Laser scanning optimisation process in mountainous terrain

Mária Mrázová[1]

[1]Air Transport Department, University of Žilina, Žilina, 010 26, Slovakia

Abstract Digital terrain model is applicable for many possibilities related to aerial works by use of photogrammetry or laser scanning of the earth's surface. For the purpose of this research we consider just laser scanning used for work in difficult mountain terrain. The terrain of the Slovak Republic has many high hills and it signifies more complex flight planning, as laser scanning is usually flown in lower heights than photogrammetry. Moreover, as lower height is above terrain than the overlap between subsequent LIDAR strips is also lower. This situation can also lead towards the negative value in extreme instances.
This paper also describes the most effective way for flight planning during laser scanning of mountain terrain by comparison of two different technologies from operational and economical point of view.

Keywords laser scanning, LIDAR, optimisation, mountain terrain

JEL L93

1. Introduction

Optimisation process plays key role in any industry in order to find the most sufficient way to save costs and simplify the work process. Laser scanning is a method used for determination the spatial position of a large number of points on the Earth, such as buildings or vegetation. The result of points collection creates so called the point cloud that makes conditions for generation of needed digital terrain models in high definition resolution that cover all considerable detail.

Moreover, as was mentioned above, laser scanning process is executed at a relatively low flight level compared to the photogrammetry mainly due to the LIDAR's low range and consequently due to low level of radiant energy. Whereas the flights are made in low flight levels, it brings some kind of problems linked with overlaps adjacent LIDAR strips. As the altitude terrains is greater, then the greater strips overlap has to be done.

Briefly, in mountainous terrain the settings of the overlaps LIDAR strips has to be in close proximity due to the fact that if we make settings for 55% overlap and consequently difference of altitudes of the terrain will be less than 400 meters then the real overlap will drops to just 15 %. Whereas the resolution of LIDAR is higher, the overlap is smaller and also the flight level is lower due to the LIDAR and scanner operational efficiency.

2. Laser scanning technology

LIDAR – *Laser Instrument Distance and Range* - originally invented in the early 1960s short time after the laser invention and combined laser-focused imaging with radar's ability to calculate distances by measuring the time for a signal to return. [1]

LIDAR is a remote sensing technology based on the measurement of distance by illuminating a target with a laser and consequent analysis of the reflected light.

University of Zilina has also acquired photogrammetric technology for the purpose of applied research that is used in different fields of research, such as for the survey of localisation of damage forests caused by wind, or for the survey of the places with frequent landslides, etc.

The following paragraph will take closer look at the equipment that is used for the purpose of laser scanning.

The system that is bought for the purpose of University of Zilina use is called TRIMBLE HARRIER 68i that consists of the camera device and LIDAR technology. The Trimble Harrier 68i is an advanced corridor mapping system with a 400 kHz blasting pulse repetition rate and it ensures generation of extremely dense point clouds on one side and high quality geo-referenced ortho images on other one.

DOI: 10.26552/tac.C.2015.2.2

Digital camera specifications are shown in Figure 1.

Model	Trimble AC P65 +
Operating altitude	0 – 10,000 ft AGL
Array size	60 MP
No. of channels	Three RGB
FMC	Fully integrated
Max. Exp. Rate	Down to 2.8 sec.
Image pixel size	Down to 0.03 m
Image scales	1:250 to 1:10,000
Calibration	Geometrical and Radiometrical

Figure 1. Trimble Camera's specifications [2]

The main disadvantage of this model is the absence of the NIR channel that is part of the alternative solutions. This channel absence partly limits the camera's use for the purpose of mapping of forest areas and tree's health whereas the temperature is one of the basic diagnostic tools for large forest areas. In addition, another limit represents the maximum exposure time down to 2.8 seconds.

Another camera's limitation is based on the fact that maximum exposure time is down to 2.8 seconds where this is limitation for the maximum longitudinal overlap scanning areas during flights in low flight levels and also with high resolution setting.

The laser scanner is the second part of technology. The laser ray is deflected by the rotating polygon at adjustable pulse repetition rate of 80 – 400 kHz what means that it is possible to scan about 400,000 points per second. FOV (field of view) is adjustable between 45 – 60 degrees whereas the camera has the FOV 56 ° setting. Therefore, for the planning of the FOV overlap the setting is done by another device. If the LIDAR set to 60 ° FOV, the camera is a limiting factor, and vice versa.

University of Zilina also use another technology for the purpose of aerial work– the Leica RCD30 system that offers high performance and makes digital multispectral photogrammetry at lower costs compared to another laser scanning technology.

Leica RCD30 single camera head CH62 provides co-registered RGBN imagery. It also offers 60 MP medium format with 8956 x 6708 pixels. Also this camera can be easily combined with other 3rd party sensors and LIDAR systems. Moreover, Mechanical Forward Motion Compensation along two axes and it also has ruggedized and thermal stabilized lens system with innovative bayonet mount and user replaceable central shutter with automatically controlled high precision aperture. [3]

3. Flight planning procedures in mountainous terrain

For the purpose of this paper we make comparison of two different technologies used for flight planning procedures in mountainous terrain. We make flight planning for the North part of Slovakia with choose of 3 polygons where both technologies – Trimble and Leica are used.

If customers do not require laser scan then we use Leica Frame Pro software. This software is designated for the downloading and consequent post-process image data acquired with the Leica RC30 medium format camera.

Moreover, after achieving files from the airplane, we use *Harrier Config v2.9* for flight planning procedures, where we make all needed settings related to requirements. For clearer understanding, use of Leica or Trimble depends on the customer's requirements - it means if customer also requires laser scan then we use Trimble.

The area that was planned for laser scanning is illustrated in Figure 2.

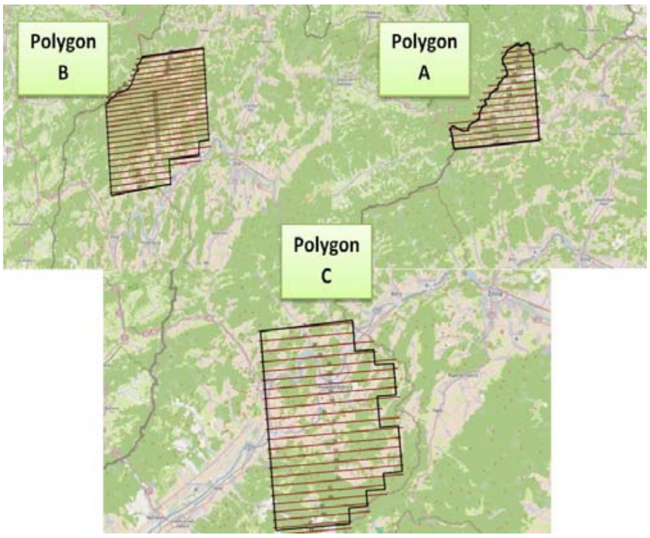

Figure 2. Illustration of the scanned polygons [author]

Following Figure 2, *Polygon A* lies around Korňa village close to Turzovka and Makov. From the geographical point of view this terrain is covered by altitude differences in the range from 150 to 400 meters.

Polygon B lies around the nearest towns as Bytča on southern part of the polygon and the northern part of polygon reached boundaries with Czech Republic. In this case altitude differences due to the hills were from 300 to 500 meters.

Polygon C is bordered by Udiča, Púchov and Považska Bystrica towns on northern part and southern part is bordered by Beluša, Domaniža and Pružina villages.

Following customer's requirements we made flight planning by use of both technologies. Due to the achieving many parameters we will consider just selected features in order to find out the best choice from operational and economical point of view.

LEICA OUTPUTS

Figure 3 illustrates the final mapping achieved by Leica MissionPro software.

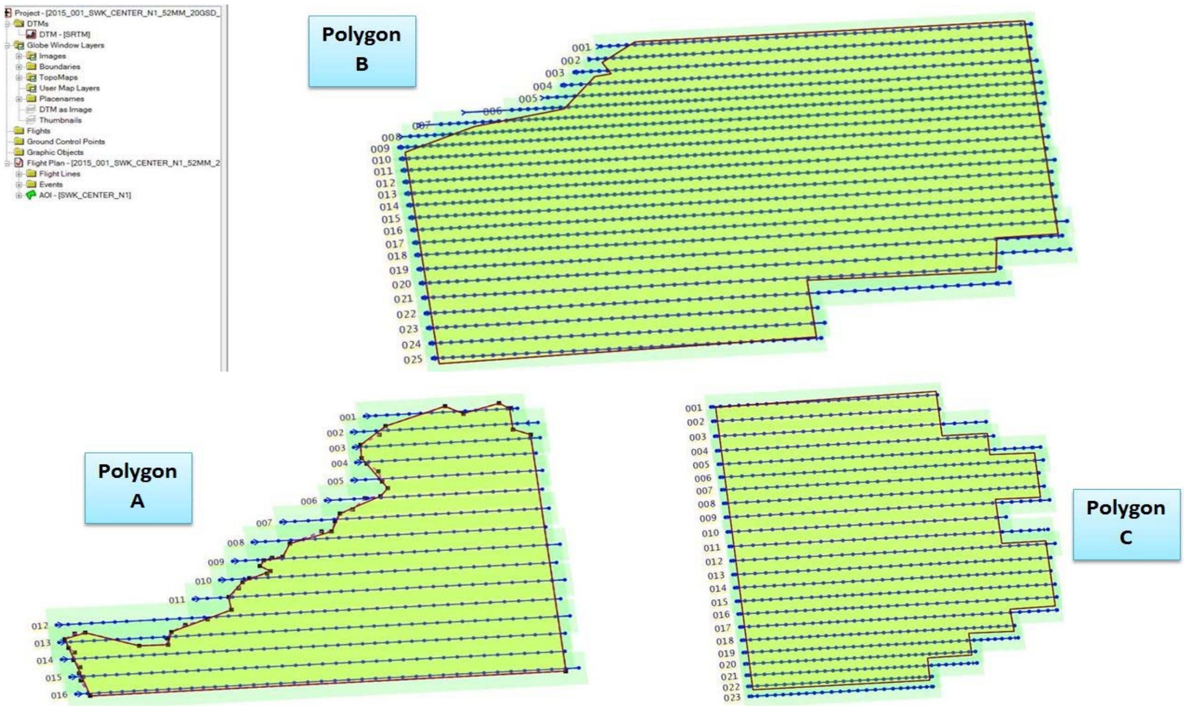

Figure 3. Illustration of the scanned polygons – Leica MissionPro software [author]

TRIMBLE OUTPUTS

Figure 4 illustrates the final mapping achieved by Trimble Harrier Config v2.9.

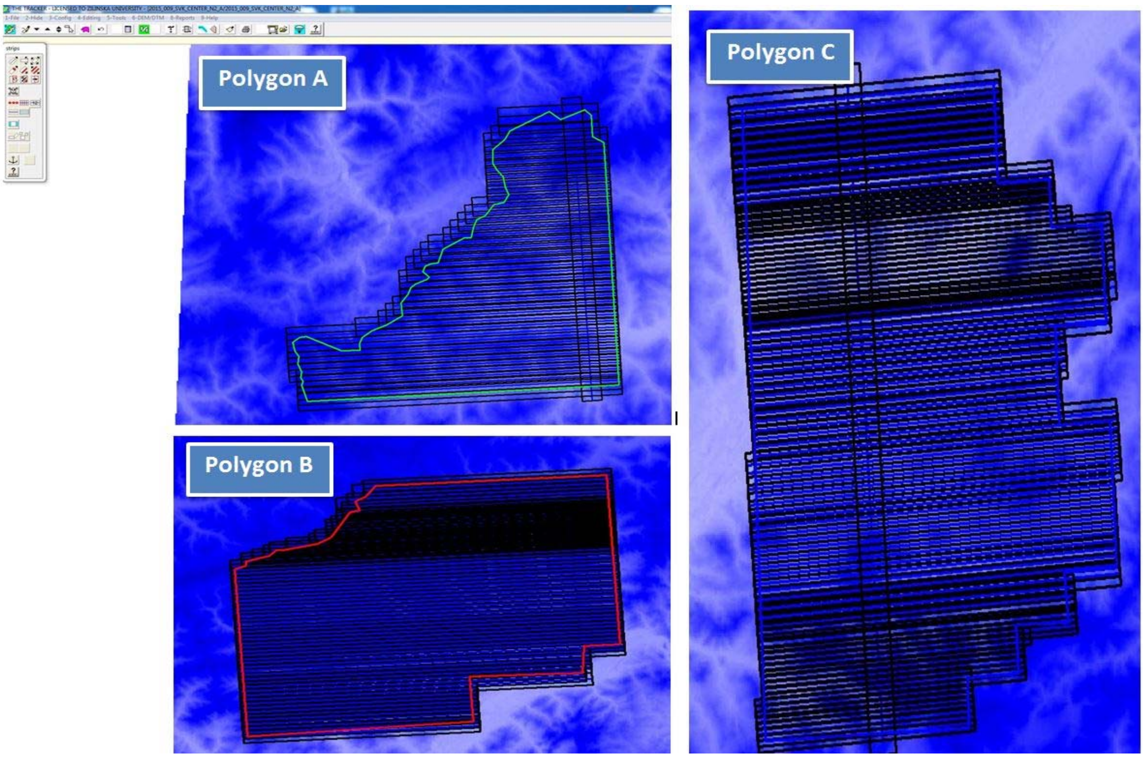

Figure 4. Illustration of the scanned polygons – The Tracker software [author]

4. Conclusions

Following results illustrated in Figure 5, we can see that from operational and economic point of view, the most effective way of flight planning in mountainous terrain showed the results achieved by *Leica MissionPro* Software.

LEICA	Lines	Photos	AGL Flying Height (ft)
Polygon A	16	432	7370
Polygon B	25	1528	6802
Polygon C	23	714	8083
TRIMBLE	Lines	Photos	AGL Flying Height (ft)
Polygon A	43	1245	12 657
Polygon B	65	3799	3858
Polygon C	88	3712	12657

Figure 5. Illustration of the scanned polygons – The Tracker software [author]

Moreover, in the case of *Polygon A*, by Leica Software we flew about 27 less lines as by Harrier software. From the photos point of view, Leica saves about 800 photos and the flight also was made in lower altitude (5200 feet).
In the case of *Polygon B*, Leica software planned 25 lines to fly while Trimble 65 lines. Also number of photos planned by Leica was 2271 less like in the case of Harrier software. The last *Polygon C* consists of 23 lines by Leica and it represents 65 less planned lines like in the case of Harrier software. In addition, the number of photos increased about 2998 photos in the case of Harrier software.

Briefly, *Leica Mission Pro software* flight planning procedures showed that save time needed to fly all lines about triple value and it produces triple times less number of photos that have to be processed what also safe work time.

ACKNOWLEDGEMENT

This paper is published as one of the scientific outputs of the project: ***„Broker centre of air transport for transfer of technology and knowledge into transport and transport infrastructure ITMS 26220220156“.***

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Project is co-financ

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