Draft 1-5-2017

Multibeam Sonar Equipment Mounting Protocol

Aquatic Assessment Monitoring Team

January 2017

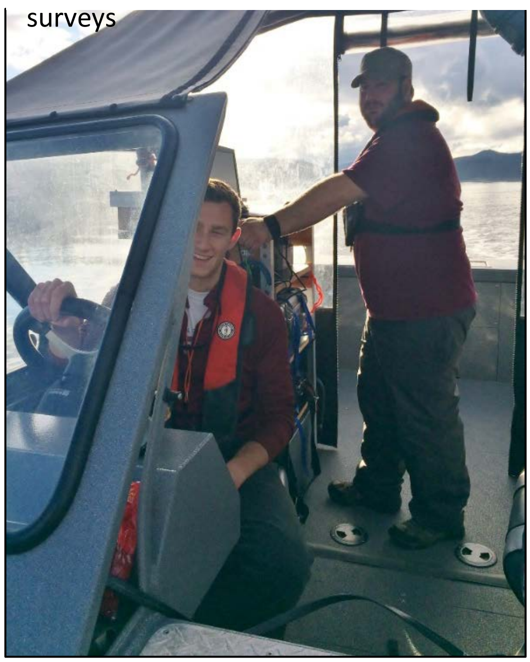
Contents

Introduction

The purpose of this protocol is to describe mounting procedures for the Washington State Department of Natural Resources (DNR) Multibeam Sonar (MBS) system. The MBS system is mounted to the Aquatic and Assessment Monitoring Team's (AAMT) Weldcraft Rebel 202 22ft research vessel. The research vessel is custom designed by AAMT scientists to conduct shallow water bathymetric and habitat surveys in fresh and saltwater environments throughout Washington State.

Conducting MBS surveys requires multiple pieces of hardware, software, computers, and electrical equipment; becoming familiar with the gear and best-use practices is essential to successful data collection. The document contains two sections, equipment descriptions and equipment mounting protocols. Section 1, equipment descriptions, familiarize staff with the main components of MBS equipment, documents the placement of equipment on the boat, and provides an inventory of equipment required for surveying. Section 2, equipment protocols, guides staff in mounting the MBS to the research vessel, preparing mounts for fieldworks, and maintaining the sonar equipment.

Figure 1. DNR staff (From left to right) Casey Pruitt and Andrew Ryan conducting surveys



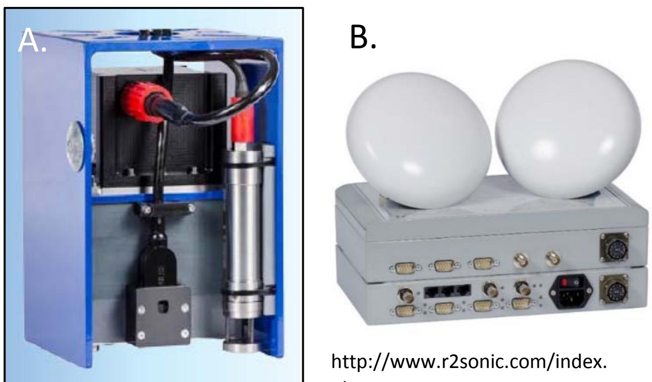
Section 1: Multibeam Sonar Equipment Descriptions

MBS description

The MBS system is a turnkey multibeam sonar sold by R2Sonic. The MBS integrates sonar and motion sensors into one unit. The system is comprised of an R2Sonic 2020 multibeam sonar transducer, an inertial measurement unit (IMU), an AML surface sound velocity probe (SVP), two GNSS antennas, an integrated IMU/MBS controller (SIM), and a Alien laptop (LPT) survey computer. A mounting frame secures the transducer, IMU, and SVP into one unite, creating a compact sonar capable of shallow water data collection. For system specifications, installing equipment and cabling see R2Sonic manual (link: https://www.seatronics-group.com/files/4214/1822/6193/R2_Sonic_2020_-_Manual.pdf).

When installing MBS equipment on a research vessel an offset is required to calculate distances between equipment and boat features. DNR conducted a total station offset survey on February 16, 2016. See appendix II for a description of the survey and offset values.

Figure 2. A. R2Sonic 2020 transducer, a POS MV and SVP mounted in frame. B. GNSS antennas and SIM

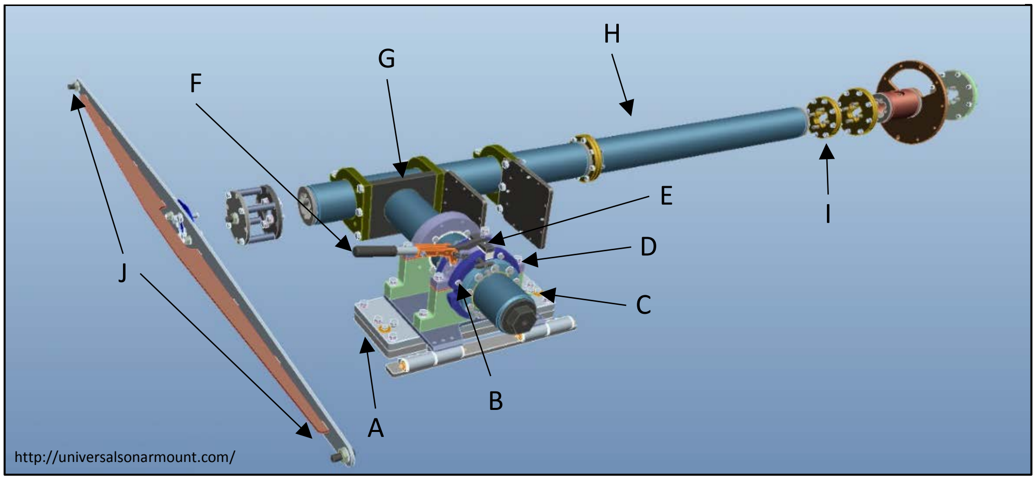


http://www.r2sonic.com/index.php

Universal Sonar mount:

The mount is sold as an off the shelf system designed to secure MBS equipment and GNSS antennas to survey vessels. The mount is comprised of multiple components, manufactured to tight tolerances that consistently place the MBS in the same survey position. Minimizing error in equipment positioning is necessary for collecting quality data. For information on USM, bolt sizes and torque specifications see Appendix I. For additional mount information see: http://universalsonarmount.com/.

Figure 3. USM: Components schematic



USM components description

A. *Welded sub-plate and base plate: Secured to the boat and base plate
B. Carriage bolts: Placed through base unit to prevent the pole from pivoting while in transit
C. *Hinge plate: Bolted to base plate at hinge, allows the mount to hinge into the boat
D. Base unit: Bolted to hinge plate. Holds X-pole in place
E. Breakaway block: Prevents pole from pivoting during surveying
    - If Z-pole or MBS head encounter a nearshore feature, the block breaks allowing Z-pole to move; minimizing damage on of sonar head.
F. Breakaway lever: Manually releases breakaway block so pole can pivot
G. X-pole: Connects Z-pole to Base unit
    - 23 inches long
H. Z-pole: Bolted to sonar mounting frame, held in place by X-pole via braces
    - 4” diameter pole, 60” long
    - Cables for MBS run down the center of the pole
I. Flange kit: Attaches Z-pole to R2Sonic sonar mounting frame
J. *GPS mount: Bolts to base unit, mounts GNSS receivers
K. *X-pole wrench: (Not shown) Moves Z-pole from transit to survey position
L. Indexing equipment for Z-pole: (Not shown) Secures Z-pole in the same position

*see figure 4 below for additional USM equipment details

Universal Sonar Mount (continued)

USM components description:

A. Welded sub plate: Welded to the boats gunnel and structural mount
B. Base plate: Bolted to the sub-plate
C. Hinge supports: Bolted to hinge and base plate
    - Used to support base plate when in transit position
D. Hinge plate: Bolted base by a hinge
E. Custom Z-pole support: Placed under Z-pole while in transits
F. Structural mount: Attaches USM mount to boat
    - Custom designed and welded
    - Made from 3” square aluminum tubing
    - Designed to stiffen the gunnel and disperse any load the USM puts on the boat
G. X pole support: Supports X-pole when mount is hinged
H. GNSS mount spanner bar: Bolted to mast, GNNS receivers are screwed into both ends
    - 2m wide
I. GNSS mount mast: Bolted to the base unit
    - 3ft long
J. X-pole wrench : Adjust Z-pole to transit and survey positions

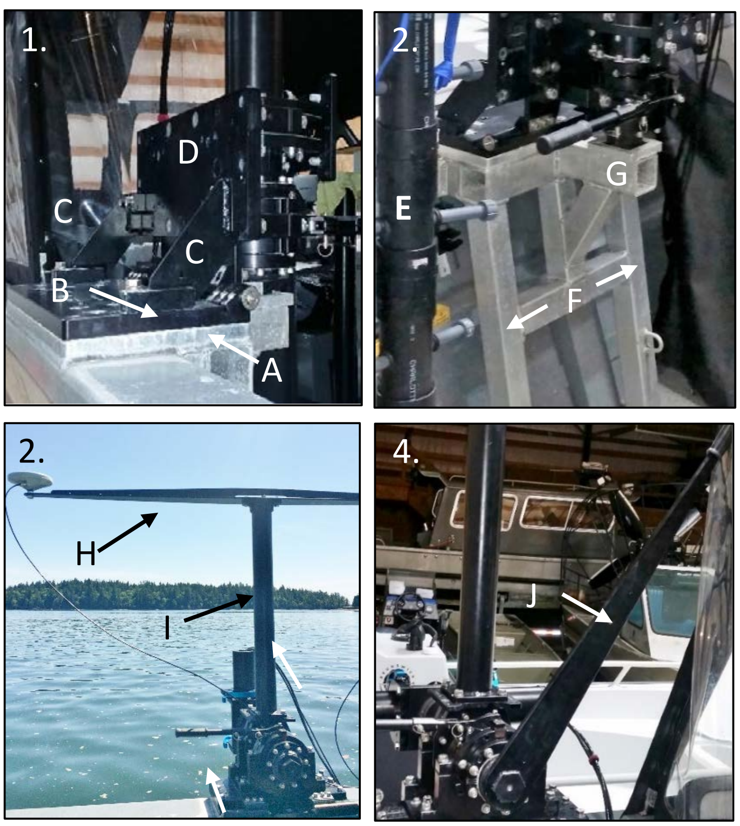
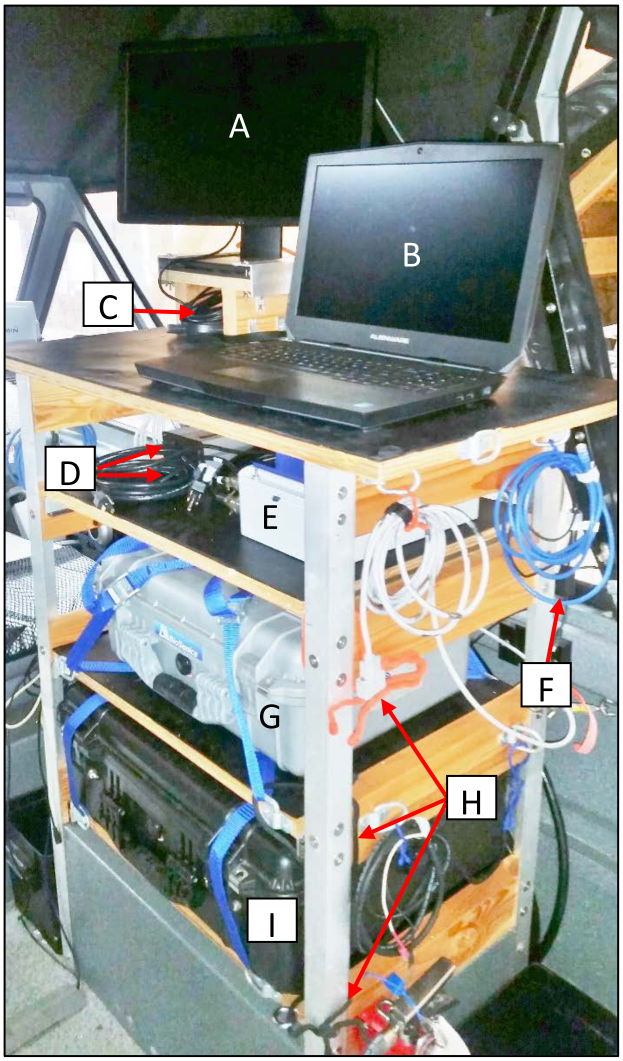


Figure 4. 1. & 2. Shows mount in transit position 3. GNSS mast and spreader bar in survey position 4. X-pole wrench in position for Z-pole adjustment

Equipment rack

The equipment rack is located behind the helmsman chair on the starboard side of the research vessel. It is constructed from 2" aluminum angle, plywood shelves (covered by neoprene), and shelve sliders. The rack is bolted to the boat's storage compartment and attached to the gunnel with tensioners. Rubber gear ties lock shelves in place and attached MBS and SBS cables used for surveying. The rack stores MBS, singlebeam and video electronics and cabling.

Figure 5. Electronics in position for MBS surveying. Equipment descriptions correlate to labels in picture.



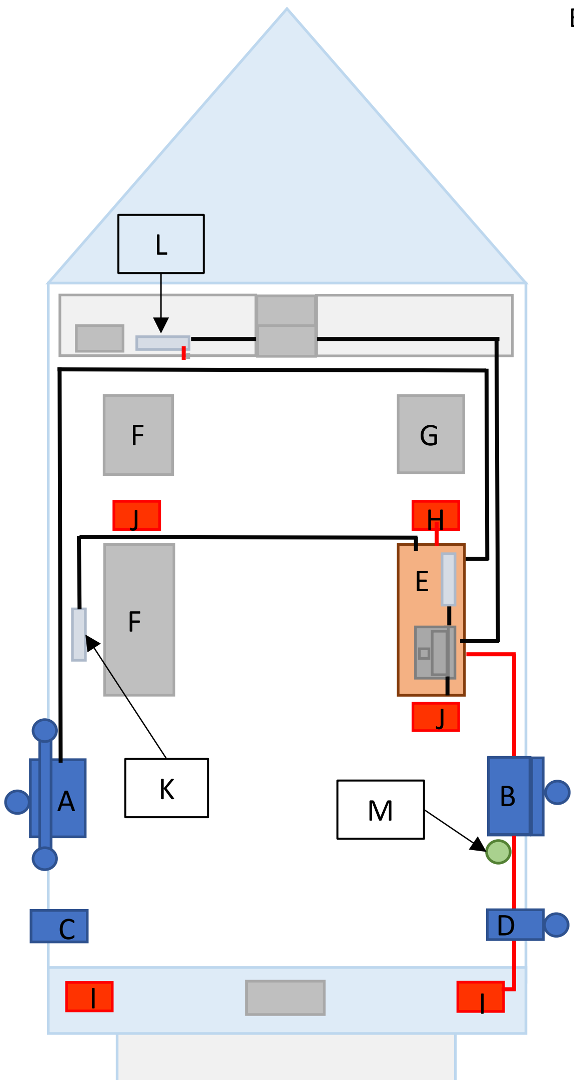
Equipment descriptions

A. Survey Monitor
B. LPT: Connects to SIM – Runs software and collects data
C. HDMI and mini HDMI cables: Connects survey and helmsman monitors to LPT during surveying
D. PSW inverter: Powers SIM
E. SIM: Controls transducer and motion sensor
F. Ethernet cable: Connects SIM to LPT – (additional cables in picture are used for singlebeam sonar (SBS) surveys. See SBS protocol for additional details.)
G. BioSonics surface unit: See SBS mounting protocol for details
H. Gear tie locks: Used to lock sliding shelves in place
I. SeaViewer video camera surface unit: See SBS mounting protocol for details
J. Boat storage compartment

<u>Multibeam sonar equipment schematic</u>

Boat schematics depict the placement of equipment on the Weldcraft Rebel 202 research vessel and the layout of wires used for communication and to power equipment.

Figure 6. MBS mounting schematic describes the placement of mounting and MBS equipment, and on board batteries.

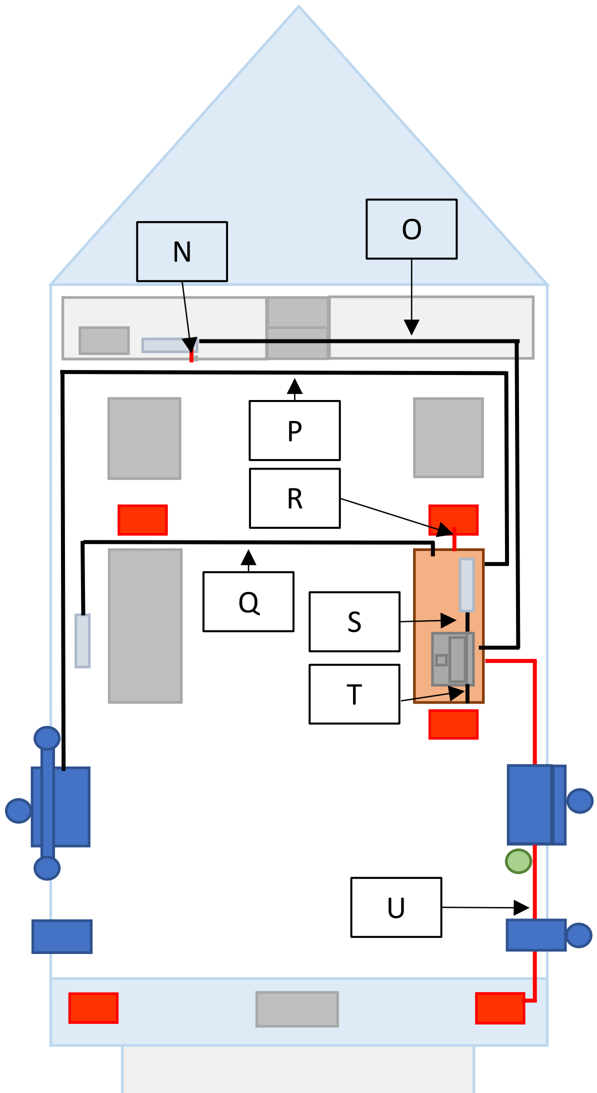


Equipment descriptions

A. MBS mounting frame, USM mount, Multibeam transducer, IMU, SVP, GNSS antennas, GPS mast and spanner bar
B. Singlebeam sonar mount, transducer, and GPS receiver: described in SBS mounting protocol
C. Downrigger mount
D. pH and YSI data sonde mount
E. Equipment rack: SIM, Alien LPT, survey monitor, and 400-watt PSW and standard inverters
F. Seating
G. Helmsman chair
H. Group 27 deep cycle marine battery
I. Group 27 deep cycle marine starting and house batteries
J. Group 24 deep cycle marine batteries: Used as back up batteries
K. Video camera monitor: described in SBS mounting protocol
L. Helmsman/navigation monitor
M. Sontek CastAway CTD probe, 100ft rope, 5lb weight, 5-gallon bucket

Equipment schematic (continued)

Figure 6. (continued): MBS mounting schematic describes wire placement and connections to equipment. Communication wires are colored black and electrical wires are colored red.

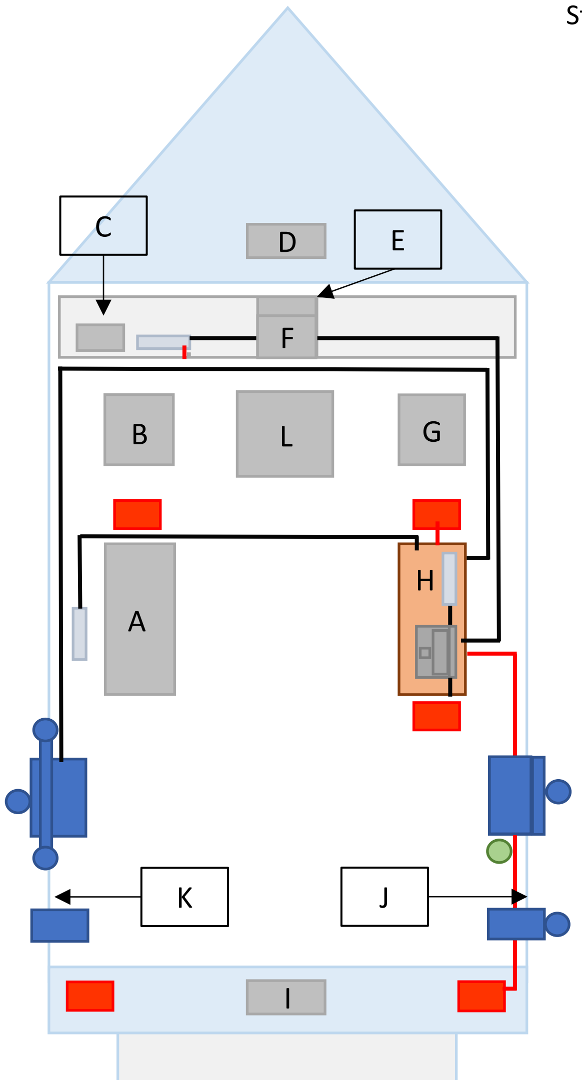


Wiring descriptions

N. USB to M Barrel 5v DC power cable: Connects to USB power port - Powers helmsman monitor
O. HDMI cable: Connects LPT to Helmsman monitor
P. Multibeam transducer deck cable, IMU cable, SVP cable, GNSS cables: Connects SIM to survey equipment
Q. Video RCA and power cables: Connects SeaViewer surface unit to video monitor (described in singlebeam/video mounting protocol)
R. Electrical cable: Connects group 27 battery to standard inverter - Powers LPT and survey monitor
S. Mini HDMI cable: Connects LPT to survey monitor
T. Ethernet cable: Connects SIM to LPT
U. Electrical cable: Connects house battery to PSW inverter - Powers SIM

Boat storage schematic

Figure 7. MBS boat storage and contents



Storage contents

A. Safety/Cleaning: First aid, Horn, flares, cleaning supplies, spot light, pens pencils, oil sponges
B. Electrical storage: battery charger, back up inverters, power strip
C. Inverter storage
D. Danforth anchor and rope
E. Life jackets
F. Tools and Bolts for the MBS/USM mount, Spare rope and webbing. Fire extinguisher #1 is next to compartment
G. Back up audio/visual cables
H. Storage under bottom shelf: stores manuals, fire extinguisher # 2 mounted to aft side of shelf
I. Spare ropes, buoys, mushroom anchor, MBS and SBS dry bag covers
J. Gunnel storage: Paddle and removable stern safety light
K. Gunnel storage: USM x-wrench, paddle
L. Tool set, Spare bolts, large wrenches, torque wrench

Equipment inventory

The research vessel integrates multiple pieces of hardware and electronics. Each component of the system is necessary to completing a successful survey. The following list the equipment used for MBS surveys. The list is complete as of 12/2016.

Table 1: Inventory of SBS equipment used on the AAMT 20ft Weldcraft Rebel202 research vessel to conduct MBS surveys. Figure 6 labels are correlated to labels in the mounting schematics on pg. 6. The quantity refers to the number of pieces of equipment needed to conduct surveys.

Figure 6 labels	Multibeam Equipment Inventory	Quantity
	Multibeam head	
A	R2Sonic 2020 wideband multibeam head receiver/projector, 200-400 kHz, 2°	1
M	15m multibeam head deck cable	1
A	Surface sound velocity probe (SVP): AML Micro.X SV probe	1
M	SVP: 15m cable	1
	R2Sonic Integrated Inertial Navigation System (INS):	
E	Modified sonar interface module (SIM)	1
A	Inertial Measurement Unit (IMU), type 42b	1
A	GNSS antennas	2
M	GNSS antenna cables, 8m	2
M	IMU Cable, 15m	1
O	Power cable	1
	Water column profiler	
J	Sontek CastAway CTD probe	1
J	100ft Rope for water column profiler	1
J	5lb weight	1
J	5-gallon bucket	1
	Software	
Alien LPT	Sonic 20xx Operator Control Program DLL	1
Alien LPT	Applanix POSView software	1
Alien LPT	QPS Quincey software (dongle needed)	1
Alien LPT	CastAway CTD software	1
	Mounting equipment	
A	R2Sonic Multibeam Mounting Frame	1
A	Universal sonar mount (USM), 60" pole, hinged platform	1
A	GPS antenna Mast 3' with Dual GPS spreader bar 2m	1
A	X pole wrench	1

Table 1: Continued

Figure 6 labels	Equipment inventory	Quantity
	Computer/monitors	
E	Alien Laptop (LPT), 17" w/ accessories (2TB backup hard drive (BHD), 4 port USB hub, and two wireless mice (helmsman and surveyor))	1
Q	6FT Ethernet cable	1
H.1	Helmsman/navigation monitor	1
L	20ft HDMI cable	1
E	Survey monitor	1
P	6ft mini HDMI cable	1
	Power	
G and G.1	Group 27 deep cycle marine battery	3
J and J.1	Electrical wire 6 gauge	2
G.2	Group 24 deep cycle marine battery	2
E	400w pure sine wave (PSW) DC to AC inverter	1
E	400w DC to AC inverter	1
K	3ft USB to type M Barrel 5v DC power cable	1
	Transport Bags (to and from office)	
N/A	Pelican 1495 waterproof laptop case (For transport of LPT)	1
N/A	Lowepro backpack (for transport of 2TB BHD, 4 port USB hub, wireless mice, GNSS antennas, and LPT charging block)	1

Section 2: Multibeam Sonar Equipment Mounting/Fieldwork Protocol

Equipment transport to and from boat

Equipment listed below is transported to the boat ramp and on the boat when preparing for a field survey and returned to the office or Blue Mountain after surveys.

Equipment stored at DNR Natural Resources building

- Pelican 1495 waterproof laptop case: stores a protects Alien LPT
  - Code for locking mechanism is 042
- Lowepro backpack: stores 2TB back up hard drive, 4 port USB hub, wireless mice, GNSS antennas, and LPT charging block
  - Data is transferred off hard drive, in the office, after surveys

Equipment stored at Blue Mountain

- Water column profile equipment: Sontek CastAway CTD probe, 5 gallon bucket, 100ft rope, 5lb weight
  - Weight attaches to the bottom of the CastAway
- Deep cycle marine batteries: One Group 27 battery and two Group 24 batteries
  - Connect batteries to smart chargers after each survey day
  - If conducting surveys with overnight travel use smart chargers stored on the boat to charge batteries

Figure 8: Equipment stored at DNR headquarters

On-the-road transit

Describes the steps required to position the USM mount for on-the-road transit (also left in this position for storage). See mount description section (pg. 3 & 4) for the descriptions of USM components. Required tools and bolts are inside two tool cases stored in compartment F. Dry bag is located in compartment I (see storage and safety equipment schematic for storage location pg. 8).

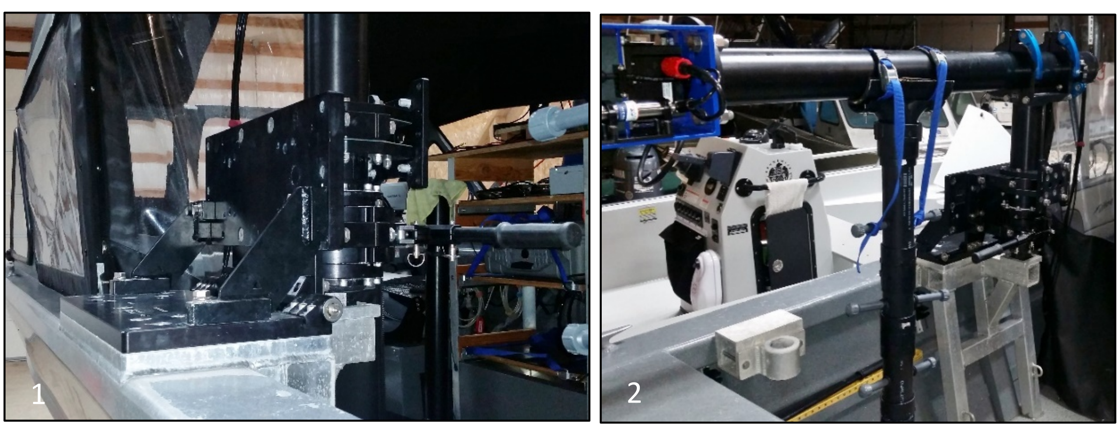
Tools:

- ¾" ratchet wrench
- 4 - ¾ " hex bolts

Protocol:

1. Bolt hinge supports to base plate and hinge plate using a ¾" wrench
    a. L shaped portion of bracket should be butted to the hinge plate (figure 9. 1)
2. Use a 55 LTR SeaLine dry sack to cover MBS assembly (not shown)
    a. Secure the bag with Velcro straps
    b. Sonar head must be protected from ultraviolet light
3. Install Z-pole support
    a. Place under pole and strap tie downs around pole(figure 9. 2)
    b. Twist gray levers counter clockwise to expand pole
    c. Expand the pole until it is secured against the floor
        i. Support should be level, vertically
4. Make sure MBS equipment and accessories are safely stored in boat or vehicle during transit

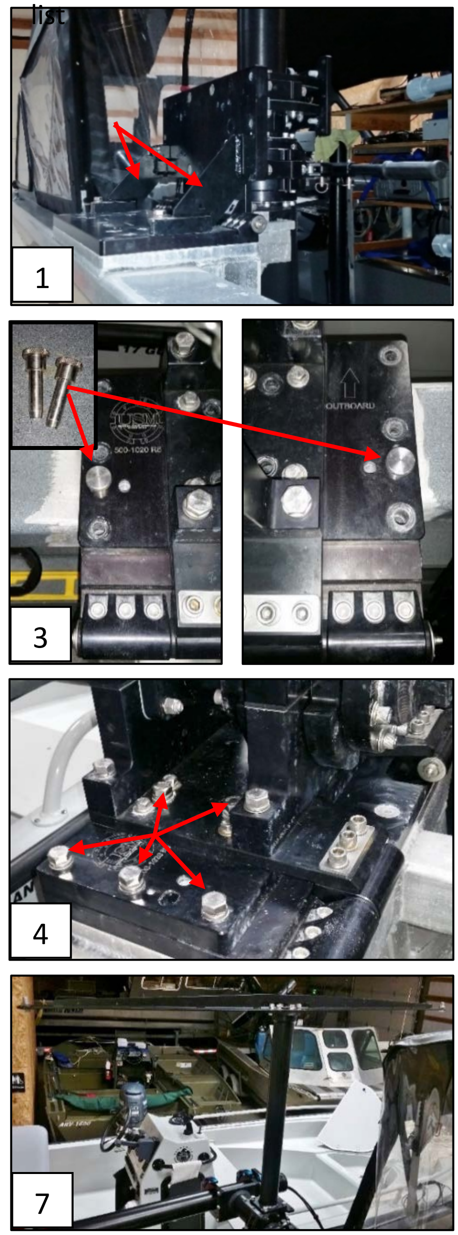
Figure 9: 1. USM in transit position 2. Z-pole support in place



On-the-water transit

Protocol describes the steps required to prepare the USM mount for on-the-water transit. Mount preparation is conducted, before the boat is placed on-the-water, at a boat ramp' set up area. See mount description section (pg. 3 & 4) for the descriptions of USM components. Required tools and bolts are inside two tool cases stored in compartment F (see storage and safety equipment schematic for storage location pg. 8).

Figure 10: USM mounting numbers correspond to protocol list



Tools:

- ¾" ratchet wrench
- USM set pins
- 6 - ¾ " bolts

Base unit:

1. Remove 4 hinge support bolts (red arrows) using ¾" wrench
2. Lower the hinge plate onto base plate
    a. 1-3 people will be need to lower mount
3. Place set pins (red arrows) in alignment slots
4. Ratchet ¾" bolts into open holes on hinge plate (red arrows), five on each side of mount
    a. Can reuse the 4s bolt removed from hinge supports
5. Remove set pins and return the tool case
6. Keep carriage bolts in place during transit

GPS Mast:

1. Remove bolts (4) from base plate GPS mount using ¾" wrench
2. Put mount in place
    a. Make sure arrow on the bottom of spreader bar is facing forward
3. Bolt down GPS mast using ¾" wrench
4. Attach GNSS antennas to spanner bar
    a. Antennas are labeled GNSS 1 and 2
    b. Screw on GNSS 1 antenna to the front position
    c. Screw GNSS 2 to the rear
5. Attach GNSS cables
    a. Wrap cables around mast to take up any cable slack
    b. Be careful not to crease cables

Fieldwork preparation

Protocol describes how to prepare the mount and equipment for data collection. To conduct surveys the USM pole will need to be put in position, and wiring will need to be connected to electronics. See MBS equipment schematic (pg. 6) for a visual reference.

Tools:

- X-pole wrench

USM protocol

1. Position X-pole wrench as shown in In Figure 11 (blue arrows)
2. Lift breakaway lever (orange arrow) to unseat breakaway block
    a. Lifting breakaway lever will all z pole to move freely
    b. Make sure someone is supporting the x- pole wrench and the z pole
3. Slowly lower the z pole into the water
4. Replace breakaway block by aligning slots on base unit and pushing breakaway lever back to original position
5. MBS unit is now ready for surveying

Electronics

1. Connect ethernet cable, HDMI cable, mini HDMI cable, 4 port USB hub, and back up hard drive to LPT
2. Plug in SIM to PSW inverter
3. Plug in survey monitor to standard inverter
4. When the battery runs low, plug in LPT to standard inverter (about 2hrs after survey begins)
    a. LPT only gets charged when battery is low
5. Plug in helmsman monitor to USB port
6. Connect HDMI cable to helmsman monitor

Figure 11: USM mounting X-pole in position to lower Z-pole in water

Mount removal

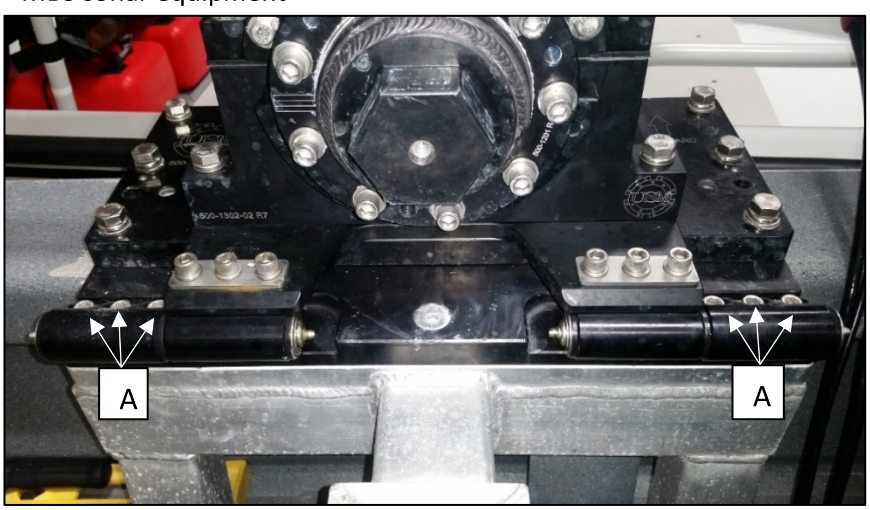
Protocol describes how to remove the hinge plate, base unit, Z and X-pole, and the MBS equipment from the base plate and structural support. The research vessel is used for multiple AAMT projects, some involving multiple pieces of heavy equipment or more personnel than should be transported with the mount in place. Removal of USM may be necessary if field gear weighs more than 300lbs or if more than three people are being transported. Removal is also advised when USM gear could get in the way of other fieldwork equipment or if the boat is scheduled for multiple consecutive days on other projects.

Tools: Allen Wrench, torque wrench, Allen bolts
Note: 2-3 people will be need to remove the USM and MBS sonar. The equipment weighs about 100lbs

Removal

1. Disconnect multibeam transducer, IMU, SVP, and GNSS cables from SIM.
    a. Open cable cover (located at the front of cabin)
    b. Remove cables from cover
    c. Coil cables and place them in an easily accessible area near USM
2. If necessary, remove hinge supports so that hinge plate is resting on base plate
3. Use the Allen wrench to remove the six hinge screws from the base plate (figure 12. A)
    a. Make sure at least two people are supporting the z and x pole while bolts are being removed
4. Transport hinge plate, base unit, z and x pole, and the MBS equipment/cables
    a. Place the mount in a safe temperature controlled room for storage
    b. No further disassembly of equipment is required
    c. If there is any corrosion on cables use DeoxIT spray and a brush to clean cables

Figure 12. Arrows point to bolts used to remove/mount USM and MBS sonar equipment



Mount installation

Mounting

1. Check that screws on baseplate are properly torqued with torque wrench
    a. Screws should be torqued to 45lbs
2. Move Hinge plate, base unit, Z and X-pole, and MBS equipment from storage to boat
    a. Make sure at least two people are supporting the Z and X-pole while equipment is being installed
3. Align hinge plate to base plate threads
    a. Make sure at least two people are supporting the Z and X-pole while equipment is being aligned
    b. Place hinge plate flush against base plate
    c. Place set pins in alignment slots (as in step 3 of the on-the-water transit protocol pg. 13)
    d. Ratchet ¾" bolts into open holes on hinge plate (as in step 4 of the on-the-water transit protocol)
    e. Place Allen head bolt in hinge plate openings
        i. Use Allen head bolts and Allen wrench to tighten bolts (figure 12. A)
        ii. If needed, use anti seize grease on bolt threads
4. Check all bolts on Base plate, make sure they are properly torqued
    a. See, appendix I, figure 14 for torque specifications
5. Run cables through cover at front of boat
6. Connect cables based on labels on the cables and SIM
    a. Reference R2Sonic Manual for instructions if (see pg. 2 for link)
    b. If there is any corrosion on cable use DeoxIT spray and a brush to clean and lube cables

Equipment maintenance

MBS maintenance includes all systems used for surveying it does not include boat or computer maintenance.

MBS:

- Clean with freshwater after each survey.
  - Cleaning is generally conducted during boat cleaning
  - Cleaning requires removing base plate supports and lowering the base unit onto the base plate
  - If being stored outside cover transducer with dry bag
  - If being stored inside leave dry bag off
- Wash quarterly with Salt-Away soap
- Cover MBS head when outside to protect it from UV
  - Exposure to UV voids the warranty

USM

- Clean and use Salt-Away same as MBS
- Check that all bolt are properly torqued
- Grease hinge fitting quarterly
  - Hinge has a Zerk grease port fitting
  - Use grease gun and marine grease

Cables

- Sprayed quarterly (more frequent during heavy field use) with DeoxIT contact cleaner and scrubbed with a soft bristle brush (tooth brush)
- Check O-rings on cables connecting the sonar head, IMU, and SVP (and any other cable frequently submerged) for damage
  - Lube O rings with silicon grease if needed

Batteries

- Keep marine batteries on a smart charger when not in use

Sontek CastAway CTD probe

- Rinse probe in freshwater after each survey
- Unscrew cap on probe to Remove batteries
  - store batteries in case when not in use
  - Check o rings for damage
- Needs to be calibrated by the manufacturer every spring

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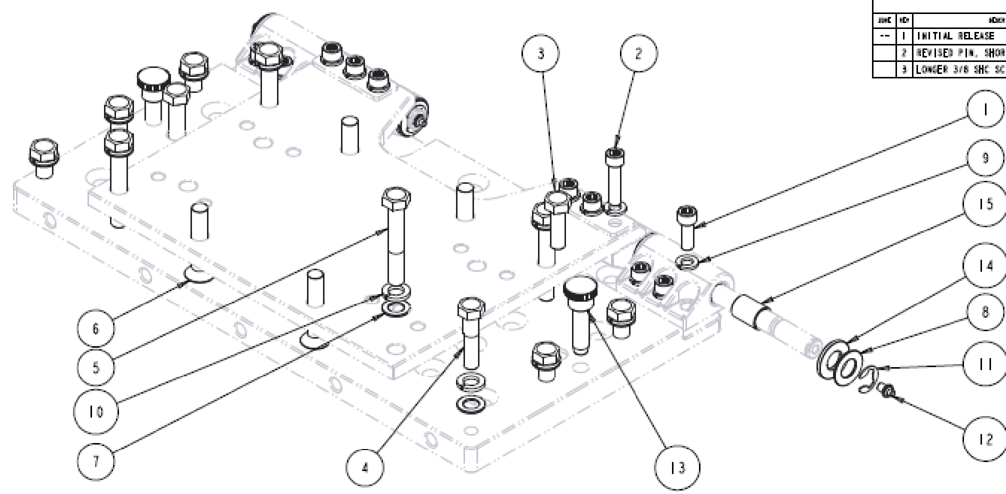
Appendix 1

Universal Sonar Mount bolt and torque specifications

Figure 13. USM bolt Specs and washer specifications

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
--	1	INITIAL RELEASE	02012-JUN-14	- -
	2	REVISED PIN, SHORTER BUSHINGS	02012-SEP-27	
	3	LONGER 3/8 SHC SCREWS	02014-NOV-13	



ITEM NO.	QTY REQD.	PART NO.	DRAWING TITLE OR DESCRIPTION	MANUFACTURER	MFG PART NO.
17	1	502-4002-CFG-04	PLASTIC BOX, 10 7/8 X 6 7/8 X 1 7/8 , 500-9040 RBI	MCMASTER	4629T69
16	2	500-1043	USM, HINGE MOUNT WASHER PLATE	FAB	---
15	12	500-1042	BUSHING, PTFE, 5/8 X 3/4X 2.950 LONG	FAB	---
14	6	500-1038	USM, HINGE WASHER, 1.275 OD X .630 ID X .125 TH	FAB	---
13	2	500-1023	BASE PLATE PIN, USM	FAB	---
12	4	94-350-250P-01-23	GREASE FITTING, STRAIGHT, 1/4 IN PRESS FIT, SST	MCMASTER	2304K22
11	4	90-355-485-042-20	E-CLIP, .625 SHAFT, .485 GROOVE, .042 W, SST	MCMASTER	98408A140
10	10	90-310-510-870-120-20	WASHER, SPLIT LOCK .510 ID X .87 OD X .120TK, 18-8 SST	MCMASTER	92146A033
9	12	90-310-380-680-090-21	WASHER, SPLIT LOCK .380 ID X 68 OD X .090TK, 316 SST	MCMASTER	92147A031
8	4	90-300-640-1190-060-20	WASHER, .640" ID X 1.19" OD X .060" TH, 300 SST	MCMASTER	98017A215
7	10	90-300-515-875-060-20	WASHER, .515 ID X .875 OD X .060 18-8	MCMASTER	98017A210
6	4	90-110-500C-2500-20	SCREW, 1/2-13 UNC X 2.5 FHC 18-8	MCMASTER	92210A722
5	4	90-104-500C-3000-20	HEX BOLT, 1/2-13 X 3.000 SST 18-8	MCMASTER	92198A724
4	6	90-104-500C-2000-20	HEX BOLT, 1/2-13 X 2.000 SST 18-8	MCMASTER	92198A720
3	2	90-104-500C-1500-20	HEX BOLT, 1/2-13 X 1.500 SST 18-8	MCMASTER	92240A715
2	6	90-100-375C-1500-20	SCREW, 3/8-16 X 1.50 SHC 18-8	MCMASTER	92196A628
1	6	90-100-375C-1000-20	SCREW, 3/8-16 X 1.00 SHC 18-8	MCMASTER	92196A624

UNIVERSAL SONAR MOUNT

KIT, USM HINGE W/ EXTENSION, REBUILD

C --- 500-9040-RBI 3

SCALE 0.500 SHEET 1 OF 2

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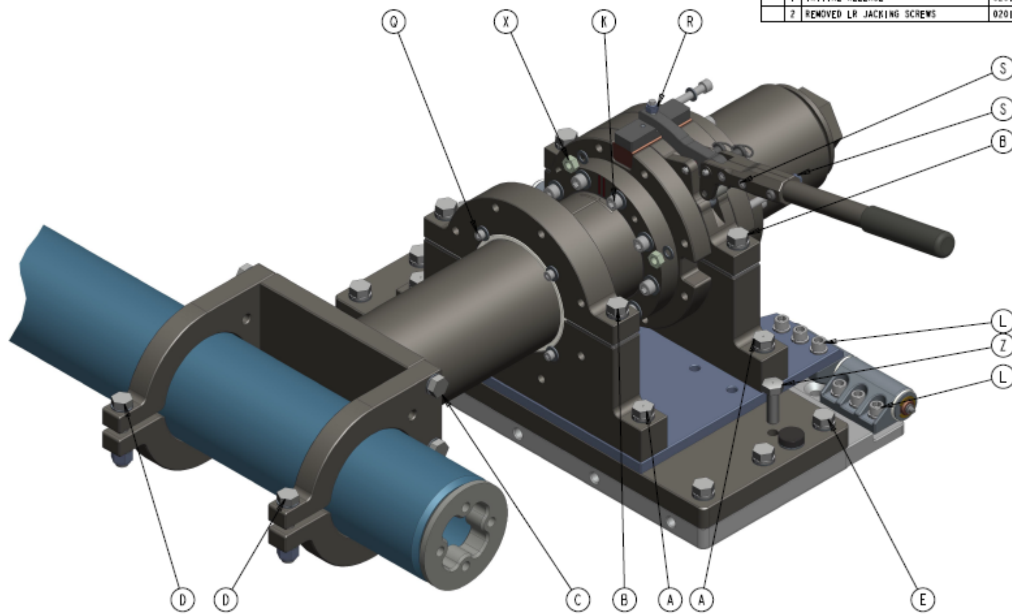
Figure 14. USM bolt Specs and washer specifications

	REVISIONS			
ZONE	REV	DESCRIPTION	DATE	APPROVED
--	1	INITIAL RELEASE	02012-FEB-23	- -
	2	REMOVED LR JACKING SCREWS	02012-MAR-01	



ITEM	QTY	TORQUE	SIZE	NOTES
Z	2	10 FT-LBS	1/2-13 UNC	JACKING SCREW
Y	4	10 FT-LBS	5/16-18 UNC	FOR SETUP ONLY, REMOVE BEFORE USE
S	3	10 FT-LBS	1/4-20 UNC	
R	1	SEE NOTE	1/4-20 UNC	LEAVE .03" OF CLEARANCE UNDER BASE OF NUT
Q	4	10 FT-LBS	1/4-20 UNC	
L	12	25 FT-LBS	3/8-16 UNC	
K	18	35 FT-LBS	3/8-16 UNC	TIGHTEN IN STAR PATTERN (10-20-25-35 FT-LBS)
E	6	45 FT-LBS	1/2-13 UNC	
D	2	45 FT-LBS	1/2-13 UNC	
C	6	45 FT-LBS	1/2-13 UNC	
B	4	45 FT-LBS	1/2-13 UNC	
A	4	45 FT-LBS	1/2-13 UNC	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.	PRO/E REPORTED PARAMETERS	DESIGNER: REASON BRADLEY		INERTIA LABS		
TOLERANCES ARE: .X +/- 0.1	PRO/E MATERIAL: N/A	ENGINEER: G STAPLES	02012-FEB-23	USM, MOUNT, TORQUE SPEC		
.XX +/- 0.01	PRO/E MASS: 200.783	DRAFTER: G STAPLES	02012-FEB-23	SIZE: C	CUSTOMER DRAWING/PART NO.: ---	REV: 2
.XXX +/- 0.001 ANGLES +/- 0.5	PRO/E VOLUME: N/A	CHECKED: ---	02012-FEB-23		DRAWING/PART NO.: 500-9001-04	
INTERPRET DIMENSIONS PER ASME Y14.5M 1994 (R2004)	PRO/E DRAWING FILE NAME: 500-9001-TORQUE	DO NOT SCALE DRAWING		SCALE 0.400	SHEET 1 OF 2	

Appendix II

Weldcraft Multibeam Sonar System Instrument Survey Report

Andrew Ryan
Survey Date 16 February 2016
Report Date 8 March 2016

Project Background and Goals

In 2015, the Washington State Department of Natural Resources (DNR) began to develop a high-precision bathymetry data collection program. The goals of this program are to:

- Set up and operate a top-of-the-line multibeam sonar system that can be quickly deployed to DNR areas of interest.
- Accurately map bathymetric depths and features in nearshore areas that are not usually mapped by Federal Agencies and others (National Oceanic and Atmospheric Administration, Army Corps of Engineers). Usually shallow of the minus four meter contour line.
- Improve the modeled contour lines the DNR uses for program planning using more accurate depth data.
- Develop habitat mapping capabilities for ecological research and monitoring.

In order to produce the accuracy of data needed to meet these goals, the software that is used to calculate depth values needs accurately measured distances between each instrument in the sonar system. DNR surveyors from the Tumwater land survey crew were used to perform these high-accuracy measurements. Surveyors Jake Edminster and John Linzee, with support and direction from Andrew Ryan and Cinde Donoghue (DNR aquatics GIS and AAMT units respectively) performed the survey on 16 February 2016 at the DNR Tumwater Compound.

Pre-survey Procedures and Center of Rotation Determination

Because the Inertial Motion Unit (IMU) sensor is not located at the center of gravity (COG) of the vessel, software calculations require an accurate distance from the position of the IMU to the COG. This distance affects the ability to differentiate heave (direct upward motion) from roll (lifting due to the boat spinning around the COG. To find this point Casey Pruitt, Peter Markos, Bart Christiaen, and Andrew Ryan performed on-the-water measurements at Swantown Marina on February 3rd and 4th 2016.

In order to mimic future survey conditions on the boat, all survey equipment, computer equipment, personnel and safety gear were placed on the boat in the position they will be in during active surveying. Fuel level was set to 3\4 full to reflect average condition. Some equipment substitutions had to be made due to system incompleteness at the time of measure. The equipment shelves were not yet constructed, so equipment boxes (pelican cases) and two extra 12 volt car batteries were placed on the starboard side of the boat where the equipment shelves are to be mounted (~80-90 pounds). The full R2Sonic mount and system were deployed off of the port gunwale, and the biosonic system was deployed off of the starboard gunwale using the new mount recently constructed by Zigler's welding, Olympia.

The boat was held at dock, with a driver in the pilot seat and an equipment technician standing at the computer stand. Black tape had been applied to the side of the boat to allow for marking the water line with a sharp knife. A fourth person stood first on the bow of the boat, and then the engine bracket. Water lines were carved into the tape at these two different pitches, with the resulting line intersection

representing the Fore, and height location of the center of rotation. Due to the difference in weight between the port and starboard sides of the boat, the COG point was further aft on the port side than the starboard. To get the 3 dimensional position of the COG point, a third axis was determined by rocking the boat side to side and driving the boat in tight turns to cause rotation about the center line. Professional judgement was used to determine the pivot point of the roll. All three DNR personnel independently chose their estimate of this axis, and an average position was decided upon.
The Water Line of the boat at a natural/neutral position was also determined in order to level the boat to the ground for the equipment survey. In this procedure, all equipment from the COG was left aboard and in the same location, and the two staff members stayed in the same place. A new line was drawn on the boat at three locations marking where the water was on the hull using a china pencil. One mark at each aft corner, and near the bow.

Survey Network Set-up and Equipment Preparation

The equipment survey was performed at the DNR Tumwater Compound. In the South West area of the facility (behind the fire cache building). A control network was established, consisting of 4 stations placed in the shape of a square; one station at each corner of the boat. This way each instrument on the boat could be measured from at least two different stations. The three control points on the boat could also be measured from 2-3 different stations. The boat was leveled to the ground using the neutral water line marks established during the COG measuring. A total station was used to level the aft corners of the boat, with automotive jacks raising the trailer and boat into alignment. The bow was then leveled using the water line from the total station, and the jack on the trailer was used to make height adjustments.
The entire R2Sonic 2020 system was deployed in its final location on the Universal Sonar Mount (USM). The multibeam and IMU were placed in the blue mounting frame from R2Sonic, and the GNSS antennas were placed on the USM antenna mast. For one set of measurements, the USM “Z pole” was lowered 10 centimeters (to the next higher indexed hole) to get positions of the instruments at this deeper depth. By taking deeper measurements, we have values available if conditions cause extra noisy data due to non-laminar flow of water around the multibeam and the pole needs to be lowered.

Field Measurements and Calculated Values

Three control stations on the boat were created using a small round tap. Each station is able to be measured from at least two angles, and serve as monuments for any future surveys that may need be done. Station “A” is located a few millimeters aft of the bow, on the top of the deck. “B” station is near the starboard transom corner, and “C” is on the Port transom corner.
Besides the locations of the equipment necessary for the R2Sonic system set-up, points were taken at major features throughout the boat. Thus allowing for the re-creation of the boat in a 3D computer program (such as CAD).

Data Products

Data products received from DNR’s survey crew included a spreadsheet of all measurements made (after processing), and a digital drawing of the vessel with major positions displayed and labelled (Table 1 and Figure 1 respectively). These products are currently stored internally at DNR:

J:\GIS_Shared\GISUnit\Bathymetry\Mount_specs\Weldcraft_Survey

Table 1: Surveyed values for the DNR Weldcraft with multibeam set-up. The survey was performed by DNR survey personnel on 16 February 2016. All values are referenced to the “center of gravity” as determined by Andrew Ryan, Peter Markos, and Casey Pruitt (DNR Aquatics). Points

that do not have a numerical "PtID" were later added by Andrew Ryan from values provided by the surveyors from the vessel drawing. These values were not originally surveyed, but are calculations from surveyed data and calculated from manufacturer offset values (for Multibeam, IMU, and GNSS antennas).

PtID	X (Bow positive)	Y (Starboard Positive)	Z (up positive)	Name
1	-8.05465	-7.69155	-0.80892	
1A	-8.05321	-7.69098	-0.80813	
2	-7.95118	7.89104	-0.56496	
2A	-7.95377	7.89114	-0.56688	
3	8.87734	8.78915	-0.63131	
4	10.23368	-7.73517	-1.11274	
1000	0.11829	2.35446	-0.25644	KEEL
1001	0.12515	-2.6625	-0.38887	KEEL
1002	0.95707	-2.09084	-0.01461	H2O LINE
1003	0.94403	1.71482	-0.01281	H2O LINE
1004	1.05636	0.04599	0.00621	CL GRAVITY
1005	1.29234	1.85434	0.72901	GUNWALE
1006	1.29455	-0.00832	0.69762	GUNWALE
1007	1.29645	-2.14997	0.65431	GUNWALE
1008	1.29852	-2.15547	0.59441	TRANSOME
1009	0.99855	-2.06847	-0.19685	TRANSOME
1010	0.99391	-2.0892	-0.23888	PROFILE
1011	1.00314	0.81147	-0.1261	PROFILE
1012	0.92061	1.83236	-0.03253	PROFILE
1013	0.2378	3.55714	0.42232	PROFILE
1014	1.19607	2.16332	0.74322	CABIN
1015	1.18732	1.63118	1.39577	CABIN
1016	1.16523	0.74581	1.7073	CABIN
1017	1.17143	0.17047	1.74168	CABIN
1018	1.18477	0.26426	1.4513	CABIN
1019	1.19743	0.05493	0.72694	CABIN
1020	1.26272	2.31845	0.74413	GUNWALE
1021	0.65765	3.3522	0.76611	GUNWALE
1022	0.71319	-2.11047	0.09219	OB BRACKET
1023	0.61936	-2.62201	0.09863	OB BRACKET
1024	0.57904	-2.71197	0.09878	OB BRACKET
1025	0.41119	-2.7984	0.10292	OB BRACKET
1026	-0.44661	-2.11219	0.11676	OB BRACKET
1027	-0.54969	-2.12845	0.2751	KICKER BRACKET
1028	0.83482	-2.08634	-0.22629	BTM EDGE
1029	0.12779	-2.04888	-0.40661	BTM EDGE
1030	-0.58186	-2.07995	-0.22376	BTM EDGE
1031	-0.73802	-2.06776	-0.23178	BTM EDGE

1032	-0.75558	0.76871	-0.12473	BTM EDGE
1033	-0.60069	2.22621	0.03712	BTM EDGE
1034	-0.44521	3.34998	0.77001	GUNWHALE
1035	-1.01581	2.30874	0.75376	GUNWHALE
1036	-1.03871	1.8475	0.73828	GUNWHALE
1037	-1.03723	0.11558	0.70597	GUNWHALE
1038	-1.03341	-2.15118	0.66181	GUNWHALE
1039	-1.03636	-2.15878	0.6006	GUNWHALE
1040	-0.79662	-2.08804	-0.0418	GUNWHALE
1041	-1.30204	-0.50801	-0.17493	SONAR
1041A	-1.30468	-0.50527	-0.27503	SONAR
1042	-1.49489	-0.50697	-0.17155	SONAR
1042A	-1.49798	-0.50436	-0.27031	SONAR
1043	-1.49367	-0.30553	-0.16649	SONAR
1043A	-1.49997	-0.3046	-0.26653	SONAR
1044	-1.33647	-0.44666	-0.26183	SONAR
1044A	-1.33904	-0.44335	-0.36345	SONAR
1045	-1.39977	-0.43631	-0.28673	SONAR
1045A	-1.40265	-0.43318	-0.38778	SONAR
1046	-1.30925	-0.50146	-0.47672	SONAR
1046A	-1.30911	-0.49775	-0.57693	SONAR
1047	-1.49747	-0.49631	-0.4726	SONAR
1047A	-1.50275	-0.49722	-0.57248	SONAR
1048	-1.50171	-0.2992	-0.46721	SONAR
1048A	-1.50332	-0.29483	-0.56898	SONAR
1049	-0.79446	-0.03746	-0.00467	CL GRAVITY
1050	-1.33003	-0.46707	-0.123	CL BOLTS
1051	-1.46471	-0.4662	-0.12028	CL BOLTS
1052	-1.46461	-0.33151	-0.1173	CL BOLTS
1053	-1.35901	-0.43036	1.36916	CL MAST
1054	-0.98191	0.56111	2.05075	TOP CTR GPS
1055	-0.98929	-1.43657	2.02753	TOP CTR GPS
1056	0.00056	-0.35121	-0.0193	CL GRAV INSIDE
1057	-0.8394	-2.1279	0.27703	KICKER BRACKET
1058	-0.83028	-2.59949	0.33549	KICKER BRACKET
1059	-0.8381	-2.12077	0.08592	KICKER BRACKET
1060	-0.83367	-2.55399	0.13941	KICKER BRACKET
1061	-0.35917	-2.6135	0.10219	OUTBOARD BRACKET
1062	-0.29841	-2.73165	0.10365	OUTBOARD BRACKET
1063	-0.08196	-2.79899	0.10445	OUTBOARD BRACKET
1064	0.32991	-2.6813	-0.34242	OUTBOARD BRACKET

1065	-0.0804	-2.67845	-0.3409	OUTBOARD BRACKET
1066	-0.21718	-2.07012	-0.30338	OUTBOARD BRACKET
1067	-1.03704	-0.16366	0.72615	ANT MOUNT
1068	-1.0386	-0.66944	0.71627	ANT MOUNT
1069	-0.76281	-0.66896	0.70905	ANT MOUNT
1070	0.47766	0.00941	1.95916	CABIN
1071	-0.21547	0.01021	1.96468	CABIN
1072	-0.94686	2.15682	0.75215	CABIN
1073	-0.92929	1.62311	1.40482	CABIN
1074	-0.89822	0.7524	1.72474	CABIN
1075	-0.89871	0.15386	1.7615	CABIN
1076	-0.9294	0.25593	1.40759	CABIN
1077	-0.95285	0.03818	0.72767	CABIN
1078	0.42868	1.74117	1.42408	CABIN
1079	-0.15577	1.75227	1.42512	CABIN
1080	-0.16225	2.30978	0.74648	CABIN
1081	0.40127	2.31847	0.74249	CABIN
1082	0.00154	3.54715	0.42254	PROFILE
1083	-1.33017	-0.3328	-0.12016	BOLT
1084	-1.3381	-0.32	-0.2554	SONAR
1085	-1.46452	-0.32209	-0.25531	SONAR
1086	-1.4794	-0.32278	-0.45575	SONAR BOLTS
1087	-1.47593	-0.44778	-0.45751	SONAR BOLTS
1088	-1.33169	-0.44261	-0.46236	SONAR BOLTS
1089	-1.33356	-0.32052	-0.45913	SONAR BOLTS
1090	-1.42013	-0.38003	-0.45358	SONAR ELEV
A	0.12147	3.9583	0.77589	
AA	0.12438	3.96115	0.77531	PUNCH
B	1.28852	-2.13215	0.65675	
C	-1.03051	-2.1266	0.66333	PUNCH
ATR1	-0.982	0.561	1.979	GpsFore
ATR2	-0.989	-1.437	1.956	GpsAft
ATR3	-1.4	-0.384	-0.287	IMU
ATR4	-1.417	-0.379	-0.454	R2Sonic

Figure 1: Computer aided drafting drawing of the DNR Weldcraft from the survey conducted on 16 February 2016. All values are referenced to the "center of gravity" or Vessel Reference Point (VRP) as measured by Andrew Ryan, Peter Markos, and Casey Pruitt (DNR Aquatics). Multibeam, IMU, and GNSS antennas have phase centers that occur inside the physical unit and are therefore calculated positions using exterior measured points (see manufacturers specifications for more information).