CARTOGRAPHIC ACCURACY OF STEREO SPACE PHOTOGRAPHS TAKEN BY LARGE FORMAT CAMERA - A CASE STUDY IN JAPAN -

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ABSTRACT

A part of Japan Main Island was taken stereo space photographs by Large Format Camera on October, 8, 1984. In order to study the capability for cartographic application, aerial triangulation with bundle adjustment, contour mapping by three types of analytical plotters and comparisons with 1:25,000 topographic maps were done by the research project team under the cooperation of Geographic Survey Institute and six private survey companies. The author served himself as the chairman of this team.

The test mapping with respect to the change of Base-Height Ratio, that is, 0.3, 0.6, 0.9 and 1.2 corresponding to overlaps of 80, 60, 40 and 20% respectively, as well as digital elevation data were compared with those of existing topographic map. The result showed that the contour interval of 40 or 50 meters is available though 20 meters is not stable.

The cartographic accuracy was as follows:

Aerial Triangulation with Bundle Adjustment
- Planimetric 26.8 meters
- Height 24.0 meters
- Relative 9.5 meters

Local Aerial Triangulation by Analytical Plotter
- Relative orientation 3-7 micro meters
- Absolute orientation Planimetric 15-20 meters
- Height 10-15 meters

1. LFC Films

The following films were utilized in this study.

Film type: black and white #3412
Film No.: No. 0794, 0795, 0796, 0797, 0798
Date: October 8, 1984; 1:20 p.m.
Location: Central Japan, Izu Peninsula

Four sets of stereo pairs as shown in Table 1 were used for test.
Table 1  Stereo pairs of cut films (23x23cm) for test

<table>
<thead>
<tr>
<th>Left</th>
<th>Right</th>
<th>B/Hratio</th>
<th>overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center of No.0796</td>
<td>Center of No.0797</td>
<td>0.3</td>
<td>80%</td>
</tr>
<tr>
<td>Center of No.0795</td>
<td>Center of No.0797</td>
<td>0.6</td>
<td>60%</td>
</tr>
<tr>
<td>Right of No.0794</td>
<td>Center of No.0797</td>
<td>0.9</td>
<td>40%</td>
</tr>
<tr>
<td>Right of No.0794</td>
<td>Left of No.0798</td>
<td>1.2</td>
<td>20%</td>
</tr>
</tbody>
</table>

Figure 1 shows an enlarged LFC Photograph of the test site. (Kozu)
Figure 2 shows the corresponding topographic map of 1:25,000 (7.5km x 7.5km)

2. Aerial Triangulation

24 triangular points (X, Y and Z), 32 planimetric control points (X and Y), 13 level points (Z) and 38 pass points were selected both on the films and 1:25,000 topographic maps for aerial triangulation.

Effect of earth curvature was corrected into a local orthogonal coordinate system from UTM coordinate systems.

Although the self calibration was done, the accuracy was a little improved.

The accuracy is as follows.

Residuals on film
without self calibration: 27 μm (R.M.S.), 35 μm (max.)
with self calibration: 25 μm (R.M.S.), 31 μm (max.)

Absolute errors of control points
without self calibration:
  planimetric 29.5m (R.M.K.), 77.9m (max.)
  height 30.9m (R.M.K.), 71.5m (max.)
with self calibration:
  planimetric 26.8m (R.M.K.), 66.1m (max.)
  height 24.0m (R.M.K.), 65.1m (max.)

Relative errors
without self calibration: 11.3m
with self calibration: 9.5m
3. Contours

Zeroing

The Relativistic Absolute

Figure 1 LFC photograph at a test site

Figure 2 Topographic Map (1:25,000)
3. Contour Mapping by Analytical Plotters

Zeiss C-100, Wild Aviolit BC-1 and Kern DSR-1 were utilized for local orientation and mapping.

The accuracy of local orientation is as follows:
Relative orientation : 3-7 wmm (R.M.S.)
Absolute orientation :
  planimetric : 15-20 m (R.M.K.)
  height : 10-15 m (R.M.K.)

Mapping tests were done for the following items with respect to the four B/H ratios.

1) Contour interval
   In order to challenge the utmost capability, contour interval was taken 20 m at 1:25,000 scale.
2) Coast lines
3) Roads and railways
4) Vegetation boundaries
5) Any other remarkable feature

Figure 3 shows a plotted map which was produced from a stereo pair with B/H ratio of 0.6 by using Zeiss C-100.

The operator reported the followings.

1) It was rather difficult to draw the contour lines at an interval of 20 m. However, to draw 40 m or 50 m interval would be certainly possible.
2) Stereoscopic visibility was not much for 0.3 B/H ratio while it was very large for more than 0.6 B/H ratio.
3) Wide national roads and the bullet train (Shinkansen) railway were clearly visible, while narrow roads were partially invisible.
4) The area of forest was recognized as a group of black tone. The boundary could be discriminated.
5) Only big buildings were recognized while dense urban area with small houses was not discriminated.
6) Bare soils and exposed rocks were recognized because of high contrast.
7) Plotting scale could be taken up to 20 times at maximum.

4. Cartographic Accuracy

Contour lines at elevations of 100m and 200m from 1:25,000 topographic map were compared with those from LFC photographs.

Figure 4 shows contour lines of 100m and 200m in thick solid line as well as 80m, 120m, 180m and 220m in thin solid line of 1:25,000 topographic map. Those contour lines of 100m and 200m which were plotted by analytical plotter from LFC photographs are shown in dotted lines. In this figure, dotted lines are fluctuating in the range of ±20m in height.
Figure 3  Contour map produced from LFC photographs (0.9 B/H ratio or 60% overlap)

Figure 4  Comparisons of contour lines of 100m and 200m with 1:25,000 topographic map (solid line; 1:25,000 ; dotted line: LFC)
In order to evaluate the height accuracy quantitatively, 30 grid points at 100m interval were taken along a certain section both from 1:25,000 topographic map and LFC photographs.

Mean errors and maximum errors are shown in Table 2.

<table>
<thead>
<tr>
<th>Overlap</th>
<th>B/H ratio</th>
<th>Mean Error</th>
<th>Maximum Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>0.3</td>
<td>21.7 m</td>
<td>45.0 m</td>
</tr>
<tr>
<td>60</td>
<td>0.6</td>
<td>15.7 m</td>
<td>44.0 m</td>
</tr>
<tr>
<td>40</td>
<td>0.9</td>
<td>13.9 m</td>
<td>29.8 m</td>
</tr>
<tr>
<td>20</td>
<td>1.2</td>
<td>14.1 m</td>
<td>30.7 m</td>
</tr>
</tbody>
</table>

From this table, the best accuracy was for the case of 40\% overlap or 0.9 B/H ratio.

5. Conclusion

1) The contour lines were drawn in the range of ± 20m. The height accuracy was 13-15m in average for more than 0.6 B/H ratio. Therefore, the interval of contour line can be chosen 40m or 50m.
2) From the above result, the map scale should be smaller than 1:50,000 or 1:100,000.
3) As LFC photograph covers very large area, the map revision would be very useful.

Acknowledgement

I express my heartfelt thanks to Dr. Frederick J. Doyle for his kind arrangement in obtaining LFC photographs.

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