Mapping of Bulgaria with A3 EDGE

Yuri Raizman, Angel Angelov

ABSTRACT

A3 Edge, the newest model in the A3 family, provides better image quality, greater efficiency, and higher GSD than other A3 models. The A3 Edge camera provides a complete solution together with the A3 LightSpeed Processing system. The latter automatically performs aerial triangulation and produces orthophotos, stereo pairs and DSM from all A3 cameras. As VisionMap customers take on larger and larger projects, A3 LightSpeed has to deal with an incredibly large amount of imagery. It does so successfully, with the complete A3 Digital Mapping System meeting all industry standards. In 2012, the A3 Digital Mapping System received the IFPs stamp of approval, as noted in IFP’s report, “VisionMap’s A3 System obtained very satisfactory empirical accuracy results from this Vaihingen/Enz test.”

The next step for LightSpeed will be introducing 3D modeling capabilities. In the last couple of years, the use of aerial photogrammetry techniques to generate 3D models has become a popular trend in the geospatial industry. VisionMap’s A3 family is ideal for such 3D applications, as it combines high resolution with a wide field of view. This paper will review the applicability of data captured by A3 Edge for nationwide coverage orthophoto generation, mapping and 3D modeling.

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1. Introduction

VisionMap is one of the world leaders in aerial survey equipment and software development for photogrammetry and mapping. The company has developed and successfully implemented the new innovative aerial survey and mapping system A3. The A3 aerial systems with LightSpeed ground processing system are used worldwide. Over the last four years, more than thirty A3 systems have been delivered to customers.

In mid-2013, production of the newest camera model, A3 Edge, began. A3 Edge provides better image quality and higher aerial survey productivity.

In addition to the new camera model, in collaboration with the German company SOMAG, the new gyro stabilized mount SOMAG VSM 500 was developed. The mount serves to further improve image quality and aerial survey productivity.

VisionMap is constantly working on the improvement of existing software and on new developments. Two new versions of the main LightSpeed and related programs were released in 2013. Additionally, two new programs were developed. FlightViewer is designed for quick viewing of images during or immediately after the flight without pretreatment, and TopoFlight is designed for more efficient and accurate planning of aerial survey flights.
2. **A3 Edge – A New Model from VisionMap.**

The new camera model, A3 Edge, is briefly characterized by the following parameters:

- Ground resolution of 5 cm can be obtained from a height of 2,000 meters, and from a height of 10,000 m the ground resolution is 25 cm,
- Geodetic accuracy of the final products without control points and without GPS ground stations varies between 20 - 50 cm depending on ground resolution,
- Aerial survey productivity – up to 11,000 sq.km per hour, depending on the altitude and the ground speed of the aircraft,
- Ground processing productivity - up to 9,000 sq. km orthophoto per day depending on the ground resolution of the images,
- Automatic aerial survey and ground processing,
- Virtually no need for field geodetic work.

The following table summarizes the main technical characteristics of the A3 and A3 Edge cameras.

<table>
<thead>
<tr>
<th>Camera model</th>
<th>A3</th>
<th>A3 Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>38</td>
<td>42</td>
</tr>
<tr>
<td>Size (cm)</td>
<td>50<em>60</em>60</td>
<td>50<em>60</em>60</td>
</tr>
<tr>
<td>Focal length (mm)</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>Color</td>
<td>RGB or RGB+NIR</td>
<td>RGB and RGB+NIR</td>
</tr>
<tr>
<td>Color depth (bit)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Image motion compensation</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Max FOV (°)</td>
<td>106</td>
<td>108</td>
</tr>
<tr>
<td>Vertical images</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Oblique images</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pixel size (µ)</td>
<td>9.0</td>
<td>7.4</td>
</tr>
<tr>
<td>CCD size (pixel)</td>
<td>4006 x 2666</td>
<td>4864 x 3232</td>
</tr>
<tr>
<td>Image size (pixel)</td>
<td>62000 x 7900</td>
<td>78000 x 9600</td>
</tr>
<tr>
<td>Image volume (Mbps)</td>
<td>480</td>
<td>718</td>
</tr>
<tr>
<td>On-board storage capacity (hour)</td>
<td>7 – 8</td>
<td>6 – 7</td>
</tr>
<tr>
<td>Operating temperature (°C)</td>
<td>-15° - +55°</td>
<td>-15° - +55°</td>
</tr>
</tbody>
</table>

The main differences and advantages of the A3 Edge camera relative to the A3 model can be expressed as follows:

- A new generation of CCD provides superior image quality,
- Only a CCD built-in electronic shutter is used,
- The high resolution CCD may improve ground resolution from a given flight altitude or improve the image quality,
- The maximum off-nadir angle for high ground resolution (3-5 cm) and sufficiently high ground speed is increased up to 54 degrees,
- Improved image stabilization during rotation of the telescopes improves image quality.

The following are examples of high quality images in different spectral bands. The first is a common color image (RGB), the second is an infrared image (NIR, in gray colors) and the third is a color infrared imagery (CIR). The first two pictures are images of the same part of the Earth’s surface and received simultaneously by two telescopes of the A3 system in different parts of the spectrum. The third image is a composite of the first two.
Example 1 - RGB image.

Example 2 – NIR image.
The above images were obtained by the A3 Edge camera from a flight altitude of 2,225 m with a ground resolution of 5.5 cm.

3. **A3 Edge – The Highest Aerial Survey Productivity.**

All cameras in the A3 family mapping systems are characterized by very high aerial survey productivity.

The following table presents the parameters and the productivity of aerial survey for A3 EDGE camera and aircraft King Air B350.

<table>
<thead>
<tr>
<th></th>
<th>RGB</th>
<th>RGB+NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthophoto ground resolution (cm)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Image GSD (cm)</td>
<td>4.17</td>
<td>8.33</td>
</tr>
<tr>
<td>Altitude (m)</td>
<td>1,700</td>
<td>3,300</td>
</tr>
<tr>
<td>Ground speed (km/hour)</td>
<td>300</td>
<td>370</td>
</tr>
<tr>
<td>Permissible orthophoto angle 2α (deg)</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>Distance between flight liens (m)</td>
<td>700</td>
<td>2,600</td>
</tr>
<tr>
<td>Aerial survey productivity (sq.km/hour)</td>
<td>210</td>
<td>985</td>
</tr>
</tbody>
</table>

These parameters are calculated for KingAir B350 with acceptable flight altitude of 9,000 m and a cruising speed of 536 km/hour. Increasing the altitude and the speed, will also increase the aerial survey productivity.

For GSD = 15-25 cm the permissible orthophoto angle of 65° was used for the aerial survey productivity calculations. It should be noted that such angle corresponds to 20% of the side overlap for standard analog cameras like RC30 with a focal length of 150 mm. Also, for the calculations, the forward overlap of 55% and the side overlap more than 55% were used. This aerial survey productivity was calculated for the A3 Edge camera with gyro stabilized mount.
The wide field of view angle of the camera and, subsequently, its impact on the aerial survey coverage on the ground, can be represented as follows:

![Illustration showing field of view angles of different cameras](image)

The illustration above shows that at the maximum opening of the field of view angle, the aerial survey productivity of the A3 Edge is several times greater than that of all other aerial survey cameras.

4. **An Example: Mapping Bulgaria with A3 Edge.**

Suppose that our goal is to create color orthophoto coverage with ground resolution of 25 cm over the entire territory of Bulgaria. At our disposal is one A3 Edge camera with the LightSpeed ground processing system, and an aircraft that can fly at an altitude of 9,000 m with ground speed of 370 km/hour.

The following picture presents a real flight plan for the implementation of such a project. This project is designed using the flight planning program TopoFlight, and with the following parameters:

- Flight altitude - 8,800 m,
- Ground speed - 370 km/h,
- Total area of the orthophoto - 112,500 sq.km, which corresponds to the entire area of Bulgaria,
- GSD - 21 cm.
After the flight planning calculations, the following results were obtained: To cover the whole territory of Bulgaria by aerial survey using the A3 Edge camera, 44 flight lines and 33 hours of flight time are needed. Assuming the duration of 5 hours for a flight day, only 6-7 flight days will be needed to cover the entire territory of Bulgaria.

The LightSpeed ground processing system is used for automatic image processing. The system automatically performs the following processes: aerial triangulation and adjustment, DSM (digital surface model) creation and orthophoto production.

The system provides very high processing productivity. For example, processing all the images resulting from this aerial survey flight and producing the final products in the form of color orthophoto with a resolution of 25 cm for the entire country will require a total of 18 days of automatic system operation. This result suggests a ready DEM (digital elevation model). If the DTM's creation is also necessary, the automatic operation of the system will increase by 30%, to 27 days.

5. Conclusion

The introduced system includes the A3 Edge digital mapping aerial camera and LightSpeed ground processing system. The main advantages of the system are:

- The highest aerial survey productivity, expressed in tens thousands of square kilometers of aerial survey a day,
- The highest ground processing productivity, expressed in thousands of square kilometers orthophoto a day,
- High automation of all processes,
- The ability to obtain vertical and oblique images by a single camera in one flight,
- Light weight and small dimensions of the camera allow its use on virtually any type of aircraft,
- High ground sample distance from high flight altitude,
- A variety of shooting techniques makes this system universal and indispensable for mapping of large areas, and for building 3D models of cities.