Getting a Correct Geometrical Information from TLS Data for Building Constructions Control Surveying

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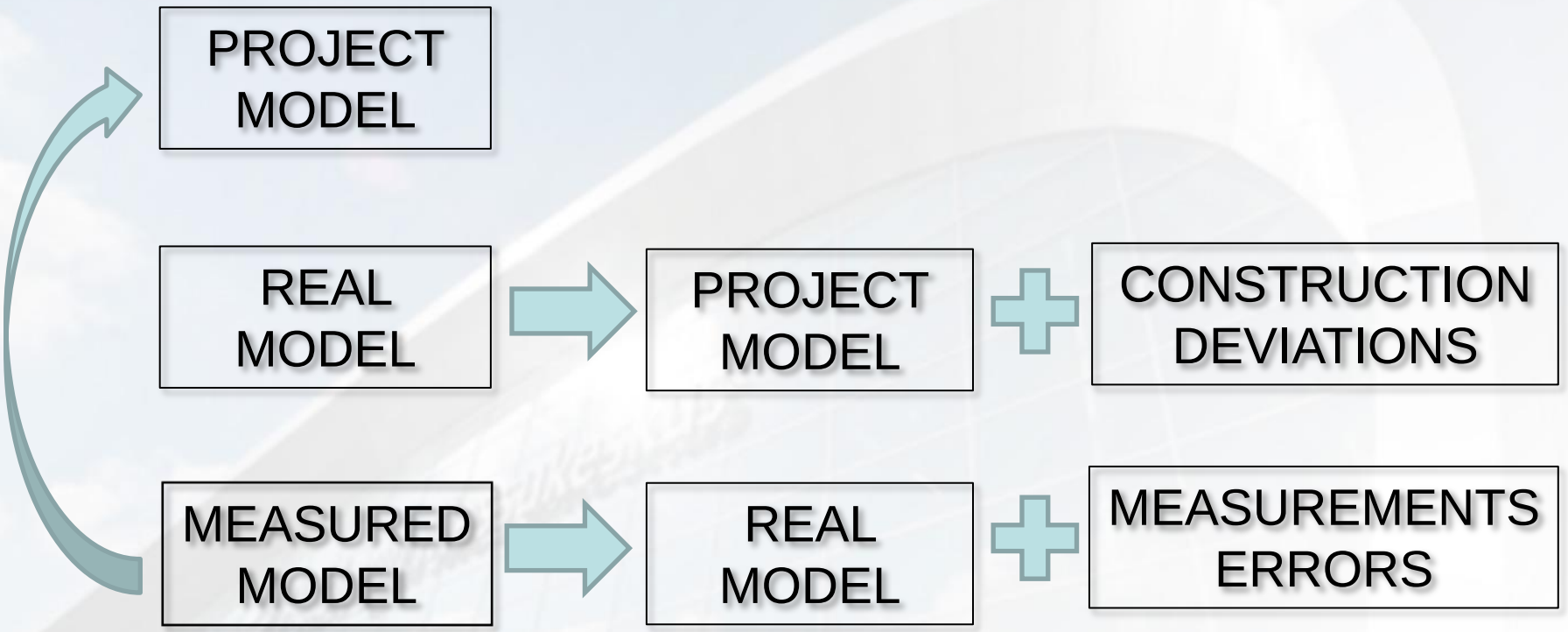
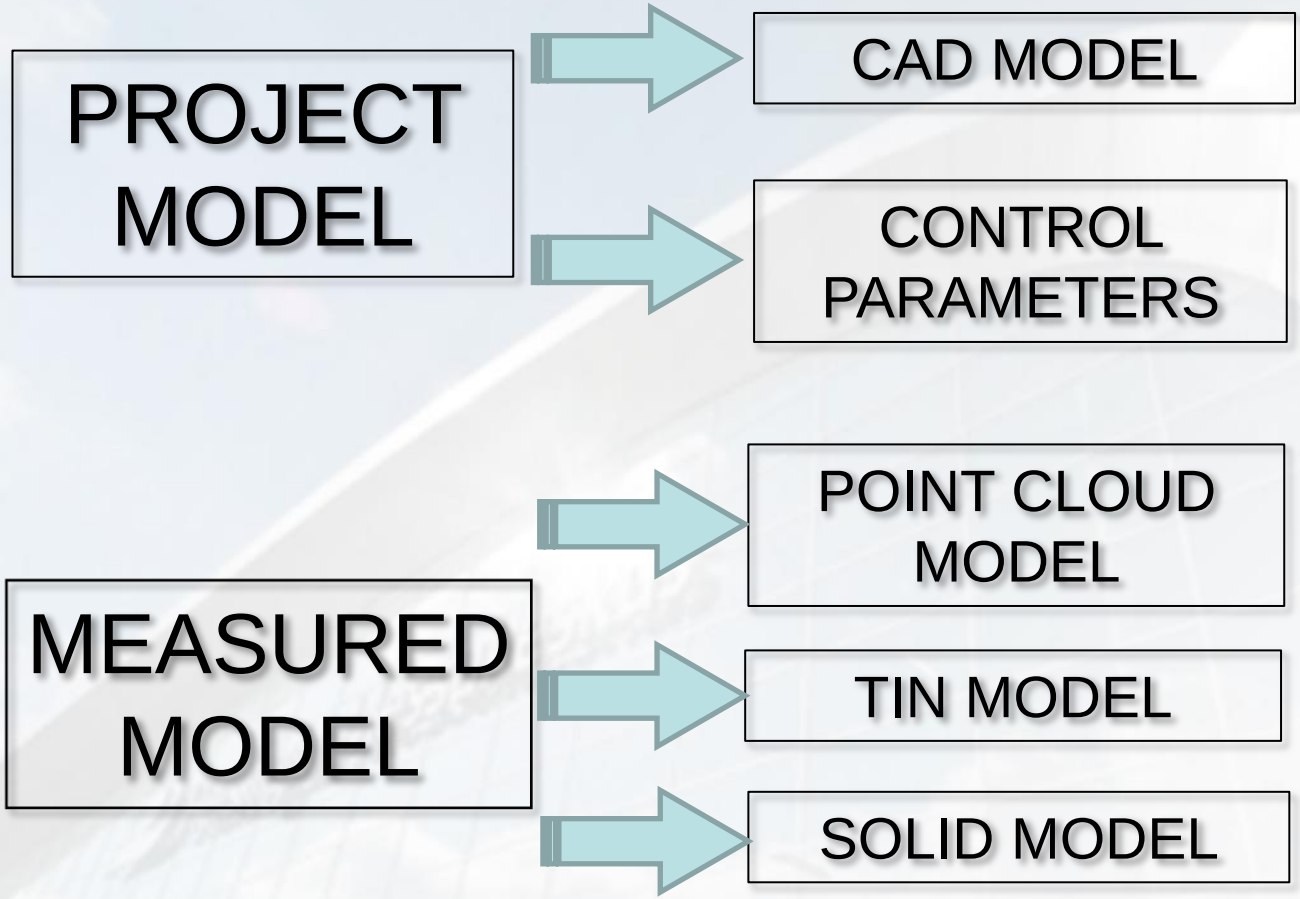
THE MAIN IDEA OF CONTROL SURVEY



THE MAIN IDEA OF CONTROL SURVEY BY TLS



THEORY OF PRELIMINARY ACCURACY CALCULATION OF CONTROL SURVEY BY TLS

$$\mathbf{K}_{CS} = \mathbf{AMA}^{\mathrm{T}} + \mathbf{BKB}^{T} + \mathbf{K}_{SS}$$

$$\mathbf{A} = \begin{bmatrix} S\cos z\cos\beta & -S\sin z\sin\beta & \sin z\cos\beta \\ S\cos z\sin\beta & S\sin z\cos\beta & \sin z\sin\beta \\ -S\sin z & 0 & \cos z \end{bmatrix} \qquad \mathbf{M} = diag\begin{bmatrix} m_z^2 & m_\beta^2 & m_S^2 \end{bmatrix}$$

$$\mathbf{K}_{SS} = \begin{bmatrix} m_{X_{SS}}^2 & k_{X_{SS}Y_{SS}} & k_{X_{SS}Z_{SS}} \\ k_{X_{SS}Y_{SS}} & m_{Y_{SS}}^2 & k_{Z_{SS}Y_{SS}} \\ k_{X_{SS}Z_{SS}} & k_{Z_{SS}Y_{SS}} & m_{Z_{SS}}^2 \end{bmatrix}$$

THEORY OF PRELIMINARY ACCURACY CALCULATION OF CONTROL SURVEY BY TLS

$$\mathbf{K}_{SN} = \mathbf{B}\mathbf{K}\mathbf{B}^{T}$$

$$\mathbf{K} = \begin{bmatrix} m_{X_1}^2 & k_{X_1Y_1} & k_{X_1Z_1} & \dots & k_{X_1Z_n} \\ k_{X_1Y_1} & m_{Y_1}^2 & k_{Z_1Y_1} & \dots & k_{Y_1Z_n} \\ k_{X_1Z_1} & k_{Z_1Y_1} & m_{Z_1}^2 & \dots & k_{Z_1Z_n} \\ \dots & \dots & \dots & \dots & \dots \\ k_{X_1Z_n} & k_{Y_1Z_n} & k_{Z_1Z_n} & \dots & m_{Z_n}^2 \end{bmatrix} \quad \mathbf{B} = \begin{bmatrix} \frac{\partial X_{SS}}{\partial X_1} & \frac{\partial X_{SS}}{\partial Y_1} & \frac{\partial X_{SS}}{\partial Z_1} & \dots & \frac{\partial X_{SS}}{\partial Z_n} \\ \frac{\partial Y_{SS}}{\partial X_1} & \frac{\partial Y_{SS}}{\partial Y_1} & \frac{\partial Y_{SS}}{\partial Z_1} & \dots & \frac{\partial Y_{SS}}{\partial Z_n} \\ \frac{\partial Z_{SS}}{\partial X_1} & \frac{\partial Z_{SS}}{\partial Y_1} & \frac{\partial Z_{SS}}{\partial Z_1} & \dots & \frac{\partial Z_{SS}}{\partial Z_n} \end{bmatrix}$$

$$\frac{\partial X_{SS}}{\partial X_1} \approx \frac{X_{SS}^0 - X_{SS}}{\Delta X_1} = \frac{\Delta X_{SS}}{\Delta}; \frac{\partial Y_{SS}}{\partial X_1} \approx \frac{Y_{SS}^0 - Y_{SS}}{\Delta X_1} = \frac{\Delta Y_{SS}}{\Delta}; \frac{\partial Z_{SS}}{\partial X_1} \approx \frac{Z_{SS}^0 - Z_{SS}}{\Delta X_1} = \frac{\Delta Z_{SS}}{\Delta}.$$

RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The object of research

Leica ScanStation P40

$$m_{X_{CS}} = 2.0 \text{ mm}$$

$$m_{Y_{CS}} = 2.0 \text{ mm}$$

$$m_{Z_{CS}} = 2.4 \text{ mm}$$

$$m_{CS_1} = \sqrt{m_{X_{CS}}^2 + m_{Y_{CS}}^2 + m_{Z_{CS}}^2} = 3.7 \text{ mm}$$

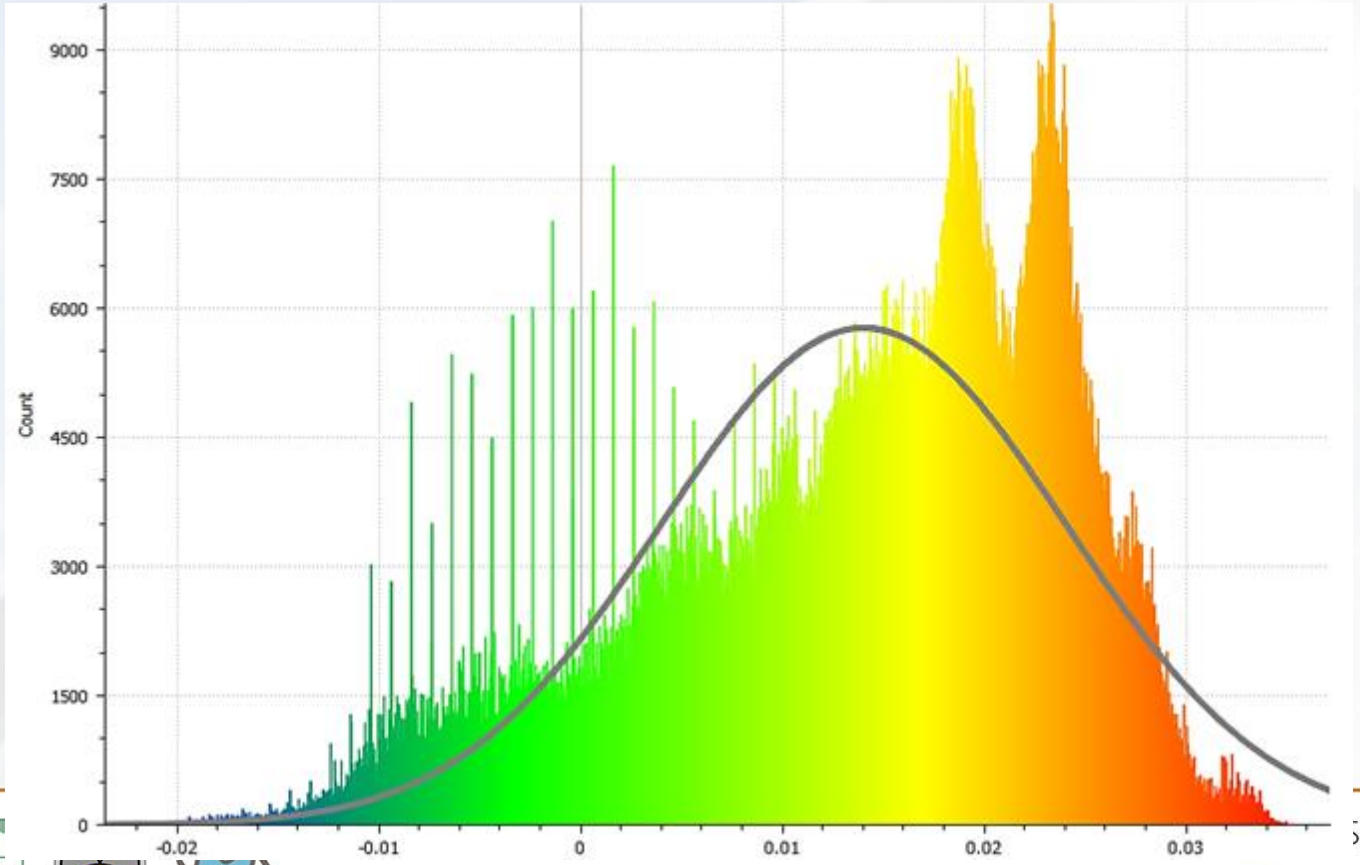
m_{CS_1} lesser than 5 mm

RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The deviations field for comparison CAD and point cloud model

RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The histogram of deviations distribution between CAD model and point cloud until blunders exclusion

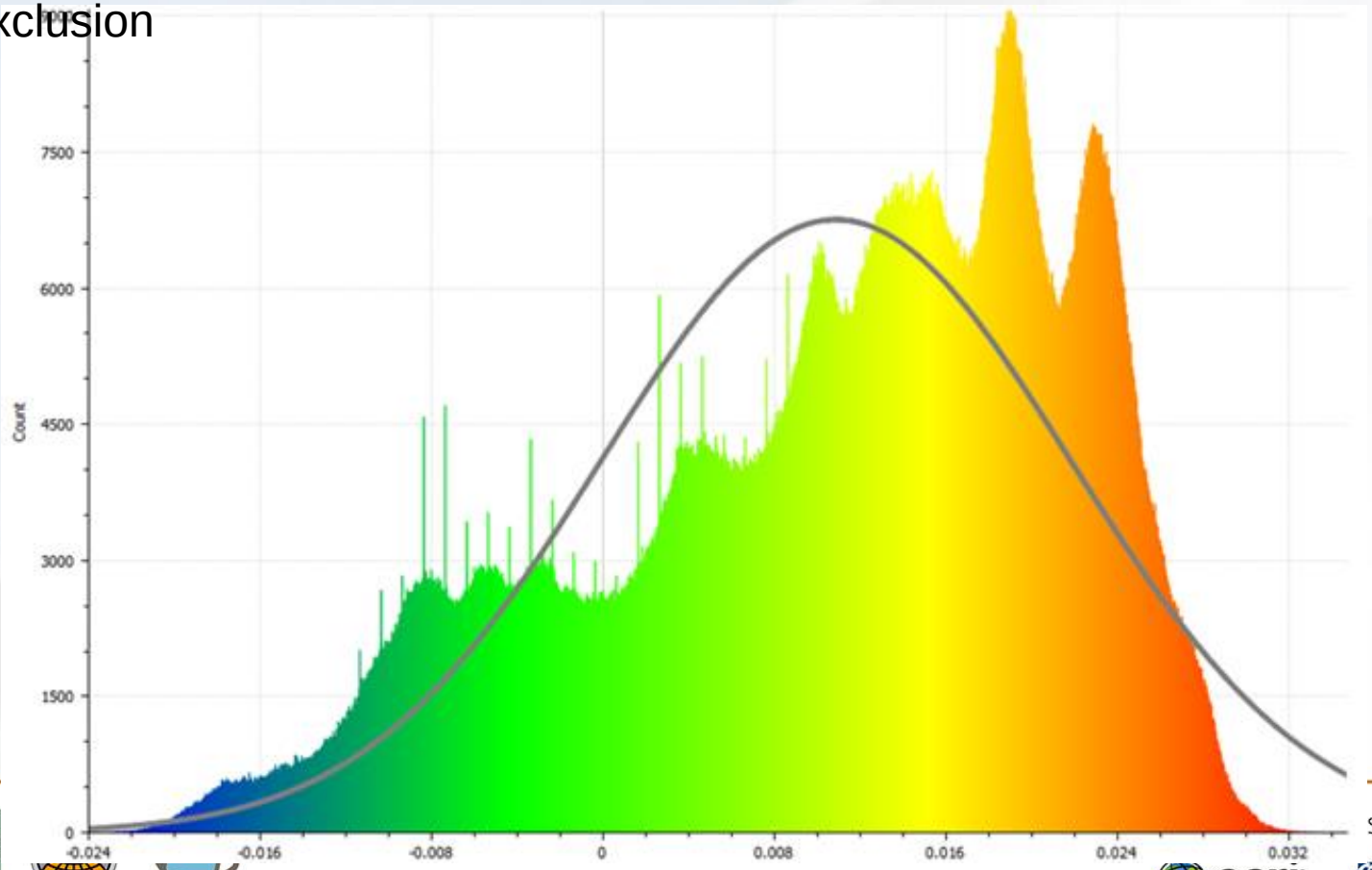


RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The deviations field for comparison CAD model and TIN model

RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The histogram of deviations distribution between CAD model and TIN model until blunders exclusion

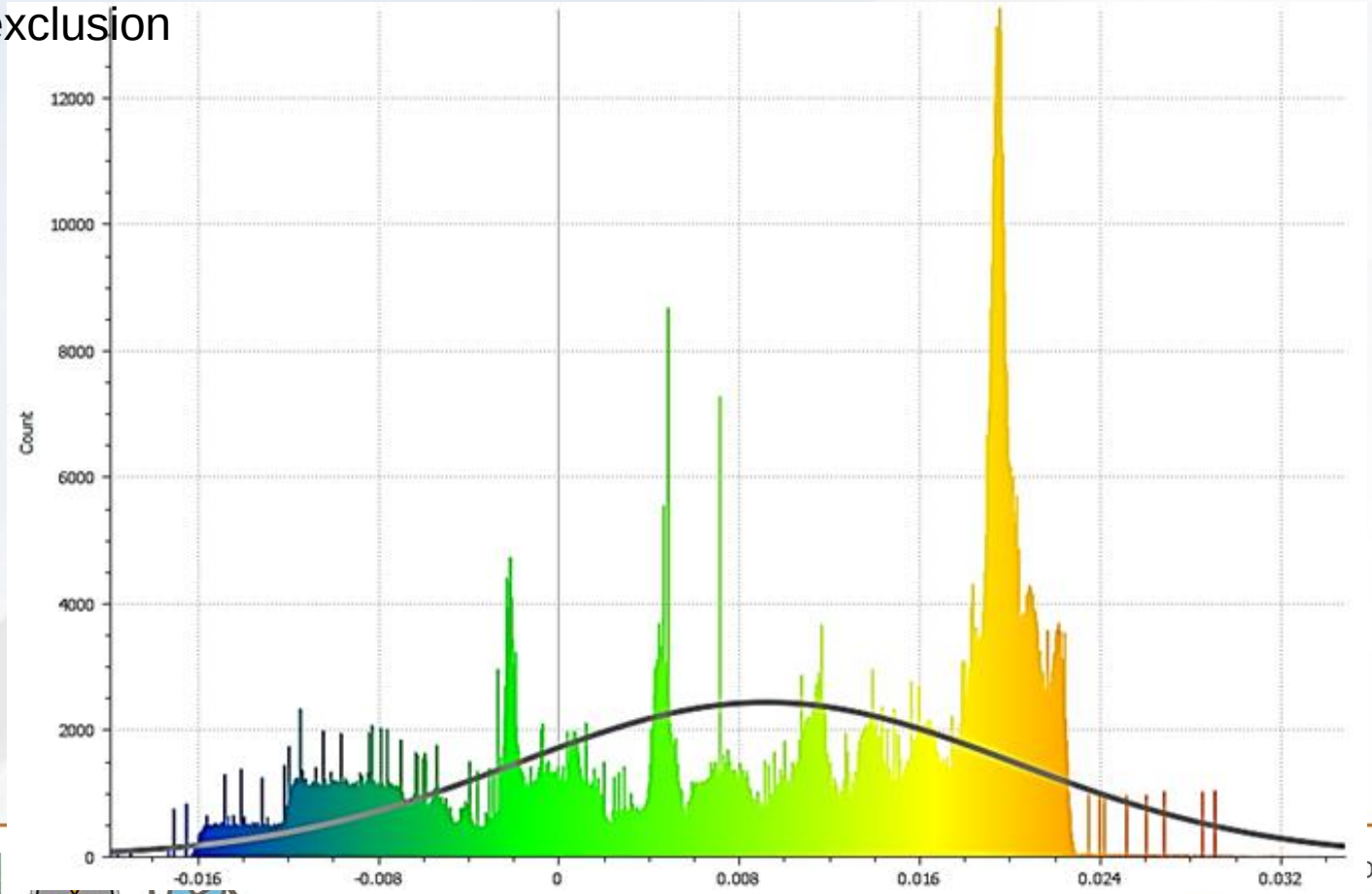


RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The deviations field for comparison CAD model and solid model

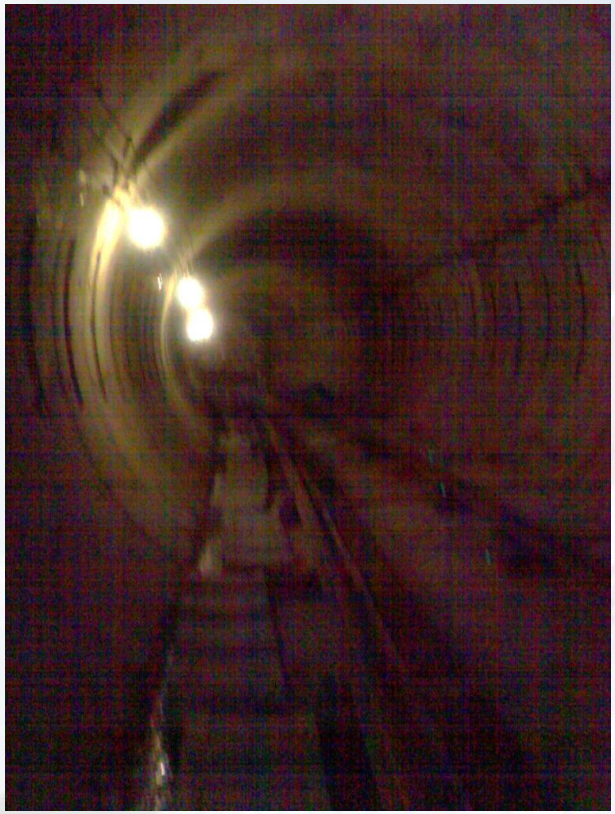
RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The histogram of deviations distribution between CAD model and solid model until blunders exclusion

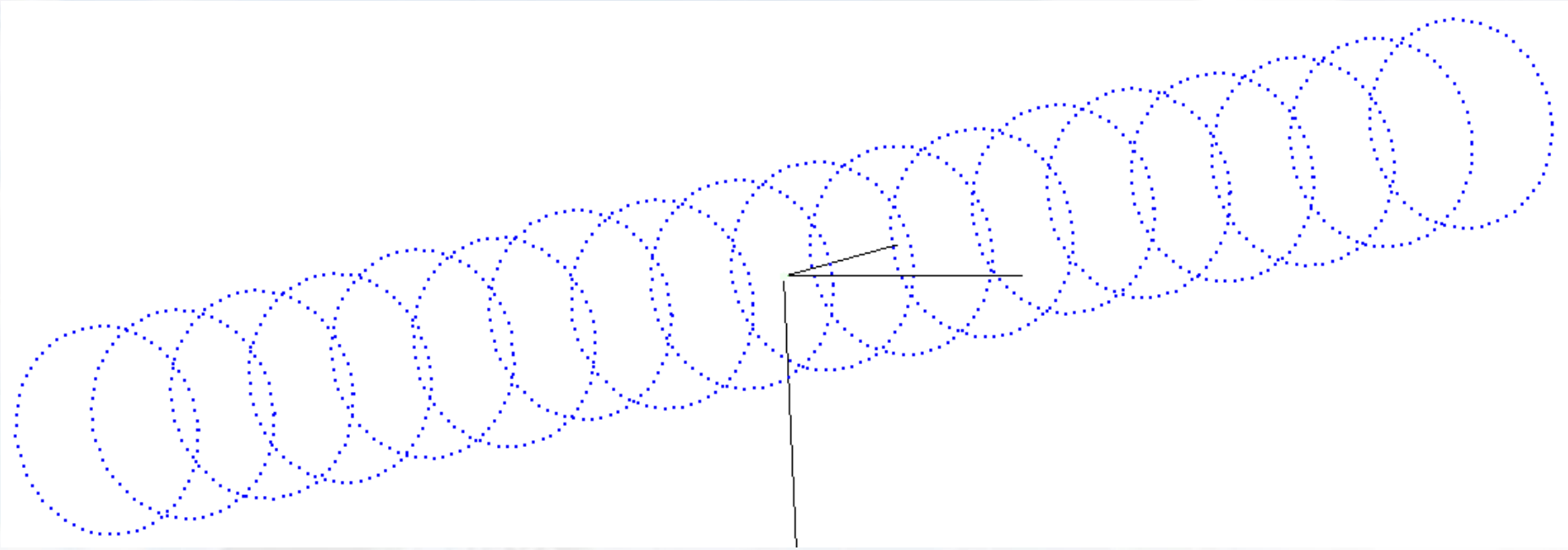


RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The underground section of the metro tunnel



RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

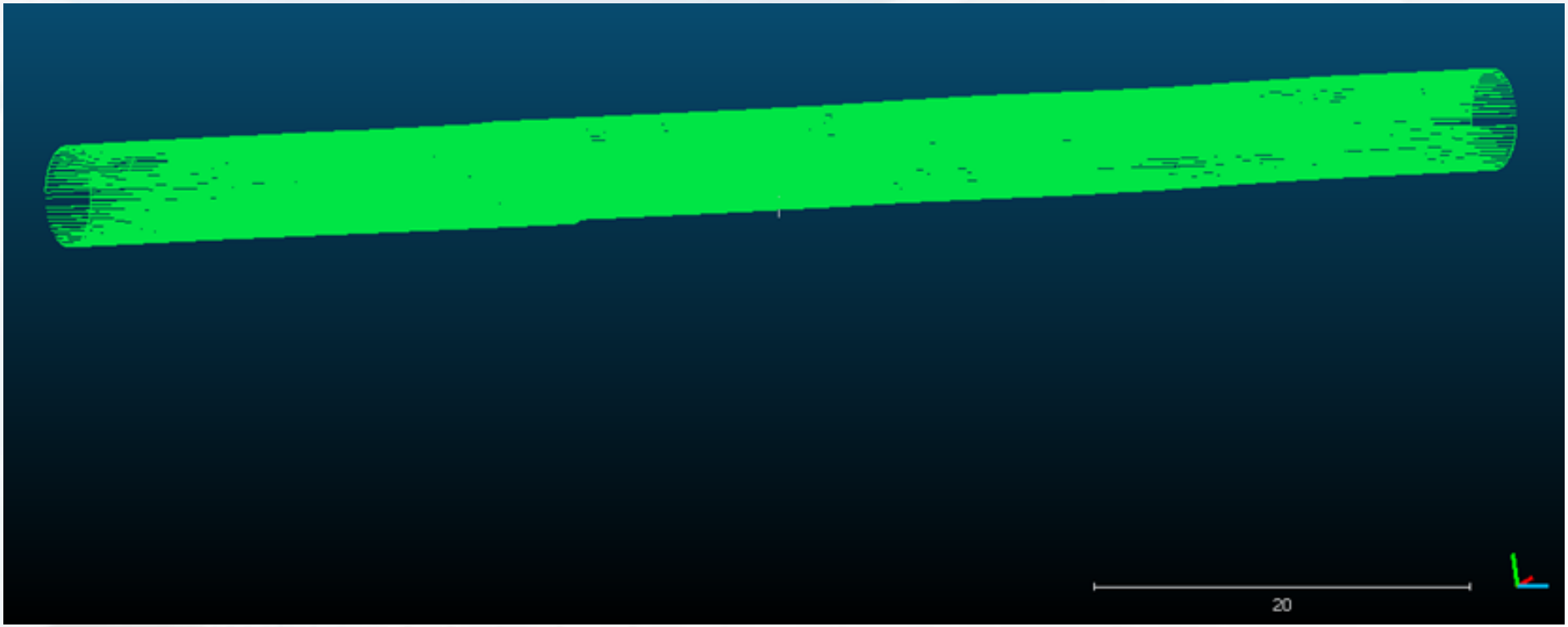


$m_{X_{CS}} = 3.9$ mm $\quad m_{Y_{CS}} = 3.9$ mm $\quad m_{Z_{CS}} = 4.9$ mm

$$m_{CS_2} = \sqrt{m_{X_{CS}}^2 + m_{Y_{CS}}^2 + m_{Z_{CS}}^2} = 7.4 \text{ mm}$$

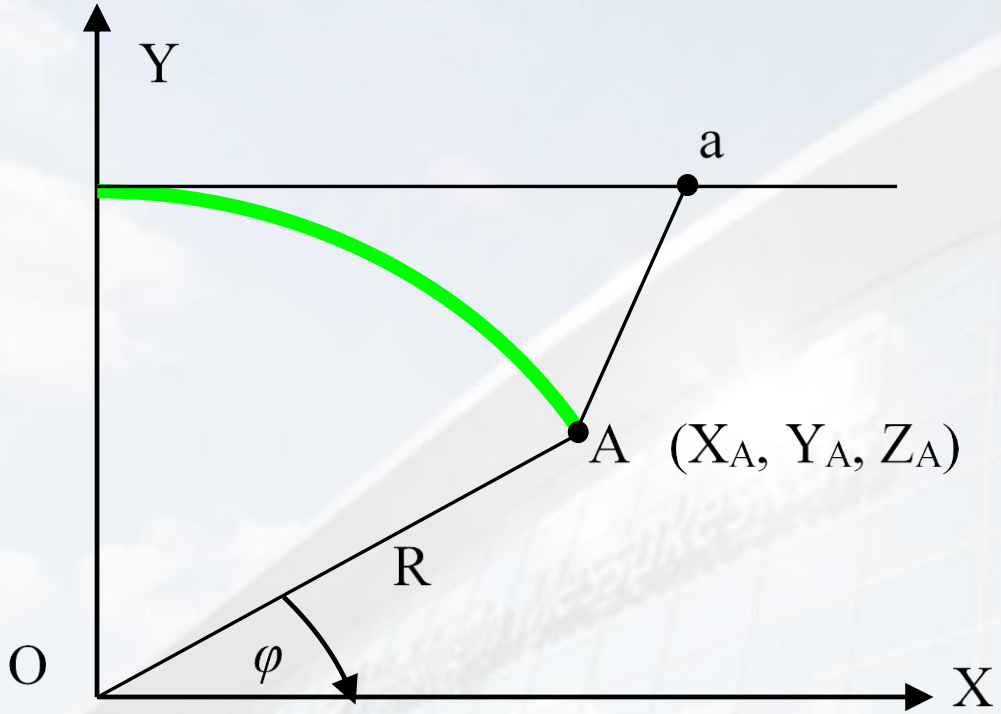
RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

Underground tunnel TIN model



RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The projection of tunnel surface on the plane in equidistant projection



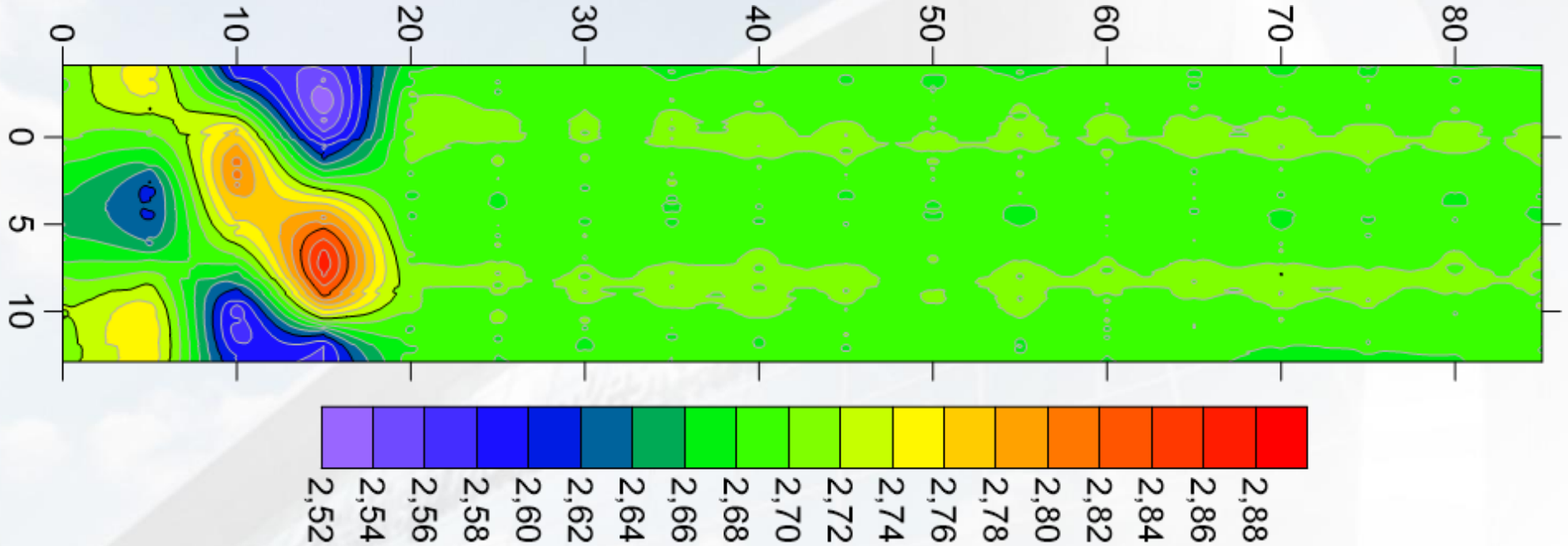
$$X_a = R\phi_A$$

$$Y_a = R = \sqrt{X_A^2 + Y_A^2}$$

$$Z_a = Z_A$$

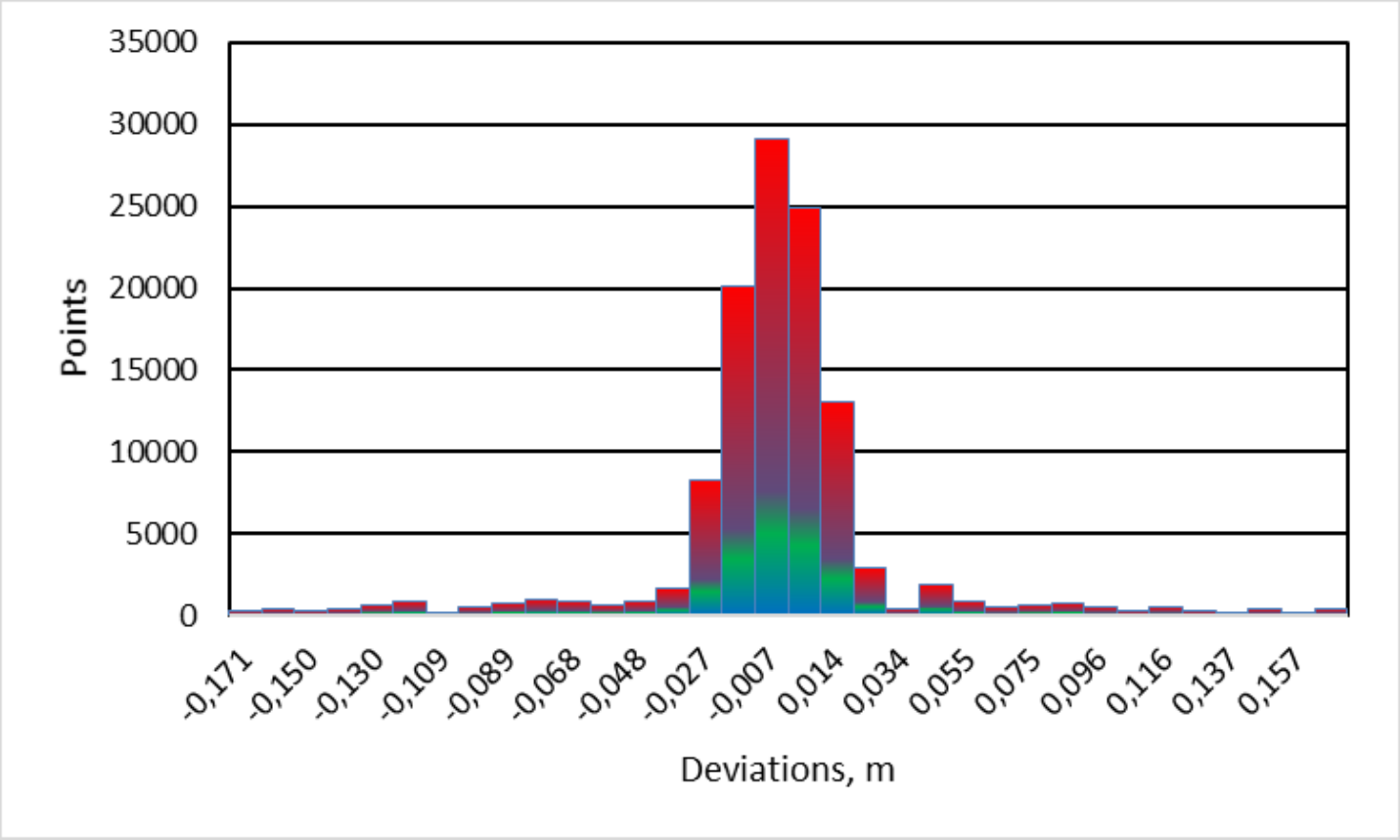
RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The projection of tunnel surface on the plane



RESEARCH OF DIFFERENT APPROACHES FOR GETTING A CORRECT GEOMETRICAL INFORMATION FROM TLS DATA

The histogram of deviations distribution between project and measured radius



CONCLUSIONS

1. The first conclusion is that we have to choose right model for comparison according to circumstances. Sometimes, will be enough only point cloud. In another cases we will need a surface modelling with follow comparison. In any case, we have to account TLS accuracy in order to be confident that, our measurements do not distort our control survey. We would like to recommend use solid model for control survey, if we have CAD model for comparison. From the other hand if we do not have CAD model, one of the possible way just use point cloud. In addition, we again want to point out that all control surveys must be done with already filtered and referenced point clouds.
2. The second, our results are preliminary estimates. They require further investigation. It is necessary to investigate the influence of the point cloud density and mathematical algorithms for the models constructing on the quality and accuracy of control survey. We also must remember that different models are source of different information. For example, a solid model, as a TIN model allows to determine deviations in sections, while the geometric model allows to compare mathematical models of different elements.

Thank you for attention