VisionMap A3 Edge – A Single Camera for Multiple Solutions

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ABSTRACT

While other solutions in the market require multiple camera systems for various applications, VisionMap's A3 Edge is a unique Digital Mapping System that can function both as a large format and an oblique camera. Compared to other commercial oblique cameras, A3 Edge is twice as productive in oblique projects and four times as productive in orthophoto projects. The complementary A3 LightSpeed processing system automatically produces highly accurate photogrammetric products at record-breaking time.

VisionMap's highly productive A3 Edge System simplifies the complex task of performing oblique projects. The system provides an automatic, end-to-end solution for capturing and processing vertical and oblique imagery – completing entire projects in less than half the time compared to other oblique cameras.

1. INTRODUCTION TO VISIONMAP

VisionMap is a leading provider of digital automatic aerial survey and mapping systems. Its flagship A3 Edge Digital Mapping System, comprised of the A3 Edge camera and LightSpeed automatic processing system, is known for its ability to capture and process areas much larger than other available systems in significantly less time, while reducing operational costs.
The system supports extremely large-scale projects and automatically produces Aerial Triangulations, DSM and Orthophoto mosaic as well as Stereo Models and Geo-referenced Oblique images. VisionMap systems are successfully deployed around the world.

2. A3 EDGE

2.1. A Single Camera replacing both Large Format and Oblique Cameras

A3 Edge is the only camera that provides an ideal solution for efficient wide-area mapping and for oblique imagery and 3D modeling. While other camera manufacturers have a portfolio which includes both a large format camera and a separate oblique camera, A3 Edge is a single product fulfilling both needs.

Figure 1: A3 Edge.

Compared to **large format** cameras in the market, A3 Edge provides the best capture efficiency; it is two to four times as productive in orthophoto projects. See below some coverage figures for different flight scenarios:

Ortho GSD (cm)	5	10	15	20	25	30
Altitude above ground (ft)	5,542	11,084	16,626	22,168	27,709	33,251
Ground Speed (knot)	160	250	330	410	440	480
Orthophoto angle (deg)	25	35	40	45	55	65
Distance between Flight Lines (m)	674	1,917	3,320	5,038	7,914	11,622
Footprint Width (m)	1,658	4,558	8,195	12,167	19,704	28,563
Aerial Survey Productivity (ortho coverage, sq.km/hour)	200	888	2,029	3,825	6,449	10,332

Forward overlap – 55%, Side overlap – above 60%

Compared to other commercial **oblique** cameras, A3 Edge is twice as productive in oblique projects when it flies a crisscross pattern. For cities with aviation traffic restrictions, A3 Edge is the only camera to provide the high resolution needed for oblique imaging from high altitudes.

In addition, A3 Edge is a flexible system suitable for various applications, flight altitudes, weather conditions and forms of the Earth relief. For example, in order to acquire 15 cm GSD imagery, the user can choose to fly at an altitude anywhere between 5,500 to 16,620 feet, maintaining a field of view of at least 71° at all altitudes (depending on the ground speed at a given flight altitude). Thus, the user may fly low when constrained by weather, or very high when possible, providing incredible productivity.

For example, at 16,620 feet, for GSD=15 cm, A3 Edge can fly at a ground speed of 330 knots with an orthophoto angle of 40°, yielding 2,029 square kilometers of imagery for orthophoto per hour of flying. Thus, A3 Edge can efficiently acquire high resolution imagery in variable atmospheric conditions, aviation constraints and relief of the Earth.

2.2. A3 Edge Technology Overview

Like all camera's in the A3 family, VisionMap's A3 Edge provides high resolution and a wide field of view at various altitudes. A3 Edge takes the A3 advantages to a higher level – with better image quality and even higher capture efficiency.

Figure 2: A3 view from below the aircraft.

A3 is a family of digital aerial cameras and photogrammetric processing systems. The camera is based on a unique technology of two "sweeping" telescopes, each with 300 mm focal length. The telescopes capture single frames while sweeping perpendicular to the flight direction. By doing so, they generate a wide field of view while maintaining a high ground resolution due to the long focal length.

Each telescope consists of a folded lens, which includes an innovative, patented motion compensation mechanism. The motion compensation mechanism moves the secondary mirror in the folded lens telescope in order to compensate for forward motion, for the sweeping (roll) motion and for vibrations (FMC+RMC+VC).

Each telescope has a 300 mm focal length, providing a very high GSD at even high altitudes. Although each frame has a narrow field of view, the sweeping mechanism, which can capture up to 60 single frames in a sweep (amounting to a maximum of 695 megapixels per sweep) generates a very wide field of view of up to 106°.

Another benefit of the sweeping mechanism is that both nadir and oblique images are captured simultaneously, in a single flight, using a single camera – providing ideal data for 3D products.

See the illustration below:

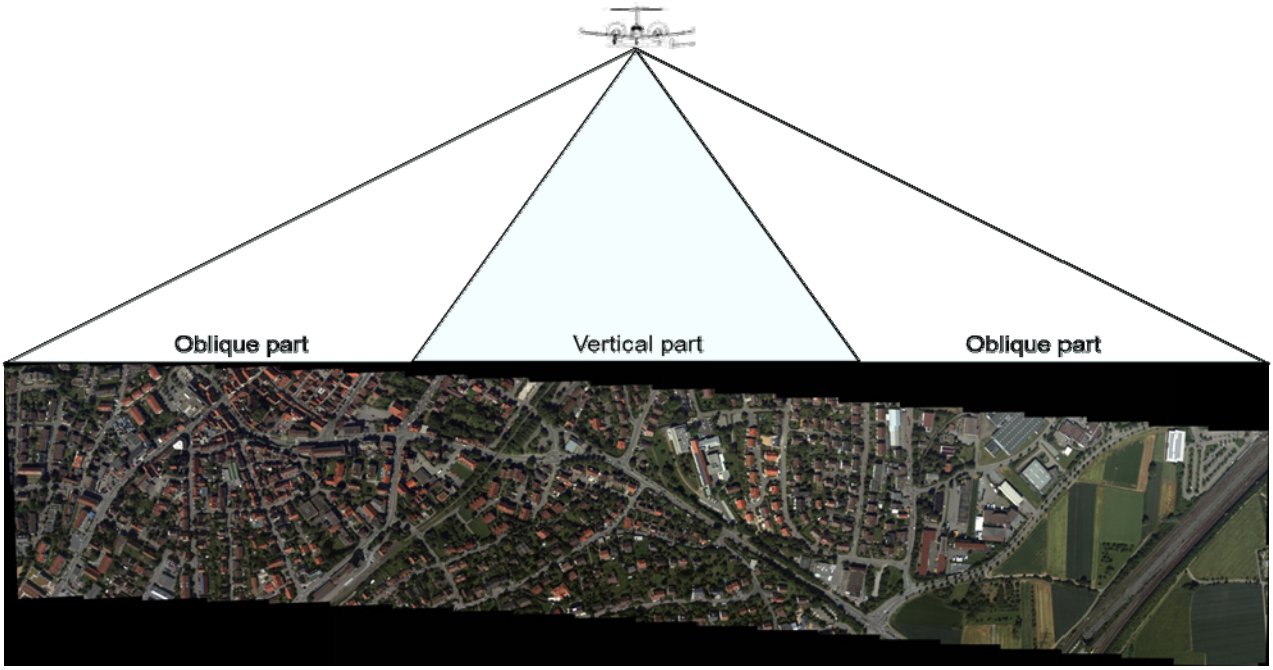

Figure 3: A3 SLF – Super Large Frame.

Angles for vertical and oblique parts of the image are defined at the flight planning stage, and they are dependent on the final mapping products requirements such as orthophoto angle, building leaning, maximal and minimal oblique angles.

A3 Edge specification summary:

Sensor technical data	
Sensor CCD	KODAK KAI-160
Pixel size (micron)	7.4
Focal length (mm)	300
Frame rate (FPS)	8
Single frame size (pix)	4,864 * 3,232
Max footprint (pix)	78,000 * 9,600
Cross track FOV (deg)	106
Along track FOV (deg)	13.5
Color	RGB or RGB+NIR
CCD dynamic range (bit)	12
Motion compensation	Forward, Roll, Vibration (FMC,RMC,VC)

Flight operational data	
Total weight (Kg)	42
Camera dimensions (cm)	50*60*60
Operating temperatures (deg, C)	-15 to 55
GPS	L1/L2
Power Consumption	26-32
Peak Current	Typical: 5, Peak: 10

Table 1: A3 Edge specification summary.

3. HIGH QUALITY OBLIQUE AND 3D PRODUCTS

3.1. Uses of Oblique Imagery

Captured from multiple directions and angles, oblique images can provide accurate information about a structure's dimensions, its height, the size of its windows and balconies, and much more. Oblique imagery and measurements have numerous applications and can be used for municipalities, insurance and real estate, emergency planning and response, law enforcement, utility management and others.

The growing demand for oblique imagery can be attributed to its useful applications in a wide variety of fields, and most recently, to an increasing interest in 3D modeling. Consumers have come to expect access to accurate 3D models of cities around the world.

3.2. A3 Edge for Oblique Imagery and 3D

VisionMap's highly productive A3 Edge system simplifies the complex task of performing oblique projects. The system provides an automatic, end-to-end solution for capturing and processing oblique imagery – completing projects in less than half the time.

Thanks to its unique image capture mechanism, A3 Edge provides vast imagery from various angles, whereas other oblique cameras provide only a fixed angle of 35 or 45 degrees off-nadir. This huge amount of imagery from different angles provide different views of each point, multiple overlaps and multiple tie points - ensuring high quality and high accuracy oblique imagery and 3D models while eliminating typical problems such as occlusions and shadows.

VisionMap's A3 LightSpeed processing system automatically performs aerial triangulation, and produces orhtophotos, stereo pairs and DSM from all VisionMap cameras.
A3 LightSpeed performs bundle adjustment of vertical and oblique images simultaneously, yielding sub-pixel accuracy for vertical and oblique images. This is crucial for high quality oblique imaging and 3D modeling. Comparatively, other oblique cameras use only the nadir images in the bundle adjustment, obtaining much lower accuracy for the obliques. LightSpeed processes thousands of km^2 of vertical and oblique imagery per day.

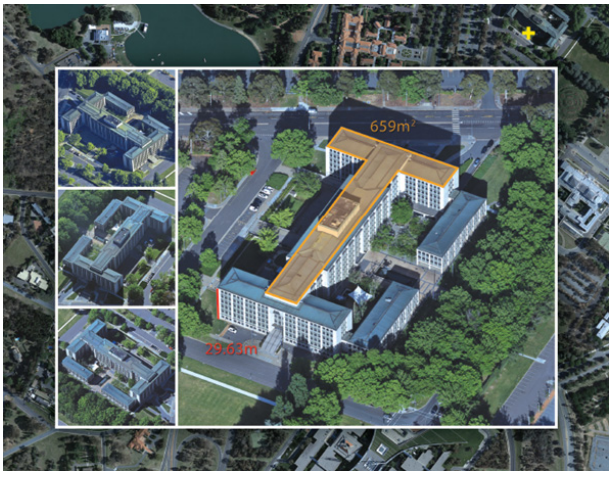

Figure 4: Oblique Measurements.

A3 Edge is also ideal for 3D modeling. The system has been integrated with 3rd party software that enable automated 3D model generation, quickly and in high quality. VisionMap is working on further optimization of 3D modeling with its partners and R&D team.

Figure 5: Jerusalem in 3D with A3 Edge.

3.3. Processing Automation

A3 LightSpeed produces final photogrammetric products of the highest quality, nearly eliminating the need for manual processing. Compared to other oblique processing software, A3 LightSpeed cuts manual processing time by 50-75%.

Recently the A3 Edge Digital Mapping Camera and another oblique camera both surveyed an area of 1400 km^2 in Georgia, US. A3 Edge completed the survey in 3.5 hours at 16 cm GSD, collecting vertical and oblique imagery of the entire area, while the other camera took 7.1 hours to cover the area at 25 cm GSD.
VisionMap's A3 LightSpeed automatically processed the imagery and generated a 16 cm orthophoto in 26 machine hours. The other camera's imagery required 50 hours of machine processing by third party software to generate the 25 cm orthophoto. The huge difference was in the amount of manual work – data from the other camera required an additional 100 hours of manual processing, whereas the A3 Edge data from LightSpeed required less than 10 hours.

4. MAPPING OF SAINT PETERSBURG WITH A3 EDGE

4.1. Aerial Survey with A3 Edge

In 2014 A3 Edge was used for mapping of St. Petersburg by "Baltaeroservice" company.

The urban project presented several challenges: minimal flight altitude restrictions, the need to use vertical and oblique images for orthophoto and 3D city model creation, and year-round scarcity of good flying weather in this part of the world. This project required a system that would be able to fly at high altitudes while meeting large scale mapping resolution and accuracy requirements, and being able to capture the area quickly and efficiently.

Due to its long focal length, A3 Edge can be flown at high altitudes while providing very high ground resolution and aerial survey productivity. Furthermore, the camera's simultaneous collection of vertical and oblique imagery makes it ideal for 3D city modeling.

The purpose of the project was to provide an orthophoto of the entire city, and prepare vertical and oblique accurately oriented images for the visual investigation of the area and for further 3D City modeling. During the course of the project, RGB vertical and oblique images of the city were captured, spanning a total area of 2007 sq.km.

Figure 6: Peter and Paul Fortress, Saint-Petersburg, A3 Edge vertical and oblique images.

The aerial survey flight was executed at an average altitude of 13,300 feet, providing a ground sample distance (GSD) of 10 cm. The ground speed of the aircraft (Cessna 210) was about 140 – 150 knots. The city was covered by means of crisscross flight lines, providing further capability for 3D city modeling. The flight was executed with the following aerial survey parameters:

Forward overlap – 60%
Side overlap – 80%
Side oblique overlap – 30%
Distance between flight lines – 1,500 m
Maximal oblique angle – 55°

The aerial survey flight took 11 hours and the total flight time was 14 hours. During the flight, 450,000 vertical and oblique images were captured.

4.2. Processing with LightSpeed

The A3 LightSpeed photogrammetric software enables automatic aerial triangulation (AT), DSM creation and orthophoto production. In this project, a previously created DTM was used for the orthophoto creation.

In the first stage, all images, vertical and oblique, were simultaneously adjusted in AT receiving highly accurate orientation parameters. In the second stage, only the vertical images were used for the orthophoto creation.

The total processing, AT and orthophoto, was done automatically over 15 days. All of the mapping products met the accuracy requirements of a 1:2,000 mapping scale.

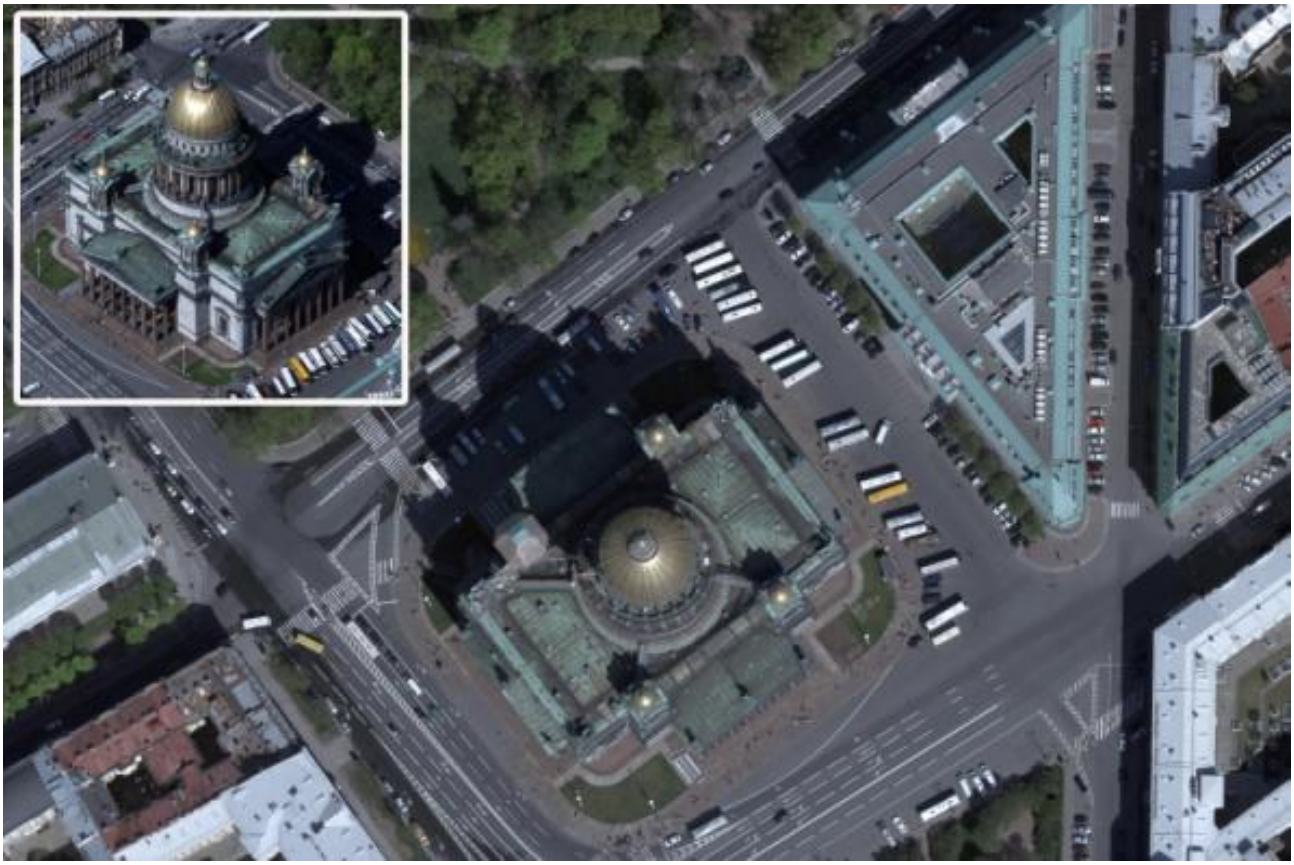

Figure 7: Saint Isaac's Cathedral, Saint Petersburg, A3 Edge vertical and oblique images.

For comparison, in 2011 the same company was contracted to survey the exact same urban area. The camera used at the time was PhaseOne, and processing was performed by Talca 4.0 photogrammetric software. It took five operators six months to do the job. This time, with A3 Edge, the entire project took only 15 days with one operator.

As a result of the aerial survey and processing, accurately oriented vertical and oblique RGB images, and orthophoto from the vertical images were obtained. All of the images will be used for the creation of a 3D model of St. Petersburg.

5. CONCLUSIONS

VisionMap's technology has always shown spectacular performance in terms of area coverage efficiency, and high resolution capture and processing. While other solutions in the market require multiple camera systems for various applications, the A3 Edge Digital Mapping System provides a unique solution that can function as both a large format and an oblique camera. Compared to other commercial oblique cameras, A3 Edge is twice as productive in oblique projects and four times as productive in orthophoto projects. The A3 LightSpeed automatically produces highly accurate photogrammetric products at a record breaking time.

6. REFERENCES

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