# CONSIDERATIONS CONCERNING THE CHOICE OF THE WORKING METHOD AND OF THE INSTRUMENTS TO REALIZE OBSERVATIONS

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**Abstract.** Accomplishing the specialized tasks in the domains of geodesy, topography, cadastre requires - depending on the specificity of the task - to adopt, in a preliminary stage, the working method and the apparatus corresponding to the intended purpose. This paper presents several considerations to be taken into account when choosing the working method and the equipment with which field observations will be made, so that the precision conditions are respected.

**Keywords:** measuring errors , working methods, instruments utilized.

## INTRODUCTION

The jobs in terrestrial measurements, depending on their destination, are differentiated by the precision conditions imposed by technical regulations. In view of this fact, a careful analysis should be made for each job in the choice of the working method and the tools with which field observations will be made, also taking into account the endowment we have at our disposal.

Generally, errors occurring in the field while making observations using theodolites or total stations are caused by: the instrument used and its centering at the point of the station, the conditions existing at the time of the observations, the centering of the target signal, and the proper conduct of the observations.

Thus, the error with which a direction is measured in the field is established (Ortelecan, Pop, 2005) with the help of the relation:

$$s_d = \pm\sqrt{s_e^2 + s_r^2 + s_i^2 + s_m^2 + s_{ce}^2} \qquad (1)$$

In relation (1), these notations are used:

$s_e$ - the centering error of the instrument in the station point;

$s_r$ - the centering error of the targeted signal;

$s_i$ - the error caused by the chosen instrument;

$s_m$ - the measuring error;

$s_{ce}$ - the error caused by the existing conditions.

At the same time, the error caused by the chosen instrument is determined with the realation:

$$s_i = \pm\sqrt{s_1^2 + s_2^2 + s_3^2 + s_4^2 + s_5^2} \qquad (2)$$

where:

$s_1$ - the collimation error;

$s_2$ - the main axis of the instrument tilting error;

$s_3$ - the secondary axis of the instrument tilting error;

$s_4$ - the error for the division of the horizontally graded circle and the reading device of the instrument;

$s_5$ - the extra-centric error of the alidade of the instrument.

For the observations made with the level, mirror reading is affected by the established quadratic average error (Nistor, 1993) with the relation:

$$s_c = \pm\sqrt{s_{or}^2 + s_p^2 + s_t^2 + s_f^2 + s_d^2 + s_l^2 + s_i^2} \quad (3)$$

The notations used in (3) represent:

$s_{or}$ - the error for horizontal targeting the axis of the instrument;

$s_p$ - the vision error on the leveling staff;

$s_t$ - the reading error on the micrometer of the instrument;

$s_f$ -the error caused by the tracing precision of the cross-link wires of the instrument;

$s_d$ - the error caused by the division precision of the leveling staff;

$s_l$ - the counter-perpendicularity error of the foot of the longitudinal axis of the leveling staff;

$s_i$ - the reading error from the tilted leveling staff.

## MATERIAL AND METHOD

In order to make a comparison between classic and modern instruments, the following tables present the main features for several such tools.

Table 1 (from Ghiţău, 1983)

| Instrument | Manufacturer | Angular precision | Magnification | Focus range | The sensitivity of the toric level [ ″ ] |
|---|---|---|---|---|---|
| Theo 020A | Zeiss -Jena | $1^c$ | 25x | 1.5m to ∞ | 30 |
| Theo 010A | Zeiss -Jena | $2^{cc}$ | 30x | 1.5m to ∞ | 20 |
| Theo 010B | Zeiss -Jena | $1^{cc}$ | 30x | 1.5m to ∞ | 20 |
| T2 | Wild*) | $2^{cc}$ | 28x | 1.5m to ∞ | 20 |
| T3 | Wild*) | $1^{cc}$ | 40x | 3.6 to ∞ | 7 |
| Theo 003 | Zeiss -Jena | 0″.2 | 58x | | 10 |
| T4 | Wild*) | 0″.1 | 70x | 70m to ∞ | 1 |

Table 2 (from Leica Geosystems)

| Instrument | Manu-facturer | Angular precision | Accuracy of distance measurement: −with reflector −without reflector | Magnifi-cation | Focus range | Internal memory |
|---|---|---|---|---|---|---|
| FlexLine TS02 plus | Leica | 3″; 5″; 7″ | 1.5mm + 2ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 24000fixp<br>13500meas |
| FlexLine TS06 plus | Leica | 1″; 2″; 3″; 5″; 7″ | 1.5mm + 2ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 100000fixp<br>60000meas |
| FlexLine TS09 plus | Leica | 1″; 2″; 3″; 5″ | 1.5mm + 2ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 100000fixp<br>60000meas |
| ICON robot 60 | Leica | 1″; 2″; 5″ | 1.0mm + 1.5ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 1GB |
| Viva TS11 | Leica | 1″; 2″; 3″; 5″ | 1.0mm + 1.5ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 1GB |
| Nova MS60 | Leica | 1″ | 1.0mm + 1.5ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 2GB |
| Nova TM50 | Leica | 0″.5; 1″ | 0.6mm + 1.0ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 1GB |
| Nova TS60 | Leica | 0″.5 | 0.6mm + 1.0ppm<br>2.0mm + 2ppm | 30x | 1.7m to ∞ | 2GB |

Table 3 (from Ghiţău, 1983)

| Instrument | Manufacturer | Standard deviation for 1km double-run | Magnification | Shortest focusing distance |
|---|---|---|---|---|
| Ni 030 | Zeiss -Jena | 3.0mm | 25x | 1.8m |
| N 2 | Wild*) | 3.0mm | 30x | 1.6m |
| Ni 025 | Zeiss -Jena | 2.5mm | 25x | 1.8m |
| NA 2 | Wild*) | 0.7mm | 32x | 1.6m |
| Ni 007 | Zeiss -Jena | 0.7mm | 31.5x | 2.2m |
| Ni 004 | Zeiss -*)Jena | 0.4mm | 44x | 3.0m |
| N 3 | Wild | 0.2mm | 46x | 1.5m |
| Ni 002 | Zeiss -Jena | 0.2mm | 40x | 1.5m |

Table 4 (from Leica Geosystems)

| Instrument | Manufacturer | Standard deviation for 1km double-run | Magnification | Shortest focusing distance | Internal memory |
|---|---|---|---|---|---|
| NA2 / NAK2 | Leica | up to 0.7mm | 32x | 1.6m | - |
| LS10 | Leica | 0.3mm | 32x | 0.6m | 30000 meas. |
| LS15 | Leica | 0.2mm;0.3mm | 32x | 0.6m | 30000 meas. |

Thus, Table 1 presents the main features for classic theodolites, while Table 2 lists the main features of current total stations.

*) The company was linked with Leica in 1989, then it became part of Leica Holding B.V. Its subsidiary Leica Geosystems AG became part of the Swedish Hexagon AB Group of companies in 2005 (https://en.wikipedia.org/wiki/Wild_Heerbrugg)

For leveling tools, the main features are presented in Table 3 - classic instruments, respectively Table 4 - current optical and digital instruments.

## RESULTS AND DISCUSSION

For each specialized work, careful specifications of the precision required and the working conditions in the area where the work is to be carried out should be carefully analyzed, in order to choose the methods and instruments that correspond, taking into account the material endowment we have and economic efficiency.

The development of land measuring instruments' manufacturing technology has made the total stations in the usual series more and more accessible.

From the analysis of the characteristics of the instruments presented in Table 2, it is noted that the precision of determining directions differs from one instrument to another, even in the case of the total stations from the same series. Thus, a total Leica FlexLine TS06 plus station can have the angular accuracy of 1 "($3^{cc}$), but also 7" ($22^{cc}$), the retail price of an instrument being influenced by this precision. At the same time, it is noted that the distance measurement accuracy is identical not only for the instruments from the same series but also for the instruments belonging to different series; a Leica FlexLine TS02 plus total station has the same distance measurement accuracy with one from the Leica FlexLine TS09 plus series, when the measurements are made with a reflector, or even with a Leica precision total station Nova TS60 when the measurements are made without a reflector.

It is therefore preferable that, in some jobs, observations on distances replace the observations on directions, even if their processing seems more difficult (Arsene, Bondrea, 2018).

If precision conditions do not allow the directional and distance observations to be replaced, total precision stations can be used - Leica Nova TM50, Leica Nova TS60 – although at a price of 6-7 times larger than a regular total station, or classic instruments (eg Theo 010B Zeiss-Jena, T3 Wild, T4 Wild) can be used, however they do not provide the same performance.

In the case of leveling instruments, a careful analysis of precision specifications and working conditions is required. It has been found (Ienciu, Oprea, Dimen, 2006) that the observation of leveling in industrial areas with vibration-based installations is preferable to be carried out with classic instruments of the same precision class, rather than with digital instruments, precision of the latter being affected by the operation of the machines due to the sensitivity of the digital instruments. At the same time, it should be noted that each manufacturer uses a barcode specific to the bridegroom, which can not be used to make observations with a tool from another manufacturer.

## CONCLUSIONS

Achieving work in the field of terrestrial measurements under specific precision conditions implies an in-depth analysis of the choice of the working method and the tools to be used. Using the working method and the appropriate instruments, we must be certain that, when carrying out the work, the chosen equipments are characterized by instrumental errors corresponding to the purpose of the job, the efficiency of the field operations is high and the conditions of general precision are followed. When choosing the method to be used and the equipments, account must be taken of the need for full consistency between those and the specific working conditions.

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