# Study on Application of Aero-photography and Remote Sensing Systems by Unmanned Aerial Vehicle in Mapping of Gansu West Plateau Mining Area

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**Key words**: Unmanned aerial vehicle (UAV) , Plateau mining area, Image-control point , Topography

## SUMMARY

The purpose of the study is to map of Gansu West Plateau Mining Area with the high efficiency by the aero-photography and remote sensing systems of unmanned aerial vehicle (UAV).
The main research way is 1) to overcome the precipitous geography, scarcity of image features, and hard access, which is practical that setting the image-control points and measuring the co-ordinates and height, then carrying on the flight in the west plateau mining area. 2) The explored zones lack of the highly precision image-control points, so it is provided that the technology of precise point positioning(PPP) and rapid static GPS to set on the co-ordinates.
The results indicate that 1) compared with the digital surveying and mapping (DSM), the remote sensing and mapping of UAV can not only greatly increase the measuring efficiency, but also save 1/3 measurement cost with the data collection from the outdoor to the indoor. 2) The image-control points are clearly marked and accurately measured, which makes 1:2000 topographic map accuracy to meet specification requirements.
The conclusion: the aero-photography and remote sensing technology of UAV has the obvious advantage in the west plateau mining area that can ensure the job security and improve the measure accuracy to meet regulatory requirement, besides of reducing the workload of field measurements and saving cost. It's worth promotion in the unmanned areas, desert area, and the zones with particular difficulties.

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## 1. THE INTRODUCTION

Basing on UAV Flying Platform, UAV aerial remote sensing system, which is stable and reliable with high intelligent and strong operational capacity of low altitude remote sensing system, can achieve route several functions: route planning, monitoring information, data compression, automatic transmission pre-processing image and so on by high-resolution camera system to obtain remote sensing images and using of air and ground control systems to capture images and access automatically. This project uses the Wiccan "Type II" fixed-wing aircraft with sensors Nikon D800 35mm fixed focus camera, UP30 drive apparatus for outside aerial photography, and use pix4dmapper, ImageSation SS, VirtuoZoNT and other softwares to proceed aerial images, create a figure of about 3 square kilometers of 1 : 2000 topographic maps.

## 2. THE CASES OF MEASUREMENT AREA

The mine is located in Subei County of Gansu Province at 3100-3400 meters above sea level, which is belong to the depopulated zone in mountain with harsh climatic conditions, full of valleys, steep terrain, difficult access, and without electricity power. It is scarce that the feature points and obvious topographical points in the mine. According to the needs of exploration and development, it is determined that the aerial photography area of 13.8 $km^2$, aerial surveying area of 3 $km^2$.

## 3. THE KEY TECHNOLOGY

### 3.1 Aero-photography by UAV

According to the digital low-altitude aerial photography regulatory requirements[1], to determine the ground resolution (GSD) is 0.14m, Air relatively high as 1000m, the absolute flying height 4100m, flying a total of two sorties, 24 routes, taking pictures 1975. According to the characteristics of large-scale flight Cece figure, combined with the terrain conditions subject area, and set the camera exposure route spacing intervals to ensure that there is sufficient overlap aerial degrees under aerial parameters in Table 1.

Tab.1 Aerophotography parameters

| Sortie | relative flying height /m | Forward overlap | Side overlap | Forward interval /m | Exposure interval /m | GSD/m | Number of photos |
|---|---|---|---|---|---|---|---|
| 1 | 1000 | 75 | 45 | 300 | 100 | 0.14 | 987 |
| 2 | 1000 | 75 | 45 | 300 | 100 | 0.14 | 988 |

Each aircraft are taken after completion of the export POS data and photo data points overlap and imaging quality inspection, inspection, heading degree of overlap between 70% to 75%, next to the degree of overlap in the 40% to 45% between, no aerial vulnerability photograph tilt angle is less than 3 °, flight quality standard requirements. Aerial image color uniformity clear, no clouds blocked, normal tone, contrast medium, to meet the set requirements.

### 3.2 Photo control survey

Field reconnaissance showed that the surveyed area steep terrain, topography and the influence of environmental factors, can not find clear terrain and land features like control point as a thorn points. Conventional first post-flight camera control point measurement methods in the survey area is not applicable, requiring laid landmarks like handles. Area near a national survey control point data damage can not be used, there is no mobile signal, the system continuously operating reference stations (CORS) technology can not be applied to the test area measuring control points. According to the actual situation of the project area were two aerial views, taken after the first use of aircraft sorties Pix4DMapper fast image stitching the DOM as a landmark control points laid the base map, according to the " Specifications for field work of low-altitude digital aerophotogrammetry "[2] in the course of three degree and into the next five or six degrees of overlapping ranges laid landmarks like handles, arrangement laying surface with a white cloth as a cross-shaped control points mark, cross the center of control points coordinates.
The surveyed area were set up 18 control points, such as control network layout is shown in Figure 1, the first use of Precise Point Positioning (PPP) precision measuring 5 control points as the heads of the control point, then use the cloth fast static GPS methods surveying and other control points coordinates. All control points laid measurement is completed, the second aerial sorties. South mapping using GNSS data processing software solver GPS network control points, accuracy specifications meet the technical requirements.

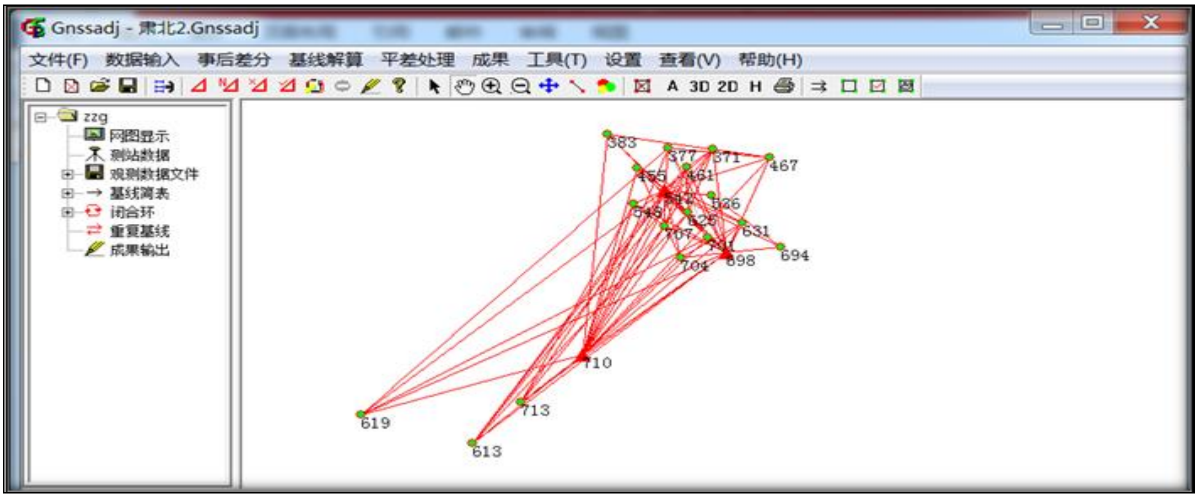


Fig.1: GPS net of image-control point

### 3.3 Aerial triangulation

Aerial triangulation, referred to as aerial triangulation, based on a small amount of field control point elevation and the plane position calculating the unknown point and measurement methods photograph of exterior orientation elements. The use of aerial triangulation can reduce the workload of field measurements, topographic mapping to provide directional control point. UAV equipped NikonD800 non-metric digital camera camera, untreated aerial image distortion difference is large, performing aerial triangulation ago, according to the appraisal report on the original flight camera imaging slices distortion aberration correction, then use ImageSation SSK ISAT software modules aerial triangulation. During operation, the first route network for automatic matching to build free adjustment, and then follow the control chip industry to provide the results of the control points, the control point measurement outside the industry, and finally the whole regional network adjustment. The root mean square error (RMSE) of the basic orientation points and the checking point show as in Table 2 and Table3, block adjustment results for " Specifications for aerotriangulation of digital aerophotogrammetry " [3]1:2000 mountains accuracy.

Tab.2 RMSE of the basic orientation points

| | Δx | Δy | Δxy | Δz |
|---|---|---|---|---|
| **383** | -0.016 | 0.026 | 0.031 | 0.063 |
| **455** | 0.015 | -0.093 | 0.094 | -0.067 |
| **704** | -0.076 | 0.005 | 0.076 | -0.103 |
| **530** | -0.085 | -0.024 | 0.088 | 0.097 |
| **536** | -0.129 | 0.043 | 0.136 | -0.015 |
| **625** | -0.115 | -0.049 | 0.125 | 0.077 |
| **548** | 0.161 | 0.005 | 0.161 | 0.006 |
| **694** | 0.132 | -0.076 | 0.152 | 0.085 |
| **707** | 0.054 | -0.049 | 0.073 | -0.161 |
| **461** | -0.156 | 0.124 | 0.199 | 0.029 |
| **701** | 0.003 | -0.208 | 0.208 | -0.071 |
| **377** | 0.15 | -0.038 | 0.155 | -0.175 |
| **631** | 0.014 | 0.071 | 0.072 | 0.227 |
| **698** | 0.152 | -0.205 | 0.255 | -0.063 |
| **467** | -0.216 | 0.154 | 0.265 | -0.054 |
| **542** | -0.059 | 0.196 | 0.205 | -0.179 |
| **449** | 0.172 | 0.117 | 0.208 | 0.304 |

Tab.3 RMSE of the checking points

| | Δx | Δy | Δxy | Δz |
|---|---|---|---|---|
| **461** | -0.156 | 0.124 | 0.199 | 0.029 |
| **701** | 0.003 | -0.208 | 0.208 | -0.071 |
| **698** | 0.152 | -0.205 | 0.255 | -0.063 |
| **467** | -0.216 | 0.154 | 0.265 | -0.054 |
| **449** | 0.172 | 0.117 | 0.208 | 0.304 |

### 3.4 Stereomapping

Stereo acquisition using VirtuoZoNT Full Digital Photogrammetry system is completed, the results of the use of aerial triangulation encrypted automatically as directional direct modeling, three-dimensional mapping. Before mapping, the checkpoint outside the industry, GPS data import stereoscopic acquisition interface Heights and inspection, as the region feature rare, steep terrain, it only checks the height accuracy. 2 times in the " Specifications for office operation of low-altitude digital aerophotogrammetry "[4] provisions error as the difference between the altitude error limit, the maximum elevation error is less than 2/3 of tolerance and meet regulatory requirements. Data should be collected to ensure data integrity, since the region landforms are basically natural topography, contour lines, elevation points based annotation, symbols, supplemented by geomorphological, said after the acquisition is complete data edit checks, the resulting topographic map ,as shown in figure 2.

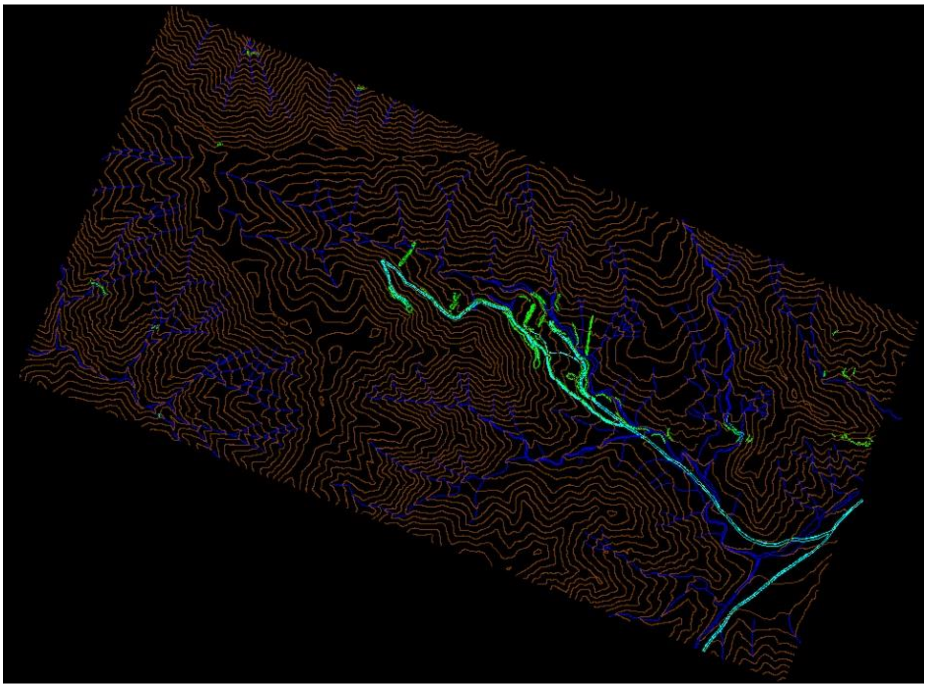

Fig.2 Topographic map

### 3.5 DEM and DOM

The collected data can be edited directly generate DTM interpolation delete unwanted data, and finally generate DEM. DOM making use Pix4Dmapper UAV data processing software to automatically generate orthophoto and mosaic and uniform color. Production of DOM image clarity, brightness, contrast, moderate, soft colors, image topography, surface features, topography no significant deformation, as shown in figure3.

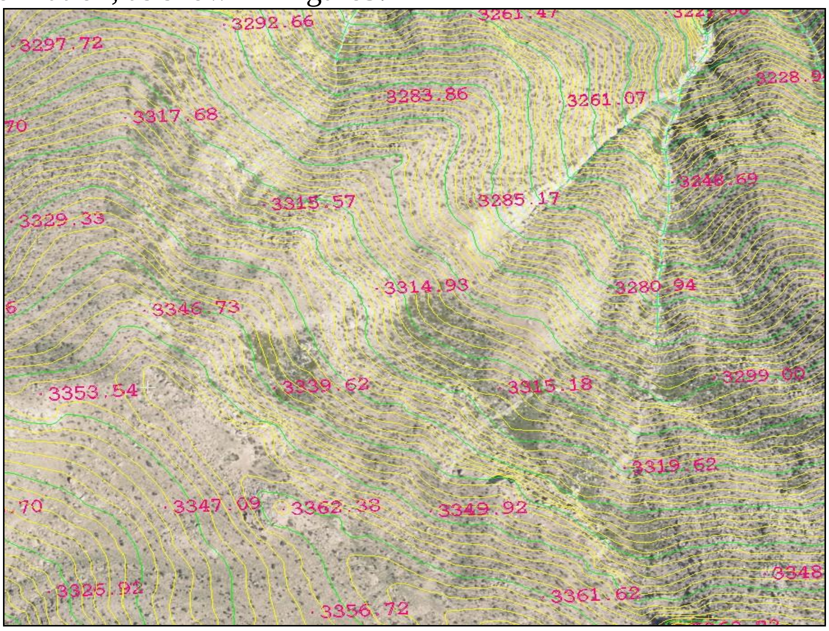


Fig.3 DOM and DLG nested effect map

## 4. COMPARED WITH THE DIGITAL SURVEYING AND MAPPING

(1) In this project study, aerial and field Photo Control measurement invested a total of 12 people completed within 3 days. Data processing within the industry invested 600 staff, completed within 7 days. Such as the use of traditional methods of digital terrestrial mapping Topographic Map of the mine due to the steep terrain, is located in no man's land, it is difficult to complete topographic map production work within 10 days. UAV aerial remote sensing is not only the job faster, but also a large number of field data collection work moved indoors to reduce the workload of the field, operating costs only about 1/3 of the conventional measure.
(2) conventional digital terrestrial mapping only provide DLG, UAV aerial remote sensing can not only provide DLG, but also provide DOM, DEM and other results, in combination with a variety of outcomes, expanding the scope of application of the outcome.
(3) substantially free of the survey area without vegetation cover, terrain, a lot of artificial hard to reach places, using the traditional method of digital terrestrial mapping, topographic features many points can not be collected resulting in uneven landscape feature points, thus affecting the mapping accuracy. UAV aerial remote sensing from topography, arranged in advance landmarks like ground control point, the control point high accuracy greatly improve mapping accuracy.

## 5. CONCLUSION

Research shows that the UAV aerial remote sensing quick access to the mining area in western Gansu mine has obvious advantages with regard diagram, greatly reducing the workload of field measurements, reduce costs, protect worker safety measure, aerial 1:2000 topographic map in the west high altitude mining to meet the accuracy requirements specification, can play a bigger role in the digital mine construction, it should be promoted in a particularly difficult area to work uninhabited desert area and the like. Aerial aircraft flying high to reach the absolute 4200m, on broadening at high altitude UAV applications with demonstration projects also have some significance.

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## BIOGRAPHICAL NOTES

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