EchoBoat and HYPACK: user guide

v 1.0

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This guide must always be with the EchoBoat

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1. Introduction

The Swiss National Science Foundation supported the purchase of an EchoBoat system during the calendar year 2019, with matching funds provided by the University of Lausanne and the University of Geneva. This manual is designed to allow effective deployment of the EchoBoat and also to provide some introductory guidance regarding data processing.

1.1   The EchoBoat system

The EchoBoat system comprises a miniature multi-beam echo sounder (the Pico MB120SF) that is mounted on a specially designed micro-boat, the latter also containing an integrated differential GPS (dGPS) system and allowing for both autonomous navigation and towing behind a boat or on rope-pulley-systems. The lightweight nature of the PicoMB120SF (<5 kg in air) reduces the draft meaning that the system is especially suitable for autonomous deployment in shallow water bodies, in optimal conditions up to 240 m depth.

The PicoMB120SF measures distances from the sensor of up to 240 m. It emits 256 beams instantaneously at a frequency of 337-450 kHz and with an angle of 0.47^o between beams making a swath angle of 120°. Each beam spreads along its distance of travel at an angle of 1.4^o. It has been specifically developed to work at shallow depths (>0.5 m depth, reliable >0.8m depth). As it is lightweight, it is mounted on a specially designed platforms, which can be motorised to operate remotely or rope-towed, behind a boat or from bank attached rope-pulley systems.

The PicoMB120SF is integrated with a dGPS system, two antennas (necessary to resolve heading, heave, pitch, yaw and roll precisely), and a continuously recording probe for temperature and spend of sound profiling, and post-processing software.

The depth resolution of the sensor is 37 mm, lower than other larger, heavier and more powerful MBES platforms which can survey to greater depths but can only be boat based limiting their use for shallow flows in rivers and shallow lakes. Tests with the instrument show that the maximum surveyed depth is around 40 meters. Starting from this depth, several noise sources and artifacts will appear.

Data are collected by Hypack control software and it is vital that the computer that will be used with Hypack is checked in terms of communication with the EchoBoat and that the necessary dongle is available.

For dGPS communications there are two solutions. One uses the EchoBoat system coupled directly via cell phone to a continuously communicating fixed GPS network (like the Swiss Positioning Service, SwiPos-GISGeo). The other one, consist in connect the EchoBoat to a fixed dGPS base (e.g. Trimble) using it as a rover.

2. EchoBoat and PicoMB120SF inventory

The following inventory should be checked against the equipment before leaving for field data collection and upon return. Any missing components should be flagged with the UNIL technician responsible (currently aurelien.ballu@unil.ch).

1.1 EchoBoat
- 1x EchoBoat hull with thrusters
- 1x EchoBoat internal mounting deck
- 1x EchoBoat lid
- 10x lid screws
- 1x sonar (PicoMB120SF) mount
- 2x EchoBoat support frame
- 1x EchoBoat mast
- 8x socket cap screw
- 8x nut
- 16x washer
- 8x lock washer
- 2x EchoBoat fins
- 1x Taranis FrSKY X7 remote controller
- 1x Ansmann remote controller charger
- 1x Venom PROQUAD battery charger
- 4x LiPo 4S battery
- 2x LiPo 6S battery
- 2x bolt (installed on mast)
- 2x nuts (installed on mast)
- 4x washer (installed on mast)
- 2x lock washer (installed on mast)
- 1x rear pole mount bracket
- 2x rear pole mount clamps socket screw
- 3x XT90 parallel connector
- 1x Allen driver 1/4
- 1x Allen driver 1/8
- 1x Allen driver 3/16

1.2 PC Wi-Fi communication kit
- 1x industrial PC
- 1x industrial PC power supply
- 2x Ethernet cable
- 2x N-type M/F connector (installed on boat and mast)
- 1x N-type to N-type 18" cable
- 2x 18" Wi-Fi male Wi-Fi antenna
- 1x 18" Wi-Fi female antenna
- 1x USB optical isolator
- 1x boat side Wifi bridge
- 1x shore side Wifi bridge + PoE adapter
- 3x US to CH plug adapters

1.3 AutoNav
- 1x AutoNav topside
- 2x antenna
- 1x USB antenna adapter
- 1x port motor to AutoNav cable
- 1x starboard motor to AutoNav cable
- 1x AutoNav charger
- 1x RS232 to amphenol male cable
- 1x RS232 to amphenol female cable
- 1x amphenol male to amphenol female cable

1.4 PicoMB120SF
- 1x Pico topside
- 1x Pico RX transducer
- 1x Pico TX transducer
- 1x Pico power/data cable
- 2x Trible GPS antenna
- 3x 3ft TNC to TNC GPS antenna cable
- 1x 6ft TNC to TNC GPS antenna cable
- 1x Ultra SV
- 1x Ultra SV data cable

1.5 Hypack
- 1x Dongle

2. Fieldwork checklist

In addition to the **EchoBoat**, the following items of equipment are needed.

Item	Quantity	Check	Observations
For Transportation			
Large van	1		
Platform/foam bars or cart	1		
Shore PC / laptop			
Battery (with solar panels)/generator	1		
Shore PC (DELL 25943)	1		
PC power supply	1		
Shore Wifi antenna with ethernet cable	1		
Socket Strip	1		
US to CH plug adapters	2		
Rod for shore antenna	1		
Ethernet adapter for shore antenna-PC connection	1		
Wifi antenna power supply	1		
RTK			
Huawei 4G mobile device	1		Solution 1
SwiPos-GIS/GEO subscription	1		
Trimble dGPS base + rover	1		Solution 2
dGPS base tripod	1		
dGPS rover rod	1		
Other useful equipment			
Tape	1		
Waders	2		
Tent to protect the EchoBoat (only in case of long fieldwork)	1		
Camping table for shore PC station	1		
Venom PROQUAD charger (only in case of long fieldwork)	1		
Remote controller charger (only in case of long fieldwork)	1		

3. Fieldwork guide

3.1 Charge the EchoBoat's batteries

The EchoBoat's batteries are charged using a Venom PROQUAD charger with four individual charging channels. It is important to note that the EchoBoat is powered by two types of LiPo batteries (4S and 6S, see labels on the battery), **which need different settings on the charger**.

> The **4S LiPo batteries** are used to power the two propellers (thrusters); they have to be installed horizontally in the compartment behind the Pico on the aft of the boat.

> The **6S LiPo batteries** supply all other electronic devices; they have to be installed horizontally on the bow of the boat (it is necessary to remove the AutoNav for loading and unloading operations).

ATTENTION: **charge the six batteries the day before their deployment** and **ensure that each battery is fully charged** (check their status using the red Venom voltmeter). Every battery should have at least a voltage of ca. 4.3v/cell; **never** use the system if the voltage drops down the limit of 3.7v/cell to avoid damage. When fully charged, the batteries should supply power for 8 hours (depending on several factors as, for example, the survey cruise speed).

1. **Prepare the Venom PROQUAD charger**
   a. Connect one balance connector to each of the four charging channels on the front of the charger (Figure 1).
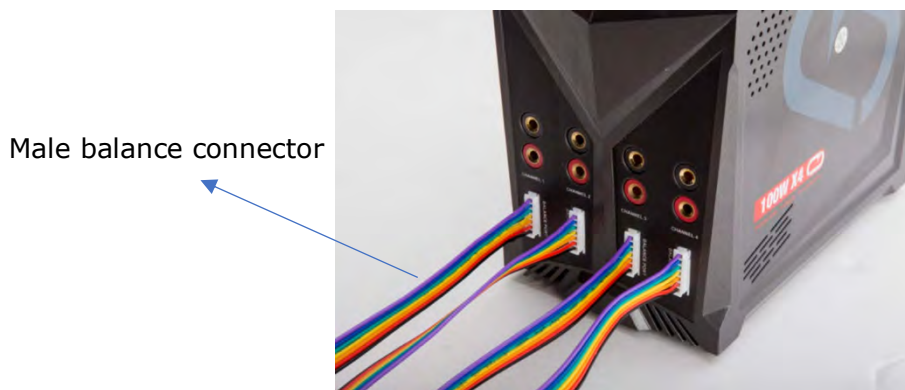

Male balance connector

Figure 1: Front side of the Venom PROQUAD charger and balance connector cables

   b. Connect the four XT90 plug leads to each charging port (black plug into the black port; red plug into the red port). Each lead should be inserted in the **same vertical channel** (Figure 2).
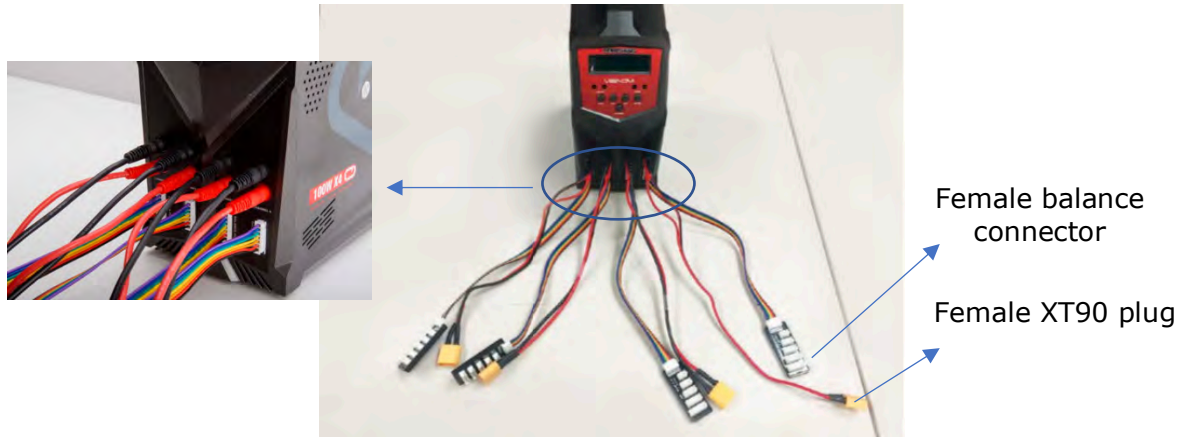
Figure 2: Venom PROQUAD channels plugged with both XT90 and balance connector cables

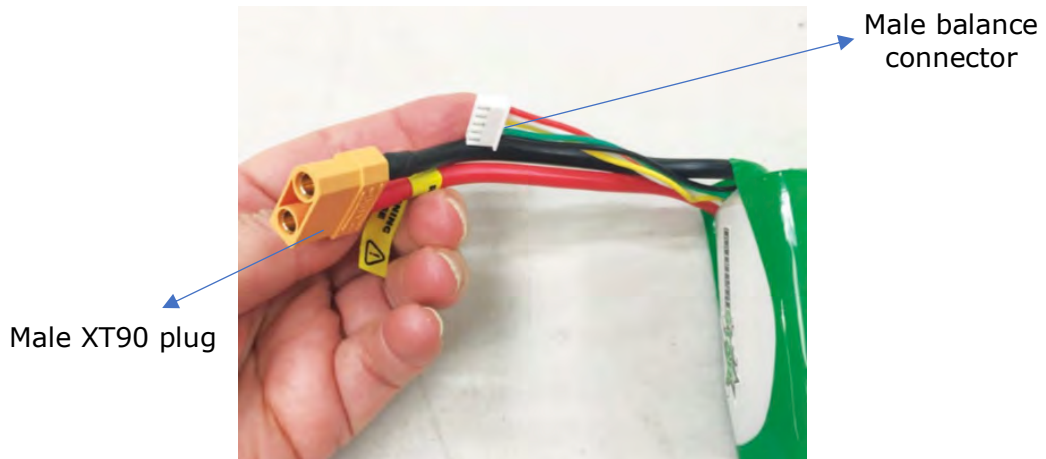c. Each battery comes with a male XT90 plug and a male balance connector (Figure 3).

Figure 3: battery's connection plugs

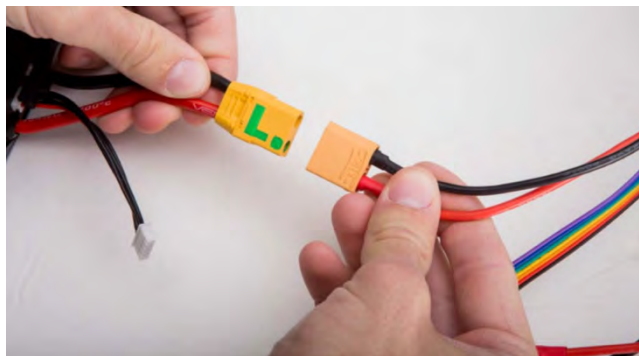d. Connect the male XT90 plugs from the batteries to the charger's female XT90 leads (Figure 4).

Figure 4: XT90 connection between the charger and the battery

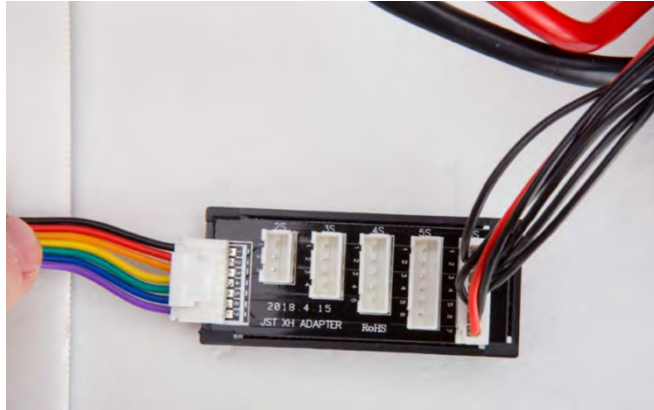e. Connect the male balance connectors from the batteries to each charger's female balance connectors (Figure 5).

Figure 5: balance connector

f. Each battery **must** be connected with the XT90 and the balance connector leads coming from the same channel! If hooked up incorrectly, the charger will display a battery voltage error!

g. Plug the three-prong power cord into the back of the charger. Use an US to CH plug adapter to connect the charger to an electrical outlet.

h. The Venom PROQUAD charger automatically turn on.

i. As the charger own four channels, it is possible to charge up to four batteries at the same time (cycle to the different channels - see below).

2. Charge the 4S LiPo batteries

a. 4S batteries charger settings:
- Type of battery = LiPo BATTERY
- Type of charge = LiPo BALANCE
- Amperage = 6.0A
- Voltage = 14.8v

b. On the PROGRAM SELECT menu choose LiPo as battery type ("LiPo BATT"). The charger should already display this option but, if it is not the case, change it using the SELECT/STOP button and then press the START/ENTER button to confirm the choice.

c. Check that the charger mode is corrected for the type of connected battery. If settings display anything other than "LiPo BALANCE" use the DEC and the INC buttons to adjust it (**ATTENTION**: do not use "LiPo CHARGE" as charging mode!). Press the ENTER button to confirm (Figure 6).

d. To adjust the amperage (6.0A) and voltage (14.8v) settings, press the ENTER button until the setting you want to change flashes then press either the DEC or INC button to change the values (Figure 6). Press the ENTER button to confirm.

Figure 6: Venom PROQUAD charger displaying the right settings for the 4S batteries and meaning of the different buttons

e. To start charging press and hold the START/ENTER button for 2 seconds. A battery check will be performed by the charger, press the START/ENTER button to confirm. The charging of the battery will immediately start.

f. If more than one 4S battery is connected to the charger, cycle through the different channels using the CHANNEL button and then repeat points 2a. to 2e. for each used channel (the red LED will illuminate over the channel that is currently selected).

g. When a battery is fully charged (at 16.8v), the charger will display a "FULL" message on its top-left corner and emits a tone. Press the STOP button and then disconnect the battery (repeat the operation for every channel). Use the CHANNEL button to cycle trough the different channels and check their charging status.

3. Charge the 6S LiPo batteries

a. 6S batteries charger settings:
   - Type of battery = LiPo BATTERY
   - Type of charge = LiPo BALANCE
   - Amperage = 6.0A
   - Voltage = 22.2v

b. Repeat the instructions given for the 4S batteries (point 2a to 2g) changing the settings for the voltage (22.2v). The batteries are fully charged at 25.3v.

4. The Taranis FrSKY X7 remote controller has its own charger. Connect the balance connector cable to the plug on the side of the remote controller (Figure 7) and plug the charger to an electrical outlet using an US to CH adapter. Once the battery is full (the green LED on the charger stops blinking and display a steady light), press the little lever on the balance connector plug and remove the connector cable from the remote controller.

Figure 7: Charger plug on the side of the remote controller

IMPORTANT considerations about the LiPo batteries:

- Batteries should be supervised while charging even if we already preset the charger capacity limit at 16000mAh in order to avoid overcharge (risk of fire and/or explosion). In this regard, place the charger and batteries on a heat-resistant, non-flammable and non-conductive surface during charging operations. Immediately discontinue the charging and isolate the battery if it begins to swell/"balloon" or it reach very warm temperatures!

- Use batteries only if their voltage is at least of 4.3v/cell. Don't use them if their voltage drops down under the 3.7v/cell limit to avoid possibly damaging effects.

- If the EchoBoat is not to be deployed for a long period of time, discharge the batteries to preserve their life. Set the Venom PROQUAD charger on the "STORAGE" mode and discharge them down to their nominal storage voltage of 3.75v/cell.

- Do not expose batteries to cold (< 2ºC) or extremely hot (>35ºC) environments when they are not in use (storage period or fieldwork). These extreme environments may impact on the battery lifetime and produce rapid discharge. If possible, it is recommended to protect the batteries using the LiPo safety bags.

3.2 EchoBoat assembly

Normally the EchoBoat is already assembled and, in order to do not modify the offsets between the primary GPS antenna and the IMU (Inertial Measurement Unit; assembled on the Pico), **it should not be dismantled**. Only the batteries should be removed for charging purposes.

However, if the EchoBoat has to be dismantled (i.e. maintenance, airplane transportation, etc.), please follow these assembly phases:

1. Put the EchoBoat on a stable surface (preferably a soft one in order to avoid damaging the hull). In this regard, use the two foam bars available inside the EchoBoat's crate. **Pay attention to the thrusters – they should not touch the foam!**

2. Install the PicoMB120SF (Pico) inside the circular panel (mount) in the middle of the deck (Figure 8A). The transmitter/receiver arrays should be out of the boat and in contact with the water, while the connectors (the Applanix system) have to be inside the boat with the plugs oriented in direction of the bow of the EchoBoat (Figure 8B).

   ATTENTION: always check that the Pico is correctly fixed to its mount (4 screws are necessary!) in order to avoid water infiltration; in addition, ensure that the transparent cable (water evacuation) is not obstructed by sediments, weed, etc.!
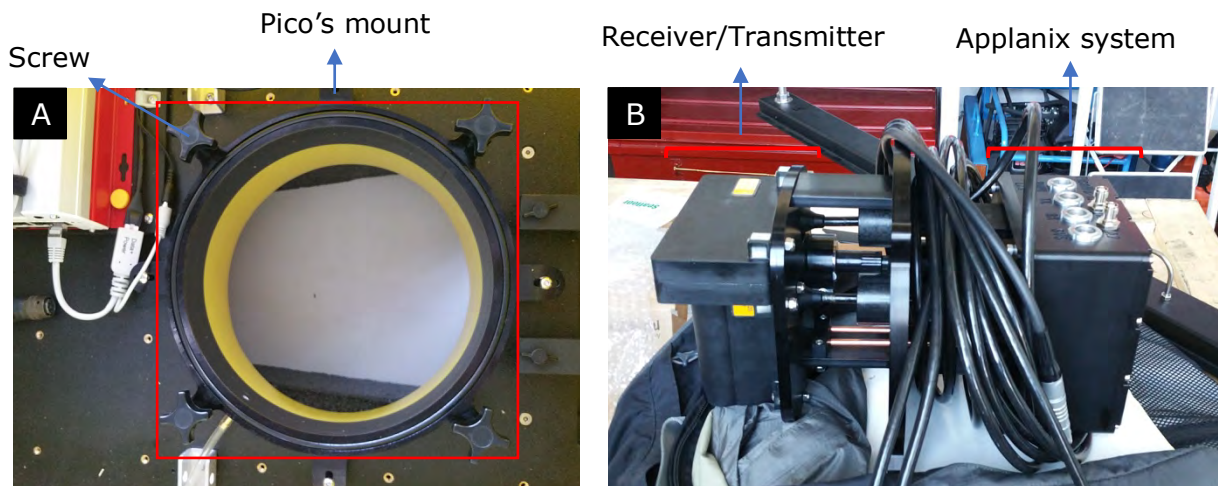

Figure 8: A) Pico mount on the EchoBoat and B) different components of the Pico

3. Install the boat PC in front of the Pico (Figure 9) and secure it to the deck of the boat with the appropriate yellow screws.

Figure 9: boat PC installed near the Pico

4. Connect the Pico to the boat PC (black ethernet cable), to the power supply (XT90 plug and amphenol cables; the color labels on the cable and on the plugs must match), to the transmitter/receiver array and to the two GPS antenna plugs located on the aft of the EchoBoat (see labels on cables).
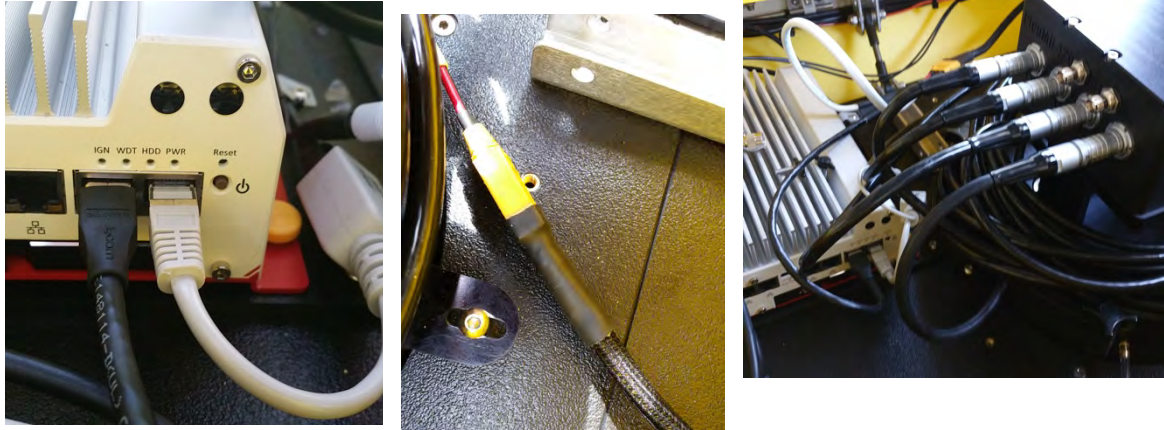

Figure 10: Connection between the Pico, the boat PC and the GPS antennas

5. Connect the boat PC to the boat side Wifi bridge (MikroTik) using the ethernet cable of the gray PoE adapter (Figure 11). Make sure that the MikroTik's power supply is also connected to the PoE adapter!
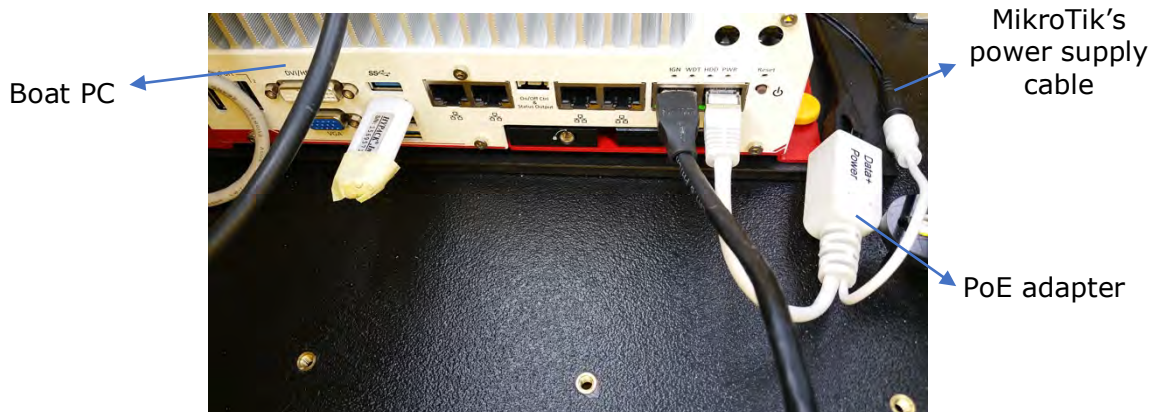

Figure 11: Connection between the boat PC and the MikroTik (wifi bridge)

6. Batteries are stored in two different panels:
   - The four 4S batteries are fixed to the back of the boat (behind the Pico). Remove the two black belts, connect the male XT90 plugs from the batteries to the two yellow EchoBoat's female XT90 connectors (two batteries for each plug) and load them horizontally with the leads facing the thrusters (Figure 12A). Before fixing them with the two belts, ensure that the two thrusters' sensors are turned on (Figure 12B).
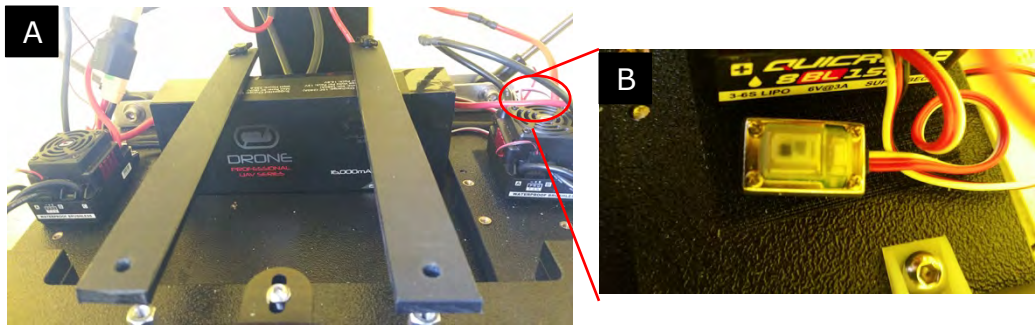
Figure 12: A) 4S batteries panel on the aft of the EchoBoat and B) thruster sensor

- The two 6S batteries are stored on the bow of the boat (behind the AutoNav). Remove the belt, connect the male XT90 plugs from the batteries to the EchoBoat's female XT90 connector, insert them horizontally and, finally, secure them with the belt. Both battery's XT90 leads should be oriented facing the left side of the hull (Figure 13). For loading and unloading the two 6S batteries, it is necessary to remove the AutoNav!

Figure 13: 6S batteries panel on the bow of the EchoBoat

7. Install the AutoNav next to the boat PC, and in front of the 6S batteries, fix it to the deck with two black screws. Ensure that the blue USB cable coming from the PC is well connected on the left side of the Autonav. Plug the two black amphenol cables on the front side and connect the gray one to the Applanix system (MV-POS integrated into the Pico topside) using the RS plug coming from the Pico labelled as COM 1 port (never use COM 3!).
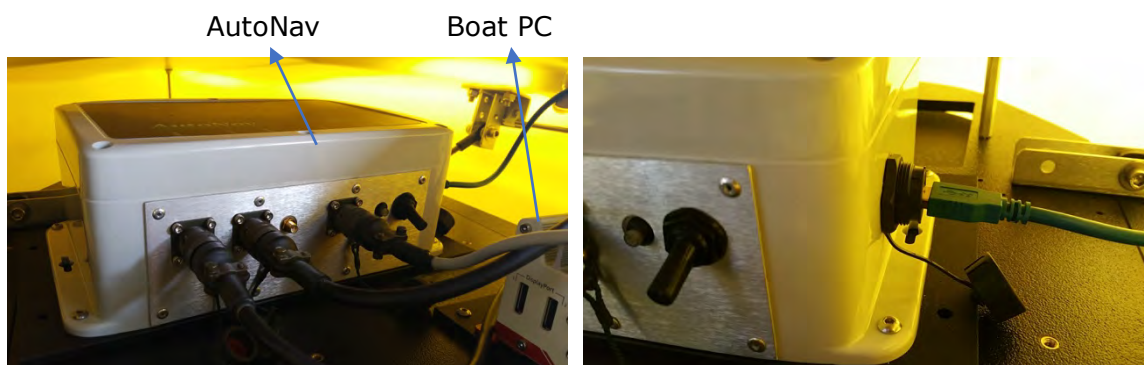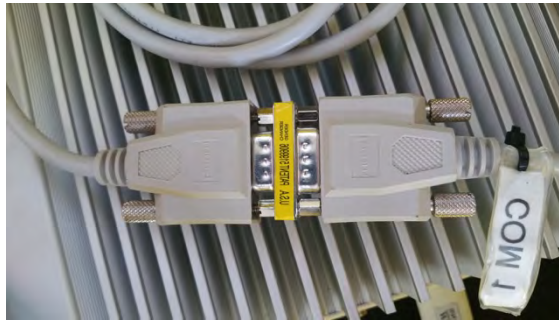
AutoNav   Boat PC

Figure 14: AutoNav connection to the batteris, the boat PC and to the Pico

8. Installation of the support frame for the GPS and Wifi antennas
   - Remove the four handles from the EchoBoat using the provided Allen keys.
   - Install the two black support frames (mast support) putting their edges between the hull and the handles (Figure 15). The two support frames must be parallel to them and cross the EchoBoat from side to side. Fix them using the same screws already used to fix the four handles.

Support frame

Handler

Figure 15: Support frame installation on the EchoBoat

ATTENTION: the support frame with straight bases should be installed on the aft of the EchoBoat (Figure 16A), while that with oblique edges goes on the bow (Figure 16B).

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Figure 16: Support frame base – A) aft of the EchoBoat, B) bow of the EchoBoat
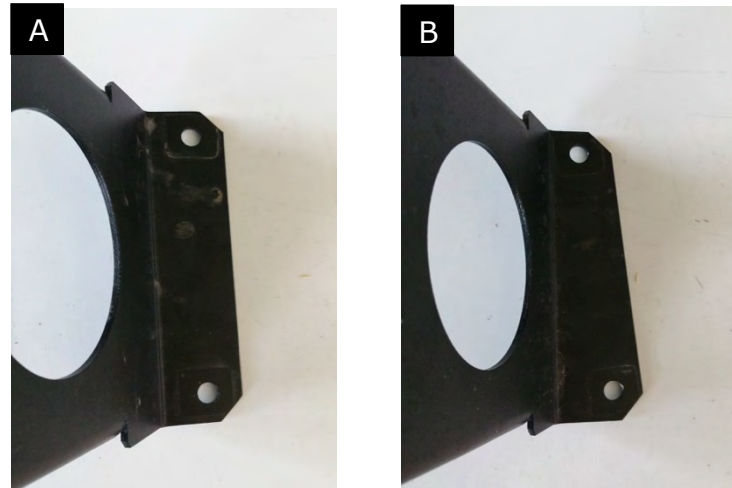
- Install the mast (the long black steel bar) perpendicular to the two support frames passing by their middle. Fix it to the two frames using eight socket cap screws, and relative nuts and washers (each screw needs one nut, one washer, one lock washer and one bolt; Figure 17). Make sure that the mast side tagged with "F" ("Front") is oriented in the direction of the bow.
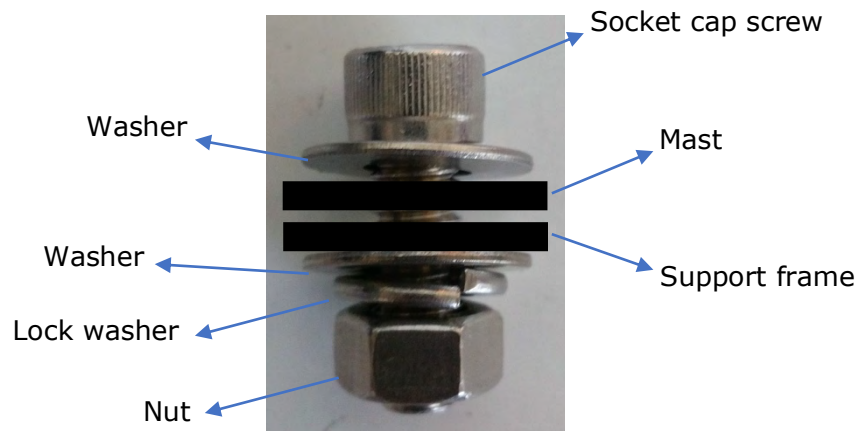
Figure 17: components for the installation of the mast on the support frames

- Install the two GPS antennas ensuring that the "Trimble" labels are both aligned and parallel to the mast. If not, rotate them moving their bolts located on the down face of the mast (use a wrench).
- Connect the GPS antennas to their plugs installed on the aft of the EchoBoat using the two TNC to TNC cables. The GPS antenna 1 is that on the aft (use the 3ft cable), while the GPS antenna 2 is that on the bow (use the 6ft cable) (Figure 18). Use a waterproof tape to protect the connections against the ingress of water (optional).
- Install the Wifi antenna at the intersection between the mast and the mast 'support frame on the bow (Figure 18).

Figure 18: EchoBoat assembled

Wifi antenna

GPS antenna 2

TNC to TNC cable

GPS antenna 1

Mast

GPS antenna plugs

Support frame

9. Close the EchoBoat's lid and screw the ten black screws by hand. Use your hand to exert additional pressure on the lid (Figure 19) to better protect and waterproof all the electronical devices. **This is a critical step**.

Figure 19: Proper way to close the lid

10. Install the two fins on the aft of the EchoBoat sliding them on the two tracks (Figure 20). It is recommended that these are installed only before the beginning of the survey and removed once the survey is finished to avoid damaging effects.

Figure 20: Fins installation on the hull

Sliding track

Fin

11.   Once the EchoBoat is assembled, it is necessary to measure the distance between the IMU reference point (Pico 120 MBES Topside phase center; Figure 21), the primary GPS antenna located on the aft of the EchoBoat (Trimble GPS Antenna phase center; Figure 21) and the Acoustic Center of the Multibeam (Pico 120 MBES phase center; Figure 21) in order to calibrate data positioning precision.
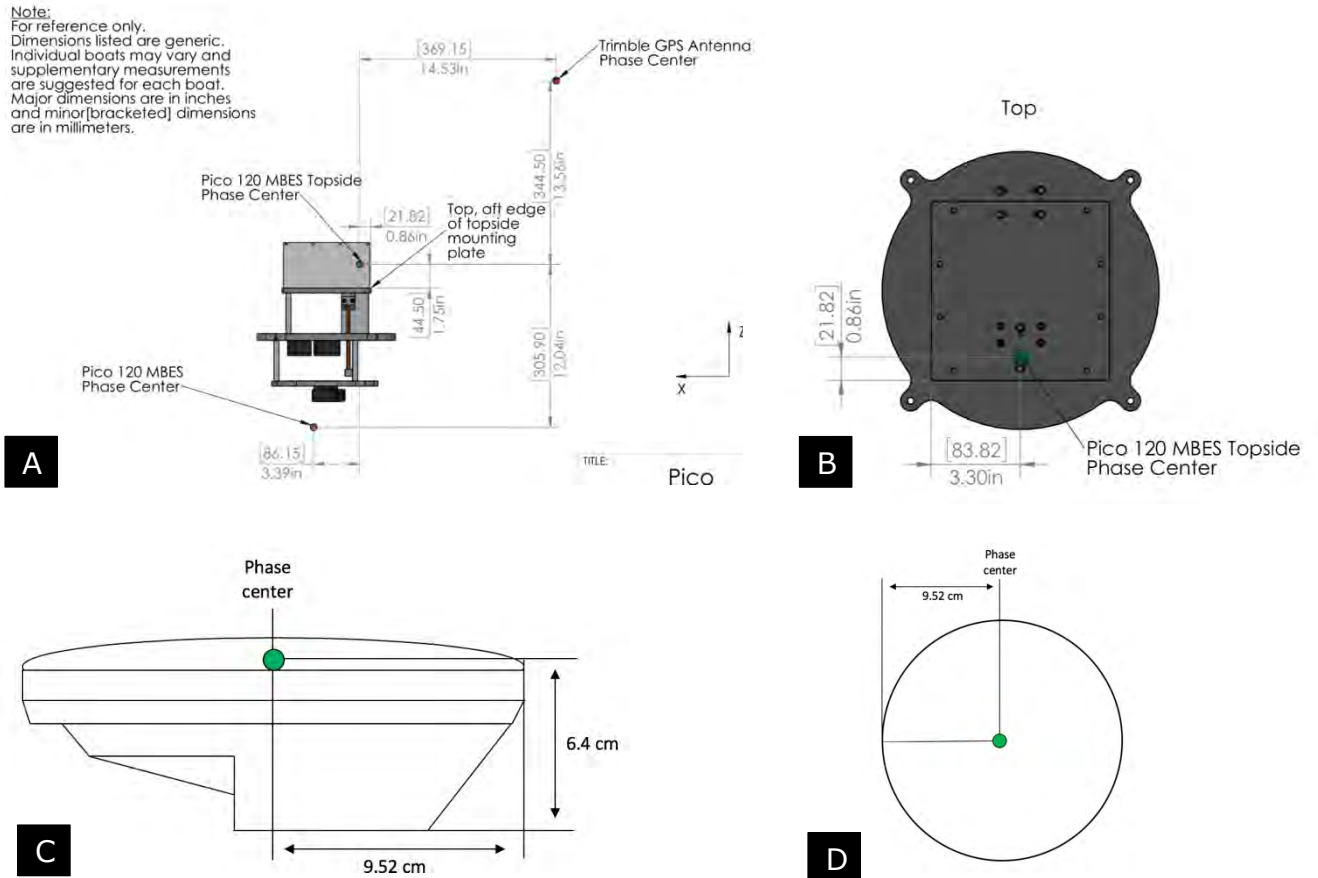
Figure 21: scheme illustrating the location of the phase center on the IMU (A and B), on the primary GPS antenna (C and D) and the reference distance between them (A and B).

The offsets shall be entered in both the **MV-POSView** and **HyPACK** programs.

- In the **MV-POSView** software, measure and enter the IMU and GNSS antenna offsets. The values have to be entered on the "Installation" tab ("Lever Arm & Mounting Angles") under the "Settings" list of MV-POSView (Figure 22).

Figure 22: Lever arms & Mounting Angles tab on MV-POSView

- o "Ref. to IMU Target" box
  - Enter the value of the distance between the Pico 120 MBES topside phase center and the waterline on the "Z" box. The vertical offset is positive downward.
  - The "X" and "Y" boxes have no offsets and they must be set with 0 values.
- o "Ref. to Primary GPS Lever Arm"
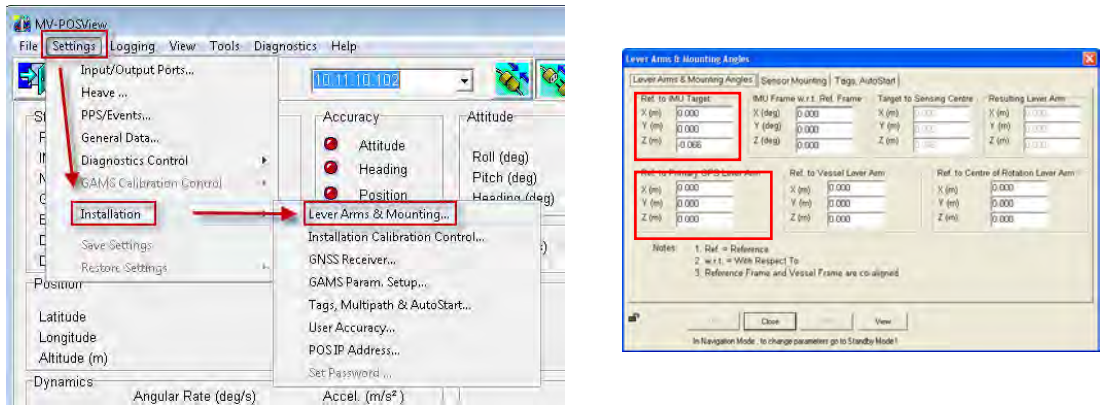 - Enter the distances forward and starboard from the Pico topside phase center and the Trimble GPS Antenna phase center. These offsets have to be entered on the "X" and "Y" boxes. Positive values mean that the primary GNSS antenna is forward/starboard to the IMU reference point.
  - Enter the distance from the Primary GNSS Antenna Phase Center to the waterline on the "Z" box. A negative value means that the antenna is above the waterline.

> All the values have to be 0!

> Y values has to be 0! Not the other ones...

- In HyPACK measure and enter the multibeam offsets. The values are entered on the "Hardware setup" ("Picotech PicoMBES" device) under the "Offsets" tab (Figure 23).
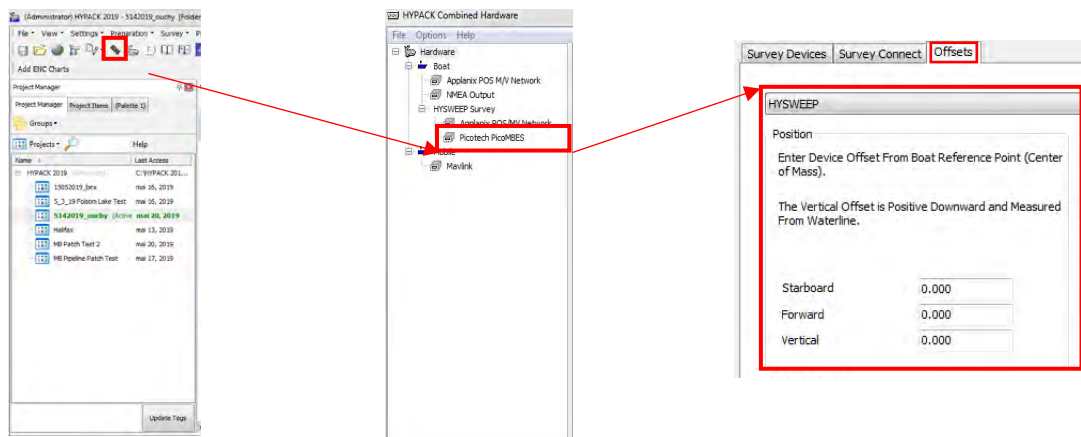

Figure 23: Multibeam offsets in HyPACK

o Choose "Sonar Head 1" on the dropdown menu

- Enter the distances forward and starboard from the Pico topside phase center to the Pico phase center. Enter the values in the "Starboard" and "Forward" boxes. Positive values mean that the Acoustic Center of the Multibeam is forward/starboard to the IMU reference point. As it is very difficult to measure these distances, it worth to use the values given in Figure 21A.

- Enter the distance from the waterline to the Pico 120 MBES topside phase center on the "Vertical" box. A negative value means that the Acoustic Center of the Multibeam is above the waterline.

12. The first time the EchoBoat is used in a survey after having been dismantled, it is also important to perform a GAMS calibration (GPS Azimuth Measurement Subsystem)

a. Turn on the EchoBoat, connect it to the shore PC, and start a new project

b. Open MV-POSView (Figure 24)

- Wait until the IP address is displayed (Pico connected to boat PC)
- Click the "Connect" and the "NAV" buttons
- Enter the measured offsets
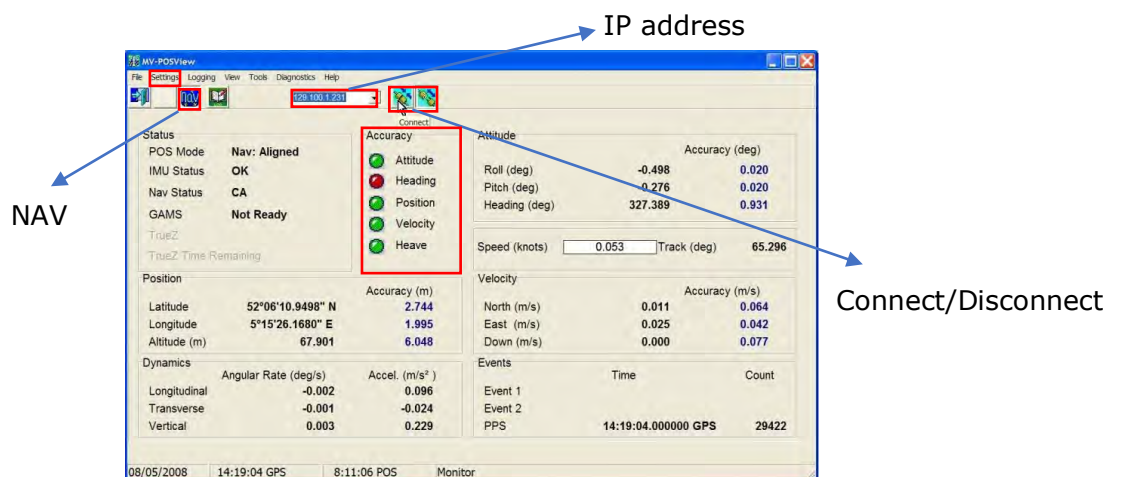- "Settings" -> GAMS calibration (all the "Accuracy" alarms must be green. If not manually move the EchoBoat)

Figure 24: MV-POSView main window

c. Once the EchoBoat is in the water, start the GAMS calibration (Figure 25). Move the boat conducting initially continuous circular trajectories and then straight lines with several stops (refer to Chapter 3.3 to know how to prepare the EchoBoat for the field).
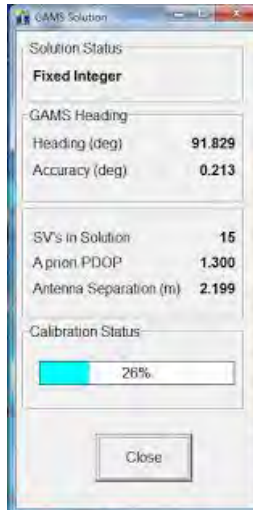
Figure 25: POS calibration status

   d. Once the GAMS calibration is finished (the status bar reached
      100%), close MV-POSView saving the changes.
   e. When you start a new project in HyPACK, remember to enter the
      measured offsets on the "Hardware Setup" settings.

13.   Patch Test
   a. Every time the EchoBoat is dismantled, it is also important to
      calibrate the angular mounting components (GPS Latency, Roll, Pitch
      and Yaw parameters).
   b. To perform the Patch Test, and to have a detailed workflow to follow,
      refer to Chapter 4.3

3.3 Deployment in the field

1. Put the EchoBoat on a stable surface (paying attention to the thrusters
   and to the fins!)
2. Open the EchoBoat lid
      a. Ensure that the HyPACK dongle is connected to the boat PC (Figure
         26) and that all cables are correctly plugged in (see chapter 3.2)

Figure 26: Boat PC inside the EchoBoat and HyPACK dongle

b. Load and plug the six batteries (point 3.2.6)
c. Turn on the boat PC's lever (on the aft of the EchoBoat; Figure 27)

Figure 27: Pico and boat PC levers ignition

d. Turn on the boat PC (little button on the lower-right corner; Figure 26)
    ⇨ Tone + lights = power from the boat PC to all electronical devices
e. Turn on the lever of the starboard thruster (STBD, on the aft of the EchoBoat; Figure 28)
    ⇨ Tone = power from the starboard to the AutoNav

Figure 28: Thruster ignition levers

f. Turn on the AutoNav's lever (Figure 29)

Figure 29: AutoNav's lever (inside the red circle)

g. Turn on the lever of the port thruster (PORT, on the aft of the EchoBoat) to complete the thruster ignition (Figure 28)
h. Turn on the SONAR lever (on the aft of the EchoBoat) to turn on the PICO (Figure 27). It is recommended to turn on the PICO only once the EchoBoat is in the water. However, it is also possible to turn it on even when the boat is outside the water but, in this case, it is necessary to change the beam frequency rate to 1 Hz (section 3.3.7.e)

3. Turn on the remote controller and rotate the antenna (Figure 30)

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a. Check the connection bars on the display
b. Arm the EchoBoat (flip down the Arm/Disarm AutoNav lever and hold the ARM/DISARM safety towards the operator for 3 seconds)
   ⇨ You will hear a tone ("beep") from the EchoBoat
c. Check that thrusters correctly respond to the remote controller
   ATTENTION: only the right stick controls the EchoBoat in the manual mode
d. Disarm the EchoBoat (flip up the Arm/Disarm AutoNav lever and hold the ARM/DISARM safety towards the operator for 3 seconds). It is recommended to arm the AutoNav only once the EchoBoat is in the water and ready to start the survey (see point 3.3.8)

Figure 30: Remote controller and main commands

4. Close the EchoBoat lid
   a. **ATTENTION**: while closing the screw, use your hands to put additional pressure on the lid in order to expand the force on a greater area and improve the waterproof effect (Figure 19)

5. Prepare the shore PC (it must be the UNIL DELL 25943) station
   a. Connect the shore Wifi antenna to the shore PC (Figure 31)
      ⇨ Connect to the PoE adapter the antenna's ethernet cable and its power supply
      ⇨ Plug the PoE adapter to the shore PC (port on the back) and the antenna's power supply to an electrical outlet (ex. portable battery or generator)
      ⇨ The shore PC's power supply must be plugged to an electrical outlet in order to avoid an unexpected shutdown during the survey!

⇨ Use a socket strip to connect the devices to the generator/portable battery
⇨ If needed, use some US to CH plug adapters

Figure 31: Equipment needed to install the shore PC station

b. Check the connection bars on the Wifi antenna
c. Put the Wifi antenna on an elevated position (use a rod/pole if necessary)
   ⇨ It is important to have a clear vision of the whole survey area
d. Connect the shore PC to the boat PC via remote desktop connection
   ⇨ Use the IP address of the PC ethernet port that the MikroTik plugs (IP = 192.168.1.8)
   ⇨ Username: EchoBoat
      Password: Seafloor
6. Open MV-POSView software (Figure 32)
   a. Press the "Connect" button
   b. All the alarms on the "Accuracy" list (Heading, Position, Velocity, Heave) must to be green!
      ⇨ If not, move the EchoBoat in a circular way until the alarms turn green
      ⇨ It is not necessary that the "Attitude" alarm is green
   c. Press the "NAV" button
   d. Look at the number of satellites connected to the EchoBoat (View tab -> GNSS data). For a good operation, they may have between 15 and 20.
   e. Check the MV-POSView clock. It must be synchronized with the boat PC clock (maximum 1 second delay). If it is not the case, connect the shore PC to the boat PC using an ethernet cable and manually set the shore PC clock (Parameters -> …).
   f. Minimize the MV-POSView window
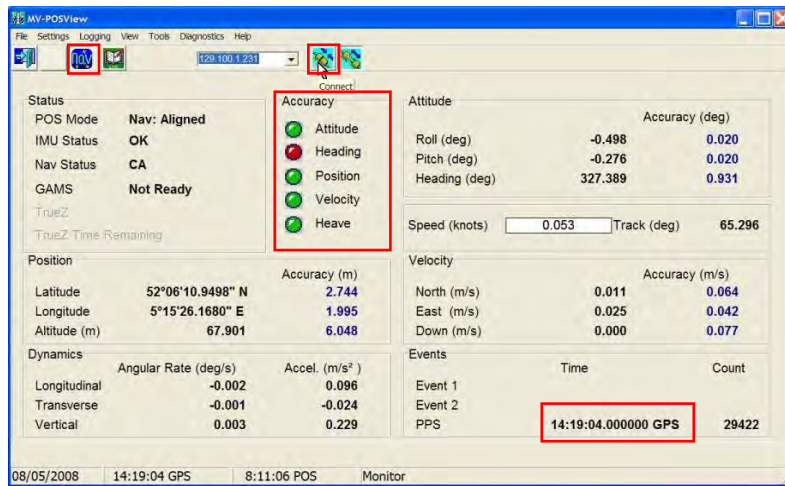
Figure 32: MV-POSView alarms

7. Open HyPACK 64-bit
   a. Create a new project
      ⇨ File -> new project -> name it as "date + name of the surveyed area" (ex. 5142019_ouchy)
      ⇨ To load an existing one to continue the survey: "Project Manager" list -> search the project name -> double click (the project turns green)
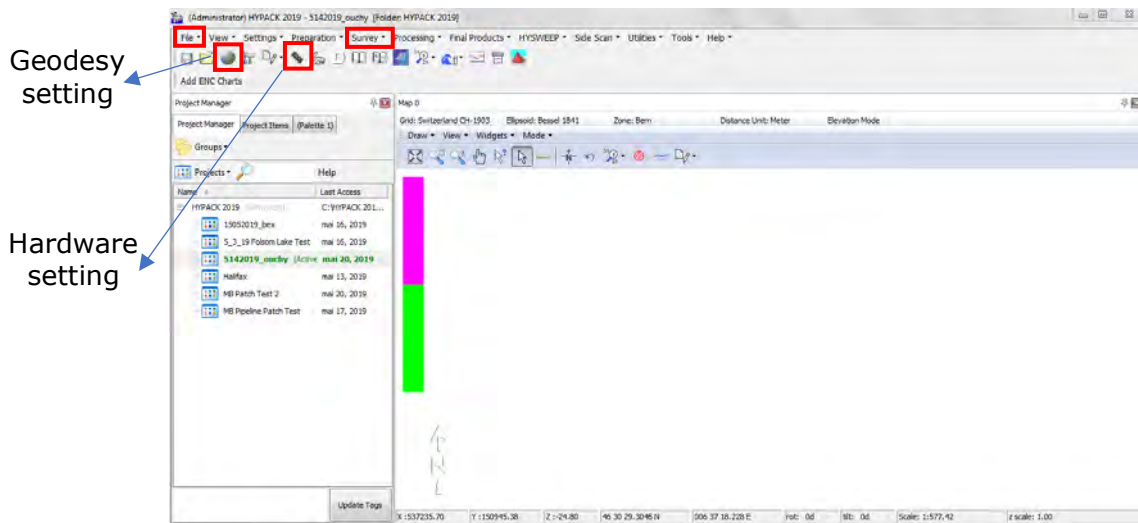
Figure 33: HyPACK main window and location of the main tools

   b. Determine/check the geodesy settings (Figure 33 and 34) -> CH_1903 (if the survey area is in Swiss)
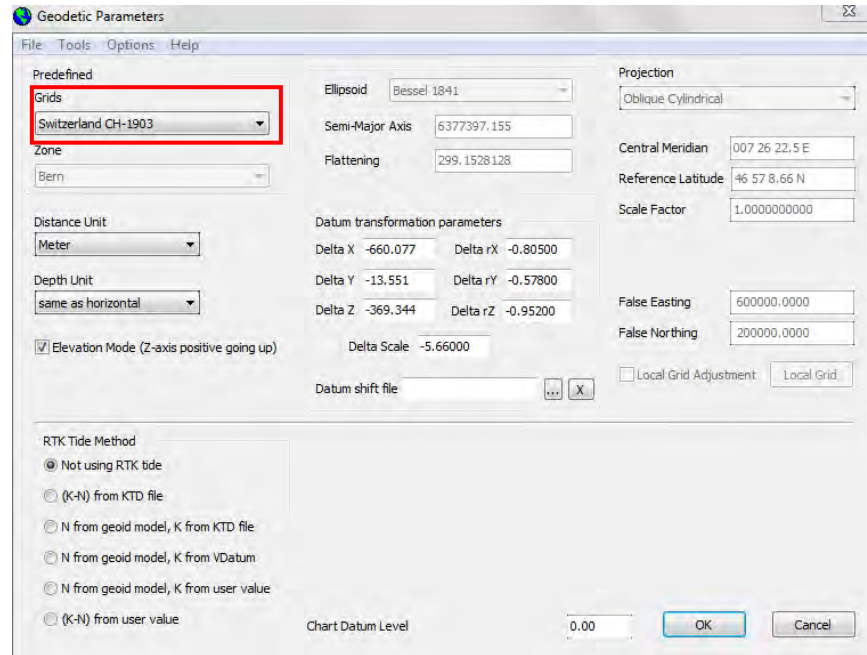
Figure 34: Geodesy window

c. If you want to add a background chart to the project map (not mandatory for the survey, but it may useful to see the spatial limits of the surveyed area; see point 9b)
    ⇨ Right click on "Background Files" folder in the "Project Files" list
    ⇨ Select "Add file", choose the file format, search the file and click OK
    ⇨ The chart will be appeared to the screen and stored in the "Background Files" folder
    ⇨ The background chart should be georeferenced!
d. Check the hardware settings (Figure 33)
    ⇨ The sidebar should show the following parameters (Figure 35)
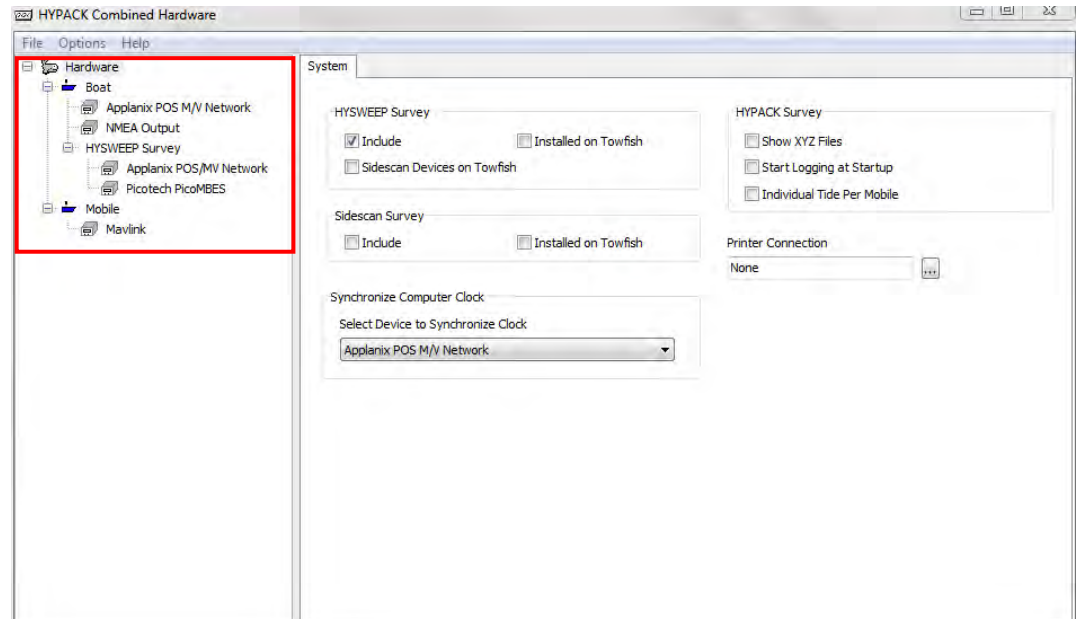
Figure 35: HyPACK hardware settings

⇨ Check that the offsets between the primary GPS antenna and the MRU are correct. If not, manually insert them (Figure 23):
- Click on "Picotech PicoMBES" in the tree view
- Click on the "Offsets" tab
- Select "Sonar Head 1" on the dropdown menu
- Enter the measured position offsets

e. Prepare the survey
⇨ "Survey" tab (Figure 33) -> "HyPACK survey and HySWEEP survey"
⇨ At this point you will hear a continuous "beep". This is an alarm informing you that no tide data is used. Select the "Survey" window and press the ESC button (on the shore PC's keyboard) to disarm the warning message.
⇨ All the alarms on the "HySWEEP survey" window (NAV, Gyro, MRU, Multibeam, Devices; not the Side Scan that stay in gray; Figure 37) must be green! Pay also attention that the "Boat Info" option is selected to obtain live data from the Pico.
If the alarms are not green, the problem may be related to an incorrect distribution of the power (check that all cables are correctly into their plugs) or to a bad connection between HyPACK and MV-POSView (close all and repeat point 3.3.6 and 3.3.7).

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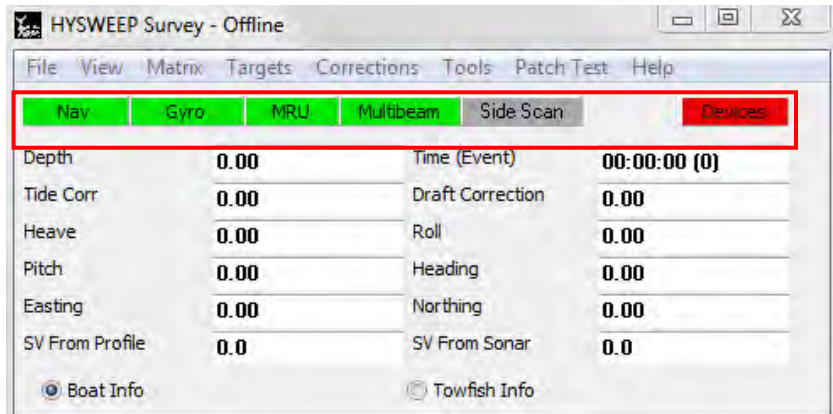
Figure 37: HySWEEP survey alarms

    ⇨ If nothing appears on the "Profile" window, which shows the real time sounding, it is necessary to control and to change the beam frequency: "HySWEEP survey" window -> Tools -> PicoTech controller -> Frequency
(for shallow water, it is recommended to use value of ca. 25Hz).
Adjust swath depth and width (c. 1.5 x depth) in function of you study area.

    ⇨ Determine matrix (resolution) using the "Multibeam Matrix Settings" (Figure 38)
        -> Cell size/grid size tab = set the cell resolution
        -> Select the data type you want displayed on the real time color map ("Average depth" is typical)
        -> "Update" tab = while logging
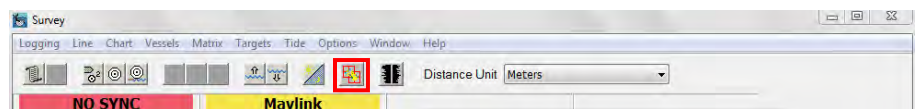
Figure 38: "Multibeam Matrix Settings" icon on the "HySWEEP survey" window

8. Put the EchoBoat in the water
    a. Arm the AutoNav
        ⇨ Just before to start the survey!
        ⇨ Flip up the Arm/disarm lever and hold the ARM/DISARM safety towards the operator for 3 seconds (see point 3.3.3 and Figure 30)
        ⇨ The MAVLINK window will show that the AutoNav is armed

9. Start the survey
    a. Wait until the "NO SYNC" alarm is gone (Figure 39)
    b. Press the start logging button to record data (Figure 39)
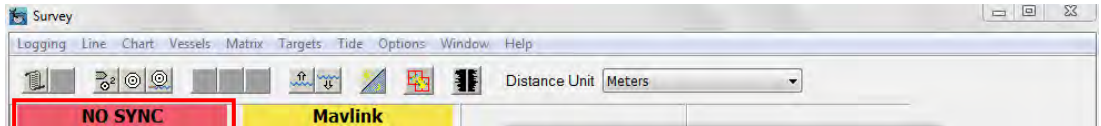
: Position of the Start logging button on the HySWEEP survey window

⇨ Bathymetry chart appears on the "Survey map" window
⇨ Status change from NOT LOGGING to LOGGING (Figure 40)
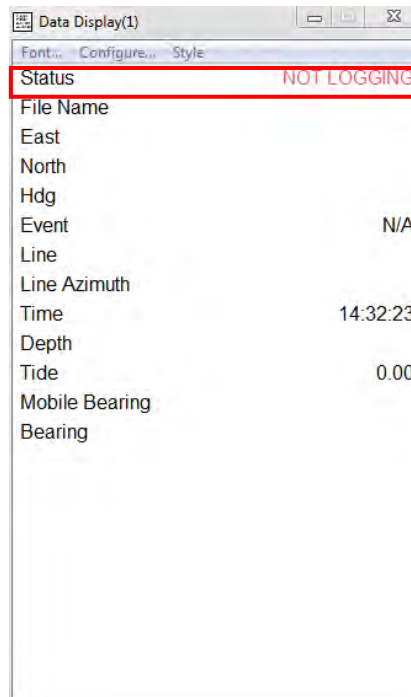
Figure 40: Logging status on the HySWEEP survey

c. It is recommended to divide the survey into two distinct stages (depending on its extent and configuration):

⇨ I: **map the spatial limits of the surveyed area** ("safe area") using the manual mode or using the "Contour editor". On this latter case:
- "Preparation" tab on the HyPack main toolbar
- "Contour" editor => click the "Cursor" button and draw a polygon on the map
- Save the edited lines (lines will be saved on the "Contour Files" folder inside the "Project Files" list

⇨ II: **map the area inside the limits** using the automatic mode. This operation needs several steps:
- Close "HySWEEP survey" window (Figure 37) and save the logged data
- On HyPACK 2019 64-bit

- Click the "Line editor" icon (Figure 41)
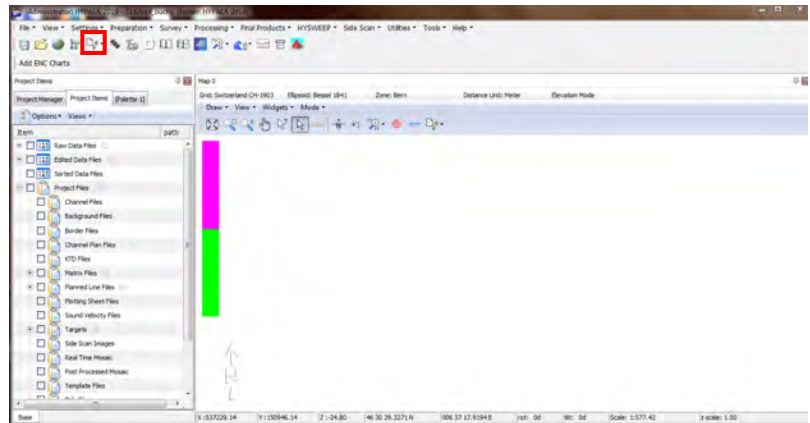
Figure 41: "Line Editor" icon

- Click the "Cursor" button (Figure 42)
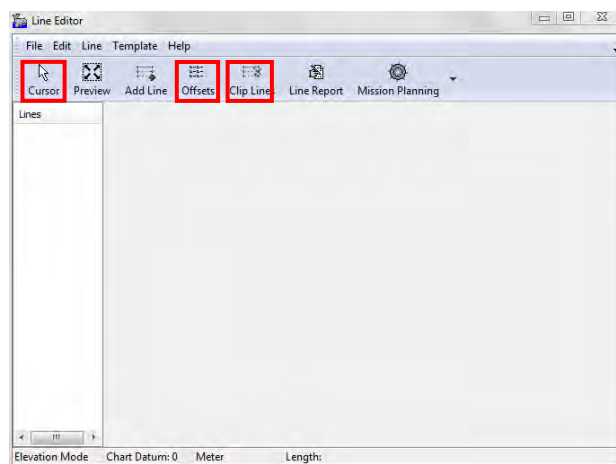
Figure 42: Line Editor window; Cursor and Offsets buttons

- Draw one line inside the survey area limits (Figure 43)
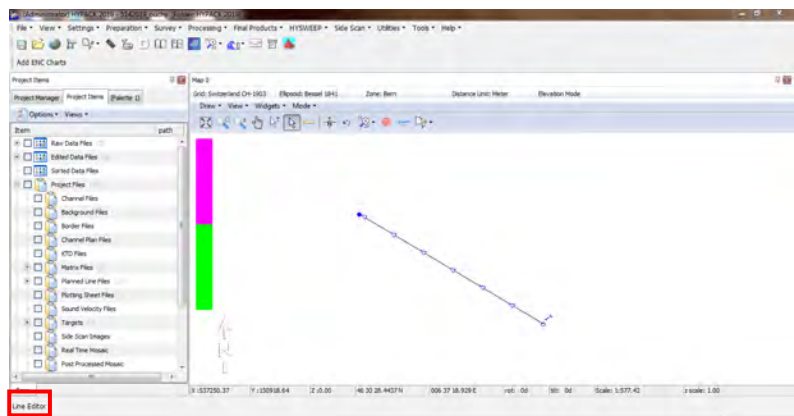
Figure 43: Single line path

- Re-open the "Line Editor" window clicking the icon on the lower left part of the display (Figure 43). Press "Offsets" button on the Editor Line menu

(Figure 42) -> add the number of lines that you wish and the spacing between them (in meters) (Figure 44). **Note**: to clip the parallel lines inside the contour, use the "Clip Lines" button (Figure 42) and then select the "Border file" you created.
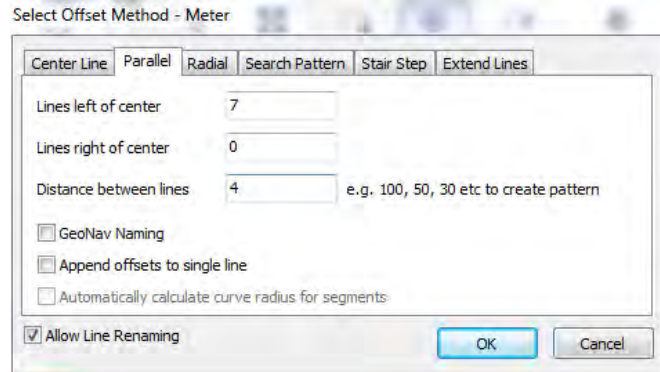
Figure 44: Offsets windows

- Click "OK" and save the edited lines (file-> save)
  ATTENTION: lines have the same direction
(Figure 45)
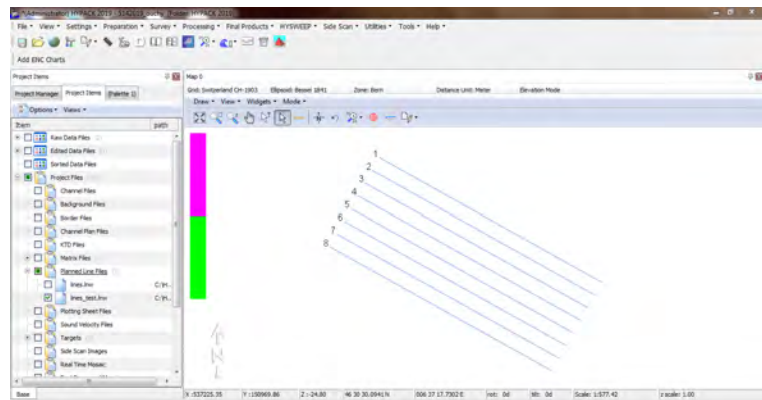
Figure 45: Offsets output; lines have all the same direction

- To reverse their direction (Figure 46): Open the line Editor -> File -> Open -> select the lines that should be reversed (CTRL+left click) -> right click -> Reverse Order
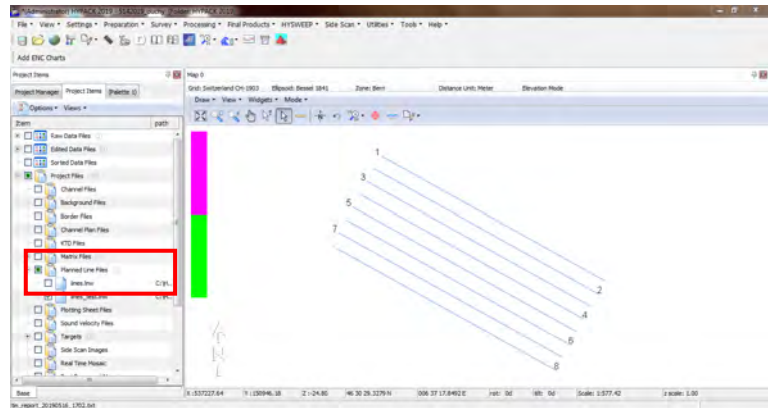
Figure 46: Lines with different directions and "Planned Lines Files" folder

- Save again the edited lines (the file will be stored on the "Planned Line Files" folder inside the "Project Files" list; Figure 46)

d. Once the lines are planned, launch the EchoBoat on the autonomous mission mode (no need to switch the remote controller on the autonomous mode; Figure 30)

⇨ On HyPACK, select one planned lines files at a time. If you decided to use the "Border editor" to generate a safe area, select and execute this file at first. If you did it manually, you can directly select the parallel lines to fill the limits.

⇨ Restart the survey clicking the "Survey" tab (Figure 33)

⇨ Choose "HyPACK survey and HySWEEP survey"

⇨ Move the EchoBoat close to the starting point of the line 1

⇨ MAVLINK window => Start mission (Figure 47)

⇨ At the end of the mission, to take control of the EchoBoat it is necessary to switch the manual/automatic lever to automatic mode and then to manual mode!

⇨ It is necessary to stop/start logging at the beginning of every line (depending on the settings: "Survey" window -> Options -> Navigation parameters)

- "Start line gate" = 0: the survey program starts and stops logging only if you manually intervene

- "Start line gate" > or < 0: the program starts logging automatically when the distance from the tracking point to the starting point of the planned line is less than the absolute set value. The trigger area is shown as a circle. A positive offset shifts the circle down line by the specified amount, while a negative offset shifts it backward along the line.
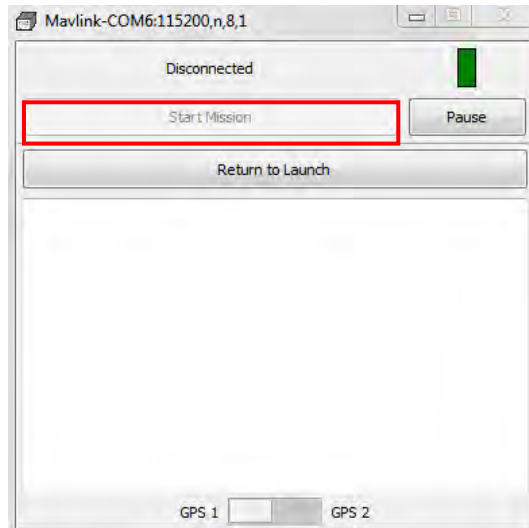
Figure 47: MAVLINK window and Start Mission button

ATTENTION:

- if during a mission there are some obstacles on the paths of the EchoBoat, press "Pause" from the MAVLINK window or turn the remote controller to manual mode (Figure 30; three steps: manual -> automatic -> manual as it is not necessary to set the automatic mode before to start the mission). To continue the mission, turn the remote controller to the automatic mode.
- If you decide to abort the mission, press the button "Return to Launch" from the MAVLINK window. **The EchoBoat will return to the point where it has been armed (pay attention!).**
- If you wish to continue the survey adding some new lines, it is important to deselect the lines from the "Planned Line Files" (inside the Project Files) and then draw the new lines using the editor.

⇨ If you want to continue the survey with other planned parallel lines (or contour lines) do the following:
  - Close the HySWEEP survey
  - On HyPACK, select (or generate) another planned lines files
  - Restart the HySWEEP survey and repeat point 3.3.9.c.

If the automatic survey is not possible (many natural obstacles on the surveyed area, weak GPS signal, etc.).

⇨ Manually move the EchoBoat generating parallel lines paying attention that all the surveyed area will be covered (look at the "HySWEEP map" window).

⇨ For every line, press "Start logging" at the beginning and "Stop logging" at the end in order to generate multiple lines

(Figure 48). This procedure makes the data post-processing easier compared to a situation where the whole surveyed area is recorded as a single and long line.
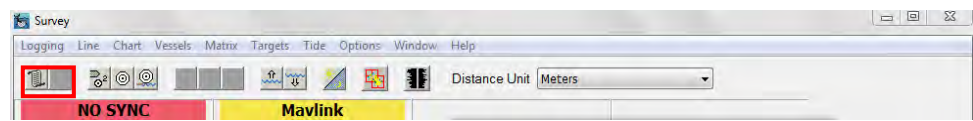
Figure 48: Position of the Start and Stop logging buttons on the Survey window of HySWEEP

e. The bathymetry will start to be drawn on the "Survey" map
   ⇨ To change the way in which live data are displayed, press the "View" button on the HySWEEP survey windows (Figure 37) and then choose your preferences (Profile, 3D Seafloor, Multibeam Waterfall, Real Time Point Cloud,…)

10. At the end of the survey
   a. Open the PicoTech controller window ("HySWEEP survey" window -> Tools -> Picotech controller) and turn down the beam frequency to 1Hz
   b. Close the main window ("Survey") in HySWEEP survey to save the logged data
   c. Shutdown the boat PC from the shore PC
   d. Turn off the thrusters (PORT and STBD levers located on the aft of the EchoBoat)
   e. Turn off the SONAR and the PC (levers located on the aft of the EchoBoat)
   f. Turn off the AutoNav opening the EchoBoat's lid
11. Download data from the boat PC
   a. Open the EchoBoat lid
   b. Turn on the PC lever on the aft of the EchoBoat
   c. Turn on the boat PC
   d. Connect the shore PC to the boat PC using the Wifi antenna or using an ethernet cable (you can use that used for connecting the antenna to the shore PC)
   e. Connect the two devices using the remote desktop connection
   f. Connect a hard disc to the boat PC
   g. Follow this directory: Computer -> OS (C:) -> HyPACK 2018 -> Projects
   h. Search your projects and paste them on the hard disc
   i. Shut down the boat PC from the shore PC -> the remote connection will automatically end
   j. Turn off the PC lever on the aft of the EchoBoat to shut down all the electronic devices

3.4 OPTIONAL: RTK correction during survey

Two main solutions may be used (see "Applanix User guide" pag. 117):

⇨ Solution 1: use the VRS stations network of SwissTopo as dGPS base (it is necessary to have at its disposal a GSM connection via hotspot and a subscription to SwiPos GIS/GEO service to receive real time GPS corrections):

    a. Prepare the EchoBoat and connect the boat PC to the shore PC using the remote connection

    b. Connect the boat PC to internet using the GSM connection provided by a mobile device (your smartphone or the 4G Mobile Huawei device) through the hotspot service. If you use the Huawei device, please follow these specific steps:

- Long press the button in the middle of the device
- Two led will be light up indicating the status of the battery and of the connection (green = good; yellow = middle; red = bad)
- On the shore PC, search the network called "Swisscom"
- Enter the WiFi key 4r6r74hb
- You are now connected to internet
- **ATTENTION**: at the end of the survey remember to turn off the device (press again the button and check that the connection is no more availabe)

Note: the Huawei device contains a prepaid card. You can have 4G GSM data via WiFi for 24h for a price of 2 CHF/day. When you use the network, this cost will be automatically charged. The status of the credit could be checked using the "Swisscom cockpit".

To reload the credit, connect the device into the "Swisscom cockpit" (https://www.swisscom.ch/en/residential/mobile/subscription-tariffs/top-up-easy-credit.html) by entering the phone number of the card (079 691 19 95) and then choose the payment method that you wish.

    c. Open MV-POSView on your shore PC

    d. Tools -> NTRIP client (Figure 49)

Figure 49: NTRIP window of MV-POSView

e. Enter the information released by the NTRIP service provider
  - Server = www.swipos.ch
  - Port = 2101
  - Username = B1041
  - Password = 823566
  - Mountpoint = define the correction sources (generally is it better to use VRS-LV95-LHN95, table 1)

Table 1: Characteristics of the different mountpoints available on SwiPos

Stream	Position	Height	Format	Remarks
VRS-LV95-LHN95	LV95	LHN95	RTCM 3.1	Satellite systems: GPS/GLO No server-side transformation
VRS-LV03-LN02	LV03	LN02	RTCM 3.1	Satellite systems: GPS/GLO Real-time FINELTRA* und HTRANS**
VRS-LV95-LN02	LV95	LN02	RTCM 3.1	Satellite systems: GPS/GLO Real-time HTRANS**
MSM-LV95-LHN95	LV95	LHN95	RTCM 3.2 MSM4	Satellite systems: GPS/GLO/BDS/GAL No server-side transformation
MSM-LV03-LN02	LV03	LN02	RTCM 3.2 MSM4	Satellite systems: GPS/GLO/BDS/GAL Real-time FINELTRA* und HTRANS**
MSM-LV95-LN02	LV95	LN02	RTCM 3.2 MSM4	Satellite systems: GPS/GLO/BDS/GAL Real-time HTRANS**

* Approximate; mean FINELTRA transformation accuracy 2 cm (data set CHENyx06); map of transformation accuracy available under map.geo.admin.ch → LV95 Transformation accuracy

** Approximate; transformation accuracy a few cm.

ATTENTION: the options "Use POS position" and "Automatically select options" must be selected!

f. Press the "Connect" button. The LED on the bottom right side of the NTRIP window will turn green meaning that the Pico is receiving the corrections (Figure 49).

⇨ Solution 2: use a physical dGPS base (ex. Trible R10) installing the compatible rover on the EchoBoat
  a. Prepare the EchoBoat and connect the boat PC to the shore PC using the remote connection
  b. Install the dGPS rover antenna on the EchoBoat's aft (use an appropriate rod)
  c. Connect an RS232 output cable from the installed dGPS antenna and plug it to one of the Pico's topside RS232 COM Port (**ATTENTION**: use the COM 1, 2, 4 or 5 but never the 3!)
  d. Measure the distance between the rover and the IMU reference point and the dGPS rover antenna (see point 3.2.11 and Figure 21)
  e. Enter the new offsets for the dGPS rover antenna (Figure 50)
    - Setting
      - Installation
        - Lever Arms & Mounting Angles
          - Sensor Mounting tab
            - Ref. to aux 1 GNSS Lever Arm
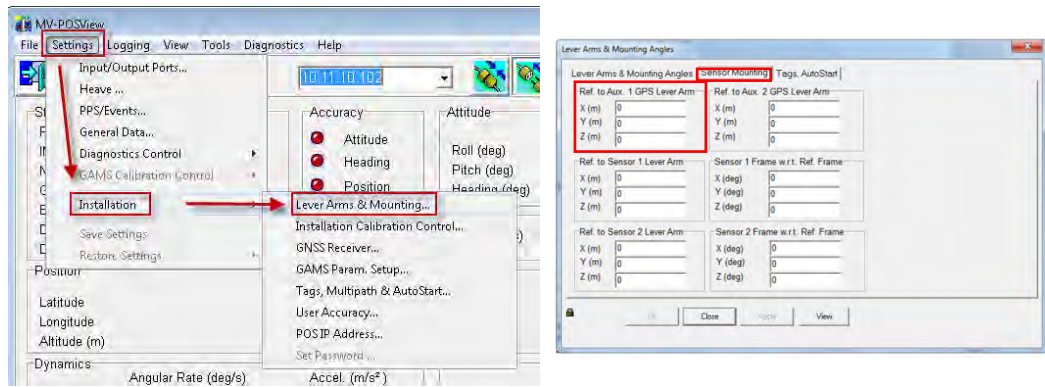
Figure 50: MV-POSView and settings location of the distance between the IMU and the dGPS rover

ATTENTION:
- A positive value for the X lever arm means the auxiliary GNSS antenna is forward of your reference point
- A positive value for the Y lever arm means the auxiliary GNSS antenna is to starboard of your reference point
- A negative value for the Z lever arm means the auxiliary GNSS antenna is above your reference point

f. Prepare the dGPS base and connect it to the rover
g. Open MV-POSView and conFigure it to receive corrections (Figure 51)
    - Settings
        - Input/Output Port
            - Choose the COM Port in which the RS232 output cable has been plugged
                - Input select = Aux 1 GNSS
                    - Aux GPS input = NMEA standard
                        - Baud rate = 38400
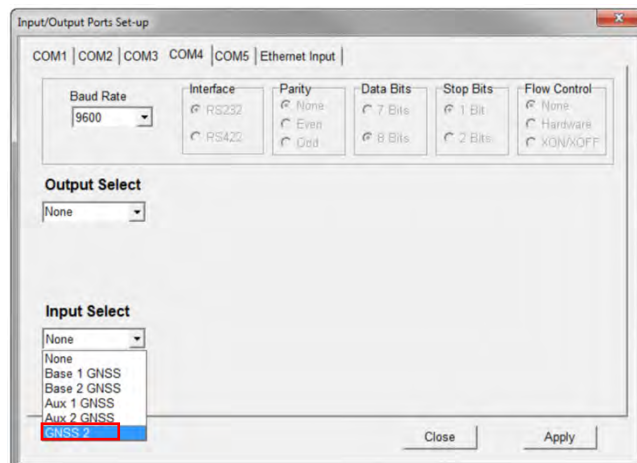
Figure 51: Input/Output Ports Set-up of MV-POSView

3.5 Schematics to aid deployment

3.5.1 Schematic view of the steps needed to power the EchoBoat
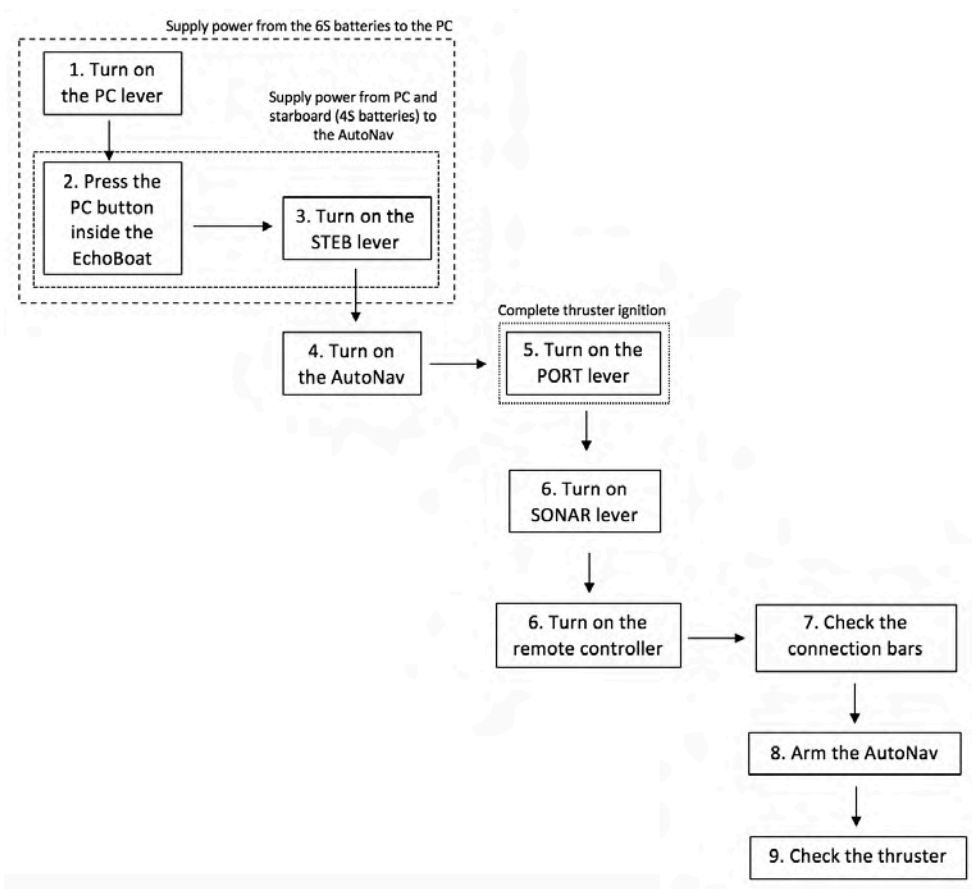
3.5.2 Schematic view of the steps for start a survey

1. Shore PC - - - - - - - →
a. Connect the Wifi antenna to the shore PC
b. Connect the shore PC to the EchoBoat using remote connection

2. MV-POSView - - - - - - - →
a. Press the "Connect" button
b. Check the alarms (the LEDs must be green)
       => if not, move the EchoBoat
c. Press the "NAV" button

3. HyPACK - - - - - - - →
a. Create a new project (or open an existing one)
b. Check the geodesy settings
c. Open the "HyPACK survey and HySWEEP survey"
       => check the alarms (they shall be green)
       => check the profile window -> if nothing is displayed change the beam frequency
       => determine matrix resolution

Put the EchoBoat in the water and arm the AutoNav

d. Start the survey
       => map the spatial limits of the surveyed area using the manual mode
       => map the area inside the limits using the automatic mode
          - draw one line using the "Cursor" mode of the Line editor
          - use the offsets button to generate multiple parallel lines
          - reverse the orientation of even lines
          - save the lines
          - open the "HyPACK survey and HySWEEP survey"
          - Press the start button on the Mavlink window

3.5.3 IP addresses relative to the different devices installed on the EchoBoat

- Devices on the boat:
    - PC ethernet port that MikroTik plugs into = 192.168.1.8
    - MikroTik = 192.168.1.20
    - PC ethernet port that Pico plugs into = 10.0.100.70
    - Applanix system (integrated into the Pico) = 10.0.100.121

- Shore PC:
    - PC ethernet port that MikroTik plugs into = 192.168.1.9
    - MikroTik = 192.168.1.21

4. Data post-processing guide on HyPACK

4.1 Download data from the boat PC and import it on your PC

1. Open the EchoBoat lid
2. Turn on the PC lever on the aft of the EchoBoat
3. Turn on the boat PC
4. Connect the shore PC to the boat PC using the Wifi antenna or the ethernet cable (that of the shore antenna)
5. Connect the two devices using the remote desktop connection from the shore PC
6. Connect a USB or a hard disk to the boat PC
7. Follow this directory: Computer -> OS (C:) -> HyPACK 2018 -> Projects
8. Search your projects on the "Project" folder of HyPACK and paste them on the hard disc
9. Shut down the boat PC from the shore PC: start -> shut down
10.   Turn off the PC lever on the aft of the EchoBoat
11.   Remove the HyPACK dongle from the boat PC and put it on your PC to pair the HyPACK software with his license

4.2 Data post-precessing and filtering on HySWEEP (with Patch Test done)

IMPORTANT: *If you haven't already done a Patch Test to calibrate your data from the angular errors linked to the EchoBoat's reel on the water, please first complete the activities in Chapter 4.3.* **The Patch Test is a very important operation to adjust your surveyed data**.

1. Connect the hard disc to the shore PC, or to a PC having HyPACK 2019 installed
2. Paste the project into the "Project" folder of HyPACK 2019 of your PC (directory: Computer -> OS (C:) -> HyPACK 2019 -> Projects)
3. Ensure that the HyPACK dongle is connected to the PC
4. Open HyPACK 2019 64-bit
5. Open the project that you want to work on (Figure 52)
   ⇨ Double right click on the name of the project in the "Project Files" list
   ⇨ The project name turns green, meaning the you are working on it
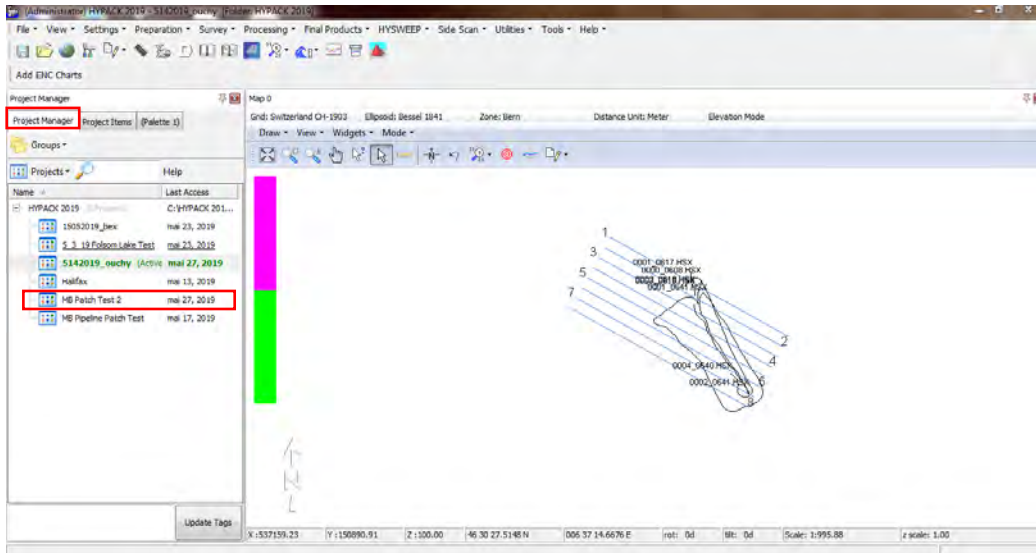
Figure 52: Determination of the project on HyPACK

6. On the "Raw Data Files" of the "Project Items" list select the lines/rows (*.HSX format) you want to clean (Figure 53)
   ⇨ You can process all the rows at the same time, or you can also do it with multiple sub-samples
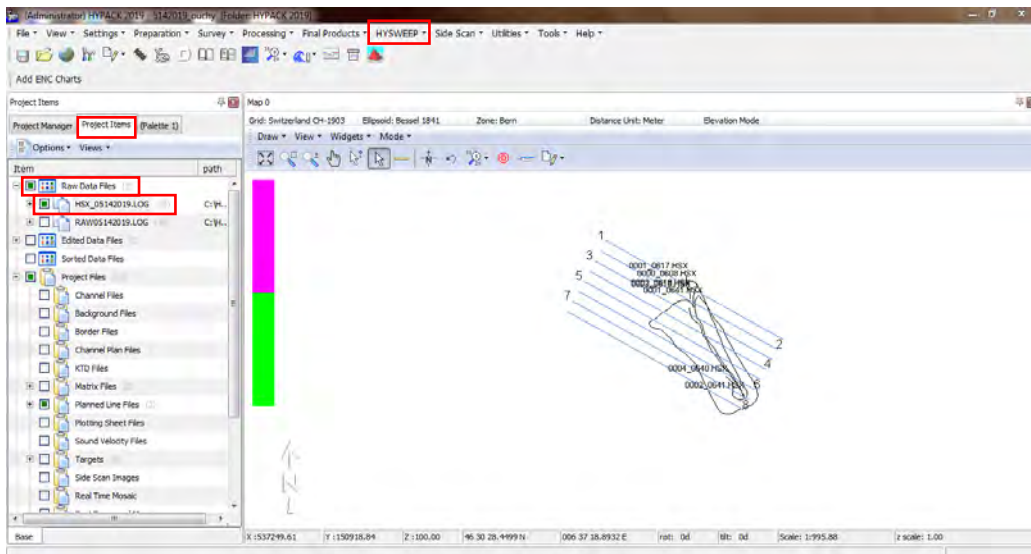
Figure 53: Lines selection in HyPACK

7. Open HySWEEP Editor (64 bit)
   ⇨ HyPACK 2019 main menu -> HySWEEP -> HySWEEP Editor 64bit (Figure 53)
   ⇨ A new window, called MBMAX64, will be displayed (Figure 54)
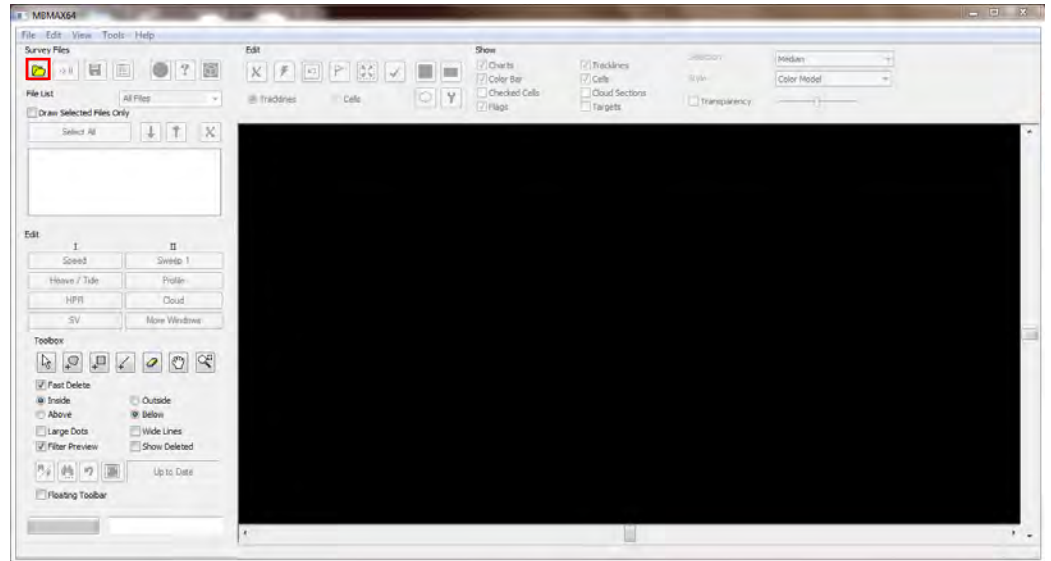
Figure 54: "Load survey" icon on MBMAX64 windows of HySWEEP

8. Load the survey in MBMAX64
   ⇨ Click on the yellow folder icon ("Load survey") (Figure 54)
   ⇨ On the "Open" window click the "Raw" folder (Figure 55A) and select the *.HSX format (Figure 55B)
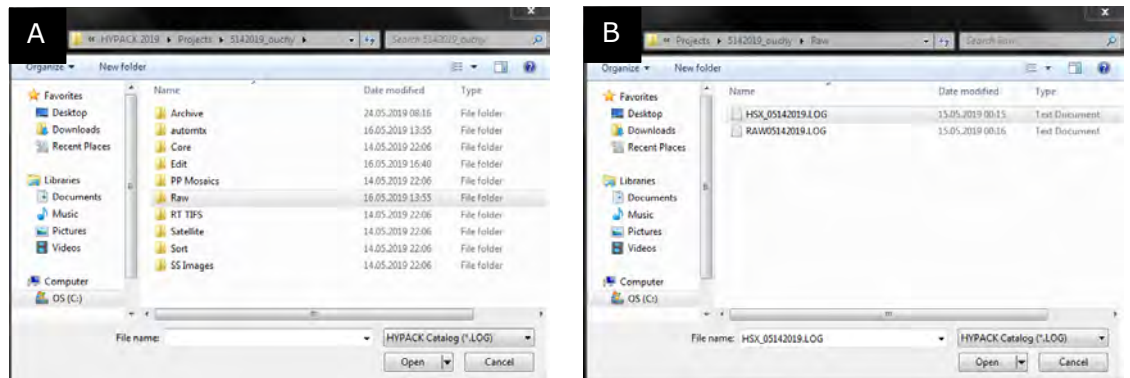
Figure 55: Load files on HySWEEP. The "Raw" folder (A) contains the HSX surveyed data (B)

   ⇨ Select the files (logged lines) that you want to import on HySWEEP (CTRL + right click) (Figure 56)
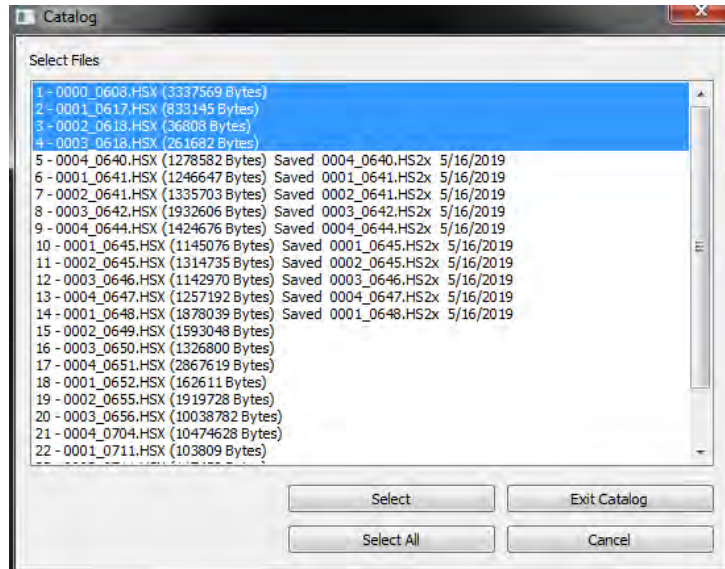
Figure 56: Determination and loading of the logged lines in MBMAX64

9. The "Read Parameters" window will appear
   ⇨ "Survey" tab (Figure 57)
      - Select "Depth Mode" as survey mode
      - Check the "Matrix" values (clicking "Edit" is it possible to modify the resolution) -> Choose "Auto Cell Size" to use the cell size determined during the survey, or input the resolution that you want)
      - Ensure that "Auto Stage 2" is selected on the "Auto Processing" list
      - **IMPORTANT**: Check the "Memory Test" (pay attention that the Required Memory is not too high. If needed, manually change it setting a value around 20 MB (as recommended!).
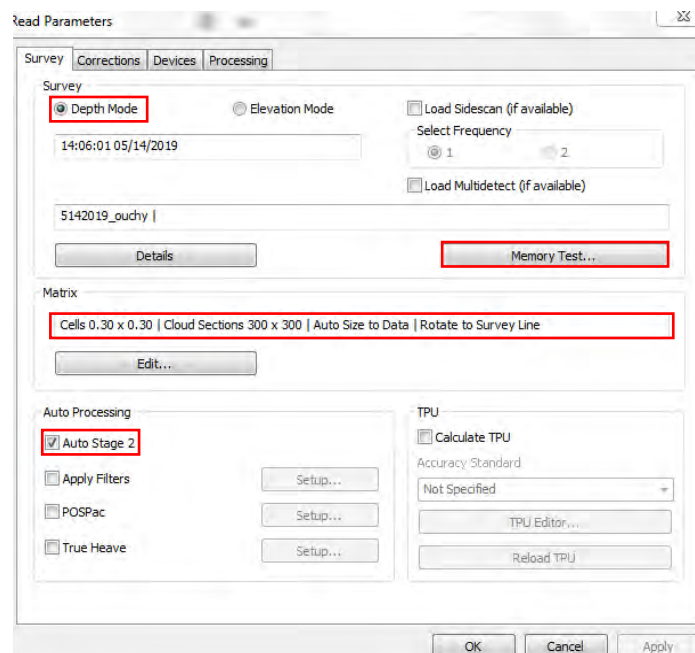
Figure 57: Important parameters to check on the "Survey" tab

45

⇨ "Corrections" tab (Figure 58)
- This section enables you to apply tide and sound velocity corrections to your bathymetric data
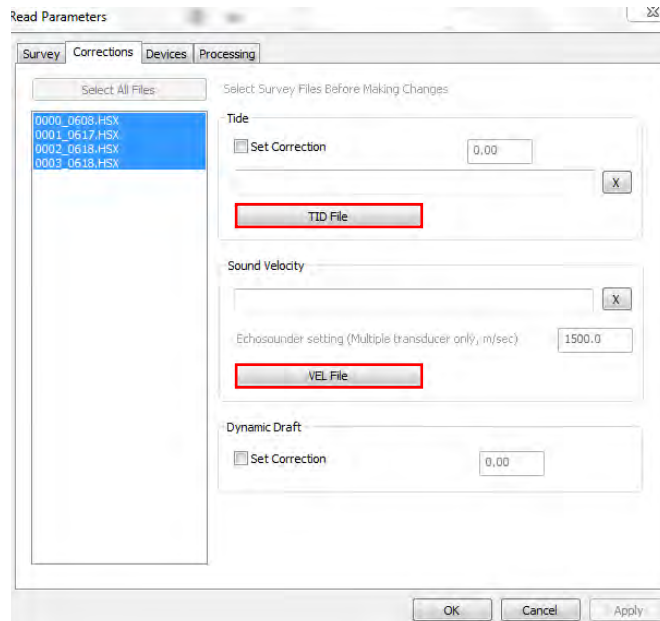
Figure 58: Load correction files on the "Corrections" tab

⇨ "Devices" tab (Figure 59)
- Check that "Sonar Head 1" have the corrected offsets between the primary GPS antenna and the Pico reference point. Edit it if necessary.
- **ATTENTION**: MV-POS -> X= forward; Y = vertical
  HyPACK -> X = vertical; Y = forward
- Check the "Patch Test" values.
- The different parameters (GPS Latency, Yaw, Pitch and Roll) should be already be set with the values determined during the last Patch Test. If not, search the good values on the Patch Test Diary (chapter 5), or on the Patch Test History ("Edit" button), and manually insert them (clicking on "Edit").
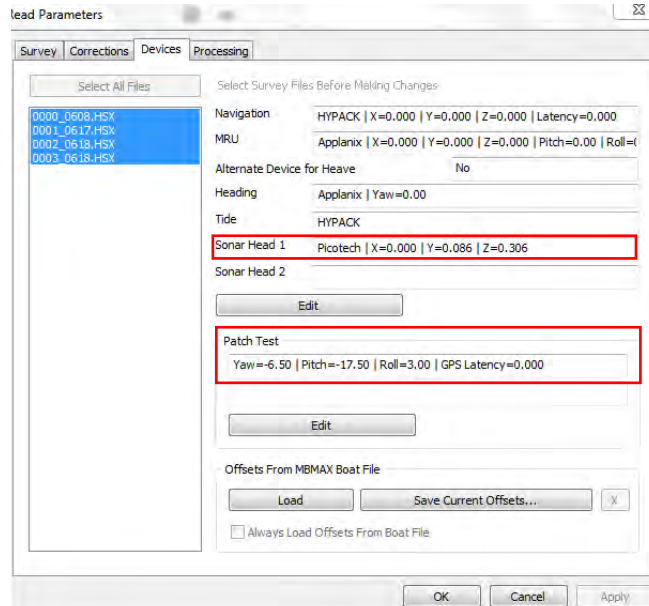
Figure 59: Important parameters on the "Devices" tab

10. Press "OK" to complete the loading process
11. The 3D bathymetric model will appear on the MBMAX64 main window (Figure 60)
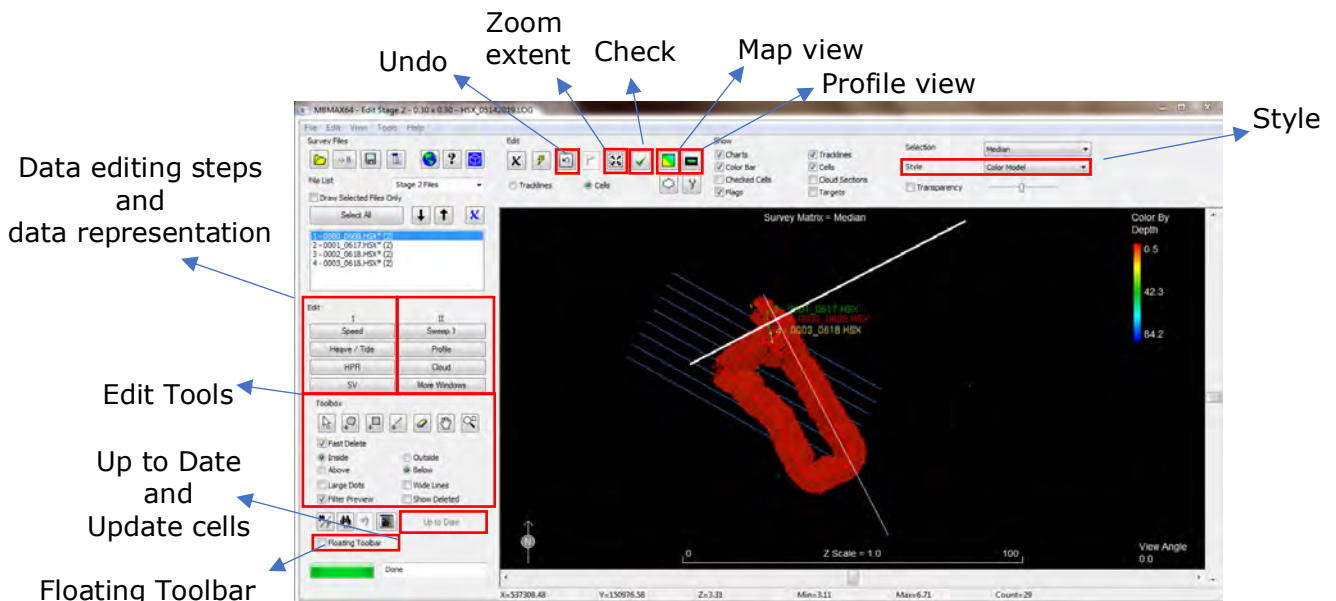
Figure 60: MBMAX64 window, 3D model and principal edit tools

⇨ Important tools (Figure 60)
- Zoom extent = draws the 3D model at a zoom scale that displays all enabled data
- Map View = change the 3D model view orthogonally to the displayed data (remove the oblique view)
- Profile View = set the view laterally of the displayed data
- Show list = type of data displayed (ensure that the option "cells" is selected to see the logged data)

- Style = choose the data representation mode
- Edit Tools = tools to move the 3D data model on the space and to edit/filter noise data
    - Measure tool = click and drag this tool between two point and the status bar displays measurements relevant to the position, distance and direction of the measurement
    - Lasso select = defines a free-form area for use with delete and filter operations
    - Block select = defines a rectangular area for use with delete and filter operations
    - Line select = defines a straight line across your data for use with delete and filter operations
    - Eraser = delete small, square areas of data at a time
    - Tilt and rotate = see the data from any angle (click and drag in the data display); left-click to move the displayed data without applying any rotation
    - Zoom Window = drag a rectangle in the window to define the extent of your desired view
12. The filtering operations are conducted through two different stages ("Edit" list)

IMPORTANT: after editing, the "Update Cells" button turns red (Figure 60). Always click on it to save and update modifications to your data! If you are working on a large dataset, you may choose to do multiple edit operations and recalculate only once to account for all changes at once. During the editing process, to undo the erasure, press the "Undo" button or use CTRL+Z.

⇨ Stage I (Figure 60): stage I editing includes several display windows allowing correction of position data (Speed velocity, Heave/tide, Heave Pitch Roll [HPR] and Sound velocity [SV]).
To delete erroneous data from the graph, select the tool on the "Edit Toolbox" list (Lasso, Block, Line or Eraser), select the area that you want to delete (in reference to the drawn area) and drag the form on the graph. At this stage, there is not a real rule defining the erroneous data; in general, it is appropriate to delete the spikes!
⇨ Stage 2: stage II is where you clean most of the bad/noise data. There are two main ways to clean the soundings:
    1. Automatic
        a. Right click on the MBMAX64 main window
        b. Select the "Search and Filter Options" tab
        c. Select the "Basic" tab and choose the filter you want to use (Range, Corrected Depth or Elevation,…). The filter will delete all point that fall outside the filter limits.

d. On the "Actions" tab, select the lines to which the filter should be applied ("All files" = the entire dataset; "Selected files" = selected lines on the file list)

e. All deleted point will be displayed in yellow

f. **ATTENTION**: Automatic filtering is fast, but it can also be dangerous as is purely statistical based! Use with caution!!

2. Manual

a. Manual processing gives you full control in cleaning your data. This procedure allows you to scroll through your data and view them from different angles/zooms, in order to take yours editing decisions.

b. The "Sweep 1", "Profile", "Cloud" and "More Windows" buttons allow you to display the data in different ways (Figure 60). The entire dataset is displayed on several sections; you can scroll within the different sections and lines using the arrows during the cleaning operations. To check the location of a determined section, look at the white lines on the 3D model.

c. Instructions:

- Click with the cursor at the beginning of the 3D model.

- In each section use the editing tools to remove any noise (click on the "Floating toolbar" option to have the editing tools on a separate window; Figure 60). Use the "Tilt" and "Rotate" tools to move the 3D model on the space. Press CTRL + Z to undo the editing operations.

- When each section is clean, press the "Checked" icon to confirm that the section has been reviewed (optional, but very useful to track editing progress).

- Scroll to the next section (Figure 61).

- Once all the sections of a single line have been cleaned, skip to another line (Figure 61).

- Save the edited data using the red "Update Cells" button (Figure 60). Do it periodically to preserve your work.

d. In order to assure that you have reviewed all of your data, you should choose a methodical order to follow ("edit, check, scroll and, once the line is finished, skip line and repeat")

Change section   Change line
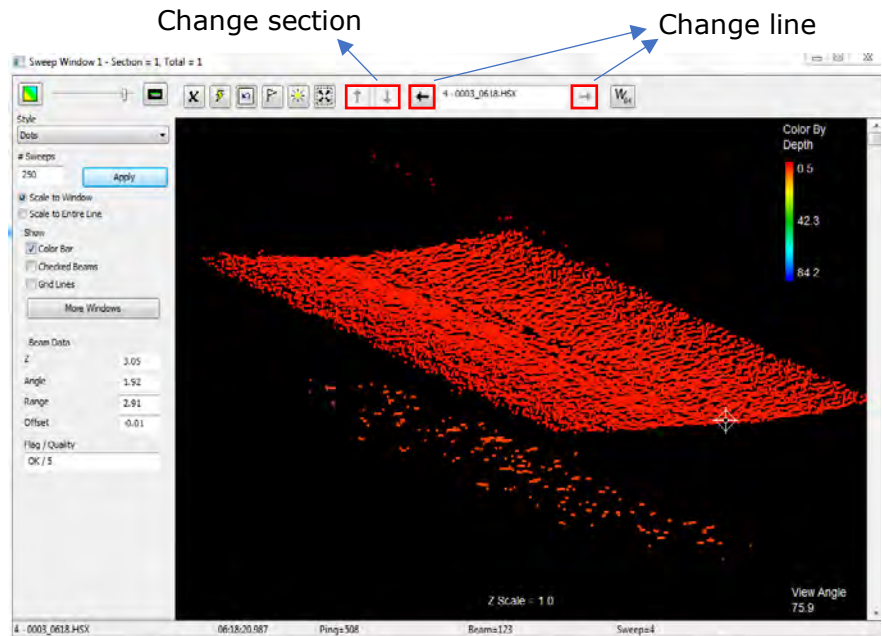
Figure 61: Sweep 1 window and change section/line buttons

13. Once you have reviewed and cleaned all of your data, save the edited rows
   ⇨ File -> Save Survey (Figure 62)
   Use "Save All files" to save the entire edited dataset or "Save Selected Files" to save only specific lines.
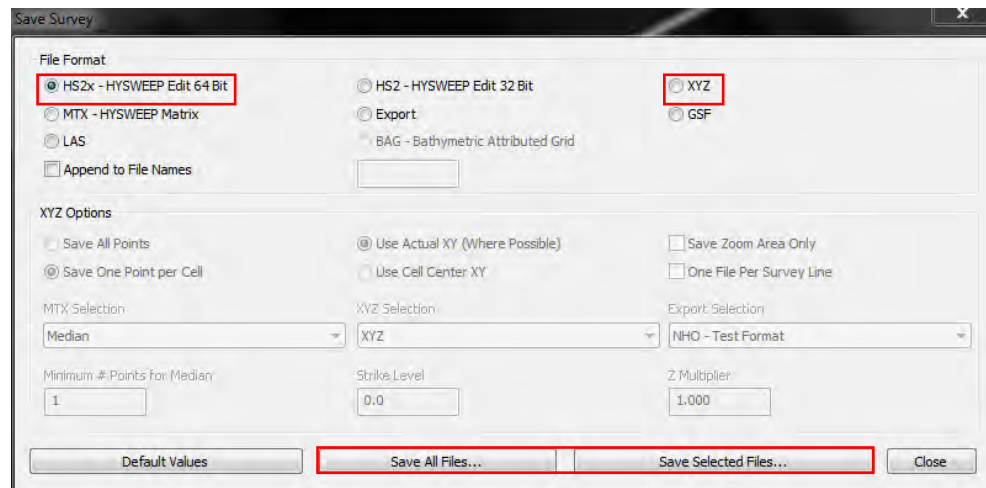
Figure 62: HySWEEP saving formats

   ⇨ Choose the HS2x file format to save your data on the edited format of HySWEEP (the edited rows will be stored on the "Edited Data Files" folder in the "Project Items" list of HyPACK 2019; the original data without any modifications are still stored on the "Raw Data Files" folder on the *.HSX format).
   ⇨ Choose the XYZ file format to export the edited data on another software, as Matlab or ArcMap.

On the "Save survey" window, make sure to select "Save One Point per Cell" and "Median" as MTX selection on the "XYZ Options" list.

The *.XYZ file will be saved on the "Sorted Data Files" folder in the "Project Items" list of HyPACK 2019; if you don't see your file on the list: right click on "Sorted Data Files" tab -> Add File -> search your *.XYZ file.

4.3 Patch Test on HySWEEP

The Patch Test is a data collection and processing procedure to calibrate the angular mounting components (GPS Latency, Roll, Pitch, and Yaw) of multibeam systems. It is a fundamental process to determine the correction values for the logged bathymetric data. Errors in these measurements can lead to systematic error propagation into DEM.

Angular components and errors (Figure 63):
- Latency = delay between position fix and data arrival time which can cause positional errors. **N.B.:** During the Patch test you could also skip the analysis of this parameter as the latency error is less important using the today's modern equipment.
- Roll = vertical misalignment, port and starboard, between sonar and MRU can cause depth errors, especially at the outer beams.
- Pitch = vertical misalignment, forward and aft, between sonar and MRU can cause depth and position errors across the swath.
- Yaw = misalignment of the sonar and gyro relative to the boat frame can cause position errors.
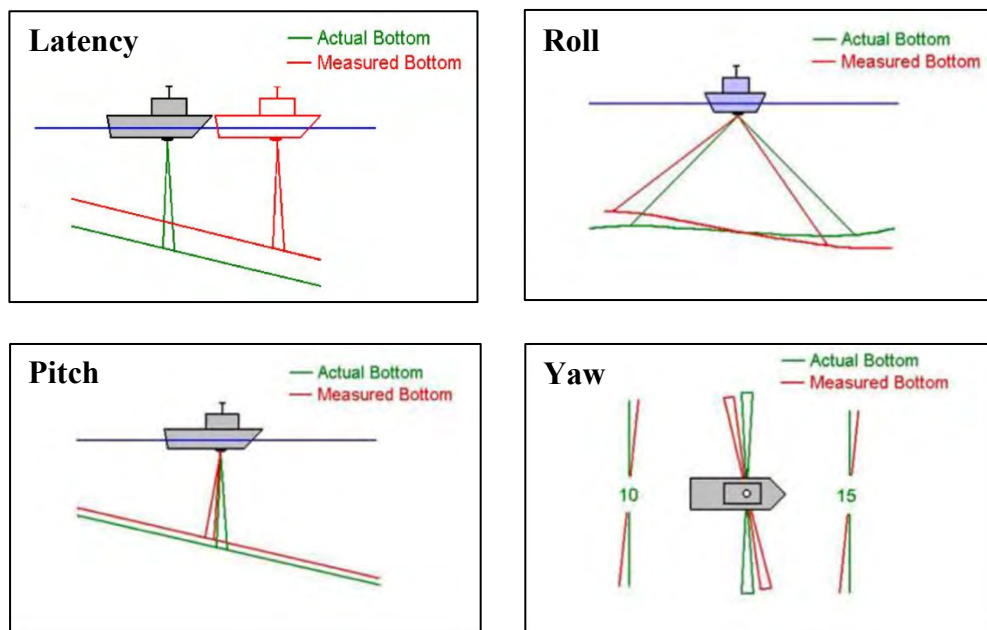
Figure 63: Angular components and related errors

IMPORTANT:

- It is not necessary to do a Patch Test every time a survey is performed (do it only in case of modifications on the structure of the EchoBoat; ex. disassembly for transportation or maintenance). Nevertheless, it is highly recommended to do periodically a Patch Test to check the correction values.
- Since in HySWEEP the calibration of one offset will affect the result of subsequent tests, you should process each pair of test lines separately following the Latency, Roll, Pitch and Yaw order. Save the results of one test and then load the next pair of lines applying the offsets calculated thus far (this is usually a good thing to do).

Patch Test Steps:

1. In the field
    a. Collect some data on the prescribed pattern for every parameter (Figure 64)
       You can do it manually or editing the EchoBoat's lines ("Line Editor") and then log data using the mission mode (point 3.3.9b). Patch Test data could be collected on a single new project or on multiple projects, one for each parameter.

Parameter	EchoBoat lines and bottom topography	Survey characteristics
Latency		- Flat bottom to an object or sloped bank feature - Same direction line - Unequal survey speed
Roll		- Flat deep bottom - Opposite lines - Same survey speed
Pitch		- Flat bottom to an object or sloped bank feature - Opposite lines - Same survey speed
Yaw		- Flat bottom to an object or sloped bank feature - Parallel lines that are run in the same direction - Overlap needed - Same survey speed

Figure 64: Patch Test lines and bottom characteristics for each parameter

b. Fill the Patch Test table shown in Chapter 5. Pay attention to correctly indicate the name/number of the row. This information is displayed on the "Data display" window in HySWEEP (Figure 40).

2. On HyPACK
   a. Load the specific lines with the relative bathymetric data.
      ⇨ Paste the project(s) on the "Project" folder of HyPACK 2019 64-bit
      ⇨ Open the project that you want to use for the Patch Test (one project having all the parameters or one project for each parameter)
      ⇨ Double left-click on the name of the project in the "Project Files" list. The project name turns green, meaning that you are working on it (Figures 33 and 52)
      ⇨ On the "Row Data Files" of the "Project Items" list select the test lines/rows (*.HSX format) you want to use (Figure 53)
   b. Clean data from noise
      ⇨ Follow the chapter 4.2
      ⇨ Carry out the operation for the data relative of all parameters. Before to proceed with the Patch Test the bathymetric data **must** be cleaned from noise in order to extract the right adjustment values!
   c. Load the bathymetric data relative to a single parameter
      ⇨ Open HySWEEP Editor 64 bit (HyPACK 2019 main menu -> HySWEEP -> HySWEEP 64 bit; Figure 53 and 54)
      ⇨ The MBMAX64 window will be displayed (Figure 54)
      ⇨ Load the surveyed data relative to a determined parameter clicking the yellow folder inside the "Survey Files" menu (step 4.2.7 and 4.2.8). As you have already cleaned your data, you may search the rows on the "Edit" folder (*.H2Sx format).
         ATTENTION: Load and perform the Patch Test for one parameter at a time following the **Latency, Roll, Pitch and Yaw order**! The calibration values calculated from each test can be applied to each subsequent test for better result!
      ⇨ Select the files relative to a single parameter (CTRL+click).
         ATTENTION: On the "Read Parameter" window ("Devices" tab), the Patch Test values should be zero (Figure 59)! If not, manually change these settings.
   d. Perform the Patch Test for a determined parameter
      ⇨ Click the "A-B Cross Section and Patch Test" button (wrench icon; red square on Figure 65)

Patch Test

Remove files
from survey
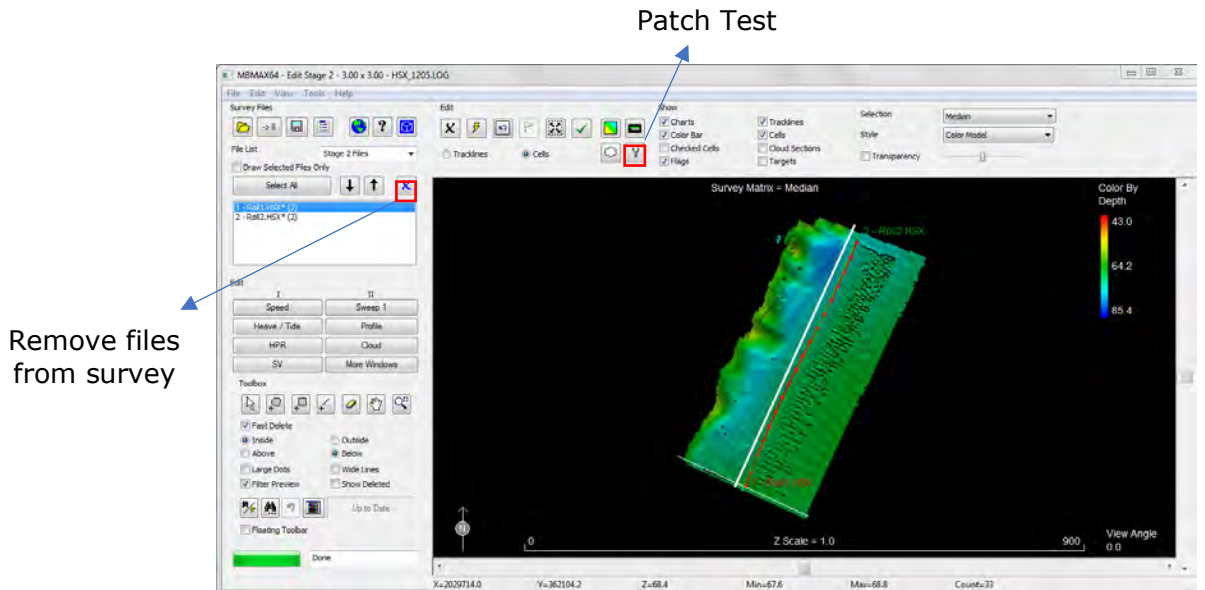
Figure 65: "Patch Test" tool and "Remove file from survey" icon on the MBMAX64
window

⇨ Drag the cursor across your data cutting the section that
you need. For every parameter you have to select a
different transect of the surveyed area that, in addition to
take into account the bathymetric characteristics of the
bottom (Figure 64), should intersect the two sampled lines
in a different way (Figure 66).
ATTENTION: it is also possible to do a Patch Test using a
complete transect on the surveyed data (choose the "Patch
Test" option from the "Tools" tab). This solution is usually
not recommended as the morphology of the bottom play an
important role. Nevertheless, this option could give a first
overview of the correction needed.
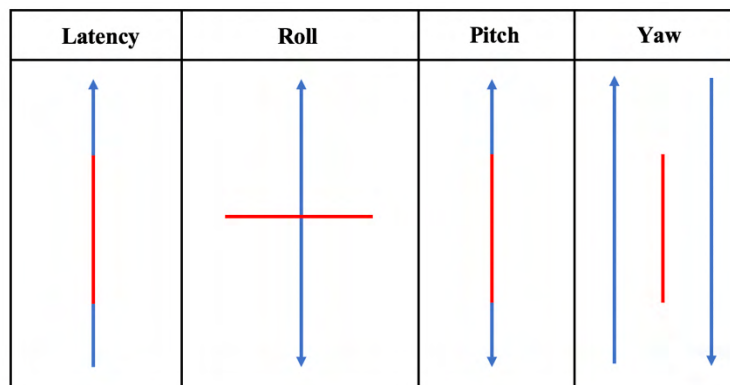
Figure 66: Patch Test' sections (red lines) for each parameter in
reference to the test lines (blue lines)

⇨ The Patch Test window will appear displaying the selected test data
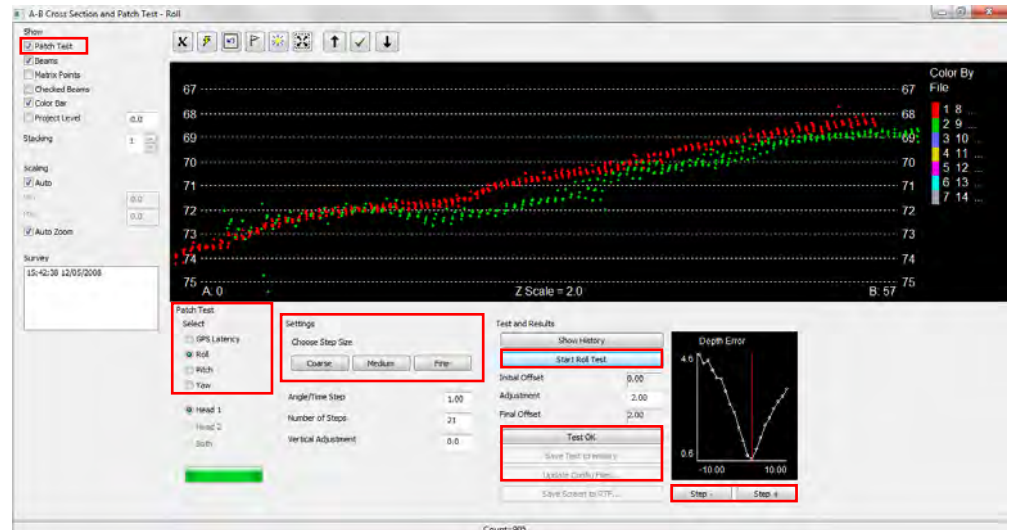
Figure 67: Patch Test window

⇨ For every parameter of the Patch Test do the following (Figure 67).
  • Make sure that on the "Show" tab the "Patch Test" option is selected
  • On the "Patch Test" tab, select the test that you want to run (Latency, Roll, Pitch or Yaw).
  • Run the test with different adjustment settings clicking on the "Coarse", "Medium" and "Fine" tabs. Start with the "Coarse" one.
    For every tab, there are different settings ("Angle/time steps" and "Number of steps") with suggested values that you can modify if you wish.
  • Click "Start Test". The software will calculate the adjustment needed to overlap the two sampled data. You can increase the accuracy of their overlap using the "Step-" and "Step+" buttons. **IMPORTANT**: the plot showing the depth error should be U-shaped.
  • Repeat the operation for the "Medium" and "Fine" adjustment settings. Once the test data are correctly overlapped, and you are satisfied of the correction, click the "Test OK" button.
  • To save the final Patch Test value ("Adjustment" value) for a determined parameter, press the "Save Test to History" button (save the value on the HySWEEP's Patch Test records) and then press also the "Update Config Files…" button to apply the calculated values to the subsequent loaded data.
  • Apply the adjustment to the data using the red "Up to Date" button!

- To have a more accurate adjustment value, it is recommended to perform two time the Patch Test for each parameter (if it possible in different locations), and then consider the averaged value.
- **Do not forget to fill the Patch Test diary with the found values!**

e. Repeat the Patch Test for the other three parameters (Roll, Pitch and Yaw)

  ⇨ To load the data relative to another parameter: File -> Add Files -> search the files that you need.
  ATTENTION: ensure that the "Read Parameter" window, the "Patch Test" tab show the adjustment value for the parameter just examined. If you want to use the averaged value, you may manually insert it using the "Edit" button.

  ⇨ To delete the files relative to the previous parameter, select them (CTRL+right click) and then click the blue cross icon (Figure 65)

  ⇨ Repeat the Patch Test's operations (points 4.3.2b to 4.3.2d)

5. Patch Test diary

Figure 68 shows the EchoBoat's survey trajectories and bottom bathymetry needed to carry out an accurate Patch Test (for further information refers to chapters 3.2 and 4.3). The Patch Test data should, if possible, be recorded in the deeper region of the surveyed area.

Parameter	EchoBoat lines and bottom topography	Survey characteristics
Latency		- Flat bottom to an object or sloped bank feature - Same direction line - Unequal survey speed
Roll		- Flat deep bottom - Opposite lines - Same survey speed
Pitch		- Flat bottom to an object or sloped bank feature - Opposite lines - Same survey speed
Yaw		- Flat bottom to an object or sloped bank feature - Parallel lines that are run in the same direction - Overlap needed - Same survey speed

Figure 68: EchoBoat's lines and bottom's characteristics to perform an accurate Patch Test

Instructions:

1. Usually, if the structure of the EchoBoat is not modified, it is not necessary to carry out a Patch Test as the right adjustment values to correct the Roll, Yaw and Pitch orientation of the EchoBoat are already loaded in HySWEEP. Nevertheless, it is recommended to lead a Patch Test with regularity.
2. Every time a Patch Test is conducted, please fill the below table with the appropriate information in order to have a history relative to the time between each Patch Test and the evolution of the adjustment values.
3. On the Patch Test table, the information within the solid bold lines are to be filled during the survey, while those within the dashed lines are to be completed during the post-processing when the Patch Test will be performed on HySWEEP in order to determine the adjustment values.
4. The table should be available at any time. Please reprint it once filled!

Parameter	Date	Project name	Rows (# or name)	Time (start/end)	Observations	Calculated values	Average value
Latency							
Roll							
Pitch							
Yaw							
Latency							
Roll							
Pitch							
Yaw							
Latency							
Roll							
Pitch							
Yaw							

N.B. Please reprint this table once completed!

6. EchoBoat fieldwork: brief summary

1. Open the EchoBoat lid
    => plug the batteries and the HyPack dongle on the PC
    => ensure that all cables are correctly plugged
2. Put the EchoBoat in the water
3. Install the two fins on the oft of the EchoBoat
4. Turn on the PC lever
    => tone from the boat
5. Turn on the boat PC
    => tone + lights
6. Turn on the STARBOARD lever
7. Turn on the AutoNav
8. Turn on the PORT lever
9. Turn on the SONAR lever
    => turn it on only when the EchoBoat is in the water! If you need to it on
    when the boat is outside the water, ensure that the beam frequency is 1
    Hz
10. Install the Huawei mobile WiFi on the mast
    => put the modem on a grip bag to avoid water infiltration and tie it to
    the mast using some tape
    => press the button to turn it on
11. Turn on the remote controller
12. Arm the AutoNav
    => ATTENTION: arm it only in a safe location (in case that a mission has
    to be aborted)
    => flip down the arm/disarm lever towards the operator + flip up the
    safety for 3 seconds
    => tone from the boat
13. Close the EchoBoat's lid
14. Prepare the shore PC station
    => connect the shore antenna to the shore PC using the ethernet port
    => connect the shore antenna and the shore PC's power supply to the
battery
    => connect the shore PC to the EchoBoat using the remote connection
        - username = EchoBoat
        - password = Seafloor
    => check the connection bars on the antenna
    => connect to the Wifi
        - network: Swisscom-E5573-020A
        - password: 4r6r74hb
15. Open MV-POSView
    => wait until the IP address is displayed (Pico/sonar is connected to the
    boat PC), then press the CONNECT button
    => check the ACCURACY alarms => if the alarms are not green,
    manually move the boat
    => press the NAV button
    => RTK:

     - Tools -> NTRIP client

     - server = www.swipos.ch

     - port = 2101

     - username = B1041

     - password = 823566

     - Uncheck "Automatically Select Options"

       -> click on "Request Options"

         -> use the dropdown menu and select the correction
         stream "VRS_GISGEO_LV95LHN95"

           -> press on "Connect"

   => Check the total number of satellites connected to the Echoboat (View
  -> GNSS data). They must be between 15 and 20 satellites.

   => Look if the clock in MV-POSView is synchronized with the boat PC's
  clock (the maximum delay have to be of maximum 1 second). If not,
  manually change the boat PC. For a correct synchronization is it
  recommended to undertake a remote connection using an ethernet
  cable.

16. Open HyPACK

   => create a new project

   => check the GEODESY

   => check the HARDWARE settings

   => SURVEY -> "HyPACK survey and HySWEEP survey" (from the
  "Survey" tab)

     - look at the alarms on the SURVEY window

     - change the beam FREQUENCY + swath depth and width (c. 1.5 x
    depth) (Tools -> PicoTech controller)

     - determine the MATRIX and select "average depth" and "while
    logging"

     - The number of satellites connected to the EchoBoat is displayed
    on the "Data Display" window

     - Before to record data, wait until the "NO SYNC" alarm is gone

   => use the START/STOP LOGGING button to record sounding data

17. Plan a mission

   => Close the "HyPACK survey and HySWEEP survey"

   => HyPACK

     - Line editor

       - Cursor button -> draw line

         - Offsets button -> add additional lines (N.B. modify
         the single length moving their edges)

           - Reverse their orientation (CTRL + right click)

             - Save (from the "File" tab)

   => Select the lines from the "Planned lines files" folder

   => Open "HyPACK survey and HySWEEP survey"

     - MAVLINK => Start Mission

     - For every line, press the START LOGGING button to produce
    several rows

- At the end of the mission switch the manual/autonomous mode to autonomous and then again to manual to take control of the Echoboat.

18. At the end of the survey
=> Turn down the beam frequency to 1 Hz
=> Close HySWEEP survey to save the logged data
=> Shut down the boat PC from the shore PC
=> Turn off the thrusters (PORT and STARBOARD levers)
=> Turn off the SONAR and the PC lever
=> Open the lid and turn off the AutoNav

19. Download data (the shore PC must be connected to the boat PC via remote connection!)
=> plug an USB key (or a hard disk) on the boat PC
=> Computer -> OS(C:) -> Hypack -> projects
=> search for your project into the folder
=> copy it and paste it on your USB key
=> shut down the boat PC from the shore PC and turn off the PC lever on the aft of the EchoBoat

7. Annex

1. Mountpoints characteristics

Empfängerseitige Einstellungen / Configuration côté récepteur

Parameter Paramètre	Swipos Dienst **LV95 und LHN95** Service swipos **MN95 et RAN95**	Tabelle 1: Empfängerseitige Einstellungen bei Verwendung des Dienstes LV95 und LHN95 (VRS_GISGEO_LV95LHN95)
Datum / Date	Transformationsparameter / Paramètres de transformation CHTRS95 →CH1903+ $X_{1903+} = X_{CHTRS95} - 674.374$ m $Y_{1903+} = Y_{CHTRS95} - 15.056$ m $Z_{1903+} = Z_{CHTRS95} - 405.346$ m	
Projektion Projection	Schweizer Projektion **LV95** (mit 1'200000 und 2'600000 Offset) Projection Suisse **MN95** (avec offset 1'200000 et 2'600000)	Tableau 1: Configuration côté récepteur dans le cas de l'utilisation du service MN95 et RAN95 (VRS_GISGEO_LV95LHN95)
LSKS / SCSP	Kein / Aucun	
Geoid / Géoïde	CHGeo2004	

Parameter Paramètre	Swipos Dienst **LV03 und LN02** Service swipos **MN03 et NF02**	Tabelle 2: Empfängerseitige Einstellungen bei Verwendung des Dienstes LV03 und LN02 (VRS_GISGEO_LV03LN02)
Datum / Date	Transformationsparameter / Paramètres de transformation CHTRS95 →CH1903+ $X_{1903+} = X_{CHTRS95} - 674.374$ m $Y_{1903+} = Y_{CHTRS95} - 15.056$ m $Z1903+ = ZCHTRS95 - 405.346$ m	
Projektion Projection	Schweizer Projektion **LV03** (mit 600000 und 200000 Offset) Projection Suisse **MN03** (avec offset 600000 et 200000)	Tableau 2: Configuration côté récepteur dans le cas de l'utilisation du service MN03 et NF02 (VRS_GISGEO_LV03LN02)
LSKS / SCSP	Kein / Aucun	
Geoid / Géoïde	CHGeo2004	

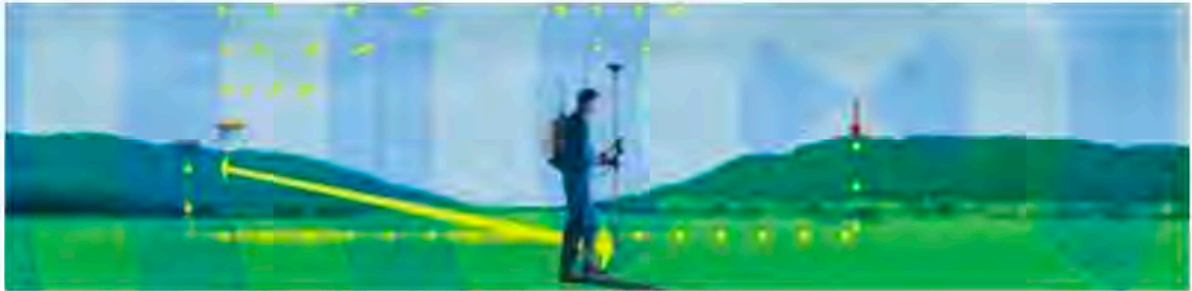| Parameter Paramètre	Swipos Dienst **LV95 und LN02** Service swipos **MN95 et NF02**	Tabelle 3: Empfängerseitige Einstellungen bei Verwendung des Dienstes LV95 und LN02 (VRS_GISGEO_LV95LN02)
Datum / Date	Transformationsparameter / Paramètres de transformation CHTRS95 →CH1903+ $X_{1903+} = X_{CHTRS95} - 674.374$ m $Y_{1903+} = Y_{CHTRS95} - 15.056$ m $Z_{1903+} = Z_{CHTRS95} - 405.346$ m	
Projektion Projection	Schweizer Projektion **LV95** (mit 2'600000 und 1'200000 Offset) Projection Suisse **MN95** (avec offset 1'200000 et 2'600000)	Tableau 3: Configuration côté récepteur dans le cas de l'utilisation du service MN95 et NF02 (VRS_GISGEO_LV95LN02)
LSKS / SCSP	Kein / Aucun	
Geoid / Géoïde	CHGeo2004	

2. Configuration of the rover using the SwiPos GIS/GEO service

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Defence,
Civil Protection and Sport DDPS

Federal Office of Topography swisstopo

Service swipos – GIS/GEO

Access

Server	www.swipos.ch
Port	2101
Protocol	NTRIP
Data format for approximate position (→ VRS)	NMEA (GGA)
Mountpoints	VRS_GISGEO_LV95LHN95
	VRS_GISGEO_LV03LN02
	VRS_GISGEO_LV95LN02
	MSM_GISGEO_LV95LHN95
	MSM_GISGEO_LV03LN02
	MSM_GISGEO_LV95LN02

Data formats

Stream	Position	Height	Format	Remarks
VRS-LV95-LHN95	LV95	LHN95	RTCM 3.1	Satellite systems: GPS/GLO No server-side transformation
VRS-LV03-LN02	LV03	LN02	RTCM 3.1	Satellite systems: GPS/GLO Real-time FINELTRA* und HTRANS**
VRS-LV95-LN02	LV95	LN02	RTCM 3.1	Satellite systems: GPS/GLO Real-time HTRANS**
MSM-LV95-LHN95	LV95	LHN95	RTCM 3.2 MSM4	Satellite systems: GPS/GLO/BDS/GAL No server-side transformation
MSM-LV03-LN02	LV03	LN02	RTCM 3.2 MSM4	Satellite systems: GPS/GLO/BDS/GAL Real-time FINELTRA* und HTRANS**
MSM-LV95-LN02	LV95	LN02	RTCM 3.2 MSM4	Satellite systems: GPS/GLO/BDS/GAL Real-time HTRANS**

* Approximate; mean FINELTRA transformation accuracy 2 cm (data set CHENyx06); map of transformation accuracy available under map.geo.admin.ch → LV95 Transformation accuracy

** Approximate; transformation accuracy a few cm.

Rover configuration

Mountpoints	Datum (CHTRS95 → CH1903+)	Projection	CSCS	Geoid
VRS_GISGEO_LV95LHN95 VRS_GISGEO_LV95LN02 MSM_GISGEO_LV95LHN95 MSM_GISGEO_LV95LN02	$X_{1903+} = X_{CHTRS95} - 674.374$ m $Y_{1903+} = Y_{CHTRS95} - 15.056$ m $Z_{1903+} = Z_{CHTRS95} - 405.346$ m	Swiss Projection LV95 (with 2'600'000 and 1'200000 offset)	None	CHGeo2004
VRS_GISGEO_LV03LN02 MSM_GISGEO_LV03LN02	$X_{1903+} = X_{CHTRS95} - 674.374$ m $Y_{1903+} = Y_{CHTRS95} - 15.056$ m $Z_{1903+} = Z_{CHTRS95} - 405.346$ m	Swiss Projection LV03 (with 600'000 and 200'000 offset)	None	CHGeo2004

Measuring accuracy

Horizontal (2 Sigma, 95%)	2 cm
Vertical (2 Sigma, 95%)	4 cm

Remarks

- Accuracy specifications based on the mean yearly standard deviations of the monitoring station results at swisstopo.
- Measuring accuracy may vary in time, locally and in function of atmospheric influences.
- As far as possible a minimal observation time of 10s per point should be maintained and measurements should periodically be controlled on a well-known ground marker.

Availability

The service is monitored only during the official office hours of swisstopo. There is no warranty for a continuous and error free operation of the service.

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