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## Abstract

Stereophotogrammetry is an emerging technique being applied in many areas of subtidal aquatic research that are supported by scientific diving. It is a method of generating three-dimensional computer models from standard forms of image. The technique is dependent on two main factors: (a) how the imagery is obtained, in terms of survey design, camera types and image resolution; and (b) how the various types of software operate with different operators, different environmental influences, and different underwater scales or targets. Missing from the application of this technique is any form of standardisation of how it should be used. This Work Package has developed a full and tested Standard Operating Procedure (SOP) for the application of stereophotogrammetrical techniques underwater. This report is the result of a two-stage process whereby an initial unpublished draft was used to test methods of standardised data collection, data processing and the final delivery of computed models. The draft was tested by the WP members and then modified at a workshop prior to the delivery of the final version.



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## 1. INTRODUCTION

Stereophotogrammetry is a computer-based technique that generates highly complex three-dimensional point-cloud models using standard photo- or video-graphic source material obtained relatively simply and quickly. The models produce permanent records that can be analysed many times in multiple ways and can be measured in three-dimensions to much higher levels of accuracy than are possible using traditional methods. Although still an emerging technique, its use is becoming more widespread in the fields of underwater research and applications range from ecological to structural modelling.

The technique is highly dependent of two main factors: (a) how the imagery that forms the basis of the models is captured, and (b) how the resultant data are managed during and after model generation. The variability in the accuracy of the models that could be inherent in either of these two areas of the technique has not been assessed. This is the main aim of ASSEMBLE+ Work Package 11 (Joint Research Activity 5): to assess the levels of variability, determine where the main areas of generating error are, and to attempt to minimise error through the adoption of a tested Standard Operating Procedure (SOP).

This SOP has been developed in two stages. The first stage provided an initial template of the SOP for testing by the partners; the partners had variable prior experience of underwater photogrammetry. Through a workshop, the results of models generated by the partnership based on the draft SOP were analysed and assessed and the outcomes informed the structure and content of a second draft. That second draft is now presented as a final version in this report.



## 2. OBJECTIVE

The objective is to deliver a Standard Operating Procedure (SOP) document for use in generating underwater three-dimensional models in a consistent format that permits science-based pan-European comparison. The document provides a tested and validated operational template that provides workflow guidance on how to collect, process and import the raw imagery into programmes that generate the final three-dimensional models. Guidance is also provided on the types of export and some methods for optimising analysis.





## 3. DATA COLLECTION

### 3.1. Pre-fieldwork preparation

#### 3.1.1. Survey plan

- Research the site/structure to be surveyed to get an understanding of its scale and complexity as well as environmental considerations, such as the local bathymetry.
- Evaluate the best approach to conduct the survey, with consideration of safe diving practices (i.e. if surveying over a range of depths, start at the deepest section). Large structures might require splitting into sections for processing purposes, even if the entire structure can be photographed during one dive. If this is the case, consider the most useful placement of tile markers, such that they can be used to merge the chunks once they are modelled (see Section 5.4.2). The section including the markers should therefore essentially form an area of model overlap and must be modelled in both adjacent chunks.
- Try to establish whether images of the structure may be obstructed by algae, and if so, this must be cleared prior to the photogrammetric survey.
- For structures such as pier piles which are situated within the intertidal region, consider the tides on the day and plan to dive during high tide to maximize the coverage.

#### 3.1.2. Equipment preparation

- Prepare camera rig:
  - Ensure all batteries are charged, including spares if required, and SD cards inserted.
  - Prepare the underwater housing, ensuring O-rings are clean and sufficiently greased.
  - If using GoPro/Paralenz, attach to camera tray, and set to time-lapse.
  - Attach video lights, using floaty arms if the camera rig is heavy.
- Prepare spirit level (used to level, orient and scale the model):
  - Compass and base (gorilla pod or plate) attached securely.
- Prepare any means of defining the spatial extent of the model region, such as measuring tapes or reels (which could either be measured in-situ or previously measured with loops inserted along the reel to indicate the required length).

### 3.2. Fieldwork

#### 3.2.1. Survey area preparation

- If modelling a large region (and particularly those which are relatively featureless, such as an area of seabed with primarily a sandy substrate), it will be necessary to define the spatial extent of the region using tape measures or reels.
- Position the spirit level: flat, and ideally with the compass end of the spirit level pointing north (for ease of identification of model orientation when placing the reference markers).



- If modelling a large area, such as a 10m squared area of seabed, it may be beneficial to use multiple spirit levels (to ensure accurate scaling), or if only one spirit level is available, have an assistant reposition the spirit level in a different region within the site (only after it has already been modelled in its original location, and before the camera operator has reached the region where the spirit level will be relocated).
- Position the tile markers to be spread relatively evenly throughout the model region (not in a straight line).
  - If photographing sections to be modelled in individual chunks (which will later be merged), place a marker within each of the overlapped areas in order to assist the merging procedure.

### 3.2.2. Image collection

- Turn on video lights
- Set SLR camera to desired mode and/or start GoPro/Paralenz time-lapse.  
**NB:** If using automatic mode, consider using manual exposure settings if the camera is struggling to automatically correct variable exposures (for instance, compensating for bright sunlight on the outer edges of a pier and subsequently under-exposing the pier itself).
- Position yourself just outside of the area of interest to fully capture the more vertical surfaces within the outer region (and continue photographing just beyond the area boundaries throughout the survey).
- Swim slowly in a lawn-mower pattern, with camera angled slightly obliquely in the direction of motion (particularly for more complex structures).
- Take photos at a frequency which achieves at least a 75% linear overlap of photos (this can be checked by ensuring the same point appears in at least 3 photos).
- Upon turning to swim the second pass, ensure a lateral overlap of at least 50% is achieved (half of the previous pass is photographed again).
- Repeat the above until the survey is complete.
- For best results, and if time permits, repeat the process perpendicular to the initial passes, to create a crosshatch survey pattern.

## 4. PRE-PROCESSING

### 4.1. Data management

- Create a Project folder (ideally on the Desktop; avoid working on an external hard drive).
- Save all photo and/or video data in a sub-folder within the project folder.
- Download the latest version of Agisoft Metashape, and then open and save a project within the project folder.
- In Metashape, create “chunks” for each of the models to be created: right-click on Workspace; Add Chunk
- Rename the chunks: right-click on the chunk; Rename...



- Type the new chunk name.

## 4.2. Keyboard shortcuts

It is recommended that some of the most used commands are set up with a keyboard shortcut to facilitate efficient processing and model manipulation.

- Tools
- Preferences...
- General
- Customise...
- Filter the list of Actions to find the shortcut you would like to create.
- Double click on the adjacent space in the Shortcut column
- Where it says, 'Press shortcut', type in the shortcut (e.g. 'ctrl + T') and select the tick.
- OK
- Apply

A list of some of the most useful commands and their recommended shortcuts can be found in Appendix 1.

## 5. IMPORTING IMAGERY

Data can be imported either as a collection of photos or (one or more) videos.

### 5.1. Import photos

- Highlight selected photos within the sub-folder
- Drag and drop selected photos into the respective chunks within Agisoft

Camera and lens type are detected automatically from the image EXIF metadata but can be specified further to increase accuracy (*optional*).

- Tools
- Camera calibration...

#### 5.1.1. Remove poor quality photos

The inclusion of poor-quality photos will undoubtedly affect the resolution of the textured/tiled model. The photo quality can be assessed automatically as described below, and those of poorer quality can be disabled so that they are excluded from the model (*optional*). Note that this is a process which can be easily reversed.

- View
- Photos
- In the Photos pane, click on the 'Change View' drop down arrow: Details
- Highlight all rows: click on a row, ctrl + A



- Right click: Estimate Image Quality...
- In the Analyze Photos window, Apply to: 'Selected cameras' (or 'All cameras')
- OK
- Click on the 'Quality' column heading to list the photos in ascending order of photo quality
- Highlight those less than 0.5 (click and drag over those rows to be selected)
- Right click: Disable Cameras

If the photos fail to align, it is possible to re-enable some or all of those disabled to see if their inclusion helps the alignment, however, the quality of the model texture will ultimately be reduced.

### 5.1.2. Change the path of photos

If files or folders have been moved it will be necessary to redirect the software to the new location of the data.

- View
- Photos (if not already open)
- Right click on any photo
- Change Path...
- Apply to: All cameras
- OK
- Find photo location and click 'Open'

It is only necessary to locate one of the photos within a folder; the rest will be redirected automatically.

## 5.2. Import a video

K-lite Codec Pack is required for encoding and decoding video formats. If not already installed, download the Basic pack from <[https://www.codecguide.com/download\\_kl.htm](https://www.codecguide.com/download_kl.htm)>

- File
- Import
- Import Video...
- Select the video file
- Output folder: click on the 'browse' folder on the right: create a sub-folder, within the folder containing the videos, to store the frames extracted from the video
- Filename template: for a single video, leave this as 'frame{filenum}.png'
- Frame step: define the interval between extracted frames (i.e. to extract 2 frames per second (fps) from a video of 30 fps, use a frame step of 15). You can check the fps by right-clicking on the video file and selecting: *Properties, Details*.
- Start from: and End at: can be used to trim the video



### 5.2.1. Import multiple videos (into the same chunk)

This may be necessary for instance when using a GoPro, where longer videos get split into multiple shorter clips.

- File
- Import
- Import Video...
- Select the video file
- Output folder: click on the 'browse' folder on the right: create a sub-folder, within the folder containing the videos, to store the frames extracted from the video
- Filename template: change 'frame' to 'a' (i.e. a{filenum}.png)
- Frame step: define the interval between extracted frames (i.e. to extract 2 frames per second (fps) from a video of 30 fps, use a frame step of 15). You can check the fps by right-clicking on the video file and selecting: *Properties, Details*.
- Start from: and End at: can be used to trim the video
- Repeat above steps, changing the Filename template to 'b{filenum}.png', and then 'c{filenum}.png' etc (successive)

## 5.3. Masks

Some parts of the photos might need to be excluded from the model, such as background noise or distorted imagery (*optional*). Masks may either be created on individual photos where the section to be masked is not consistent throughout the dataset, as is the case in some instances where photos are taken at such an oblique angle that blue water is visible in the background (complete Section 5.3.1 only). In other cases, a single mask may be applied to all or multiple photos where the exact same section of the photograph needs to be masked, for instance if the outer edges of all the images are warped by a fish-eye lens or not well illuminated (complete Sections 5.3.1, 5.3.2 and 5.3.3).

### 5.3.1. Create mask

- View
- Photos
- Select photo to be masked
- Click on the Selection drop-down arrow and select the Magic Wand tool
- Click on an area to be masked
- *Ctrl + shift + A*: add selection
- Repeat on all areas to be excluded

### 5.3.2. Export mask

- File
- Export
- Export Masks...
- File type: Single channel mask image
- Apply to: Current photo



- OK
- Name the file
- Save

### 5.3.3. Import mask

- File
- Import
- Import Masks...
- Method: From file
- Operation: Replacement
- Apply to: All cameras
- Filename template: ([type in filename].jpg)
- OK
- Select Folder (where mask is saved)

## 5.4. Chunks

If the model is too big to attempt to process as one chunk, or the software is unable to align all of the photos relative to one another but appears to recognize discrete sections, these sections can be processed as individual chunks and later merged into one model (*optional*).

### 5.4.1. Split into chunks

- View
- Photos
- Click on the 'Change View' drop down arrow: Large
- Highlight those to be moved to new chunk
- Right-click: Move Cameras
- New chunk or Chunks > (select chunk)
- Rename the chunk (as in Section 4.1)

### 5.4.2. Merge chunk

*This can only be completed once a model has been created.*

- Add markers to recognizable points visible on both chunks, on the textured mesh
  - Open two versions of the project: a 'working' version to view and edit the *first* chunk, and another (read-only) 'reference' version to view the *second* chunk
  - On the working version, add markers to points which are discernible on both chunks
  - Save the changes
  - Close the (now outdated) read-only version, open another (up to date) read-only version, and open the *first* chunk to view the new markers.
  - On the *working* version, open the *second* chunk and add markers to the same points (now visible in the *first* chunk on the *read-only* version).



- Check that the corresponding markers are labelled the same ('Point 1', 'Point 2' etc.), and otherwise rename them:
  - View
  - Reference
  - Under 'Markers' section, right-click on marker label: Rename
- Check that the markers are accurately positioned on the photos (see Section 6.1.6)
- Align the chunks:
  - Workflow
  - Align Chunks
  - Deselect / select chunks to be merged
  - Method: Marker-based
  - Align
- Merge the chunks:
  - Workflow
  - Merge chunks
  - Select those to be merged
  - Select Merge markers, and Merge Models
  - Merge

## 6. MODEL CREATION WORKFLOW

The following workflow includes all the possible processing options. Depending on the analytical software being used, only certain outputs may be required (e.g. Cloud Compare uses the dense cloud or mesh).

Processing as a "Batch Process" can be useful if commanding the software to carry out the same process to multiple chunks, or if consecutive stages of the process can be carried out upon completion of the previous stage, without intervention. However, it is recommended that the initial alignment (creating the sparse point cloud) is carried out individually and the outcome inspected prior to batch processing the subsequent stages, as it often requires some alteration of parameters.

- Workflow
- Batch Process...
- Add...
- Job type: Add each process, in order (expand drop-down menu)
- Apply to: All chunks (expand drop-down menu), or select/deselect as required
- Settings: Adjust the settings as described in the workflow below. Double click on the cell within the Value column to access the drop-down menu of setting options.
- OK
- Select 'Save project after each step'
- OK



If the same processing parameters are going to be used on different projects, the batch can be saved as an .xml file to be opened when batch processing other projects where the same parameters are used.

## 6.1. Align imagery to create sparse point cloud

- Workflow
- Align photos...
- Accuracy: Medium
- Deselect Generic preselection (This will take longer than having Generic Preselection selected, since Agisoft is comparing each photo with every other photo rather than comparing the photos in the same succession that they are taken. However, Generic Preselection has been found to produce poor results and so it is advised that it is deselected.)
- Reference preselection: Source
- Expand Advanced
- Key point limit: 40,000 (default)
- Tie point limit: 4,000 (default)
- Apply masks to: None (unless a mask has been created)
- Deselect Guided image matching (default)
- Deselect Adaptive camera model fitting (default)
- OK
- When complete, check cameras aligned: click on chunk drop-down arrow: 'Cameras (y/x aligned)'

### 6.1.1. Force camera alignment

*This section is only advised if a significant number of cameras haven't aligned (optional), otherwise continue from Section 6.1.2.*

- View
- Photos
- Drop down arrow: Details
- Highlight those not aligned (click and drag mouse down over all rows to be selected)
- Right-click over selection: Align Selected Cameras

#### 6.1.1.1. Re-size the bounding box ("region")

*If more cameras have been aligned through Forced Alignment, check the 'bounding box' and expand it if required (bounding box will be constrained to the extent of the initial alignment and subsequent processing will be incomplete).*

- Click on drop down arrow next to the 'Region' icon (found two icons to the right of the Navigation icon), to select Resize Region
- Adjust corners of the rectangle (click and drag) to encompass all the points of interest

### 6.1.2. Optimise camera alignment (bundle adjustment)

- Tools





- Optimize Cameras
- Use default optimisation settings

### 6.1.3. Add reference markers to Spirit Level

- View
- Photos
- Open an image which shows the spirit level
- On the bottom left (southwest) corner of the spirit level (where spirit level oriented relative to north); Right-click: Add Marker
  - It is important to add the markers in a particular order as these will be given local coordinates based on the dimensions of the spirit level. With the spirit level oriented relative to north, begin with the bottom left (SW) and progress clockwise (NW, NE, SE).
- Repeat for the other corners of the spirit level, as above, selecting Add Marker. There should now be four markers, one on each corner.

### 6.1.4. Provide the reference markers with local coordinates

- View
- Reference
- In the Markers section of the Reference pane, amend the X, Y and Z values (in metres) for each of the Points, such that the dimensions of the spirit level are established (i.e. for a spirit level of length 58.5cm and width 6cm, Point 1: X = 0.0, Y = 0.0, Z = [depth]; Point 2: X = 0.0, Y = 0.585, Z = [depth]; Point 3: X = 0.06, Y = 0.585, Z = [depth]; Point 4: X = 0.06, Y = 0.0, Z = [depth])
- Select (tick) each of the Markers in the Reference pane
- Press the Update Transform button in the Reference pane.

#### 6.1.4.1. Saving, editing, and importing marker reference information

If the same reference has been used for multiple models (i.e. the spirit level), the local coordinates (its length and width) may be saved and imported to subsequent models to avoid updating the coordinates manually each time (*optional*).

- View
- Reference (if not already highlighted; otherwise, find on the left near 'Workspace')
- In Reference pane: Export Reference
- Name the file
- Save as type: .txt file
- Save
- Select Markers
- OK
- Open the new, unreferenced model
- Add markers on the new model (see Section 6.1.3 6.1.3)
- In Reference pane: Import Reference
- Select .txt file
- Open



- Coordinate System: Local Coordinates (m) (drop-down menu)
- Delimiter: Tab
- Use all other default settings
- OK

#### 6.1.5. Reduce model error and refine 3D coordinates

- Model
- Gradual Selection...
- Criterion: Reconstruction uncertainty (Geometry)
- Level: 10 (limit = 50)
- If more than 50% of the points are selected (see bottom left of the model view pane, e.g. "5,045 points, 2,762 selected"), increase the level to a higher value and repeat.
- OK
- Delete selection
- Repeat Optimisation of camera alignment (Section 6.1.2).
  
- Model
- Gradual Selection...
- Criterion: Projection accuracy (Pixel Matching Errors)
- Level: 2 – 3
- If more than 50% of the points are selected (see bottom left of the model view pane, e.g. "5,045 points, 2,762 selected"), increase the level to a higher value and repeat.
- OK
- Delete selection
- Repeat Optimisation of camera alignment (Section 6.1.2).

#### 6.1.6. Reduce the marker errors

The software will usually recognize the points in images not yet marked and will place a marker automatically. To reduce any errors, it's necessary to check and potentially correct the automatic placement of the markers.

- On the photo upon which markers were added, right-click on one of the markers: **Filter by marker**. This will filter the photo selection to show only the photos containing that same point (the bottom left corner of the spirit level).
- From the filtered selection of photos, open a different photo. Where markers have been added automatically, check the accuracy of the marker position, and move the point slightly if necessary: left click and drag. Where markers haven't been placed automatically; right click: **Place marker** and select from the list of previously identified markers.

To specifically identify the photos with large pixel errors:

- In the *Markers* section of the Reference pane, right-click on a marker with a high 'Error (pix)' value: **show info**
- Select the photo with a high pixel error (double click on the row)
- Close the window and adjust the position of the marker on the photo. Where the point is not determinable (e.g. seaweed has obscured it), simply delete the point; right-click: **Remove Marker**.
- Press the **Update** button in the reference pane.



- Repeat Optimisation of camera alignment (Section 6.1.2, or press the Optimize Cameras icon in the Reference pane)
- Repeat the above process on at least 4 other photos showing the spirit level (or GCP tile), with the aim of reducing the 'Error (pix)' (in the *Markers* section of the Reference pane) as low as possible (i.e. a value less than 1). The marker position will become increasingly accurate.
- Repeat Optimisation of camera alignment (Section 6.1.2, or press the Optimize Cameras icon in the Reference pane) after each iteration.

#### **6.1.7. Add reference markers to “Ground Control Points”**

- View
- Photos
- Open an image which shows the GCP tile
- On two adjacent corners; Right-click: Add Marker. These should automatically be labelled Point 5 and Point 6.
- Repeat Section 6.1.6 (reduce the marker errors)
- Repeat for the other GCP tiles, as above, adding two markers to two adjacent corners of the tiles and correcting any marker errors.
- Repeat for at least three marker pairs

#### **6.1.8. Scale the GCPs**

- In the reference pane, select two marker points placed on the same tile (e.g. Point 5 and Point 6): Ctrl + Left-click on the two rows
- Right-click: Create scale bar
- Add distance in metres (e.g. 0.1 for a 10cm<sup>2</sup> tile)
- Press the Update Transform button in the Reference pane.

In the reference pane, Scale Bar Error should be less than 0.005 m, aiming for less than 0.002 m over a site greater than 10 square metres. Include the Z value (depth) if known.

#### **6.1.9. Reduce RMS reprojection error**

- Model
- Gradual Selection...
- Criterion: Reprojection error (Pixel Residual Errors)
- Level: approx. 0.3
- If more than 10% of the points are selected (bottom left of the model view pane, e.g. “5,045 points, 834 selected”), increase the level to a higher value and repeat.
- OK
- Delete selection
- Repeat Optimisation of camera alignment (Section 6.1.2).



## 6.2. Build Dense cloud

Multiple 'chunks' within the same project can be run as a batch at this stage.

- Workflow
- Build Dense Cloud...
- Quality: High
- Depth filtering: Moderate (this depends on the object being modelled. Depth filtering reduces noise: *Mild* only eliminates the greatest outliers, *Aggressive* removes all outliers, but can artificially flatten the surface if the surface includes very complex/branching structures).
- Select Calculate point colors
- Select Calculate point confidence

### 6.2.1. Crop dense cloud to the area of interest

- Model
- Rectangle selection
- Drag across screen to select area of interest within a rectangle
- Edit
- Crop selection

### 6.2.2. Remove anomalous point scatter

Automatically filtering out the low confidence points is advised in the first instance, though there may be artefacts within the model which have not been identified by the software as outliers. Therefore, it is recommended that the model is always additionally rotated at all angles and visually inspected for such anomalies.

#### 6.2.2.1. Automatically delete anomalies

- Tools
- Dense cloud
- Filter by confidence
- Min: 0
- Max: 2
- OK
- Select the remaining points (all low confidence)
- Delete
- Tools
- Dense cloud
- Filter by confidence
- Min: 0
- Max: 255
- OK



#### 6.2.2.2. Manually delete anomalies

- Rotate the model such that anomalous point scatter can be seen proud of the rest of the model
- Select free-form selection tool
- Select the anomalies (click and drag to draw selection around anomalies)
- Delete the selection

### 6.3. Build Mesh

- Workflow
- Build Mesh...
- Source data: Dense cloud
- Surface type: Arbitrary (3D)
- Face count: High
- Interpolation: Enabled (default)
- Select Calculate vertex colors

#### 6.3.1. Crop the mesh

It's usually necessary to tidy up the mesh and remove any noise.

- Right-click on drop down arrow next to the selection tool
- Select Free-form Selection
- Click and hold to highlight section of mesh to be deleted
- Delete (keyboard) selected section of mesh
- Repeat, or alternatively select multiple sections to delete simultaneously:
  - **Ctrl [+select]**: selects multiple sections
  - **Shift [+select]**: deselects sections

#### 6.3.2. Close holes

It is possible to fill unintentional holes in the mesh (*optional*). This can be done to a range of extents; the model should be positioned so that the hole to be closed is visible and the level of hole filling adjusted along the scale (0-100%) until only the hole intended to be closed, is closed.

- Tools
- Mesh
- Close Holes...
- Drag the Level to fill the hole

#### 6.3.3. Build texture

- Workflow
- Build Texture...
- Texture Type: Diffuse map
- Source data: Images



- Mapping mode: Generic
- Blending mode: Mosaic (default)
- Texture size/count: 16384 x 1
- **Select** Enable hole filling
- **Select** Enable ghosting filter

## 6.4. Build Tiled model

A tiled model cannot be used for analysis but can be produced to display the model to the highest resolution.

- Workflow
- Build Tiled Model...
- Source data: Mesh
- Pixel size (m): **use default**
- Tile size: 256
- Face count: Medium
- **Deselect** Transfer model texture
- **Select** Enable ghosting filter (if objects such as fish or seaweed are moving in the images)

## 6.5. Build DEM

- Workflow
- Build DEM...
- Type: Geographic
- Local Coordinates (m)
- Source data: Dense cloud
- Interpolation: Enabled (default)
- **Use all remaining default settings**
- **Increase resolution on DEM if looks blocky (decrease the value, e.g. /10)**

## 6.6. Build Orthomosaic

- Workflow
- Build Orthomosaic...
- Type: Geographic
- Surface: DEM
- Blending mode: Mosaic (default)
- **Deselect** Refine seamlines
- **Select** Enable hole filling
- **Use all remaining default settings**

## 7. MODEL OUTPUTS



## 7.1. Exporting the models

### 7.1.1. Export the Dense cloud

- File
- Export
- Export Points...
- Save as type: (as appropriate)

### 7.1.2. Export the DEM

- File
- Export
- Export DEM
- Export Tiff/BIL/XYZ...
- Use default settings
- Export...
- Save as type: (as appropriate)

### 7.1.3. Export the Orthomosaic

- File
- Export
- Export Orthomosaic
- Export JPEG/TIFF/PNG...
- Use default settings
- Export...
- Save as type: (as appropriate)

### 7.1.4. Export the Textured mesh

- File
- Export
- Export Model...
- Save as type: (as appropriate)

#### 7.1.4.1. Decimate the mesh (to reduce file size)

Decimate the mesh to reduce the file size for upload onto platforms which have a file size limit, or to allow the model to be viewed on Agisoft more smoothly.

- Tools
- Mesh
- Decimate Mesh...
- Target face count: (alter as appropriate)
  - 600,000 faces = approximately 50 Mb (limit for use on Sketchfab Basic)
  - 2,300,000 faces = approximately 200 Mb (limit for use on Sketchfab Pro)



- Tens of thousands of faces might be more appropriate (for less intricate models where such decimation won't be so noticeable) as this will allow the model to be optimised for viewing on mobile devices.

### 7.1.5. Export shapes

Shapes delineating areas/features of interest in the model can be created and exported as .SHP files (e.g. polyline, polygon, or point)

- File
- Export
- Export Shapes...
- Save as type: (as appropriate)

## 7.2. Create an animation

### 7.2.1. Preset animation

- In Animation pane, click on the Create icon
- Preset: Vertical (for a straight camera track line) or Horizontal (for a rotation camera track line)
- Keyframe count: 50 (default)

### 7.2.2. Custom animation

A custom animation will create a camera track based on a set of appended viewpoints.

- View
- Animation
- Move/rotate model view to desired position for the start of the animation
- Click on the Append icon to capture that view. ('+' icon)
- Move to next desired location
- Click on the Append icon
- Repeat until desired camera track has been established

#### 7.2.2.1. View and edit camera track

- Model
- Show/Hide Items
- Show Animation

On the model view you will see pentagons which indicate the position and angle of each viewpoint, connected by a line representing the transition between them. The pentagon positions can be moved easily on the model view, though their angle of view will stay the same.

*To change the angle of a viewpoint:*





- In the Animation pane, double click on the row representing a viewpoint which needs to be changed
- Move/rotate model view to corrected desired position
- Click on the Update icon in the Animation pane (the parameters for that row will all change)

*To add and rearrange viewpoints:*

- Position the view as desired
- Click on the Append icon to capture that view. This will add another viewpoint to the *end* of the list.
- Re-order the list of viewpoints such that the new position is where it was intended to be, by clicking on the row to be moved and then click on the Move Up icon.

#### **7.2.2.2. Change animation length**

- On the Animation pane, click on the Settings icon.
- Duration (s): (as appropriate)
- Use all remaining default settings

#### **7.2.2.3. Change transition speed between viewpoints**

- In the Animation pane, Right click on viewpoint: Modify...
- Column: Speed (%)
- Value: (as appropriate)



## 8. CONCLUSION

This document provides a Standard Operating Procedure (SOP) for the generation of standardised three-dimensional models of underwater targets.



## 9. APPENDICES

### 9.1. Appendix 1

Table 1: Suggested keyboard shortcuts

<b>Space bar</b>	Switches between last 2 used functions (i.e. selection tool & navigation tool)
<b>5</b>	Perspective/Orthographic (View Mode)
<b>9</b>	Stereo Mode (View Mode)
<b>7</b>	Top (Predefined Views) - planar view, looking down
<b>Ctrl + 7</b>	Bottom (Predefined Views) – planar view, looking up
<b>0</b>	Reset View (View)
<b>F11</b>	Full Screen (View)
<b>Ctrl + M</b>	Shows Markers (Show/Hide Items)
<b>Ctrl + I</b>	Show Images (Show/Hide Items)
<b>Ctrl + C</b>	Show Cameras (Show/Hide Items)
<b>Ctrl + A</b>	Add Marker (Markers)
<b>Ctrl + X</b>	Invert Selection (Model)
<b>Ctrl + D</b>	Delete Selection (Model)
<b>Ctrl + Shift + A</b>	Add Selection (Photo)
<b>Ctrl + Shift + S</b>	Subtract Selection (Photo)
<b>Ctrl + Shift + I</b>	Invert Selection (Photo)

