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ARTICLE

Surveying of Tall Buildings over Theory Height within Obstacle Free Airspace

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ABSTRACT

According to the National Airport standards, this article has looked over the height of 180000 buildings in the airfield control height region of Cencun Airport (about 123.6 sq. km) for the first time. In the paper, based on the planning & approving data and ADS40 aerial survey data, GIS spatial analysis, ADS40 stereo-altimetry technology, field digital measurement and 2D/3D visualization are used synthetically to achieve the results above. Furthermore, the quantity and spatial distribution of over theoretical height buildings are clarified, which is significant to review the airfield height management and to guide the regulatory plan of Tianhe Intellectualized Business District.

1. Introduction

Tianhe District, as a national central city core zone under construction, continues to extend its urban area to the north-east suburb area, with the strategy of "eastward development" implementation acting on. There arises with a result that the Cencun airport located in a remote situation earlier also gradually starts the progress of urbanization, which makes the guarantee of airfield control height an important consideration when planning management. However, a phenomenon of partial over theoretical height buildings was caused by varieties of historical reasons, leading huge hidden danger to the flight safety.[1]

Under such background, based on the National Airport Standards and the Scheme of the Airfield Clearance and Control height Region of Cencun Airport brought out by the Guangzhou Military Region Air Force in 2001 , this paper has looked over the height of 180 000 buildings in the airfield clearance control region of Cencun Airport for the first time. With the full advantage of the planning and approving data, and ADS40 aerial survey data existed, using GIS spatial analysis, ADS40 stereo-altimetry technology as well, field digital measurement and 2D/3D visualization systematically and comprehensively, the results mentioned above are synthetically achieved under the combination of internal and external business. Furthermore, the quantities, space distribution, breaking rules and its historical reasons of over theoretical height buildings are all clarified. On one hand, the discuss results can enhance the dynamic monitoring system of over theoretical height buildings, and rethink profoundly on the

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planning management, in order to positively figure out the danger hidden in the flight safety;[2] On the other hand, the fundamental data is provided for Tianhe Intellectualized Business District as a regulatory plan.

2. Study Area and Data

In this paper, airfield clearance control region of Cencun in Tianhe District of Guangzhou (about 123.6 sq. km) is selected as the study area. The Scheme of the Airfield Control height of Cencun Airport was put forward in accordance with National Airport Standards by Guangzhou Military Region Air Forces, which control height region consists of the takeoff and landing strip, terminal clearance zone, side clearance zone, fillet surface, inside horizontal plane,[3] conical surface and so on, shown as the Figure 1 and Figure 2.

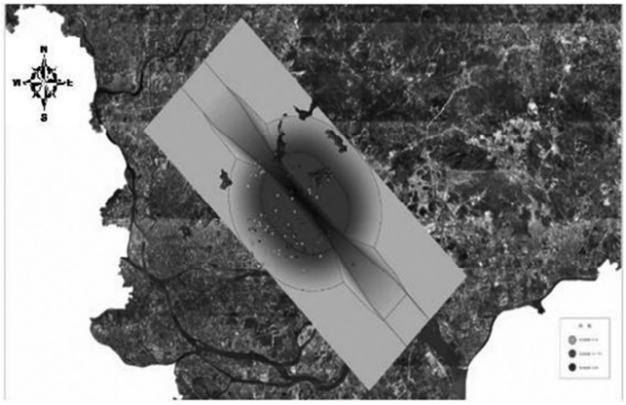

Figure 1. Location of the study area

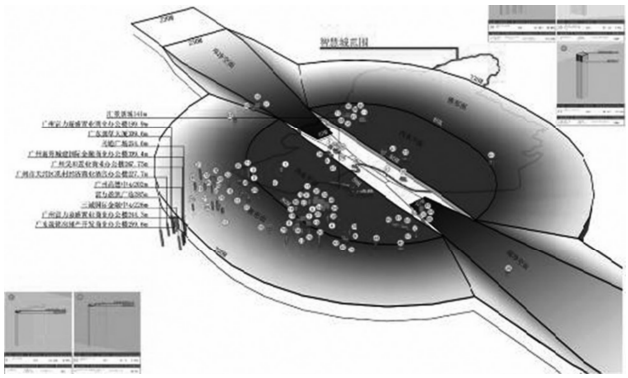

Figure2. 3D map of the study area

Judging by this scheme, the clearance control region of Cencun Airport, 30 kilometers long and 13 kilometers wide, has an area of 390 square kilometers. In terms of Tianhe District, over 90% region has been included into this control area, which covers 123.6 square kilometers approximately and involves about 180 000 buildings, other than a small area in the north, the Fenghuang Mountain.[4]

Here, buildings that exceed the "control tall" in this airfield can be defined as the following principles: it referrers to the ones apogee altitude (shift the ±00 sign of the building into Guangzhou elevation and plus the highest clear height which includes annexes like day surface, ladder house, pool, decorating frame, lightning rod and so on, drawn on the construction blue print) consented and approved by the Logistics Department of Guangzhou Military Region Air Forces, within the airfield clearance control management region of Cencun Airport, has exceeded the theory height stipulated by the Scheme of the Airfield Control height of Cencun Airport (according to the highest limited elevation in theory stipulated by the Scheme of the Airfield Clearance Control of Cencun Airport from Guangzhou Military Region Air Force, calculated based on related mathematical models).[5]

In addition, the fundamental data includes:1) Guangzhou city, a new generation of height precision dynamic three-dimensional urban space in surveying and mapping constructed in 2005 (including the continuous operation reference system detailed application in city surveying with comprehensive services and the Precision Quasi-geoids Determining Result of Guangzhou City); 2) "Three-Plan-Coordination" decision support platform in the Tianhe District and the planning and approved information database cut-off by the end of 2013; 3) the ADS40 aerial survey data of Guangzhou City in 2008, (covering the whole city about 7400 square kilometers with the resolving power of 0.2 meters), the DEM data with a precision of 5m*5m of the whole Guangzhou city in 2008 and an electronic topographic map scale 1:2000 in the best shape of reality of 2013.[6]

3. Integrated Technology Scheme for the Census of Airfield Clearance Control Region

Based on the planning and approving data, ADS40 aerial survey data as well, varieties of technical methods and software platform are used synthetically with the combination of internal and external business to achieve the census above. Five steps were studied:[7]

(1) Firstly, obtaining the clearance control region of study area according to the National Airport Standards and the Scheme of the Airfield Clearance and Control height Region of Cencun Airport brought out by the Guangzhou Military Region Air Force in 2001;[8]

(2) Using the similar "isohypse" model to start the process of interpolation encryption on the fillet surface, conical surface, terminal clearance zone and side clearance zone in the control height region, and then generate the "control loop" to construct a computing model for the control height of buildings in theory;[9]

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(3) Based on the "Three-Plan-Coordination" decision support platform in the Tianhe District with the GIS spatial analysis technology, this paper screens the suspected over theoretical height buildings from the planning and approving data existed, in order to quickly narrow the searching region of "over theoretical height" buildings, ;[10]

(4) Regard the suspected over theoretical height buildings screened out as a target organ, using the method of ADS40 stereo-altimetry technology and field digital measurement synthetically, and, ultimately clarify the quantities and space distribution of "over theoretical height" buildings;

(5) Analyze the research achievements and put forward reference suggestions to detailed control planning for Tianhe Intellectualized Business District.

4. Surveying of "Over Theoretical Height" Buildings Based on GIS Spatial Analysis Technology and ADS40 Stereo-Altimetry Method

4.1 Construct a Similar "Isohypse" Model for Theoretical Control Height Calculation of Buildings

With the thought of "isohypse", aiming at simplifying the calculation process of the theoretical control height of buildings, in the paper, the distance between the index contour is designed as 100 meters, which is regarded as a unit, starting the process of interpolation encryption respectively in accordance with 1/10, 1/20, 1/50, 1/75 on the fillet surface, conical surface, terminal clearance zone and side clearance zone, and then generate the "control loop" (see Figure 3). That is to say, the basic control height distances of these surfaces respectively are 10 meters, 5 meters, 2 meters, and 4/3 meters. Therefore, the calculation of the control height of buildings is more likely to the interpolation calculation of the elevation points' height based on the contour model.[11]

Specific steps are as following: ① Firstly, obtain the basal graphs of the buildings; ② Register the building bases to the model for control height calculation according to the spatial coordinates; ③ Obtained the angular point which is the closest to the inside horizontal plane from the building basal graphs; ④ Regard the control height gained from the model for control height calculation at the angular point through interpolation calculation, as the control elevation of the building. As Figure 4 shown, the building is on the 1/20 of the conical surface, which can prove that the theory height of this building is 102 meters.[12]

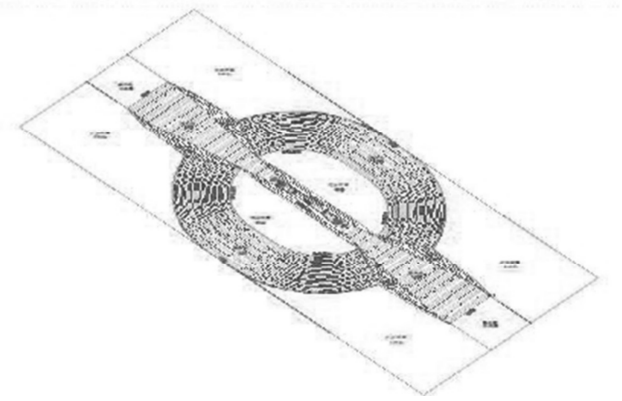

Figure 3. A theoretical calculation model for control height of buildings

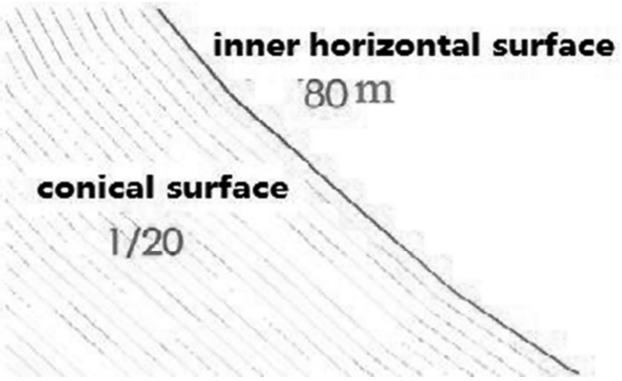

Figure 4. Example of the control height calculation of buildings

4.2 Obtain the Searching Region Based on GIS Planning Decision Support Platform

In order to narrow the searching region of "over theoretical height" buildings, this paper screens the suspected over theoretical height buildings from the planning and approving data existed of the Tianhe District. Specific steps are as following:[13]

(1) Lead "the control red line of the Cencun Airport region" into the platform mentioned above, which is overlay-analyzed with the "E-government map", "the administrative map of Tianhe District" in the platform database. Conduct the preliminary selection of related cases from the platform database, which own the "Construction Planning Permit", "acceptance certificate" and "letter" with approval information from adjusted planning permission, according to the query builders, such as the handling time, post types and whether located within the control height region.[14]

(2) The calculation of the height construction application: the planning elevation construction application of the building's highest point can be gained through referring to the construction graphs and pluses the biggest elevation

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of the building and the ±00 elevation shown in the general layout plan.

(3) Obtain the building basal graphs and check: find the general layout plan from the construction graphs downloaded, and by means of 1/1000, zoom out into a building basal graph with actual coordinates.

(4) Based on the model for theory height calculation, achieve the results of obtaining suspected evidences and buildings, through getting the theory height from the building basal graphs and comparing the building elevation planned and approved with the approvals from the air forces.[15]

4.3 Surveying of the "Over Theoretical Height" Buildings with ADS40 Stereo-Altimetry Technology

This paper applies two ways to obtain the elevation information of suspected over theoretical height buildings: to the cases approved by the end of 2008, one is the stereo-measurement, based on the ADS40 aerial survey achievements of 2008; to the ones approved after 2008, the other way is the field digital measurement (GPS+ total station).

4.3.1 Obtain the Height of Buildings through ADS40 Stereo-Altimetry Method

Based on the ADS40 stereo-altimetry technology, the general technological route to get the elevation information of buildings is:

(1) Firstly, the disposal of ADS40 data includes areophoto, photo field work control measurement, aerial triangulation, L1 level image generation and stereo-models construction. And obtain the elevation information of buildings through stereo-altimetry technology with automatic stereo-image;

(2) Then, the newest DEM data can be gained through semi-automatic DEM generation, correction of height anomaly, and the methods of updating DEM;

(3) At last, the elevation of each building can be gained by overlaying the DEM data and the elevation information of buildings.

Taking the resources of data and its accuracy requirements into consideration synthetically, the main steps to obtain the heights of buildings by means of stereology are as following:

(1) Using the PR0600 module in the Leica Photogrammetry Suite, add the 2D GIS house surface data which has already shifted into the utm84 coordinates into it and open corresponding air strips images before and after L1 level, conducted under stereo-environment.

(2) The top of the building and the basal height are needed to measure respectively in order to get the height of building. In the area of low visibility on the ground, the one-to-many pattern is advisable. Namely, first of all, a set of elevation points on the top of buildings are measured by the same building basal elevation point, and then, measure the building basal elevation point.

(3) Construct an automatic treatment process to eliminate the artificial errors. What follow is the specific methods: Firstly, the dense homonymy points are over theoretical through the algorithm of image matching and the parallax errors can be figured out, automatically building a database of homonymy points with parallax errors. In the single image, two points, one on the top of the building and the other one at the bottom, are chosen as centers by the computer. And then a N*N template (N depends on the circumstances to select) is used for searching selected points in the database that are the closest to and more similar to the pixel and obtain its parallax error; In the end, volume calculate the heights of buildings by means of formulas. As for the buildings sheltered from houses or trees, which cannot be measured, a field measurement as renewal surveying is needed.

4.3.2 DEM Generation and Updating

Under the premise of L1 level image, homonymy points can be over theoretical automatically before, after and under the visual image, with the image matching technology. Then, on the basis of elements of exterior orientation on each scanning line, geographic coordinate values of this point can be calculated. In the end, start the process of interpolation to over theoretical the DEM grid elevation. However, in the practical operating, with the surface features higher than the ground like houses, trees etc, the elevation of grid point is needed to be adjusted onto the ground, generating the DEM. The automatic over theoretical for DTM can be achieved by Inpho MATCH-T, and then, DEM can be generated after editing the DTM data based on the LPS software platform, which specific process refers to reference.[1] As for the region having changed recently, the newest large scale topographical map is required to update and distilled process the DEM data[1].

5. Experimental Analysis

In terms of Tianhe District, over 90% region has been included into this control area, which covers 123.6 square kilometers approximately and involves about 180 000 buildings, other than a small area in the north, the Fenghuang Mountain. 1109 planning cases yet to be investigated with control height requirements are screened out through the "Three-Plan-Coordination" decision support

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platform in the Tianhe District. 379 "over theoretical height" buildings are ultimately clarified and measured elevation practically. The accuracy of 337 buildings' elevation information, based on ADS40 stereo-altimetry technology, basically can reach 0.5 meters. 42 buildings' elevations were measured by GPS and total station, which accuracy gets to ±15 centimeters. 2D/3D visualization technology is used to analyze the quantities distribution, space distribution, breaking rules and causes of "over theoretical height" buildings.

5.1 Quantities Distribution of the "Over Theoretical Height" Buildings

With the analysis of quantities (As shown in Figure 5 and 6), the "over theoretical height" buildings' breakthrough proportion <10% covers the biggest part, almost 30%; breakthrough proportion <20% occupies about 50%; breakthrough proportion <60% takes up about 94%. As can be learned, almost half of the "over theoretical height" buildings' breakthrough proportion account for small part (<20%), and the overwhelming majority of them is <60%.

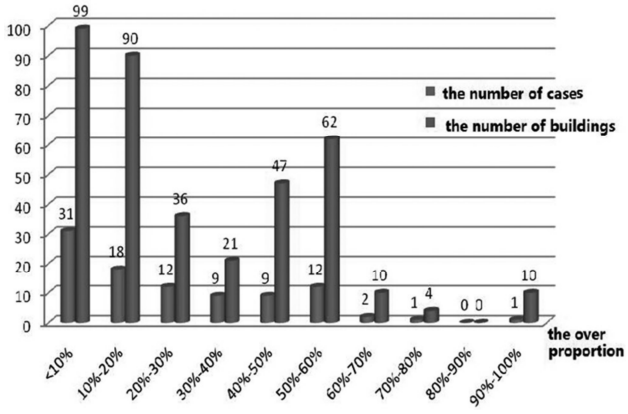

Figure 5. Statistics for proportion of the "over theoretical height" buildings

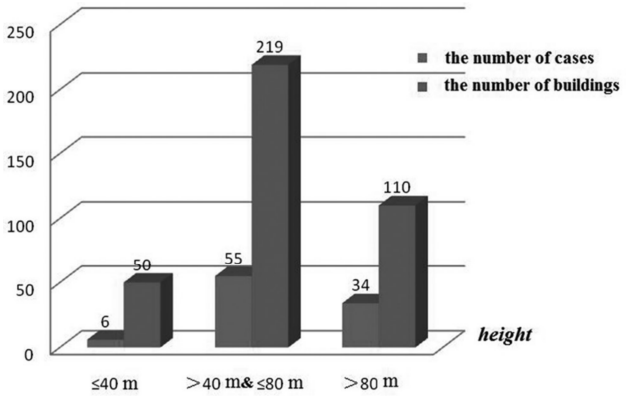

Figure 6. Statistics for Distribution of the "over theoretical height" buildings

Secondly, about 60% "over theoretical height" buildings located within the theory height of 40 meters to 80 meters (including 80 meters inside horizontal plane), and approximately 30% situated within the theory height of 80 meters to 230 meters, while only about 10% lied within the theory height of 40 meters.

In addition, as seen in the Figure 7, the building elevation construction of 13 cases (13.7%) and 36 buildings (9.5%) have exceeded the elevation document approval from the air forces, other than the historical causes. The rest building elevation construction of 82 cases (86.3%) and 343 buildings (90.5%) lie between the "airfield theory height" and "air forces approved height".

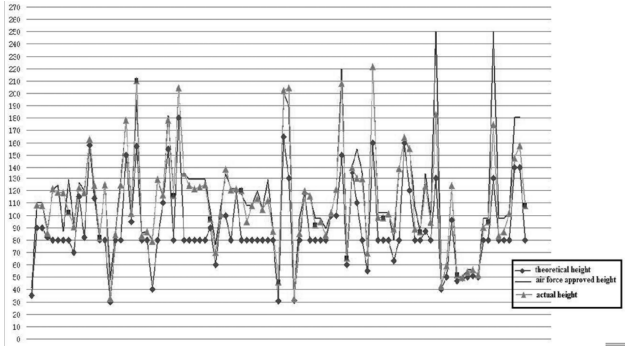

Figure. 7 Comparison for "theoretical height"," air force approved height" and "actual height" of the tall buildings

4.2 Spatial Distribution of the "Over Theoretical Height" Buildings

The colored points shown in the Figure 8 are the situation of over theoretical height buildings. The over theoretical height scope of buildings gradually increasing varies from pale red to russetish, while the blue ones are the extremely over theoretical height buildings. Seeing from the space, the "over theoretical height" buildings mainly distributed over the Zhujiang New Town, Huijing New Town, Tangxia Town Village, the Tianhe Sports Center, the Tianhe Park and the neighbor buildings of Cencun (for example, the security housing and the commercial residential buildings of the Guangdan District in Guangyuan Road, the both sides of Guangshen Railway, the Non-ferrous Metals Institute in the Changxing Road District, the Baocui Garden residence community and so on), focusing on the south, south-west and south-east of the Tianhe District. Some historical reasons cause the Zhujiang New Town and Huijing New Town (the distribution of blue point group) become part of the main accumulation of "over theoretical height" buildings with higher over theoretical height extent.

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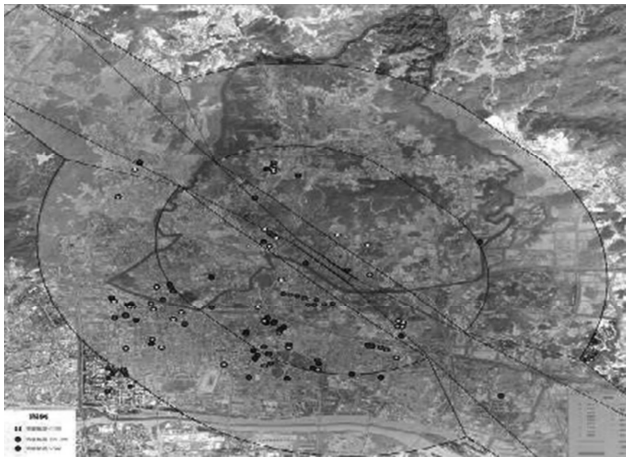

Figure 8. 2D spatial distribution map of the "over theoretical height" buildings

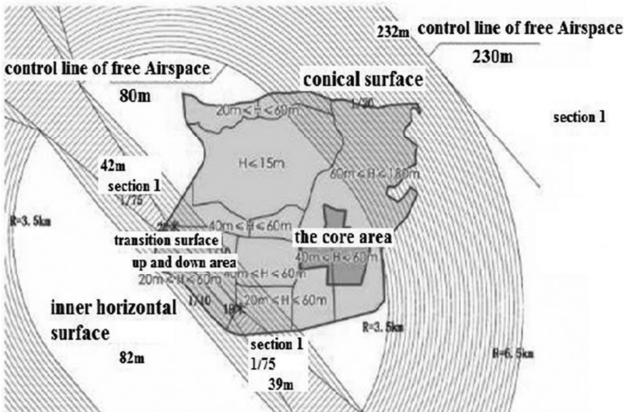

Figure 9. Comparison for "regulatory planning height" and "theoretical control height" of buildings in the core area of intellectualized city

4.3 Suggestions for the Regional Regulatory Planning

As Figure 9 suggested, the overwhelming majority region (over 70%) of the Tianhe Intellectualized Business District lied on the 80-meter inside horizontal plane within the theory height, namely airfield theory height of 40~80 meters, which caused universally the low development intensity of lots located in the core zone of Intellectualized Business District, leading to low land leasing revenue.

On the assumption that the average theory height of the whole region in the Intellectualized Business District is 80 meters, under the premise of good negotiation and understanding with Guangzhou Military Region Air Force, combining the research achievements mentioned above, (a number of buildings around the Cencun Airport have broken the requirements for restriction of the Cencun Airport, such as Huijing New Town, Shiji Lvzhou Garden, Huajing New Town etc, which breakthrough range lies between 30%-40%). Therefore, according to the 40% of allowed breakthrough theory height, the theory height is able to increase 80*40%=32 meters. As for the newest regulatory plan of Intellectualized Business District, the restriction of theory height has been taken into consideration. Calculating the weighted average measurement of the lots area, with the average control height of the buildings being about 60 meters of the Intellectualized Business District core region, assuming that the average height of buildings increase 32 meters on average with the theory height, (still satisfying the restriction of theory height), then the proportion of the construction scale is able to increase approximately 32/60=53.3% in accordance with the hypothetical theory, namely the overall floorage reaching 20 million six hundred and fifty-seven thousand square meters. The Tianhe District, being the motive force for the urban booming of Guangzhou City, advances itself further by land consolidation and economical use, greatly promoting the land output, economic and social effects synthetically.

5. Conclusion

This paper has surveyed the "over theoretical height" buildings within the theory control height of Cencun Airport in Tianhe District systematically and comprehensively for the first time, analyzing its quantities and space distribution, breaking rules and causes, and predicting quantitatively for easing the airfield control height standards or the influence on the construction planning of the Intellectualized Business District might being caused by the removal of the airports. It is not only significant to analyze the airfield height control, the management of engineering construction as well, and positively figure out the hidden danger of flight safety, but also provide exact fundamental data for a regulatory plan of the Tianhe Intellectualized Business District. What follows are the conclusions:

(1) In terms of the project implementation: this paper takes the full advantage of the planning and approving data, ADS40 aerial survey data as well, using multiple technology and software platforms, combining the office and field work, making a progressive, focused and practical technological route, and improving working efficiency.

(2) In terms of the creative technology: this paper builds up a easy yet efficient computing model for building theory height control; based on the "Three-Plan-Coordination" decision support platform in the Tianhe District, use the GIS spatial analysis technology, greatly zooming out the surveying building region; focus on and operate the key technology such as ADS40 data processing,

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height measurement, DEM generation and update; use the algorithm of image matching to automatically construct a database of identical points with parallax error, greatly reducing artificial interference, improving the automation; achieve the semi-automatic DEM generation and update based on the LPS software and ADS40 digital photogrammetry measurement data automation processing system. The conclusions mentioned above are significant to the process of the same type of projects.

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