 5). If the link with bedrock becomes unrealistic (bedrock is very deep, almost unreachable), then for the construction of elements should be given more attention and resources – which would allow spatial stability (at least between elements in the same polygon).

Figure 5. Measurement of baseline at Olkiluoto

As the next position of impact sets the possible quality usage of specific geodetic instruments when using polygon elements – in which again as the first position is stability, associated with the opportunities to create uniform and stable placement for instrument in measurement process, for example – the options to of the installation location stability and uniform installation (uniform and precise alignment or fixed installation) for the instrument and its set of elements (Giniotis V., Rubokas M., 2010). The solution of problems associates with a well-considered creation of geodetic benchmarks and other places of centering and alignment and in the simplest cases with a practical, convenient instrument collocation capabilities in the element construction itself, as in more difficult cases a forced manufacture of centering devices and use of elements in exploitation processes (Fig. 4.; Fig. 5.; Fig. 6.).

Figure 6. Total station on the baseline in Hlohovec

Next position of impact is associated with mitigating the effects of climatic and environmental factors on the polygon element construction dimensions and parameters (including spatial positioning) in long-term and in short-term processes during the using of geodetic instrument. Such positions of climatic impact as frost, temperature, solar radiation and wind effects in different combinations are capable of changing both the spatial position of the element itself and the mathematical size of the element – thereby changing the position of the measuring spot. The long-term solution is associated with overall stable placement (on the bedrock), or taking in account the subsurface freezing winters border in our climatic zone (when the element is not sustained to bedrock), the soil composition in the territory of interest and climate impacts on its stability – providing the already in engineering construction mentioned effects of compensation, prevention or at least minimization. Part of element above the surface is exposed to the effects of temperature – which can affect its mathematical parameters and as a consequence will change the centering spot position of instrument, both in the measurement process and in long-term, so in practice are used different screens and pylon insulation techniques from the environment (Fig. 5.).

Since the primary issues are related to the stability and positioning of the polygon elements and are solved, there follows the next challenge – linked to the efficacy of the polygon element practical use where main positions are collocation and convenient operating of instruments. This line is one of the factors that contribute to both the quality of completed work processes and the opportunity to reduce term times in polygon. Initially during the development of geodetic polygons as element constructions often are used the centers and benchmarks of national geodetic reference grid points, which usually according to the requirements for local climatic and geological situation have necessary stability. The designs of these points are usually developed and classified according to the increasing stability requirements - from the level of local grid to the highest geodetic grid's reference points. Thereby when forming a geodetic polygon - the construction of elements originally is applied to existing point designs. But this original design has a number of lacks for practical use, where the first is simple and easy access to the instrument centering place on a daily basis - because the central element of the work is beneath the earth's surface (and thereby protected from a variety of negative effects) and on each time of using the elements need to do additional activities to gain access to it. Then need to be able to perform instrument setup and alignment procedures - which are above the excavation pits but not very comfortable and have threats to center the instrument and to determinate accurate height and uniformity. Considering the facts that the geodetic reference grid measurement activities are carried out in the country with an average frequency not more than once a year, that outweigh the inconvenience of creating the complex surface center construction (who would guarantee its position and physical preservation). In case of use intensity of polygon elements, usually it is much larger and too frequent access (frequent digging up) may even damage the position of centering, not mentioning the increase of centering errors that possibly appear after uncomfortable activities. That is why some significant changes are introduced to polygon element constructions – firstly, lifting the centering points (without changing the placement depth of elements below the surface) to the surface or higher (often to the height of tripod), while making additional measures to ensure the stability of the position against the effects of climate and other mechanical damage (Fig. 2.; Fig. 3.; Fig. 4.; Fig. 5.; Fig. 6.). Also around the polygon elements can be created special work fields (Fig. 5.) which provides not only comfortable working to staff, but also provides accurate and uniform installation options for instrument in horizontal and vertical planes. In many cases the constructions of elements in polygons are created deeper than the classical geodetic points to locate their base on solid bedrock (whichever is deeper) or existing massive underground construction or to increase stability

with the weight of construction and reference square in ground.
As final questions of creating polygon elements are related to the possibility of creating exclusions or minimization of selective different external and internal factors of influence or registration of their size in measurement processes. These constructive options are made to elements of superior quality by incorporating special accurate centering or deployment devices in their constructions. For example, excluding the necessary to use tripods with the attributable effects – the pylon is created on same height as instrument, and it is placed as an installation table of instrument. After excluding the centering errors of instrument there are formed compulsory centering /installing devices, etc. These and similar improvements and developments in the list can be continued for each individual polygon and in process of development its elements can be added variety of different shifts, movement registrations and measurement accessories, which helps with the obtained information to get very high accuracy and reliability of the processed measurement results.

CONCLUSIONS

The major components of element structure and constructions in geodetic instrument calibration polygons corresponds to them defined meanings, configuration and targeted calibration polygon creation and exploitation. They consist of elements and element sets which are designed in accordance with clearly defined tasks and practical use of the role.
The most important role of polygon elements is to ensure that the measurement results comply with the requirements of particular elements, constructions, as well as with their mutual placement – the structure, which provides the best and the most reliable compliance with the high-precision measurement tasks and stability.
The structure of specific geodetic instrument calibration and test polygons is designed according to realize two basic tasks:

- the possibility and the technical quality of testing specific instruments and instrument sets;
- the possibility of the quality requirements and the ability to work for applicable instruments while processing specific works and technologies.

The choice of the geodetic instrument calibration and test element polygon constructions is based on:

- the supported stability (constancy) of the spatial position during long periods of time;
- the suitability for intensive use (easy instrument installation and workplace);
- the possibility to selectively exclude influence of various external and internal factors, minimize them or register them after performed measurement.

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