DEPARTMENT OF TRANSPORTATION

Multi-Beam Sonar Infrastructure Mapping Research

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Collins Engineers, Inc.

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The hydraulics unit in MnDOT's bridge office applied for a research grant to develop in-house underwater acoustic 3D imaging capabilities. This research report presents both stationary and mobile scanning techniques, outlines the setup of both systems, discusses field operations, summarizes the data analysis and post-processing of images, and reviews lessons learned. Several case studies will frame a discussion of the capabilities and limitations of 3D acoustic imaging for underwater bridge inspection. The case studies provide examples of different applications of this technology. Underwater acoustic imaging has been shown to have real value to bridge inspectors and owners for a variety of applications.

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EXECUTIVE SUMMARY

In the fall of 2012, the hydraulics unit in MnDOT's bridge office applied for a research grant to develop in-house underwater acoustic 3D imaging capabilities. This research report presents both stationary and mobile scanning techniques, outlines the setup of both systems, discusses field operations, summarizes the data analysis and post-processing of images, and reviews lessons learned. Several case studies frame a discussion of the capabilities and limitations of 3D acoustic imaging for underwater bridge inspection. The case studies provide examples of different applications of this technology. The primary case studies include the following bridges:

- Bridge 2440 – Third Avenue
- Bridge 4654 – Stillwater Lift
- Bridge 67805 & Bridge 67806 – Luverne
- Bridge 9040 – Red Wing

The variety of applications explored in these case studies include the documentation of large-scale underwater defects, construction inspection confirming as-built conditions, rapid condition assessment following a flood event, determination of scour extents and foundation exposure, as-built and site conditions for construction pre-planning, and diver safety and efficiency improvements for challenging dive conditions.

Underwater acoustic imaging has been shown to have real value to bridge inspectors and owners for a variety of applications. The following is a list of recommendations to aid in the safe and efficient adoption of this technology in the state:

- Develop and publish MnDOT underwater imaging policy
- Provide outreach to MnDOT districts, counties, cities and other bridge owners in the state informing of MnDOT bridge office's imaging capabilities and expertise
- Develop adequate post-processing capabilities and data storage of completed projects
- Generate a list of bridges suitable for underwater imaging, look for input from bridge owners across the state
- Provide indication in bridge record that underwater imaging of bridge exists and is available for review
- Ensure field personnel performing underwater imaging are properly trained in both bridge inspection and underwater imaging techniques

CHAPTER 1: INTRODUCTION

In the fall of 2012, the hydraulics unit in MnDOT's bridge office applied for a research grant to develop in-house underwater acoustic imaging capabilities. As part of this effort, MnDOT purchased a multi-beam sonar from Teledyne Technologies, Inc.

According to the 2016 National Bridge Inventory data, Minnesota has 13,355 bridges, 11,183 of these structures span waterways, and 306 are scour critical. Approximately 585 bridges in the state's inventory require an underwater bridge inspection. The use of underwater acoustic imaging is becoming more common as bridge inspectors and owners use this technology to supplement the current requirements of the National Bridge Inspection Standards (NBIS) with regard to underwater inspections.

1.1 BACKGROUND AND LITERATURE REVIEW

In general, underwater imaging is a broad term that that encompasses a wide variety of technologies. Optical technologies, such as underwater photography and videography, and non-optical technologies, such as sonar, laser, and radar, have all been used to produce underwater images. Sonar relies on sound to detect objects. Sonar technologies can be classified into two general categories based on the kind of data produced, two-dimensional models and three-dimensional models.

This discussion is limited to underwater sonar producing three-dimensional models, specifically multi-beam sonar. The creation of a 3D point cloud is valuable because it allows dimensions/volumes to be taken and also creates images that are understandable to most viewers.

When applied to underwater inspection, sonar can be a useful tool. Federal Highway Administration Underwater Bridge Inspection Manual (FHWA-NHI-10-027) outlines some uses, including enhancing inspection diver safety and making evaluations of bridge substructures in emergency situations where water conditions preclude deploying divers. The underwater environments of many bridges can have swift moving and sediment filled water that makes sonar a prime candidate for collecting underwater images.

A multi-year Transportation Pooled Fund study titled "Underwater Inspection of Bridge Substructures Using Underwater Imaging Technology," (TPF-5(131), is complete and awaiting public release. TPF-5(131) is a comprehensive investigation of the entire range of underwater imaging technologies. One important conclusion of TPF-5(131) is that sonar technology may be acceptable as a Level I intensity effort for underwater inspection.

1.2 RESEARCH OBJECTIVES

The objective of this research is to outline the steps taken to establish the in-house underwater acoustic 3D imaging capability of the MnDOT bridge office's hydraulic unit. This research report presents the setup of the system, discusses field operations, presents the data analysis and post-processing of images, and summarizes lessons learned. Several case studies will frame a discussion of the capabilities

and limitations of 3D acoustic imaging for underwater bridge inspection. In particular, this discussion will present examples of this technology in use including: documentation of large-scale underwater defects, construction inspection confirming as-built conditions, rapid condition assessment following a flood event, determination of scour extents and foundation exposure, as-built and site conditions for construction pre-planning, and diver safety and efficiency improvement for challenging dive locations.

1.3 PROJECT ACTIVITIES

For the sonar technology, the unit used was the Teledyne Blueview BV5000 multi-beam sonar. The system functions by mechanically rotating a sonar head and combining vertical sonar slices into a final 3D point cloud. In addition to this hardware, Blueview Proscan software was used in the collection of field data. Some basic hardware specifications for this model include:

- Operates at 1350 kHz
- 256 beams with 45^{o} view
- Beam width = 1^{o}
- Beam spacing = .18^{o}

The system can be deployed in two distinct modes: stationary and mobile. Both modes typically require the use of a boat. Although for the stationary method the unit can be deployed using drops from the bridge deck or from an articulated arm of a vehicle from the roadway above. This discussion will be limited to the boat deployment method for both modes. The MnDOT bridge office's boat, a 20' long Kann aluminum flat bottom work boat with twin 50-hp mercury motors, was used for the entire project and will be referred to throughout this report as the boat.

Regardless of the deployment method, the sonar data should be calibrated to the sound velocity conditions present at the site during the time period of the scanning. This is typically accomplished with the use of a sound velocity probe.

1.3.1 Stationary Scanning System Setup and Field Data Acquisition

When performing stationary scans, the sonar needs to be used in conjunction with a mechanically scanning pan and tilt unit. This pan and tilt unit allows the sonar to rotate through the full range of angles with precisely known positioning at all times.

For stationary scanning, there are three basic deployment methods: tripod, metal plate, and boat-mounted surface. Each method was used during the course of the project. The existing setup of the boat was used without significant modification. Refer to Figure 1-1 for an annotated view of the boat illustrating existing aspects of its design useful in the application of this technology.

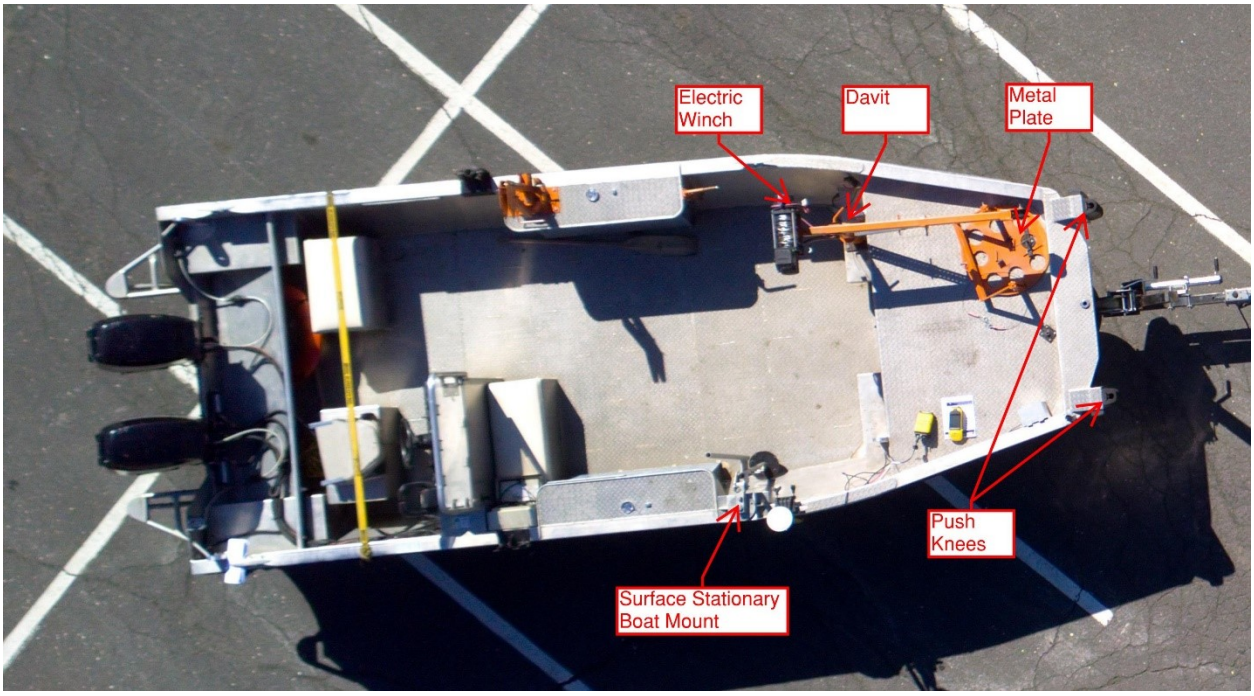


Figure 1-1: MnDOT Bridge Office's Boat Overview for Stationary Scanning

A summary of the required hardware and software for stationary scanning is listed below.

- Deployment of choice (boat mount, tripod, plate)
- Pan and tilt unit
- Field computer
- Sound velocity probe (or other instrument to measure sound velocity indirectly)
- Sonar software (to operate the sonar unit)

The specifics of the MnDOT equipment setup (equipment brand names, etc.) can be found in Appendix A.

1.3.2 Stationary Scanning Data Analysis and Post-Processing

This type of deployment utilizes the center of the sonar head as the baseline coordinates (center of head has coordinates 0, 0, 0). When the sonar is moved to a new location, it will produce a scan that does not have unique coordinates and is not georeferenced to real coordinates or to previous scans. This creates a unique problem during the post processing stage that requires repositioning the individual scans in space and reassigning of coordinates of each of the unique points within the cloud. This process is completed with the use of Leica Cyclone software. Parts of this process can also be completed with other point cloud software, such as Cloud Compare or Blueview Quick Stitch.

The data from stationary scans must be post-processed to create useable images. Most piers or scanned areas are made up of a number of different scans that need to be combined and processed further. The

raw field data output is .xyz file type. The following is a basic breakdown of the post-processing steps required for stationary datasets:

- Create project in Cyclone
- Import raw field data from scans
- Clean each set of data in Cyclone, removing points deemed to be noise
- Create waterline reference and orient coordinate system so z-axis is normal to water surface in each scan
- Export to Quick Stitch for first scan
- Align registered data of each scan to fit following Quick Stitch protocol
- Continue to process cleaned additional scans one at a time until registration containing all scans is finished
- Finish cleaning process by removing any additional noise and trim edges where data density may not meet required levels and export each to Cyclone as separate .xyz files
- Estimate Cloud Normals for all clouds (optional depending on required sharpness of data)
- Perform final registration with all clouds and optimize cloud alignment
- Organize and separate dataset into different layers, (e.g., channel bottom, pier wall, debris, etc.)
- Export each layer as an .xyz layer
- Open Cloud Compare and import each file containing the separate layers
- Color shade each material differently to finalize desired look

Additional training and help for the Quick Stitch software is available from Teledyne Blueview.

Alternative process using only Cyclone and Cloud Compare software:

- Create project in Cyclone
- Import raw field data from scans
- Clean each set of data in Cyclone, removing only points deemed to be noise
- Create waterline reference and orient coordinate system so z-axis is normal to water surface in each scan
- Export to Cloud Compare and estimate Cloud Normals for first scan
- Align registered data of each scan to rough fit
- Import registered and rough fit scans back to Cyclone and estimate Cloud Normals of second scan
- Complete more refined registration of scans once Cloud Normals are computed
- Continue to process cleaned additional scans one at a time until registration containing all scans is finished
- Finish cleaning process by removing any additional noise and trim edges where data density may not meet required levels and export each to Cyclone as separate .xyz files
- Estimate Cloud Normals for all clouds (optional depending on required sharpness of data)
- Perform final registration with all clouds and optimize cloud alignment
- Organize and separate dataset into different layers, (e.g. channel bottom, pier wall, debris, etc.)

- Export each layer as an .xyz layer
- Open Cloud Compare and import each file containing the separate layers
- Color shade each material differently to finalize desired look

Detailed stationary post-processing instructions for the MnDOT specific setup are included in Appendix B.

1.3.3 Mobile Scanning System Setup and Field Data Acquisition

For mobile scanning, the boat requires precise setup and mounting of additional hardware. In addition to the sonar head, this technique requires a significant amount of additional software and hardware beyond the requirements for stationary scanning, including the following:

- Stable mount that can scan at fixed head angles
- Hypack Software or equivalent multibeam software
- Motion Reference Unit (MRU)
- Dual Antenna GPS unit (location and heading)
- Pulse Per Second Timing Box (PPS) – optional, dependent on sonar unit
- Power source (Generator)
- Wifi or other internet connection
- NTRIP or other software for GPS correction (if connecting to a real-time GPS correction data site)
- GPS Base station (ONLY if correcting the GPS signal in real-time with a base station)

Note: Some of this equipment can be purchased together as units, such as a combination GPS and MRU unit.

Refer to Figure 1-2 for a schematic of the mobile scanning setup.

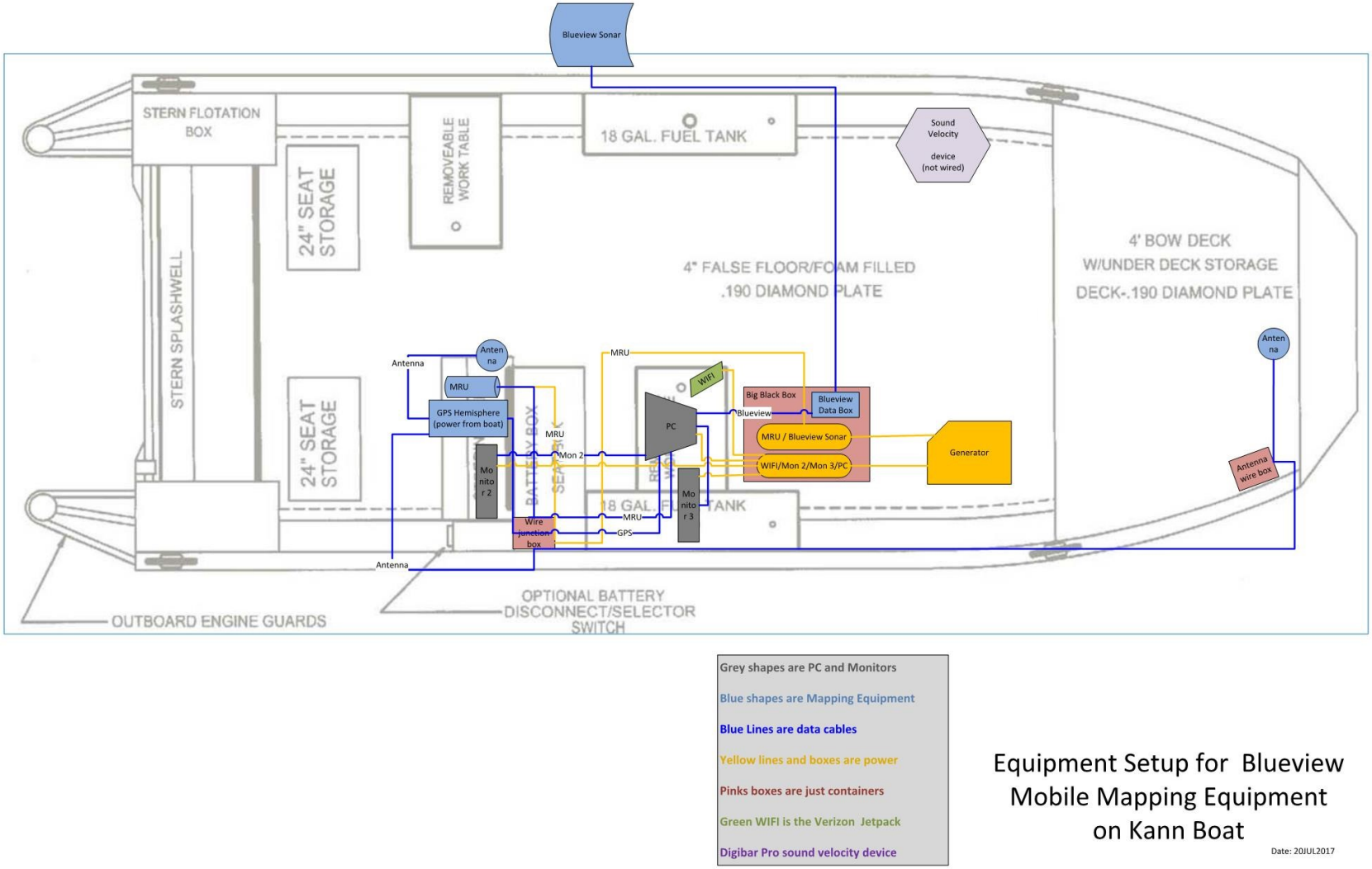


Figure 1-2: Mobile Scanning Setup Schematic

1.3.4 Mobile Scanning Data Analysis and Post-Processing

The data from both stationary and mobile scans must be post-processed to create useable images. For stationary scans, post-processing requires the stitching together of different scans. For mobile scans, the setup of the system requires different tests to be performed prior to collecting data.

Like the stationary scans, the data from mobile scans must be post-processed to create useable images. The raw field data output is .xyz file type. Hypack is used in both the collection and post processing of mobile sonar imagery. While the number of separate scans for a mobile application requiring stitching may be less, the datasets themselves from mobile scanning usually consist of many more data points. It is possible that stitching of stationary datasets with a mobile dataset may be required depending on site-specific limitations imposed on the collection of data. Both stationary and mobile datasets may be required where GPS signal is lost (i.e., under a bridge). The following is a basic breakdown of the set-up and post-processing steps in Hypack required for mobile scanning:

- Establish coordinate system in Hypack
- Bring in background charts, or create georeferenced map using Google Earth
- Create matrix to delineate area of data capture
- Create planned lines needed for patch testing and during scanning
- Determine sound velocity and download and process the velocity cast
- Conduct patch tests
- Collect field data
- Start post-processing and clean data with MBMAX 64
- Perform patch test processing

Detailed multibeam collection and post-processing instructions for the MnDOT specific setup are included in Appendix C.

CHAPTER 2: PROJECT FINDINGS

2.1 STATIONARY SCANNING

The tripod drop method utilizes a three legged platform that is lowered to the channel bottom from the boat, or bridge deck / other platform. During scanning the only connection between the boat and the sonar unit is the data cable and tripod line. The boat does not have to remain stationary, although consideration should be given to boat movement and possible entanglement issues as a result of the boat's path between deployment and recovery. The tripod allows the sonar head to scan from a location located near, but not on the channel bottom. This provides a viewing angle that has fewer shadows due to debris on the channel bottom than the plate mount but increases resolution of deep items in comparison to boat mounting.

Figure 2-1: Tripod Stationary Deployment Method

The tripod method is generally a stable platform once in place on the channel bottom, but additional weight may be required to get the unit to reach and stay firmly in contact with the bottom, especially at sites with excessive current or depth.

The metal plate deployment method utilizes a heavy metal plate platform that is lowered to the channel bottom from the boat. It is similar to the tripod drop method in that the only connection between the boat and sonar unit during scanning is the data cable and plate line. The boat has a bow mounted davit with electric winch that aids in deployment and recovery of the metal plate setup. Unlike the tripod drop method, the metal plate method places the sonar head directly on the channel bottom. This causes large acoustic shadows from any debris on the channel bottom but provides the benefit of a viewing angle that can be used for imaging foundation undermining and exposed piling.

Figure 2-2: Metal Plate Stationary Deployment Method

The boat mounted surface deployment method utilizes the boat as the scanning platform. Unlike the two previously outlined methods, the sonar head is attached directly to the boat so it is important that the boat remain stationary during scanning. Often this is achieved by using the motor to steadily push the bow of the boat against the structure for the duration of the scan. The boat has push knees on the bow which are invaluable for this deployment method. Also, because this method positions the sonar head near the water surface, it creates a top-down view resulting in minimal acoustic shadows and higher resolution of objects located high in the water column.

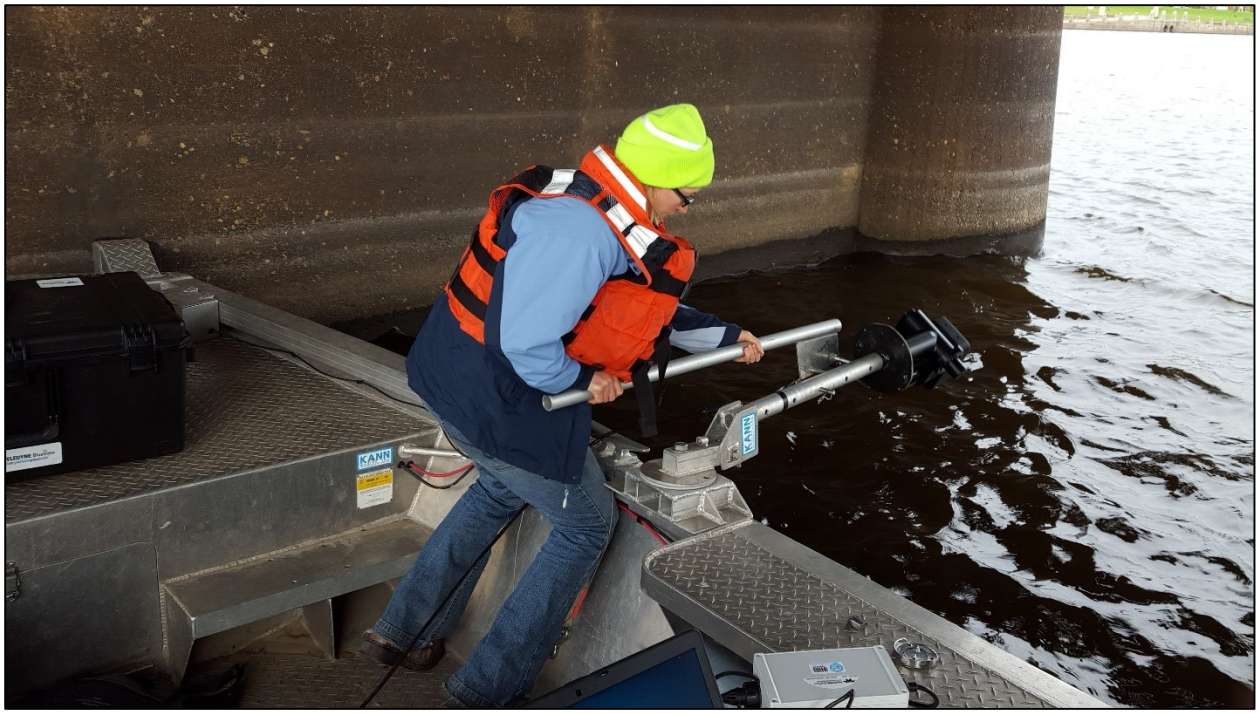


Figure 2-3: Boat Mounted Surface Stationary Deployment Method

The boat mounted deployment method is the preferred and most often used method for the following reasons:

- Top-down (eagle-eye) viewpoint
- No need to deploy anything down to the bottom where it might snag or get stuck.
- Quickest method to deploy and complete data collection

2.1.1 Lessons Learned – Stationary Scanning

The following are stationary equipment and data collection lessons learned:

- The tripod can get caught up on debris on the river bottom. A boat mounted surface stationary deployment method should be used initially to see if debris is an issue at your site. You may want to have divers on standby so you can retrieve the equipment if it gets stuck.
- Power source is key. A small generator is now used to power the equipment. MnDOT selected a Honda EU1000i inverter generator, which is quiet and powerful enough to run all of the necessary equipment.
- Make sure the unit is correctly placed in the pan and tilt unit. There are two ways the sonar head can be attached to the pan and tilt.
- Junction box for the sonar unit may overheat, causing system shutdown. Shade junction box or vent if possible.

- Settings for the sonar IP address (to connect to the sonar unit) can be interrupted if/when you network your field computer. Either create a batch file to set the IP address to static versus networked conditions, or refrain from networking your field computer.
- Collect a water surface elevation onsite, to allow you to assign elevations to your point cloud during processing.

The following are stationary data analysis and post-processing lessons learned:

- Cleaning of the data is easiest in Cyclone
- Translation is best done in Quick Stitch, or Cloud Compare if unavailable.
- Best graphics/display properties are done in Cloud Compare

2.2 MOBILE SCANNING

The mobile scanning deployment method utilizes the boat as a moveable platform. This process is much more complicated to setup in the field, but saves a large amount of time in the post processing stage. Like the boat mounted surface stationary deployment method, the sonar head is positioned near the water surface and mounted directly to the boat. However, unlike the stationary method the boat is free to move around the structure and scan continuously. The mechanical stepping motor is also removed to create a more stable and fixed mounting of the sonar head.

The real time correction for the movement of the sonar head requires a more complicated setup with additional hardware and software, outlined in Section 1.3.4 and Appendix C. Where the stationary methods require a number of scans to be post-processed and stitched together to get a complete scan of a structure underwater, the mobile scanning produces one data set. The data sets from mobile scanning can be augmented with various stationary deployment techniques to image portions of the structure which may not be easily imaged from a near surface position (e.g. undermining of a pier's foundation).

Figure 2-4: Boat Mount for Mobile Deployment Method

2.2.1 Lessons Learned – Mobile Scanning

The following are mobile scanning equipment and data collection lessons learned:

- Data collection and equipment initial set-up can be difficult. Precise measurements of your equipment in relation to the center of the boat (center of mass) and the sonar head is necessary for equipment offsets in the collection software.
- Dual monitors for the equipment operator (preferred), and a separate mounted monitor for the boat operator is necessary for proper multibeam collection.
- Prepare a “spaghetti” or “barney” box to contain all of your cords and power connections to limit cord interference with movement around the boat.
- Keep both an electronic copy and paper copy in a field binder of all of your equipment settings (offsets, communication settings, connections) for easier troubleshooting during collection, and for knowledge transfer to new employees.
- Establish and check all of your equipment and communication settings prior to deployment on the water.

- A GPS-aided inertial navigation system may be a better navigational choice for scanning under and near structures. Standard GPS systems may lose position and heading without line of site to satellite systems.
- Patch testing runs are required every time your equipment set-up changes (i.e. sonar head angle, GPS antenna location, MRU location or orientation), and periodically to check for consistency even if you use the same equipment set-up.
- Complete site planning and preparation in the office if possible. Bring in georeferenced images, set-up necessary matrices, and layout planned survey.
- Collect water surface elevation to verify "tide" elevation collected from the GPS unit.

The following are mobile scanning data analysis and post-processing lessons learned:

- Purchase a second software license (desk copies are available and are less expensive), to allow for another person to process while another is in the field.
- Save a final .xyz file from Hypack by changing the matrix cell size in MBMax to whatever size you want for your tin model size. Bring out 1 point per cell.

2.3 OVERALL LESSONS LEARNED

The following are overall best practices and suggestions from the research project experience:

- Power source is key. A small generator is now used to power the equipment. MnDOT selected Honda EU1000i inverter generator, which is quiet and powerful enough to run all of the necessary equipment.
- Complete all data processing for both stationary and mobile scanning in one set of units (metric or english).
- Attend Hypack or other training available for underwater imaging. The learning curve is steep, especially for mobile (multibeam) data collection and processing.
- 3D imaging results are hard to show in a report. Recommend doing video reports to show the complexity of the finished product and where any problems are.

CHAPTER 3: CASE STUDIES

3.1 BRIDGE 2440 – THIRD AVENUE

Bridge 2440 is an open spandrel concrete arch which carries 3rd Avenue over the Mississippi River upstream of Upper St Anthony Falls in Minneapolis, MN. During the 2012 underwater inspection of the bridge a previously unnoted area of undermining was discovered at the upstream end of Pier 5. The undermining was noted as a cavity measuring up to 3 feet high with a maximum penetration of more than 14 feet. The reinforced concrete piers of the bridge have spread footing founded on bedrock. Given the discovery of this defect during the routine underwater inspection and the foundation type, a special in-depth underwater investigation was required to determine next steps and possible repair options.

With the MnDOT bridge office, Teledyne Blueview scanned Pier 1 and Pier 5 of the bridge on February 26th and again on March 18th, 2014. Evidence of the undermining and concrete deterioration was confirmed with these initial scans. Figure 3-1 shows a view of the 3D point cloud from these initial scans of Pier 5.

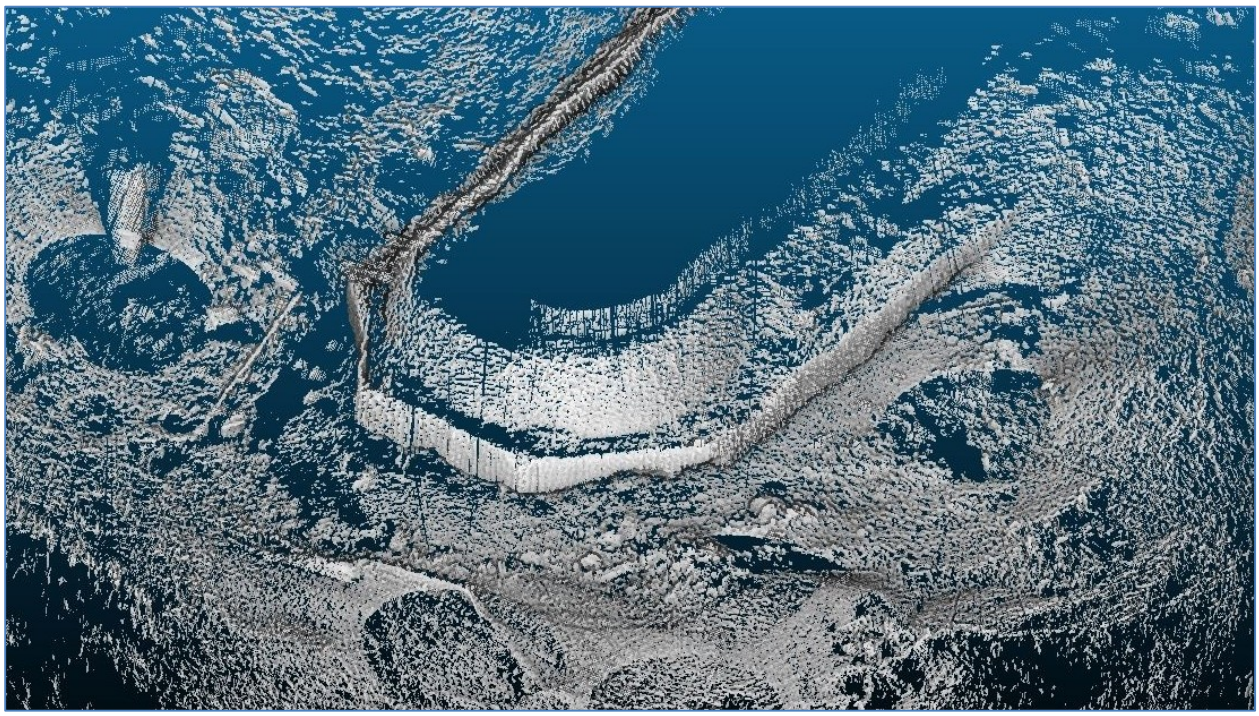


Figure 3-1: Bridge 2440 Pier 5 Initial Scan

The link below redirects to a video outlining the initial application of underwater imaging at this site.

https://www.youtube.com/watch?v=g1-ZssO04D8

In the summer of 2015, underwater imaging was utilized to assist in repairing the undermining and concrete deterioration. Additional scanning activities were used to confirm proper construction of the

repairs and to document as-built conditions as shown in Figure 3-2. Scans were completed using the tripod mount, with the tripod placement done by divers.

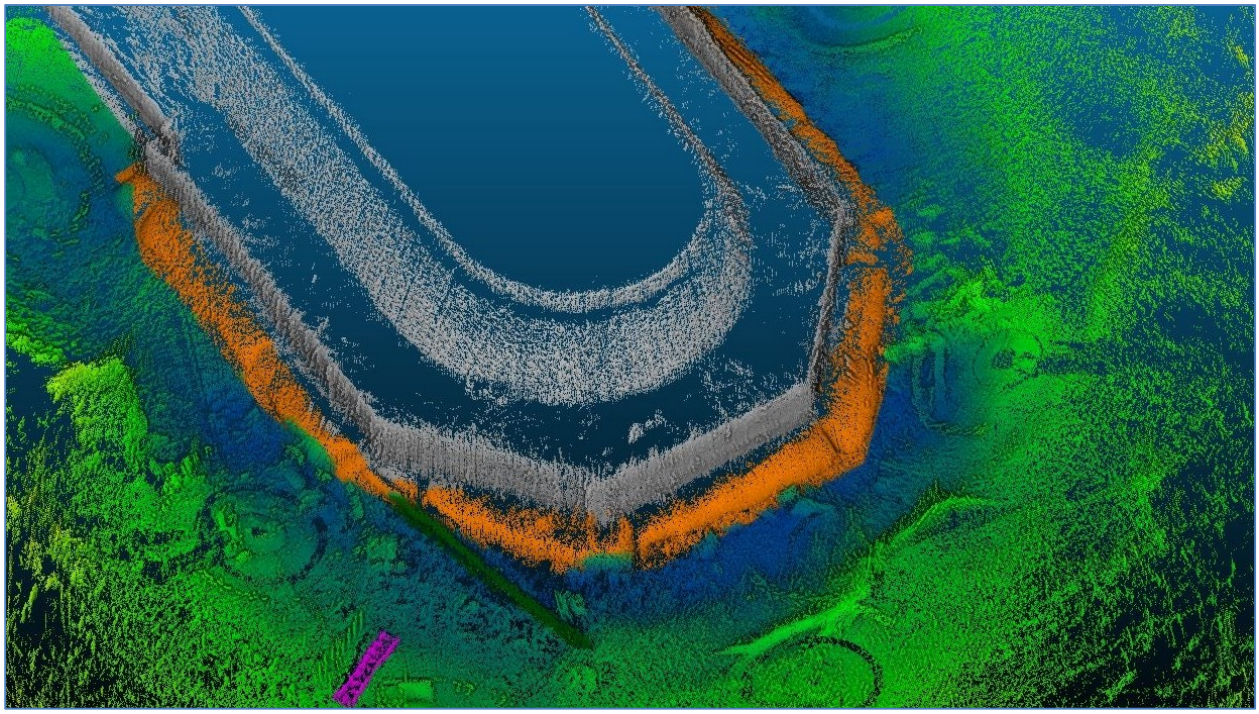


Figure 3-2: Bridge 2440 Pier 5 Post Repair Colorized Point Cloud

The link below redirects to a video outlining the post-construction application of underwater imaging at this site.

https://www.youtube.com/watch?v=U2_0pZ1hffw

3.2 BRIDGE 4654 – STILLWATER LIFT

The Stillwater Lift Bridge is a 10-span bridge with six steel through truss spans and one vertical lift span which carries State Highway 36 over the St. Croix River, in Stillwater, MN. The 2013 underwater inspection report noted the full footing height (4 feet vertically) of Pier 8 was exposed around the entire perimeter, and the seal was exposed at the upstream nose.

On October 13, 2015 the MnDOT bridge office scanned Pier 8 using all three stationary deployment techniques. The underwater imaging of Pier 8 is an example of using this technology to determine the extents of scour and footing exposure.

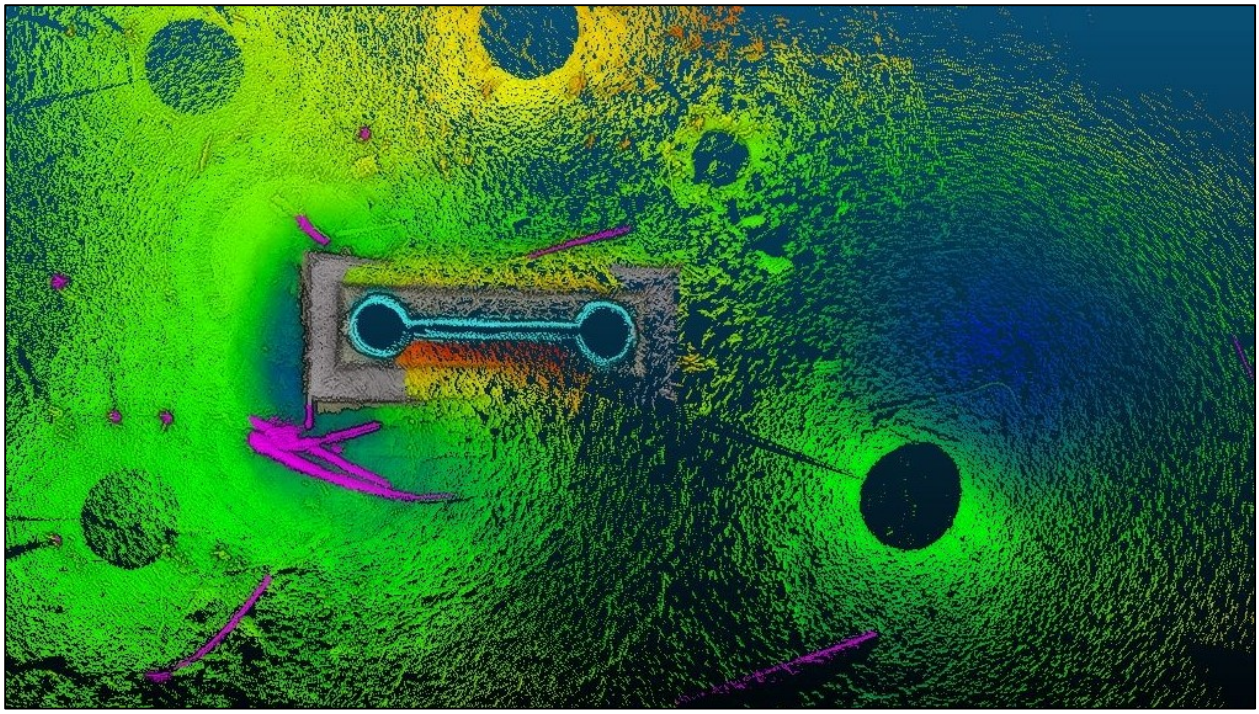


Figure 3-3: Bridge 4654 Pier 8 Colorized Point Cloud Plan View

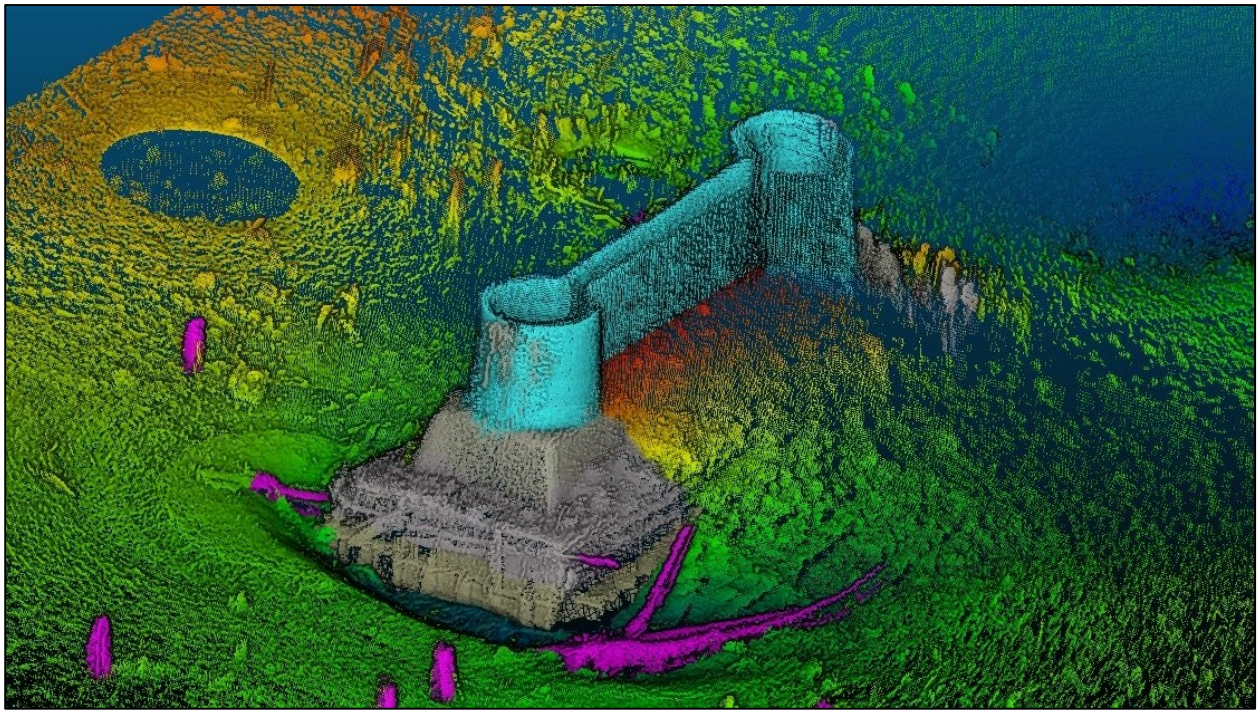


Figure 3-4: Bridge 4654 Pier 8 Colorized Point Cloud Upstream Isometric View

The link below redirects to a video outlining the application of underwater imaging at this site.

https://www.youtube.com/watch?v=9jtVPsNuQ9M

3.3 BRIDGE 67805 & BRIDGE 67806 – LUVERNE

Bridges 67805 and 67806 are each 3 span continuous steel girder bridges carrying I-90 over the Rock River near Luverne, MN. In June of 2014, following heavy rains, an upstream damn failed essentially emptying Split Rock Lake. This wall of water eroded the streambed and overtopped I-90 closing the interstate. Bridges 67805 and 67806 were monitored during this event and it was noted that scour had occurred but not to the scour critical level.

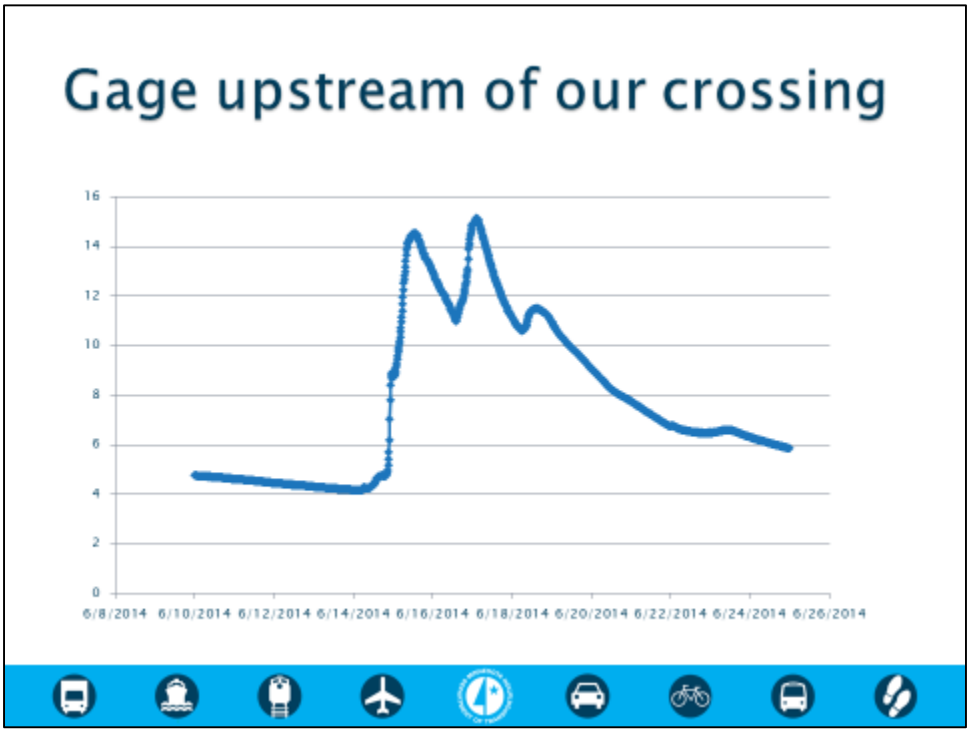


Figure 3-5: Rock River Gage Height During Heavy Rain Events and Dam Failure

In December of 2015 debris got caught up on the bridge and maintenance forces noticed that the erosion that occurred in 2014 had not filled back in.

The bridges were initially scanned on December 14, 2015 using a number of stationary scans, using the boat mounted scanning technique. The scans showed significant scour and undermining at all the piers of both bridges. Pier 2 of Bridge 67805 had a maximum of 8 vertical feet of undermining. Timber debris stuck in the pile group was also noted at this pier. The scanning was able to confirm that the scour critical elevations for these piers had not been reached. Figure 3-6 shows an overview of one pier from this initial scanning effort:

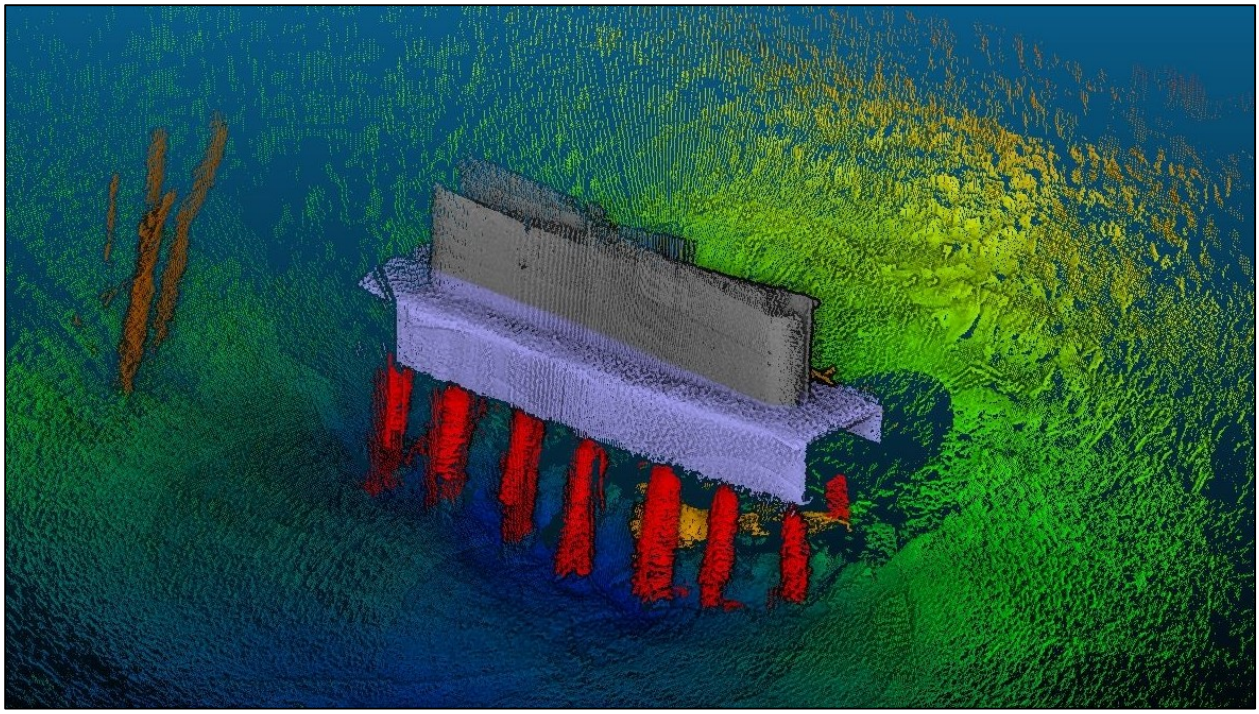


Figure 3-6: Bridge 67805 Pier 2 2015 Scan Colorized Point Cloud

This example shows value of scanning for rapid condition assessment following a flood event, and its value in determining scour extents and foundation exposure. The link below redirects to a video outlining the initial application of underwater imaging at this site.

https://www.youtube.com/watch?v=KKP3qKvPlQA

It was decided that these piers should be protected as long term exposure of the piles could create problems with deterioration of the piles and debris catching on them creating scour formation. Repairs were planned for the next construction year.

On October 6, 2016 these bridges were rescanned using stationary deployment techniques as the contractor noted that changes had occurred at the site. The channel had begun filling back in so the bridge was scanned to determine changes to the plans that were drawn from the December 2015 scans. The link below redirects to a video outlining the 2016 scans:

https://www.youtube.com/watch?v=JENm_3owm7k

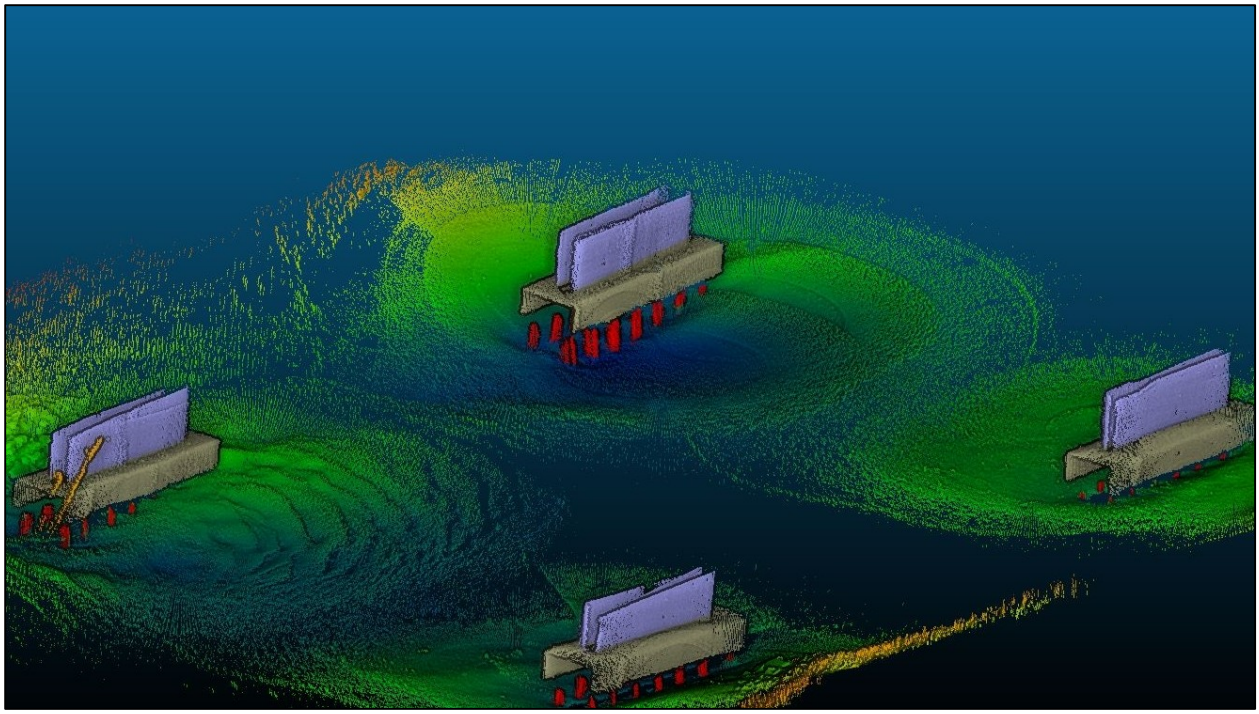


Figure 3-7: Bridges 67805 & 67806 Combined 2016 Scans Colorized Point Clouds

3.4 BRIDGE 9040 – RED WING

Bridge 9040 is a cantilevered through truss spanning the Mississippi River carrying U.S. 63 from Wisconsin to Red Wing, MN. As part of an ongoing replacement project, the bridge office completed 3D underwater scanning of Pier 2 and the main channel in September 2016. A new bridge is planned for the site directly upstream and adjacent to the existing bridge. The purpose of the scan was to locate the upstream edge of the Pier 2 footing and seal and provide as-built information to be used in pre-construction planning and bid documents.

After scanning and processing was completed, the upstream edge of the Pier 2 footing was located, but further investigation was needed to determine the location of the seal. Collins Engineers performed the routine underwater inspection of this bridge in November 2016. Using the 3D scan and previous plan information, the dive inspection confirmed the location of the upstream corner of the seal.

The scan and subsequent dive inspection provided valuable as-built information concerning the location of the seal. This information was useful for the construction pre-planning and generation of bid documents. The scan also provided up-to-date- information about the site and was useful in dive planning, ultimately improving diver safety and efficiency.

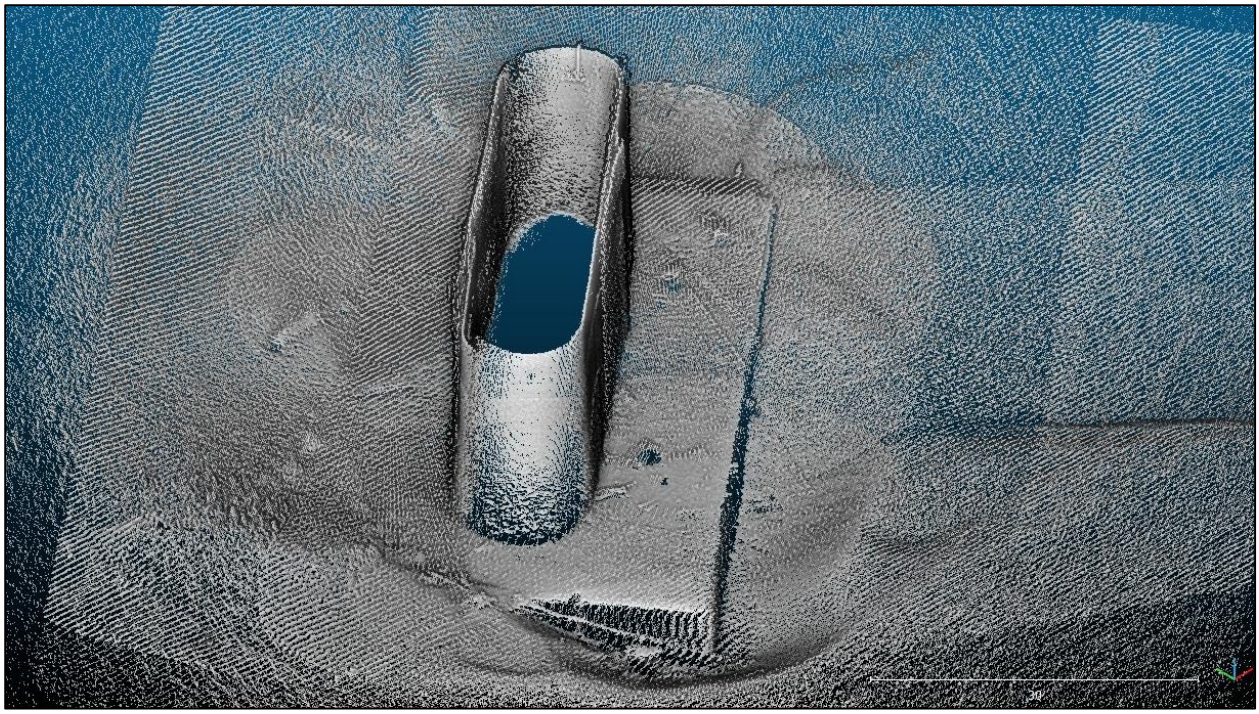


Figure 3-8: Bridge 9040 Pier 2 Upstream End

The link below redirects to a video outlining the application of underwater imaging at this site.

https://www.youtube.com/watch?v=rfAewqzFQaA

3.5 OTHER EXAMPLES

3.5.1 Bridge 19004 - Hastings

This is an example of a post construction scan. It was undertaken because the previous bridge at this site had scour issues and was rated scour critical. The scan was done to create a baseline so future scans have something to compare to. The MnDOT bridge office hydraulics unit is currently advising that all major construction projects have scans taken before the contract is closed out. As evidenced in Figure 3-9, a lot of debris was left behind by the contractor.

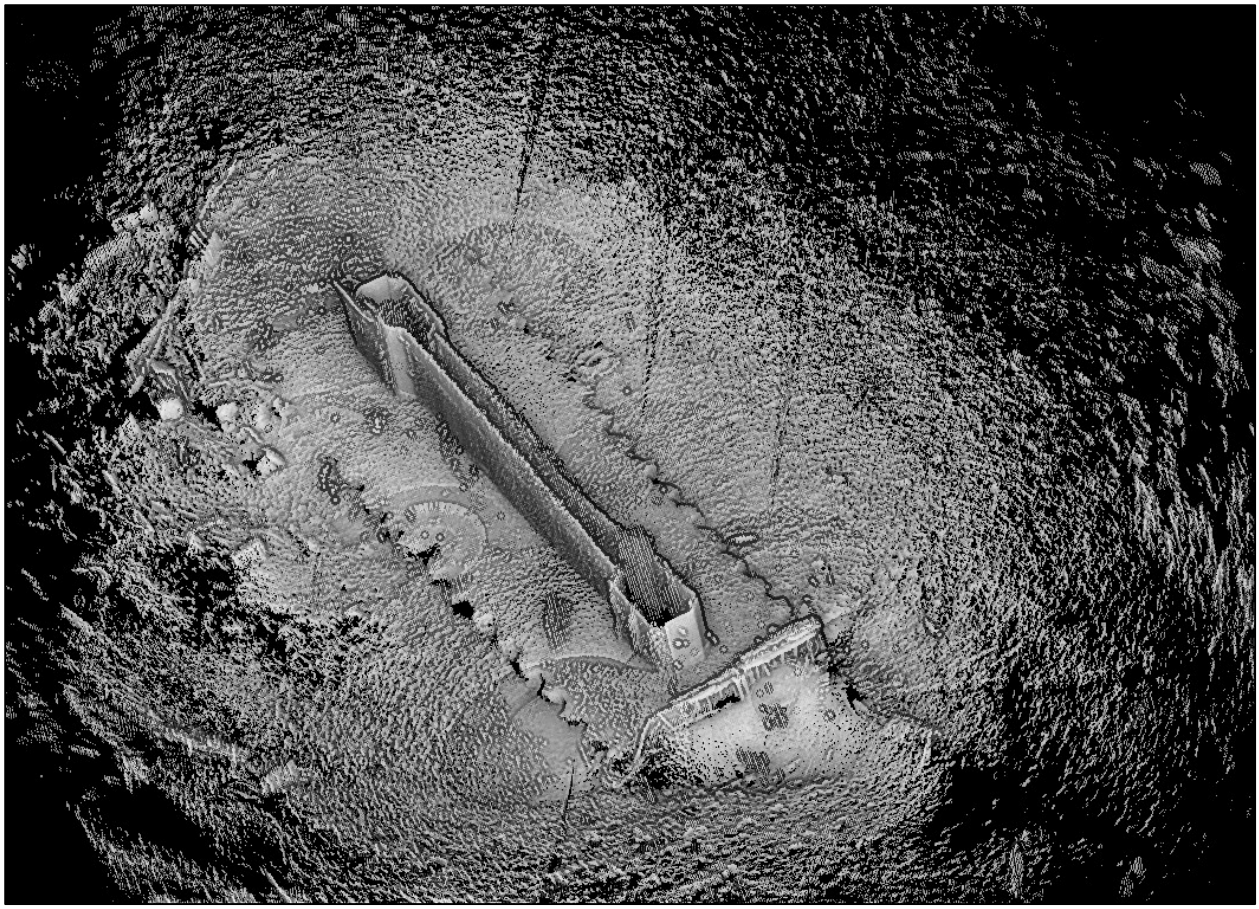


Figure 3-9: Bridge 19004 Post-Construction Scan

3.5.2 Bridge 5327 - Thief River Falls

This is an example of a post construction scan. This bridge was considered scour critical. A unique scour protection plan was constructed with micro piles and riprap protection. The scan was done to verify the contractor installed the micro piles and riprap protection per the contract. The MnDOT bridge office hydraulics unit is currently advising that all scour construction projects have scans taken before the contract is closed out. Figure 3-10 shows an example of the micro piles installed, and riprap placed inside of the micro piles, as per the plan.

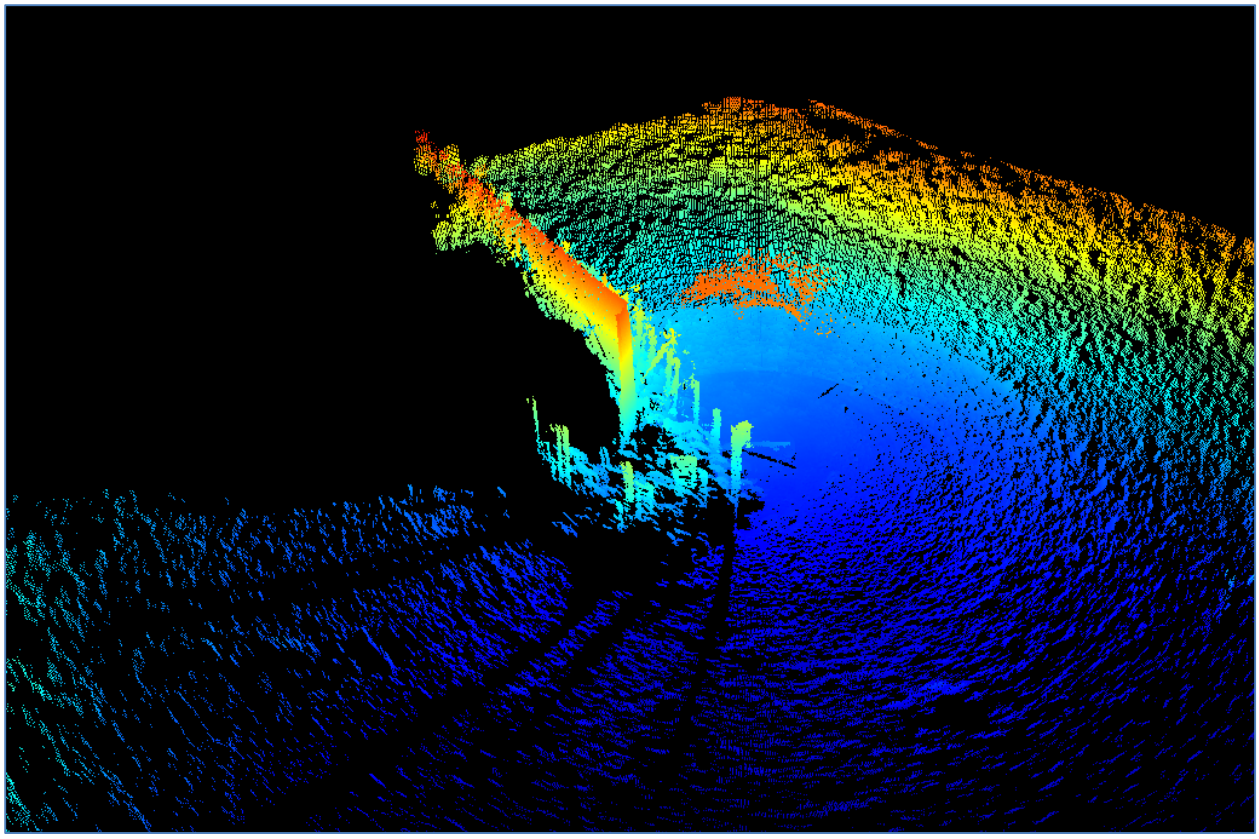


Figure 3-10: Bridge 5327 Post-Construction Scan

3.5.3 Bridge 62090 – Smith Avenue High Bridge

This is an example of a pre-construction informational scan. The High Bridge is slated for major rehabilitation in 2017. The design team wanted to know the river bottom topography to plan for construction staging, and look for any potential underwater issues. Mobile (multibeam) scanning was completed for nearly 100-percent coverage of the channel bottom. A very detailed contour map and tin model (microstation) was delivered as the final product to the designer.

Figure 3-11: Bridge 62090 Pre-Construction Contour Map

3.5.4 Bridge 40001 – Henderson

This is an example of a pre-construction hydrographic scan. The mapping/survey was completed to provide bathymetry for an extensive 2-dimensional (2D) hydraulic model of the Minnesota River near Henderson, MN. The model was over 32-miles long, so extremely detailed bathymetry was not required for the entire reach. The model was completed as part of the Henderson Flood Mitigation Feasibility Study. Figure 3-12 shows the bathymetry scatter set inside of the 2D model. The link below redirects to a video outlining the application of underwater imaging at this site.

https://youtu.be/zjypv7EXnMw.

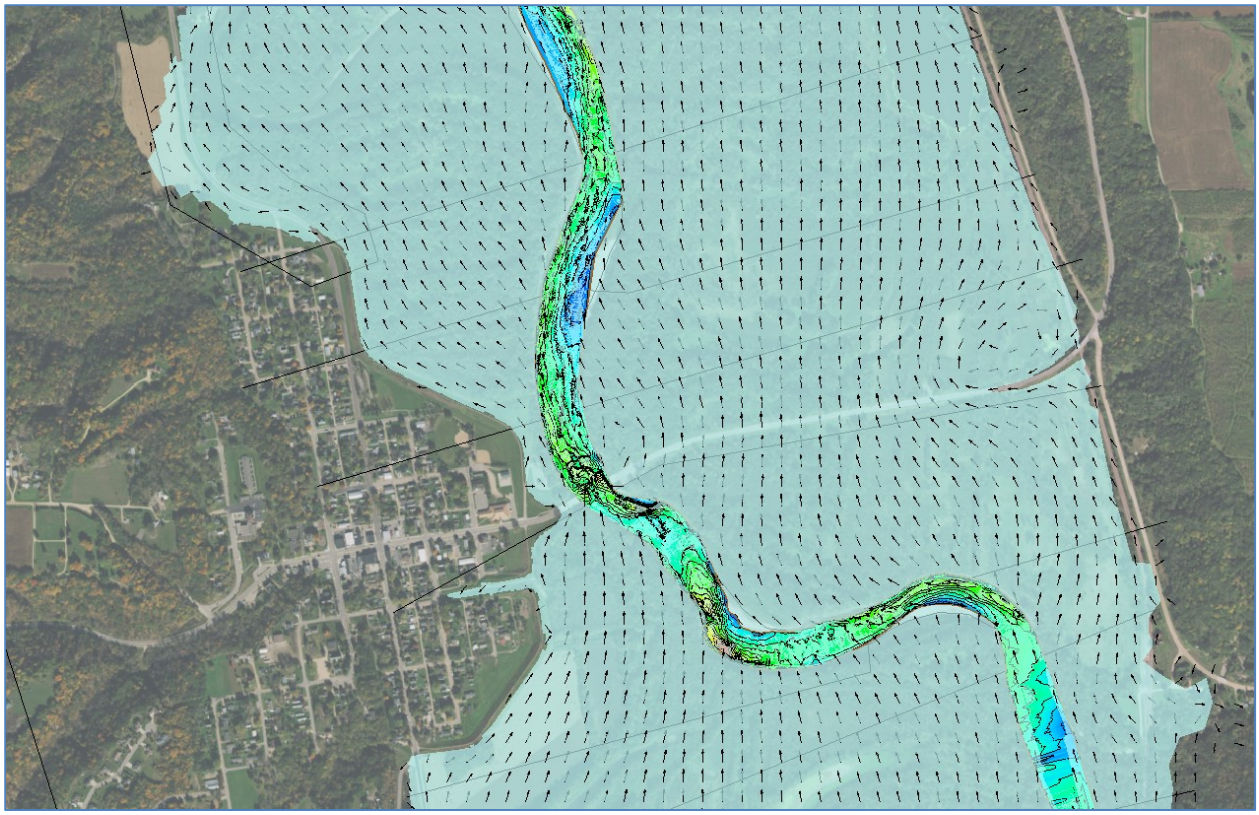


Figure 3-12: Bridge 40001 Pre-Construction Hydrographic Scan

3.5.5 Bridge 85851 - Winona

This is an example of a post construction scan. The new bridge crossing was built next to the existing bridge crossing. The existing bridge crossing will stay in-place, and is considered scour critical. As part of the rehabilitation project, the contractor placed geobag filters and riprap protection around two of the main channel piers to protect against scour. The post construction scan was completed to verify the placement of the scour protection, and as a baseline for future underwater inspections. Figure 3-13 is from a scan completed after partial construction, as the scour protection was staged over multiple construction seasons. The MnDOT bridge office hydraulics unit is planning a final post construction survey in summer 2017.

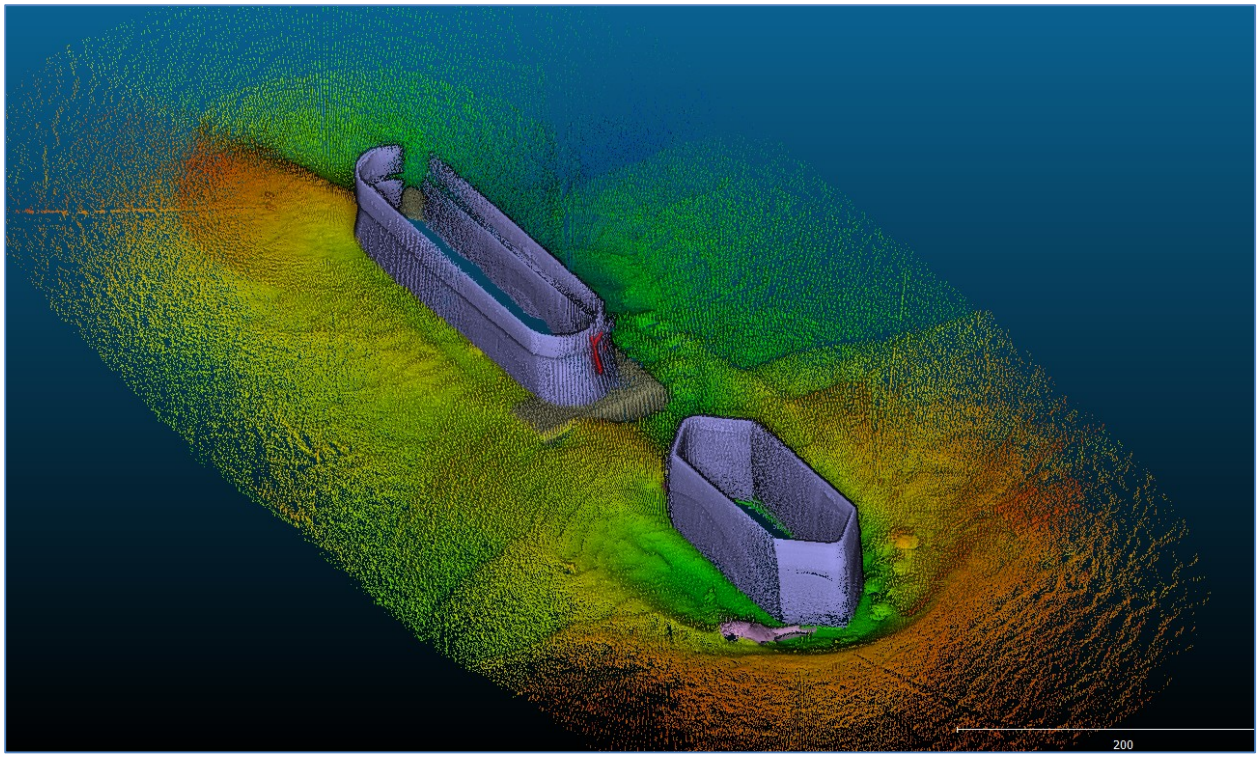


Figure 3-13: Bridge 85851 Post-Construction Scan

CHAPTER 4: RECOMMENDATIONS

Underwater acoustic imaging has been shown to have real value to bridge inspectors and owners for a variety of applications, from pre-construction planning and post-construction inspection, to routine underwater inspection and post-event emergency inspections. The case studies in this report exhibited a number of these applications. The following is a list of recommendations to aid in the safe and efficient adoption of this technology in the state:

- Develop and publish MnDOT underwater imaging policy.
- Provide outreach to MnDOT districts, counties, cities and other bridge owners in the state informing of MnDOT bridge office's imaging capabilities and expertise.
- Develop adequate post-processing capabilities and data storage of completed projects.
- Generate list of bridges suitable for underwater imaging, look for input from bridge owners across the state.
- Provide indication in bridge record that underwater imaging of bridge exists and is available for review.
- Ensure field personnel performing underwater imaging are properly trained in both bridge inspection and underwater imaging techniques.

CHAPTER 5: CONCLUSION

This report outlined the steps taken to establish the in-house underwater acoustic 3D imaging capability of the MnDOT bridge office. Following a discussion of both stationary and mobile scanning techniques, field operations, and post-processing requirements, a number of case studies were presented. These case studies provided examples of different applications of this technology on several different bridges. The variety of applications included the documentation of large-scale underwater defects, construction inspection confirming as-built conditions, rapid condition assessment following a flood event, determination of scour extents and foundation exposure, as-built and site conditions for construction pre-planning, and diver safety and efficiency improvements for challenging dive conditions.

REFERENCES

1. Federal Highway Administration, (2010) *Underwater Bridge Inspection Manual-FHWA-NHI-10-027*, U.S. Dept. of Transportation, Washington, DC.
2. Browne, T., Forsyth, R., Consi, T., (2014) "Reliability of Underwater Acoustic Imaging and Underwater Ultrasonic Testing," American Society for Nondestructive Testing, Columbus, OH.

APPENDIX A: MNDOT EQUIPMENT LIST

Here is a list of the specific equipment MnDOT purchased and uses for both stationary and mobile scanning.

MnDOT Equipment List for Stationary Scanning

Equipment Type	**Details/Use**	**Make/Model and Notes**
Field computer	Laptop computer for data collection	Dell Latitude E6540 with 256 GB Solid State Drive, 8GB memory
External Hard Drive	To store all scanning files	1 TB WB Elements external hard drive
3D Sonar (and accessories to operate the unit)	For mechanical underwater 3D scanning	BV5000, 1350 Hz model, from Teledyne Blueview
Pan and tilt unit	To rotate the sonar head 360-degrees	P-20 from Remote Ocean Systems, came with the sonar
Tripod	Deployment platform for the sonar and pan/tilt unit	Came with sonar
Plate	Deployment platform for the sonar and pan/tilt unit	Manufactured in-house, 75-lb steel plate with hinged arm
Boat mount	Deployment platform for the sonar and pan/tile unit	Manufactured in-house, retrofitted an old ADCP gunnel mount
Sound velocity probe	To collect sound velocity measurements	Digibar Pro from Teledyne Odom Hydrographic
Generator	Power source	Honda EU1000i inverter generator
Sonar collection software	To collect 3D point cloud images using BV5000	ProScan (latest version) from Teledyne Blueview

Sonar software viewer	To view collected 3D point clouds	BlueViewer from Teledyne Blueview
Point Cloud post-processing software	To clean data and complete final registration	Leica Cyclone software package
	To translate point clouds	QuickStitch by EIVA
	To color shade data and do final graphics/rendering	Cloud Compare (freeware)

MnDOT Equipment List for Mobile Scanning (all of the stationary equipment, plus the following)

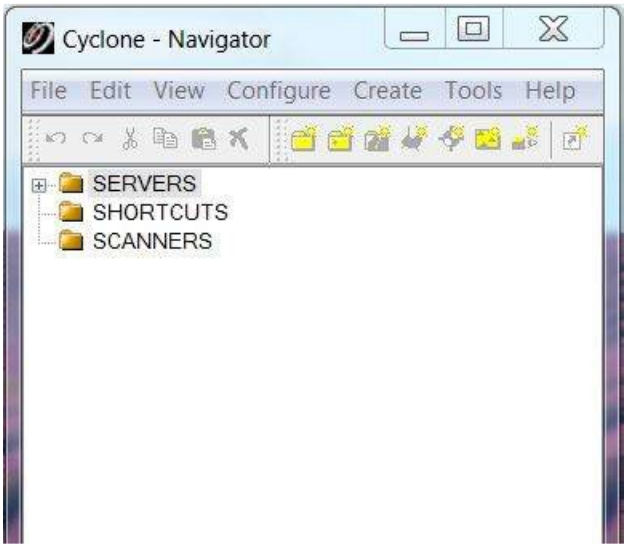
Equipment Type	**Details/Use**	**Make/Model and Notes**
Mount for sonar head	Static mount for sonar head, that can rotate to fixed tilt angles (i.e. 30-degree)	Universal Sonar Mount, Compact Mount with Hinge kit and 15-deg Knuckle Assembly
Dual Antenna GPS unit	To get location and heading	Hemisphere VS330
Motion Reference Unit	To get pitch, roll, and heave	MRU 333 from Specialty Devices, Inc
Wifi	Internet connection for real-time GPS correction	Verizon MiFi
Multibeam software	For multibeam data collection and data processing	HYPACK and HYSWEEP by HYPACK

APPENDIX B: STATIONARY POST-PROCESSING INSTRUCTIONS

(Utilizing Cyclone and Cloud Compare softwares only.)

Registering Point Clouds for Blue View BV5000 Sonar

1. Open Cyclone to bring up Cyclone Navigator.



2. Edit Settings so the same units are used for everything.

ALWAYS USE METRIC UNITS UNTIL THE VERY END OF PROCESSING (IF NEEDED).

Click “Edit” while in Navigator.

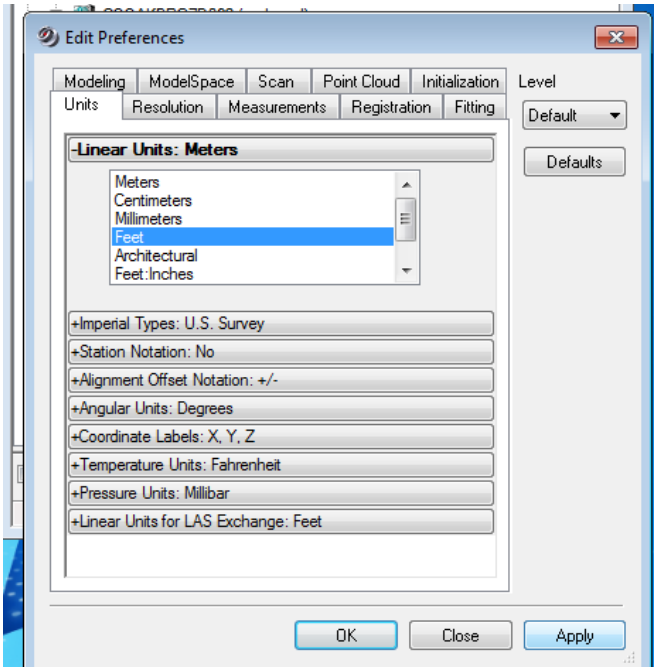
Select “Preferences” from the drop down menu.

Select the “Units” tab-change the units so that they match for everything.

Linear Units: Meters. Click Apply.

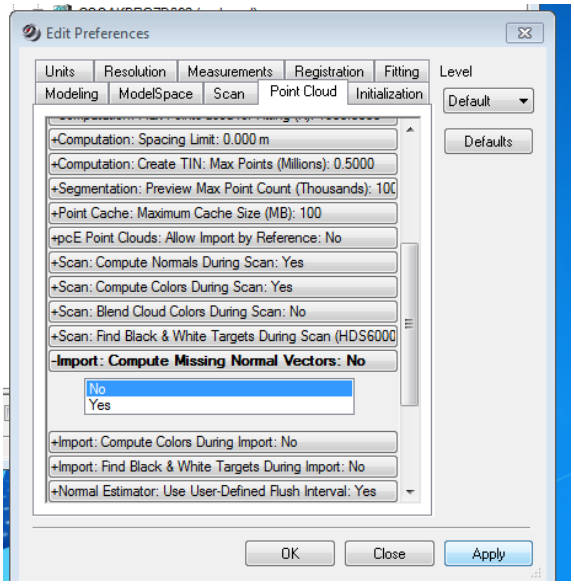
Imperial Types: U.S. Survey. Click Apply.

Linear Units for LAS Exchange: Meters. Click Apply.

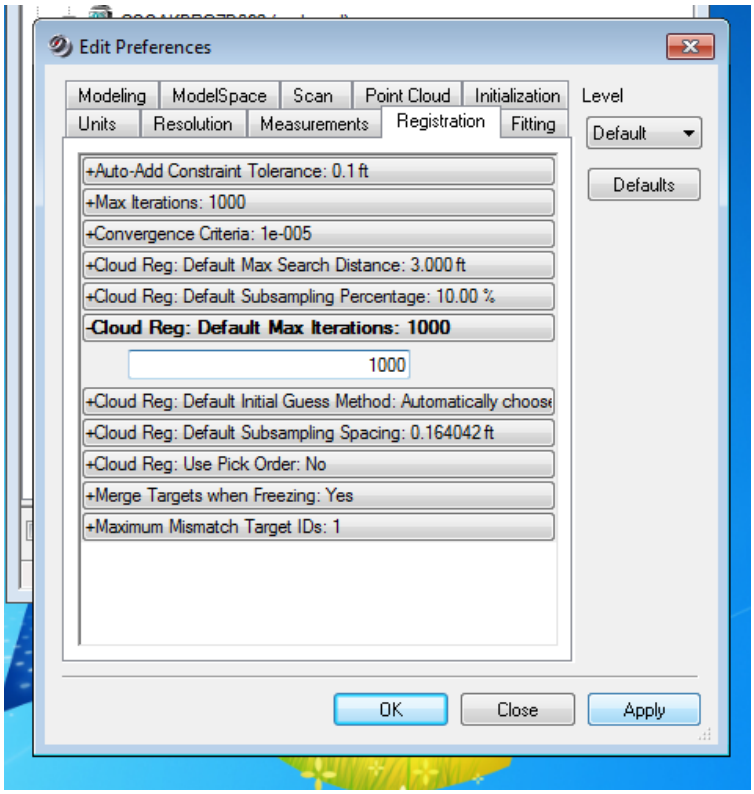


3. Select the “Point Cloud” tab. Scroll down to “Import: Compute Missing Normal Vectors:” Change to NO. Click Apply.

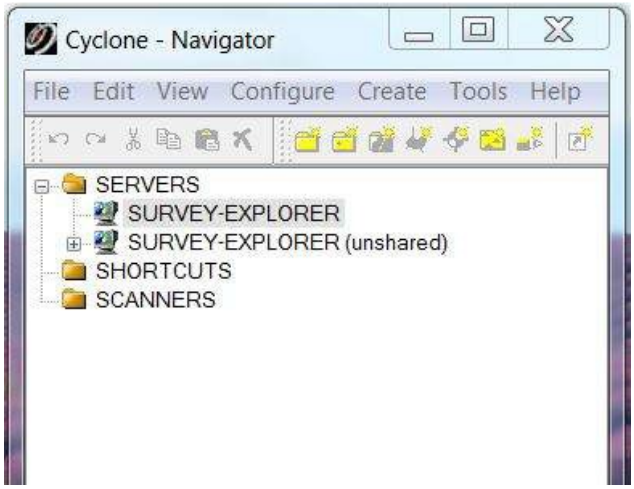
**Units and Point Cloud preferences need to be changed during every use if not saved as default (default settings can be saved by changing the level from session to default).



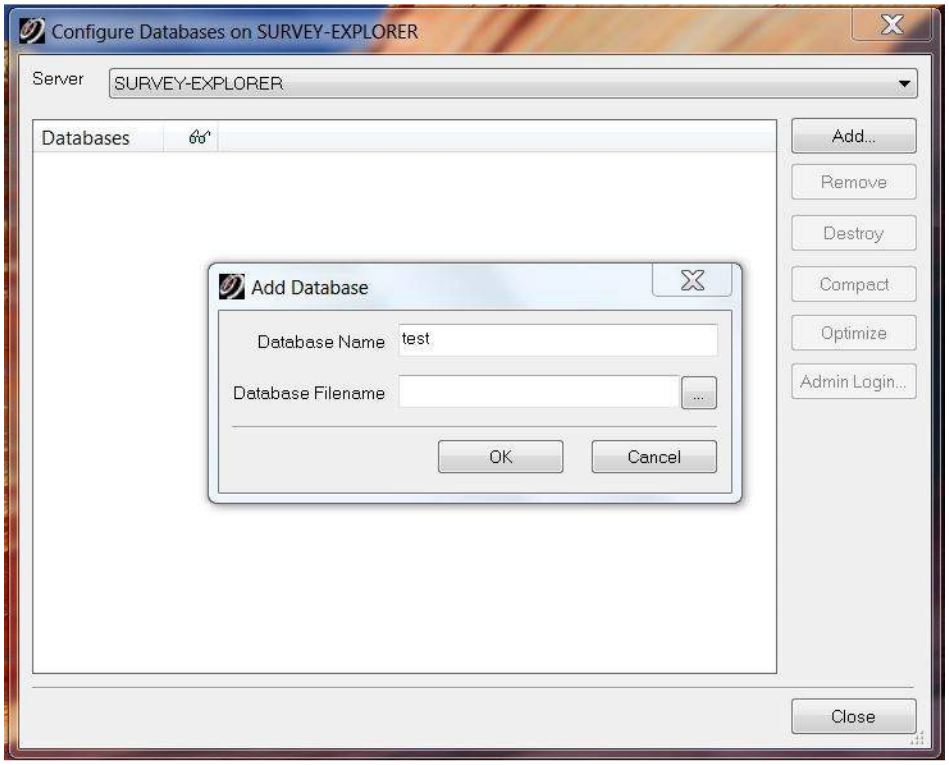
4. Select the “Registration” tab. Switch the Level from Session to Default to make adjustments to the default settings (this will only need to be done once for individual computers and will be saved as a default from then on). After each change, click Apply so that the settings match the image to the right. Click OK.



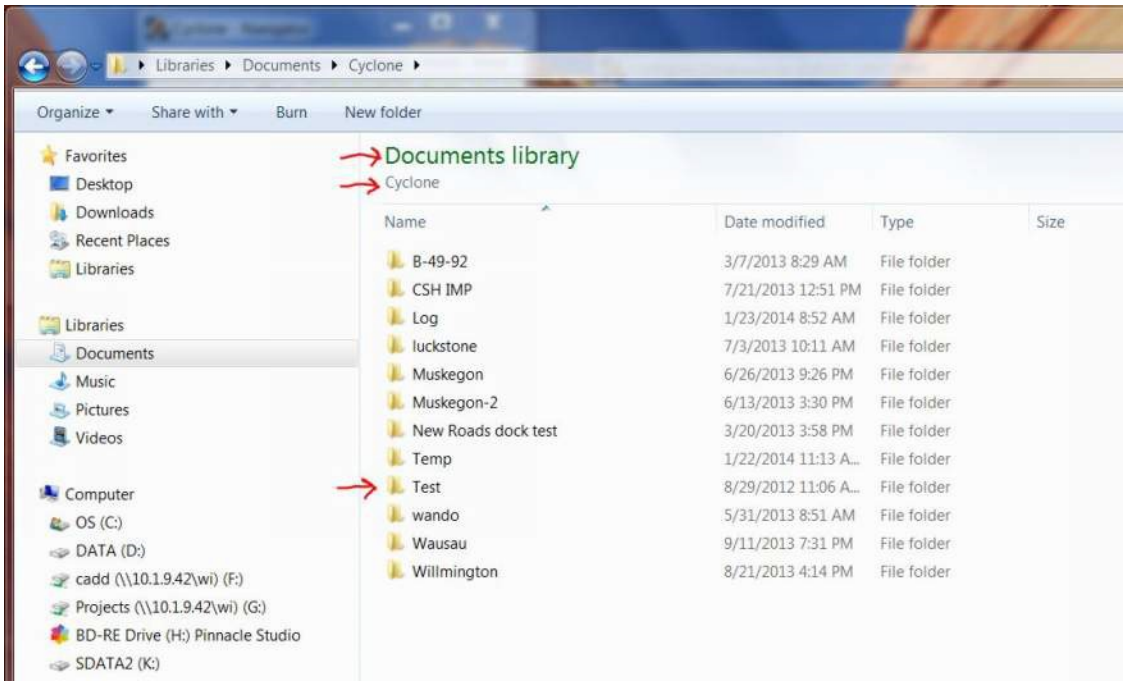
5. Expand “Servers” then right click on “Survey –Explorer (unshared)” select “databases”



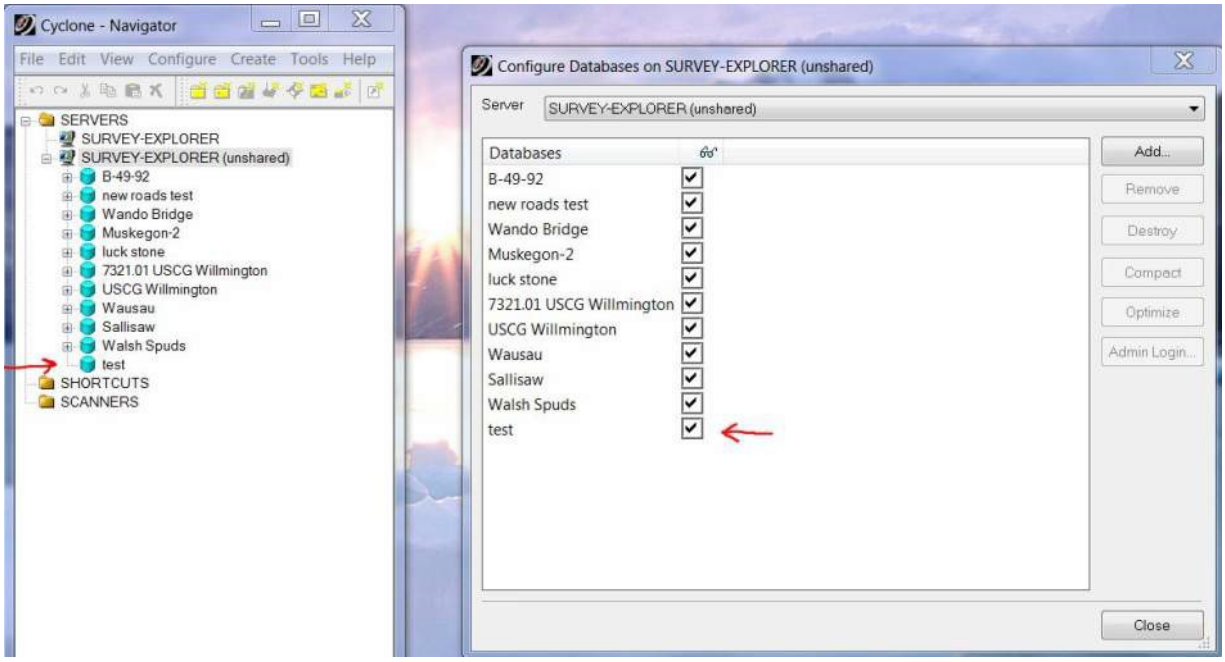
6. Click “Add” to create project then type name into “Database Name” field. Skip the “Database Filename” space unless pointing to an existing project “.IMP” file.



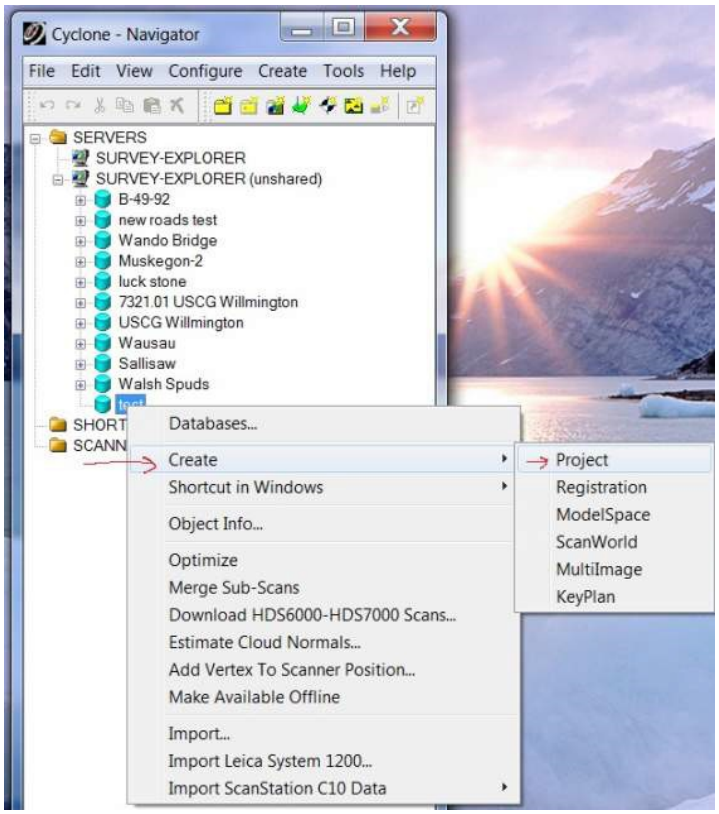
7. This creates a file in the “Documents Library” in the Cyclone folder.



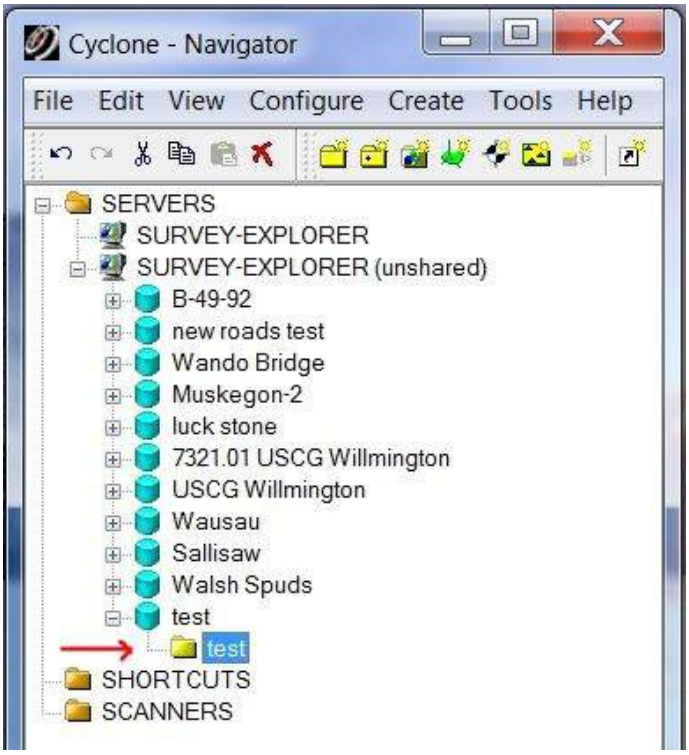
8. This also creates a new project in the “Survey-Explorer (unshared)” section of Cyclone Navigator.



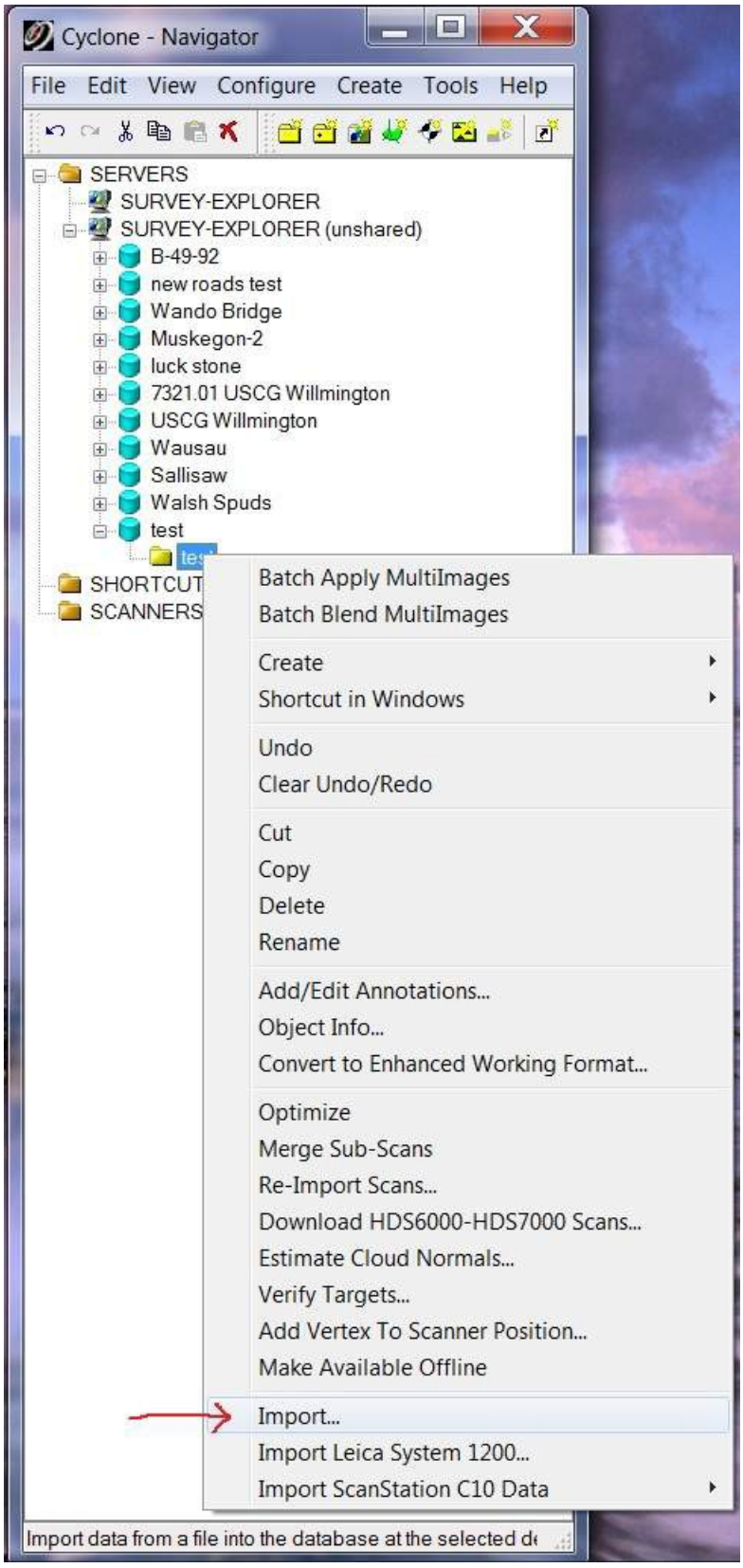
9. Expand “Survey-Explorer” in Cyclone Navigator and locate your new project. Right click on your new project and select “Create” then select “Project”.



10. Name the sub-project based on the amount of data e.g. if you have one pier just call it cleanup or if there are multiple piers make a sub-project for each one.



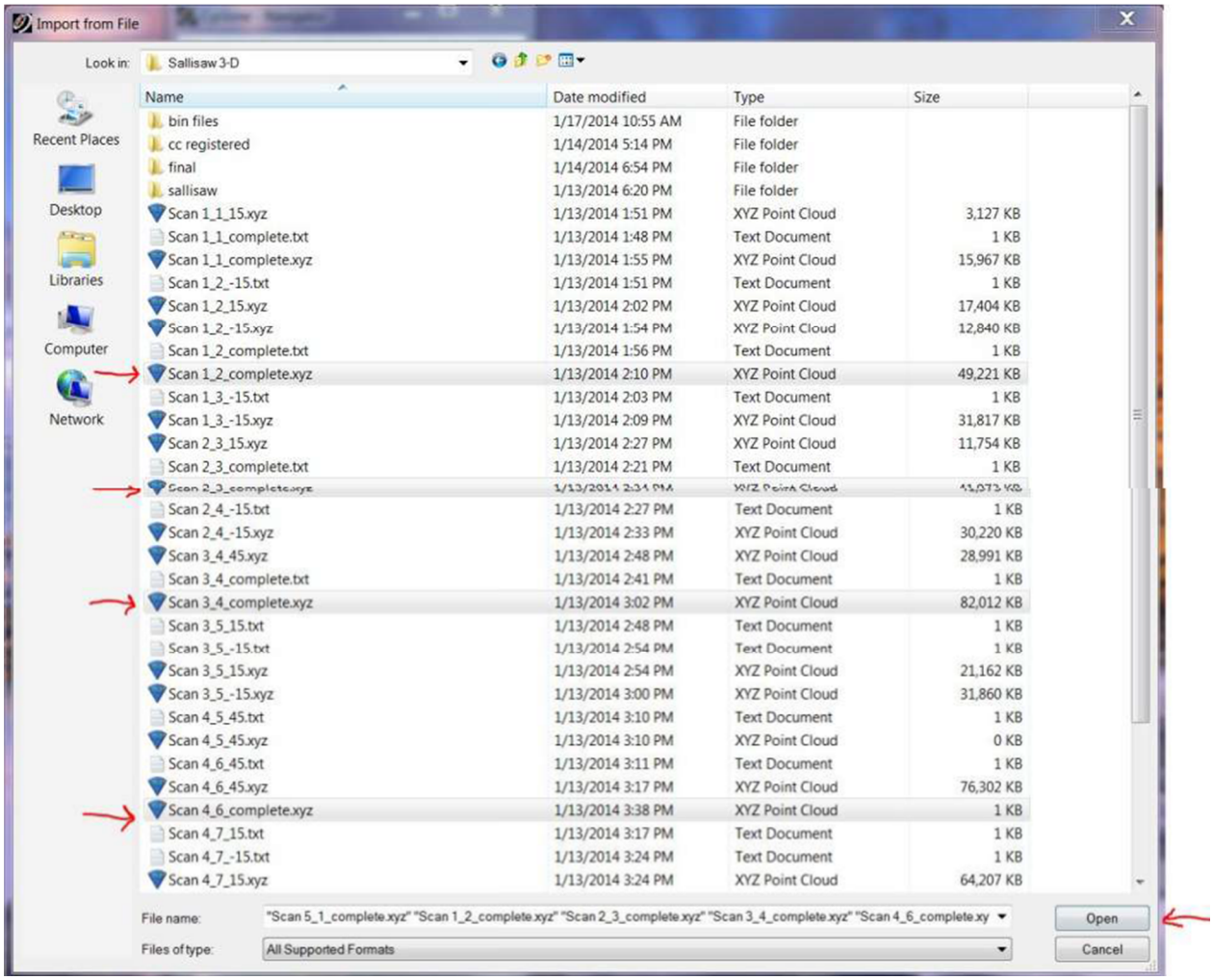
11. Right click on the new sub-project folder and select “Import”.



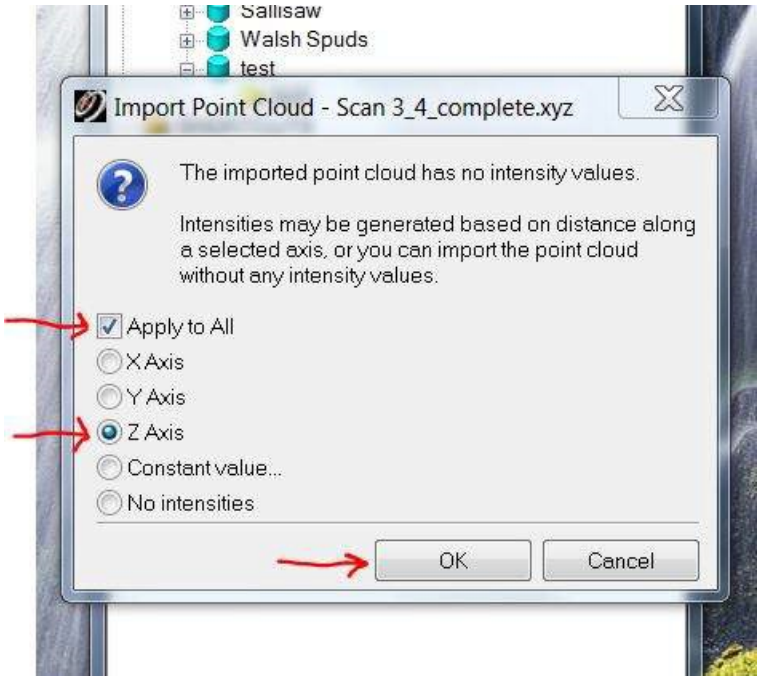
12. Navigate to the folder where you have saved your scans. Select all the ".xyz" files that you want and click "Open".

**Spherical scan data files combine individual tilt angle files and are named by the scan process followed by complete.xyz. These double the amount of data but are easier to process.

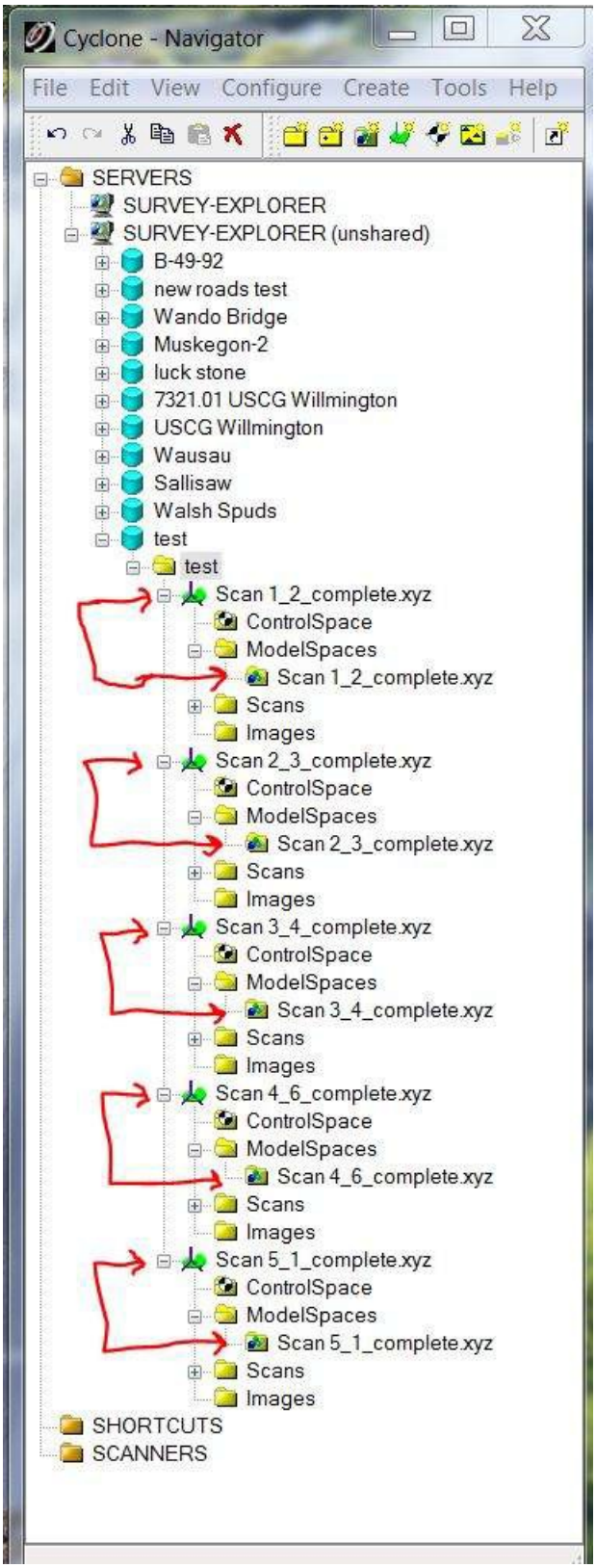
**Each individual tilt angle also exists as an independent file and are preferred if there was any movement during data collection (change in boat position between tilt angles).



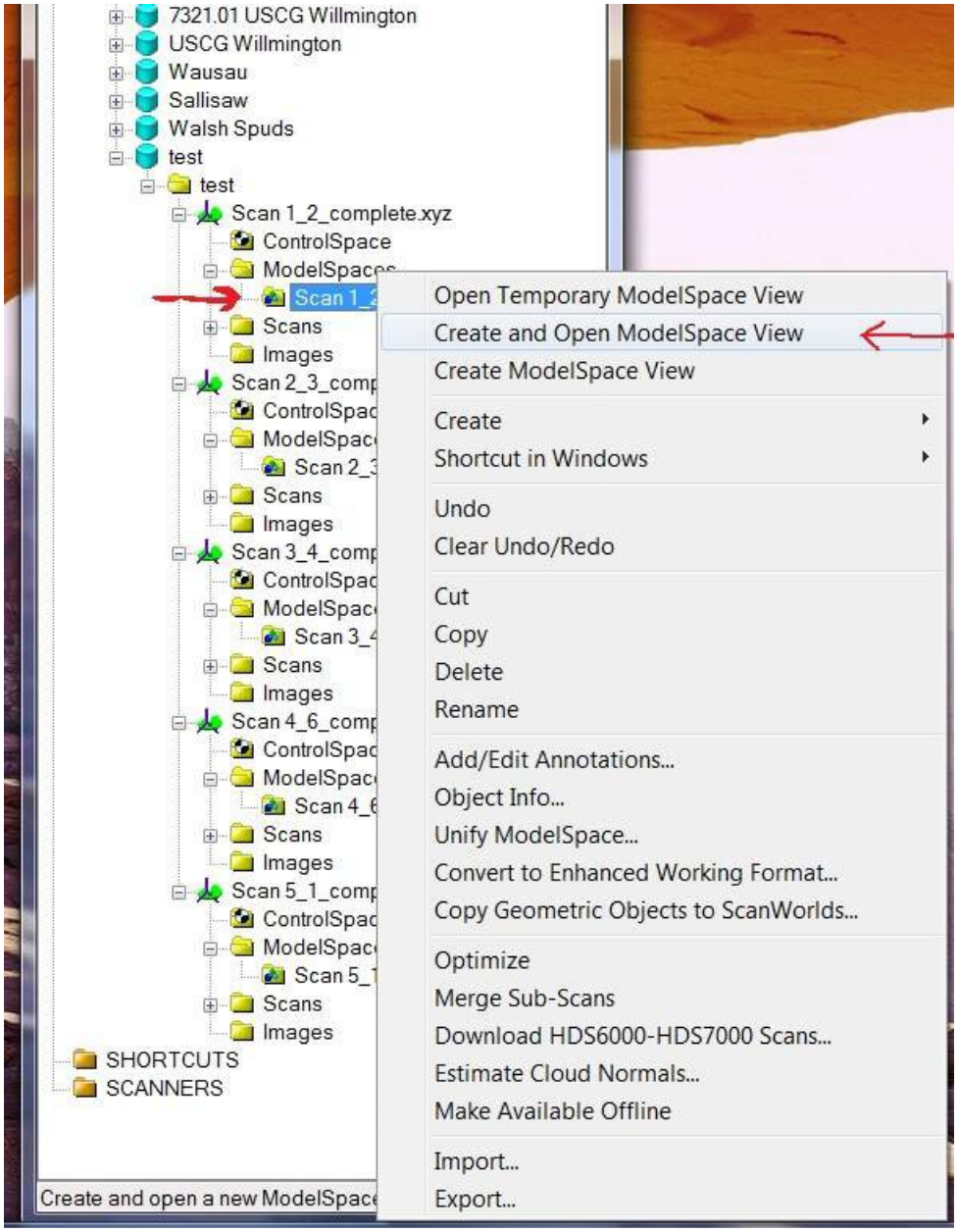
13. When the next window pops up, make sure the “Z-Axis” is selected and click “OK”. If multiple scans were selected then the window will keep popping up for each scan. You can either keep clicking on “OK” or you can select the “Apply to All” box and only click “OK” once.



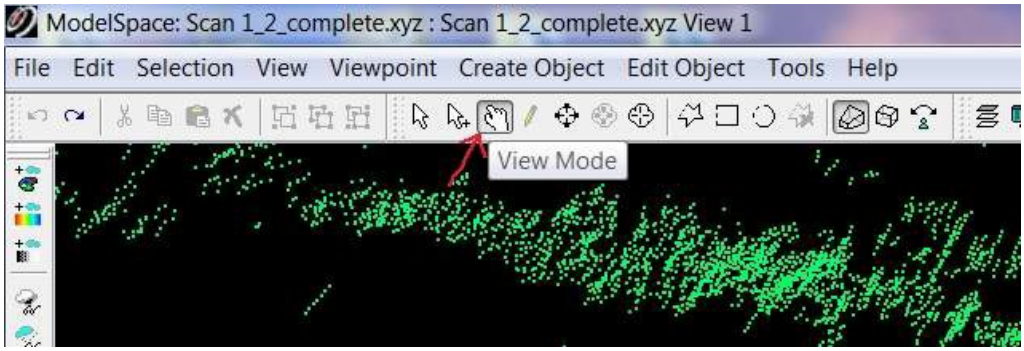
14. When the ".xyz" files are imported expand each ".xyz" file tree. Next expand the "Model Spaces" and give the "ModelSpace1" the same name as the ".xyz" file. This will allow the file name to be viewable when working in each individual model space view.



15. To start cleaning up the point clouds select the renamed “ModelSpace1” that you want. Right click and select “Create and Open Model Space View”.



16. To move around the scan in ModelSpace with a computer mouse using the “View Mode” tool. When the ModelSpace opens it will automatically be in the “View Mode”.



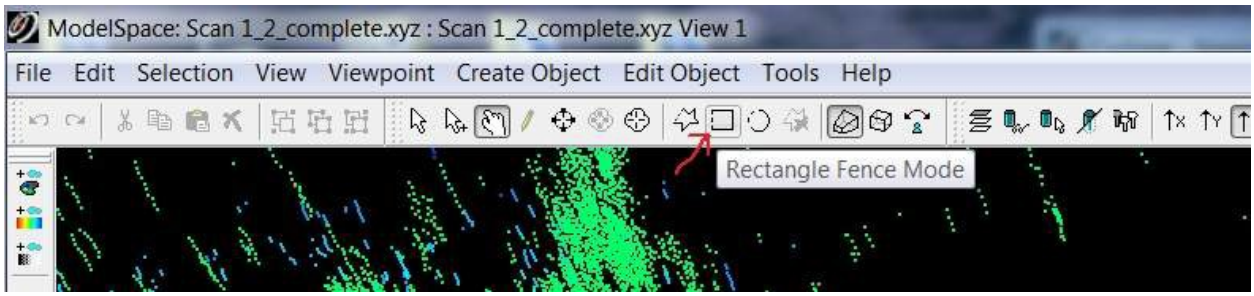
Hold down right and left mouse buttons to zoom in and out

Hold down left mouse button to rotate image

Hold down right mouse button to pan image

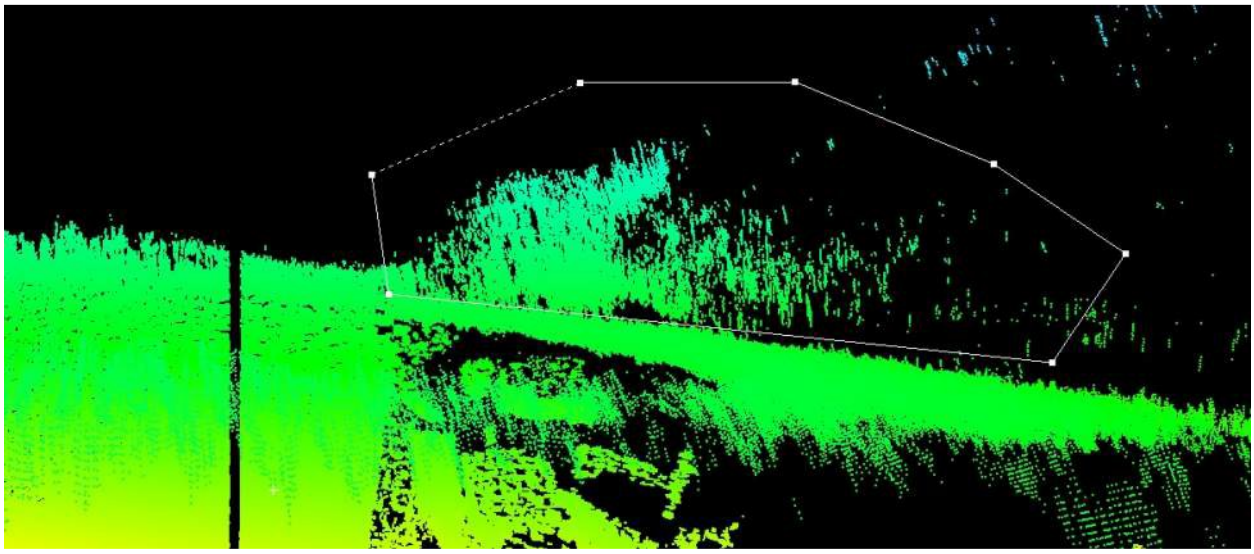
NOTE: Decreasing the point thickness may make it easier to differentiate between points. To do this select ‘View’ from the toolbar, from the drop down list expand ‘Point Cloud Rendering’ and select ‘Decrease Point Width’.

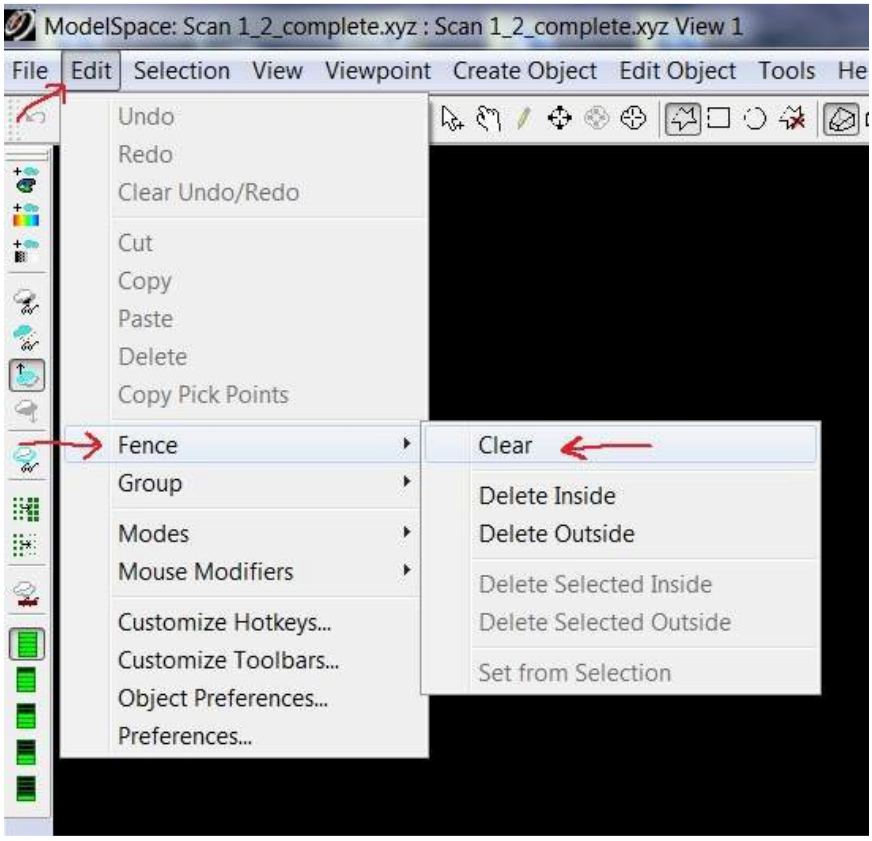
17. To clean up the image select one of the three fence modes on the toolbar. Polygonal, rectangular, and circular.



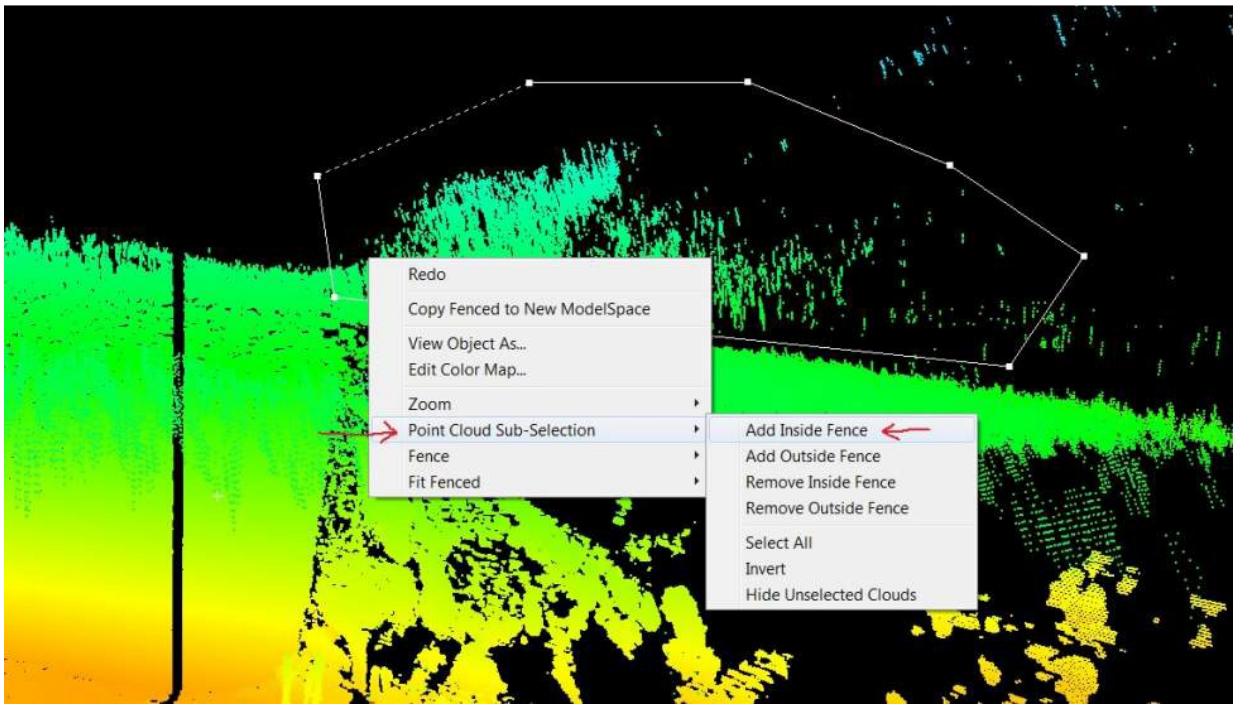
18. Using the Polygonal Fence Mode: First move to the area of points you want to remove with the "View Mode" tool. Select "Polygonal Fence Mode" from the tool bar and using the left mouse button create a fence around the points you want to remove. If you mess up the fence and wish to start over simply go to "Edit" then "Fence" then "Clear".

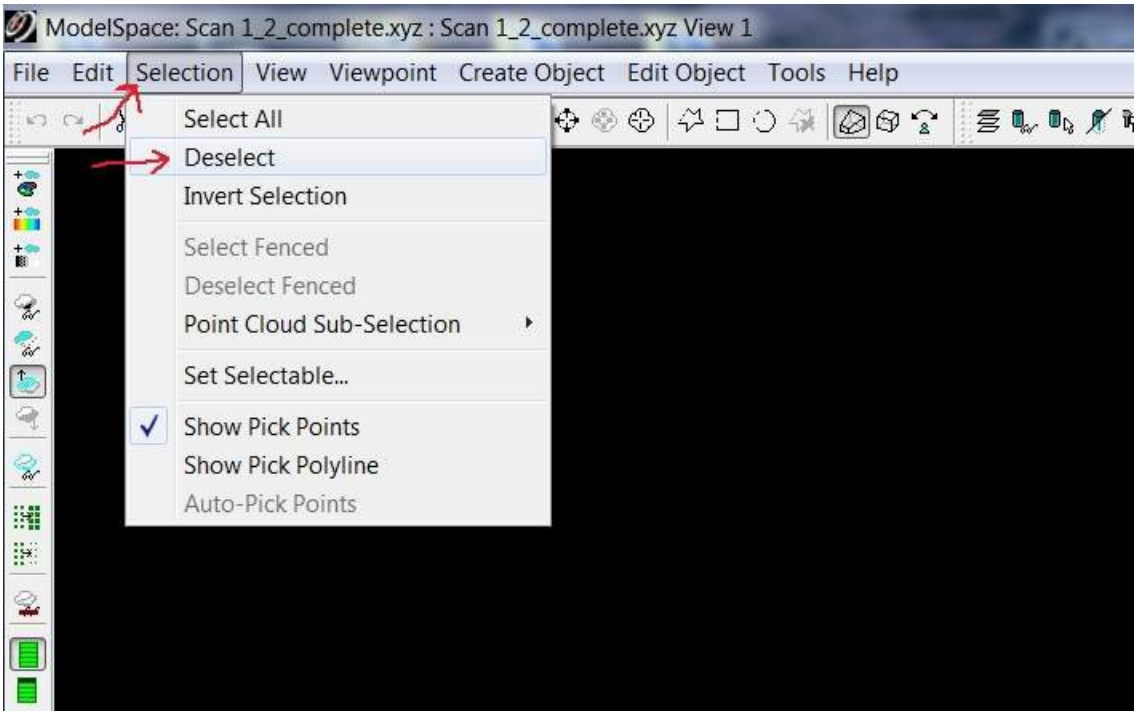
Note: Do not remove the waterline in the first scan. The waterline can serve as a reference point when matching up images and orienting the image to the X, Y, Z plane.



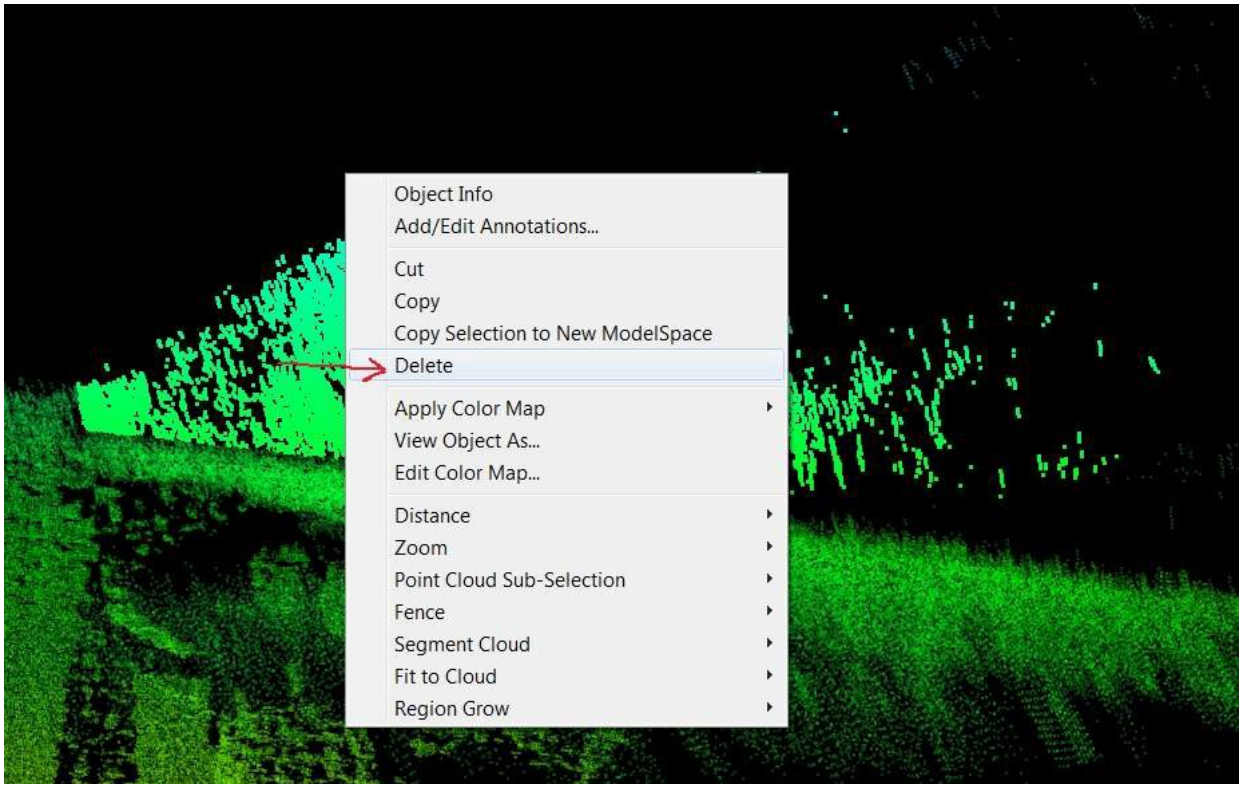


19. Once the fence is created, right click inside the fence and select “Point Cloud Sub-Selection”, then select “Add Inside Fence”. The points inside the fence will be highlighted and in this view you can select “View Mode” from the tool bar to rotate and move the image, making sure you only selected the points you wanted. If you selected points that you do not want and wish to make a new fence simply go to “Selection” then “Deselect”.

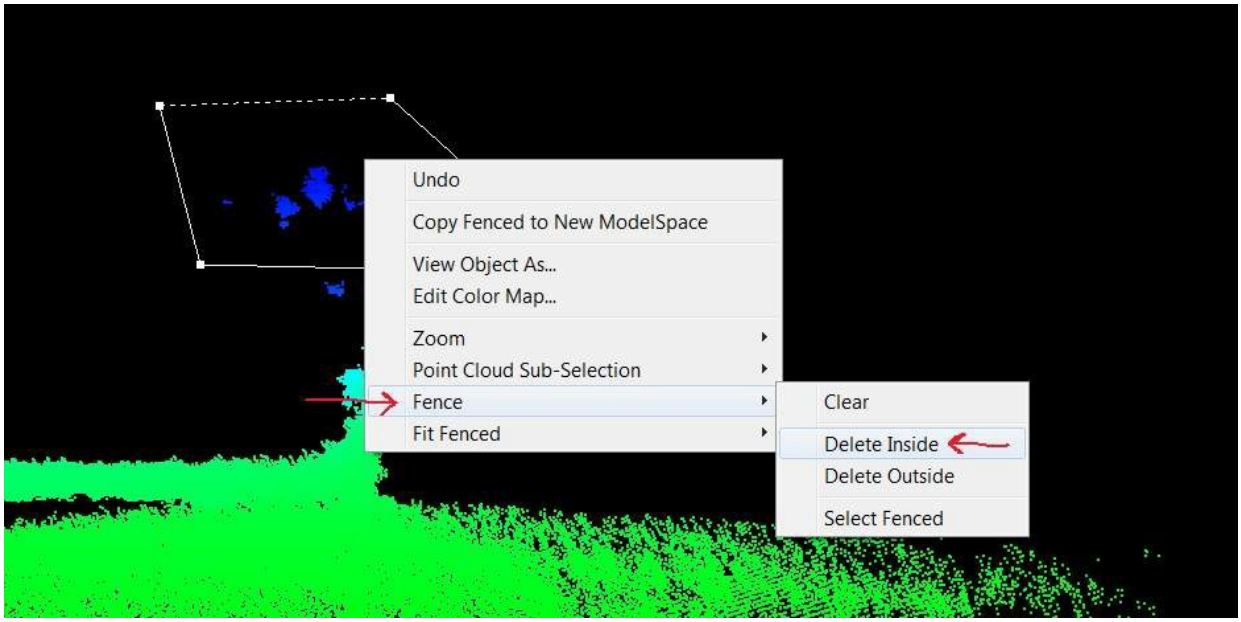




20. Once you are happy with the points selected, in “polygonal Fence Mode” right click on the screen and select “Delete”.

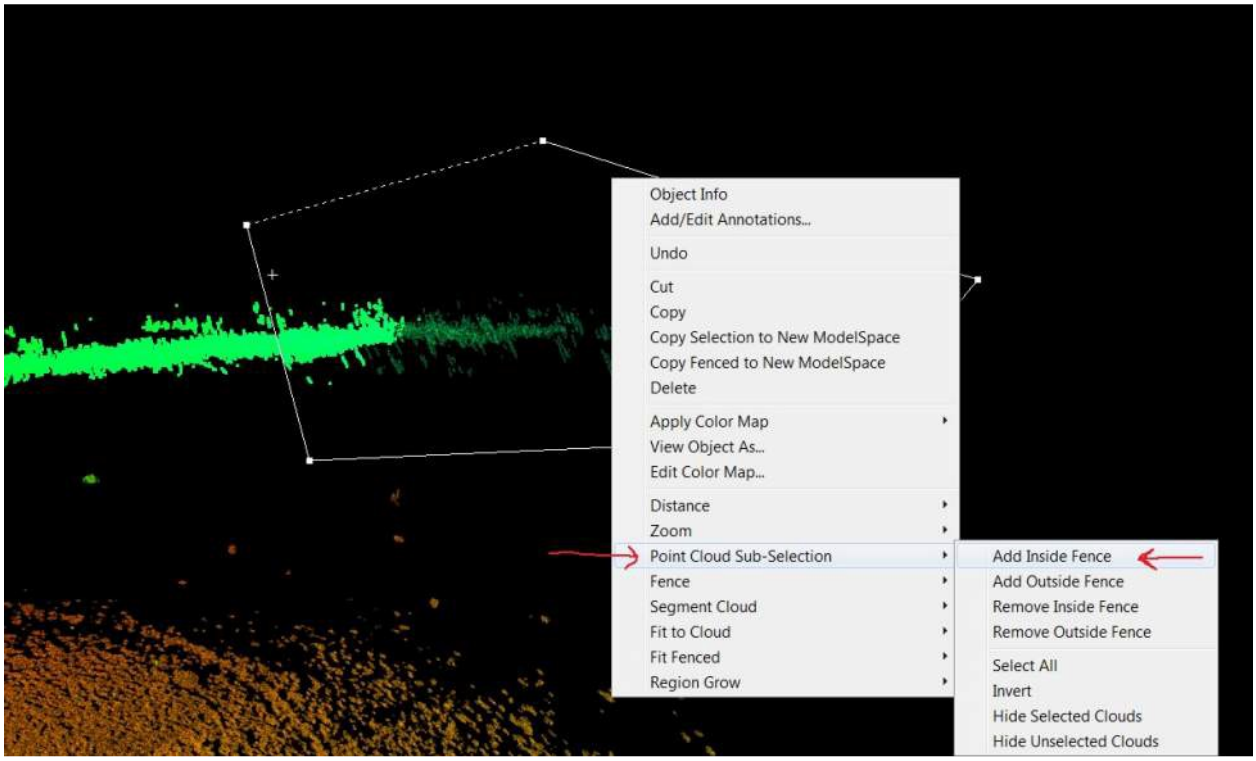


21. If you do not need to rotate and move the image after the points have been selected there is a faster way to delete points. Once the fence has been created right click inside the fence, select “Fence” then “Delete Inside”.

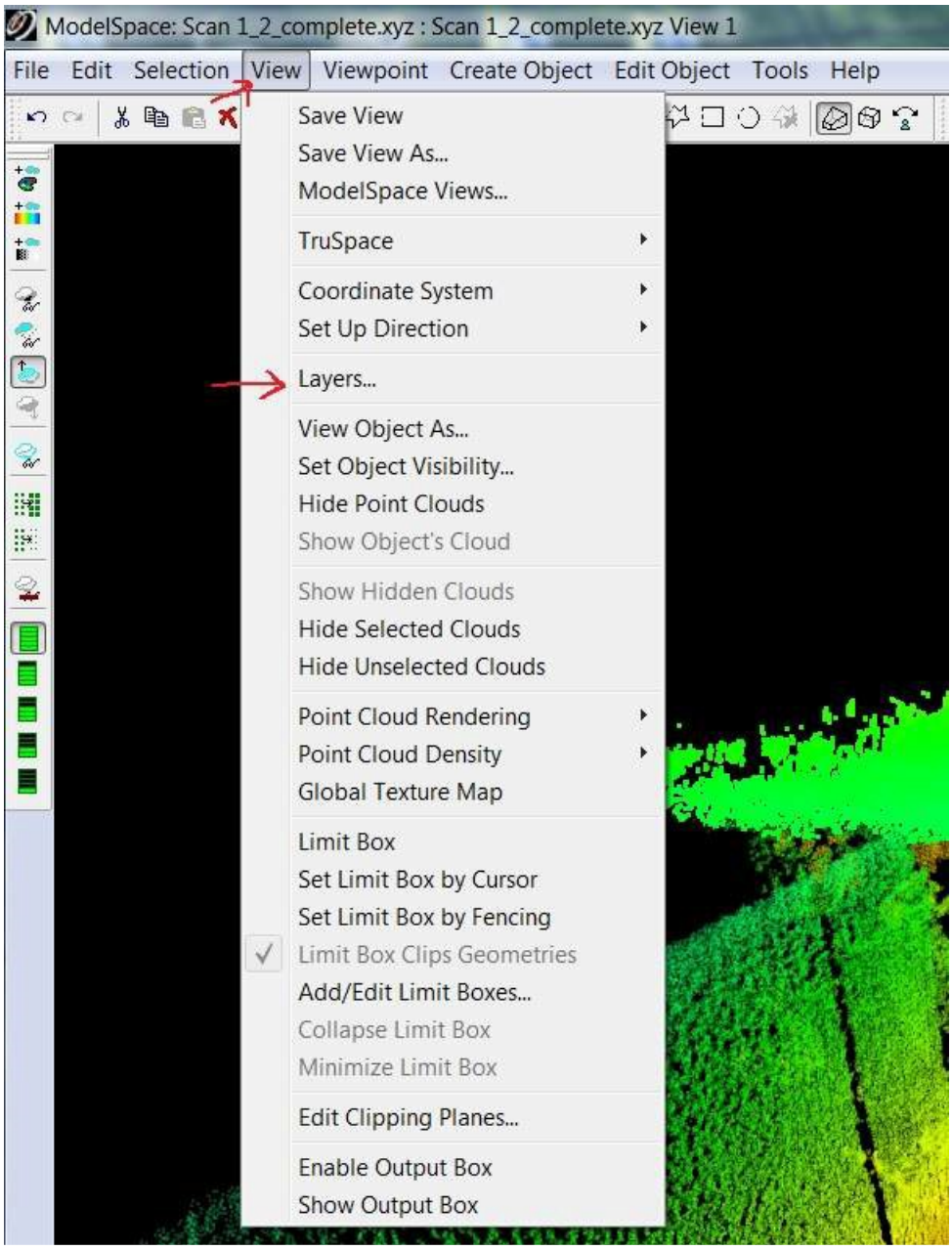


22. Keep deleting until all desired points are removed.

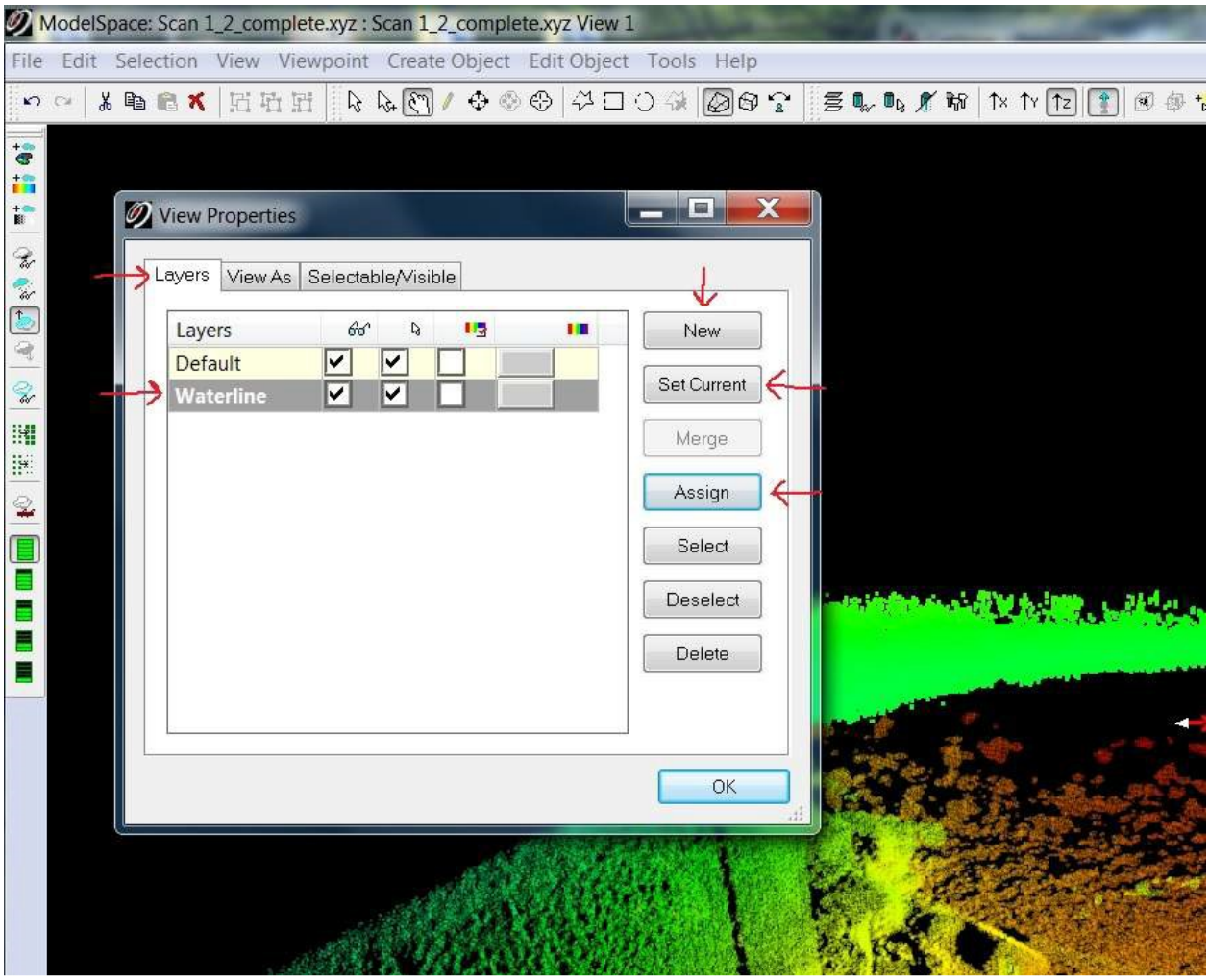
23. Once all points have been removed above the waterline you can create a waterline reference which will orient your structure to a level coordinate system. To do this, orient your view to be able to select all the points on the waterline. With the “Polygonal Fence Mode” tool create a fence that will select the waterline. Once the fence is created, right click inside the fence and select “Point Cloud Sub-Selection”, then select “Add Inside Fence”. The points inside the fence will be highlighted and in this view you can select “View Mode” from the tool bar to rotate and move the image making sure you only selected the points you wanted. If you cannot get all the points in one view just move the view and make another fence. Again select “Point Cloud Sub-Selection”, then select “Add Inside Fence”.



24. Set the waterline to a layer: Once all the points are selected go to “View” and select “Layers”



25. In “Layers” tab click “New” and name the new layer Waterline. Once you have named the level click “Set Current” then click “Assign”.


ModelSpace: Scan 1_2_complete.xyz : Scan 1_2_complete.xyz View 1
File Edit Selection View Viewpoint Create Object Edit Object Tools Help
View Properties
Layers
View As
Selectable/Visible
Layers
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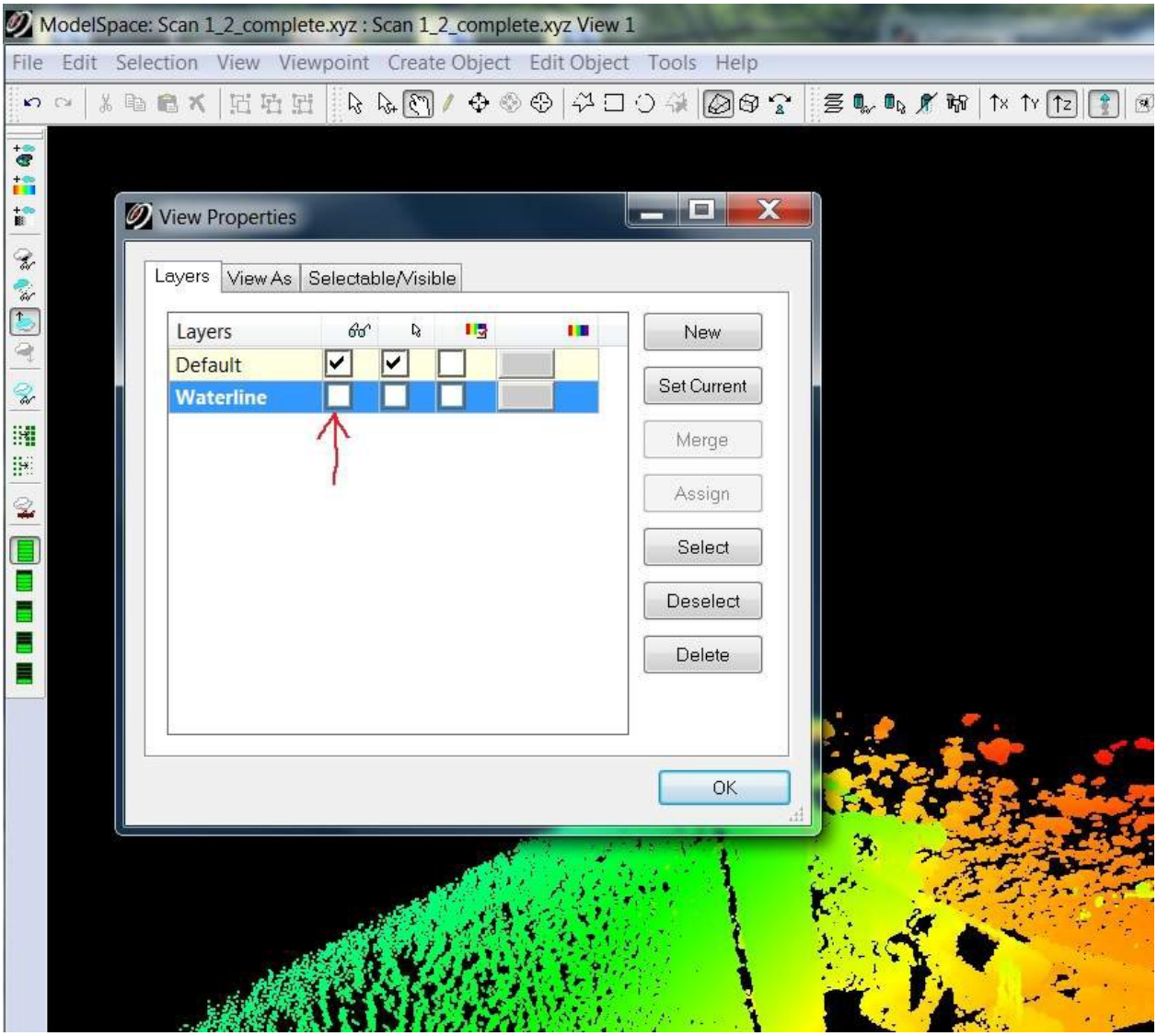
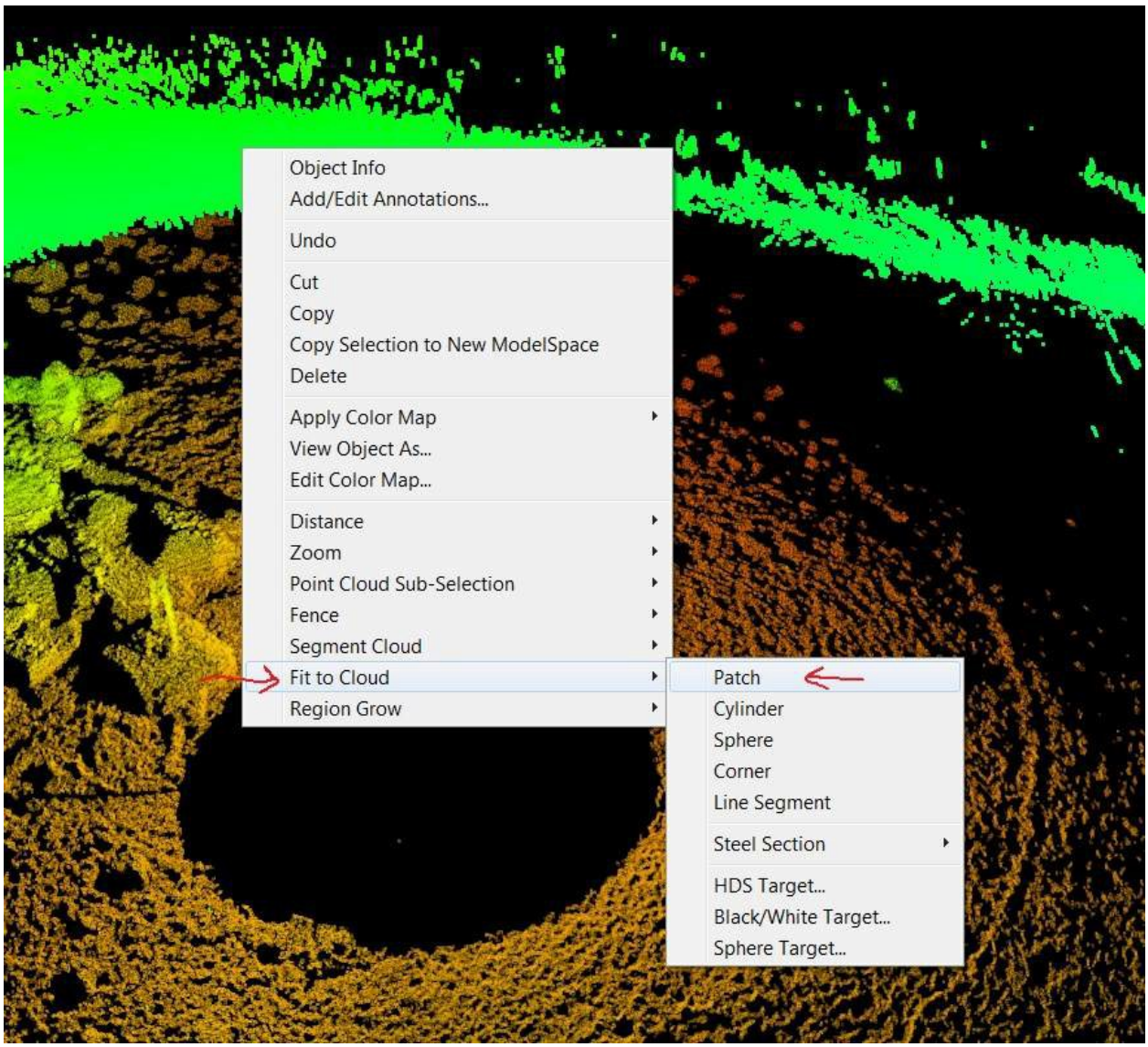
Waterline
New
Set Current
Merge
Assign
Select
Deselect
Delete
OK

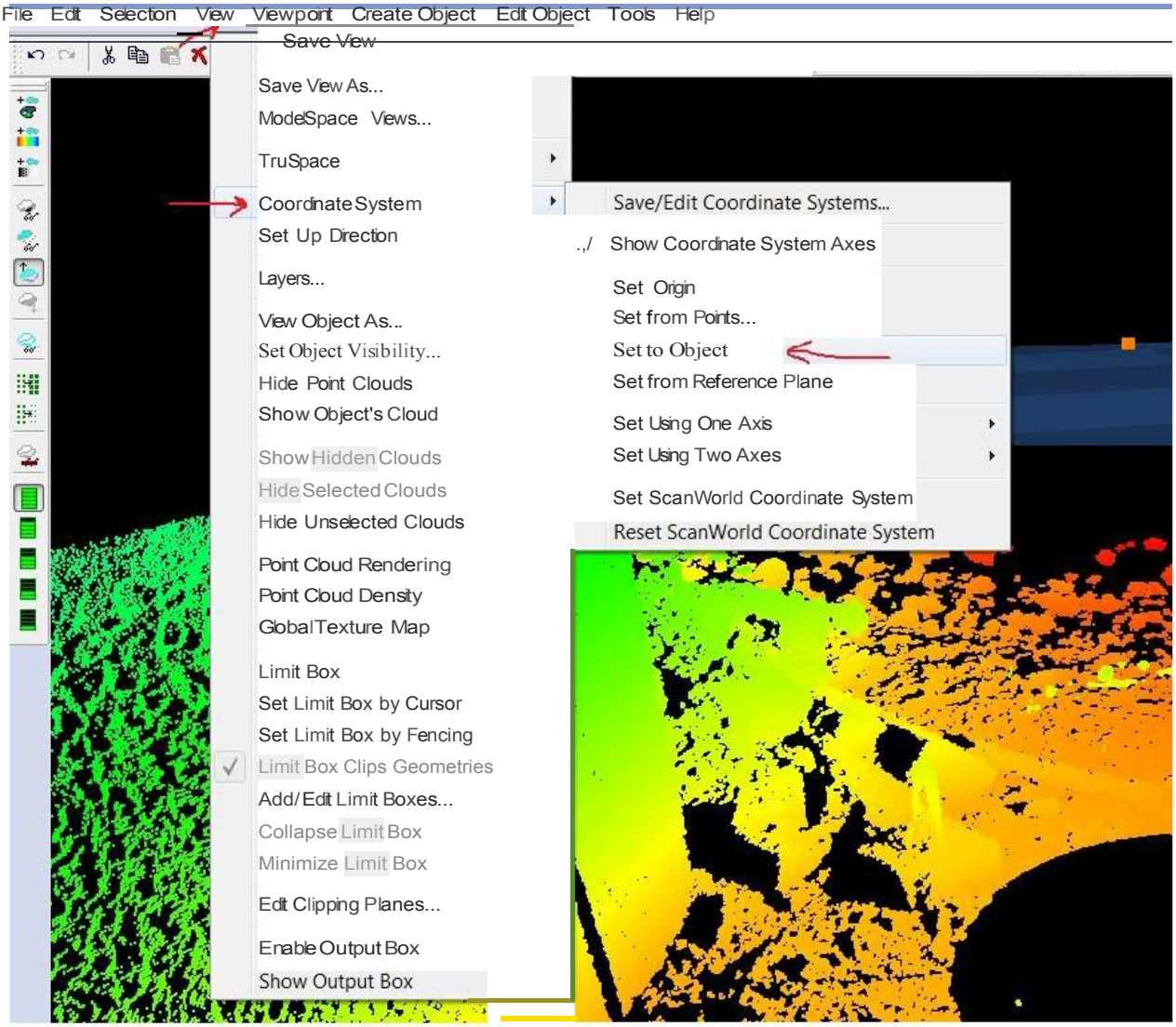
26. By clicking the View Box you can turn on or off the waterline layer.

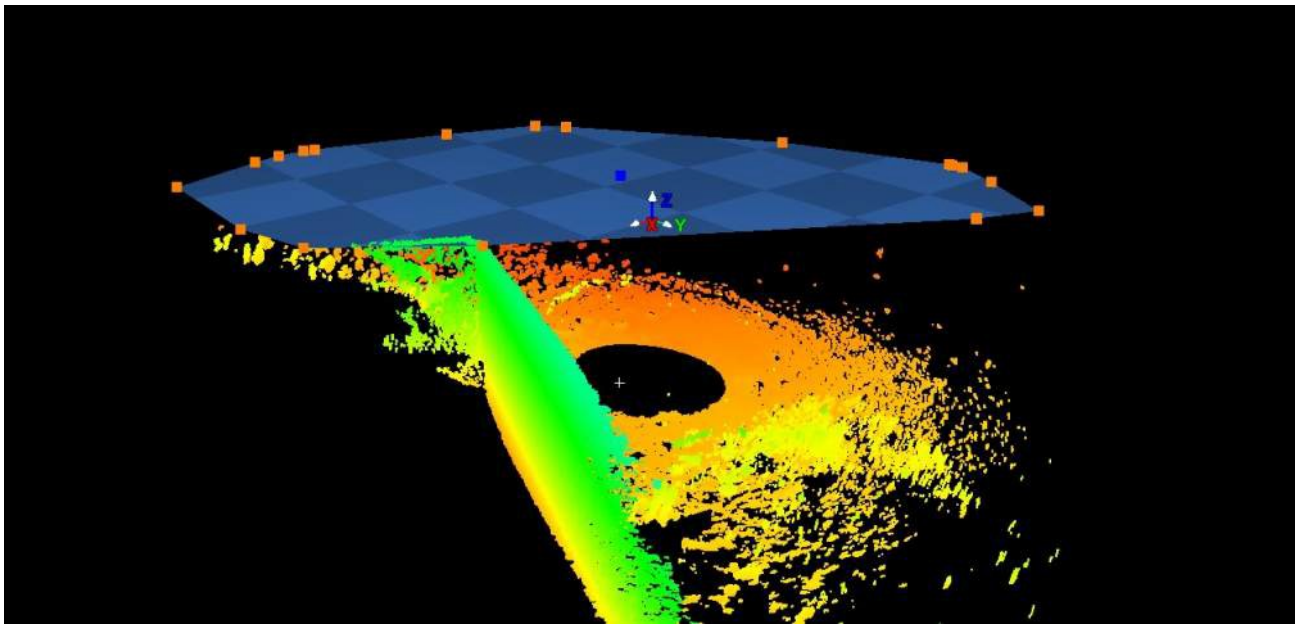


27. Once all the points are created, right click on the screen and select “Fit to Cloud”, then “Patch”. The waterline will show up as a one plane object.

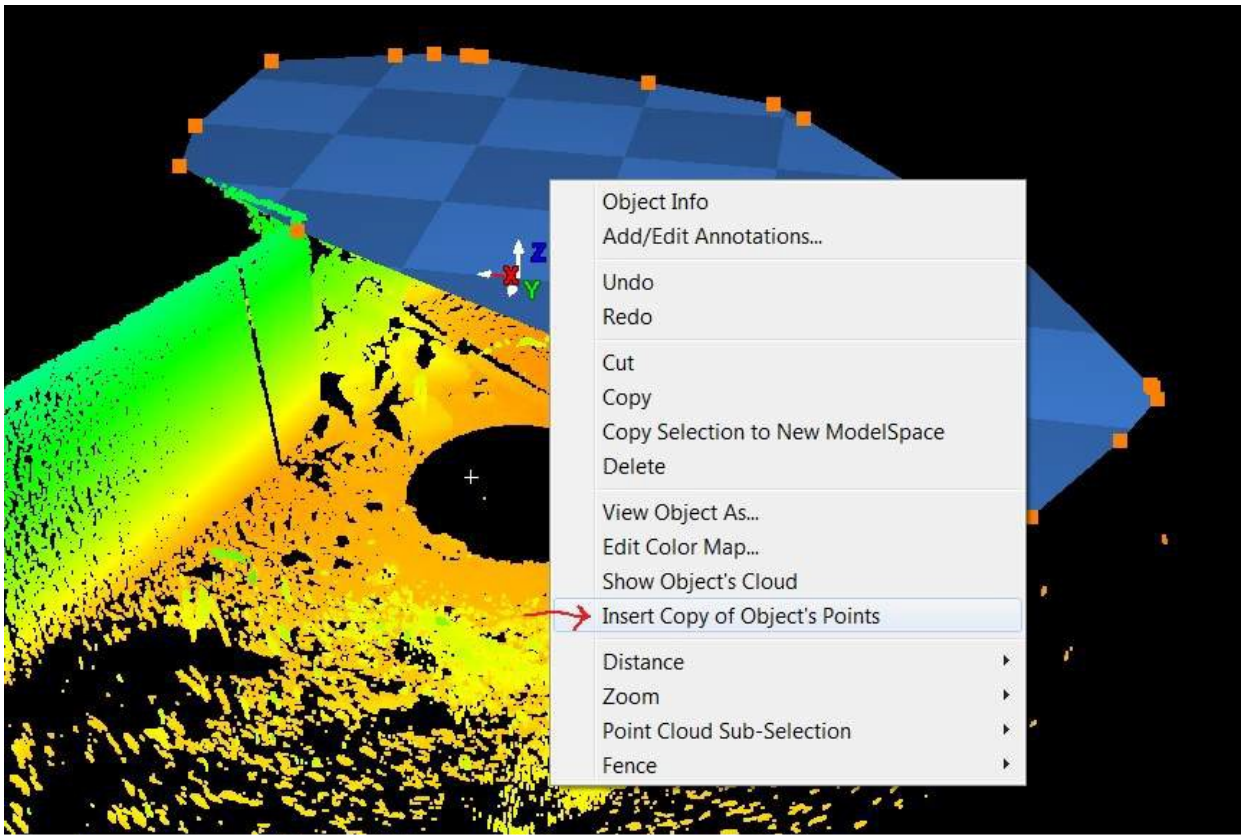


28. While the surface is selected go to “View” then “Coordinate System” then ”Set from Points…”. Set Coordinate System from Pick Points. The plane of the z axis will be set perpendicular to the waterline. **When editing and choosing “Set to Object” the z values were flipped upside down. To revert this I selected View→Coordinate System→Set Using One Axis→Z axis.





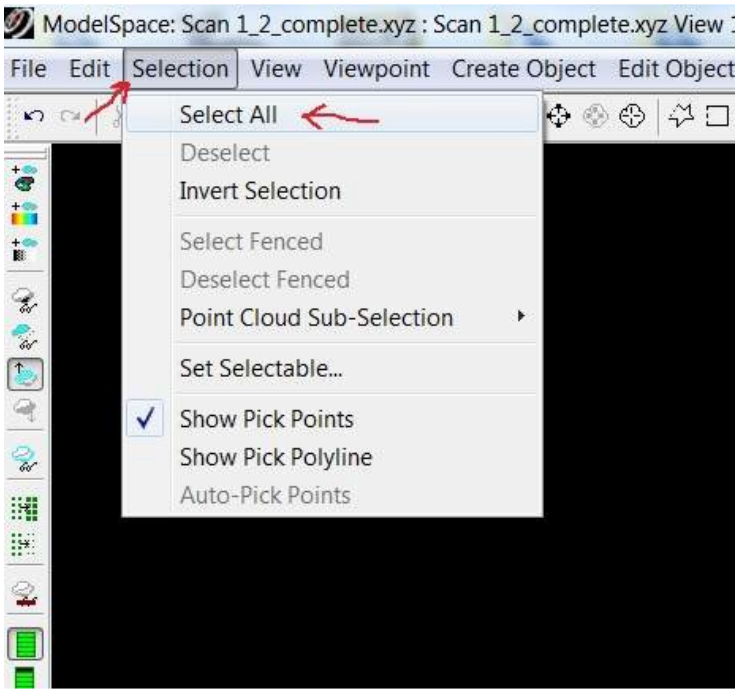
29. To bring back the waterline points right click on the object with the “Polygonal Fence Mode” tool and select “Insert Copy of Object’s Points”.

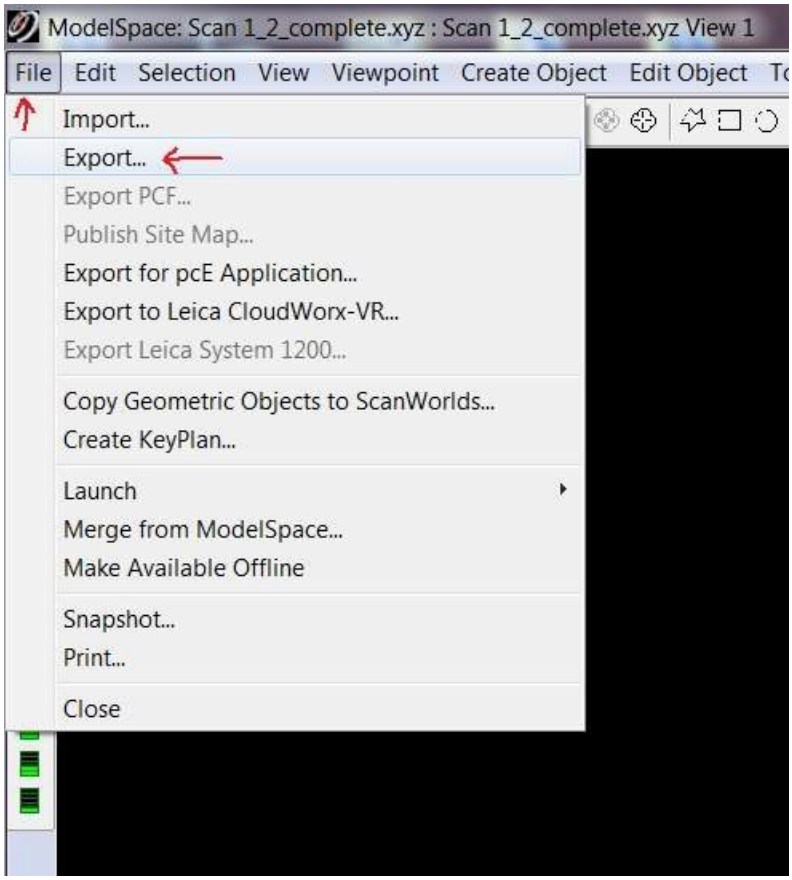


28: Clean the rest of the image with the “Polygonal Fence Mode” tool.

29: Once the image is cleaned from extra noise it can be exported. To export the file and perform rough registration with Cloud Compare (CC): First, go to “Selection” then “Select All” all the points in the image will be highlighted. Next, go to “File” then “Export” and a save window will pop up. Open the “Cleaned” folder and here is where you will save your cleaned image. Create a file name for the image and make sure it is in .XYZ format and click “Save”.

NOTE: When cleaning your first data file you will need to create a folder where you can save all your cleaned and CC Registered images. Navigate to the appropriate drive”, then open the “BlueView” folder, then create a “new folder” (here it is called test). Open up the “test” folder and create two more folders called “CC Registered” and “Cleaned”.




ModelSpace: Scan 1_2_complete.xyz : Scan 1_2_complete.xyz View 1
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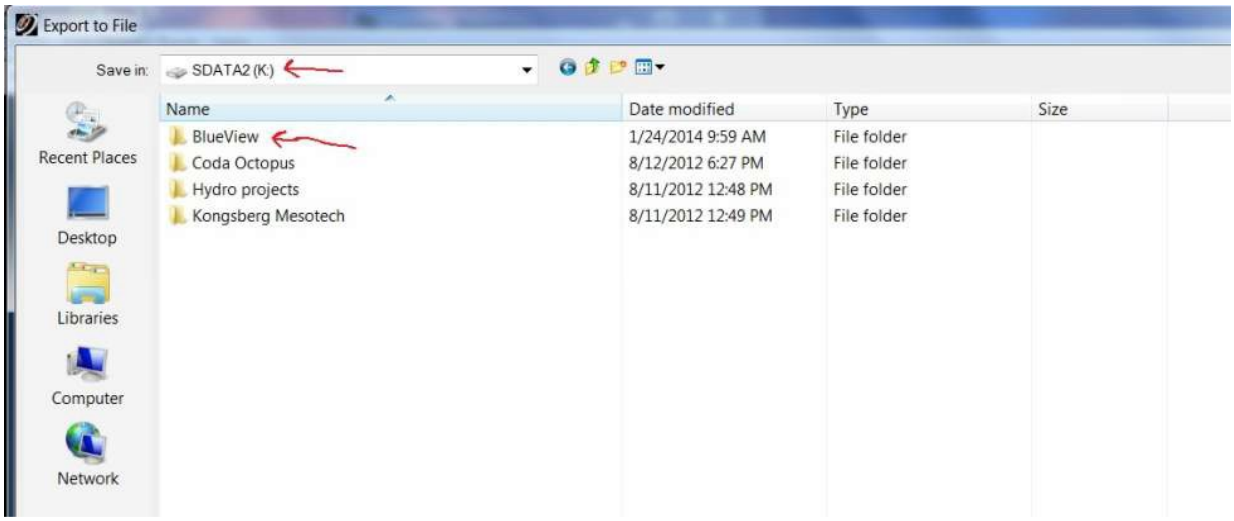
Export for pcE Application...
Export to Leica CloudWorx-VR...
Export Leica System 1200...
Copy Geometric Objects to ScanWorlds...
Create KeyPlan...
Launch
Merge from ModelSpace...
Make Available Offline
Snapshot...
Print...
Close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8/11/2012 12:48 PM
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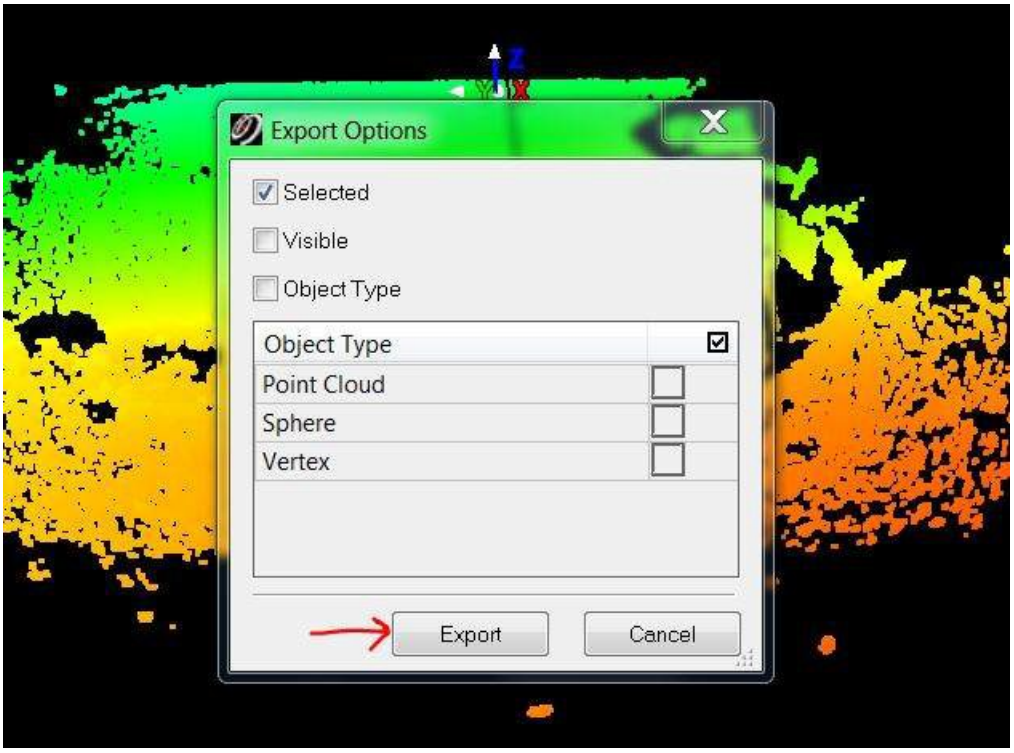
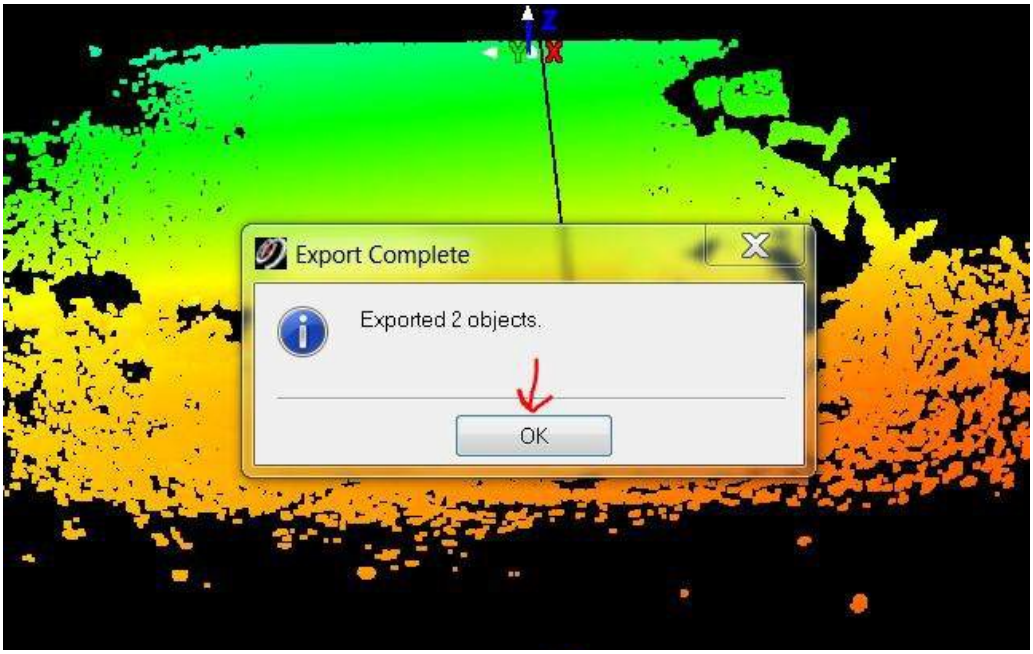
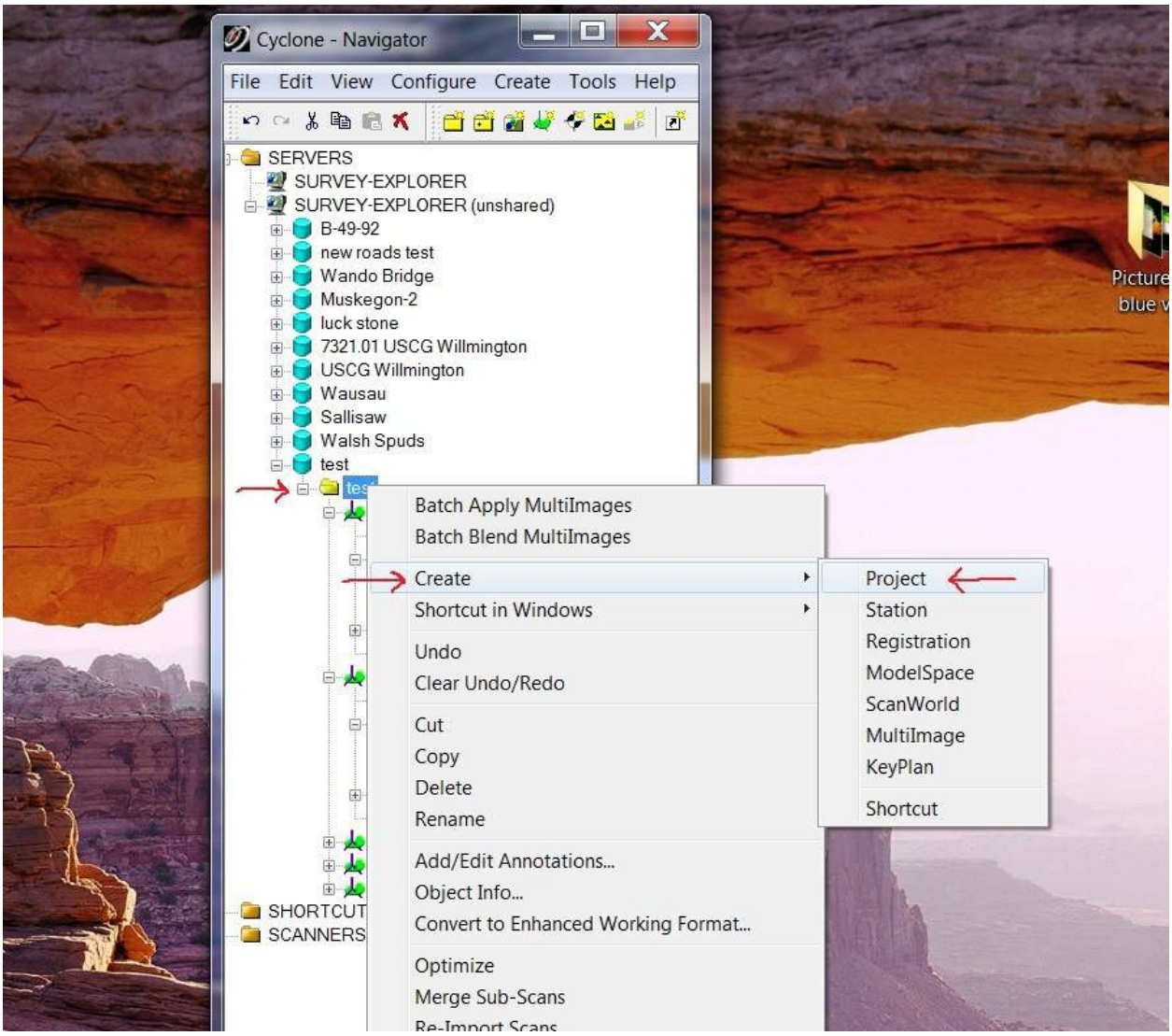
Kongsberg Mesotech
8/11/2012 12:49 PM
File folder

30. After clicking “Save” a window will pop up. Make sure “Selected” is toggled on. Click “Export”. Another window will pop up. Click “OK”. Clouse out model space when done.

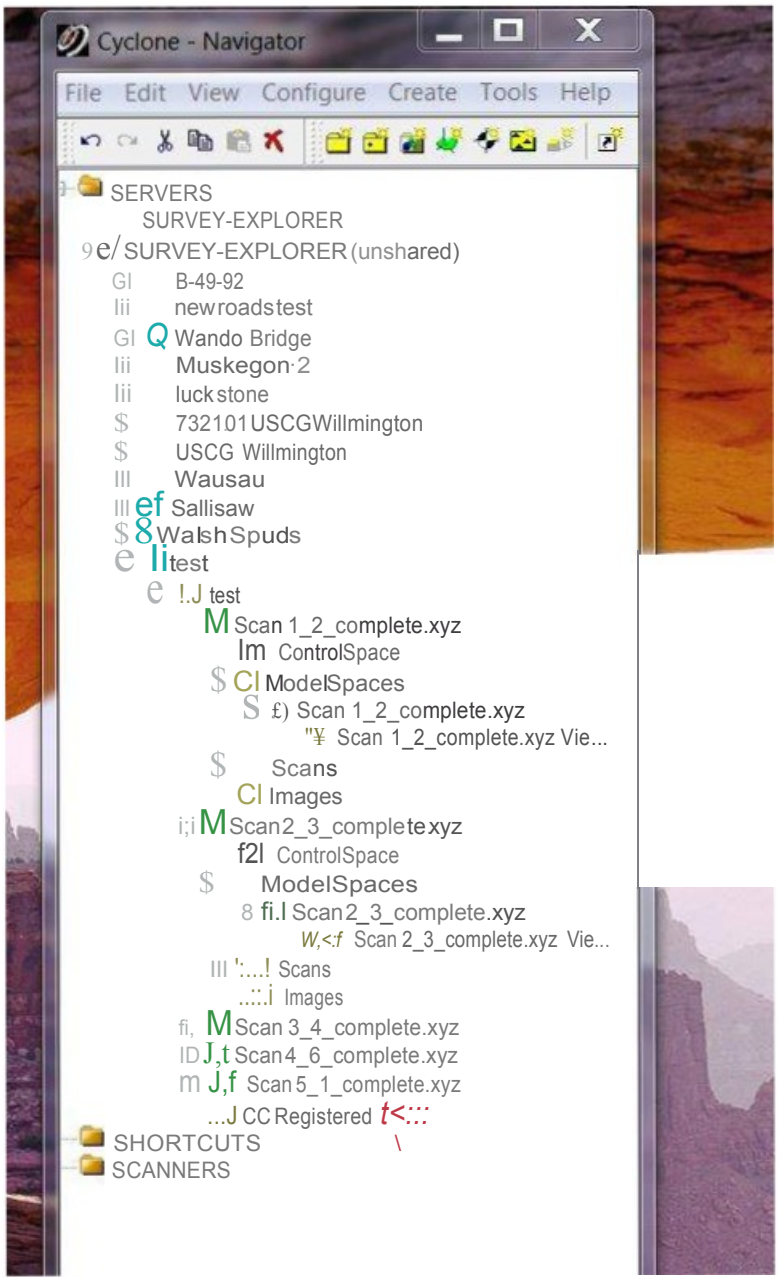


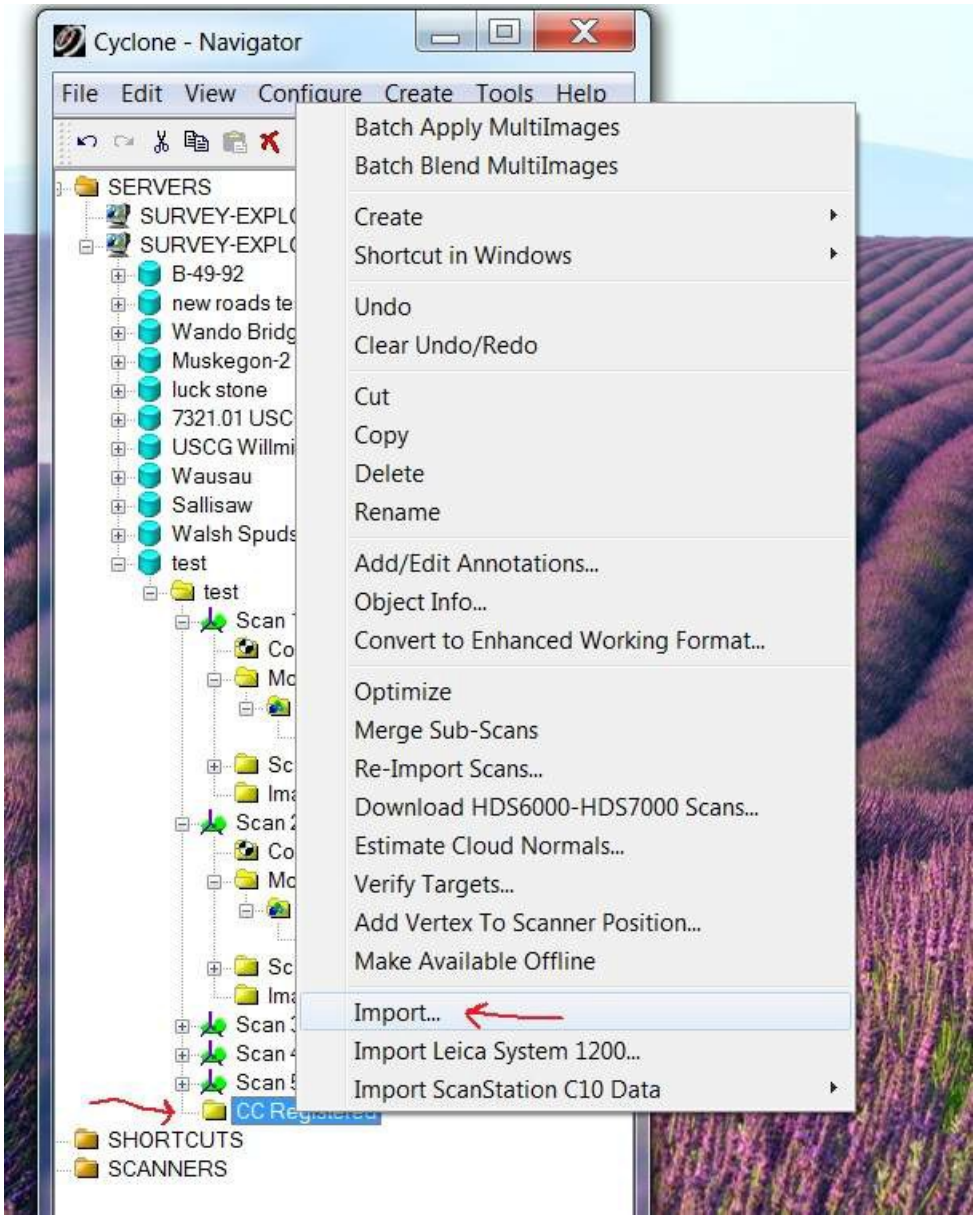


31. Rough Registering the point clouds: After the scan has been saved it can now begin the process of being registered. In Cyclone-Navigator under your project file, right click on your scan folder and select “Create” then “Project”.



32. A new folder will open up at the bottom of your scan folders. Rename this folder “CC Registered”. Right click on the “CC Registered” and select “Import”.




Cyclone - Navigator
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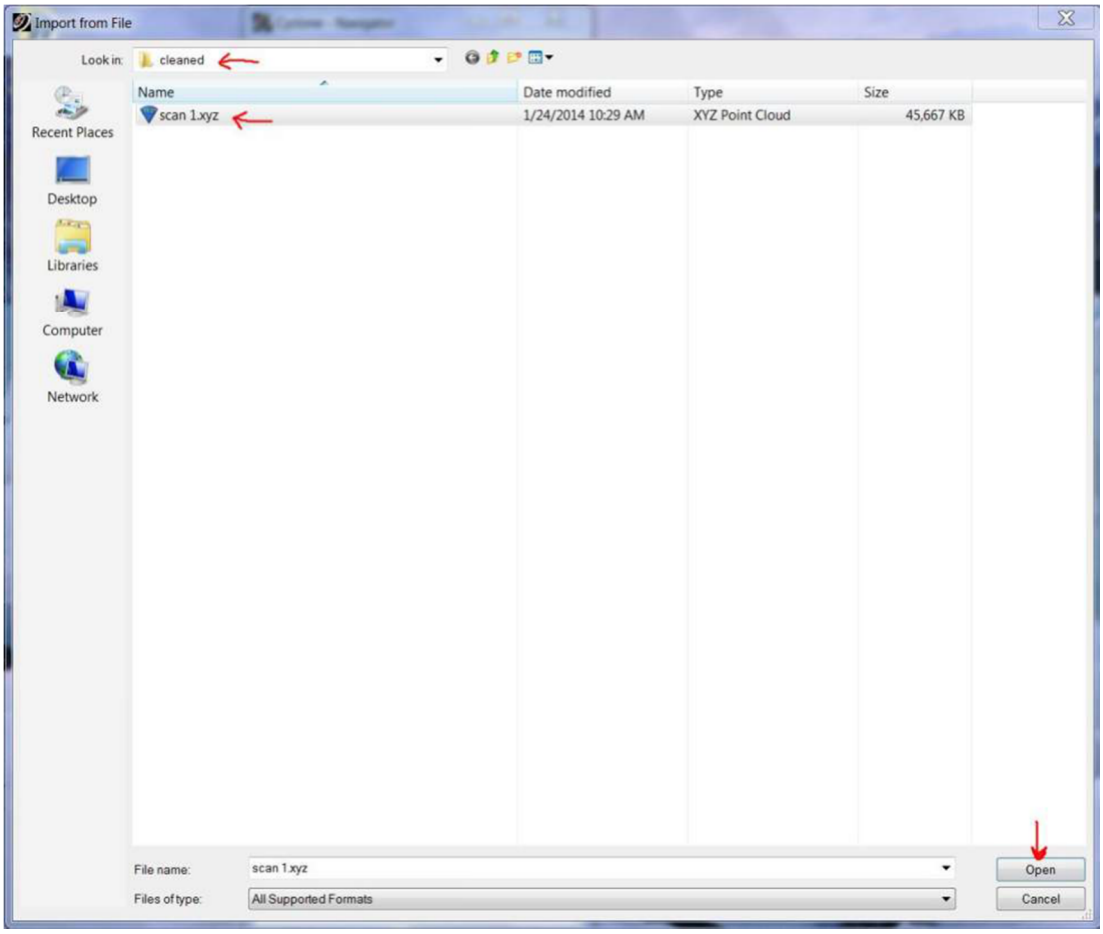
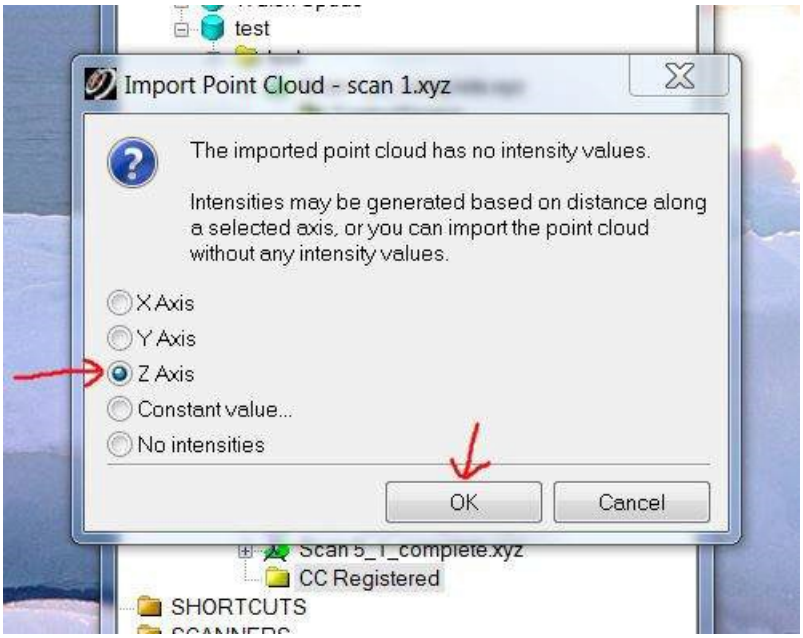
SHORTCUTS
SCANNERS
Batch Apply MultiImages
Batch Blend MultiImages
Create
Shortcut in Windows
Undo
Clear Undo/Redo
Cut
Copy
Delete
Rename
Add/Edit Annotations...
Object Info...
Convert to Enhanced Working Format...
Optimize
Merge Sub-Scans
Re-Import Scans...
Download HDS6000-HDS7000 Scans...
Estimate Cloud Normals...
Verify Targets...
Add Vertex To Scanner Position...
Make Available Offline
Import...
Import Leica System 1200...
Import ScanStation C10 Data

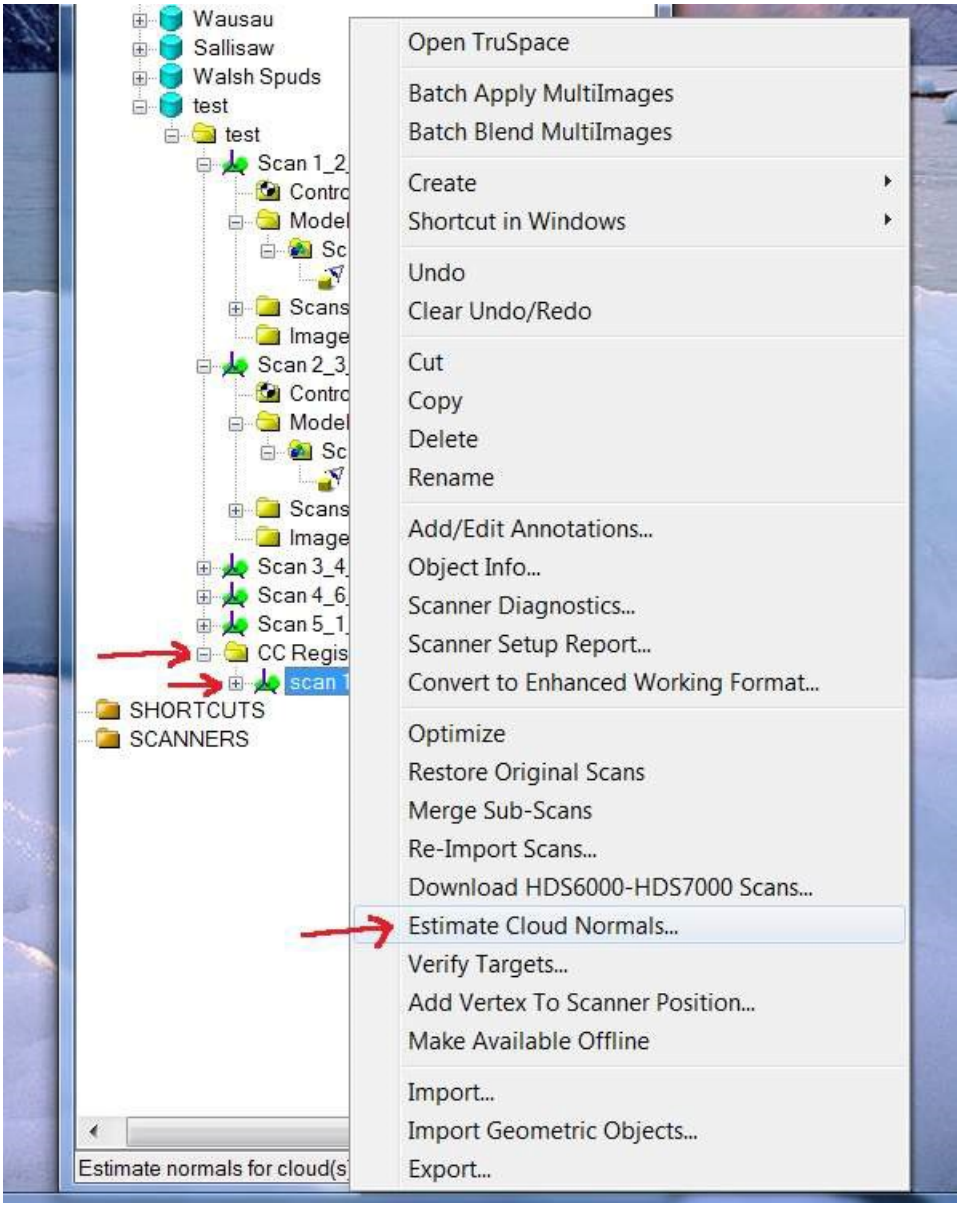
33. A save window will open up, navigate to your .XYZ scan in your cleaned folder. Click on the .XYZ scan and click “Open”. Another window will open up, make sure “Z-Axis” is selected and click “OK”.





34. Once the scan has finished loading, expand the “CC Registered” file, right click on the scan.XYZ file, and then select “Estimate Cloud Normals…”

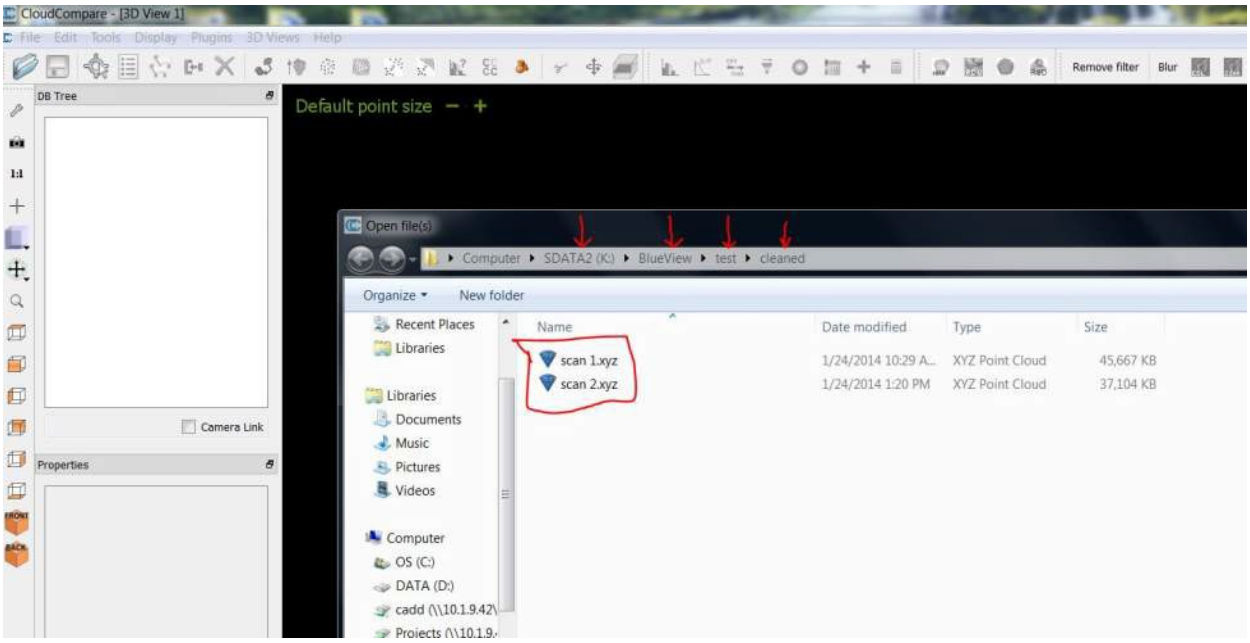
Note: The "Estimating Normals" process takes a long time so you will want to start this process before you start cleaning the next image.



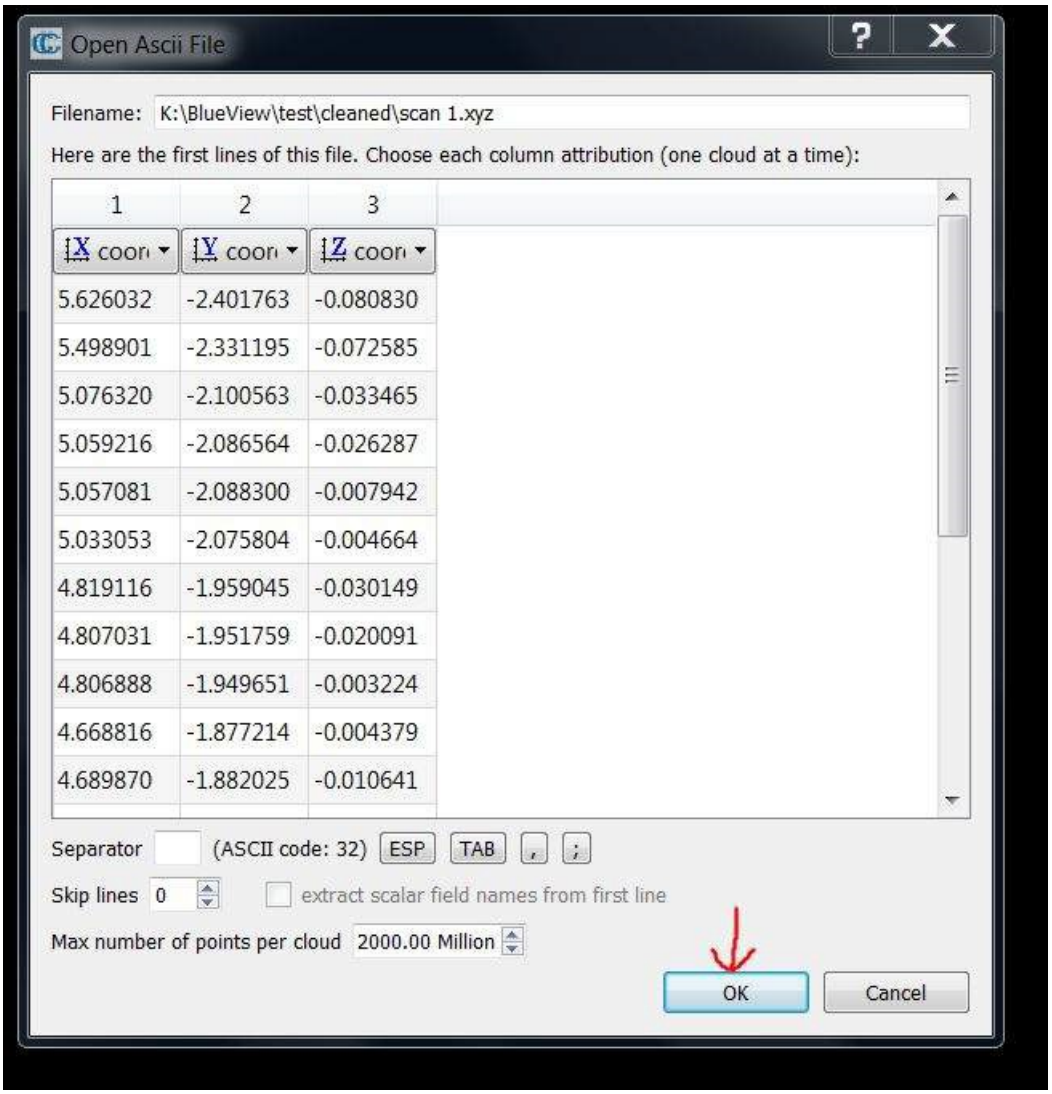
35. While the computer is processing for “Estimating Cloud Normals…” of the first scan, replicate steps 12-30 to clean scan 2.

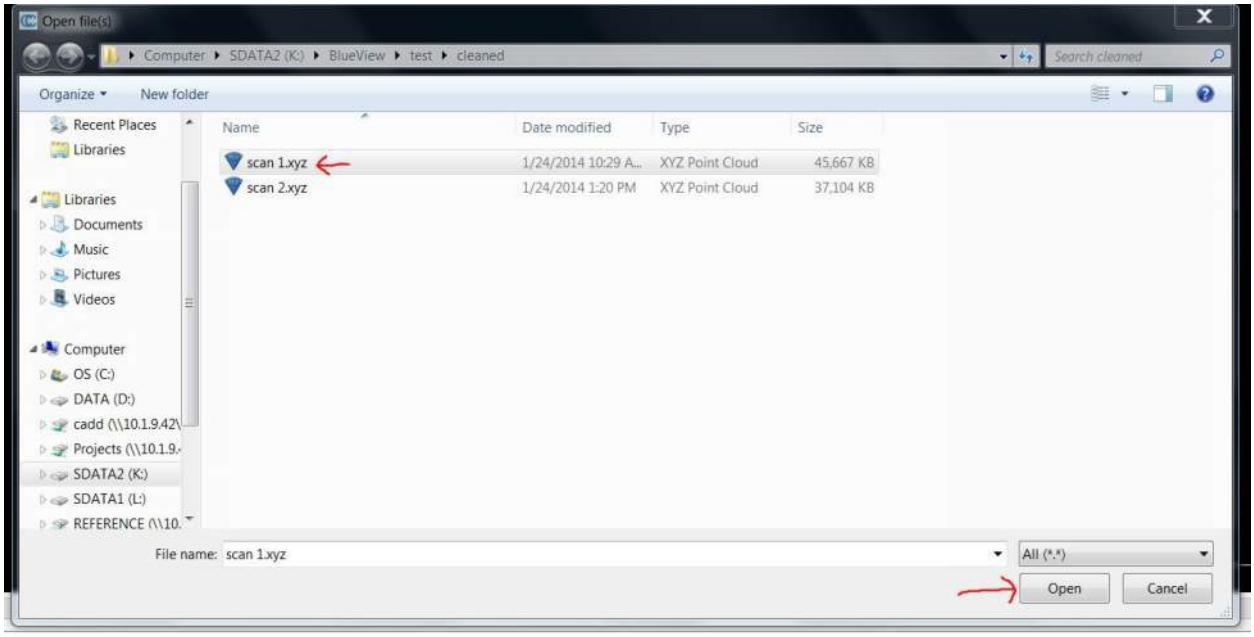
Note: You will not need to use the waterline to adjust the rest of the scans. The waterlines should be put on a separate layer and turned off.

36. Now that you have 2 scans that are cleaned you can now open up “Cloud Compare”. Open “Cloud Compare”, go to “File”, then “Open”. A save window will pop up where you will need to navigate to your “Cleaned” folder. This Folder should have both .XYZ scans in it.



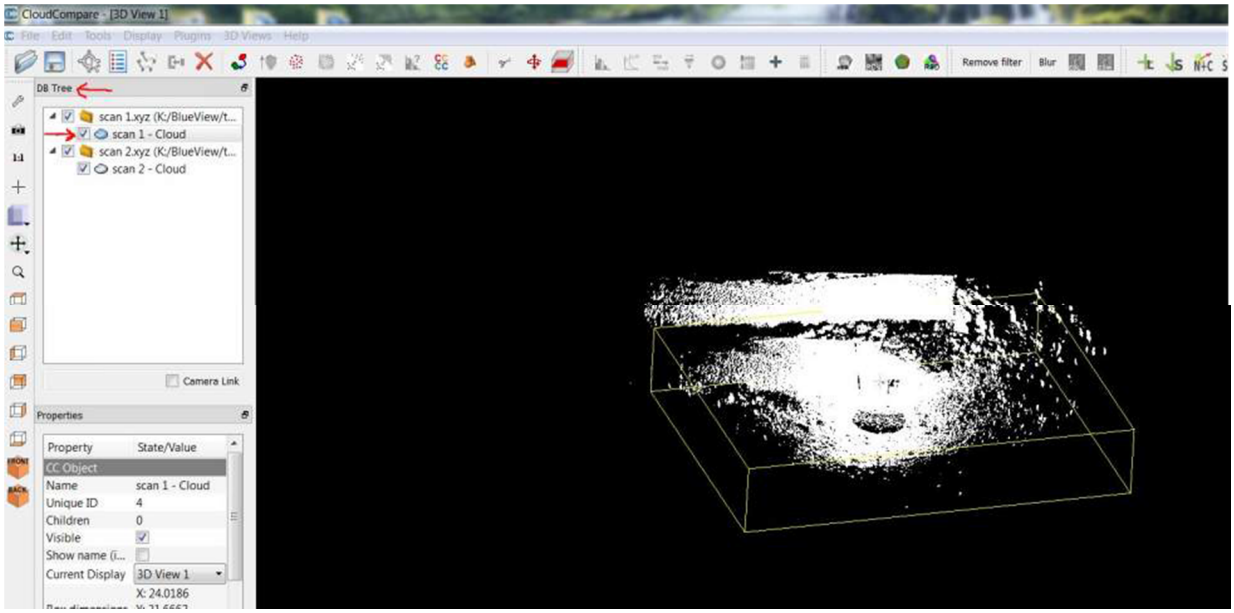
37. Locate your “scan 1.XYZ” file, click on it and click “Open”. A window will pop up just click “OK”. This will open up your cleaned scan1 image onto the screen.

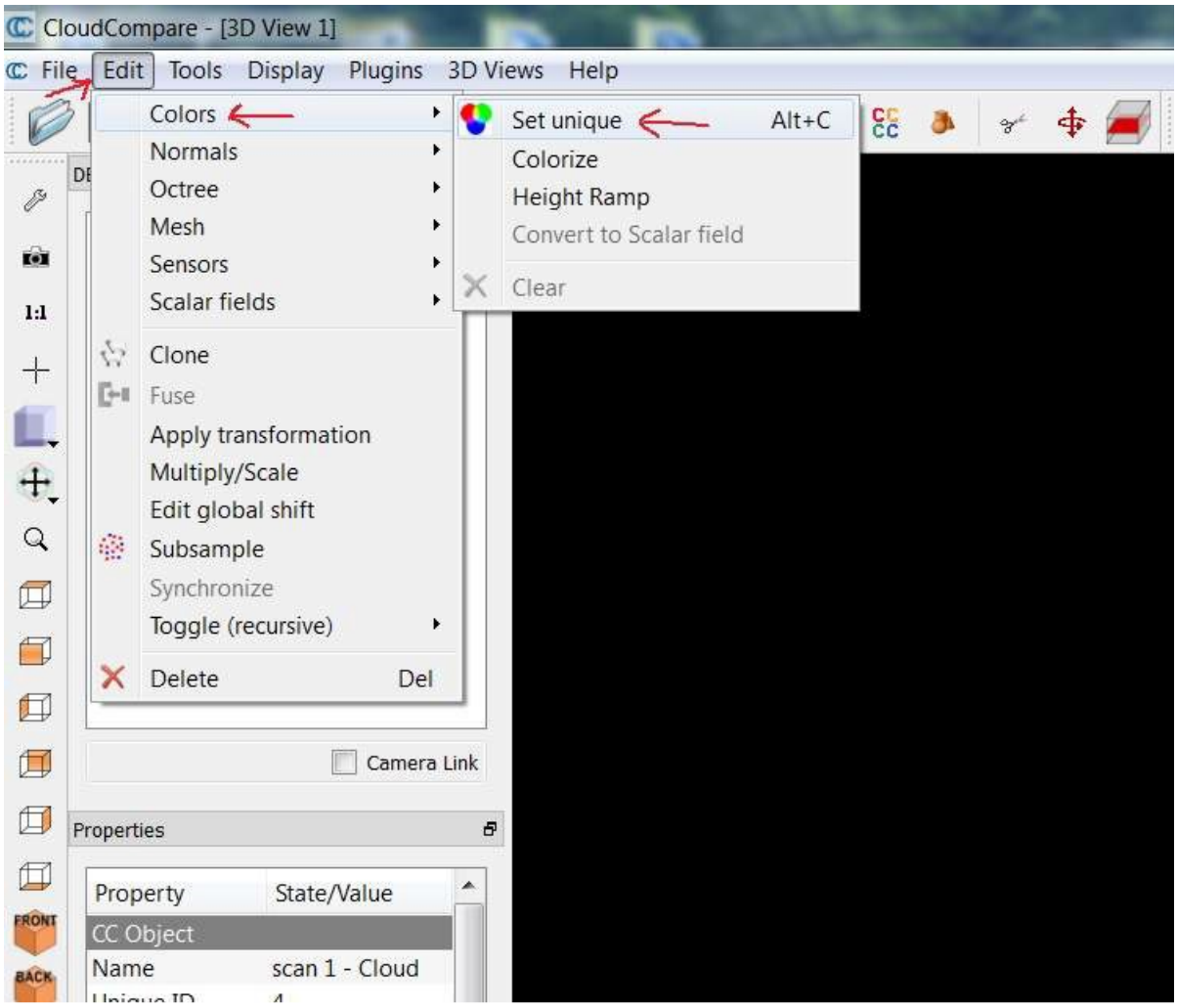




38. Open “scan 2.XYZ” the same way you did “scan 1.XYZ”.

39. When both are opened on the screen they are both in black and white which is very difficult to tell what points belong to each cloud. To help differentiate, in the “DB Tree” box click on one of the scans. A box will form around the image showing which one has been selected. Go to “Edit”, then “Colors”, then “Set unique”.




CloudCompare - [3D View 1]
File
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Tools
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Plugins
3D Views
Help
Colors
Normals
Octree
Mesh
Sensors
Scalar fields
Clone
Fuse
Apply transformation
Multiply/Scale
Edit global shift
Subsample
Synchronize
Toggle (recursive)
Delete
Del
Set unique
Alt+C
Colorize
Height Ramp
Convert to Scalar field
Clear
Camera Link
Properties
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State/Value
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scan 1 - Cloud
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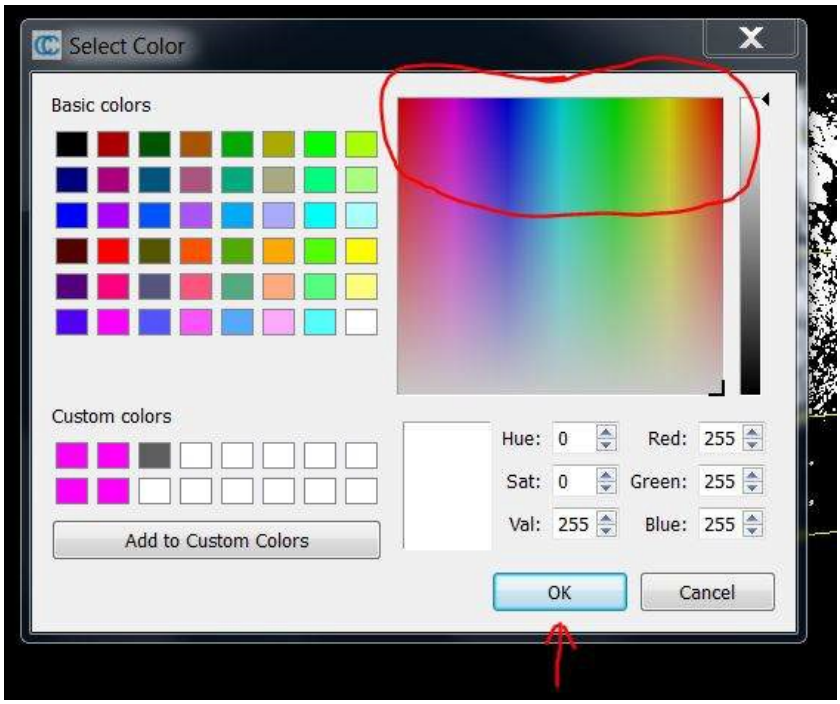
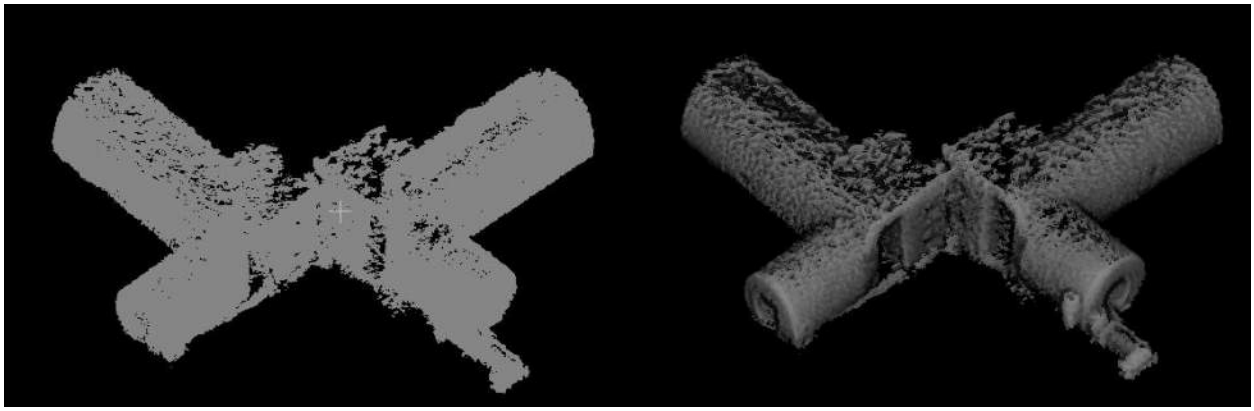
40. A window will pop up with a pallet of colors. Select an easily visible color and click “OK”.



41. Use the same process to change the color on the other scan but choose separate colors.

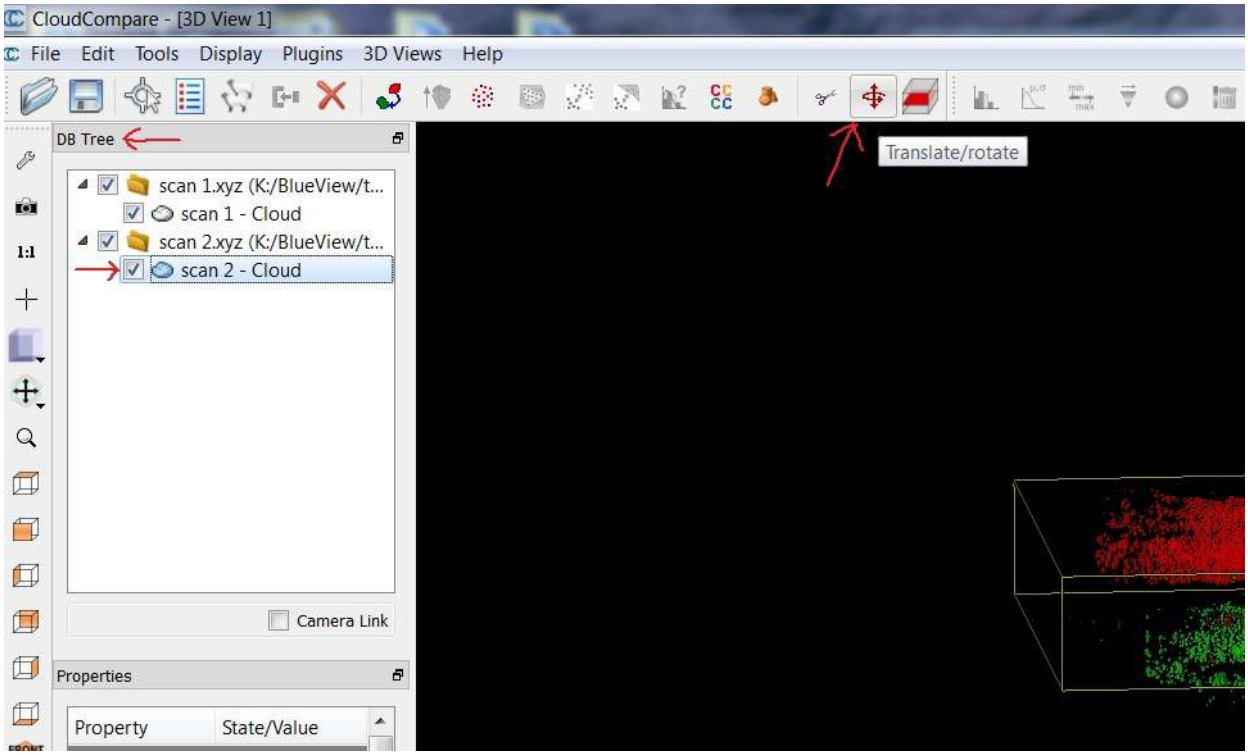
42. To make the scans even more visible, click on the “EDL” button. This will add shading to the scans which will make object detail stand out better.

**No EDL in at left and EDL applied at right in image below.



43. Now that the scans are more visible you are ready to align them.
Note: Never move the first scan! In this case don't move "scan 1". Since this scan was referenced off the waterline it will be used as your base points to match up the other scans.

44. In the "DB Tree" box click on "scan 2", (**DO NOT click on "scan 1")** then click on the "Translate/ Rotate" tool. This will allow you to move and re-assign coordinate values of Scan 2 while holding the coordinate values of Scan 1. To move in this view with the computer mouse:

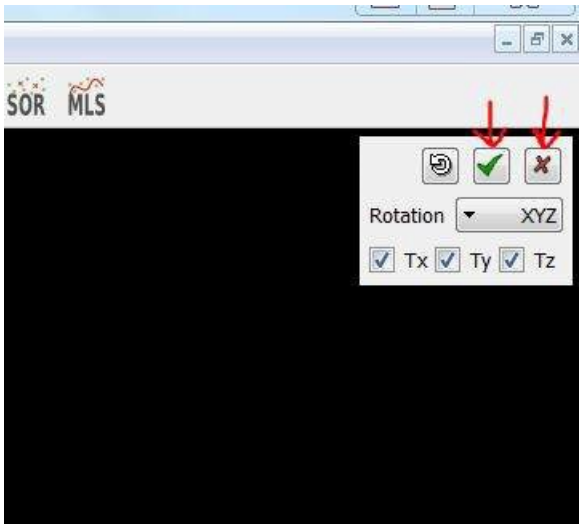


Use the wheel to zoom in and out.

Hold the right mouse button to pan the image

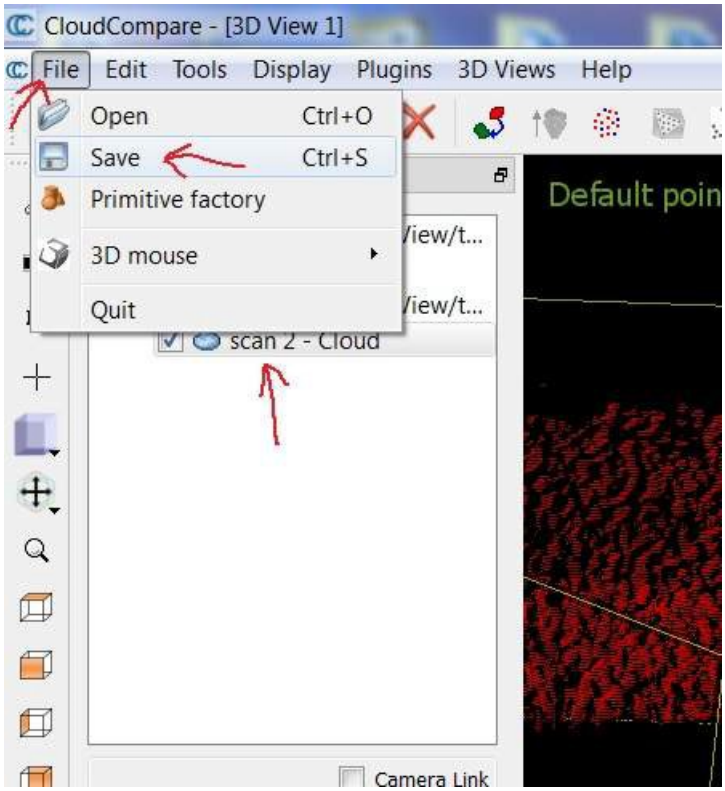
Hold the left mouse button to rotate the image

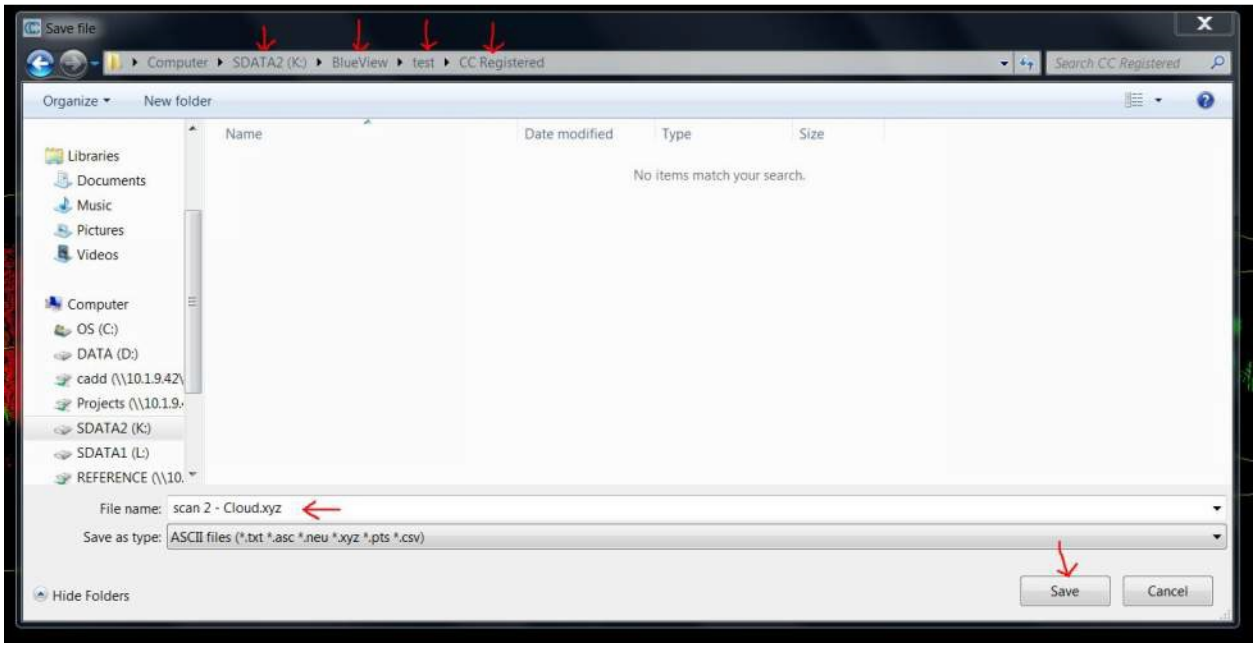
45. You will only be able to move from the set view angle. Then you will have to select the "Accept" button (the check mark) if you agree with the move you have made or the "Deny" button (the X mark) if you do not agree with the move you have made. If you select the "Deny" button the image will move back to the position it was before you made that move. If you select the "Accept" button the image will lock into place and re-assign new x, y, and z coordinates to each point in the cloud.



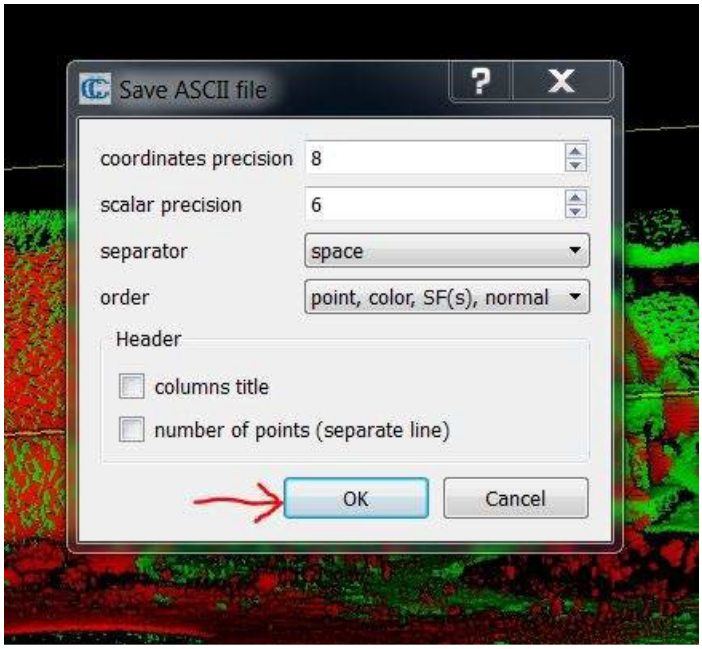
46. The view can now be changed and the process can be repeated as many times as necessary to align the objects. This is done by changing the view to the new position you want, again go to the "DB Tree" box click on "scan 2", **(DO NOT click on "scan 1")** then click on the "Translate/ Rotate" tool. Keep moving and accepting until "scan 2" is aligned perfectly with "scan 1".

47. Once the two scans are lined up as close as possible, go to the "DB Tree" box click on "scan 2", go to "File" and select "Save". A save window will pop up, navigate to your "CC Registered" folder and save the scan as a ".XYZ" file, then click "Save" (This creates a new version of scan 2 with coordinates that are close to the coordinates of scan 1.

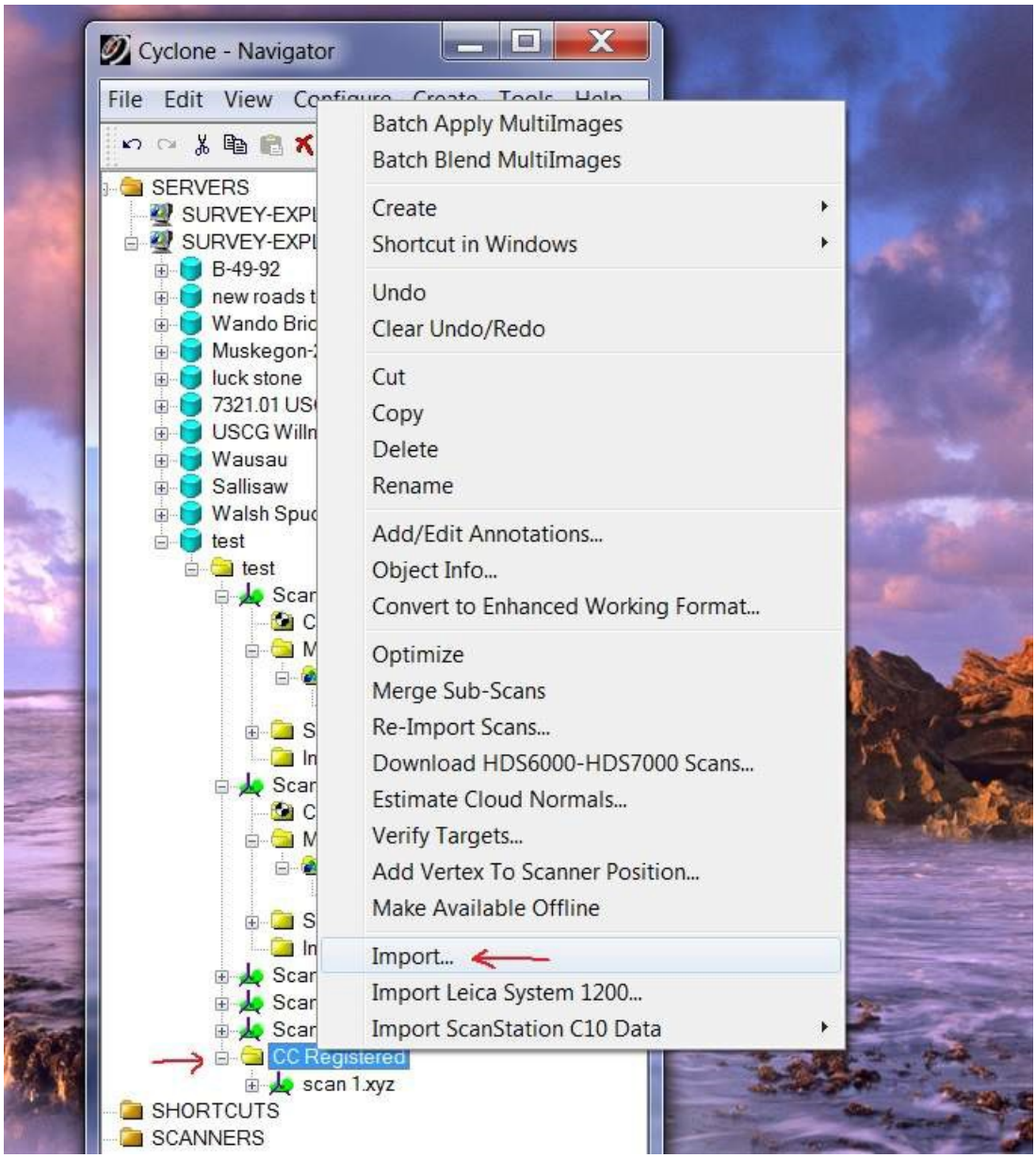




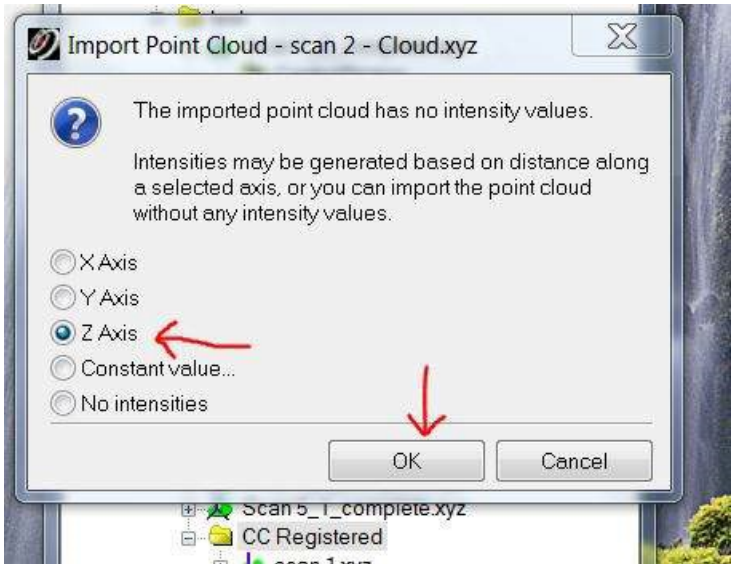
48. Another window will pop up just click “OK”.

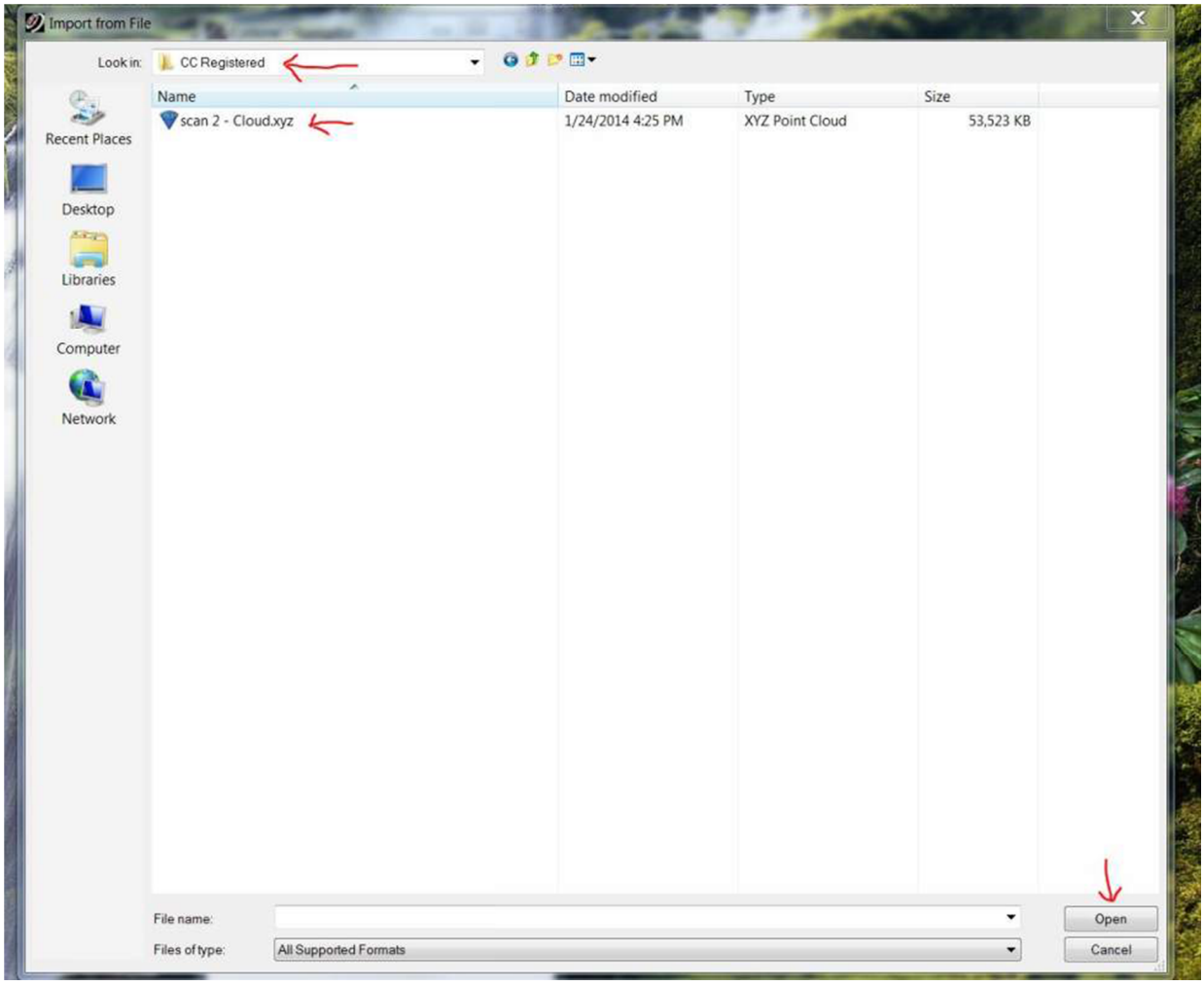


49. In Cyclone-Navigator right click on the “CC Registered” file and select “Import”.

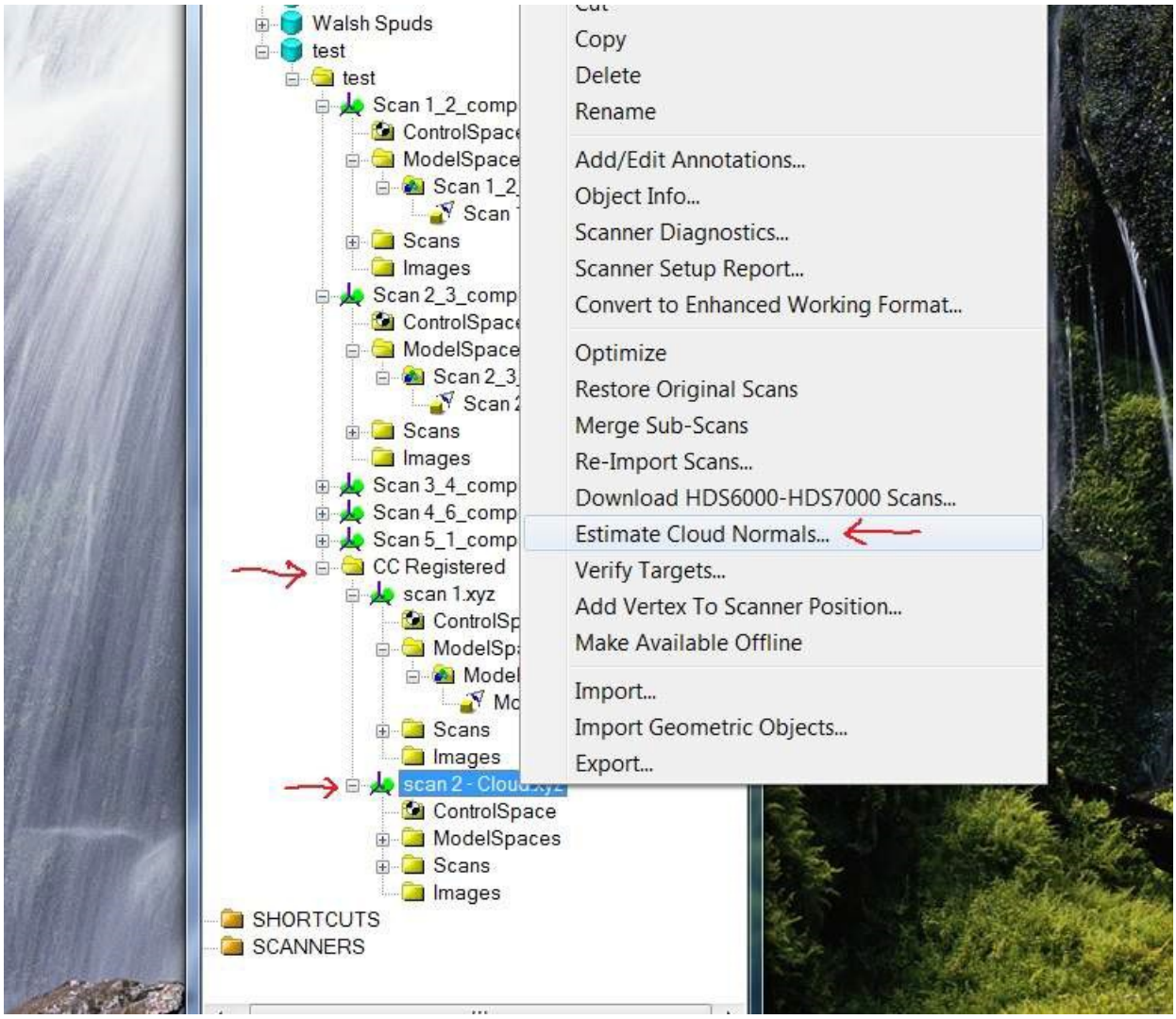


50. A save window will open up. Navigate to your .XYZ scan in your “CC Registered” folder. Click on the .XYZ scan and click “Open”. Another window will open up, make sure “Z-Axis” is selected and click “OK”.



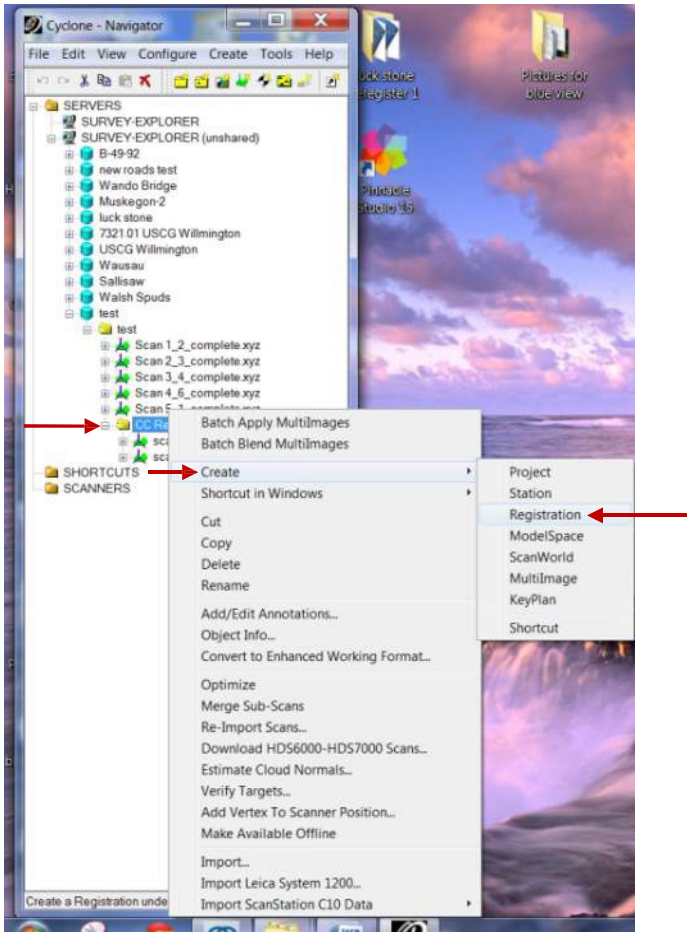


51. Once the scan has finished loading, expand the “CC Registered” file, right click on the “scan 2.XYZ” file, and then select “Estimate Cloud Normals…” (This process cannot be started until the normal estimation process from scan 1 is complete - step 34)



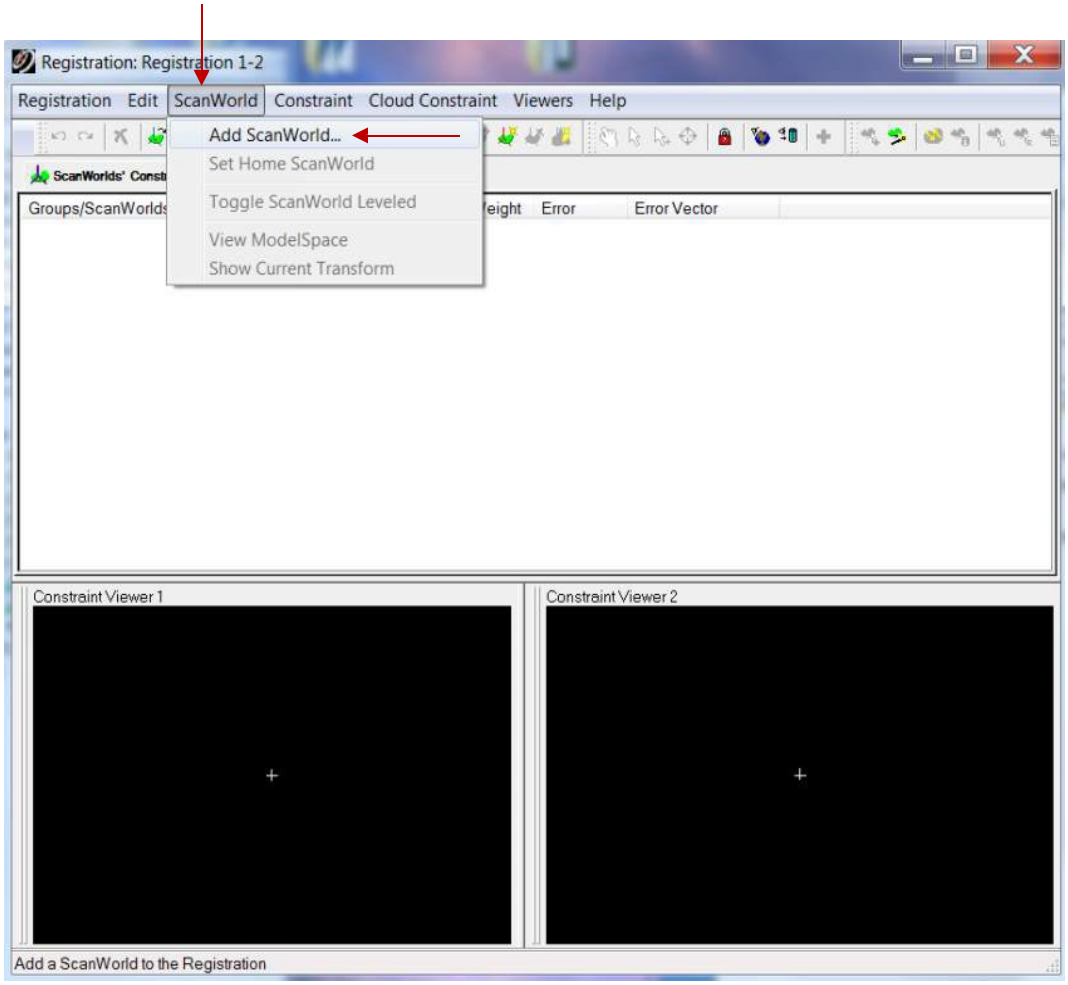
52. While the computer is processing “Estimating Cloud Normals…” for scan 2, begin cleaning scan 3 by repeating steps 12 through 19.

53. Once normals are estimated for Cloud 2, go to the Cyclone Navigator Tree and right click on the "CC Registered" Folder. Select "Create", then "Registration" to perform a more refined registration of the 2 datasets.

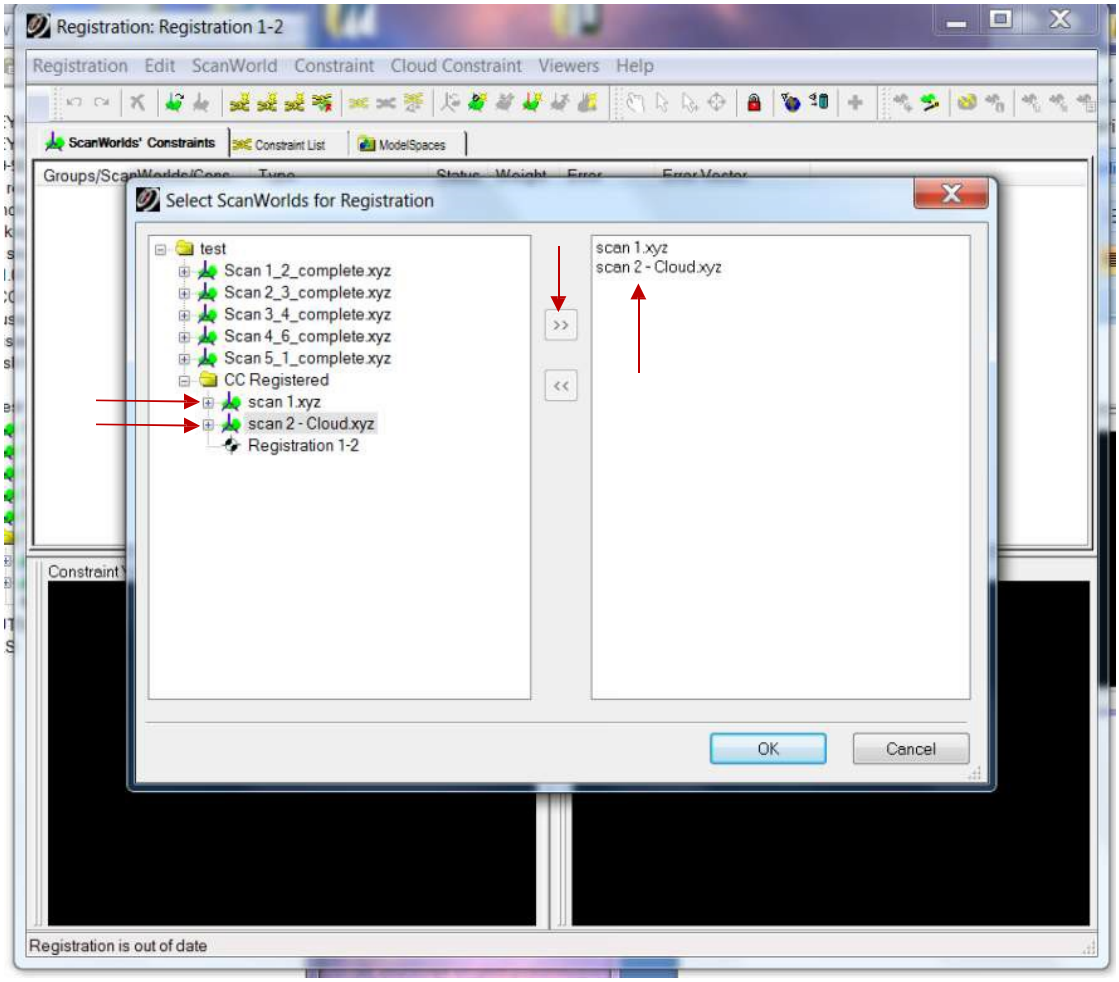


54. This will create a registration below the 2 scans in the file tree. Right click on it and re-name it Registration 1 - 2 to denote which scans are included in the registration.

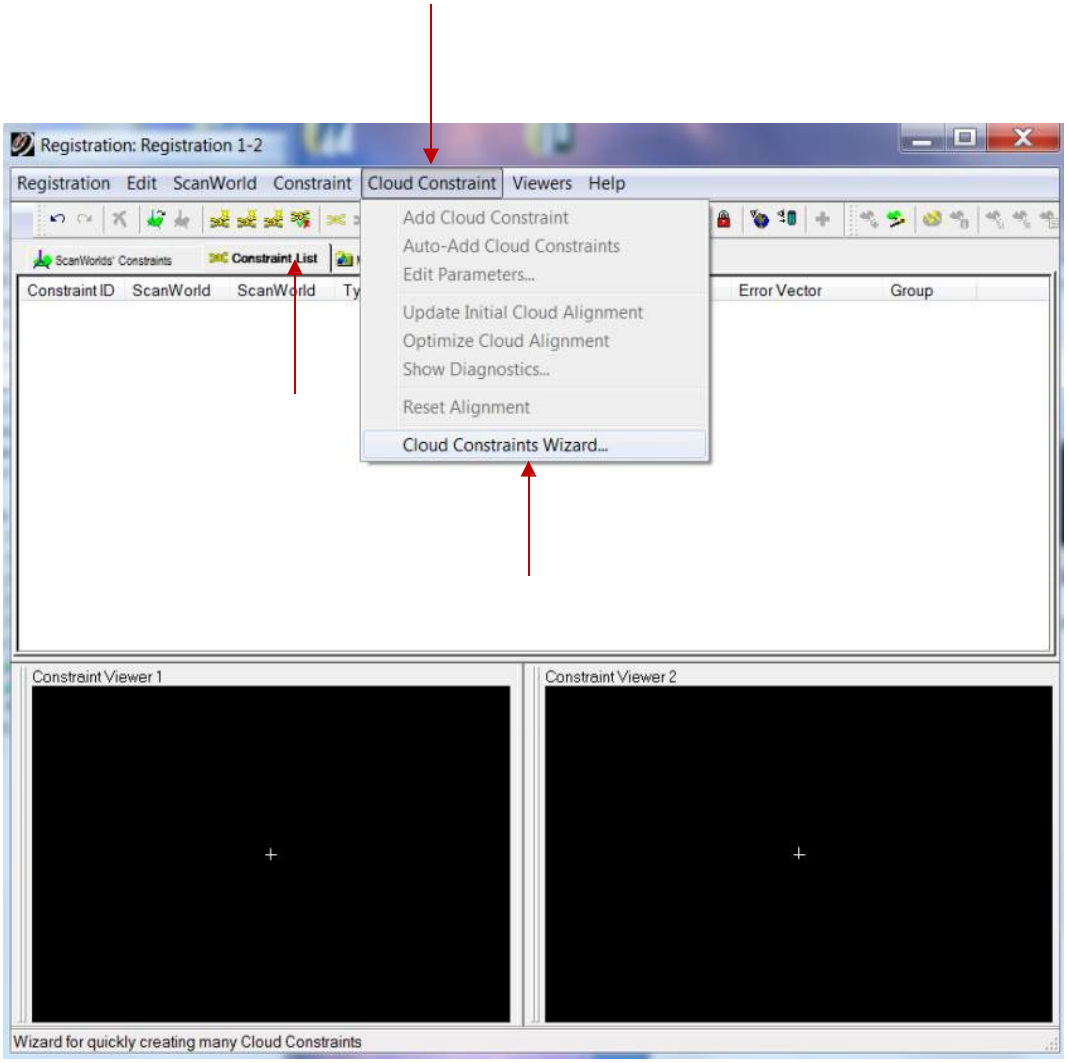
55. Double click the Registration to open it. Then go to "Scan World" and select "Add Scan World"



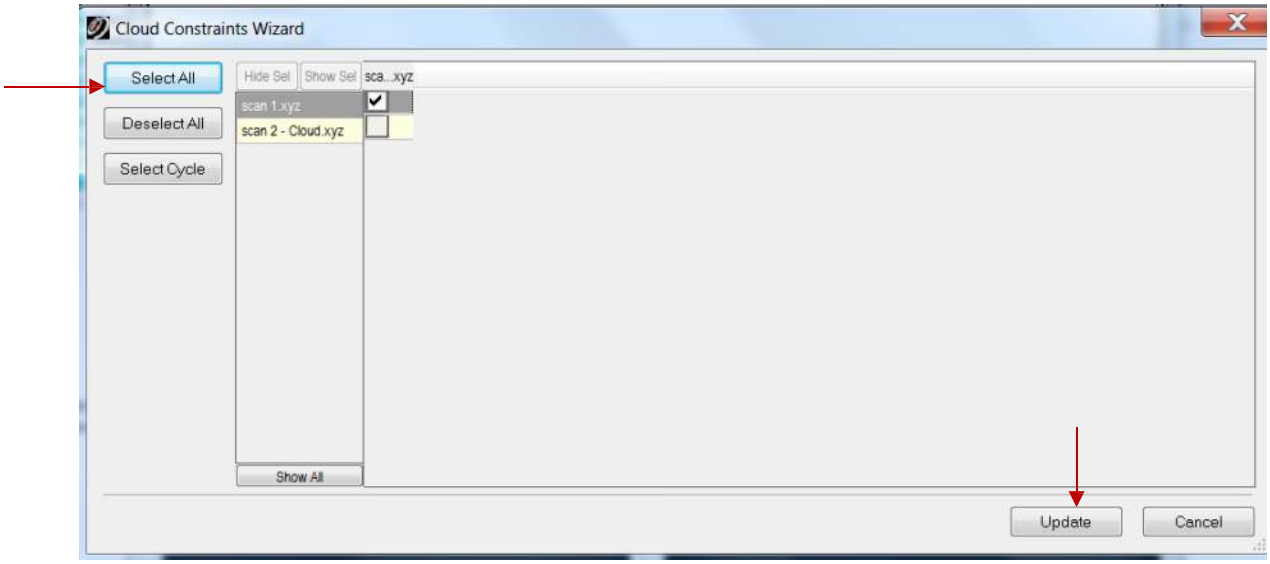
56. Navigate to the "CC Registered" files and add them to the scan world as shown below and click "OK".



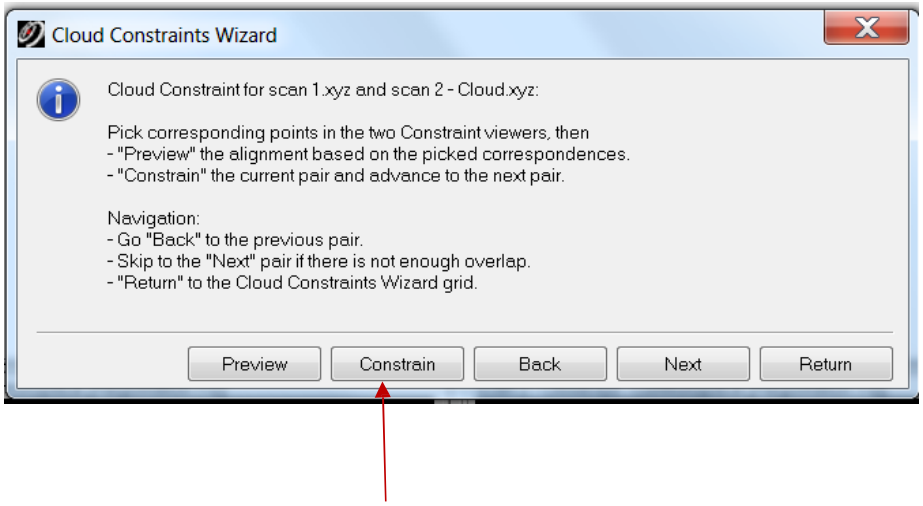
57. Next click on the "Constraint List" tab, then slect "Cloud Constraint" pull down and "Cloud Constraint Wizard".



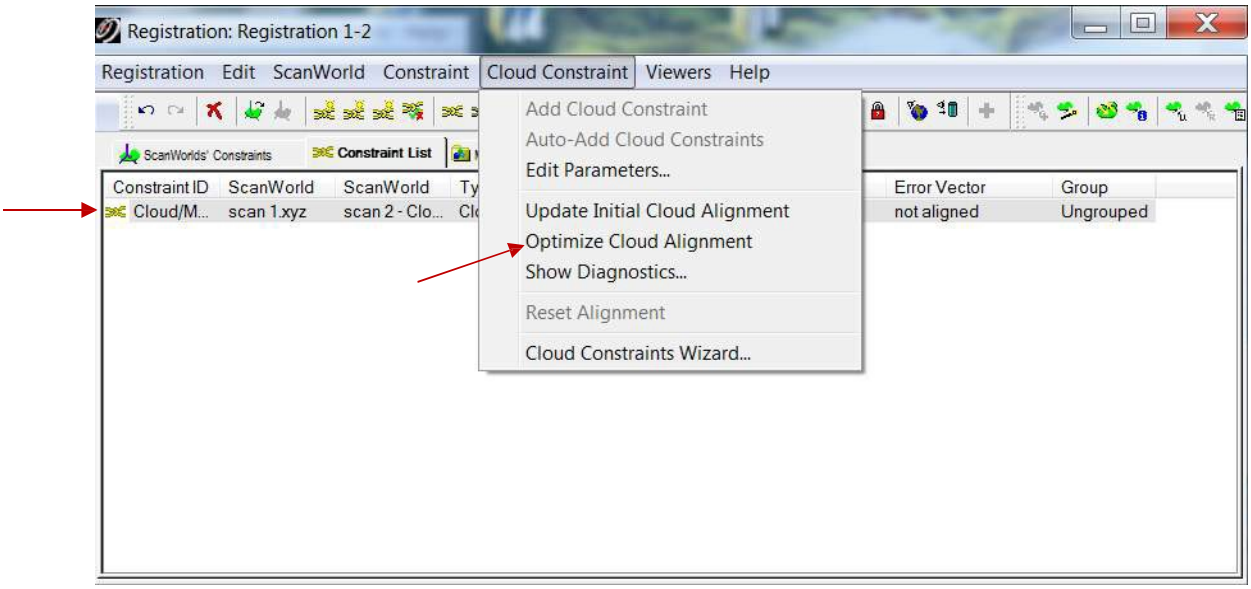
58. In the "Cloud Constraint Wizard", click "Select All" and "Update"



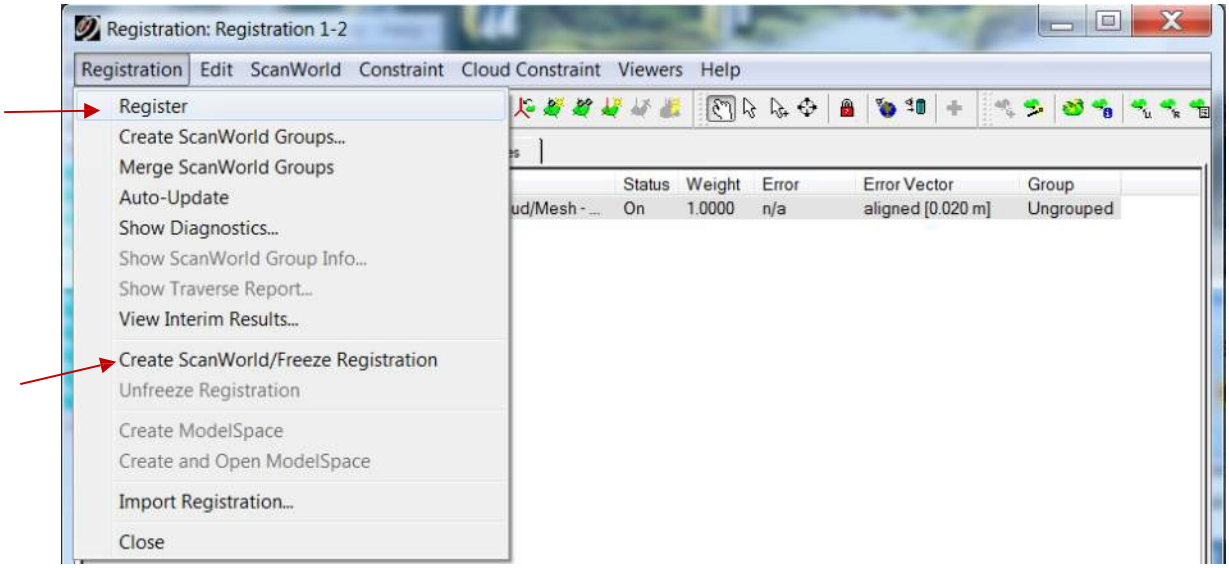
60. A box will pop up, click "Constrain".



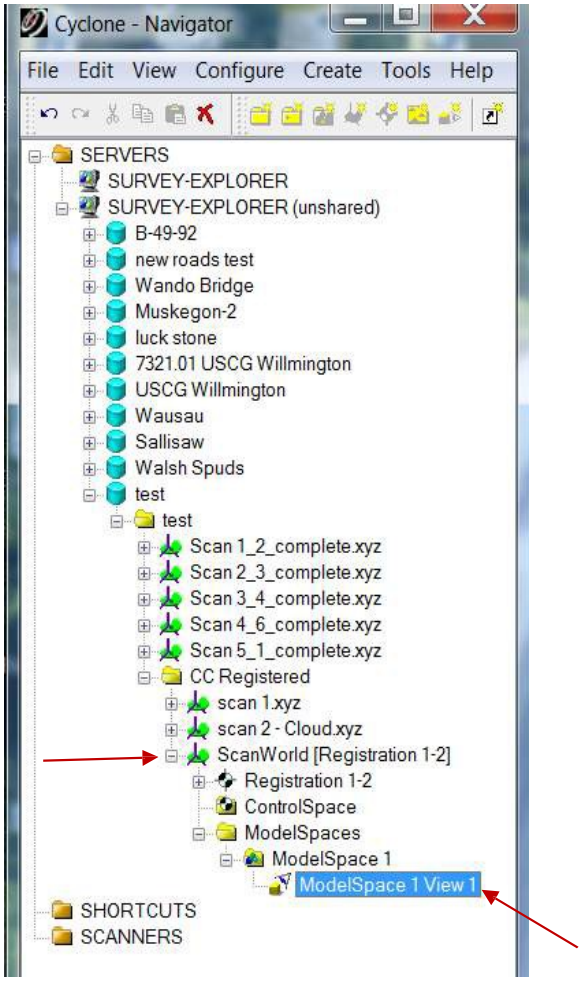
60. This will load a constraint into the constraint list. Left click on the constraint to highlight the constraint, go to "Cloud Constraint" and select "Optimize Cloud Alignment".



62. Close the results box that appears and click "Registration" then "Register" and then "Create Scan World/Freeze Registration"

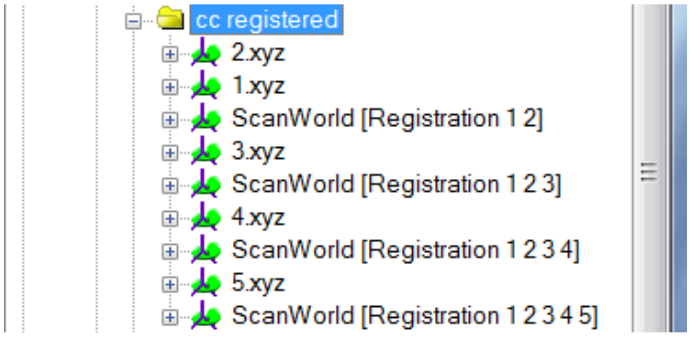


63. Close the registration. The registration should now show up in Cyclone Navigator as a ScanWorld with the same name as the Registration. In this case it is "ScanWorld [Registration 1-2]" to denote that it contains Scans 1 and 2. Expand the ScanWorld and open its Modelspace to examine. The clouds should be aligned with each other.

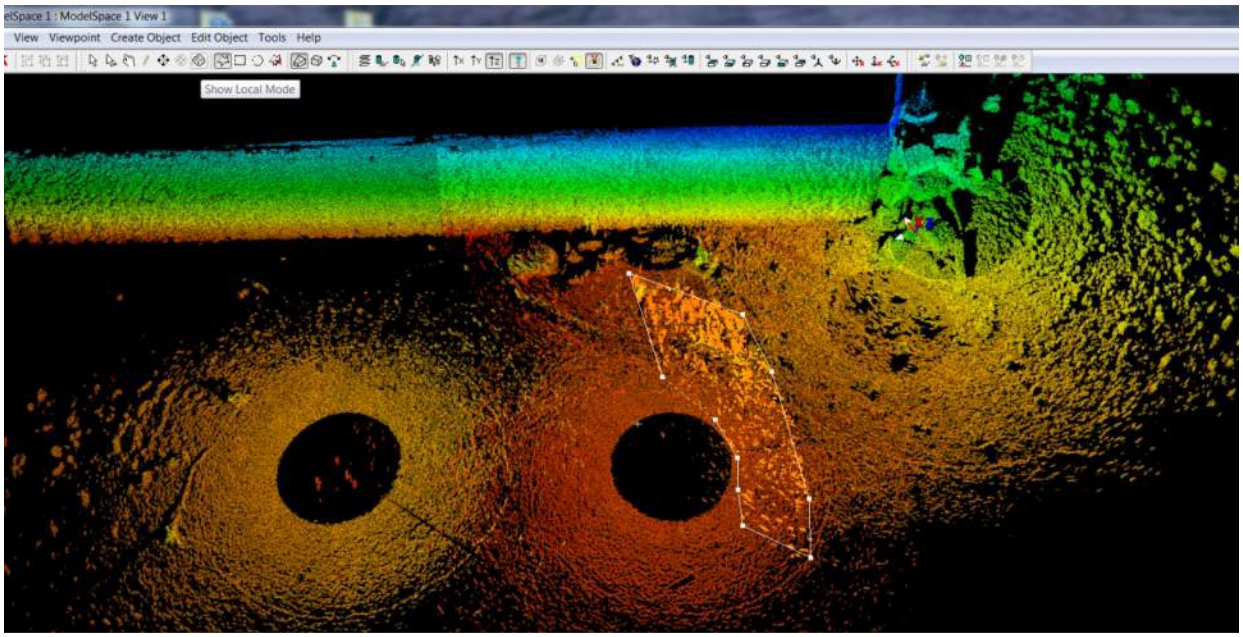


64. Assuming the registration went well, We will "Select All" in the ScanWorld modelspace and "Export to the "CC Registered" folder as 1-2.xyz to denote that it contains scans 1 and 2. We will then open CloudCompare and import 1-2.xyz and scan 3. We can now repeat the Cloud Compare Rough Registration Process by only moving scan 3 in relation to scans 1 and 2. Likewise, we will repeat the Refined Registration in Cyclone by registering Scan 3 and ScanWorld [Registration 1 2].

This process of cleaning and adding 1 cloud at a time should be repeated until a registration containing all clouds is obtained. The resultant Cyclone Navigator file tree will look like this:



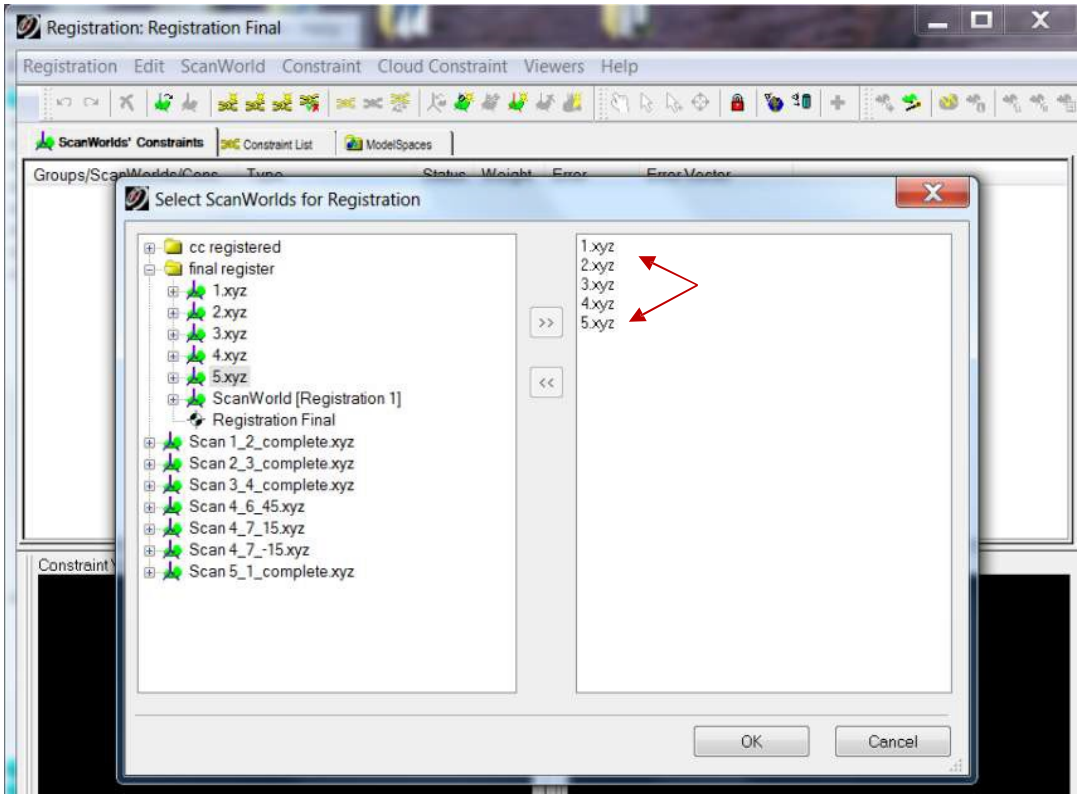
65. At this stage, the ScanWorld Model space containing all clouds should be opened for final cleaning. The cleaning process will again involve removal of any outlier points that appear to be noise. In addition, any points near the outer range of each scan that do not appear as detailed, and that have better data from an adjacent scan should be removed. (See below for example of points to be removed)



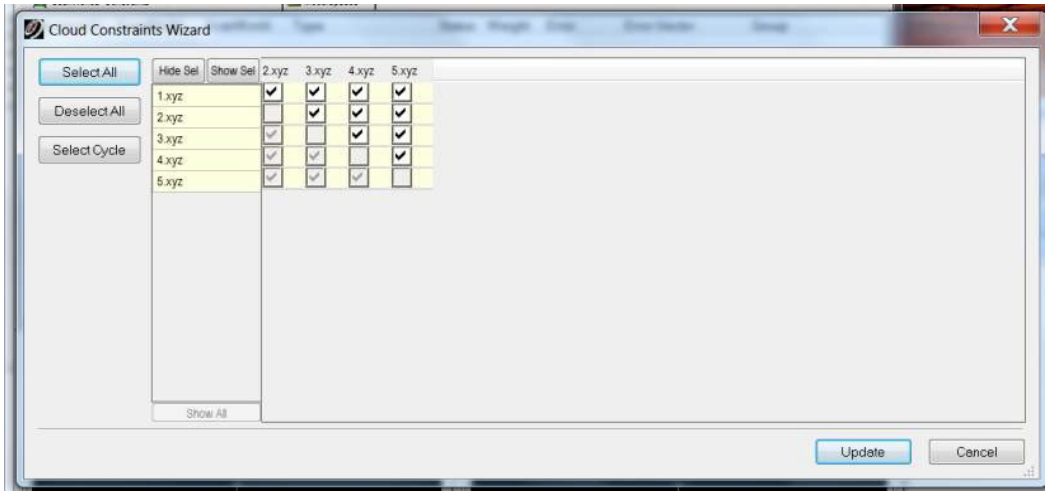
66. Once all scans are cleaned, they should be selected one at a time and exported from Cyclone as separate .xyz files.

67. We will right click on the "Test Project", in Cyclone Navigator and we will create a new Project called "Final Registration". Import all .xyz files from step 65 back into the "Final Registration" folder. At this point, you will need to "Estimate Cloud Normals" for all clouds.

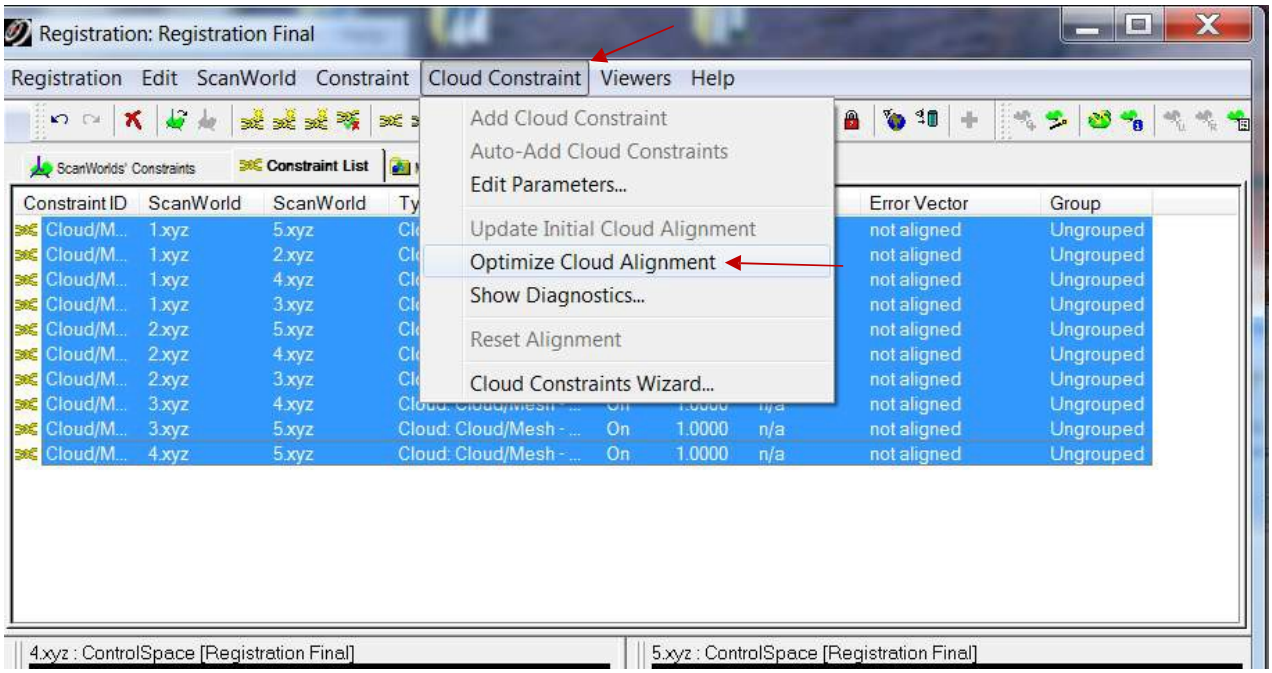
68. Create a registration in the "Final Registration" folder and add all scans.



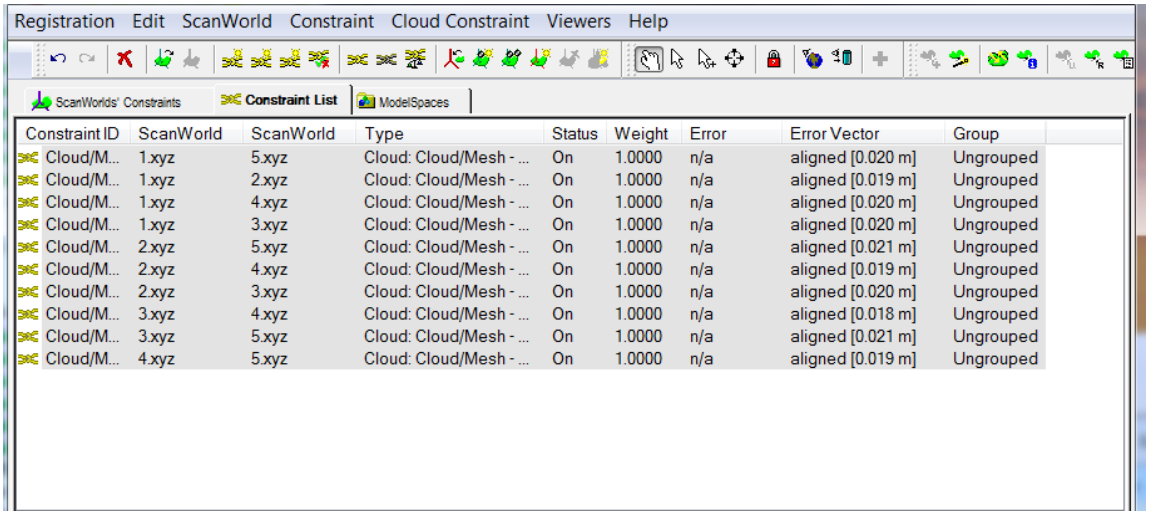
69. When assigning constraints, "select all" to lock each cloud to each other and obtain a tighter overall registration.



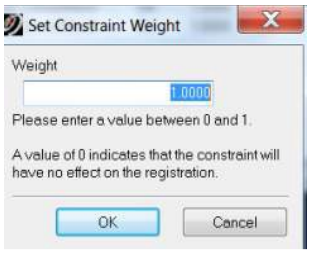
70. Once all constraints have been established, select them all from the "Constraint List" and go to "Cloud Constraint" pull down and select "Optimize Cloud Alignment".



71. Close the results box that appears. Under the "error vector" heading, select and delete any constraints that are labled "not alligned". (In this case none)



72. At this stage, you can also experiment with adding constraint weights to individual constraints that have higher error vectors. You do this by left clicking on the constraint in the constraint list and going to the "constraint" pull down and selecting "set weight". A value lower than 1 will tell the computer not to look at that constraint as hard if points are conflicting between clouds.



73. After changing the weights, you can retest by selecting all constraints and going back to "Cloud Constraint" pull down and selecting "Optimize Cloud Alignment". The values should be played with until the combination is found that results in the lowest error vectors for all constraints.

74. When this is done, finish the registration and open the modelspace for the final scanworld.

75. The resultant dataset containing all scans can now be categorized into layers for each different material such as "channel bottom", Pier wall, debris, etc.

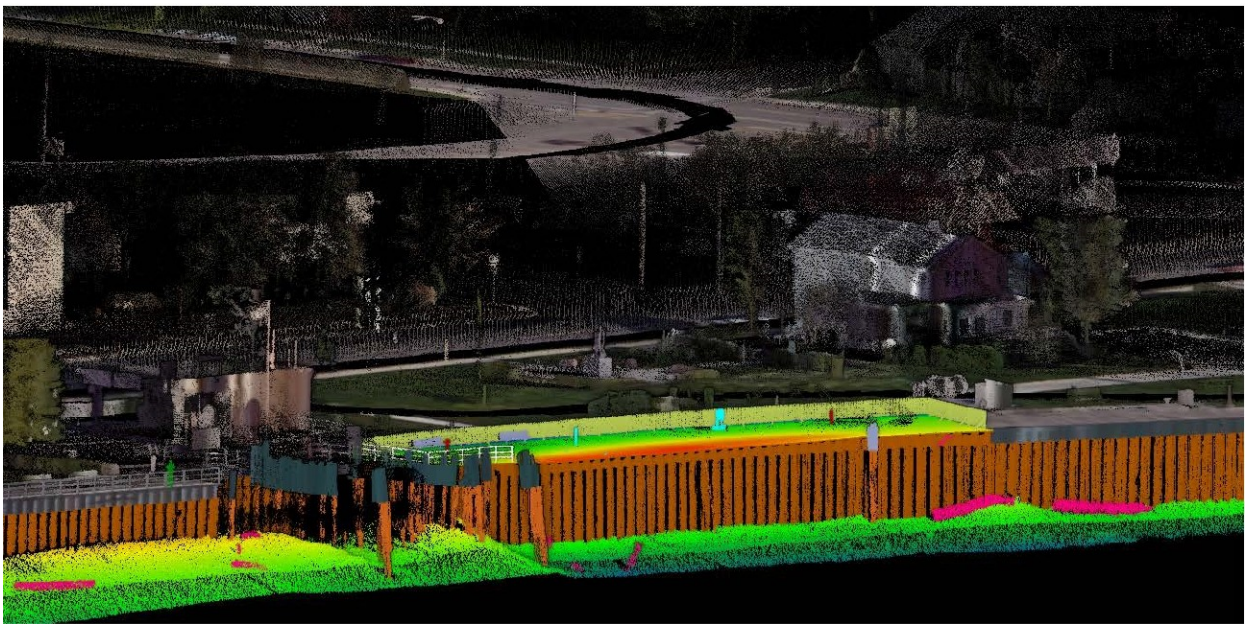
76. Turn off all layers except one and export a .xyz file for each layer.

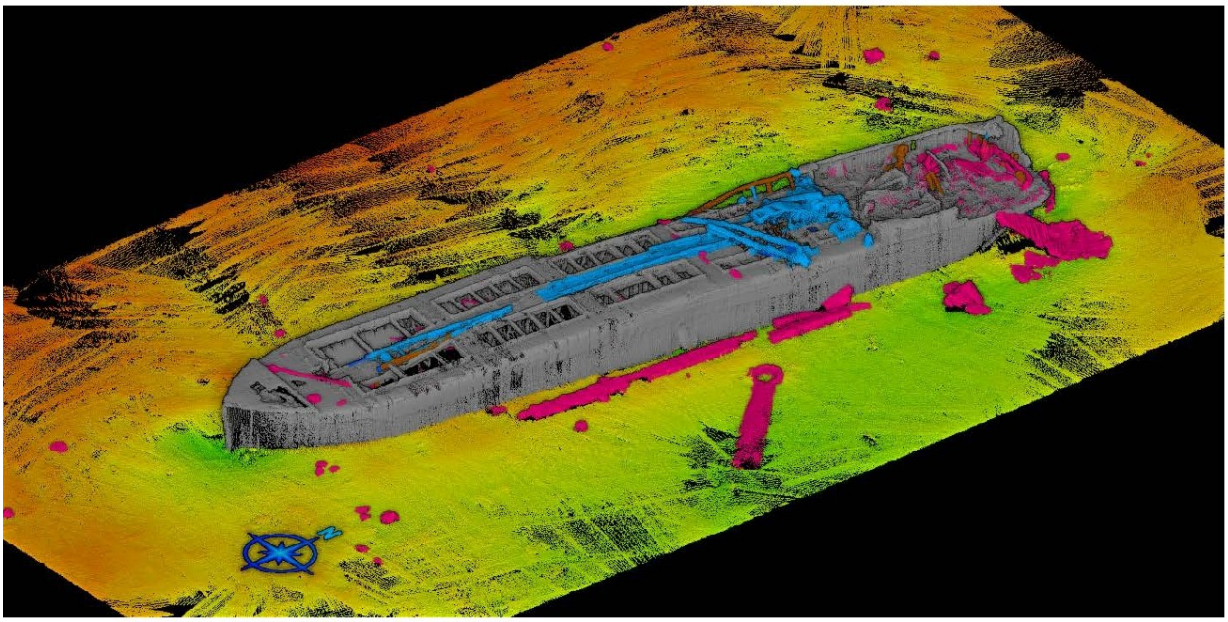
77. Open CloudCompare and import each file containing the different materials.

78. Color shade each material differently in CloudCompare to get the desired final result. Apply eye dome lighting (EDL) filter and save as a .bin file or snapshot for the final product.

APPENDIX C: MOBILE IMAGING COLLECTION AND POST-PROCESSING INSTRUCTIONS

Mobile Imaging Notes for HYPACK and BlueView





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Introduction

In this guide you will learn how to set up your mobile imaging system, collect data and post process the point cloud. This process is much more complicated in the field, but saves a large amount of time on the post processing end. It is assumed that you are already familiar with Hypack. If not, there are plenty of resources on Hypack's website to get you started. Note: Collecting multibeam data in the field requires multiple pieces of electronic equipment to be connected to the collection computer. Each piece needs to have specific IP settings on the collection computer. It is strongly recommended that the collection computer not be part of your company's domain. Connecting to that type of network requires permissions and safety settings that can prohibit the proper flow of data into Hypack.

NOTE: ALWAYS DO ALL COLLECTION AND PROCESSING IN METRIC UNITS!! THEN YOU WON'T HAVE COMPETING UNITS AND PROBLEMS WITH SCALING DURING PROCESSING. IF NEED BE, CAN CHANGE TO ENGLISH AT THE VERY END OF PROCESSING.

Getting Started

Make the "Project Manager" tab active. (red box)

Highlight the project heading (yellow box)

Click the drop down arrow on the "Groups" button (orange box) and select "Add Group"

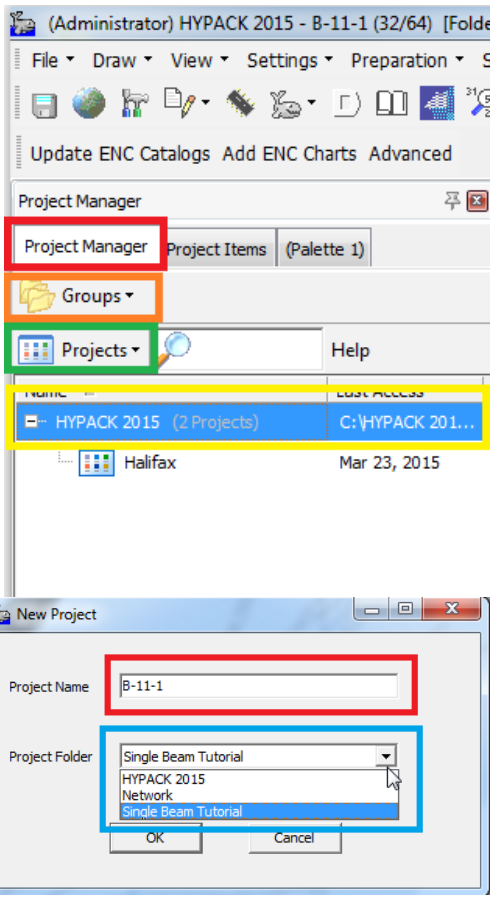
Navigate to and select the location of your project folder on the collection computer. Hypack will create its directory in that location.

Click the drop down arrow on the "Projects" button (green box) and select "New Project"

Type a name for the project in the "Project Name" box. Keep in mind, this is the name of the folder that will be created in the project directory you selected in the previous step.

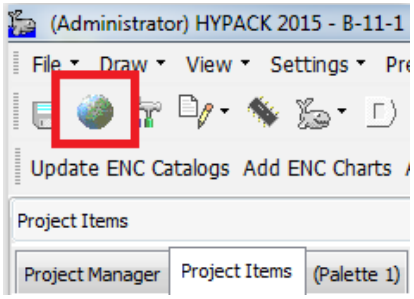
Select the Project Folder you created with the "Add Groups" step above.

Hypack will create the project and make the "Project Items" tab active.

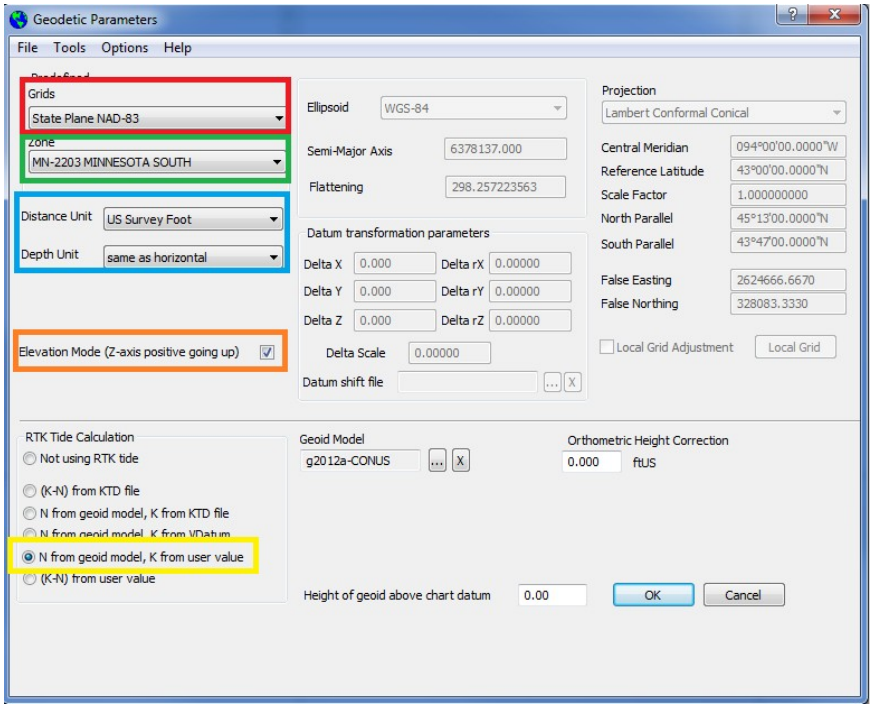


Project Geodesy

A note about Hypack Geodesy: Hypack is not only a powerful post processing tool, it is also a powerful data collection tool. Because of this, Hypack assumes that all incoming data, collected by Hypack or by other means, comes in as geographic Latitude-Longitude on WGS 84. When using or exporting the data you've collected, Hypack will translate the data to the coordinate system you specify in Geodetic Parameters.



Click the "Geodesy" button (red box) located in the upper left corner of the Hypack shell.



Start by Selecting the Predefined grid for the project. (red box) Selecting this will populate the next Zone box with the zones that are available in the selected grid.

As stated above, most data will be in WGS-84, make sure this is the selected ellipsoid (yellow box)

Select the local Zone your project is in. (green box)

Make sure the distance units in the blue box are appropriate for your project. *We may want to adjust to UTM Zone 15N metric for all-NEED to adjust offsets in hardware if we do!

Hypack treats depths below the waterline as positive numbers. If you would like to work in Elevations, check the "Elevation Mode" box (orange box)

Typically you will be using some form of RTK GPS during the collection process. You can take advantage of that in our water level calculations by using the "N from geoid model, K from user value" option in the yellow box. *Do this correction post processing with field observations (take a WSEL!) We use NAD3 2011-Geoid 12(a).

Click ok and save the project.

Background Charts

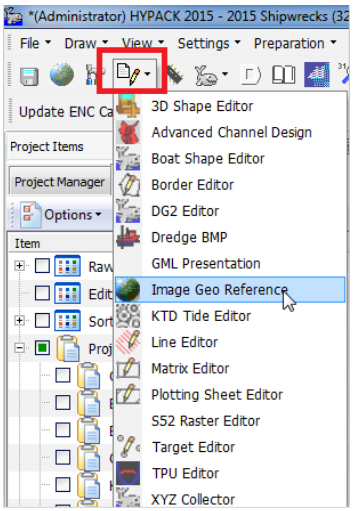
Part of preparing to collect data, you will need to construct a matrix that encompasses the survey area. Without a background chart or image it is almost impossible to know where you need to construct this.

You can use GoogleEarth to make your own Georeferenced map.

Start by zooming to the area you need in Google earth. Make sure the map is oriented North and there is no tilt on the image-to do this hold down the middle mouse button and push it forward.

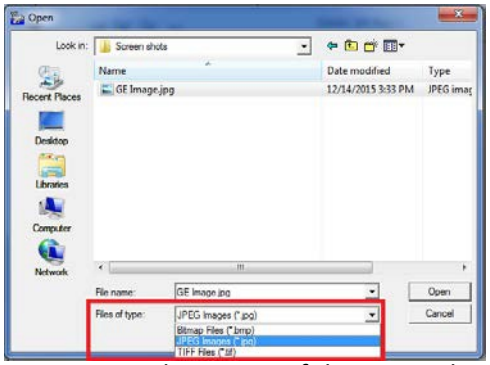
Go to the File menu select Save… then Save Image. Save the jpg to the "Satelite" folder in the Hypack project. Do not close Google Earth.

In HyPack, click the drop down on the Editors button and select "Image Geo Reference"



In the Image Geo Reference editor, click the Image menu and select Load

Navigate to the location of your image. You may need to change the "Files of type" box to match the format of your saved image in order to see it listed above.



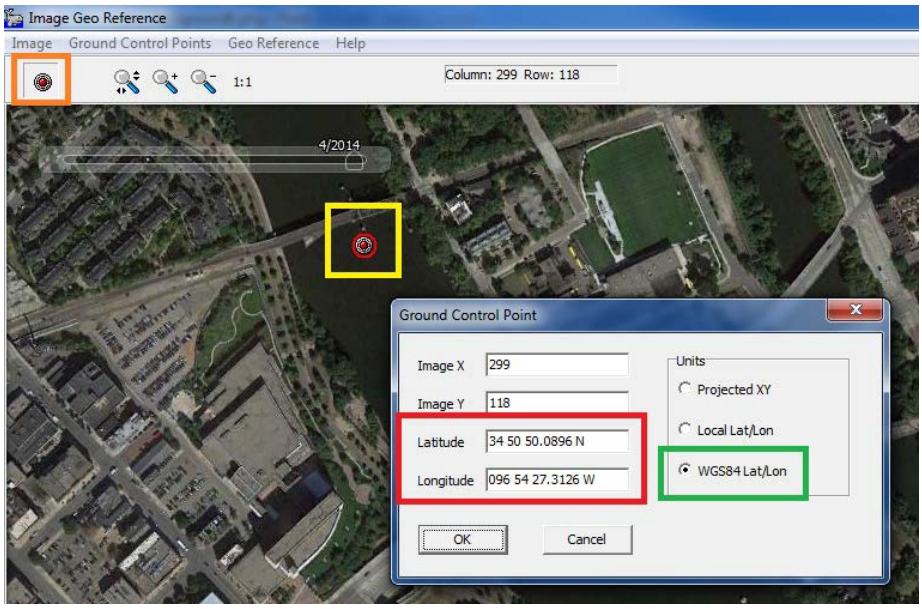
Highlight your file and click Open.

When your image loads identify a point near the corner of the image that is easy to see and will be easy to select. For this example, I've chosen the center of a dolphin. It is a small target on this image, easy to see, easy to click the center of.

Turn on the control point tool then double click the desired point to place a control point.

Make sure the Units are set to WGS84

You will need to enter the latitude and longitude of the point you've selected. Make note of the format. You need to use the same format when entering the location.*Verify this can be done in metric if using metric.

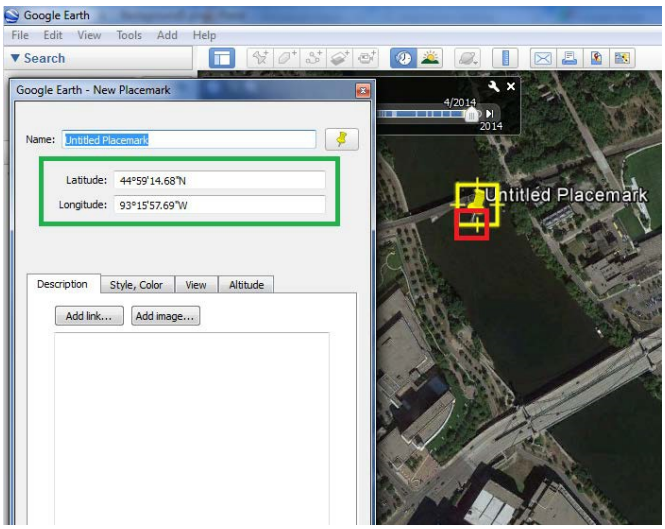


Go back to Google Earth and click the "Add Placemark" button

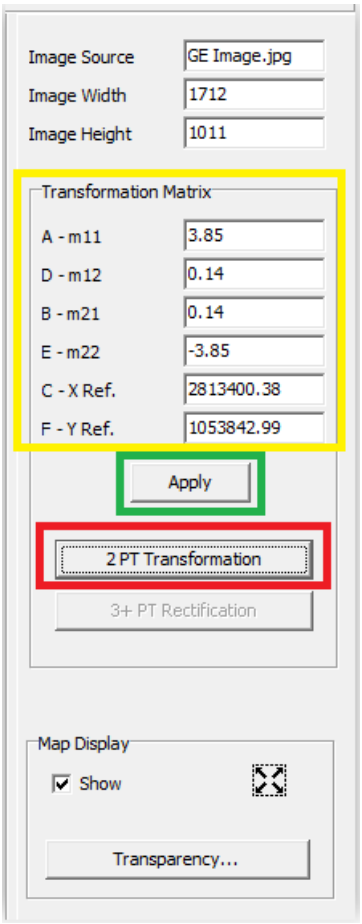
Move the pin so that the point of it is directly on top of the same point you selected in the Hypack editor.

You can now copy and paste the lat/long from the "Google Earth – New Placemark" box into the appropriate field in the Hypack editor.

Repeat this process for a second point.
Note: for the best result, try to find a second point that is in the opposite corner of the image.



Once you have 2 points established on your image you can apply the transformation to the image.



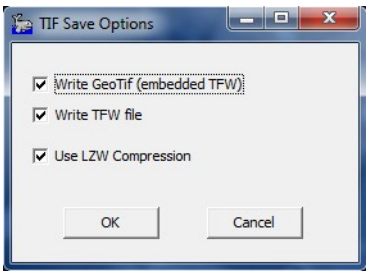
On the right side of the Image Geo Reference editor you will find that the "2PT Transformation" box is now available. Notice the numbers in the Transformation Matrix.

Click the **2PT Transformation** box and the Transformation Matrix should populate with a new set of numbers that are specific to your image.

Click the **Apply** button to make the changes to the image.

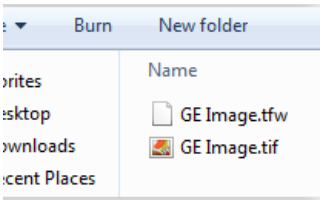
Click the "**Image**" menu in the Image Geo Reference editor and select Save.

Navigate to the Satelite folder in the project, type a file name and save the image.

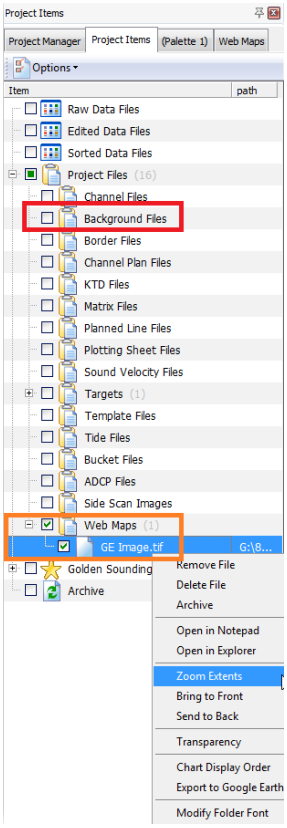


Be sure to allow both files to be saved in the dialogue box and click Ok

If you look in the Satelite folder you will see that two files exist with your image name. One is the actual image and the other is the information that Hypack needs to properly place and scale the image. DO NOT delete or rename this file.



Close the Image Geo Reference Editor.



In the Hypack shell, insert your new Geo Referenced image.

Right click Backgrounds and hover over Add File

Select “TIF Files” from the pop up menu.

Navigate to the location of your image, highlight it and click open.

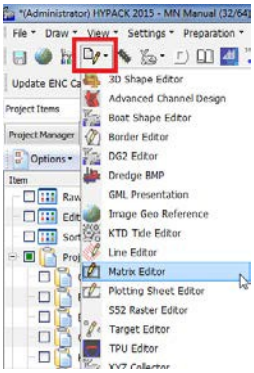
You will notice that your image does not appear under the Background Files category of the Project Items Tree. Hypack places these images under Web Maps.

Expand the Web Maps category

Right click your image and select “Zoom Extents” to center your map view over your newly inserted image.

Hint: The zoom level that you were at in Google Earth is the maximum resolution you will get in Hypack. With a little patience, you can zoom in for a higher resolution image. You will need to create multiple images to cover the entire area you need. Each image will need to be referenced using the process above.

Matrices



The matrix is used to display the coverage you are getting during the data collection process. Should you drift outside of you matrix while collecting data, you will still be recording the data but it will not appear on your screen. With your chart or image in place you can setup your survey/imaging area.

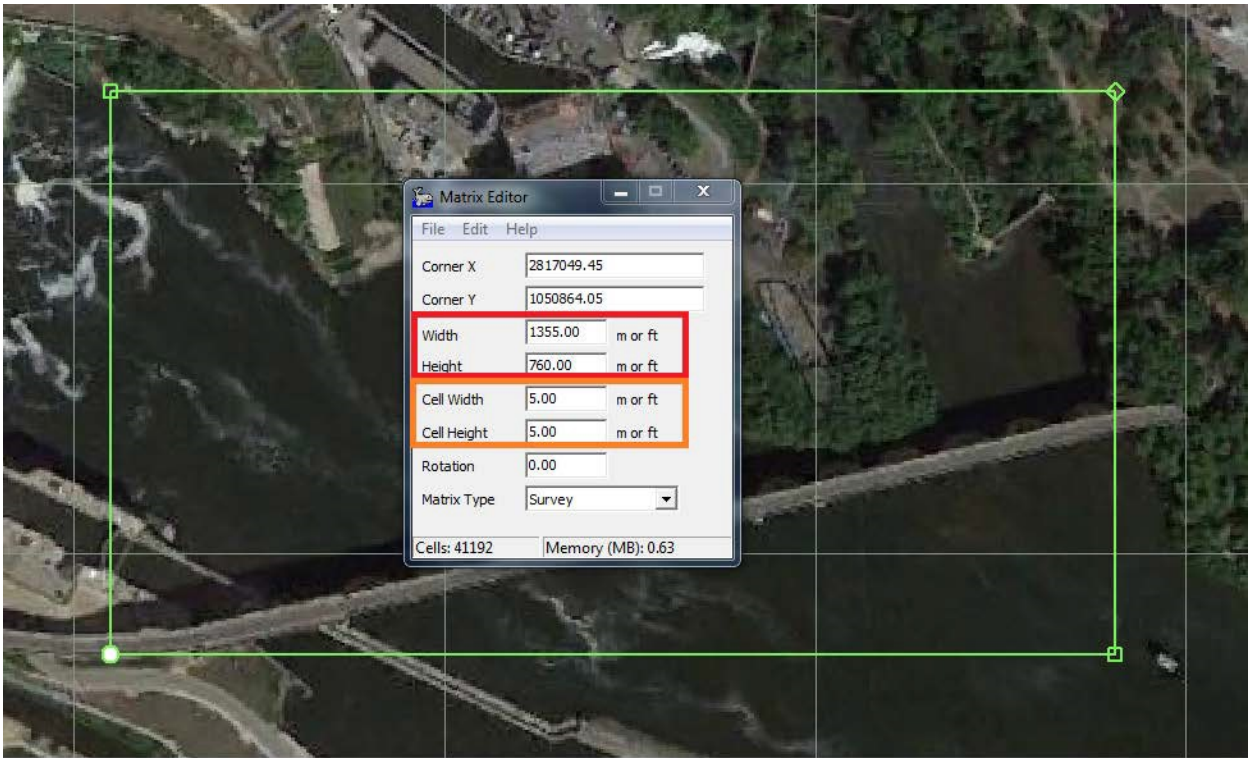
Click the drop down arrow on the Editors button.

Select Matrix editor.

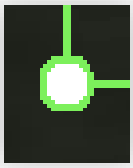
A box will be created and the Matrix Editor will appear.

In the Matrix editor you can enter the Width, Height and Rotation of the matrix. You can also adjust these things graphically using the manipulators at the corners of the box.

The Cell Width and Height should be edited if necessary. These parameters control the resolution of the data being displayed on the map during the data collection. Smaller cells give you higher resolution while lager cells will give a more pixelated look. For imaging, a 1 by 1 cell size works well. This does not affect the resolution of the actual data being collected. The factor that you should consider when choosing the cell size are the overall size of the matrix and the power of the collection computer. Large matrices with small cell sizes can cause a lesser powered machine to bog down and even cause crashes. One way to avoid this problem while still keeping a high resolution is to create a few smaller matrices to cover the work area rather than one large one.



Position, Rotate and size the box to fit your area of work.



The lower left corner of the matrix is the position manipulator. Left click and hold this to move the matrix to the desired location.

The lower right corner is used the change the width of the matrix. Left click and hold this to change the width.

The upper left corner is used the change the height of the Matrix. Left click and hold this to change the height.

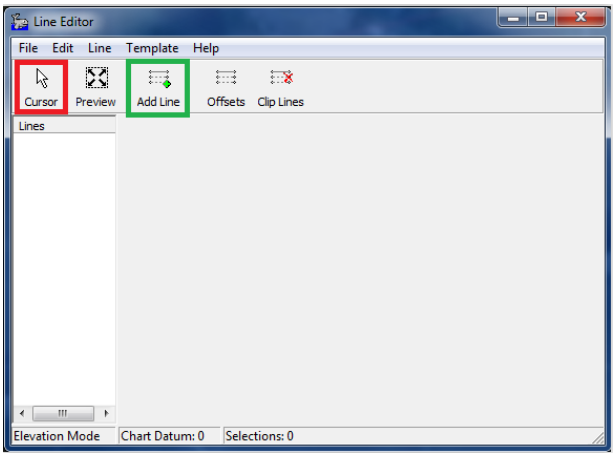
The upper right corner is used to rotate the matrix. Left click and hold this to rotate.

When you have the matrix positioned, sized and rotated to cover your work area click the file menu in the Matrix Editor and save your matrix to the project directory.

Close the Matrix Editor.

Planned Lines

Planned lines can be helpful during your patch testing or making sure you have cross section information at the prescribed locations (I.e. at bridge fascia). In order to use the Left/Right Indicator in HyPack Survey, you will need a planned line file.



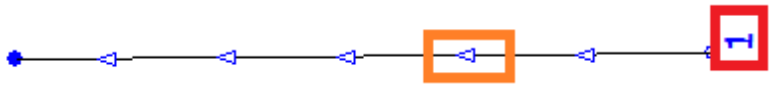
Click the drop down arrow on the Editors button.

Select the Line Editor.

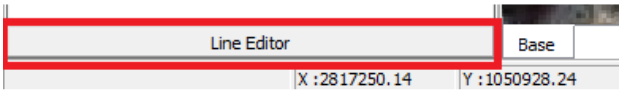
You can create multiple lines in one file. Start the first one by clicking the cursor button. The Line editor will be minimized to the bottom of the Project Items pane in the Hypack shell.

Click on the map to establish the beginning of the line. Click a second time to establish the end of the line. You can place as many points as you need to make your line.

You will see the name of the line appear at the beginning (red box) and arrows along the line (orange box) indicating the direction it was created. This information is helpful when/if you are going to create offsets from this line (I.e. 500 ft upstream of bridge fascia).



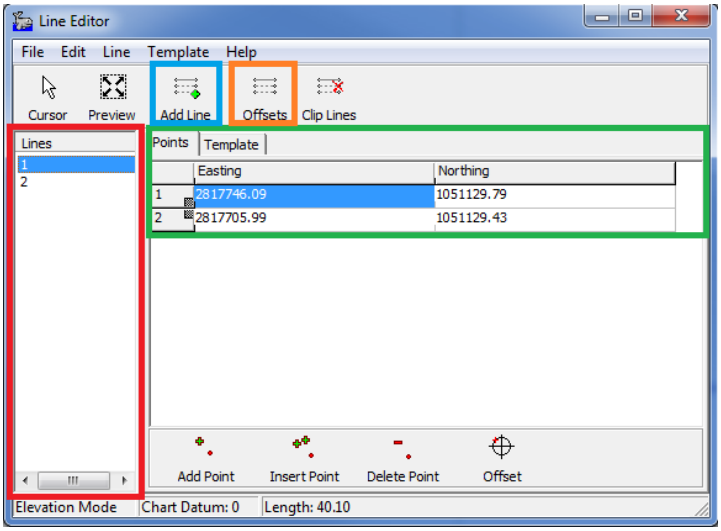
Click the Line Editor button at the bottom of the Project Items pane to restore the line editor.



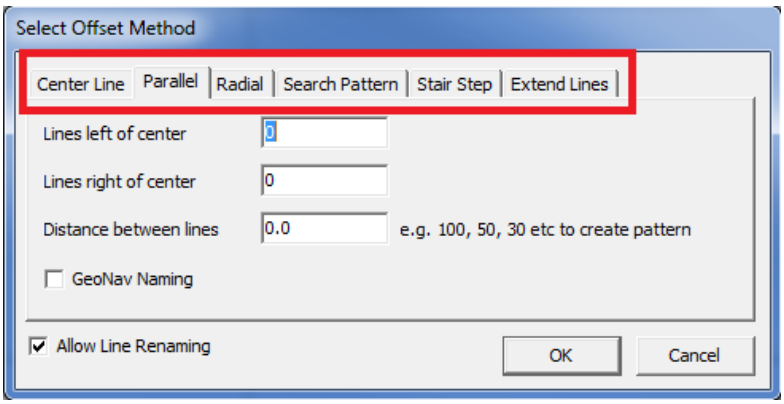
You will see the line you created listed in the left pane of the Line Editor. You can manually add more lines by clicking the Add Line button (blue box) then clicking the cursor button to pick your line points.

The coordinates of each point of the line that is highlighted in the left pane are displayed in the right pane of the Line Editor (green box). These coordinates can be edited here if needed.

You can add more lines using the Offsets button (orange Box). This is useful if you need to survey cross sections at a specified interval.



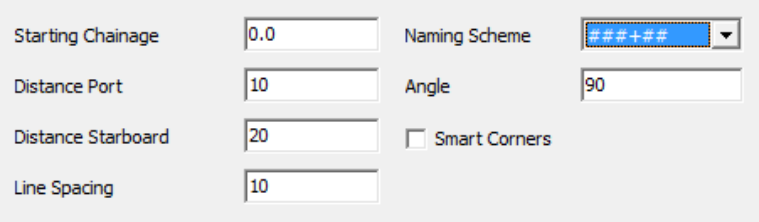
Highlight the line you would like to offset in the left pane of the Line Editor and click the offsets button.



There are plenty of options for constructing offsets within the Select Offset Method window. Click the tab of the method you would like to use.

The procedure for a few of the methods are outlined below

Centerline Offsets: Creates Cross Section lines along the original based on station.



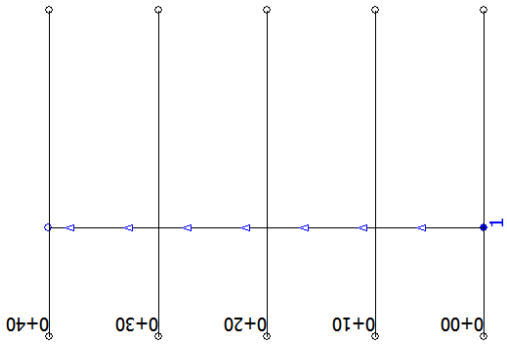
NOTE: To determine the direction of your offset, assume you are standing at the beginning point of the line looking towards the end of the line.

Starting Chainage: Set this if you do not want the cross sections to start at the beginning of the line.

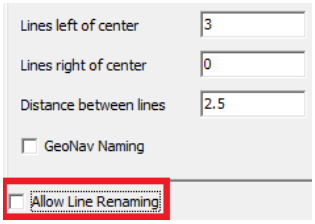
Distance to Port/Starboard: Used to determine the distance out from the original line.

Line Spacing: Specifies the frequency of the cross sections

Angle: Set to 90 for perpendicular cross section lines or use any angle you wish.

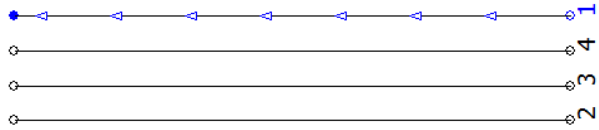


Parallel Offsets: Creates offsets on either the Left, Right or both sides of the original.



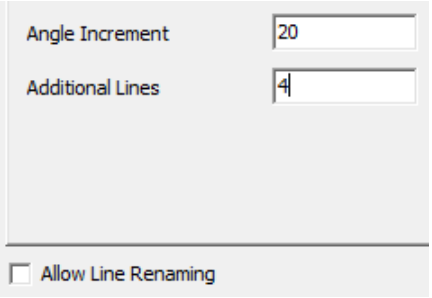
Enter how many lines are to be created and on which side.

Enter the offset distance. (same units as the project)

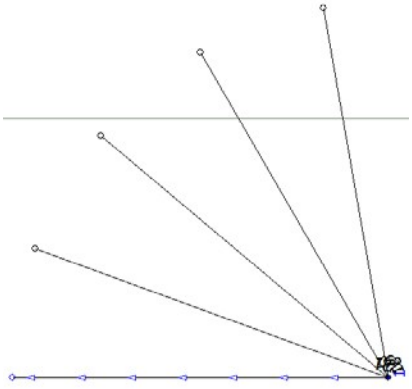


To avoid confusion, be sure to uncheck the "Allow Line Renaming" box. This function will change the name of the original line, making hard to keep track of it.

Radial Offsets: Creates lines the same length as the original radiating from the beginning point.



Angle Increment: specify the angle between each line. Lines are created in a clockwise direction when a positive number is used and a counterclockwise direction when a negative number is used.



Additional Lines: specifies the amount of radial lines to create.

To avoid confusion, be sure to uncheck the "Allow Line Renaming" box. This function will change the name of the original line, making hard to keep track of it.

When you have the planned lines you need. Click “File” in the Line Editor, then Save As..

Give your line file a name and click save.

To see your lines, you will need to enable them in the Project Items tree by checking the box next to your file under the “Planned Line Files” category.

Patch Test

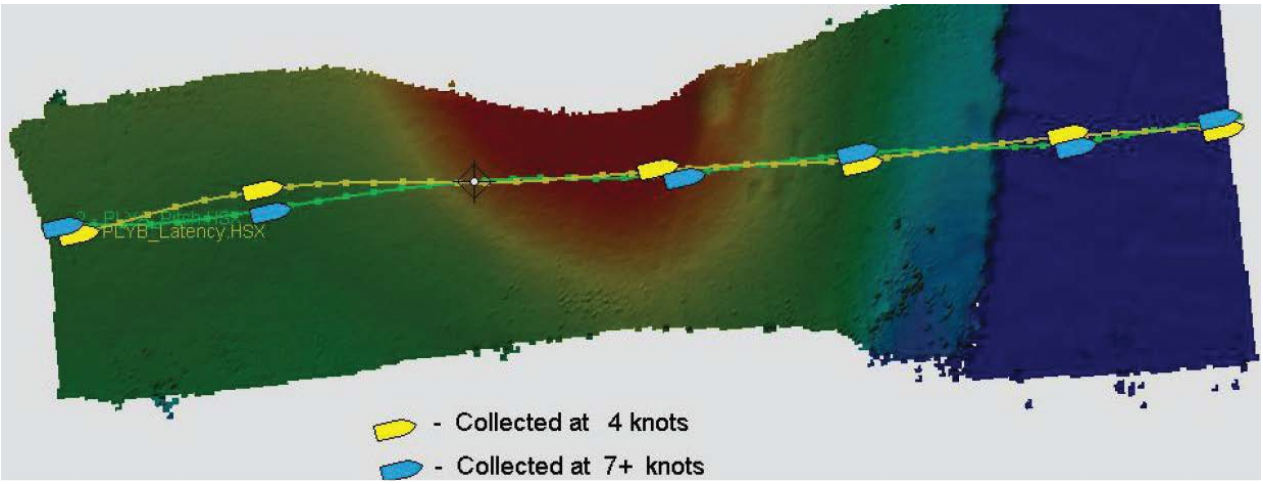
After you have mounted all of your equipment on the boat, you will need to carefully measure the X, Y, and Z positions and orientation of each of the sensors. These locations and orientations are entered into the hardware setup within Hypack. No matter the care taken during the measurement process, there will be errors in the final computed offsets. The patch test data collected and processed will be used to determine correction values for these offsets. With a well patch tested system you can save time during the post processing phase of your imaging. Without patch test data, you will not be able to rely on your data for bathymetric surveys.

A traditional multibeam patch test is conducted using two different types of channel bottom. The latency, pitch and yaw are conducted over a sloped bottom while the roll test is done over a flat bottom. The most challenging part of the patch test is actually finding the patch test area.

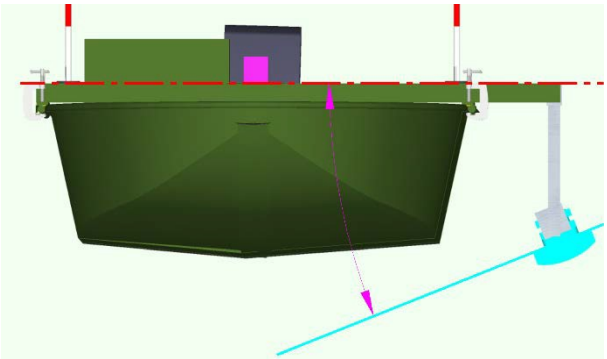
Imaging projects will require you to tilt your sonar head at extreme angles to collect data all the way to the water's surface. Because of this angle, the tradition patch test can be almost impossible with the BlueView head. For best results make use of a stationary vertical object in the water that you can drive your boat around in a square pattern. Visually, these objects are very easy to find compared to traditional patch test areas. The problem is they are not common objects in inland waters and you are rarely able to navigate on all sides of them.

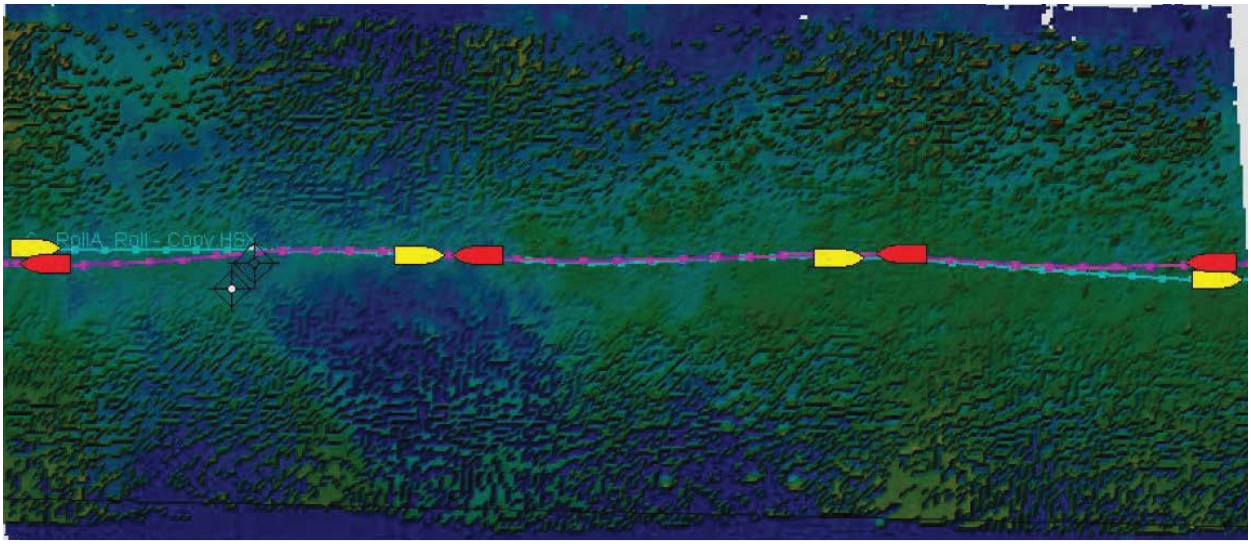
Whether you are using the traditional multibeam patch test or a vertical test, you are going to use the data to correct for four different alignments:

Latency Test: Determines if there is any lag in the timing of when a ping is recorded and when the position and heading are recorded. Collect data over at least 300 feet of a sloped channel bottom running perpendicular to the slope at normal survey speed. Return to the beginning of the line, collect data over the same line in the same direction at double survey speed.

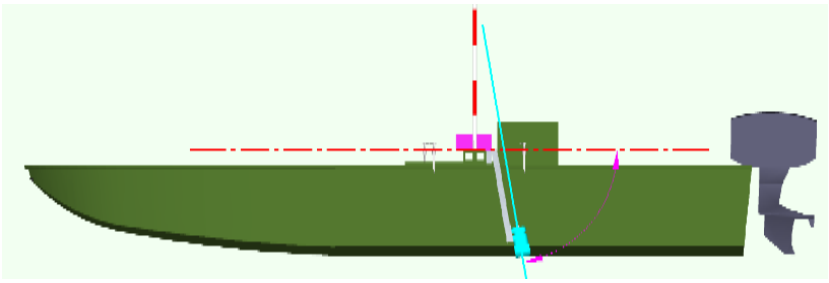


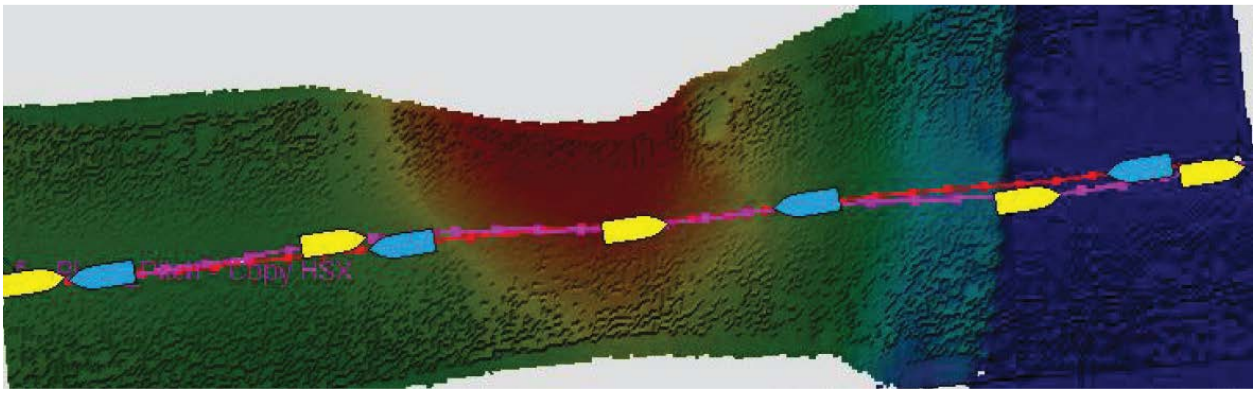
Roll Test: Determines the Port/Starboard angle of the sonar head in relation to the MRU (Motion Reference Unit). Collect data over at least 300 feet of flat channel bottom. Turn the boat around and collect data over the same line in the opposite direction at survey speed.





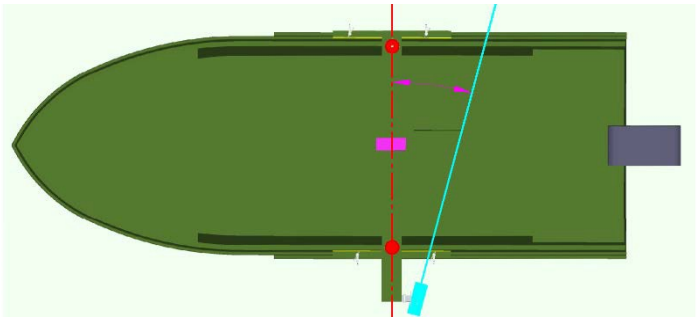
Pitch Test: Determines the Fore/Aft angle of the sonar head in relation to the MRU. Collect data over at least 300 feet of a sloped channel bottom running perpendicular to the slope at normal survey speed. Turn the boat around and collect data over the same line in the opposite direction at survey speed.

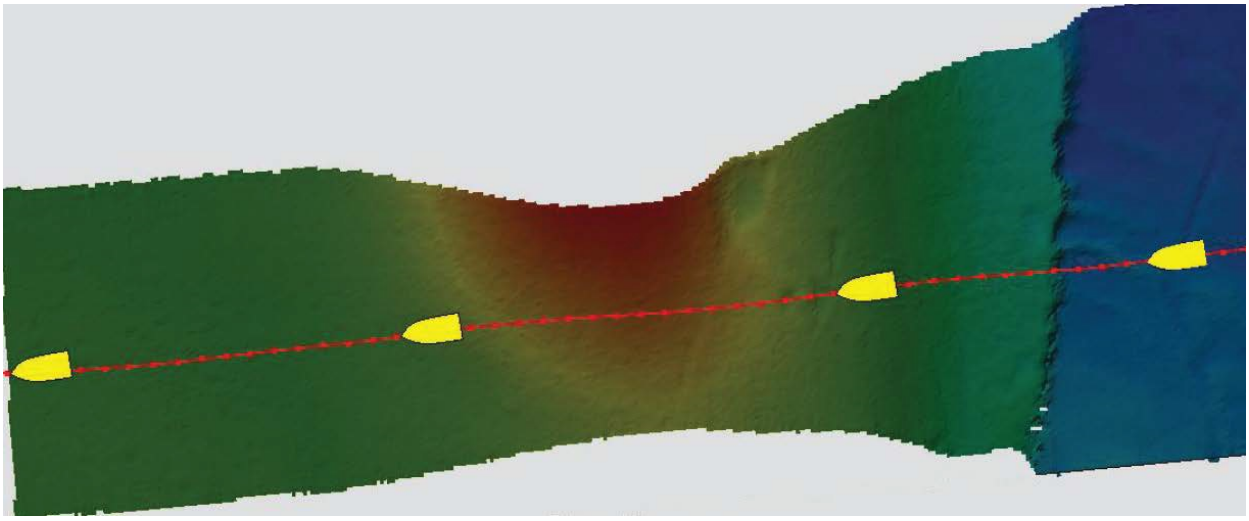




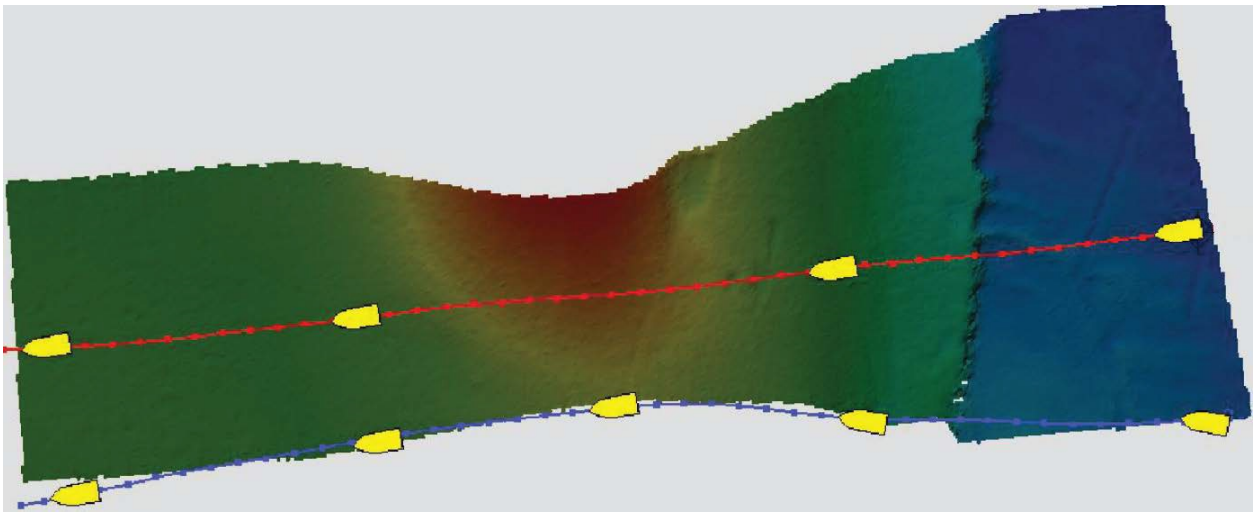
Yaw Test: Determines the angle of the sonar head to the GPS antenna base line.

Collect data over at least 300 feet of a sloped channel bottom running perpendicular to the slope at normal survey speed.





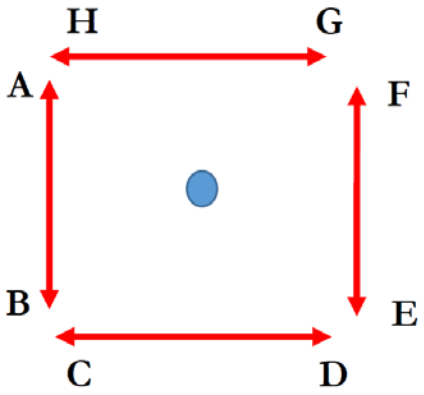
Return to the beginning of the line, collect data in the same direction, this time drive the boat over the edge of the previous Yaw pass. The goal is to be able to cut a profile in between the two passes where the data overlap is 50%.



Vertical Patch Test:

The field collection portion of the vertical patch test is quite a bit simpler than the standard patch test process. As stated before, you will need to drive the boat in a box pattern around a stationary vertical object. If at all possible, try to find an object in shallow enough of water to be able to get the channel bottom in the data for your roll test. Conduct all of your runs around the object at normal survey speed and at the same distance from the object. You can use the latency values from your standard patch test for the vertical test. The direction you need to travel will be determined by the side of the boat your sonar head is mounted on. If water depths require survey data to be gathered at multiple sonar tilt angles, a separate vertical patch test is required for each angle setting.

NOTE: As tempting as it may be, an anchored buoy will not work for this test. Even in calm waters, the wake from the survey vessel will alter the position of the buoy enough to make processing your patch test data practically impossible.



Below, you will find an example of the standard and vertical patch test forms for keeping track of your lines in the field.

Standard HySweep Survey Setup/Patch Test Form

Date: _____ Sonar Head Angle: _____

Project: _____

Crew: _____

Waterline Reference: _____

Waterline Measurement: _____

Measured Waterline Elevation: _____

GPS Waterline Elevation: _____

Entered K Value (in Geodesy): _____

Sound Velocity at Surface: _____

Sound Velocity Profile Name: _____

IMU Calibration File Name: _____

Latency Test - Line C-D (Same direction)

C-D at Survey Speed _____

C-D at Double Speed _____

C-D at Survey Speed _____

C-D at Double Speed _____

Roll Test -Line A-B at Survey Speed

A-B _____

B-A _____

A-B _____

B-A _____

Pitch Test - Line C-D at Survey Speed

C-D _____ (Copy Latency C-D)

D-C _____

C-D _____ (Copy Latency C-D)

D-C _____

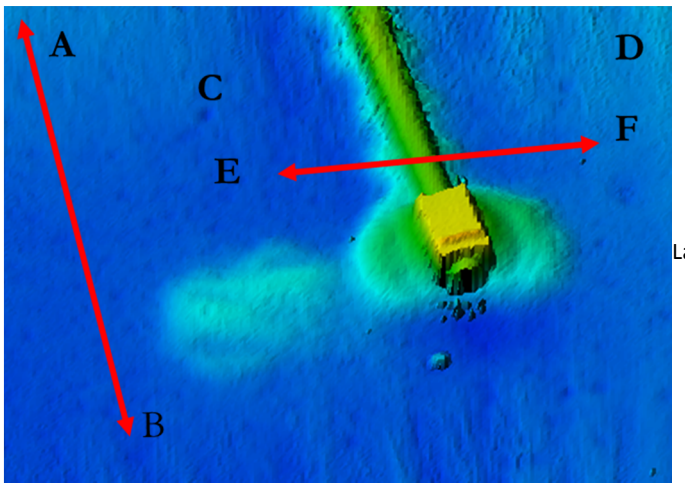
Yaw Test - Lines C-D and E-F (Survey speed, Same direction with 1/2 offset)

C-D _____ (Copy Latency C-D)

E-F _____

C-D _____ (Copy Latency C-D)

E-F _____



Patch Test Results

Latency: _____

Yaw: _____

Pitch: _____

Roll: _____

Vertical Patch Test Form

Date: _____ Sonar Head Angle: _____ IMU Log: ☐

Project: _____

Crew: _____

Waterline Reference: _____

Waterline Measurement: _____

Measured Waterline Elevation: _____

GPS Waterline Elevation: _____

Entered K Value (in Geodesy): _____

Sound Velocity at Surface: _____

Sound Velocity Profile Name: _____

IMU Calibration File Name: _____

A-B at Survey Speed

A-B or B-A _____

A-B or B-A _____

A-B or B-A _____

A-B or B-A _____

C-D at Survey Speed

C-D or D-C _____

C-D or D-C _____

C-D or D-C _____

C-D or D-C _____

E-F at Survey speed

E-F or F-E _____

E-F or F-E _____

E-F or F-E _____

E-F or F-E _____

G-H at Survey speed

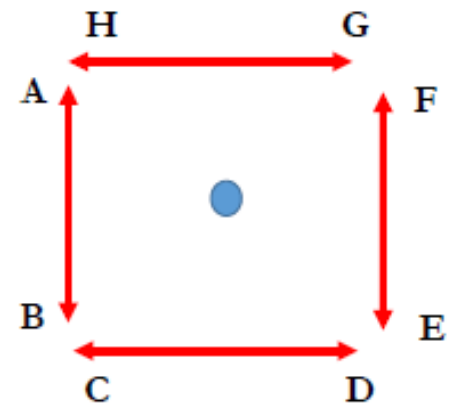
G-H or H-G _____

G-H or H-G _____

G-H or H-G _____

G-H or H-G _____

North Arrow



Patch Test Results

Latency: _____

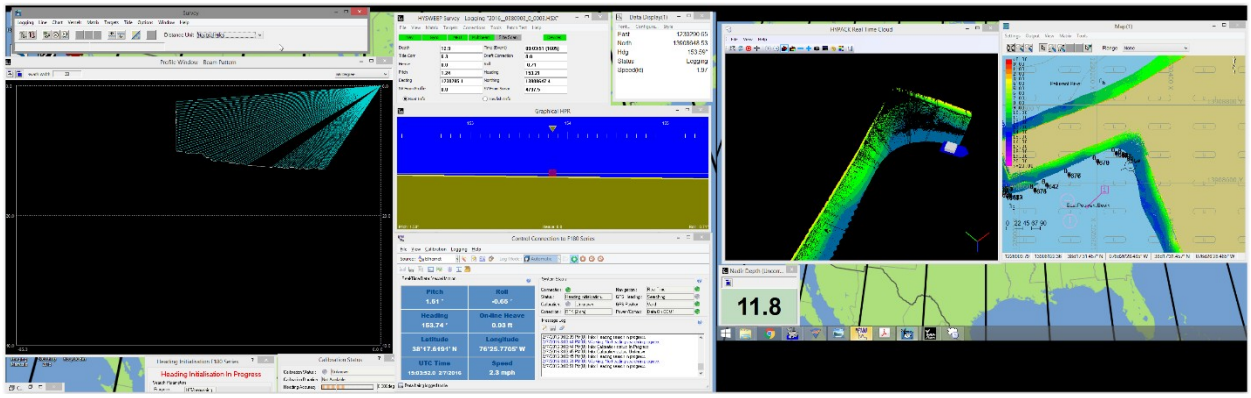
Yaw: _____

Pitch: _____

Roll: _____

Data Collection

The data collection process requires the operator to monitor a lot of information. The screenshot below shows the typical configuration of windows during data collection. This spans 2 monitors. On this vessel the operator and driver are seated next to each other and can both see the displays.

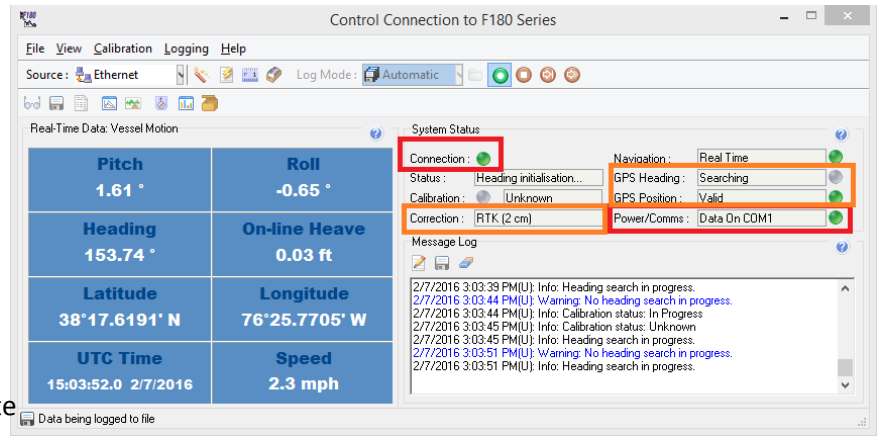


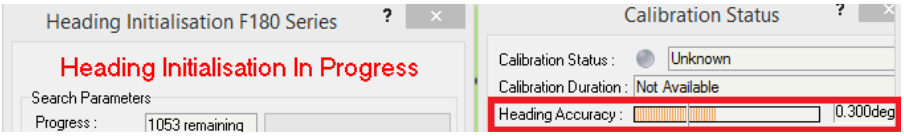
The following are some of the windows you may want to have displayed during the collection process. You can have any number of displays you like or can fit on your displays. You can even have multiple versions of the same display. This is handy when the driver has their own monitor and needs to see some of the same information the operator needs.

You should have the control software for your Positioning and heading instruments visible. (In the example used for this manual, a Coda F185+ was used for motion reference, Positioning and Heading. Positioning was aided with a GPS base station broadcasting its RTK signal via FM radio to the survey vessel.)

Positioning and Heading

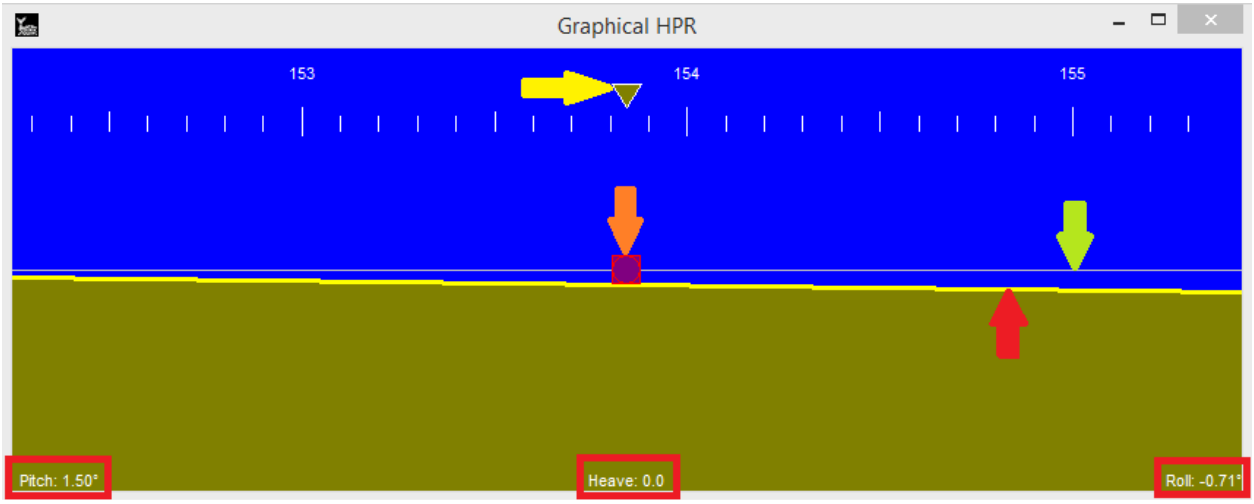
Things to keep an eye on within this software are the connection to the collection computer (red boxes) and GPS status (orange boxes). If you lose any of this information, depending on the severity of the data loss, you may need to stop collecting data and resolve the issue or at least make a note of the observation for reference during post processing.





The Coda software provides a few options for other windows to monitor in addition to what is seen above. Two of the windows used here were the status of the Heading Initialization and the status of the system's calibration. As you can see above, the calibration at the time of this screen shot was not within tolerance. The system was reporting a heading accuracy of .3 degrees. This type of inaccuracy can cause severe warping of an object being imaged. Data collection was suspended until the calibration was resolved and the heading accuracy returned to a normal range of .06 to .09 degrees.

Graphical HPR (Heave, Pitch, Roll)



This window is a great way to visually see if your Heave, Pitch and Roll data are being recorded properly. If this display does not make sense with what the vessel is doing in the real world, you should suspend data collection until the issue can be resolved.

The white line (green arrow) is used for the zero reference plane.

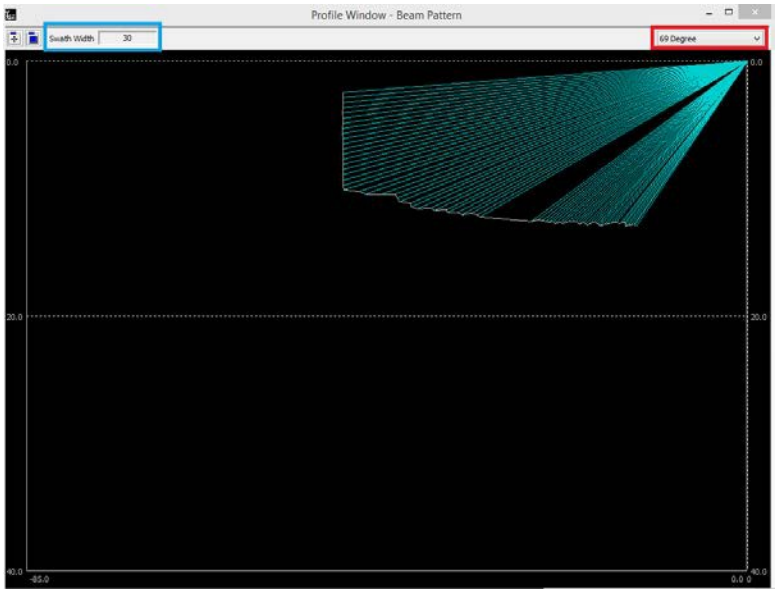
The box (orange arrow) represents the boat reference point. The position of the box above or below the reference plane will indicate the current heave state of the vessel.

The yellow line (red arrow) indicates the current Pith and Roll state of the vessel. The line tilts to indicate roll direction and severity and rises or falls in relation to the zero reference plane to indicate the vessels current pitch state.

The triangle (yellow arrow) at the top indicates the vessels heading. The triangle will stay in the center of the display and the numbers will scroll from side to side to show the current heading in degrees.

You can also see the numerical value of the Heave, Pitch and Roll at the bottom of the display. (red boxes.

Profile Window – Beam Pattern

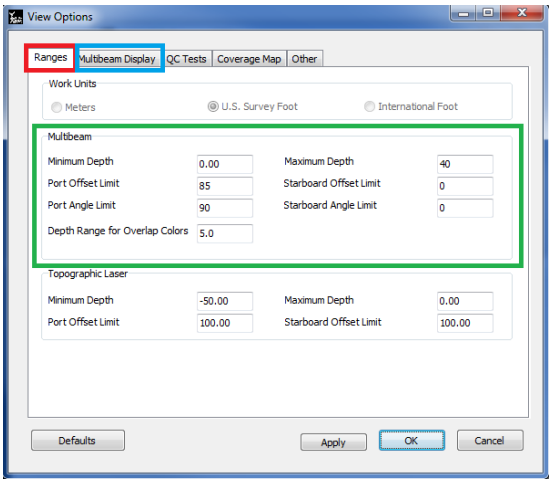


This window is handy for monitoring the data you are collecting. For example, if you are seeing a lot of noise near the head it could be preventing you from getting the data you are actually looking for. You may have to make adjustments in Proscan to clean up excess noise. *For BlueView you may need to lower the intensity threshold if getting lost beams.

If you have multiple head angles or sonar heads set up in Hypack Hardware, you will need to be sure the current configuration is being displayed by selecting it from the drop down (red box)

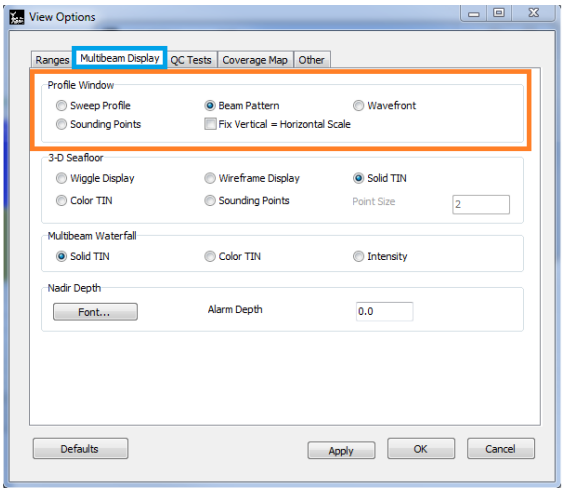
The current swath width is displayed in the project units (blue box)

The range settings can be adjusted by right clicking anywhere in the profile view and selecting Display Options.



Make the Ranges tab (red box) current and enter the appropriate values for your sonar, head angle, operating depth and range in the Multibeam section (green box).

You can change the look of the display on the Multibeam Display tab (blue box)

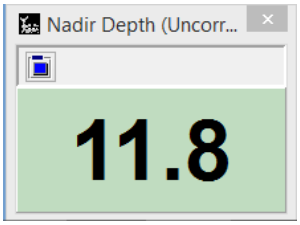


Options for the display are in the Profile Window section (orange box)

The example above is using the Beam Pattern option. The option here is entirely personal preference.

Nadir Depth

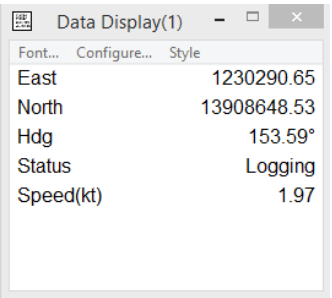
Displays the depth below the sonar head and at the center of your swath width. This depth is not the actual water depth. This window will help you keep from running your sonar head aground. Note: When using a tilted sonar head, this depth is not directly under the sonar head, but is where the nadir beam hits the channel bottom. In the example Profile Window above, the depth shown would be roughly 30 feet from the sonar.



If you right click the depth display area and select Display Options, you will bring up the View Options dialogue. The Multibeam Display tab will be active and you can set an alarm depth and change the font.

Data Display

At first glance, this appears to be a simple window. This display can be customized to display your choice of a lot of different information.



Click the Configure… menu and a dialogue will pop up for configuring what data you want displayed.

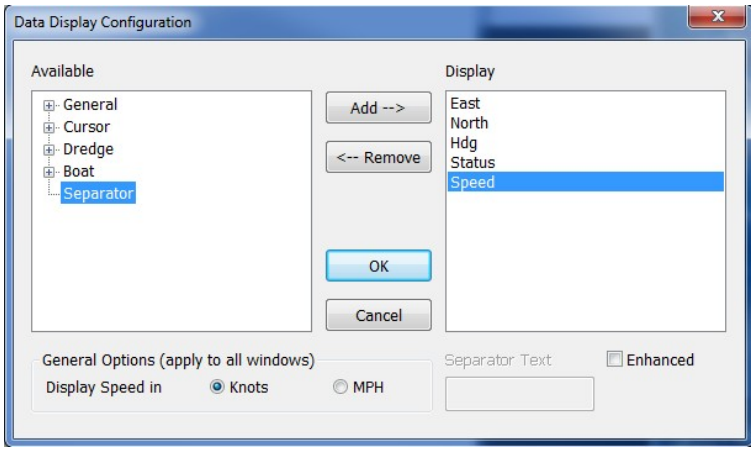
The Display box on the right side shows you what is in your current window.

Expand any of the categories on the left to find the type of data you want to add to the Data Display.

Highlight the item you want to add.

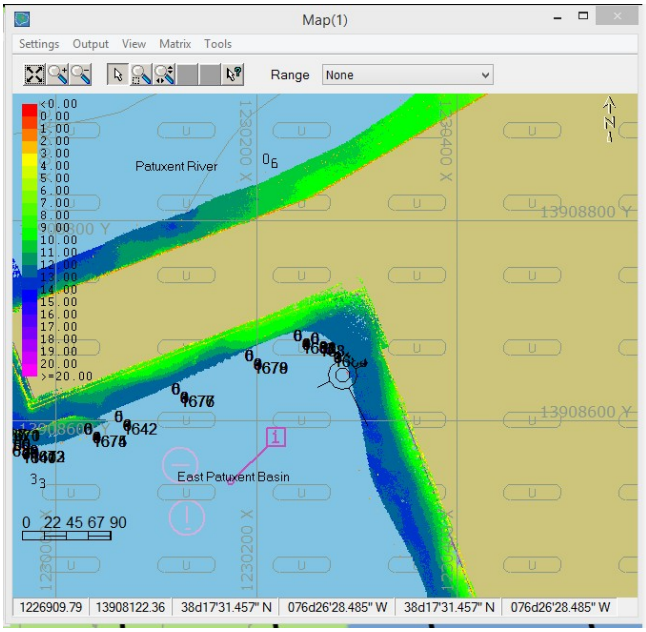
Click the Add→ button and the new data item will be added below the data item that is highlighted on the right side.

You can make this window as simple or as complicated as you like. Just remember that screen real estate can be at a premium on the survey vessel.

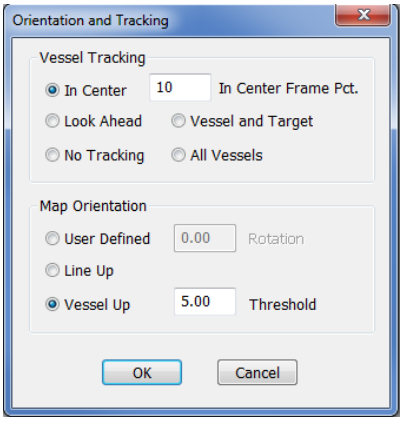


Map

When you have a matrix loaded into HyPack Survey, you will be able to use the map to monitor the coverage you are getting during the data collection process. The map will show you the current position and orientation of the vessel. The map uses the same background file you loaded into the Hypack shell when you created the project.



Under the settings menu you will be able to turn the vessel tracking on or off and specify how the map behaves when tracking the vessel.



Vessel Tracking

- In Center returns the boat to the center of the screen as it nears the edge. The In Center Frame Pct option determines when the centering will occur based on the distance between the vessel and the edge of the area map (expressed in percentage of the Area Map window size with an allowable range of 5-25%).
- Look Ahead moves the boat further back from the center to maximize the amount of space displayed ahead of the vessel.
- Vessel and Target keeps the boat and the current active target in view. The map automatically zooms to fit as you approach.
- No Tracking allows you to move the screen anywhere you want without having it zoom back to keep the boat in view. (Strike the Home key to center the vessel on your screen.) You can temporarily turn this off from the settings menu or by hitting the "T" key on your keyboard when the map window is the active window.

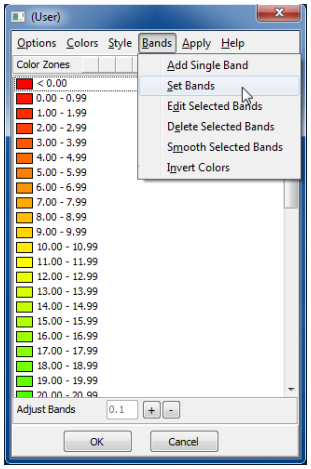
Map Orientation

- Vessel Up aligns the Area Map with the current vessel heading. Define a threshold (in degrees) to determine how much the vessel heading must change to cause the map orientation to adjust. This prevents constant (annoying) updates of the map orientation with only small changes in vessel heading.
- Line Up draws the screen so the current line segment is directly "up" the screen. If you are in the "Line Up" orientation, the boat should be progressing up the screen. If your boat is going "down" the screen, you need to "whip" the line ends (change the start-line and end-line points) by using the Ctrl-W key command or the LINE–SWAP menu item.

- User-Defined Rotation draws the Area Map according to the specified degrees. Zero degrees will orient the map with North up.

Make the driver aware that you can change these settings to which ever they prefer. Always remember, the driver makes or breaks the collection process because they are in control of where the multibeam swath goes. Make sure this display works best for them. You can always have another map display open with different settings for the operator to monitor for data coverage.

The colors plotted as you paint the matrix can be adjusted to better fit your current needs by right clicking on the color key on the map and choosing Settings.



The current band set is displayed.

Click the Bands Menu and select Set Bands.

Enter the Minimum and Maximum Depths/Elevations and the increment at which you want the colors to change.

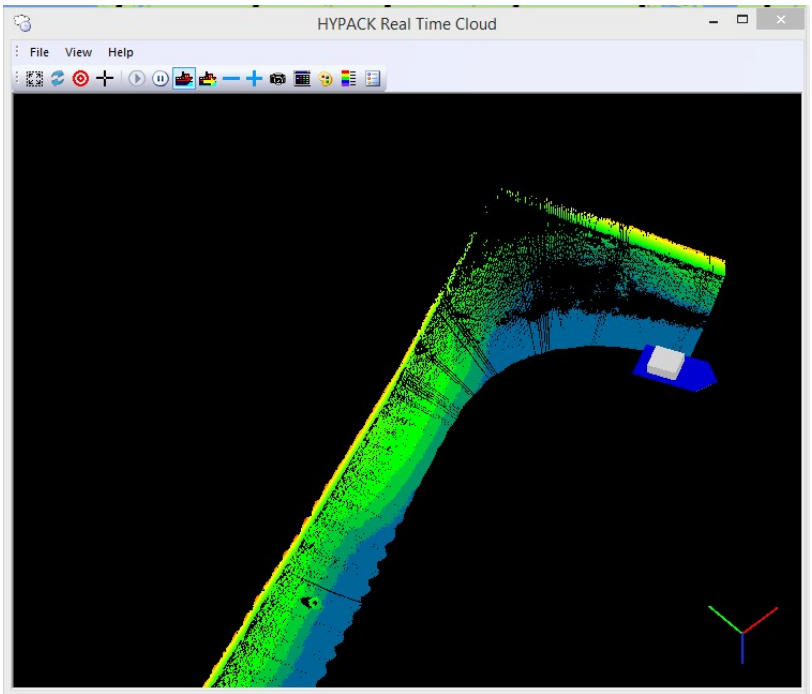
Make sure the Clear Existing Bands is checked and click OK.

The band set should change to reflect your changes. You will need to click the Apply button before you click OK to make the changes in your map display.

There are other options for the color bands to be displayed. Explore them to find one that works best for your needs.

HyPack Real Time Cloud

This window is perhaps the biggest wow factor you can have while collecting data. When collecting multibeam data for imaging, it can be the most useful display. This will give you a real time 3D point cloud that is Georeferenced. It will display up to 3,000,000 data points until it starts to remove the oldest points from the display. This display is the best way to insure that you are getting the coverage you need for your imaging project.

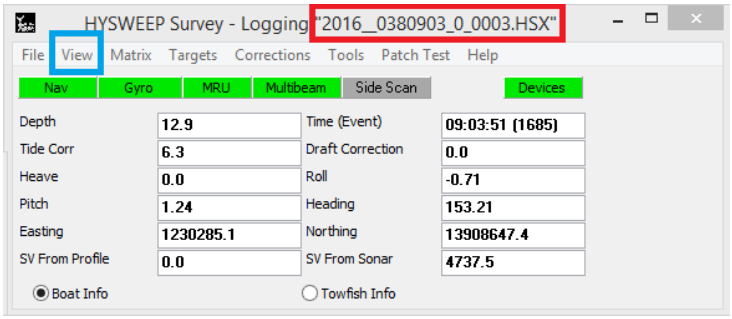


You can manipulate the view in all directions by left clicking and dragging in the view.

Zoom in and out with the mouse wheel.

HYSWEEP Survey Toolbar

The Hysweep Survey toolbar displays the status of the data connections coming into Hypack during the collection process and gives you real time data regarding your positioning and the soundings being recorded.



Some of the windows covered in this section are accessed through the View menu of this toolbar.

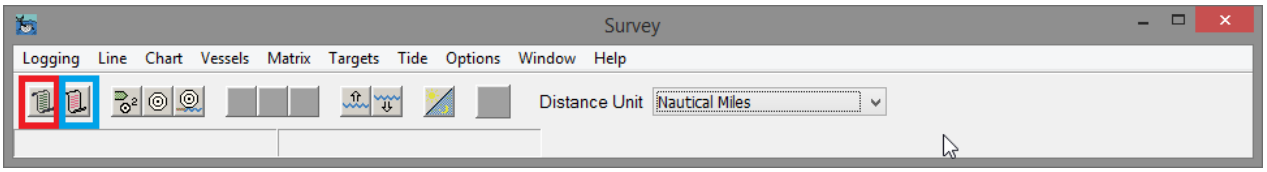
Clicking on any of the device indicators will bring up information about the connection status. If you have multiple sonar angles set up in Hypack Hardware you may see the Devices light yellow. Clicking on it will show some devices that are not connected. You have the option to dismiss the warning and force the light to show green. This will make it easier to spot a real problem if it should arise.

You'll notice that this image was captured during active file logging (red box). The information in the quotations is the file name that data is currently being logged to. You may find this important if you keep track of the files being logged in your field notes.

You can add a sound velocity profile under the corrections menu and Hysweep will process them in real time.

Survey Toolbar

The survey toolbar is used to control the logging status, add matrix and line files to your survey.



Most important are the start and stop logging buttons (blue and red boxes). You can also use Ctrl+S to start logging and Ctrl+E to end logging while this window is active. Keep in mind that you may be clicking around and adjusting things in other windows. If you don't make this toolbar active again the keyboard shortcuts will not activate these commands.

Before you begin your data collection, you will need to load the Matrix file that encompasses your survey area.

Click on the "Matrix" menu item on the Survey toolbar and select "load"

The dialogue box should open the root directory of your project. Select the matrix file you wish to load and click open.

From the same menu, you can clear the current matrix. This can be helpful if you are making multiple passes on a structure and want to monitor the coverage of each pass. This will not delete any of the data you have collected, only the matrix in the map window will be cleared.

One of the windows available to your driver is the Left/Right Indicator. This may be helpful for the driver, especially during the patch test data collection. You will need your line file loaded to be able to use this window.

Click the "Line" menu on the survey toolbar.

The dialogue box should open the root directory of your project. Select the line file you wish to load and click open.

You can use the commands in the Line menu to control which line is active and which direction you should be traveling along the line.

Swap (Ctrl+W) – Changes the travel direction of the line.

Increment (Ctrl+I) – Changes the active line to the next line in the list. (Line order is determined by the order of creation)

Decrement (Ctrl+D) – Changes the active line to the previous line in the list.

Logging Data

As discussed above, the start and stop logging buttons are located on the Survey toolbar. You can also use Ctrl+S to start logging and Ctrl+E to end logging while this window is active. Once again you may be clicking around and adjusting things in other windows. If you don't make this toolbar active again the keyboard shortcuts will not activate these commands.

One thing to consider when logging data is the file size you are creating. From a storage perspective, this is generally not important. Your survey computer should have plenty of internal storage space. Do not attempt to log data directly to an external storage device as this can introduce lag and has the potential to cause crashes.

While you are collecting data during a run, consider using the Start Logging function to end the current lag and immediately start a new one. There are 2 main concerns for limiting the size of your log files.

1. Larger files will take more memory during post processing. This will slow down your loading times and create longer wait times for the different operations you will use to post process your data.
2. Smaller file "segments" make it easier to isolate problems in your data set. Using this system to build an accurate 3D models of underwater structures requires everything in your system to be working at 100% during every second you are logging data. If, for example, you experience a momentary lapse in GPS coverage, the set of pings collected during that time will likely be positioned improperly. By breaking your log files up, you will be able to isolate that area. It will be easier to replace it with data from another run that did not see the outage, or you may be able to adjust the data manually during your post processing.

Field Notes

For patch test data, use the sheet provided to record the files you log. These sheets have places for you to record other important information for your job. If you are not patch testing because you are imaging and using the same set up you have already patch tested, you will still want to note some of the data found on the Patch Test forms.

Date: _____ Sonar Head Angle: _____ IMU Log: ☐

Project: _____

Crew: _____

Waterline Reference: _____

Waterline Measurement: _____

Measured Waterline Elevation: _____

GPS Waterline Elevation: _____

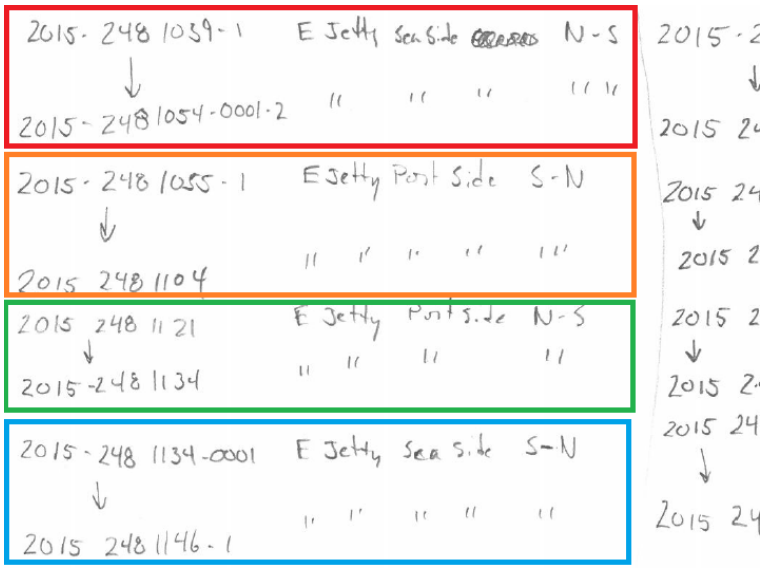
Entered K Value (in Geodesy): _____

Sound Velocity at Surface: _____

Sound Velocity Profile Name: _____

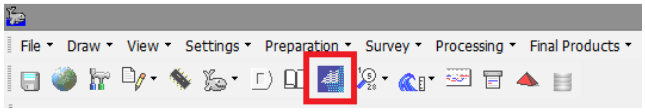
IMU Calibration File Name: _____

The field notes taken during the actual imaging process can be as detailed or as simple as is necessary. The example to the right is fairly simple. This information was recorded in addition to the data fields at the top of the patch test form. The structure being scanned here was a 2700' break wall. The data files were periodically split up during collection. For each run the beginning and ending file name were recorded along with a brief description of the area/structure being scanned and the direction traveled. This allows for a smoother workflow during post processing. The operator can now load the log files for each run separately without having to guess and use trial and error.



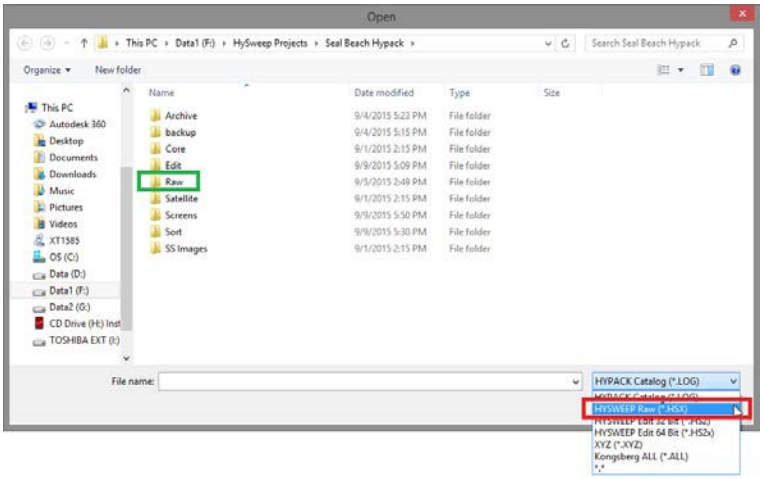
Data Processing & Clean Up

MBMAX 64 is a powerful tool for editing and cleaning your mulitbeam data. Follow the steps in this section on your patch test data before you run through the patch test processes in order to get the best results.



Start MBMAX 64.

Click the “Load Survey” button.

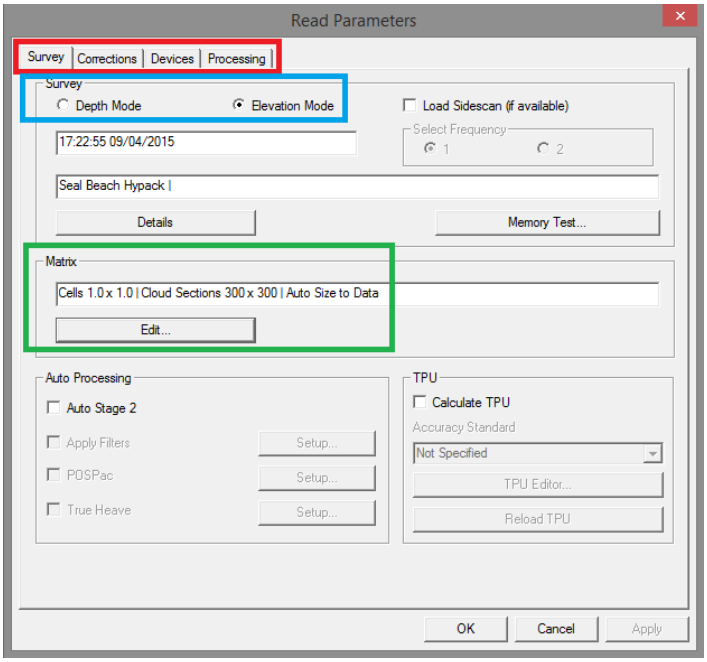


Change the file type to “HYSWEEP Raw (*.HSX)” (red box)

The raw survey files you collected will be found in the “Raw” folder in Hypack’s project directory.

Select all the patch test files for sonar angle you collected and click open. (You can only process data from one sonar angle setting at a time.)

The “Read Parameters” dialogue box will appear. You will need to go through all of the tabs of this box and make sure that everything is set correctly per your Hypack set up at the time the data was collected.



Starting on the Survey tab, make sure that the Survey type (blue box) is set to the same method as you set in you project Geodesy. Elevation or Depth.

Check to see the matrix settings are as you see here (green box), if not click the edit button and make the necessary corrections.

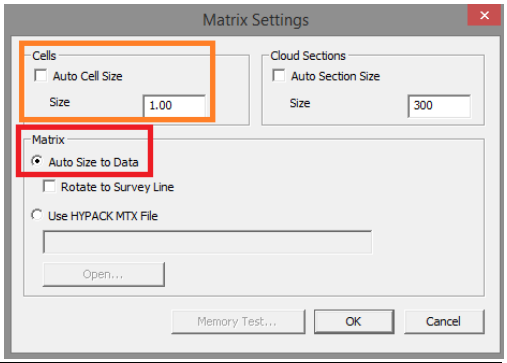
Note: This is just for display and will not impact your data.

*Matrix file can be adjusted during data collection setup.

Check the “Auto Size to Data” option

Then Make sure the “Auto Cell Size” box is unchecked.

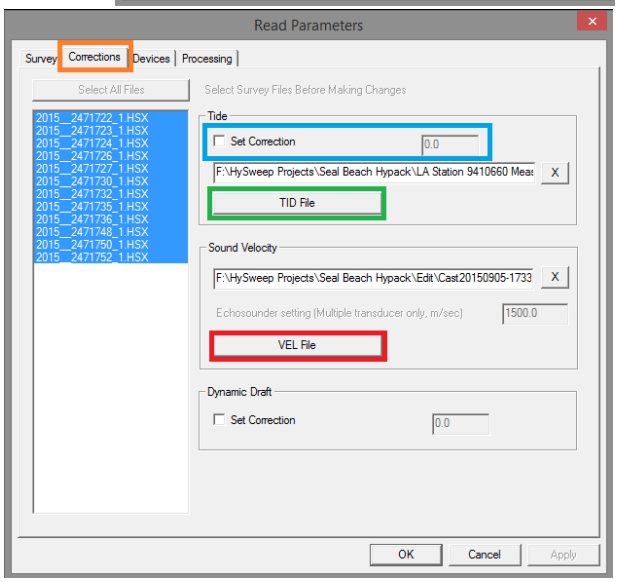
Click ok.



Auto Processing and TPU (total propagated uncertainty) should remain unchecked!

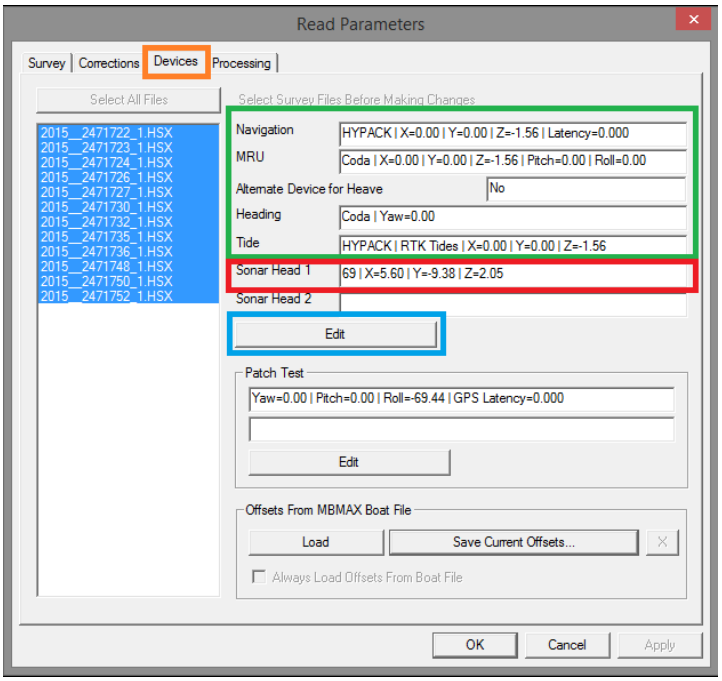
On the “Corrections” tab you will specify your sound velocity file by clicking the “VEL File” button (red box). Navigate to the file, select it and click open. *Make sure all files are highlighted.

When working in non-tidal waters, you can enter a waterline elevation to apply to the data if you took one at the time of the survey. Click the “Set Correction” box and enter the value in the blank field (blue box). Check .HSX files for “TID” values. Enter the actual elevation as a positive value (only negative if below sea level).
*Ask Hypack to see if we could “fake in” a TID file if we were on a river with a slope.



Leave Dynamic Draft unchecked (could put together a profile of the draft of the boat in relation to speed but probably isn’t necessary).

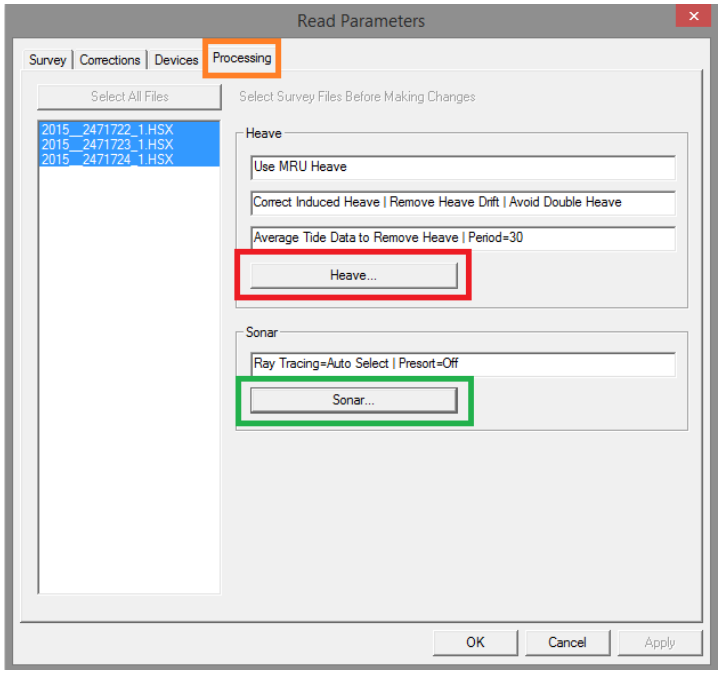
Under the “Devices” tab, all of the information in the green box should populate from your settings in Hypack Hardware. Make sure this information is correct.

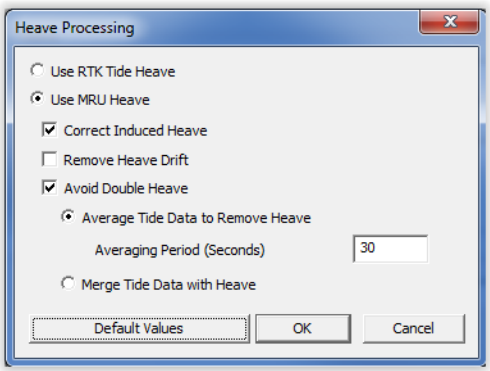


The Patch Test information should be blank at this point. With the exception of the Roll if you are using a sonar head angled at any other angle than 0 degrees (straight down). In this case we are using a sonar head that is tilted 69.44 degrees. *If need to apply/check if patch test results are applied to your data.

On the “Processing” tab we will specify how to handle the RTK Tide in conjunction with the heave.

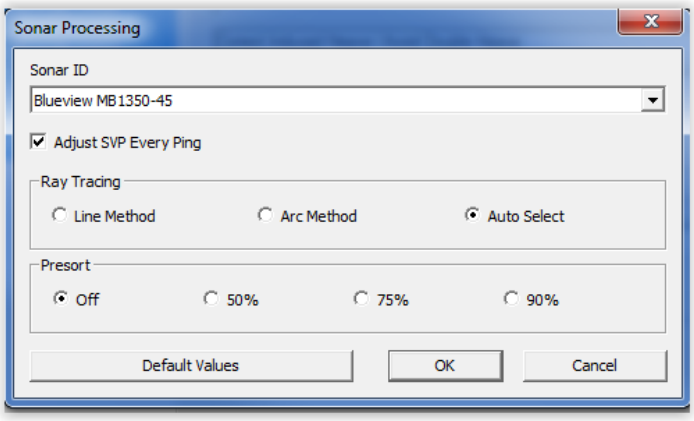
Click the Heave button (red box) under the Heave area to adjust how tide and heave data are processed during data import. Make sure the settings match what is shown here.





*Remove Heave Drift should be selected. May want to increase the Averaging Period from 30 to make the corrected “tide” (water surface elevation) more “smooth”.

Click the Sonar button (green box) to check the sonar settings.



Make sure the correct sonar is shown in the sonar ID box and the rest of your settings match what is shown here.

Finally, return to the Survey tab and click the "Memory Test" button.

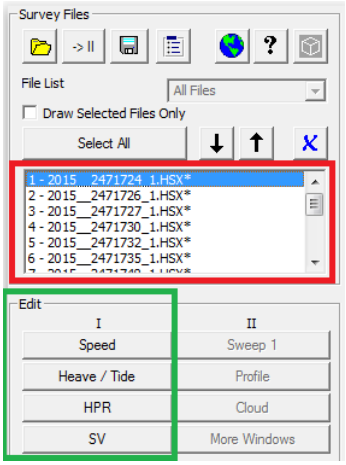
Make sure that you do not exceed 100% of the available memory. If you do, consider loading less files at a time for editing.

Click the OK button at the bottom of the Read Parameters window to begin loading the survey data.

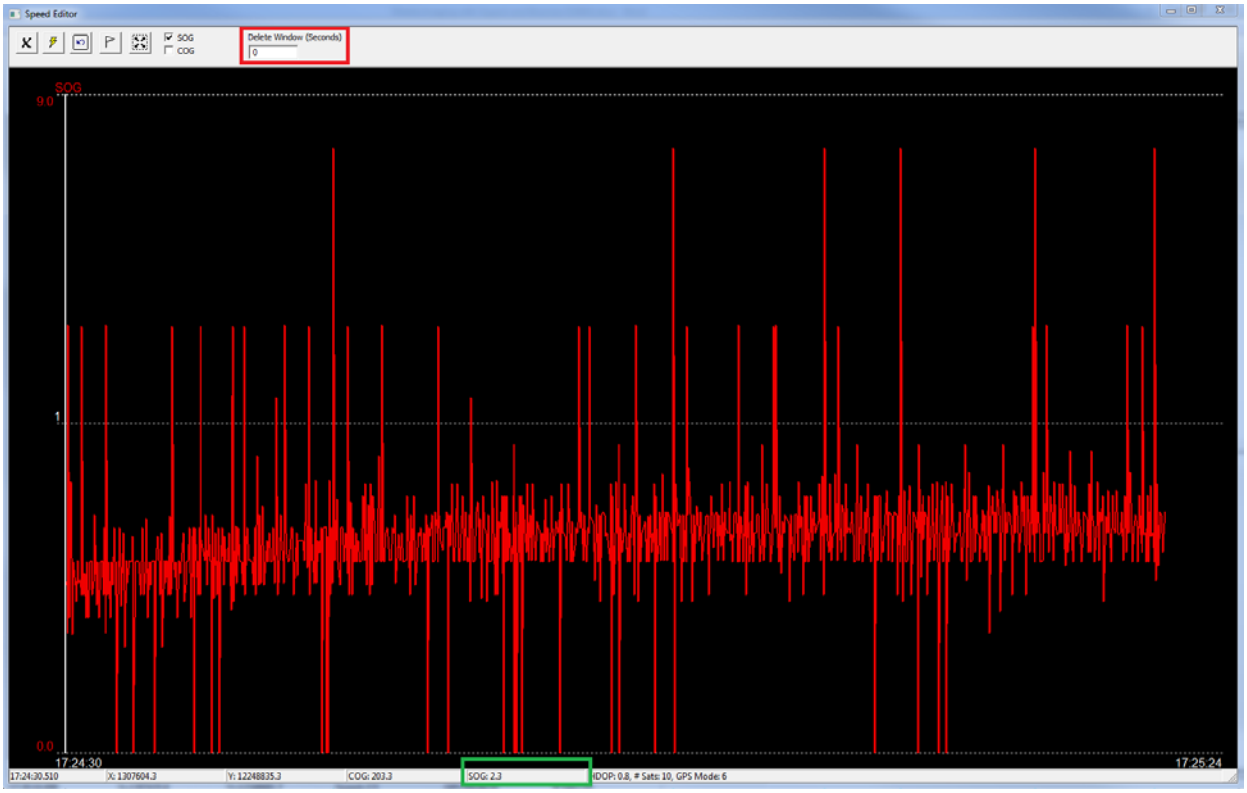
All of the files you loaded will show up in the File list on the left side of the MBMAX64 program. For first stage editing we will look at each of the files in the 3 of the four edit windows below the file list.

There are 2 stages to the editing process in MBMAX64. The majority of your editing in first stage will be the Speed window and the Heave/Tide window.

Highlight one file and click the Speed Button (it is recommended that you only view one file at a time in the editor…if a file is large you may need to zoom to sections of it and edit it one piece at a time).

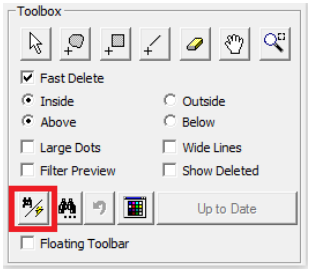


Step through stage one of editing for each individual file in the order that appears in the edit portion of MBMAX64. (Speed→Heave/Tide→HPR→SV)



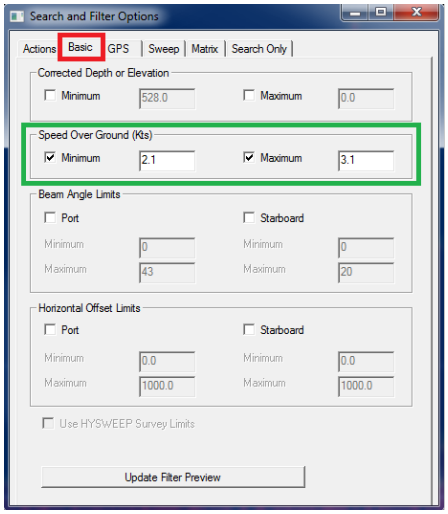
You will notice the large spikes in the speed data, theses need to be edited out. First make sure the "Delete Window (Seconds)" (red box) is set to 0. Across the bottom you can find the timestamp, x and y coordinates, the course over ground and the speed over ground (green box). Clicking on a point on the data will update the data fields with the pertinent data of the particular location you clicked.

If you were able to conduct your survey/imaging at a constant speed for all of your data files you would be able to use some automatic filters. You will need to determine the Minimum and Maximum speeds you want to keep. Click on the locations in the speed profile that represent the min and max speeds and make note of the speed listed in the SOG box



Locate the "Search and Filter Options" on the toolbox.

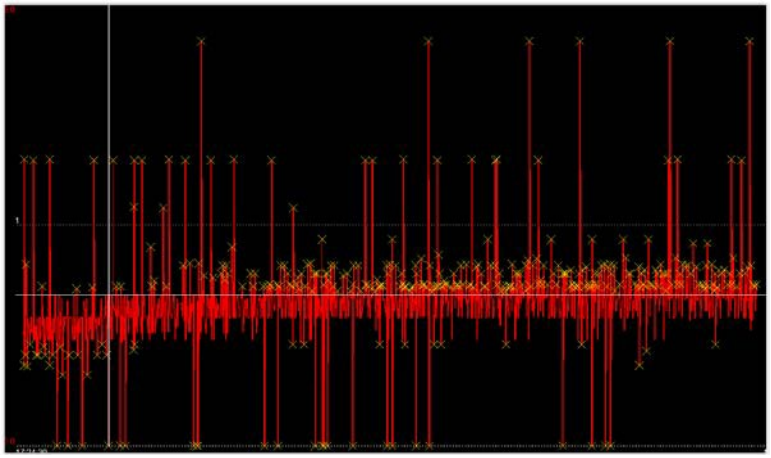
*Ctrl+T on the keyboard brings up a floating toolbox.



On the Basic Tab of the Search and Filter Options dialogue box, check the Minimum and Maximum boxes to turn the filter on and enter the min and max speeds you noted earlier.

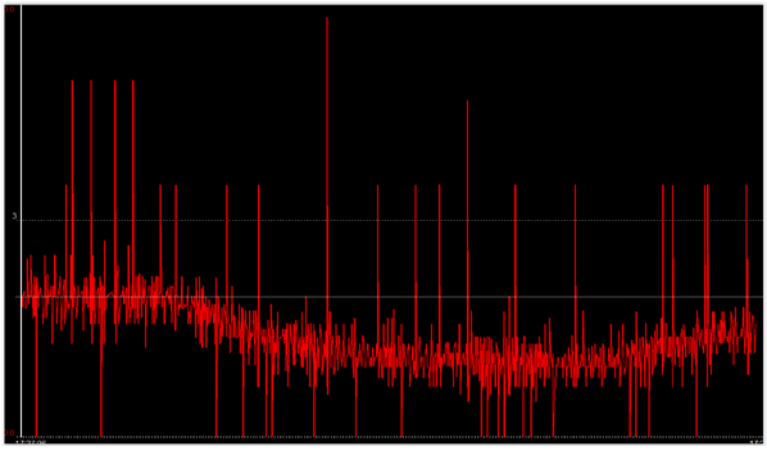
Click the Update Filter Preview button to see what points will be deleted from your speed profile.

Looking at the Speed window you will see a yellow X at each of the data points that will be deleted by these filter settings.

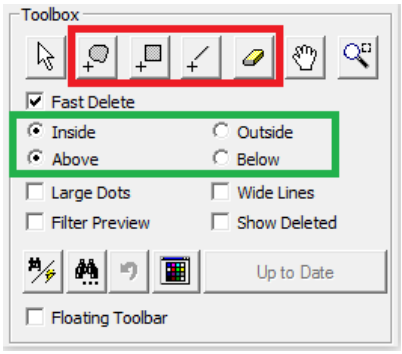


If you are happy with the preview, you can click the lightning bolt at the top of the speed editor window. This will delete only the data points you see in this view. You can repeat the process for each file you have loaded in the editor.

As you can see in this file, the speed of the boat changed during this run. This situation will make it difficult to clean the file properly using the Search and Filter options. These types of files should be cleaned manually.



The Toolbox gives you a few ways to go about this task.



In the red box you will find the tools available: Lasso select, Box select, Line and Eraser.

The Lasso will allow you to draw a free form shape around the data points. Hold the left mouse button and drag the mouse around the data, releasing the left button will close the shape with a straight line from the end to the beginning

The Box will allow you to draw a square or rectangle around the data points. Hold the left mouse button and drag the mouse, release the left mouse button to establish the opposite corner of the box.

The data to be deleted using the Lasso or box is determined by the selections in the green box. Your choices are Inside and Outside.

The Line tool creates a line using a beginning point and end point. Hold the left mouse button to start the line then drag the mouse. Release the button to establish the end of the line.

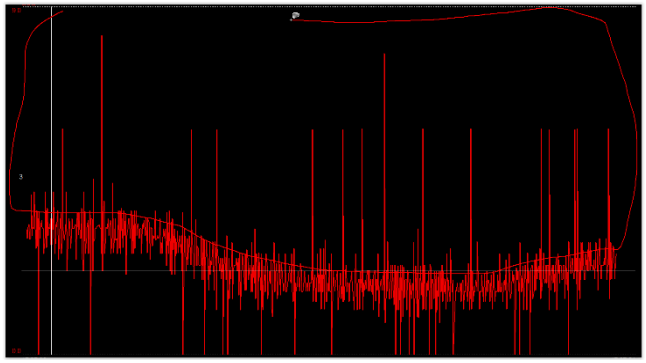
The data to be deleted using the Line is determined by the selections in the green box. Your choices are Above and Below. Only the data points that are directly above or below the line will be deleted.

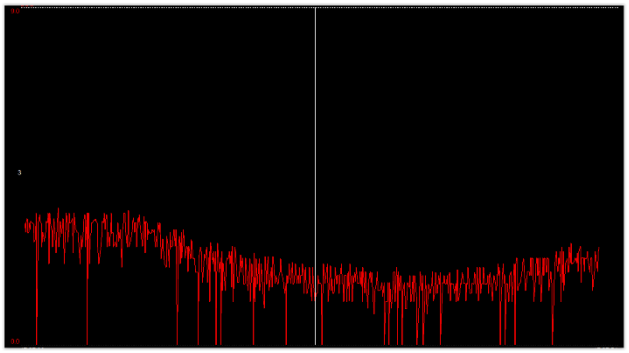
Once your shape is drawn, click the X button at the top of the Speed editor to delete the data you have marked for deletion.

Checking the “Fast Delete” button means that once you release the left mouse button to complete your shape, the data affected by the shape will be deleted.

The Eraser will immediately delete any data points under its box when you click the left mouse button, regardless of the Fast Delete box.

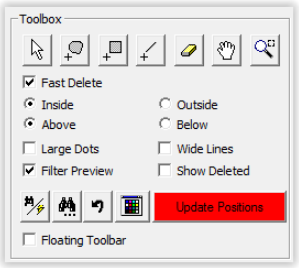
Using the settings seen above on the Toolbox, as soon as I release the button, all of the data within my lasso shape will be deleted.





Using this method will allow you to trace the profile of a varying speed run.

Repeat this for each of your files you have loaded in the editor and close the Speed Editor.

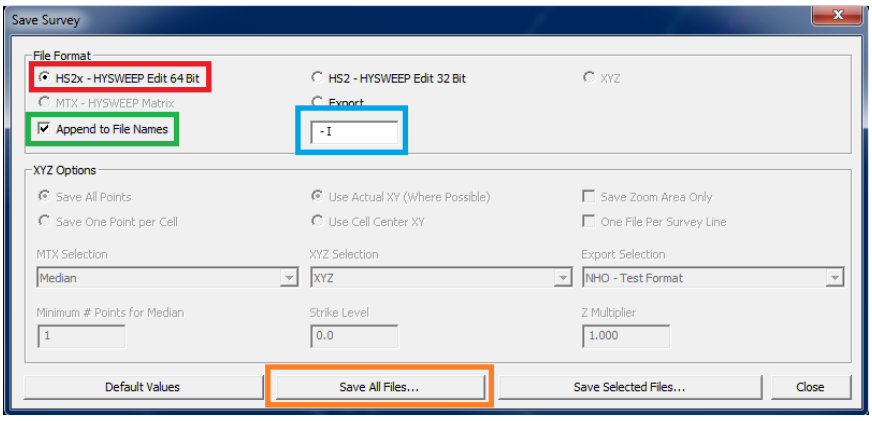


You will notice the Toolbox has a red button. Hypack wants to update the GPS positions based on your speed edits. Clicking this button will recalculate any positions affected by the speed edits. This may not be dramatic. If you zoom into one of the runs on your map, you may be able to see the change.

At this point you may have put some time into your files and you should save.

Click the Disk icon at the top of MBMAX64.

Make sure you are saving as HS2x files.



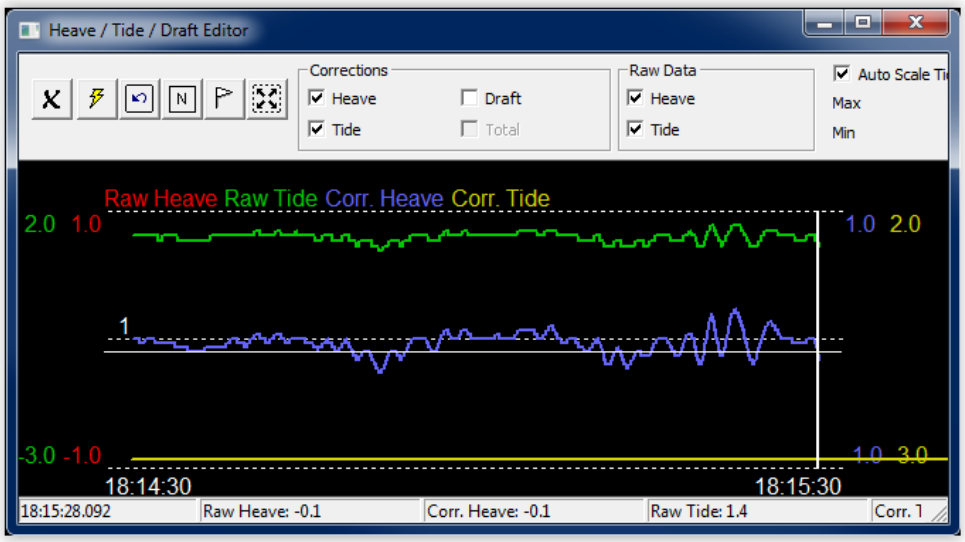
Check the Append to File Names box. Using this with the user customizable field in the blue box will help you keep track of what stage of editing a file is in.

Enter the information you want added to the end of each of the file names.

Select the “Save All Files” button to begin the saving process. (Files will be saved to the “Edit” folder in your project directory)

Next you will need to step through your files in the Heave / Tide editor.

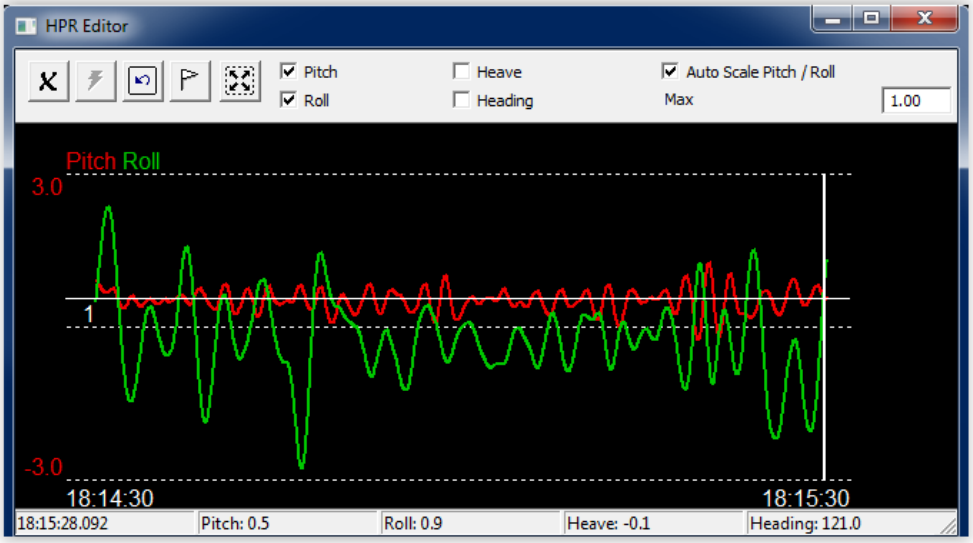
In the example used here, we used a tide file from a NOAA tide station, so there should be nothing to concen yourself with in that situation. You may have also entered a Tide elevation from your field observations. In that case your tide should look similar to this example.



If you are using your RTK data to compute your tides, step through all of your files and make sure that there are no large spikes in your raw tide data that are effecting your corrected tide. You can use the tools discussed in the speed editor section to delete any erroneous data spikes.

Next, take the time to step through all of your files in the HPR Editor (Heave, Pitch, Roll).

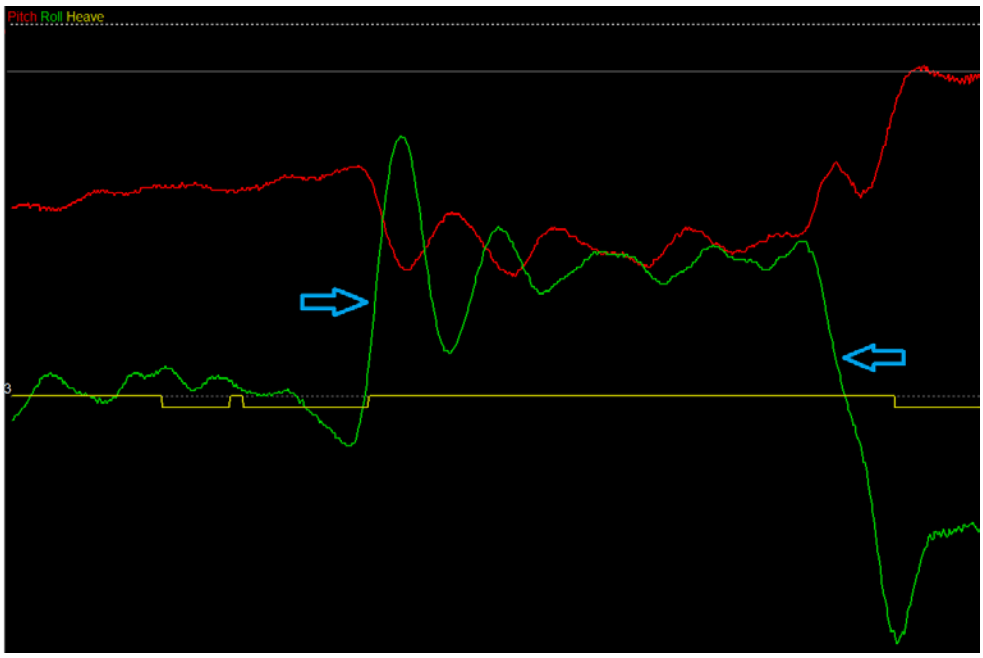
Note: This is mostly for quality control, checking to see if there was something wrong with the equipment during data collection.



There is no real corrections you would make to these files. The data from the motion sensor should remain intact. Your main concern is to make sure that the motion sensor was functioning properly during the survey.

You should be checking for strange spikes in the data. This could just be noise in the system. Should you observe any spikes, you should use caution when editing them out.

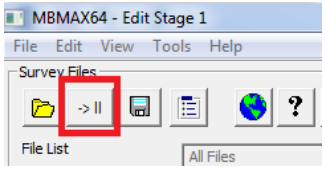
In the example here, a failing acceleromter was causing roll readings to drift from side to side. In this case, there was no way to correct for the error and the data was unusable. These problems are rare, but you should be aware of them before you continue processing.

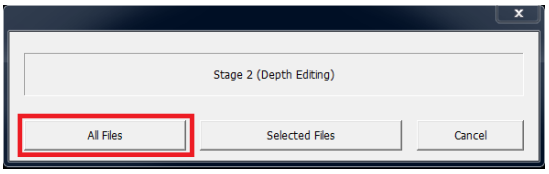


At this point you should save your files again before proceeding to stage 2 of the clean-up.

Stage 2 editing will make use of more of the automatic filtering available in MBMAX 64. One important thing to remember about these filters. They are designed for use in hydrographic surveys. The way some of them work could delete data points in your imaging data that you may want to keep. The best way to proceede with your data clean up is to load only the files you have that are scans of the channel bottom without the feature you are imaging. This way you can take advantage of the automatic filters to speed the clean up process. The following section will outline the use of the automatic filters first, then the manual proceedure that should be used on your imaging data.

Start by bringing your files into the Second Stage of editing in MBMAX64. Click the Stage "Stage 2 (Depth Editing) button.

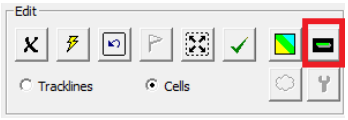


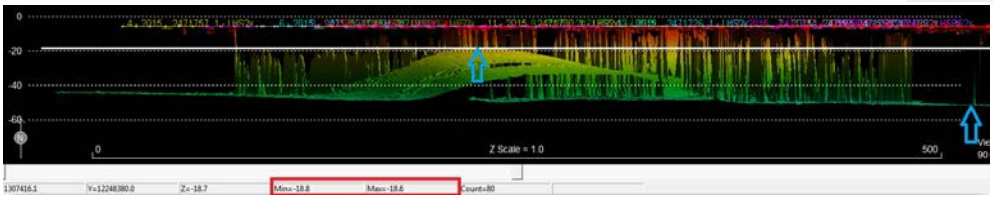


You can choose All the files you have loaded in MBMAX64 or you can select one or several at a time to bring into stage 2 editing

Once the files are loaded into second stage, you will be able to see your data displayed in the matrix. This view can be manipulated using the Tilt and Rotate Hand tool in the Toolbox.

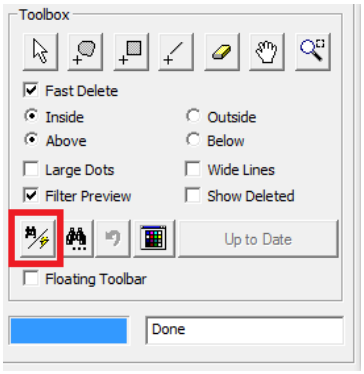
We'll start with the basic filters. You need some min and max dpeths for your valid data. Locate the Profile View button in MBMAX64 and click it.





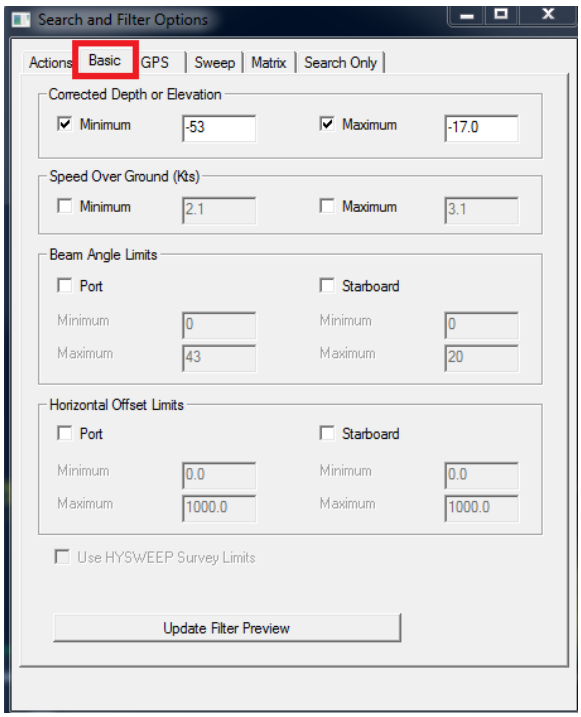
With the Measure tool active from the Toolbox, you can click on the data. Your cross hairs will show the current position you clicked and you will see the coordinate information for the cell you have selected at the bottom of the screen. The Min and Max information (red box) gives you the min and max depth/elevation of the selected cell. Identify the highest and lowest parts of the data you will be keeping and make note of the depths/elevations.

Locate the Search and Filter Options button in the Toolbox and click it to bring up the Search and Filter Options dialogue box.



On the Basic tab you have the following filter options:

Min Depth/Elevation filter filters all soundings shallower than the limit.
Max Depth/Elevation filter filters all soundings deeper than the limit.
Speed Over Ground filters POS records where the speed calculated is more than the user-specified speed.
Beam Angle Limits deletes data from transducers with a beam take-off angle within the specified range
Port and Starboard Offset Limits deletes all data that falls outside of the user-defined distance from the center beam.



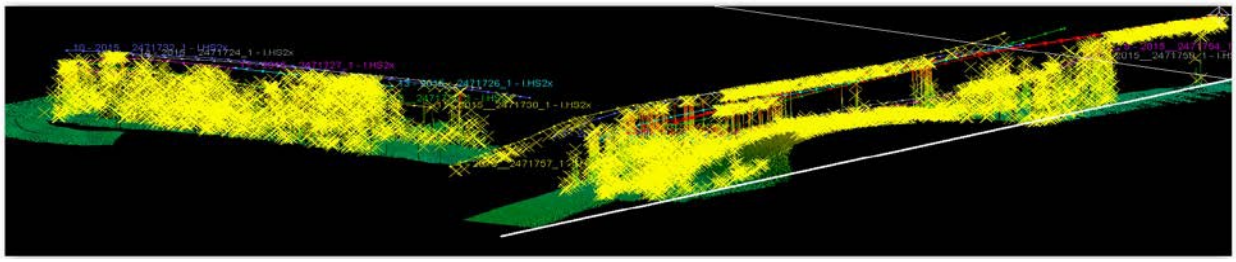
It is strongly recommended that you apply any filters in the Search and Filter options one at a time. This way you can check the filter preview for any data being deleted that you may want to keep.

Start with the Min and Max Depth or Elevation. Check the boxes to activate the filter and enter the values you noted earlier. In the example, the minimum elevation was found to be -51.4 and the Maximum depth was found to be 18.6. The filter was set to an elevation just outside those numbers to make in case you do not select the exact lowest/highest elevations.

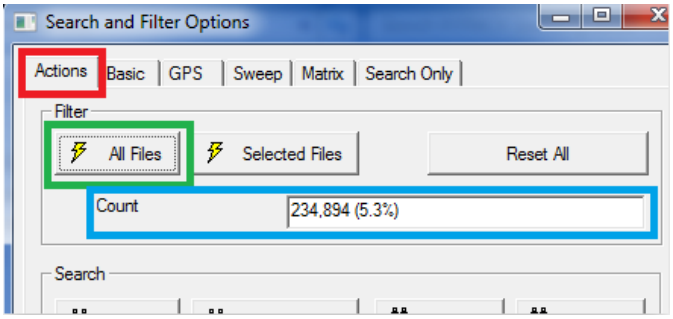
Note: If you incorrectly read the files in as depth or elevation mode then these features won't work.

Click the update filter preview button and inspect the yellow soundings that are marked for deletion.

If the filter is marking any data points you want to keep, adjust the filter settings and update the filter preview.



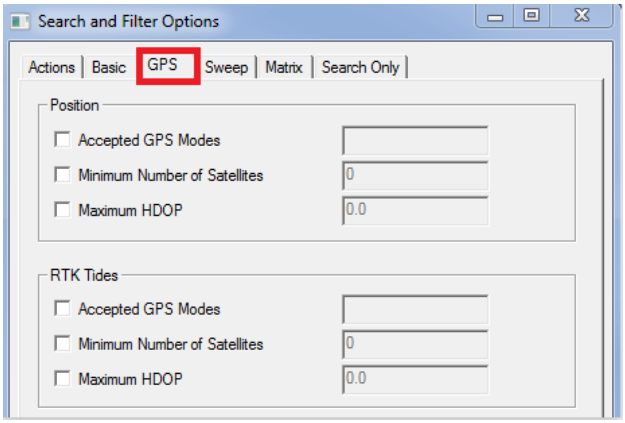
Once you are satisfied with the filter preview, click the Actions tab in the Search and Filter Options dialogue.



Clicking the All Files button will delete the soundings marked with the yellow Xs. The count box will display the amount of soundings deleted by the action.

Click the Reset All button, to turn off any active filters.

Repeat the above steps for each of the filters you wish to use on the basic tab.



The GPS tab has the following options:

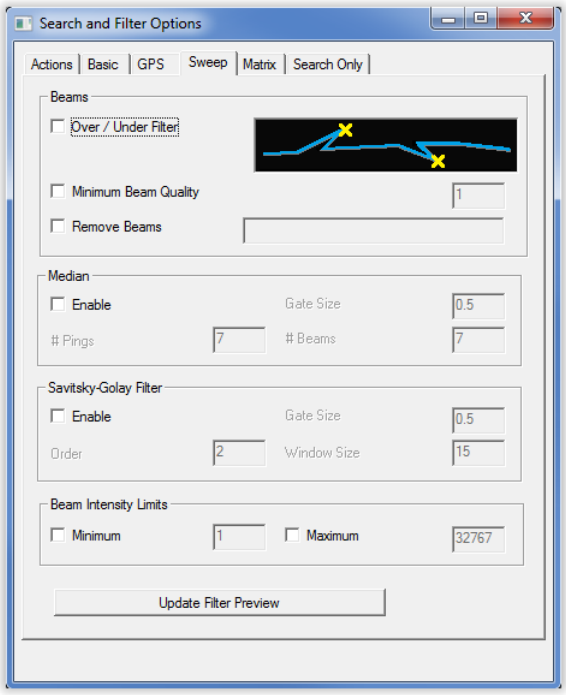
Accepted GPS Modes: List GPS modes for which you want to read data. If the GPS mode does not match any of the specified values, the POS or TID record will be omitted from being read into the editor. Values may be separated by commas or spaces.

Minimum Number of Satellites: If the number of satellites recorded in the quality information is less than the user-specified number, the POS or TID record will be omitted from being read into the editor.

Maximum HDOP: If the HDOP recorded in the quality information is more than the user-specified number, the POS or TID record will be omitted from being read into the editor.

The filters on the Sweep tab look at the surrounding data to determine if a sounding meets the criteria for deletion. Because of this, you may need to run these filters a few times before they find no soundings to delete. Simply click the “All files” button on the Actions tab. The Update Cells button on the Toolbox will light up red. Click it and the filter preview should update. You can click the All Files button on the Actions tab again to delete the newly marked soundings.

The Sweep Filters are outlined below. NOTE: The Sweep filters will most likely remove data you would want to keep for an imaging project. These should be avoided in those situations.



Beam Filters Over/Under deletes stray soundings as shown in the graphic on the Sweep tab. NOTE: Take care to preserve natural or man-made features that are really there.

Minimum Beam Quality deletes all soundings with a quality number less than the limit.

Remove Beams enables you to filter out all readings from selected beams. Enter beams to be omitted in a space delimited list.

The Median Filter divides your data into areas measured according to the number of pings and number of beams options. In each area, it finds the median value and filters any sounding that is farther than the gate distance away.

Note: As Gate Size value increases-clarity of data decreases. Typical values for gate size=0.5, # of Pings=7, # of Beams=25.

Savitsky-Golay Filter is a low pass filter that removes data appearing as high frequency (abrupt bottom changes, outliers) and keeps low frequency data (somewhat uniform) seafloor.

BEWARE! USE WITH CAUTION! This filter was designed for use with excessively noisy data and is not intended as a substitute for thoughtful editing. All automated filters carry some risk of inaccurately removing bottom features. The filter reads a number of soundings specified by the Window. It estimates the actual depth of the center point of that range by doing a series of calculations based on the Order. (Higher order values result in a faster change in the predicted values to correspond to rapid vertical changes.) If the original depth is deeper or shallower than the calculated depth by more than the Gate value, it will be removed by the filter.

BEWARE! The idea is good, but it can be unreliable. Under certain conditions it can remove too much data. Use cautiously!

The Order: Degree of polynomial approximation. It should always be less than the Window size. After that, you will have to experiment in each survey condition to determine the best order for you. A larger order filters less which results in a more varied surface, but may not remove all extraneous data.

Gate Size: Depth, in survey units, above and below the filtered surface. Depths outside of this range will be removed.

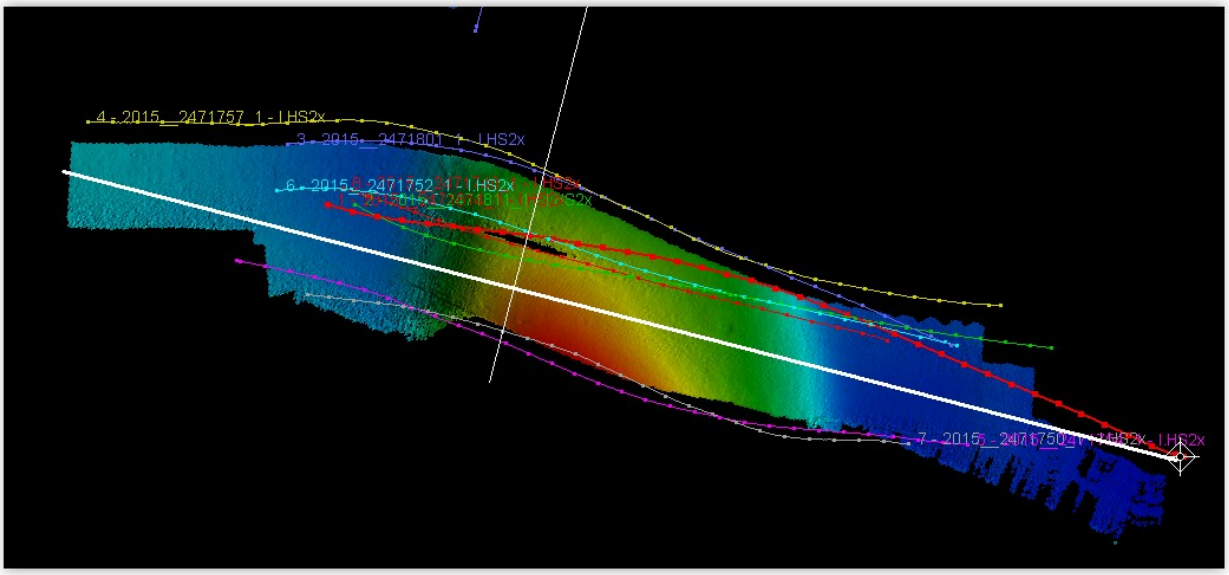
Window: Number of soundings used to estimate the surface. Should be an odd number.

For the purposes of Patch Testing, you should run the Beams Over/Under and the Median filters until they do not mark any soundings for deletion. You will need to reset the Over/Under tab everytime. Select

Over/Under→Go to the Actions Tab→Click All files→Reset All→Click and do it again.
This is the extent of the automated filters that can be used on data that has not been patch tested.

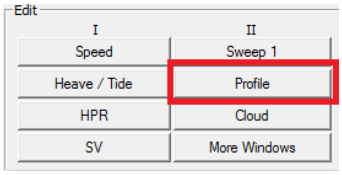
Note: To see the cell window (to view all of the soundings in the cell) click on the “More Windows” button under the 2nd phase editing column.

The last step is the manual editing. For this process we will use the profile window to examine data and delete any remaining stray soundings.

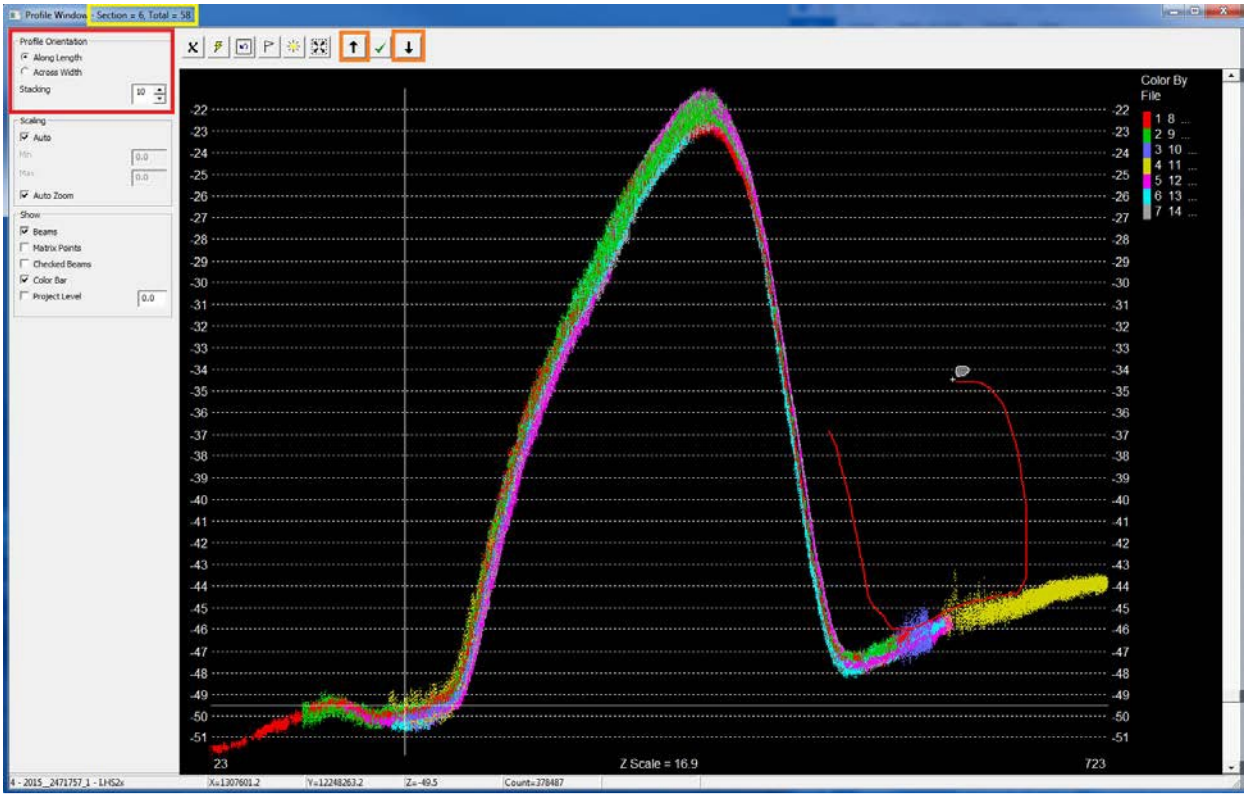


You will notice that the crosshairs on the matrix view has one axis that is thicker than the other. The thicker line is our profile line. The intersection point of the cross hairs is shown with a crosshair in the profile window.

Locate and click the Profile button on the left side of the MBMAX window.



Note: If you want you can bring up your matrix file to realign the profile (Read Parameters→Survey→Matrix), or you can select (check) rotate to survey line.



The first thing you should look at is the Profile Orientation area (red box) of the Profile Window.

The Along Length and Across Width options will change which of your cross hairs axis is used for the profile.

The stacking option controls the number of Matrix Rows are displayed at a time. Changing this will affect how many total profiles you will have to go through. This is indicated at the top of the window (yellow box). The more you stack the less individual profiles you have to go through for cleaning. The trade-off is that there may be so many soundings on the profile that it could be confusing as to which should be kept and which should be deleted. You will have to balance this based on the conditions of the survey and the time you have to compete the job.

You should now save the files.

Patch Test Processing

Make sure you have completed stage 1 and 2 of the data cleanup process before running the patch test routes. It is important to run the patch tests in a particular order and apply the corrections to the data set after each test. The order is as follows:

Latency is done first, because the 'timing' for all of your data must be correct before you can perform any of the 'angular' tests.

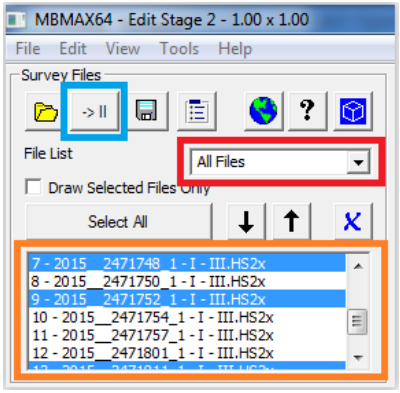
Roll is tested second, since it was collected over a flat bottom and any 'positional' errors will not significantly affect the test results.

Pitch is third, mainly because the yaw test has to be last.

Yaw is last, because it 'needs' the initial 'rough' test values from the previous three (3) tests, in order to help it calculate the best yaw test value.

Begin with all of your patch test data loaded into stage 1 editing of MBMAX 64.

Make sure "All Files" is displayed in the "File List" drop down (red box)

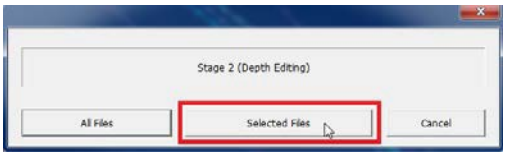


Latency Test

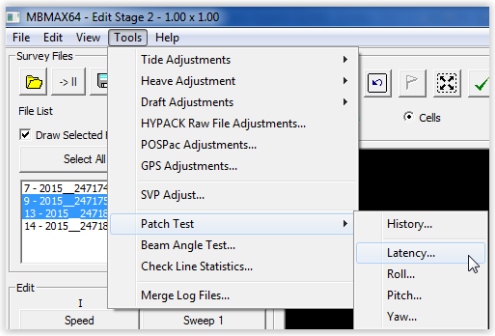
Select the files you collected for the Latency test during data collection. (orange box) (Chris tends to just pick 2 files-1 at survey speed and 1 at double survey speed)

Click the "Stage 2 (depth Editing)" button (blue box)

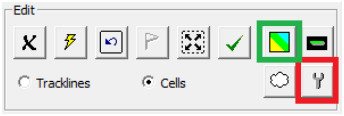
When prompted, chose the "Selected Files" button to bring only the latency test files into stage 2

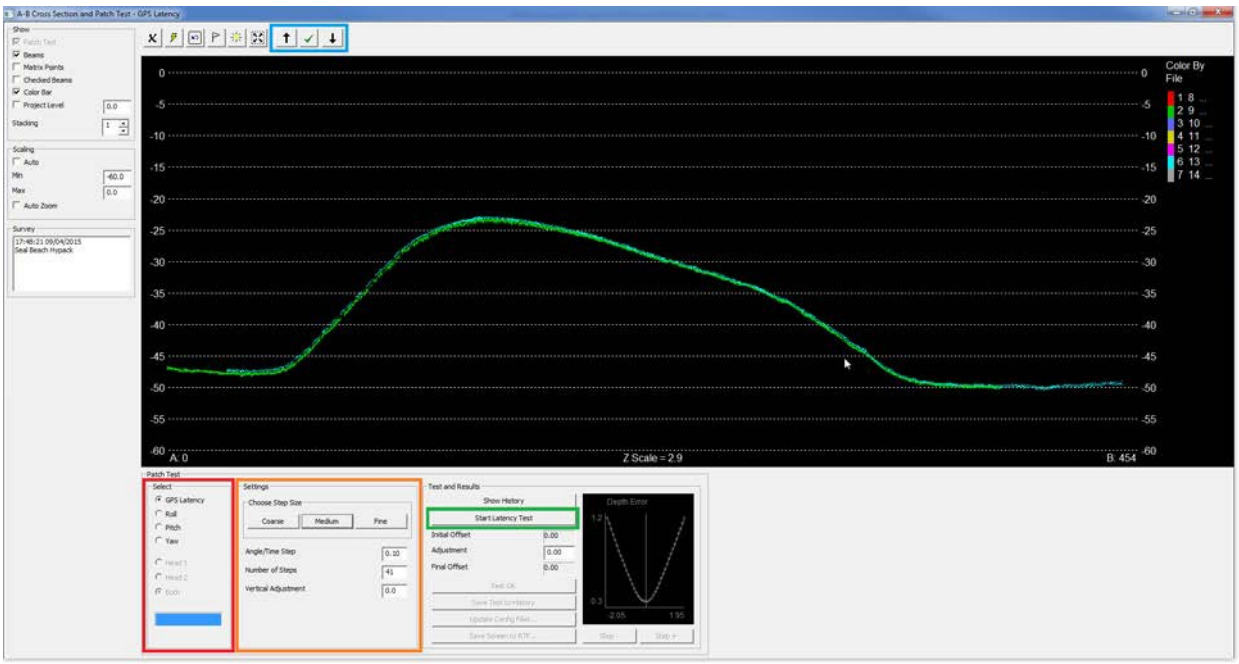


On the menu bar, click the "Tools" button, hover over "Patch Test" and select "Latency…" from the menu. MBMAX 64 will cut a profile through the data in an orientation appropriate for the test.



Alternately, with the survey matrix view in plan view (green box), you can select the Wrench icon (red box) and draw your own profile. The profile should run perpendicular to the slope.

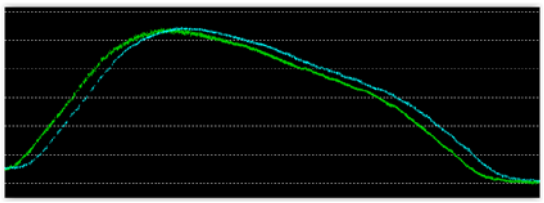




Use the arrows (blue box) at the top of the window to move your profile through the data so that you see a good overlap of data from each line you ran in the field.

Make sure that the “GPS Latency” test is selected (red box)

In general newer multibeam equipment is pretty reliable in the timing category. You should not expect to see much if any timing issues with the equipment seen on the market today. As you can see in the example above, the timing does not appear to be off. The image on the right shows what your profile would look like if you had some timing issue.

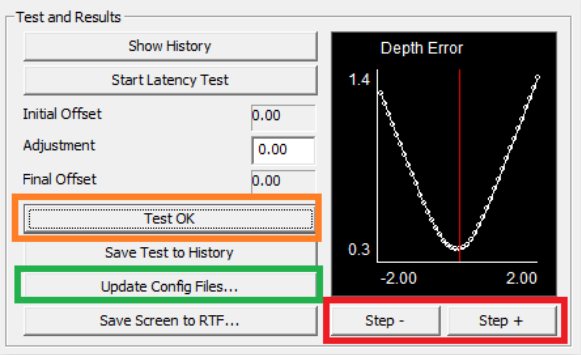


If your data does not appear to have timing problems you can start the test using the medium step size. Click the Medium button (orange box). You can see the step size will be .10 seconds.

You can specify the number of steps, just make sure you use an **odd number**. (typically 31 to 41)

Click the “Start Latency Test” button (green box). MBMAX will run through a series of calculations, you can monitor its progress with the fuel bar in the bottom of the “Select” box (red box)

You should see a “V” shape in the Depth Error window when the test completes. The red line indicates the adjustment value used to achieve the minimum Depth Error. At this point you should examine how the cross sections line up. If they line up well, the adjustment value of the patch test should be used as is.



If the profiles do not line up, change the adjustments using the “-Step -” or “Step +” buttons (red box) to align your profiles as close as the current step size will allow. NOTE: Latency adjustments should never be negative. If this is the case, use 0.

Click the “Test OK” button (orange box)

Click the “Update Config Files… button and close the Patch test window. This writes the adjustments back to the hardware.

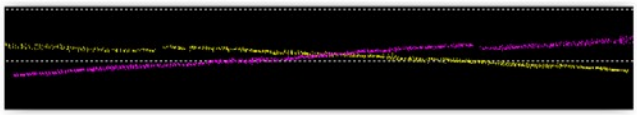
You will notice the “Update Devices” button is red in the MBMAX 64 Window. Click it to apply the adjustments of the latency test to your data.

*Run through the coarse, medium and fine latency adjustments before editing the roll, pitch and yaw.

NOTE: Within the fine patch test you can cheat the tests to get a more precise result (roll, pitch and yaw in particular) by adjusting the angle/time step (usually halfing it).

Roll Test

The Roll test uses data collected over a flat bottom. Roll misalignments show up as crossing profiles.



Make sure “All Files” is displayed in the “File List” drop down

Select the files you collected for the Roll test during data collection and click the “Stage 2 (depth Editing)” button.

When prompted, choose the “Selected Files” button to bring only the roll test files into stage 2

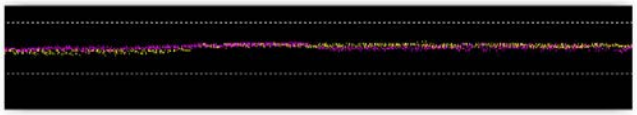
On the menu bar, click the “Tools” button, hover over “Patch Test” and select “Roll…” from the menu. MBMAX 64 will cut a profile through the data in an orientation appropriate for the test.

Alternately, with the survey matrix view in plan view, you can select the Wrench icon and draw your own profile. The profile should run perpendicular to the lines that were run to collect the data.

Make sure you have good overlap of data in the profile window. Adjust your section position as necessary. Note: You may need to adjust the zoom in the Cross Section and Patch Test window to get a better picture. Uncheck Auto Zoom in the Scaling pane and edit the min and max boxes.

Start with the coarse step size and run the test.

Make sure the red line falls at the lowest point of the “V” in the Depth Error window and that your profiles line up fairly well. They do not have to be perfect as we will step through the tests again using the medium and fine step sizes.



If the profiles do not line up, change the adjustments using the “-Step -” or “Step +” buttons to align your profiles as close as the current step size will allow.

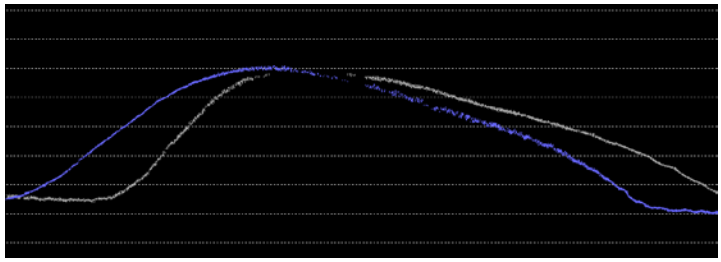
Click the “Test OK” button (orange box)

Click the “Update Config Files… button and close the Patch test window.

You will notice the “Update Devices” button is red in the MBMAX 64 Window. Click it to apply the adjustments of the Roll test to your data.

Pitch Test

The pitch test is collected over a sloping bottom. Pitch misalignments show up as Profiles that offset from each other.



Make sure “All Files” is displayed in the “File List” drop down

Select the files you collected for the Pitch test during data collection and click the “Stage 2 (depth Editing)” button.

When prompted, chose the “Selected Files” button to bring only the pitch test files into stage 2

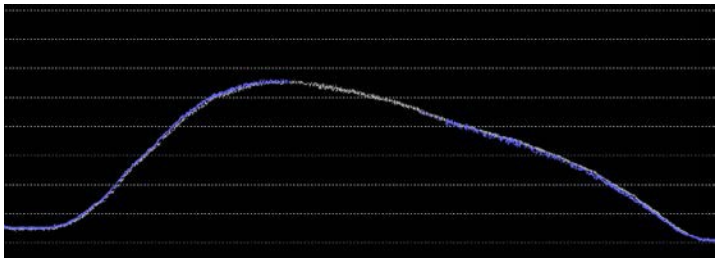
On the menu bar, click the “Tools” button, hover over “Patch Test” and select “Pitch…” from the menu. MBMAX 64 will cut a profile through the data in an orientation appropriate for the test.

Alternately, with the survey matrix view in plan view, you can select the Wrench icon and draw your own profile. The profile should run perpendicular to the slope.

Make sure you have good overlap of data in the profile window. Adjust your section position as necessary.

Start with the coarse step size and run the test.

Make sure the red line falls at the lowest point of the “V” in the Depth Error window and that your profiles line up fairly well. They do not have to be perfect as we will step through the tests again using the medium and fine step sizes.



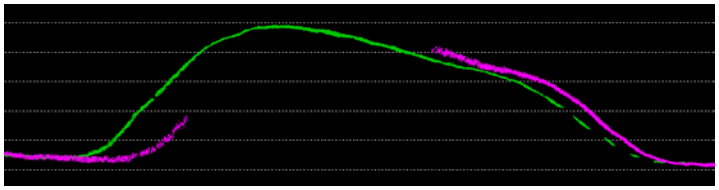
If the profiles do not line up, change the adjustments using the “-Step -” or “Step +” buttons to align your profiles as close as the current step size will allow.

Click the “Test OK” button (orange box)

Click the “Update Config Files… button and close the Patch test window.

You will notice the “Update Devices” button is red in the MBMAX 64 Window. Click it to apply the adjustments of the Pitch test to your data.

Yaw Test



The yaw test is collected over a sloping bottom. Pitch misalignments show up as Profiles that offset from each other.

Make sure “All Files” is displayed in the “File List” drop down

Select the files you collected for the yaw test during data collection and click the “Stage 2 (depth Editing)” button.

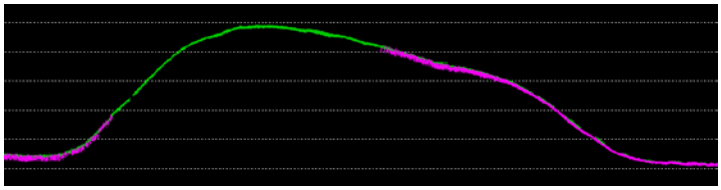
When prompted, chose the “Selected Files” button to bring only the yaw test files into stage 2

On the menu bar, click the “Tools” button, hover over “Patch Test” and select “Yaw…” from the menu. MBMAX 64 will cut a profile through the data in an orientation appropriate for the test.

Alternately, with the survey matrix view in plan view, you can select the Wrench icon and draw your own profile. The profile should run perpendicular to the slope.

Make sure you have good overlap of data in the profile window. Adjust your section position as necessary.

Start with the coarse step size and run the test.



Make sure the red line falls at the lowest point of the “V” in the Depth Error window and that your profiles line up fairly well. They do not have to be perfect as we will step through the tests again using the medium and fine step sizes.

If the profiles do not line up, change the adjustments using the “-Step -” or “Step +” buttons to align your profiles as close as the current step size will allow.

Click the “Test OK” button (orange box)

Click the “Update Config Files… button and close the Patch test window.

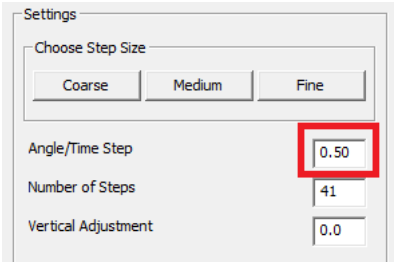
You will notice the “Update Devices” button is red in the MBMAX 64 Window. Click it to apply the adjustments of the Yaw test to your data.

After you have completed each of the patch tests using the coarse adjustment steps, you will repeat each of the tests in the same order using the medium adjustments. Make sure that you update the Config files and the devices after each test to apply the new corrections to the data set for the next test.

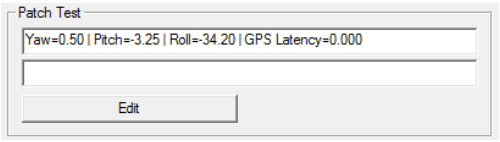
Once you have completed the patch test sequence using the medium adjustment steps, you will repeat the process a final time using the fine adjustment steps.

One thing to note is with each successive test you will notice the pattern in the Depth Error window of the patch test window begins to look less like a "V". The most important thing to look at is the alignment of the profiles. Change the adjustments using the "-Step -" or "Step +" buttons to align your profiles as close as the current step size will allow.

When running the tests using the fine steps, if you can't line your profiles up as close as you'd like, you can "cheat" the test by manually entering the step size. Setting a smaller step size should allow you to align your profiles closer.



When you have completed your patch testing you can see the final results on the Devices tab of the Read Parameters box of MBMAX 64. Write these values in on HySweep Survey Setup Form. The next time you use this setup you can enter these values in Hypack Hardware at the beginning of the job.



Consider collecting new patch test data using these values to see if you can refine your multibeam setup even further.

Vertical Patch Tests: When tilting your Blueview to extreme angles, collecting traditional channel bottom patch test data can be difficult, if not impossibe given the range limits of the sonar. In circumstances where the water depth will alow you to collect traditional patch test data at an extreme angle, the data collected could be at the outter limits of your range therefore may not acurate enough to produce good patch test results. This is where the vertical patch test comes in.

You will process the vertical patch test data in the same way you did with the traditional patch test data.

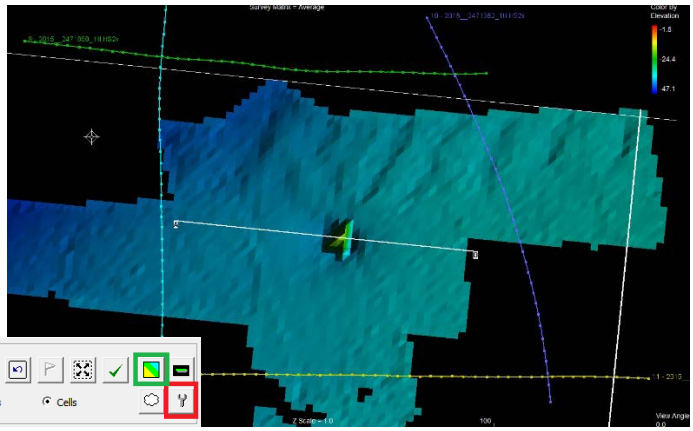
CAUTION: When editing your vertical patch test data you should avoid using the filters on the Sweep tab of the Search and Filters dialogue of MBMAX64. These filters are designed for use in hydrographic surveys. The way some of them work could delete data points in your vertical patch test data that you need.

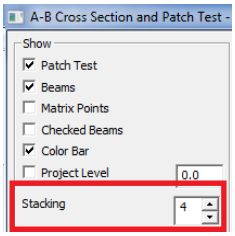
There is no process for collecting data for a latency test in a vertical patch test. You will have to use a latency value from a traditional patch test of your system.

Clean the data up in preparation of the patch testing.

Load all of your vertical patch text data into MBMAX64 and bring the files into Stage 2 editing.

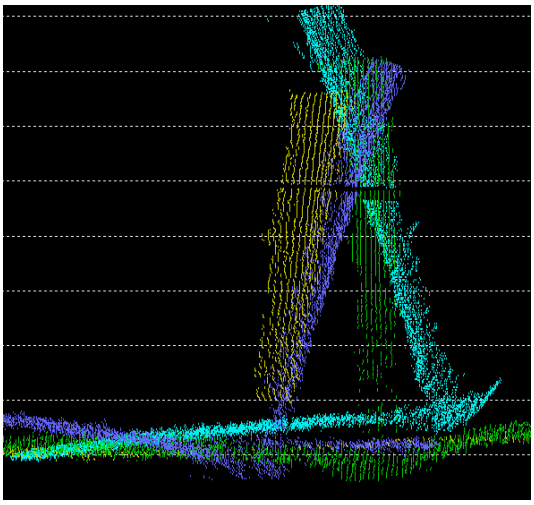
You will be able to use the same profile for all of the tests. Use the Wrench tool to cut a profile parallel to 2 of the 4 lines that were run in the field.



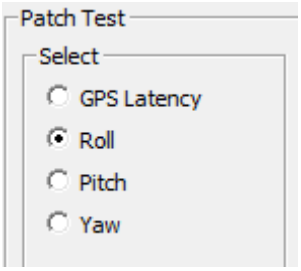


You may need to “stack” more profiles in order to have a good view of the vertical object from each line. Use the stacking option to increase the number of profiles stacked in your view.

Roll Test

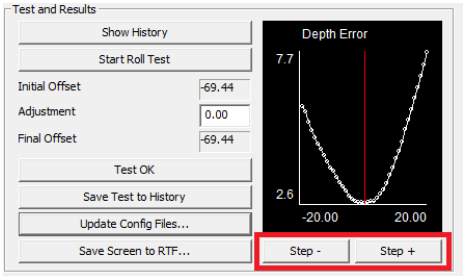


Although the roll test doesn't strictly need to include the vertical object, it doesn't hurt to leave it in. Just like the traditional test, the roll test attempts to line up the flat bottom. A roll offset will cause the bottom to make X's and affect the position of the poles somewhat.



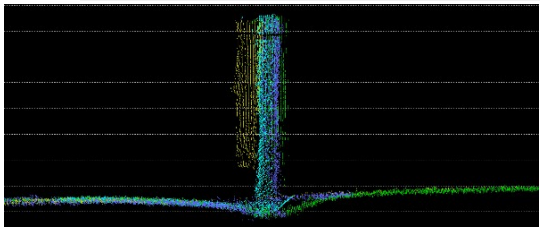
Make sure the Roll test is selected for the current type of patch test.

Start with the coarse step size and run the test.



Unlike the traditional patch testing, you may not see a “V” shape in the Depth Error window, what’s important here is that the channel bottoms line up fairly well. They do not have to be perfect as we will step through the tests again using the medium and fine step sizes.

If the profiles do not line up, change the adjustments using the “-Step -” or “Step +” buttons (red box) to align your profiles as close as the current step size will allow.

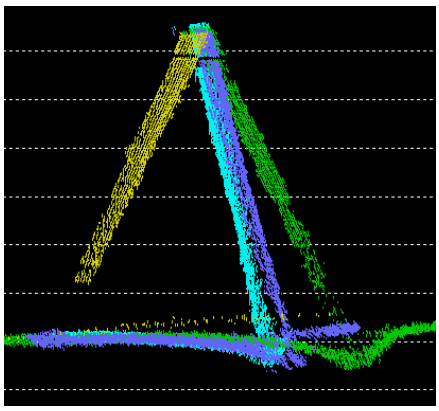


Click the “Test OK” button (orange box)

Click the “Update Config Files… button and close the Patch test window.

You will notice the “Update Devices” button is red in the MBMAX 64 Window. Click it to apply the adjustments of the Roll test to your data.

Pitch Test

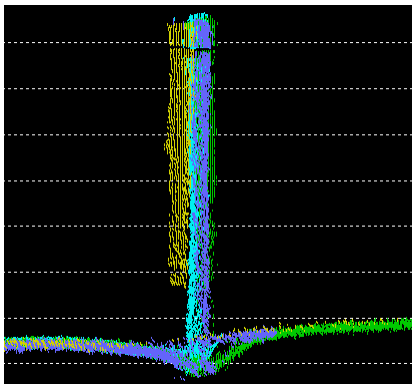


A Pitch offset will make your vertical object spread out from either the top or the base. The goal is to make all of them parallel to each other.

Make sure the Pitch test is selected for the current type of patch test.

Start with the coarse step size and run the test.

Unlike the traditional patch testing, you may not see a "V" shape in the Depth Error window, what's important here is that the vertical objects are fairly parallel to each other. They do not have to be perfect as we will step through the tests again using the medium and fine step sizes.



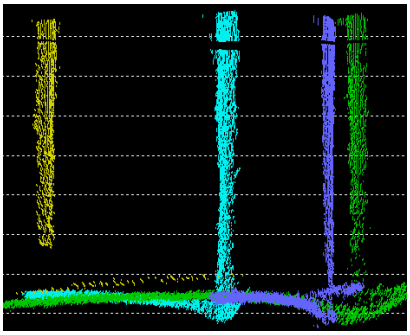
If they are not parallel to each other, change the adjustments using the "-Step -" or "Step +" buttons to align them as close to parallel as the current step size will allow. *When they are parallel they will not necessarily be vertical, depends on the orientation of the post or whatever object you are collecting against.

Click the "Test OK" button (orange box)

Click the "Update Config Files… button and close the Patch test window.

You will notice the "Update Devices" button is red in the MBMAX 64 Window. Click it to apply the adjustments of the Roll test to your data.

Yaw Test

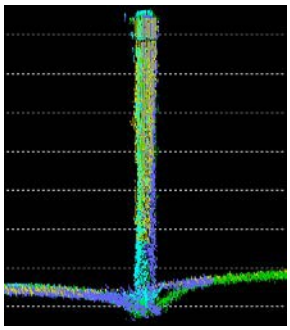


A Yaw offset will show as a group of parallel vertical objects separated from each other. The goal is to bring them all together to form one singular vertical object.

Make sure the Yaw test is selected for the current type of patch test.

Start with the coarse step size and run the test.

Unlike the traditional patch testing, you may not see a “V” shape in the Depth Error window, what’s important here is to bring them all together to form one singular vertical object. They do not have to be perfect as we will step through the tests again using the medium and fine step sizes.



If they are still separated from each other, change the adjustments using the “-Step -” or “Step +” buttons to bring them together as close as the current step size will allow.

Click the “Test OK” button (orange box)

Click the “Update Config Files… button and close the Patch test window.

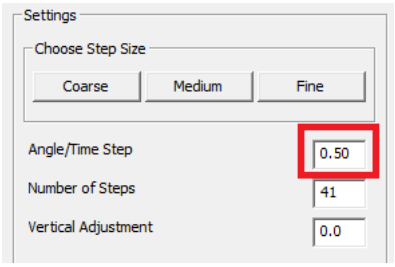
You will notice the “Update Devices” button is red in the MBMAX 64 Window. Click it to apply the adjustments of the Roll test to your data.

After you have completed each of the patch tests using the coarse adjustment steps, you will repeat each of the tests in the same order using the medium adjustments. Make sure that you update the Config files and the devices after each test to apply the new corrections to the data set for the next test.

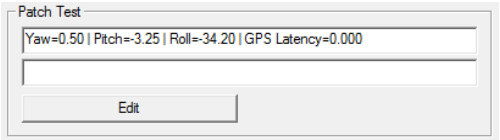
Once you have completed the patch test sequence using the medium adjustment steps, you will repeat the process a final time using the fine adjustment steps.

One thing to note is with each successive test you will notice the pattern in the Depth Error window of the patch test window begins to look less like a “V”. The most important thing to look at is to alignment the vertical objects as described above for each test . Change the adjustments using the “-Step -” or “Step +” buttons to align your profiles as close as the current step size will allow.

When running the tests using the fine steps, if you can’t line your profiles up as close as you’d like, you can “cheat” the test by manually entering the step size. Setting a smaller step size should allow you to align your profiles closer.



When you have completed your patch testing you can see the final results on the Devices tab of the Read Parameters box of MBMAX 64. Write these values in on HySweep Survey Setup Form. The next time you use this setup you can enter these values in Hypack Hardware at the beginning of the job.



Consider collecting new patch test data using these values to see if you can refine your multibeam setup even further.

Final Product Suggestions:

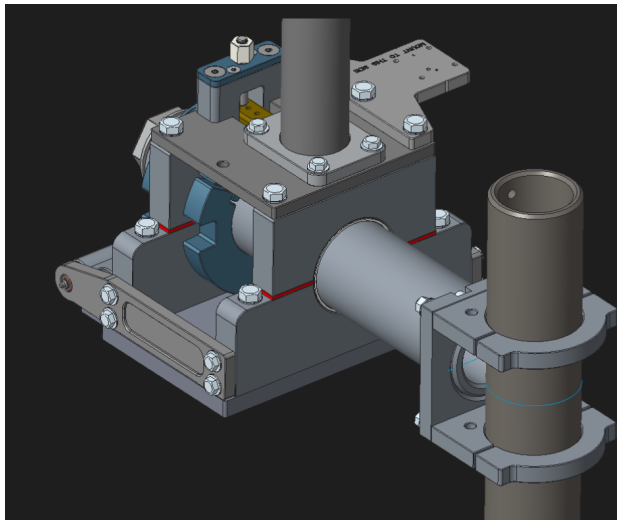
Save out .xyz:

- -Change matrix cell size in MBMax to whatever size you want your tin size.
- -Bring out 1 point per cell

If stitching together multibeam and static drops, export point cloud from HyPack, bring into Cloud Compare, QuickStitch, or Cyclone and stitch with static point cloud drops.

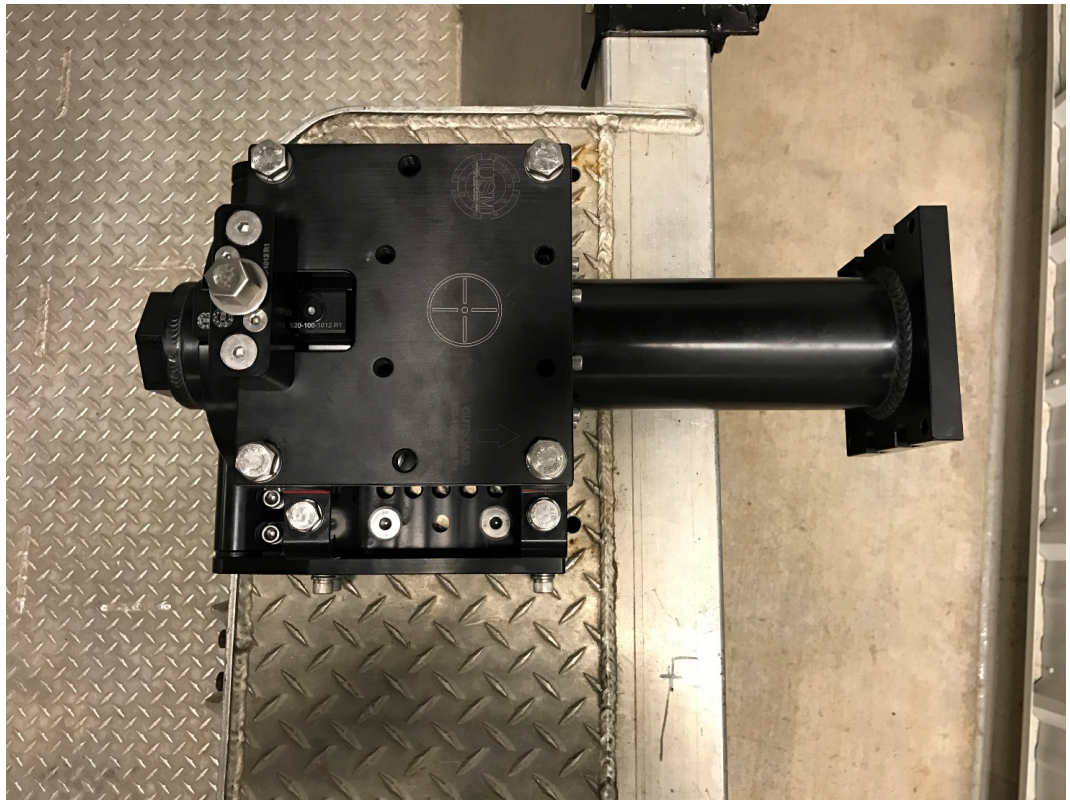
APPENDIX D: COMPACT UNIVERSAL SONAR MOUNT PRESENTATION

Compact Universal Sonar Mount



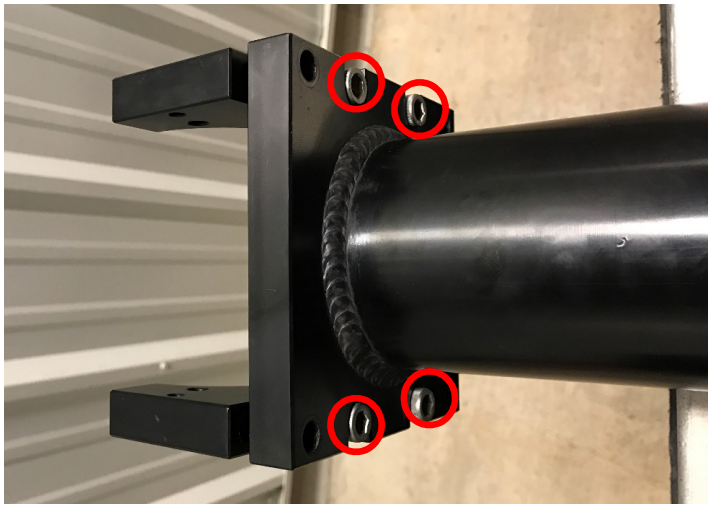
Deployment

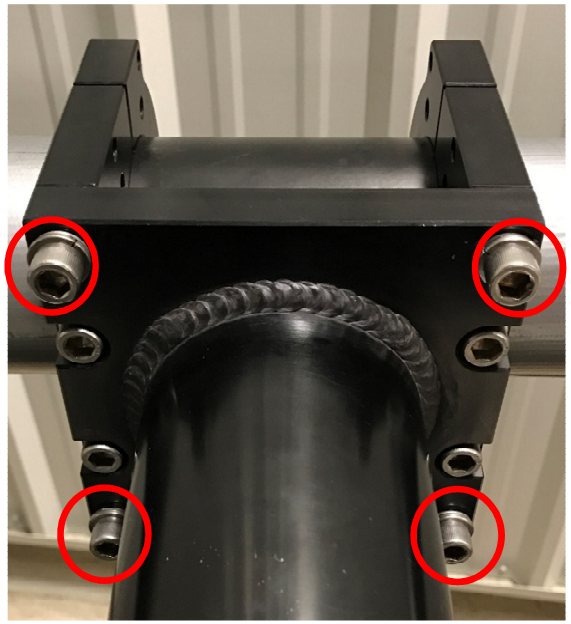
- Bracket should be laying flat as shown
- Arm should not be on
- Clamps that hold arm to mount should not be on



Attaching Arm

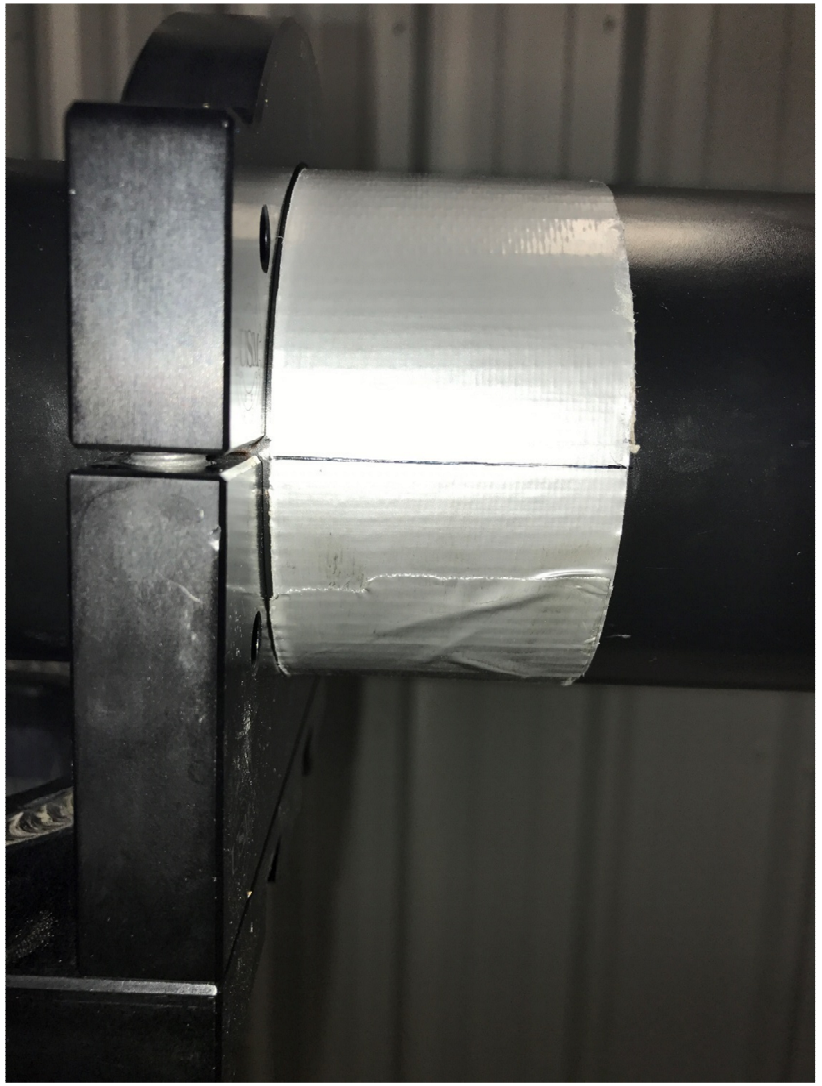
- Attach arm clamps to the end of the bracket using 5/16 hex and tighten the four screws
- Close the clamp by tightening four outside size 5/16 hex screws to attach the top of the clamp





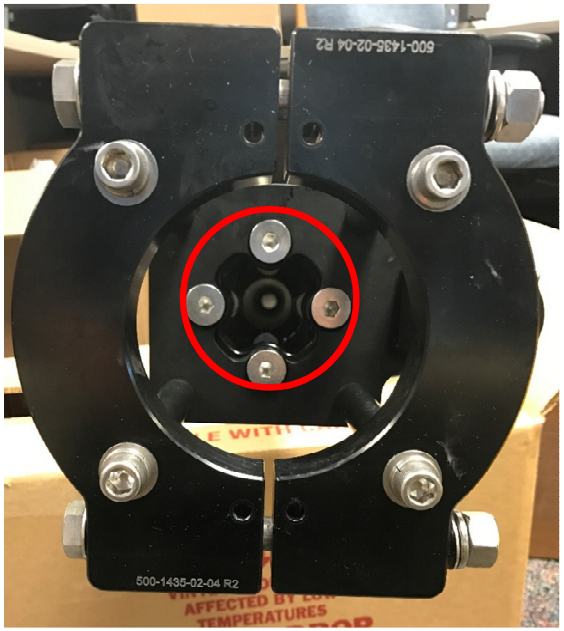
Adjusting Arm

- Move the arm so the tape lines up with each side of the bracket to get the correct length
- Twist the arm so black line, across the tape, lines up with the bottom of the opening in the clamps as shown

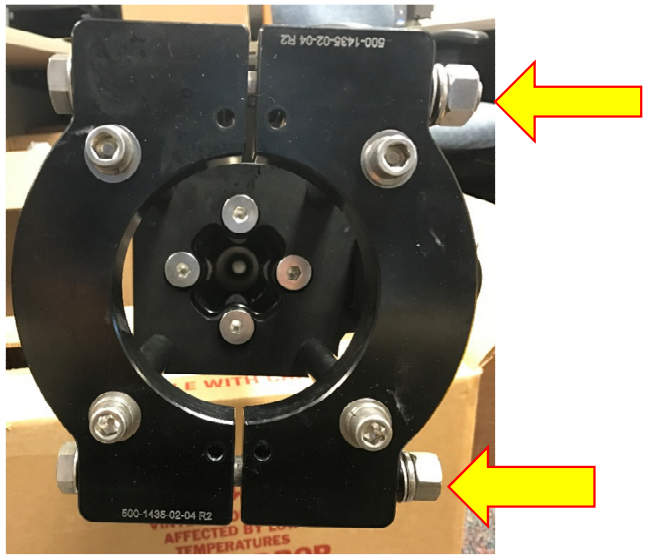


Attaching sonar mount

- Attach head with the external mount facing the boat
- Screw on four 5/16 hex screws as seen in the picture



Attaching Sonar Head



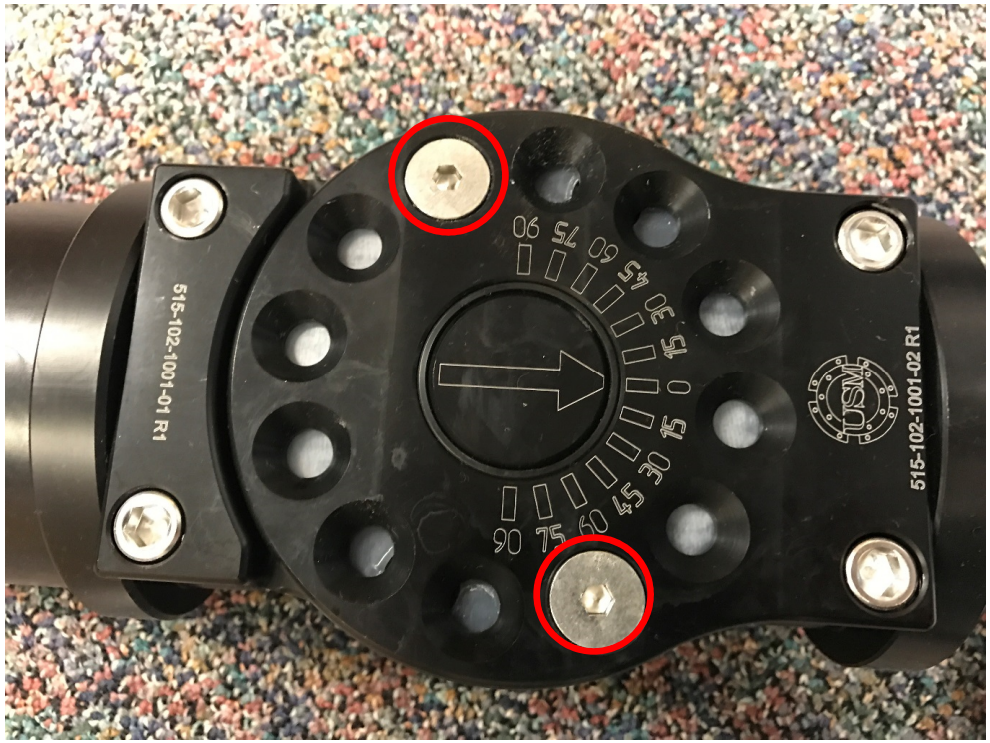
- Run sonar cable through the arm starting at the top
- Note: pulling it through the bottom can be difficult
- Put sonar head partially into mount and attached cable
- Push rest of the way in and line up marks to correct position
- Tighten ¾” bolts to secure device

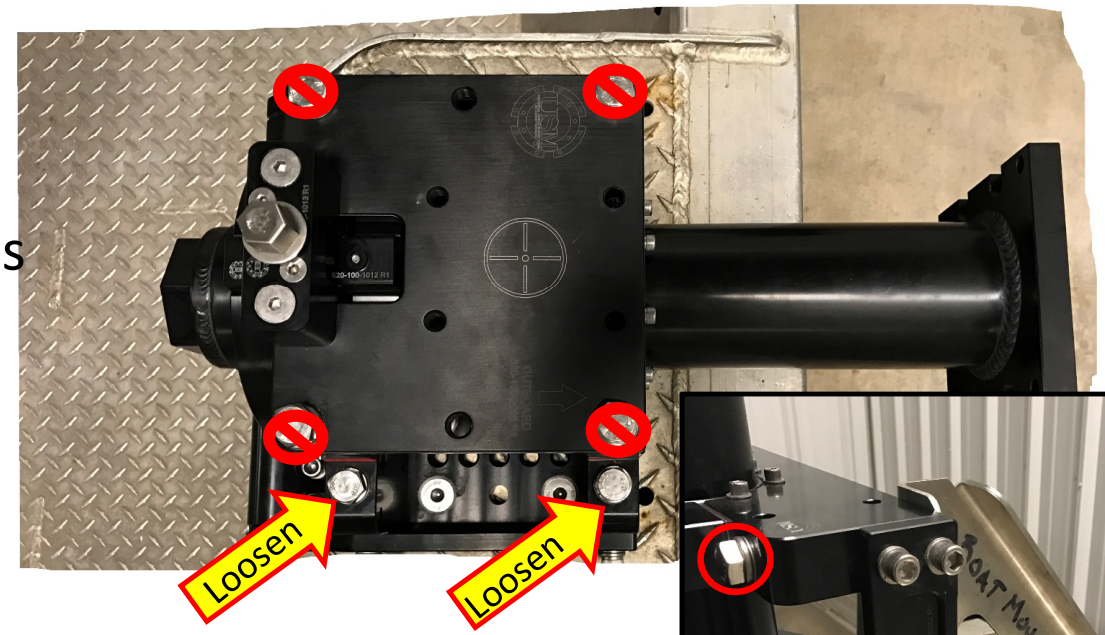
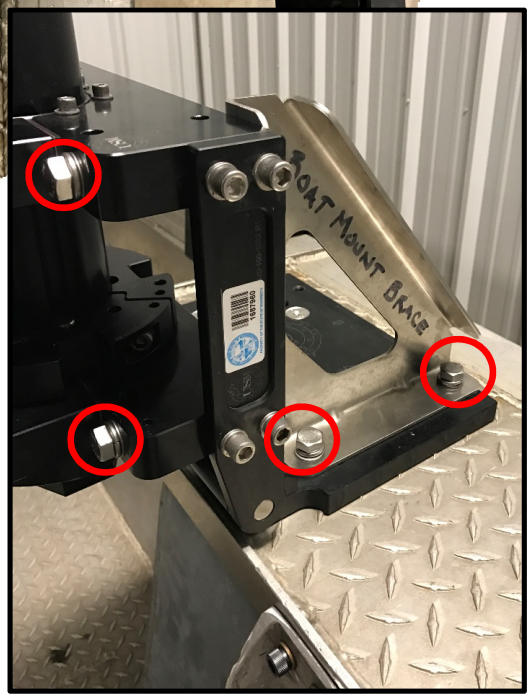
Lowering Sonar

- Attach the huge wrench to end of mount as shown
- Hold the mammoth wrench as a second person disengages shear block with a ¾” socket
- Use the ginormous wrench to rotate arm down
- Reengage shear block when arm is straight down in the water

Adjusting Sonar Angle

- Take out the four size 7/32 screws, two on top and two on bottom
- Note: If adjusting while on the water be careful not to **drop** the screws into the water
- Twist the head to desired angle as shown on the mounts side
- Reinsert screws



Using the Hinge

- Loosen four outer ¾” bolts as shown to the left (two on back side)
- Pull the mount up till its in desired position (may need two people)
- Make desired adjustments to mount or have the one person hold the mount while the second attaches the brace as shown in bottom left