EXPERIENCES OF WPG S.A IN THE USAGE OF TERRESTIAL LASER SCANNERS FOR BUILDING INVENTORY PURPOSES

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1. INTRODUCTION

Warszawskie Przedsiębiorstwo Geodezyjne S.A. (WPG S.A.) began it's first inventory project that involved terrestrial laser scanner (TLS) measurements in 2005. Since this time many projects have been finalized and WPG S.A. gathered a lot of experience in the field of TLS usage for inventory purposes. At the begging the main difficulty to solve was the lack of any standards for inventory measurements with TLS usage. That was the reason why WPG S.A., basing on it's own experience and referring to international standards and literature examples, created it's own technology to apply for inventory projects. The scope of this paper is to present and discuss main topics of the created technology. The paper is divided into four chapters that refers beggining to four steps of WPG's S.A. technology:

1. Selection of proper instruments
2. Technology of measurements
3. Orientation of scans
4. Post processing and final product presentation

2. SELECTION OF PROPER INSTRUMENTS

TLS available on the market have different characteristics. According to Shan and Toth (Shan Jie, Toth Charles, 2008) TLS can be categorized in three different ways. The first way is divide the scanners by the distance measuring technique. This categorization gives two group of scanners: TLS that uses a phase difference technique and TLS that uses a pulse (time of the fly – TOF) technique. The second categorization is by the range of scanners. Shan and Toth divide TLS into three groups: short range – up to 80 – 100 m, medium range – up to 300 m and long range – more than 300 m. The third categorization is by the area the TLS can cover in one scan session. There are two groups of TLS: panorama scanners that can cover 360 deg. horizontal area and frame scanners that can cover only selected area limited by vertical and horizontal angles.
To choose the right scanner for inventory purposes three parameters must be considered:

1. Accuracy
2. Ability to measure all details
3. Economics

The first two parameters are mandatory to achieve the final product that meets all standards. The third parameter is optional but it also has to be taken into consideration as long as TLS usage for inventory purposes has to be reasonable.
Present TLS are able to determinate coordinates of measured objects and distances at the accuracy of single millimeters. The accuracy depends on the instrument model, the

distance between scanner and measured object and on the object extraction technique (Falkowski 2008, Kersten 2008). It means that basing on TLS measurements it is not possible to define distances at 1 mm accuracy. The PN-ISO 7737:1994 „Tolerancje w budownictwie. Przedstawianie danych dotyczących dokładności wymiarów", PN-62/B-02357 „Koordynacja wymiarowa w budownictwie. Tolerancje wymiarów stolarki budowlanej i meblowej oraz elementów budowlanych. Wykończenia", PN-60/B-01029 „Projekty architektoniczna-budowlane. Wymiarowanie na rysunkach" and "Wytyczne GUGiK G-3.4" standards define that some measurements must be defined at the accuracy of 1 mm, hence for these measurements other techniques must be applied (Uchański 2008). Referring to Shan and Toth categorization, the accuracy of the measurements depends on distance measuring technique, but in two cases the accuracy is not high enough to determinate distances at 1 mm accuracy (Kersten 2008)

The building inventory involves measurements of floor plans, cross sections and façade details. For indoor measurements only panorama TLS can be used as long as they are able to measure details above the scanner that are required for ceiling plans and cross sections. For façade measurements the selection of the scanner is determinate by the size of façade and level of details to achieve. Referring to Shan and Toth categorization the selection of the scanner depends on area coverage, but also for large facades the range of the scanner must be considered.

Considering the economy parameter, as long as price of all scanners is comparable (Shan Jie, Toth Charles, 2008), the main criterion is time required to proceed measurements. Basing on comparisons of the scanners, performed by Shan and Toth, the phase difference scanners can measure few times more points at the same time and collect all measurements much faster than pulse scanners. This criterion seems to be crucial for scanner selection as long as phase scanners are also panorama scanners and many pulse scanners are frame scanners (Shan Jie, Toth Charles, 2008). The only limitation of phase scanners is the range that for all available at the market models is not higher than 80 m (Shan Jie, Toth Charles, 2008). For longer distances (façade measurements, very large rooms) scanners that uses pulse technique must be used.

Basing on the analysis presented above it can be stated that usage of TLS is limited by the accuracy requirements and technology limitations. To perform measurements that meets standard's requirements different techniques and in some cases different TLS must be used.

Fig. 1. TLS used by WPG S.A. for inventory measurements.

3. TECHNOLOGY OF MEASUREMENTS

All TLS measure polar coordinates. The disadvantage of this solution is the change of point cloud resolution and geometrical accuracy in reference to the distance from the scanner to measured object. At the stage of designing of the scan positions this problem should be considered to ensure that all the measurements will meet resolution and accuracy requirements described in standards. Other problems that has to be considered at the stage of designing of the scan position are: the problem of shadows that should be filled from another scan and the problem of scan orientation technique (this problem will be further discussed in next chapter). WPG S.A. experience shows that to measure all large or more significant (with architectural details) rooms it is required to take more then one scan, even if range limits can be fulfilled by one scan. The example of taking more than one scan to measure church façade due to trees in front of the church is presented in Fig. 2.

Fig. 2. It is very often required to take more than one scan to measure one surface. This façade was measured from 7 positions (photo by Łukasz Uchański).

4. ORIENTATION OF SCANS

The problem of scans orientation is crucial for the geometrical accuracy of final products. As it was mentioned above TLS allows to perform measurements at the accuracy of single millimetres. For most of the projects all scans has to be “georeferenced” (geocoded) in one coordinate system. It allows to crate floor plans, cross sections and façade drawings basing on measurements from many scans without any transformation. There are two ways to perform georeferencing orientation process: orientate each scan separately by measuring at least three target points (reference point that can be recognized on the scan, see Fig. 3) on the scan or to perform scan to scan orientation by defining tie points and adjusting measurements together with measurements of targets (see Leica Cyclone and Z+F Laser Control handbooks).

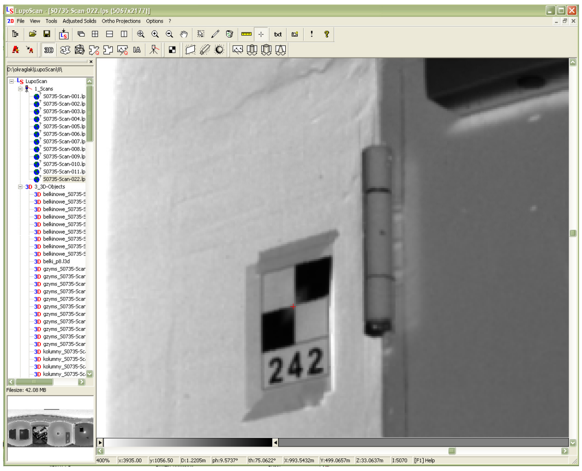

Fig. 3. Example of a flat target point.

In both ways, to perform orientation a local coordinate system has to be established. The system has to guarantee target measurements at the accuracy referred to scanner accuracy. For scan to scan orientation the coordinate system adjustment can be performed in one process with tie point adjustment (see Leica Cyclone and Z+F Laser Control handbooks).

5. POST PROCESSING AND FINAL PRODUCT PRESENTATION

According to PN/ISO standards and GUGiK standards “Wytyczne Techniczne G-3.4” the result of inventory measurements has to be presented as drawings at scales 1:200, 1:100, 1:50 or higher for some details. There are three types of drawings: floor plans, cross sections and façade drawings. Point clouds acquired with the use of TLS not only allow to create drawings mentioned above but also allow to present inventory results in new ways that for some of the receivers might be more common or useful. Main products that might be alternative or complementary to drawings are:

1. **Georeferenced point clouds, that creates a virtual 3D model of a building**
2. **Orthophotos of facades, walls, floors, ceilings**
3. **3D vector building models**
4. **Combined drawings (eg. orthophoto + vector drawing)**

Fig. 4 presents examples of alternative products crated basing on TLS measurements.

To define one of these product as a standard detailed researches has to be proceeded. Some investigations in this area has been performed by authors and presented at PTFiT Symposium 2008 (Uchański 2008).

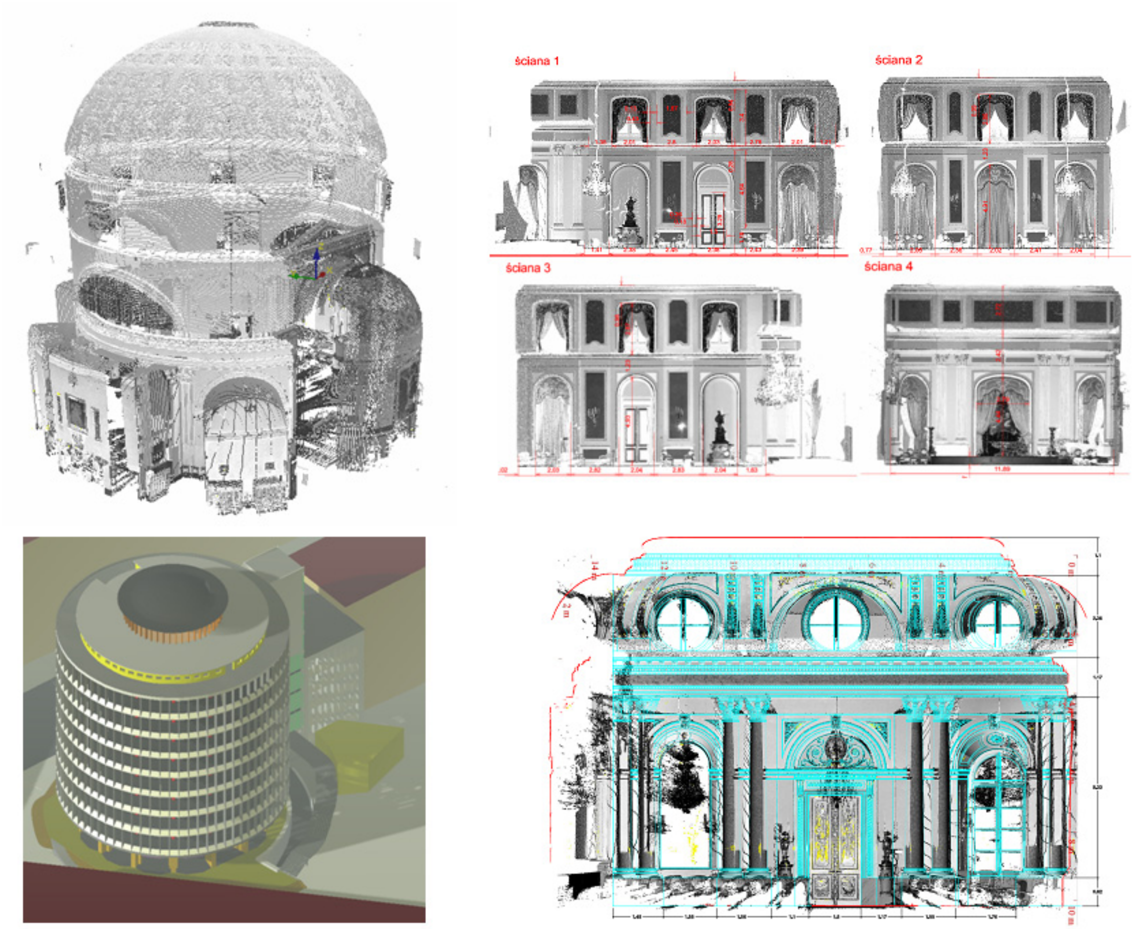

Fig. 4. Examples of alternative products: georeferenced pointcloud as a virtual 3D model, façade orthophotos, 3D vector model, vector drawing with orthophoto.

6. SUMMARY

The WPG's S.A. technology of inventory with the use of TLS bases on PN/ISO and GUGiK standards for inventory and design works. Measurements performed with the use of TLS not only allow to create inventory drawings but also give the opportunity to offer the customer some new products that in many cases are more useful and common for the receiver. The TLS technique allows to accelerate and, thanks to direct georeferencing of all scans, improve the accuracy of inventory measurements.

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