# From Landscape Surveying to Landscape Design – A Case Study in Nanjing, P. R. China

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## Abstract

GPS and Laser scanning are new buzzwords in Landscape Architecture, with the promise of precise landscape data in 3D. In this study, 3D-laser scanner and Builder were chosen to make a "tailored" DTM of a site for certain design concepts, based on which the following issues are discussed: 1. Efforts necessary to create landscape DTM in applying different surveying methods. 2. How landscape survey could influence design workflow.

## 1 Introduction

GPS and laser scanning are new buzzwords in Landscape Architecture, and both promise precise three-dimensional landscape data. Land survey data is an indispensable, fundamental basis for every landscape architecture project. Traditionally designers have worked with the undulation of topography using a two-dimensional map. Since real terrain is three dimensional, a DTM is more consistent with human visual physiology than a two dimensional map. The emergence of the above-mentioned, new survey technology means that landscape designers can now create a "tailored" DTM of a site for certain design concepts. In order to understand the efforts required to create a "tailored" DTM in applying different surveying methods, as well as how landscape survey could influence design workflow, a 2-week workshop was held in SEU, Nanjing, China in June 2013 to tackle precisely these questions. Two advanced methods of survey technology, capable of generating a high-resolution DTM, were chosen as a subject of study: a 3D-laser scanner and Builder.

**Fig. 1:** Left, students learning operation of 3D-laser scanner; middle & right, site photos

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# 2 Methods and Procedure

## 2.1 An Experiment in Applying a 3D-laser Scanner in a Landscape Design Project

In the first phase of the workshop, the students learned 3D laser scanning technology in a mountainous region of suburban Nanjing. The area is approximately 1 $km^2$, with a pond in the middle, covered with abundant trees and bushes (fig. 1). There is a 1:1000 topographic map of the site available, but the DTM generated from it is not sufficiently accurate for the design purpose, which is to reasonably determine reservoir capacity, slope length, slope ratio, and launder section, in order to meet both the aesthetical and engineering requirements, to create a balance of the dynamic interaction of multiple design factors. Determined by the site's topography and size, a middle-to-long distance scanner was chosen: a Leica Scanstation 10. It has a scanning distance up to 300 meters, scanning density reaches 1 mm, and scanning degrees between 270° and 360°. The 3D laser scanner's work contains two parts: data scanning on site and data processing inside.

The onsite data scanning was completed by a professional surveyor in approximately 30 minutes, with 2 stations. Because the each area scanner at an individual station is limited in range, large-scale landscapes require numerous stations to be set up, in order to capture the complete geometry and texture data in different directions and at different angles. In order to design an optimal set of stations and set up the proper scanning accuracy, scanners first need to investigate the specific terrain's characteristics, as well as distances and the visibility conditions of site.

Data processing offsite is done using Cyclone software, which is attached to the scanner. The Cyclone software allows point data gathered by the different stations to not only be automatically combined and converted in one coordinate system, but also be moved, flipped, deleted, or measured freely. Deleting noise points in point clouds data is a major part of the data processing work, and is very time consuming. Noise points are caused by three basic factors: 1. Errors generated by surface factors of site, such as roughness, corrugation, material, and so on. 2. Errors caused by the scanning system, such as ranging precision, scanning resolution, vibration of laser scanner, and so on. 3. Accidental noise due to occasional factors that emerge in the scanning process, for example, weather dust, moving objects like people or vehicles. When editing is finished, point clouds data can be saved as *.pts or *.rcs files in order to generate DTM.

We were confronted by an unexpected problem during the editing process. Since we did the scanning during the summer, the surface of the site was almost completely covered by different kind of plant, which means the point clouds are basically vegetation. In a situation such as this, neither manual separation nor special software can filter out plant features to arrive at pure surface features. The professional surveyor suggested two optional solutions: scanning in winter, which would mean waiting months, or using "Builder" to survey the site, which would only take a week. As a result, the resulting point clouds are not able to match the design concept.

### 2.2 An Experiment in Involving Builder in a Landscape Design Project

In the second phase of the workshop, the students learned how to survey with Builder. The site is located on the Southeast University campus, about 3,000 $m^2$, with a height difference from southeast to northwest of one meter. The southeast of the site is used as a parking lot, and there is a garden on the northwest side. The objective behind acquiring highly accurate DTM data, is to then allow students to carry out an open space design that is based on the DTM. In order to save time, the survey focused only on the ground and did not include the rounding buildings. Leica Builder Total Station 502 was chosen for the site, the survey range is up to 250 m without a prism or 3500 m with prism.

After a discussion between the surveyors and the researchers, in order to better understand the Builder survey principles, researchers told the surveyors what kind of points should be measured and how to stratify the points of landscape elements during the survey process, such as trees, stairs, parapets, and so on. Two professional surveyors required two hours to complete the survey.

The point clouds data acquired by Builder can be saved as *.ascii file, and imported directly into Civil 3D in order to build the DTM. Civil 3D is a software program by Autodesk, which could generate terrain design in 3D. Students designed the landscape scheme, while learning the different possibilities to analyze and manipulate the terrain provided by Civil 3D. Ultimately, a 3D model of the finished design was imported into 3Dmax for texturing, rendering, lighting, and post-processing of the camera (fig. 2 and 3).

## 3 Results and Discussions

### 3.1 Landscape DTM

A landscape DTM is the final goal of different survey methods. Although a DTM is generally used by various professions today, a landscape DTM has specific requirements. The terrain of a landscape project can be seen as a composition of numerous points that can be divided into ground points and non-ground points. Ground points are the bare surface points, including mountain, road, bare soil, pavement, and so on; non-ground points are those that are raised above the ground point, such as houses, trees, and so on. In a traditional 2D topographical map, contour lines represent the undulating terrain while linear features represent natural and artificial elements such as rivers, roads, and so on. Planar features represent residential, industrial enterprises, vegetation, and so on. A landscape DTM can be understood as a 3D topographical map, which means point clouds data should be classified between ground points and non-ground points with factors of location, height, and features.

### 3.2 Comparison of the Two Instruments in Creating Landscape DTM

Data scanning on site is comparatively easy when surveying with a 3D laser scanner. By bouncing a laser beam off a site, 3D laser scanners can quickly obtain high-resolution point clouds data of the target. Data processing offsite is time consuming, but the actual the time needed to delete noise points and stratify the layers of different element depends on the complexity of site. There are some limitations involved in the use of 3D laser scanners: 1. It is unadvisable for rainy, foggy and snowy weather conditions, and if there are too many moving targets. 2. It is also unsuitable for sites covered with many irregular vegetation or objects, because of the effort and time required to delete noise points in the data processing.

**Fig. 2:** Left, students learning operation of Builder; right, point clouds in Civil 3D

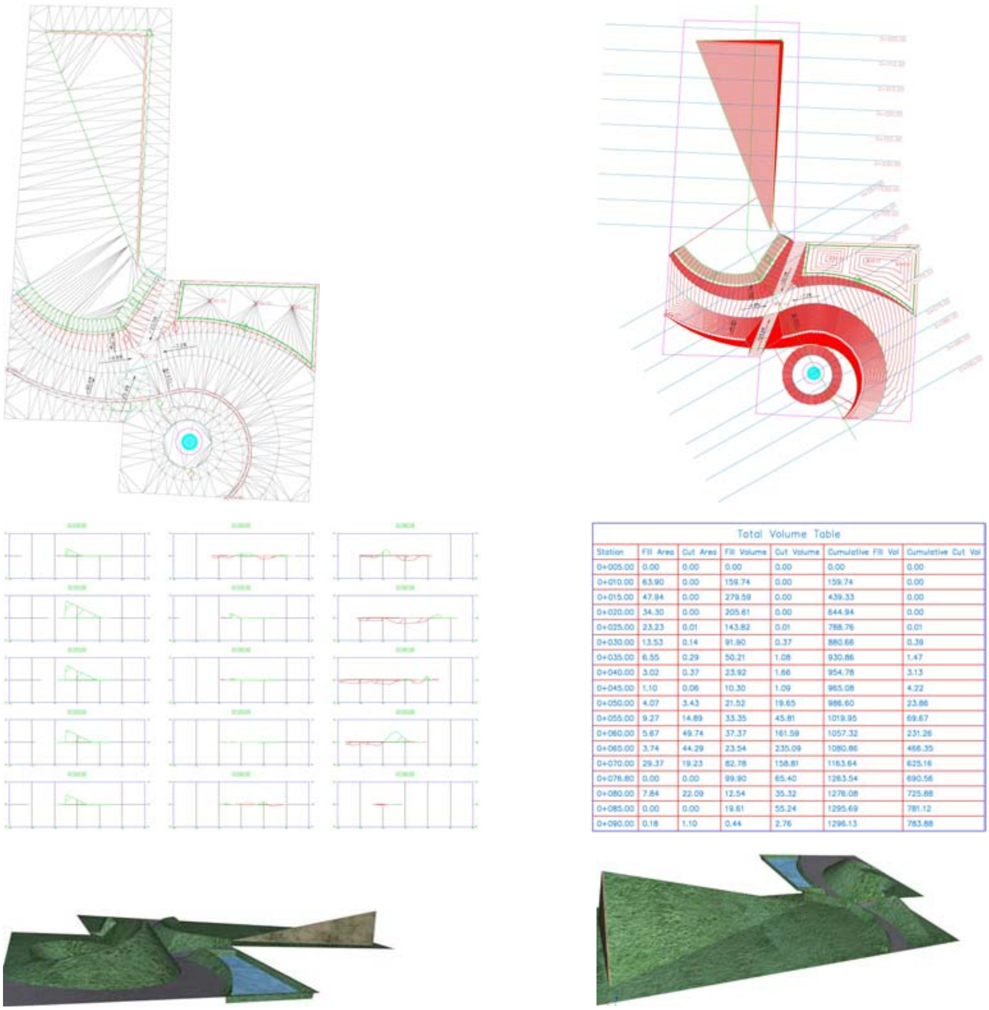
Once the survey is finished on site, the DTM is almost complete enough for Builder. Builder is a single point measurement process and requires more time than a 3D laser scanner. Considering the working efficiency, it is not possible for Builder to measure every point like a scanner, and to take every 1 mm of the surface fluctuation into account. Therefore, designers need to plan the survey process beforehand: 1. What height difference could be considered "flat" enough to be neglected in the survey and what height difference should be taken into account. 2. Which landscape elements (vegetation, manholes, open channels) need to be included in survey and which not. 3. Which landscape elements could be put on the same layer of point clouds data, and which on different layers. Concerning the application of Builder, it is not adversely affected by harsh weathers or moving objects.

Theoretically, both the 3D laser scanner and Builder could generate point clouds data as well as build a high-accurate DTM. However, this comparison demonstrates that the following aspects must be considered before choosing the specific, landscape surveying instrument:

- Survey instruments: survey method, point clouds data generation method, budget;
- Site conditions: geographical location, scale, landform and physiognomy, composition of ground points and non-ground points;
- Design tasks: time requirements, design concepts;
- Variable factors: climatic conditions, season, moving objects.

## 3.3 Comparison of Map-based and DTM-based Landscape Design Process

In a map-based design process, designers must imagine the 3D topography when reading abstract two-dimensional maps, then, based on this mental image, designers analyze and develop a three-dimensional landscape with the help of drawings on paper. This is a complex system, especially when there are multiple factors to consider. After planning the preliminary spatial concept, designers as a rule need to view and assess their spatial concept in 3D. SketchUp is often used as a simple 3D-visualization software with a powerful library of vegetation and object models. The designer can quickly complete 3D modelling and viewing it in different visual styles (fig. 4). SketchUp has many advantages: it is easy to use in 3D visualization and it aids the flow of thoughts in the design process. However, while it is more suitable for regular terrain modelling and editing, it is less suitable for irregular undulating topography, sensing a specific terrain's flow, surface runoff, and so on, which are all important for developing landscape design.



Total Volume Table

| Station | Fill Area | Cut Area | Fill Volume | Cut Volume | Cumulative Fill Vol | Cumulative Cut Vol |
|---|---|---|---|---|---|---|
| 0+005.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0+010.00 | 63.90 | 0.00 | 159.74 | 0.00 | 159.74 | 0.00 |
| 0+015.00 | 47.94 | 0.00 | 279.59 | 0.00 | 439.33 | 0.00 |
| 0+020.00 | 34.30 | 0.00 | 205.61 | 0.00 | 644.94 | 0.00 |
| 0+025.00 | 23.23 | 0.01 | 143.82 | 0.01 | 788.76 | 0.01 |
| 0+030.00 | 13.53 | 0.14 | 91.90 | 0.37 | 880.66 | 0.39 |
| 0+035.00 | 6.55 | 0.29 | 50.21 | 1.08 | 930.86 | 1.47 |
| 0+040.00 | 3.02 | 0.37 | 23.92 | 1.66 | 954.78 | 3.13 |
| 0+045.00 | 1.10 | 0.06 | 10.30 | 1.09 | 965.08 | 4.22 |
| 0+050.00 | 4.07 | 3.43 | 21.52 | 19.65 | 986.60 | 23.86 |
| 0+055.00 | 9.27 | 14.89 | 33.35 | 45.81 | 1019.95 | 69.67 |
| 0+060.00 | 5.67 | 49.74 | 37.37 | 161.59 | 1057.32 | 231.26 |
| 0+065.00 | 3.74 | 44.29 | 23.54 | 235.09 | 1080.86 | 466.35 |
| 0+070.00 | 29.37 | 19.23 | 82.78 | 158.81 | 1163.64 | 625.16 |
| 0+076.80 | 0.00 | 0.00 | 99.90 | 65.40 | 1263.54 | 690.56 |
| 0+080.00 | 7.84 | 22.09 | 12.54 | 35.32 | 1276.08 | 725.88 |
| 0+085.00 | 0.00 | 0.00 | 19.61 | 55.24 | 1295.69 | 781.12 |
| 0+090.00 | 0.18 | 1.10 | 0.44 | 2.76 | 1296.13 | 783.88 |

**Fig. 3:** Design results based on DTM, Civil 3D, and 3Dmax. Top: 3D model in Civil 3D. Center: sections and earthwork calculations generated by Civil 3D. Bottom: rendered images in 3Dmax.


**Fig. 4:** Design results of the same campus site, based on 2D map and SketchUp

A DTM-based design process with Civil 3D is more natural for the designer regarding the overall surface undulation, structure, and morphological character of the site. An overall grasp of the terrain could greatly enhance a designer's understanding and grasping of the actual situation of the original terrain. This helps designers to design suitable interventions that meet the characteristics of the landscape topography. Civil 3D features line design function, grading and site levelling capabilities, and precise engineering data of digging and filling. It also provides more possibilities of manipulating terrain in design process. Civil 3D is better oriented to civil engineers. Compared to SketchUp, Civil 3D is more complicated to operate, weaker in its representation of 3D spatial form, and does not have a large vegetation library. Therefore, Civil 3D is less suited to fine model processing, especially in regards ambiguity and fluidity of design concept development. An additional disadvantage is not allowing designers to see the full visual effect of their design concept. However, its advantages include being a good analysis tool for irregular terrain design, slope ratio and aspect during design process, and for earthwork balance while general spatial form is being developed.

# 4 Conclusion and Outlook

Introducing advanced survey techniques to create a "tailored" landscape DTM helps designers understand and analyze the terrain in the 3D perspective, but it also provides scientific and quantitative support for landscape design. Landscape architects are not surveying professionals, however, understanding how to apply different surveying methods on different landscapes will become increasingly important, and an accurate survey is the fundamental basis of a precise landscape DTM. Furthermore, researches on DTM-based design process needs to be done, by interactively using Civil 3D with SketchUp, in order to retain the freedom of form generation of the designer, as well to meet the needs of scientific evaluation in design process, as such to make the final design results reaching the optimistic state in overall performance.

# References

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