Journal scientific and applied research, vol. 22, 2022
International Journal

*Original Contribution*

ISSN 1314-6289

# THE INFLUENCE OF TURBOLITY ON LASER SIGNALS

**Kiril Yanchev**

*DEPARTMENT OF GEODESY, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, BULGARIA*

*E-mail: k.yanchev@shu.bg*

***ABSTRACT:*** *The subject of the research is to make a correct assessment of the vibrations and to choose a model for their elimination, which will allow achieving the required accuracy and high productivity with minimal material costs when performing laser measurements.*

***KEYWORDS:*** *vibrations, measurements, TLS.*

## 1. Introduction

Random changes in electromagnetic wave parameters under the influence of turbulence include fluctuations in amplitude (intensity), phase, frequency, polarization, direction of wave propagation, and angle of deflection of the laser beam. The effect of the fluctuations is to increase the spectral density of the noise power at the input of the receiver, as a result of which the signal-to-noise ratio deteriorates [2]. Fluctuations are especially pronounced in measurements in the optical range. The best way to eliminate the influence of atmospheric turbulence is to choose the most favorable conditions for measurements, which in geodetic practice are called "quiet image" times.

## 2. Errors caused by vibrations and ways to eliminate

Vibration has a great influence on range measurements and causes a chaotic displacement of the laser beam relative to a given direction to the scan point, which leads to arbitrary amplitude and phase modulations. The effect of an arbitrary change in the amplitude of the modulating signal due to the vibration of the instrument is equivalent to the effect of multiplicative noise. It has been noted in various studies [1] that the influence of the multiplicative component can lead to significant distortions in the measured distances. Random phase modulation is related to the phase inhomogeneity of the modulated radiation and, according to the results of the research presented in [1], causes errors in the measured distance of the order of 1–2 mm. Due to the vibration of the terrestrial laser system (TLS), when the instrument is at a distance of 20 to 30 m from the object, the error in measuring the distance increases by 40-50% compared to the error of the distance in the absence of vibration. At a distance of 60 to 70 m this error increases by a factor of 3-4. At distances from 80 to 90 m the error is from 10 to 15 cm. The influence of vibration always leads to an increase in the measured distance compared to the real one [1]. Vibration causes modulation of the electromagnetic signal by superimposing two oscillations (electromagnetic and vibrational), which leads to an increase in the length of the optical path compared to the geometric one. Also, vibrations largely blur the input signal, leading to misdiagnosis of the signal center.

In addition to the effect of vibration on the measured distances, it also affects the measured angles as follows:

− discrepancy between the time for reporting from the measuring protractors and the time of emission of the laser beam;

− gives the polygonal mirror or prism additional angular acceleration, which shifts the angle of the reading device of the corresponding polygonal mirror (prism);

− causes beating in the readers when the mirror (prism) rotates around the horizontal axis and the TLS rotates around the vertical axis, which leads to a violation of the basic state of geodetic instruments - the orthogonality of the axes.

Studies conducted by various authors to identify models to describe the effect of vibration on angular measurements have not been successful. These studies show an increase in the error when measuring angles.

Thus, the effect of vibration on the results of ground-based laser scanning can be recorded as follows:

− for distances

$$\delta R_{\mathrm{dist}} = F_{R\mathrm{dist}}(A, v, \lambda, R); \quad (1)$$

− for horizontal corners

$$\delta \varphi_{\mathrm{dist}} = F_{\varphi\mathrm{dist}}(A, v); \quad (2)$$

− for vertical angles

$$\delta\theta_{\text{dist}} = F_{\theta\text{dist}}(A, v,), \tag{3}$$

where:

$F_{R\text{dist}}(A, v, \lambda, R), F_{\varphi\text{dist}}(A, v), F_{\theta\text{dist}}(A, v,)$ − functions that describe the effect of vibration on the results of measuring distances, horizontal and vertical angles.

Errors caused by vibration can be eliminated or made insignificant for a specific type of task, which must be solved at the design stage of the scanner study under specific conditions. In the same way, at the stage of organizing and designing a specific type of work, errors caused by meteorological conditions can be excluded.

## 3. Conclusion

The observation time is the most optimal in terms of the influence of turbulence, as this phenomenon arises from the same physical preconditions; this is also proven by experimental studies. Therefore, it can be concluded that when measurements are made during still images, errors due to turbulence are minimized. The errors obtained correspond to the conditions of low turbulence [2].

## References


[1] Ustavich, GA On the influence of vibration on light-range measurements [Text] / GA Ustavich, AV Koshelev, OP Poshivailo // Geodesy and Cartography. - 1999. - № 8. - P. 8–10.

[2] Yanchev K., Laser scanning - achievable precision in the field of photogrammetry, remote sensing and geodesy, ISBN 978-619-201-573-2.