Processing Multi-spectral Imagery with Agisoft MetaShape Pro

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Preface

This series of manuals are intended to facilitate the safe use and teaching of Remotely Piloted Aerial Systems (RPAS, aka drones) to a wide variety of programs and teaching areas at BCIT. The ubiquitous and positively disruptive nature of RPAS make them an excellent additional tool for the collection of spatially accurate data including photos and videos in a variety of applications. From Geomatics to Forestry and from Marketing to Forensics, RPAS are quickly becoming indispensable due to their rapid deployment capability, ability to provide a unique perspective in difficult to reach areas and safely gather a rich data set in a short amount of time.

The demand for data captured by RPAS is increasing at BCIT, across the province and in fact, around the globe. These manuals aim to rapidly and effectively transfer knowledge to those who are interested in leveraging this technology in their specific fields of interest and expertise. The manuals are divided into two main categories; **Image Acquisition** and **Image Processing**. The **Image Acquisition** manuals are vehicle- and sensor-specific with the goal of being able to pick a specific unmanned aerial vehicle and sensor combination and fly a pre-programmed, semi-autonomous mission in order to gather a specific set of images or videos. The **Image Processing** manuals can be used as standalone or as a follow-on from the Image Acquisition manuals. These focus on the most effective photogrammetric processing techniques in Agisoft Photoscan (and/or MetaShape) Professional, given the specific data set and image type. Each of the Image Processing manuals is accompanied by a sample data set that provides a complete walk-through of the processing steps or they can be used to generate a variety of different 3-D mapping products using a user-supplied images.

Overview

This manual guides you through the steps of processing multi-spectral images using Agisoft MetaShape Professional acquired by a MicaSense RedEdge M sensor to create map products including;

- sparse and dense point cloud
- 3-D mesh surface and textures
- digital surface model (DSM)
- true orthophoto mosaic
- 2-D & 3-D Google Earth layers

The following manual Parts provide guidance for each step of the process;

- Project Setup
- Ground Control Points
- Generating 3-D Model
- Creating a DEM and Orthophoto
- Exporting Data

This manual includes a sample data set of multi-spectral imagery and ground control points which can be used to in conjunction with the steps described here.

PART 1 - PROJECT SETUP

Overview

The main goal of this Part, is to prepare the included images (or any user-captured images) for photogrammetric processing in Agisoft MetaShape Professional (MetaShape). The general topics included are;

- Geoids & Python Scripts
- MetaShape Project Setup
- Import Photos
- Assess Image Quality
- Adjust Altitude & Coordinate System
- Align Photos

Although this manual is written specifically for the included set of photos, with some minor adjustments, the steps can be applied to any other set of GPS-tagged, overlapping air photos acquired by an RPAS.

Overview

The steps necessary to add a **local geoid** and custom **Python scripts** to MetaShape are described below.

Geoids

In order to improve the horizontal and vertical accuracy of maps and 3-D models generated in Photoscan, it is sometimes necessary to apply a local geoid. Any geoids in the correct data format can be used or they can be downloaded from Agisoft here.

   Once downloaded, they *must* be copied to the Agisoft **geoids** directory (e.g. C:\Program Files\Agisoft\MetaShape Pro\geoids) prior to launching the software. If MetaShape is running, after the geoid is copied, it must be restarted.

Python Scripts

Python scripts are used to perform multiple sequential operations using a single command. They serve as shortcuts or give access to other functions of the software and data. The MetaShape Python script repository can be found here.

   Click here to download a script used to adjust the altitude of input photos. This updates the altitude from heights relative to the WGS 84 ellipsoid to heights relative to the ground which are much more useful and relevant.

   Any downloaded scripts *must* be copied into the MetaShape

Scripts folder (e.g. C:\Program Files\Agisoft\MetaShape Pro\python\Scripts).

Chapter 1.2 - Setting Up Images

Overview

In this chapter, the aim is to ensure that the images captured by the RPAS are ready for processing in MetaShape. A MetaShape project will be created into which the supplied RPAS images will be imported and then aligned to generate a spare point cloud with tie points.

MetaShape Project Setup

Download the RPAS images here. Create a folder called **Multi-spectral** in the **Documents** folder on your workstation. Open the **Multi-spectral** folder, create a sub-folder called **Images** and unzip the downloaded images into this sub-folder. You will have to remember the location of the **Images** folder. Ensure that all 4,465 images are present and note that each numbered image has a suffix (e.g. IMG_0131**_1**.tif). The suffix (_x, where x = 1 through 5) indicates the multi-spectral band of each photo.

Spectral Band Number	Spectral Band Characteristics
1	Blue (465 to 485 nm)
2	Green (550 to 570 nm)
3	Red (663 to 673 nm)
4	Near Infrared (820 to 860 nm)
5	Red Edge (712 to 722 nm)

The full manual for the MicaSense RedEdge M multi-spectral sensors is available [here](#).

From the **Start** menu, find and launch **Agisoft MetaShape Professional**.

Import Photos

Each of the five multi-spectral bands will need to processed separately in their own chunk. Ensure that your're in the **Workspace** tab (Fig. 1 bottom left of screen), select **Add Chunk** (Fig. 1) and rename the chunk to **Blue**.
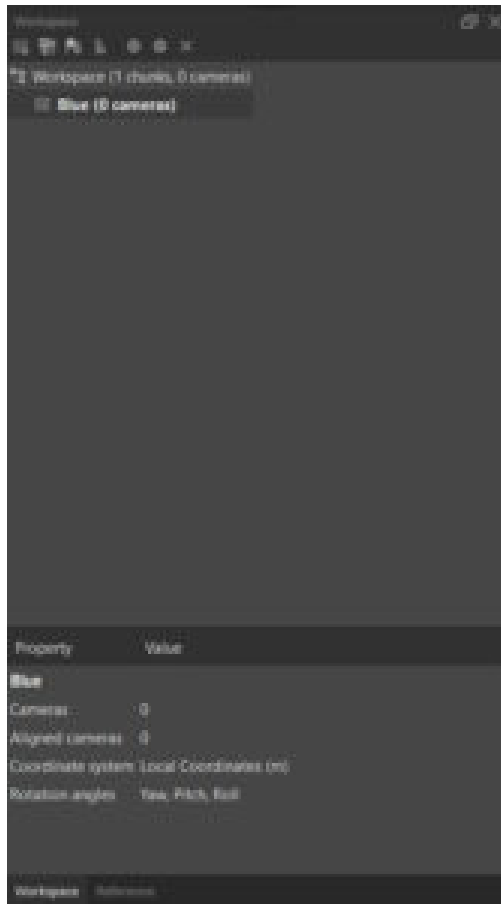
Fig. 1 MetaShape Workspace with chunk (Blue) added.

From the **Workflow** menu, select **Add Photos**, navigate to the **Images** sub-folder and in the **Search Images** box enter ***_1** to find only the blue spectral band images. Select all images and click **Open**. From the **Add Photos** dialogue box, select **Single Cameras** and click **OK**. Your should now see a view similar to Fig. 2 although you may need to select **Show Cameras** first.
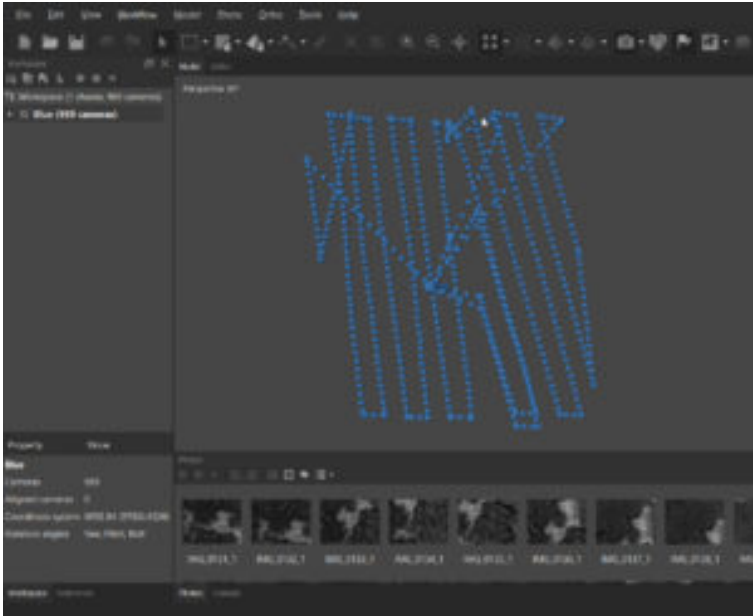
*Fig. 2 Camera centers of each image for the blue spectral band.*

Select the **Reference** tab (bottom left of screen), to view all of the photos along with their longitude, latitude, altitude and estimated accuracy. Each photo thumbnail is also visible in the bottom **Photos** pane and a full resolution image can be opened by double-clicking the thumbnail.

In the main **Model** window, all of the image centers (principal point) are shown lined up according to how the RPAS flew the pre-programmed image acquisition mission (Fig. 2). The ball in the center of the **Model** window is used to rotate and spin the model in the X, Y and Z axes using the left mouse button. The right mouse button moves the model around while zooming in/out is done using the scroll-wheel on a mouse or by sliding two fingers on a touch pad.

Spin the model 90 deg from a top-down map view to a profile view as per Fig. 3. Notice that in addition to all the photos taken

while the RPAS was at the operating altitude (approximately 68 to 93m), there is also a "column" of points extending down to the ground. These represent the photos that were taken while the RPAS was taking off and landing and need to be removed prior to any further processing.
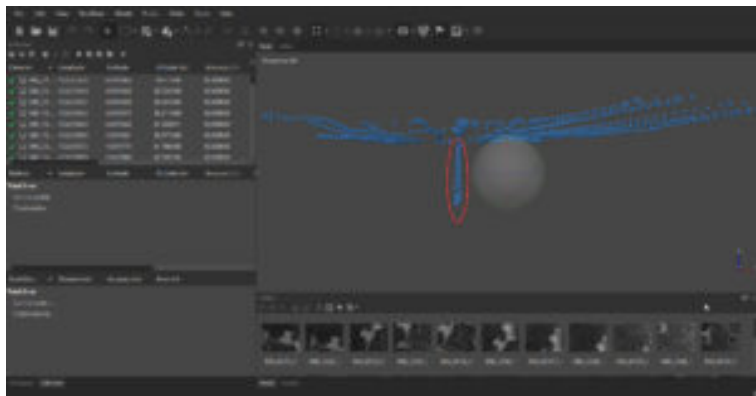
Fig. 3 Camera points that need to be filtered out.

The best way to filter out these points is to search in the **Altitude** column of the **Reference** pane for values that are lower than the altitude at which the mission was flown (i.e. lower than ~68m). The easiest way to accomplish this is to sort the **Altitude** column from lowest to highest, select all photos from the lowest altitude to ~65m, right-click, select **Remove Cameras** and click **Yes** in the confirmation box.

Press **0** (zero) to rotate the images back to map view. You'll notice there are several "transit" lines (non-parallel to the flight lines) which are due to the RPAS transitioning between the take-off/landing and the starting point of the mission. These images do not represent data that should be processed. Manually select them in the list of cameras and remove them in a similar way as described above. When finished, you should end up with between 400 and about 500 cameras and a pattern similar to Fig. 4.
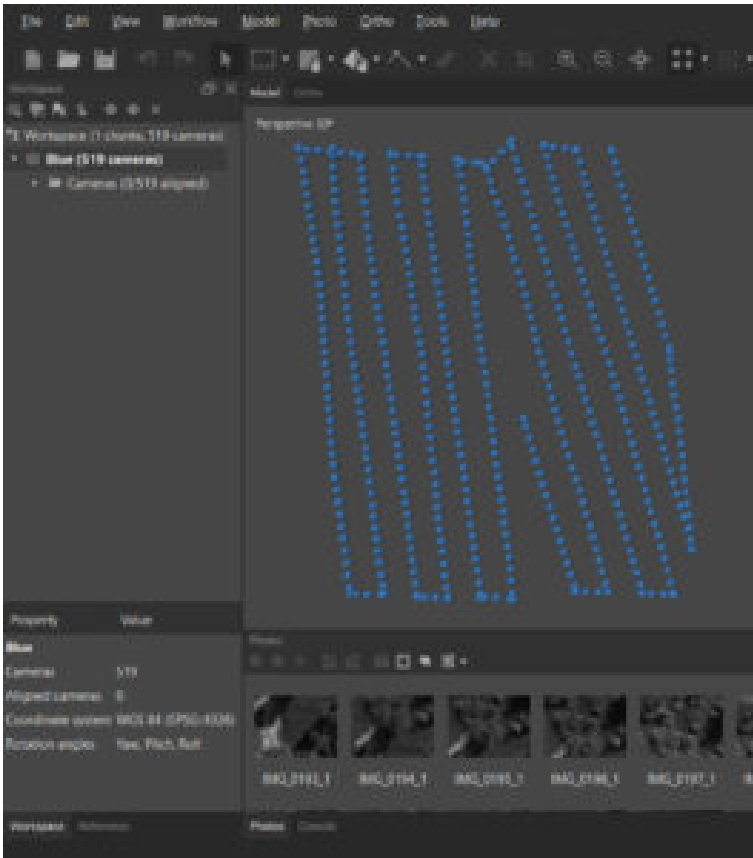
Fig. 5 Post-filtering photo centers.

Assess Image Quality

The next quality assurance step is to assess the quality of the input photos. MetaShape checks basic photo attributes such as motion blur, focus, contrast and exposure. In the bottom **Photo** pane, switch to **Details** view, right-click on one of the photos , select **Estimate Image Quality...**, select **All Photos** then **OK** to see the

quality score. Scores range from 0 (unacceptable) to 1.0 (perfect) and any photos below 0.6 should not be included in further processing and removed.

Adjust Coordinate System

At this stage, it is important to adjust the coordinate system of the photos to match that of the coordinate system of the ground control points (GCPs). The coordinate system that the GCPs were collected in is NAD83(CSRS) UTM Zone 10N with the CGVD2013 geoid. To adjust the photo centers, in the **Reference** pane click on the **Convert** icon, and from the **Coordinate System** drop down, select **NAD83(CSRS) / UTM zone 10N + CGVD2013 height (EPSG::6653)** and click **OK**. Note that the photo coordinates have now been updated to Easting, Northing and an altitude relative to the CGVD 2013 geoid.

Aligning Photos

So far, the software only knows where the center of each photo should be in absolute space (i.e. the coordinate system established in the previous step). It doesn't yet know how all the overlapping photos connect or fit together. This is the purpose of the alignment function in MetaShape. Aligning photos is based on a computer vision concept called **Structure from Motion**.

From the **Workflow** menu, select **Align Photos**, adjust the parameters to match Fig. 6 below and click **OK**.
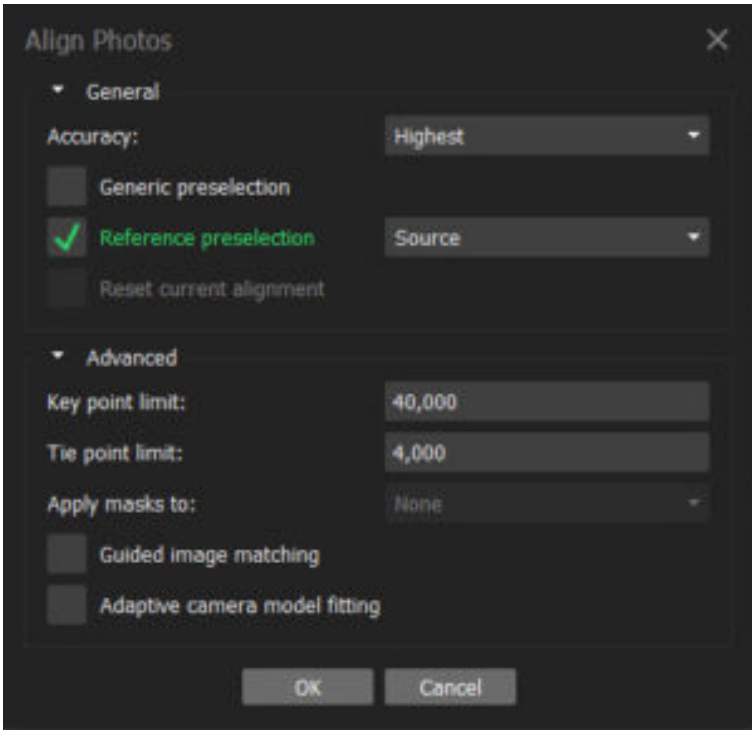
Fig. 6 *Align photos parameters.*

After a few minutes, the sparse point cloud showing the key tie points is generated and the view should look similar to the one below.
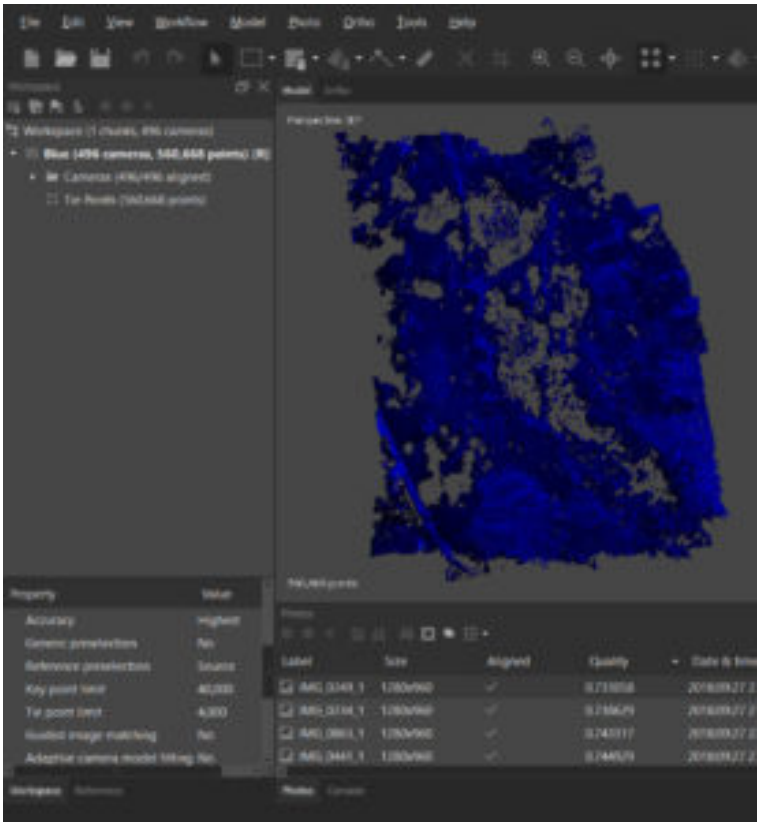
Fig. 7 Sparse point cloud showing 100% photo alignment.

Save the project by accessing the **File** menu, selecting **Save As...**, naming it and clicking **OK**.

Chapter 1.3 - Ground Control Points

Overview

In this chapter, the goal is to add ground control points (GCPs) and use them to refine the relative and absolute orientations of the photos with reference to a real-world coordinate system.

Importing GCPs

MetaShape will accept GCP files in a range of different formats and file types. For this exercise, the GCPs are in a comma-delimited format (CSV) which can be imported directly by MetaShape. In the **Reference** tab, select **Import Reference**, navigate to where your GCP file is stored (i.e. Boundary.CSV) and click **Open**. Adjust the **Coordinate System**, **Delimiter** and **Columns** as per Fig. 8, paying close attention to the **Start import at row** value (**2** in this case) and click **OK**.

Fig. 8 Import CSV parameters for GCP import.

Click **Yes to All** when asked whether to "**Create new marker**?". You should now see a view similar to Fig. 9 showing the initial locations of nine control points. If the markers flags are not visible in your image, click **Show Markers** in the main toolbar.
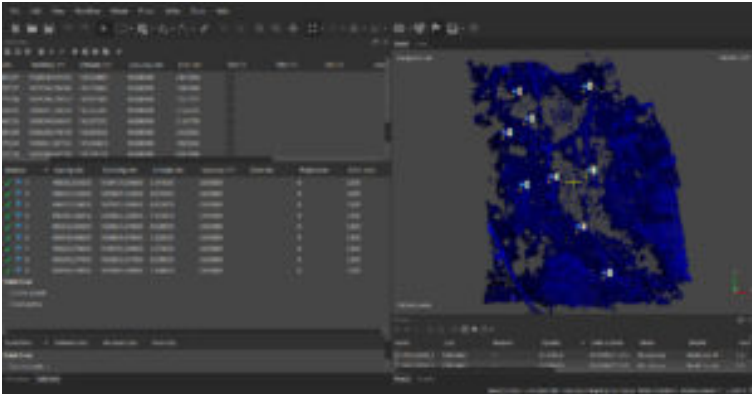
Fig. 9 *Initial location of nine GCPs.*

Placing GCP markers

In the **Reference** pane, notice the list of nine markers with their corresponding Easting, Northing and Altitude. Right-click on a **Marker** (e.g. **1**) and select **Filter photos by markers**. Now, in the **Photos** pane along the bottom of the main display window, all the photos that GCP 1 appears in are shown.

Double-click the first photo and zoom in on the flag for GCP 1. **It may be that the actual GCP is not visible in that photo**! The flag can initially be several meters from the target due to the absolute positional error of the RPAS GPS. Select the next photo if that's the case.

The goal is to left-click and drag the marker flag to the centre of the checkered GCP as per Fig. 10 below.
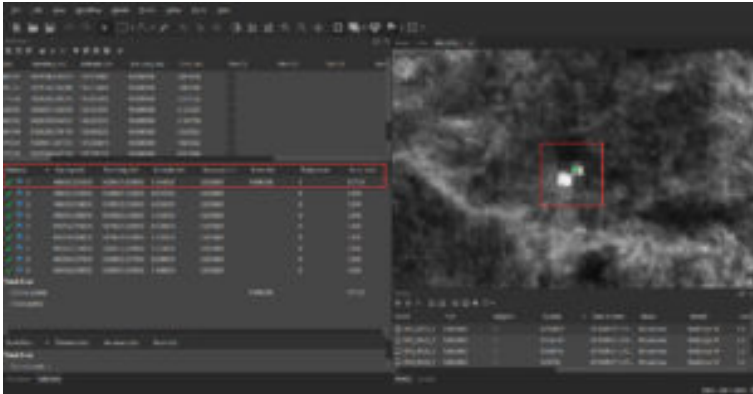
Fig. 10 First GCP marker flag placed in the center of the target.

Notice now that the columns **Error (m)**, **Projections** and **Error (pix)** now have values in them indicating the relative (pix) and absolute (m) error associated with placing that marker. In order to get a true sense of these errors, at least three GCPs need to be placed in a minimum of three photos (projections) followed by a least-squares adjustment. Double-click on the next photo and repeat the placement of the flag in the center of the target. Do this for at least six photos so as to build some redundancy. You may also find that the ground control targets are not easily visible in some photos.

Once you've placed GCP 1 into six photos, note the Error (m) and Error (pix) values. For example 0.897622m and 123.862 pixels, respectively. This means that even though we placed marker 1 in the center of the same target in all six photos, it is displaced by just over 123 pixels over the six photos. In an absolute sense, the coordinate value at the center of the ground control target, has an error of just less than 90cm over the six photos. These may seem like high error values, but recall that the last step is perform a least squares adjustment in order to distribute and minimize these errors. To do this, click the **Update Transform** icon. You should see a significant reduction in the errors now (e.g. 0.000678m and 0.199

pixels, respectively). Ideally, the goal would be an absolute error of less than 0.05m and a relative error of 0.5 pixels.

Now repeat the steps listed under the Place GCP markers section for the remaining eight GCPs. If some of the markers still yield errors higher than those specified above, refer to the section below.

Refining GCPs

Referring to Fig. 11 below, we can see that eight out of nine GCPs have been placed (GCP 9 has no data). Absolute errors range between 0.001884m and 0.012612m with an average of 0.006073m and relative errors range between 0.223 and 0.865 with an average of 0.604. These are acceptable results, but there are a few steps we can take to refine them further.
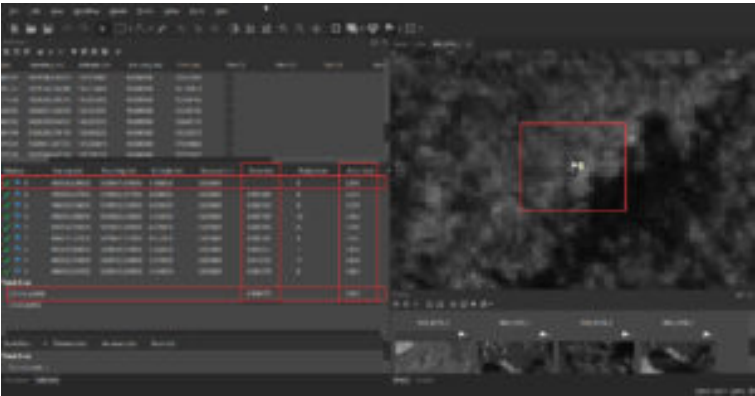

Fig. 11 *Error results from placing eight out of nine GCPs.*

First of all, GCP 9 was not placed because, as can be seen from the right side of Fig. 11 above, the ground control point was not visible in the photos. In fact, as you may have already noticed, some of the GCPs were more difficult to locate in the photos than others.

Lighting conditions, shadows, presence of vegetation are all factors in how easily a ground control target can be seen in a photo. It is better to leave out a GCP rather than try to forcefully place it when it can't be properly identified and seen.

The next step to refine the results are to identify the specific photos in which a particular GCP marker has relatively high errors. The best approach is to sort the GCPs according to the **Error (pix)** column, right click on the top-most GCP and select **Show Info...**. In the window that opens, sort the **Value** column from highest to lowest and double click on the top-most value. This will immediately open the photo in which that marker has the highest relative error and the pop-up window can now be closed. There are now two options; 1) Try slightly moving the marker flag while keeping an eye on the Error (pix) column for that marker to see if the re-positioning of the flag reduces it, or 2) Right click on the marker flag and select **Unpin Marker**. Option one is valid only when the re-positioning of the marker flag towards the center of the GCP yields a lower error. If moving it away from the center reduces the error, then the only valid option is two.

Do this for each GCP trying to reduce the **Total relative error** (pix) below 0.5. Keep in mind to leave at least three projections for each GCP. Following these steps, the errors were reduced to 0.003598m (absolute) and 0.442 pixels (relative).

One final step can be performed to minimize any residual errors. This involves optimizing the camera parameters or performing a camera calibration. In the **Reference** pane, select **Optimize Cameras**, accept the default parameters and click **OK**. This step reduces errors due to lens and camera distortions including aspherical, tangential and radial. The final errors are now 0.001541m (absolute) and 0.308 pixels (relative). These are good results and the next steps of processing the images into the data products can now be taken.

PART 2 - GENERATING 3D MAPS

Overview

Now that the RPAS images have been imported into MetaShape and aligned using GCPs, the next steps are to create a dense point cloud, and a 3D surface mesh with textures in the desired projection.

Chapters included in this Part are;

- Dense point cloud
- Filter dense cloud
- Adjust region
- 3D mesh surface
- Texture

The items above represent the main map products from photogrammetric images captured using an RPAS. They form the basis for creating other map products which will be further discussed in **Part 3 – Digital Elevation Models & Orthophotos**.

Chapter 2.1 – Dense Point Cloud

Overview

Following the creation of a sparse 3D point cloud (i.e. tie points), the steps below outline the creation of dense 3D point cloud and the means of filtering out erroneous points.

Dense Point Cloud

From the **Workflow** menu, select **Build Dense Cloud...** The **Quality** setting is directly dependent on available computing power. Reference this document to determine the suggested highest quality level based on the hardware being used. Set the quality as high as possible given your hardware configuration, as this ensures that the maximum number of pixels will be correlated in 3D space. Be aware that the higher the quality setting, the longer the processing time. Consider using lower setting for large data sets (i.e. several hundred photos). Suggested settings are shown below;
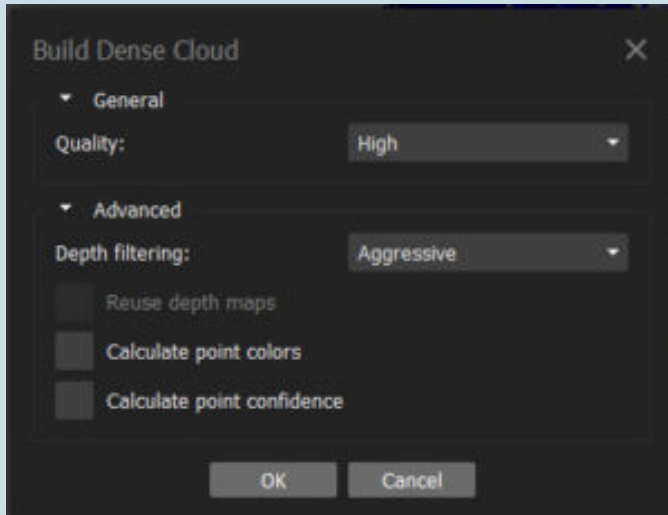
Fig. 12 Dense cloud parameters.

Maximum Density Cloud

The approximate maximum number of points in a dense cloud is calculated by multiplying the **number of megapixels** of the camera (e.g. 12 megapixel images are 4000 x 3000 pixels thus contain 12 million pixels each) by the **number of images** (496 in this data set) which equals 5,952,000,000! It is impossible to correlate all points and thus the actual number of pixels in a point cloud is generally only a fraction of the total possible (0.1 to 5%).

The resulting dense point cloud is similar to the key point, low density cloud but it contains exponentially more 3D information

(aboutt 25 million compared with 500,000). The result should look similar to the screenshot below, but don't be concerned if the number of points doesn't match exactly.
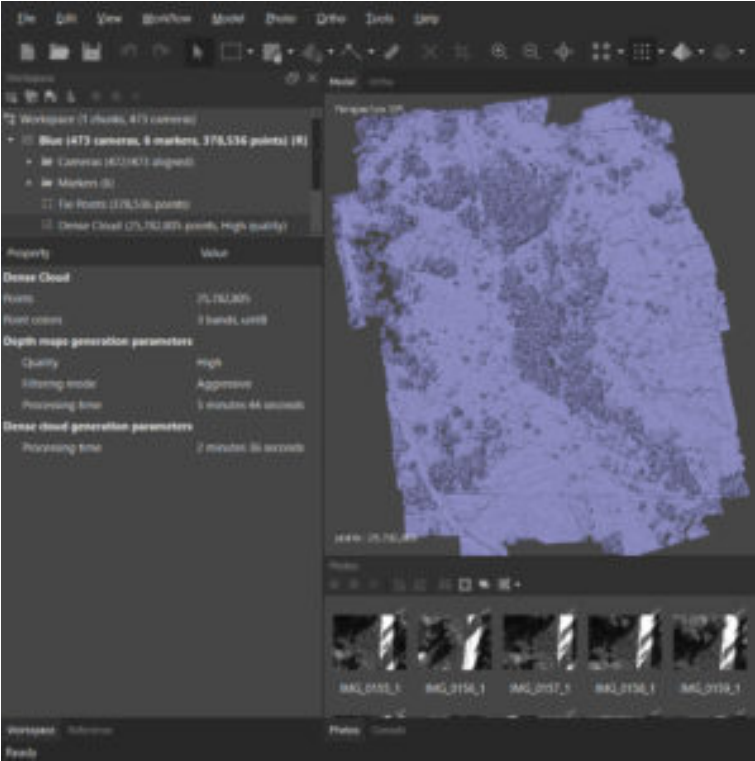

Fig. 13 3D Dense point cloud.

Although from certain perspectives, the dense cloud may look like a "solid" surface, it's still just a collection of pixels positioned accurately in 3D space based on the GPS coordinates of the center pixel of each image. Due to the addition of GCPs, the accuracy of the location of any pixel was improved from ±3m to about 1.5cm.

The next step is to filter any spurious points or outliers which are not representative of the surface being modeled.

Filtering Dense Point Cloud

The type of surface greatly affects our ability to accurately filter points. For example, the relatively level and mostly flat park field (except for some trees) means that we shouldn't expect much deviation from the "ground". Conversely in heavily treed areas or where there is high frequency, large-scale changes in elevation (e.g. a boulder field), the precision with which outlying points can be effectively filtered declines significantly.

Filter Dense Cloud

There are a number of different approaches to filtering points. They fall into two broad categories of **semi-automated** and **manual**. Here, only the manual method is demonstrated as it is the most selective and best applied to specific areas.

The general process involves rotating the dense cloud to identify individual points or groups of points that are not likely to be representative of the surface being modeled (e.g. points floating several tens of meters above the vegetation or any points below the "surface" of the field). Once points have been identified, the **Selection** (**Rectangle, Circle** or **Free-form**) is used to highlight the suspected outlier and pressing the **Delete** key on the keyboard removes them.

This is an iterative process and done well, greatly improves the chances of generating a quality 3D surface, which is the next step.

See below for a sample of outlying points selected using the rectangle selection tool.
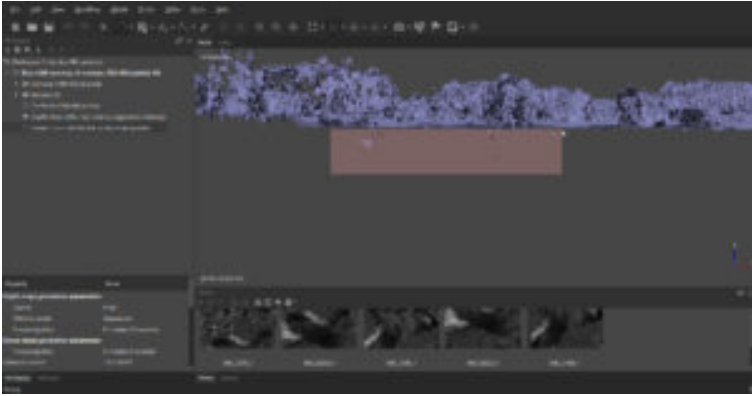
Fig. 14 Removal of erroneous points below the model surface using rectangle selection tool.

Adjust Region

On your screen, you may notice the faint boundaries of a rectangle surrounding the dense cloud. This is the **Region** and defines the outer boundaries of the data set. It appears slightly tilted relative to the points being modeled. This can be adjusted as follows;

1. From the **Model** menu, open **Transform Region** and select **Rotate Region**
2. Using the "Track Ball", adjust the angle of the region to match that of the dense point cloud as closely as possible.
3. Use the other **Transform Region** tools from the drop-down menu including **Move Region**, **Resize Region** and **Reset Region**.
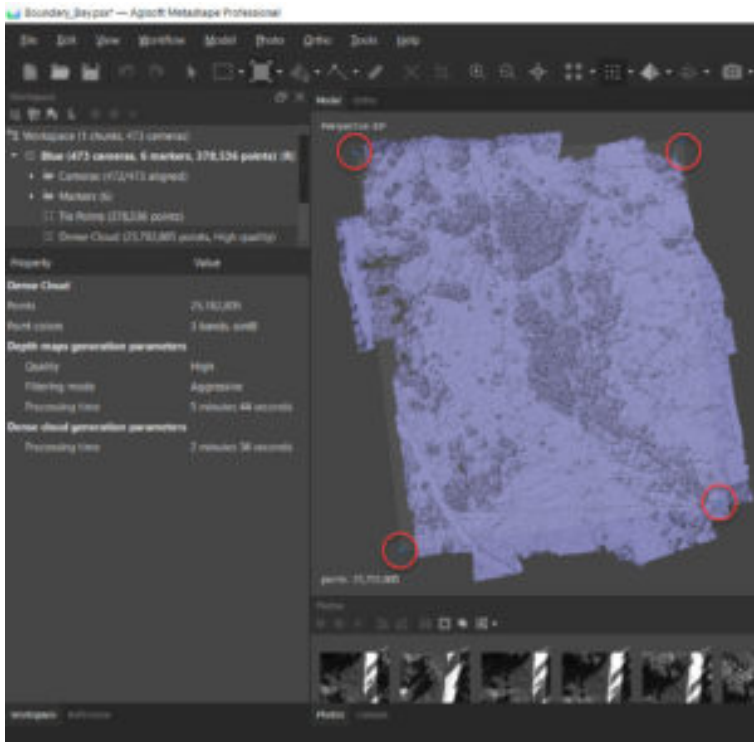
Fig. 15 The region has been adjusted to best fit the 3D dense cloud.

Refer to the next Chapter for the creation of a digital surface model (DSM).

Chapter 2.2 - Digital Elevation Models

Overview

Once the 3D dense point cloud is generated, the next step is to create an accurate **digital elevation model (DEM)**, digital surface model (DSM) or digital terrain model (DTM).

Before proceeding, be sure to save the project.

Building a DEM

A digital elevation model is a raster image (pixels, arranged in rows and columns) with each pixel representing an elevation. If the model represents elevations of the ground along with heights of structures such as buildings and trees, it can be referred to as a **digital surface model (DSM)**. If the elevations only represent the ground or the bare earth, the model is referred to as a **digital terrain model (DTM)**. The general term describing any type of raster elevation surface is **digital elevation model (DEM)**.

From the **Workflow** menu, select **Build DEM....** The dialogue box settings are described below.

Projection Type can be set according to other data sets that you'd like this DEM to geographically coincide with.

Source data allows a choice between using the **Sparse Cloud**, **Depth Maps**, or **Dense Cloud** as the source of elevation data. The **Sparse Cloud** should never be used as it is the least accurate representation of elevation. The main difference between **Depth maps** (if available) or **Dense Cloud** is that the latter is the truest

representation of the surface but may have holes or gaps where elevation data may be missing due to sparse alignment between photos. The former represents a more continuous surface (assuming that interpolation or extrapolation was enabled when building the mesh), keeping in mind that the interpolated elevations are algorithmic guesses based on surrounding known elevations.

Interpolation can be **Enabled (default)** to fill holes or gaps in elevations, **Disabled** or an **Extrapolation** can be applied instead.

Point classes can be selected (if they have been previously created through classification) or **All (default)** classes will be used.

Region settings can be adjusted if necessary, affecting the output **Resolution** and **Total size** of the DEM.

Fig. 16 below shows the suggested DEM settings for this project and don't worry if the **Region** values are slightly different.
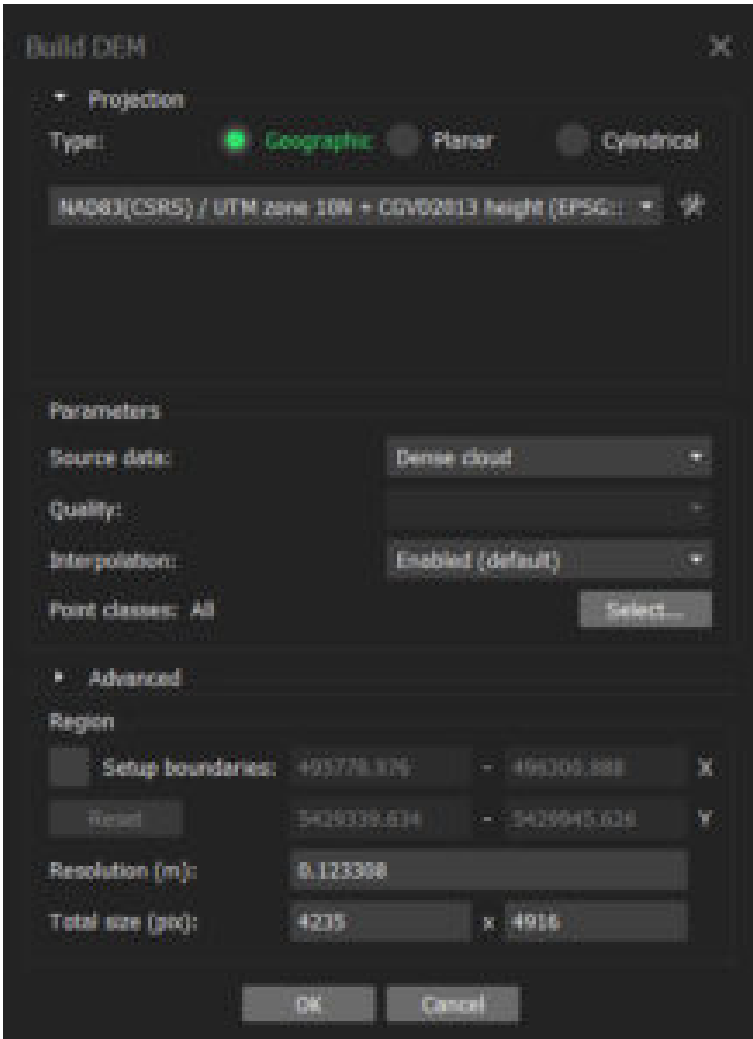
Fig. 16 Build DEM parameters.

To view the DEM, double click it in the **Workspace** pane which
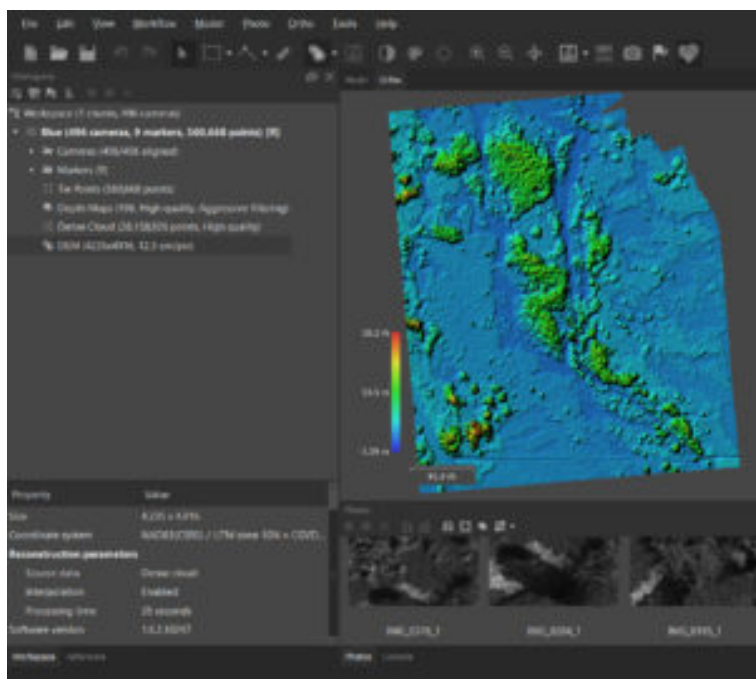brings up a new **Ortho** tab in the main view.

Fig. 17 Digital Surface Model (DSM) for Band 1 (Blue).

Note that the pixel resolution of the DSM in Fig. 17 is approximately 12.3cm. Also notice the clear demarcation of the lower and higher areas of vegetation.

The alternate type of elevations surface that can be created is a digital terrain model (DTM). A DTM shows a statistical approximation of the ground or bare earth surface under vegetation and with all surface features (i.e. buildings and trees) filtered out. To build a DTM, the first step is to classify the dense point cloud.

From the **Tools** menu, select **Dense Cloud** and then select **Classify Ground Points...**.

Configure the parameters of the Classify Ground Points window as per Fig. 18 in order to generate three classes of points; Created (Never Classified), Ground and Low Point (Noise).
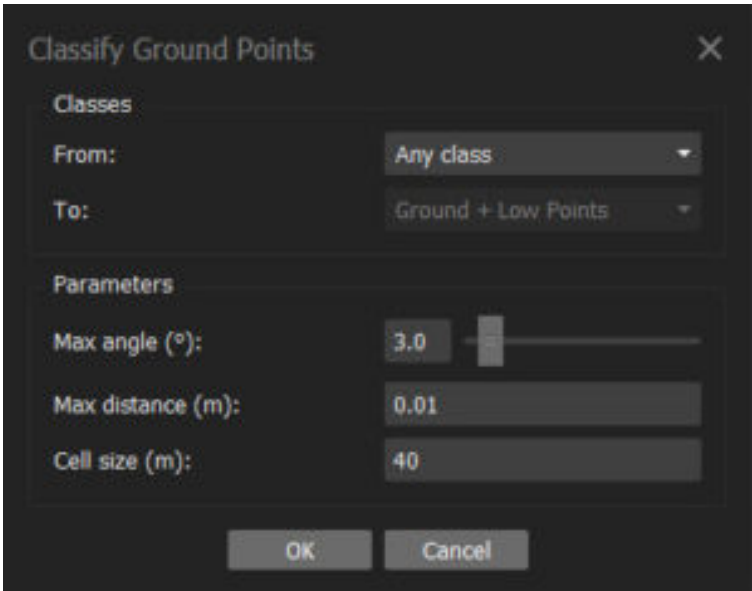
Fig. 18 Classify Ground Points parameters.

The next step is repeat the creation of the DEM, but this time specifying which class (Ground) to generate the elevation model with (Fig. 19).
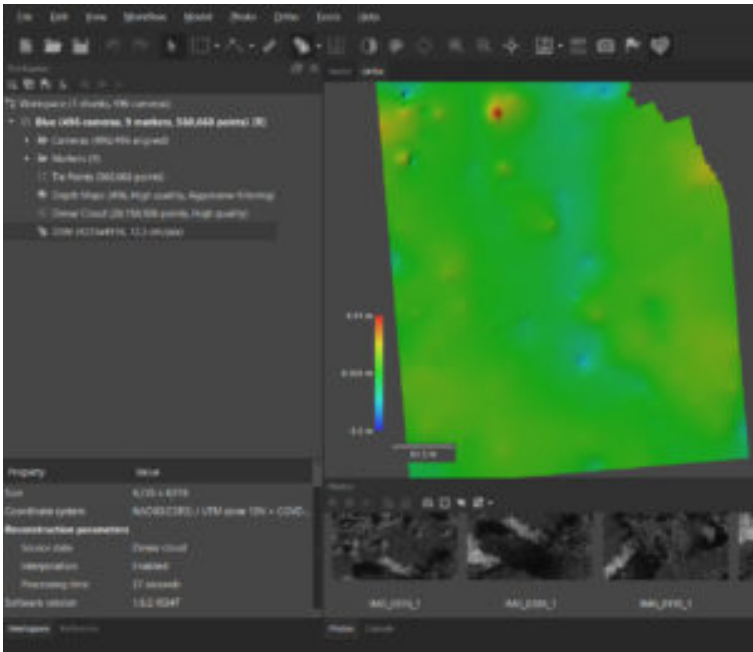
Fig. 19 Results of the classification of the dense point cloud showing the digital terrain model (DTM).

Now that an accurate raster representation of the surface is generated, it can be used to create an orthophoto mosaic as described in the next Chapter.

Chapter 2.3 - Orthomosaics

Overview

Once an accurate digital surface model (DSM) or digital terrain model (DTM) is created, it can be used along with the original air photos to create an orthophoto mosaic or simply **orthomosaic**.

Orthophoto Mosaic

An orthophoto mosaic, or simply an orthomosaic, is in some ways similar to the texture applied onto the 3D mesh surface. However, instead of the photos being distorted and warped to fit the surface, in orthomosaic generation, the photos are corrected for radial and elevation distortions and then stitched together along seam lines.

From the **Workflow** menu, select **Build Orthomosaic...**. The dialogue box settings are described below.

Projection Type is fixed based on that of the surface (DEM or Mesh, if available).

Surface can either be the **DEM** or **Mesh**. Both contain accurate elevation information but since the input photos and output orthomosaic are both in raster format, it is suggested that **DEM** is used as the input surface.

Blending mode can be set to **Mosaic (default)**, **Average** or **Disabled**. The default Mosaic mode is recommended.

Refine seamlines allows the software to adjust the lines along which the overlapping photos are stitched together in order to avoid photo edges and elevated areas such as buildings or trees.

Enable hole filling closes any small gaps that may be present in the surface.

Enable back-face culling is enabled only when the surface type is set to Mesh. This allows the "inside" faces to also show the mosaic colors.

Pixel size (m) allows the user to specify the output pixel size of the orthomosaic. It is never recommended to set this value lower than the default, though higher values can be used to reduce file size at the expense of detail. This is also useful for matching the resolution of the orthomosaic to external data sets.

Setup boundaries allows the user to adjust the output boundaries of the orthomosaic with the corresponding **Total size in pixels**.

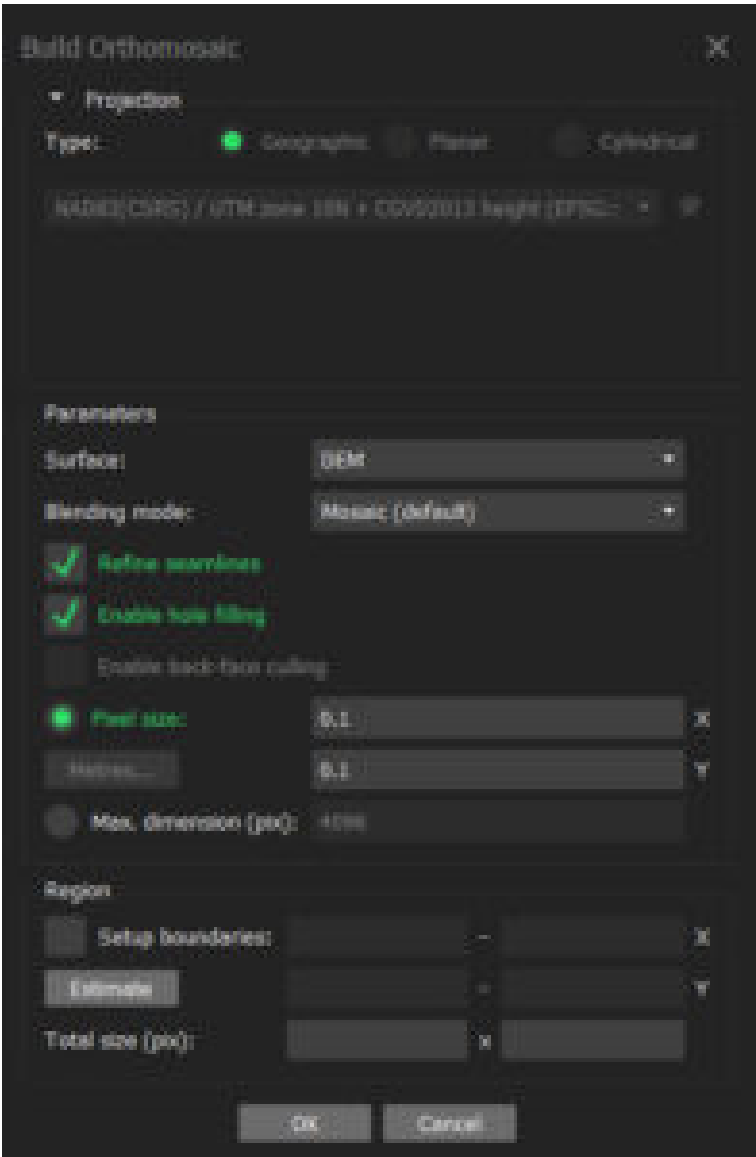Fig. 20 below shows the suggested orthomosaic parameter settings.

Fig. 20 Build Orthomosaic parameter settings.

Once the orthomosaic is generated, double-clicking on it in the **Workspace** pane opens it in the **Ortho** tab as shown below.
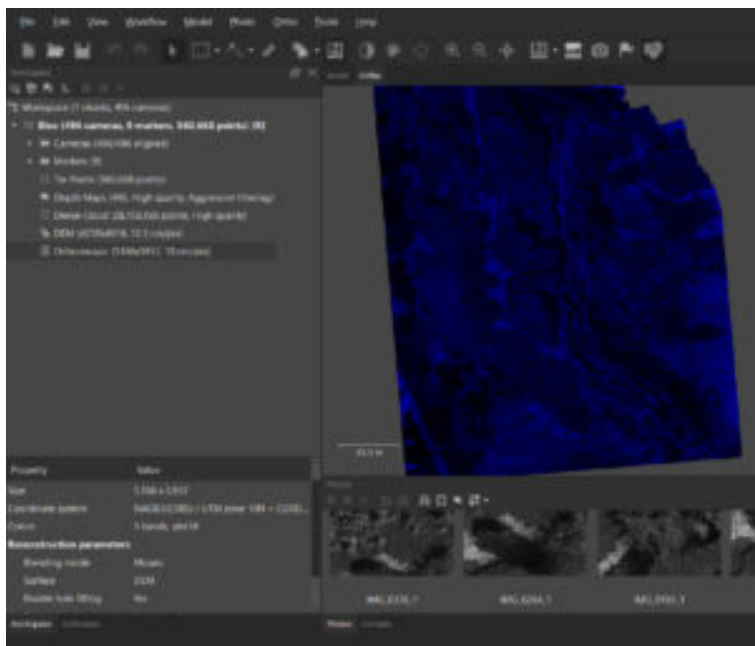

Fig. 21 *Orthomosiac based on the DTM.*

Part 3 describes how to export the orthomosaic from MetaShape to other popular data formats including Google Earth and ESRI ArcMap.

PART 3 - DATA EXPORT

Overview

Once all of the 3D map products have been generated in MetaShape, it is very useful to be able to export them to other compatible data formats for use with in other software packages such as Google Earth, ESRI ArcMap or QGIS.

Chapters included in this Part are;

- Export Dense Cloud
- Export Orthomosaic

Once the data are exported, they can be used in a wide range of analysis and applications. Some examples of the exported data in external software applications are included.

Chapter 3.1 - Export Dense Cloud

Overview

This chapter describes the steps to export the **Dense Cloud** into a variety of external data formats.

Export Dense Cloud

Although MetaShape is competently able to process dense point clouds into 3D map products, there are also other software packages which are specifically designed to process point clouds (e.g. TerraScan, SolidWorks or Cyclone). Dedicated point cloud processing software gives the user access to a wider range of tools with which to manipulate and edit the point cloud in order to produce a variety of architectural and geographic data products.

To facilitate this, MetaShape has an option to export the point cloud into a variety of industry-standard data formats including;
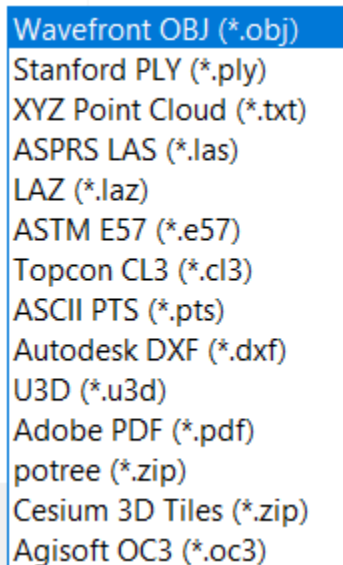
Fig. 22 Photoscan dense cloud export formats

One of the most common and widely used dense cloud data formats is LAS. To export the **Dense Cloud**, right-click on it in the **Workspace** and select **Export Dense Cloud...**. Navigate to where you want to save the data set, enter a name, select a file format and click **Save**.

The suggested output parameters are shown in the screenshot below, but they may vary depending on the specific software and user requirements.
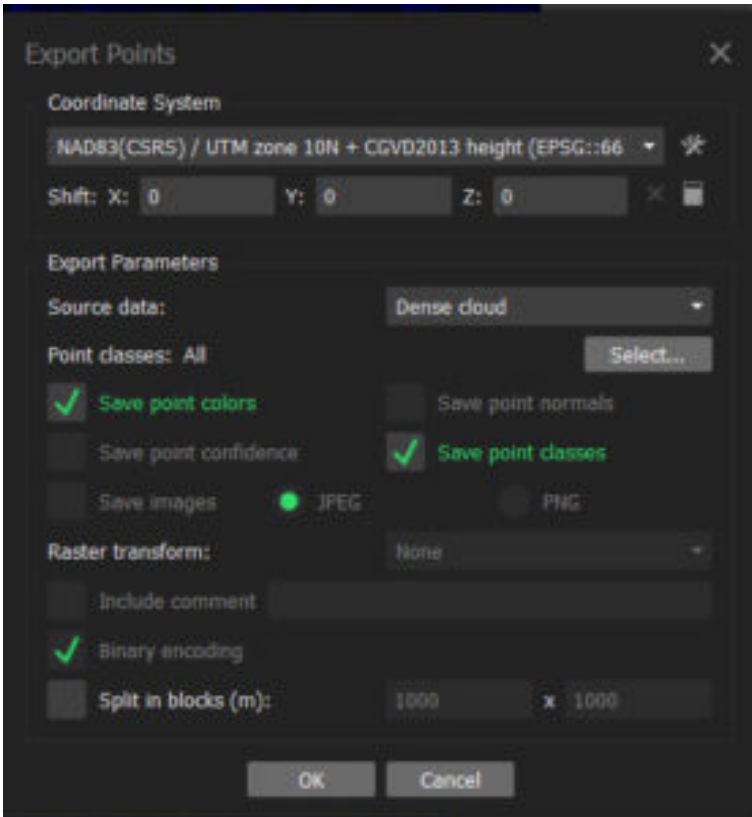
Fig. 23 Parameter settings to export dense cloud to LAS format.

Once the point cloud is exported, it can be opened directly in an external software package.

Chapter 3.2 - Export Othomosaic

Overview

This chapter describes the steps to export the **Orthomosaic** into a variety of external data formats.

Export Orthomosaic

One of the main applications for orthomosaics is to serve as a spatially accurate underlay in a mult-layer geographic information system (GIS). MetaShape allows export in the following data formats;
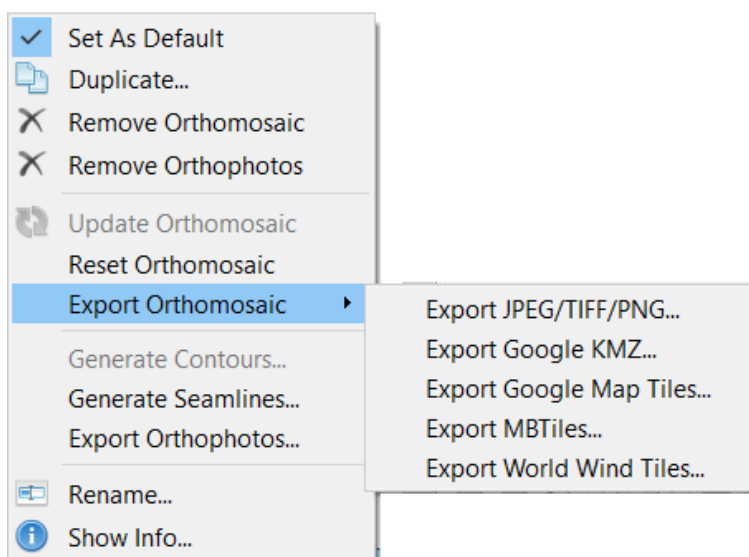
Fig. 24 Orthomosaic export formats

Exporting an orthomosaic in GeoTIFF format allows for further analysis and processing external software such as PCI Geomatica, ESRI ArcMap or QGIS. This is especially important when performing mult-spectral analysis using multi-band data.

To export the **Orthomosaic**, right-click on it in the **Workspace,** select **Export Orthomosaic...** and choose the export file format (e.g. **Export JPEG/TIFF/PNG...**).

The suggested output parameters are shown in Fig. 25, but they may vary depending on the specific software and user requirements.
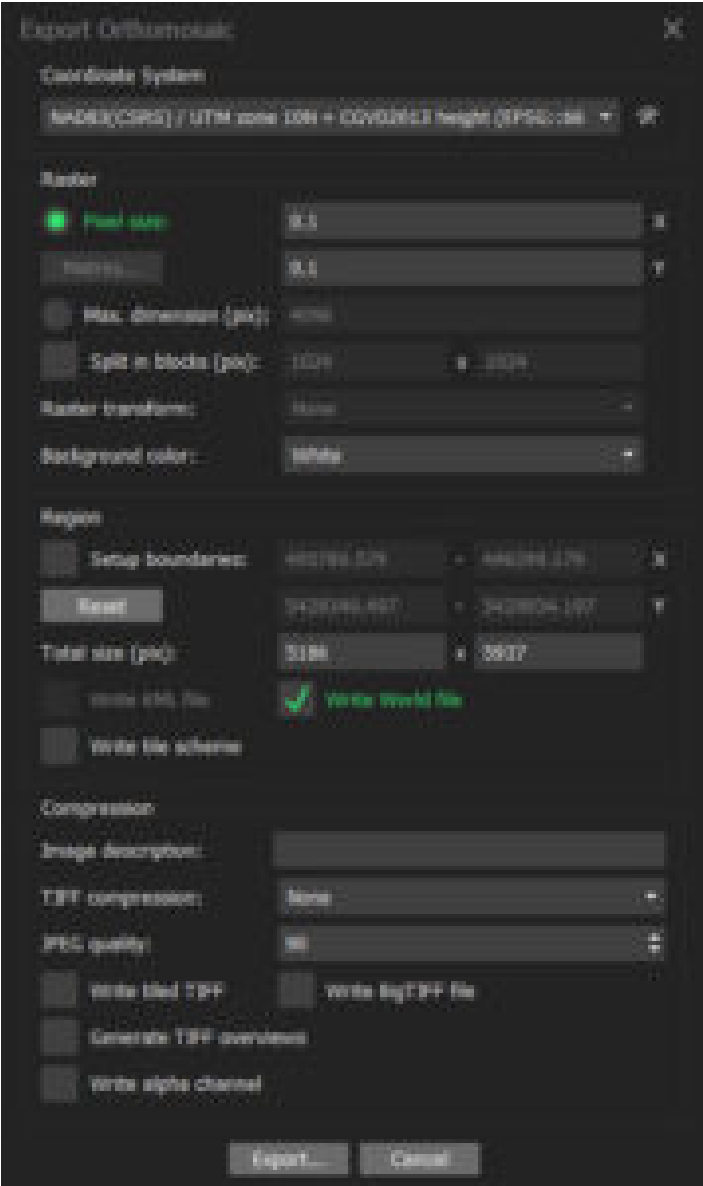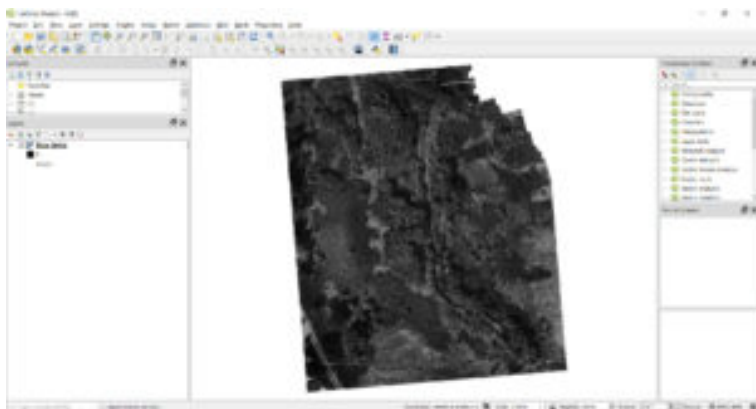
Fig. 25 Export Orthomosaic parameter settings.

Click **Export**, navigate to where you want to save the orthomosaic, enter a name and click **Save**.

The orthomosaic (Blue band), is shown loaded in QGIS in the correct projection system below (Fig. 26).

Fig. 26 *Gray scale representation of the blue band orthomosaic in QGIS.*

Summary

Following the steps in Chapters 1.2 through to 3.2 allows for the set up, processing and export of multi-spectral images using Agisoft MetaShape Pro. One of the main elements to pay attention to when processing multi-spectral imagery, is the use of ground control points (GCPs). GCPs area a key element because they ensure that all five (blue, green, red, NIR and red edge) exported orthomosaics will correctly line up with each in order to ensure that the same pixels are being analyzed from each band. This is why it of great importance to make sure that the absolute alignment errors are less than one ground sampling distance.

This is where you can add appendices or other back matter.