RTI Direct Reading

User Guide

Revision 5

Version 1.0 – Feb. 12, 2020

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1. Introduction

RTI Direct Reading (DR) is the supporting software to the RTI's 3rd generation ADCP3 systems. The RTI-DR is a PC program providing real-time user interface to RTI's direct reading ADCPs, through a cable between ADCP and PC. The ADCP has the additional capability to operational from external power and to receive data from external devices. The software supports a wide variety of ADCP deployments including surface and subsurface fixed or moving platforms.

The RTI-DR program provides a user interface for communicating with and configuring an ADCP, deploying the system, real-time data collection, data processing and display using RTI's advanced ADCP3 platform. The real-time data includes all ADCP3 measurements including vertical profile of water currents, echo intensity, correlation etc. It can also measure depth, bottom velocity, and other parameters. This manual is designed to guide users to work with RTI-DR ADCP systems.

System Requirements

RTI Direct Reading for PC requires the following specifications for the PC:

Windows Vista or newer with .NET framework 4.7

1 GHz processor or faster

1 GB RAM

1 GB hard disk space

1024 x 768 or higher screen resolution

Installation

To install the DR software on the PC, run the installer "DirectReading.x.x.x.x_Installer_Datetime.exe" from the RTI provided CD or memory stick, then follow the installation wizard instructions and keep the default settings. After installed, you should see the "Direct Reading" program icon on your desktop. Double click the icon to start the DR program. You are now ready to use the DR software.

Contact Us

If you have technical problems with your instrument, please feel free to contact us at:

Rowe Technologies, Inc.

12655 Danielson Court, Suite 306
Poway, CA 92064
USA

Tel: +1 858 842 3020
Fax: +1 858 842 3021
Email: sales@rowetechinc.com
Web: http://rowetechinc.com/

2. Terminology

- **Ping**: a single or multiple sequence of pulse transmission used for echo reception and signal processing.
- **Ping time**: the time taken (in seconds) by the ADCP to complete one Ping. It includes system wake up and initialization time, transmit time, receive time, data processing time and data recording time.
- **Water Profile Time Between Pings (*CWPTBP*)**: the time (in seconds) interval between water profile pings. This is the time interval between the start of a water profile ping and the start of the next water profile ping for each frequency.
- **Subsystem**: a subsystem if a frequency with its unique hardware properties such as transducer type, number of beams, beam angle, slanted beam or vertical beam, etc. Each subsystem has an unique id called "subsystem code" (refer to Section 3) that can be recognized in the firmware. Each subsystem has a default configuration like bin size, bin number, number of pings, time between pings, etc., the user can change the default settings to fulfil his/her specific application goals. An RTI ADCP instrument can have single or multiple subsystems depends on the hardware. A subsystem can have one or more different configurations in a deployment. The serial number of the instrument will tell you how many subsystems and what subsystems you have on that particular ADCP.
- **Pings per subsystem (*P*)**: the number of pings in each subsystem for a deployment.
- **Group (*G*)**: the collection of one or more subsystems operating sequentially one after the other. For example, *G{ABC}* is a group of three independent subsystems *A*, *B* and *C*.
- **Group Time (*GT*)**: the duration time taken (in seconds) for completing one group pings.
- **Group Interval (*GI*)**: the time interval (in seconds) between groups.
- **Subsystems per group (*M*)**: number of subsystems in one group ($1 =< M <= 12$). It will be automatically selected when you chose the instrument.
- **Ensemble**: a group of data collection of single or multiple subsystem groups over a certain time period (usually averaged) that ADCP outputs. It can include measured current profiles, correlation and echo intensity, bottom track velocities, pitch/roll, heading BIT results, and other user selectable data. The ensemble can contain the single ping data over the ensemble interval, or it can contain the averaged data from multiple groups.
- **Ensemble Interval (*CEI*)**: the time interval (in seconds) between ensembles.
- **Groups per ensemble or Group Number (G*N*)**: the number of groups to be averaged in ensemble interval ($GN >= 1$).
- **Output Time (*OT*)**: the time (in seconds) spent to output data ensemble from ADCP to user's PC through a serial port.

3. Subsystem

ADCP3 system serial number starts with SN07 in which “07” identified as ADCP3, followed by a 15-bit sequence of subsystem ids. The subsystems used for ADCP3 are listed below:

Code#	Description
0	Reserve
A	Spare
B	1.2 MHz 4 beam 20 deg piston
C	600 kHz 4 beam 20 deg piston
D	300 kHz 4 beam 20 deg piston
E	150 kHz 4 beam 20 deg piston
F	75 kHz 4 beam 20 deg piston
G	Spare
H	Spare
I	1.2 MHz 4 beam 20 deg piston, 45 degree heading offset
J	600 kHz 4 beam 20 deg piston, 45 degree heading offset
K	300 kHz 4 beam 20 deg piston, 45 degree heading offset
L	Spare
M	Spare
N	1.2 MHz 1 beam vertical piston
O	600 kHz 1 beam vertical piston
P	300 kHz 1 beam vertical piston
Q	150 kHz 1 beam vertical piston
R	Spare
S	Spare
T	Spare
U	1.2 MHz 4 beam 20 deg piston, doughnut hole
V	600 kHz 4 beam 20 deg piston, doughnut hole
W	300 kHz 4 beam 20 deg piston, doughnut hole
X	Spare
Y	Spare
Z	Spare
a	Spare
b	1.2 MHz 4 beam 30 deg array
c	600 kHz 4 beam 30 deg array
d	300 kHz 4 beam 30 deg array
e	150 kHz 4 beam 30 deg array
f	75 kHz 4 beam 30 deg array
g	38 kHz 4 beam 30 deg array
h	Spare
i	Spare
j	Spare
k	Spare
l	Spare

m	Spare
n	1.2 MHz 1 beam vertical array
o	600 kHz 1 beam vertical array
p	300 kHz 1 beam vertical array
q	150 kHz 1 beam vertical array
r	75 kHz 1 beam vertical array
s	38 kHz 1 beam vertical array
t	Spare
u	1.2 MHz 4 beam 30 deg array doughnut hole
v	600 kHz 4 beam 30 deg array doughnut hole
w	300 kHz 4 beam 30 deg array doughnut hole
x	150 kHz 4 beam 30 deg array doughnut hole
y	Spare
z	Spare

4. Grouping

A group (Figure I) is a collection of one or more subsystem pings operating sequentially one after the other within an ensemble interval. Each subsystem can have bottom track (BT) pings and water profile (WP) pings. Figure I shows a group of three subsystems *A*, *B* and *C*, each colored bar on the time axis is a ping (BT ping or WP ping) measured in seconds. Each subsystem begins with one BT ping followed by one or more WP pings. The sum of all the ping time is Group Time (GT).

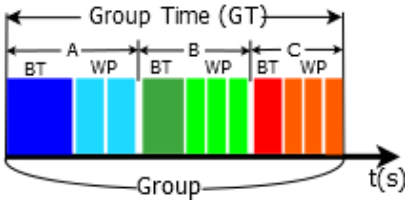


Figure I. Group

One or more group pings in an ensemble interval will be averaged into a data ensemble and will be outputted by the ADCP.

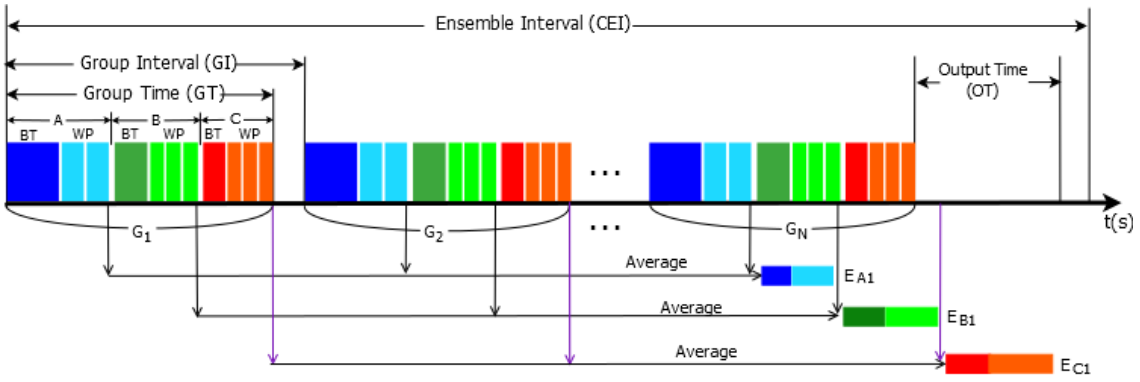


Figure II. Grouping

The example of Figure II has three subsystems *A, B* and *C*, usually represents two different frequencies and a vertical beam in a piston ADCP. There are total *N* groups in the ensemble interval in Figure II and each group has three subsystems *A, B* and *C*. Each subsystem starts with one BT ping followed by multiple WP pings. After subsystem *A* pings completed in group *N* during ensemble interval, all the subsystem *A* pings will be averaged and outputted as data ensemble E_{A1}. Same thing for subsystems *B and C*, all the subsystem *B* pings will be averaged and outputted as one data ensemble E_{B1} and all the subsystem *C* pings will be averaged and outputted as one data ensemble E_{C1} when completed pinging in group *N*.

The Ensemble Interval (*CEI*) is the time interval (in seconds) set to complete all the *N* group pings. It includes Pinging Time and Data Output Time, and is defined as

$$CEI \geq GI * GN + OT \qquad (Eq.\ 1)$$

Where, *GI* is group interval in seconds, it is the time interval between groups in an ensemble. *GT* is group time which is the time taken for completing all the pings in the group, it is defined as in *Eq*. 2.

$$GT = \sum_{i=1}^{M} (BTPT_i + TBP_i * P_i) \qquad (Eq.\ 2)$$

in which, $BTPT_i$ and TBP_i are bottom track ping time and water profile time between pings for subsystem i, respectively. They are the required time for the ADCP to complete the BT ping and WP ping for that frequency. P_i is the number of water profile pings in subsystem i. *M* is the number of subsystems in the group. In Figure I and Figure II, $M = 3$ because there are three subsystems *A, B* and *C*.

OT is data ensemble output time, it is the time that needed to output data ensemble from ADCP to PC through a serial port. There will be an overlap of pinging time and outputting time for multiple frequency systems. In Figure II, after the completion of pinging and averaging subsystem *A* in the last group, ADCP can start outputting the ensemble of subsystem *A* while subsystem *B* is pinging. Same thing for subsystem *B* and subsystem *C*, after the completion of subsystem *B* in last group of the ensemble, ADCP starts outputting subsystem *B* ensemble while still doing the subsystem *C* pinging. The actual outputting time *OT* depends on the actual ensemble size of each subsystem and the baud rate of the serial port. In the best case that uses a fast baud rate, the output of first subsystem completes before the end of second subsystem pinging, that is, it can start outputting the second subsystem data immediately when it finishes pinging and so on. Then, the overall outputting time is the time to output the last subsystem ensemble, it is defined as

$$OT = \frac{Last\ Ensemble\ (bytes)}{Baudrate/10\ (bytes/second)} \qquad (Eq.\ 3)$$

And,

$$CEI \geq GI * GN + \frac{Last\ Subsystem\ Ensemble\ (bytes)}{Baudrate/10\ (bytes/second)} \qquad (Eq.\ 4)$$

$$\geq GT * GN + OT$$

In the worst case that using a slow baud rate, the outputting time is longer than pinging time and *OT* is defined as the sum of the ensemble outputting time of each subsystem.

$$OT = \sum_{i=1}^{M} \frac{Subsystem\ i\ Ensemble\ (bytes)}{Baudrate/10\ (bytes/second)} \qquad (Eq.\ 5)$$

And

$$CEI \geq GI * (GN - 1) + PT + OT \qquad (Eq.\ 6)$$

$$\geq GT * (GN - 1) + PT + OT$$

$$= \sum_{i=1}^{M} (BTPT_i + TBP_i * P_i) * (GN - 1) + (BTPT_1 + TBP_1 * P_1) + \frac{\sum_{i=1}^{M} Ei}{Baudrate\ /\ 10}$$

Where, PT is the pinging time of first subsystem and is defined as

$$PT = BTPT_1 + TBP_1 * P_1$$

5. Pinging Scheme

There are two pinging schemes in grouping the different frequency pings together: the uniform group pinging and the burst group pinging.

5.1 Uniform Group Pinging

In uniform group pinging (Figure III), each ensemble all the groups are evenly placed within the ensemble interval. So, $GI \geq GT$.

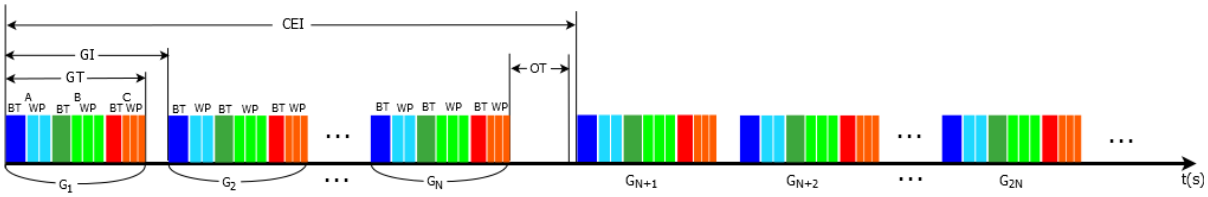


Figure III. Uniform Group Pinging

5.2 Burst Group Pinging

In burst group pinging (Figure IV), a sequence of groups will ping immediately one after another in the beginning of each ensemble. After that, it may have a sleep time before the next ensemble. In this scheme, *GI* = *GT* dependents on the group time.

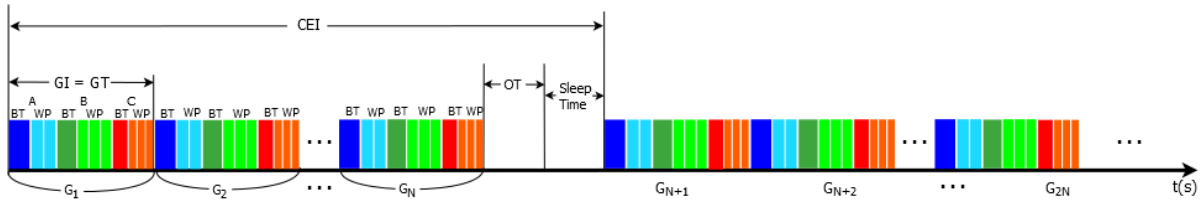


Figure IV. Burst group pinging

6. System Overview

RTI-DR (Figure 1) is a highly integrated program that allows the user to work with RTI ADCPs like communicating with ADCP, configurating an ADCP, deploying a system, downloading data from ADCP, viewing live data or playing back the existing data collected from RTI ADCPs. The large menu icons on the top of the program window are the shortcuts to start each main function. The **Deploy** and the **Download** functions require the user to connect an RTI ADCP to the PC through a serial port. While it's no need to have an ADCP available in order to **Plan** a deployment or **Playback** data from a file. We will explain all the functions in detail in the following sections. The **Terminal** window allows the user to talk directly to ADCP using commands through serial communications.

Figure 1. RTI Direct Reading

The user can choose the language between "English" and "Chinese" by clicking the "English" menu on the top right corner of the program or by clicking the "Language" icon from the tool bar of the program.

7. Connect to ADCP

Connect is used to connect to the ADCP by selecting correct serial port and baud rate (Figure 2). The "Refresh" button will scan for all the available serial ports on the user's computer that connected to ADCP and find the baud rate for the that COM port. The "Find Baudrate" button will find the baud rate that the selected COM port uses.

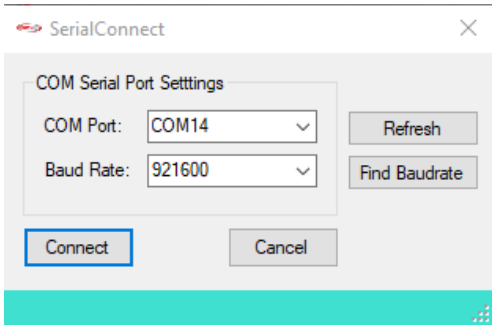


Figure 2. SerialConnect Window

8. Terminal

The **Terminal** window is used to talk to ADCP directly through serial port. It allows the user to set and change serial communications with ADCP or GPS. Click the **Terminal** icon from the tool bar to open Terminal window (Figure 3).

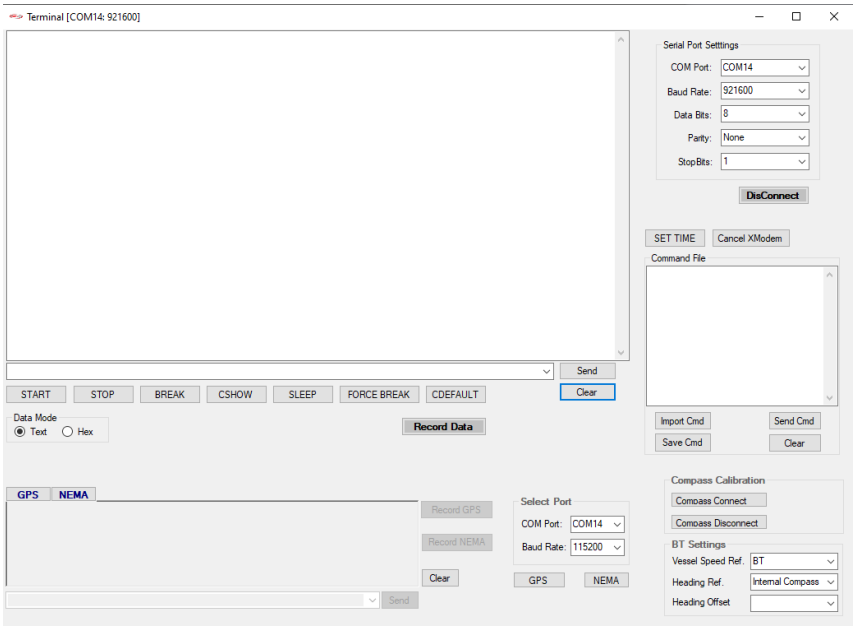


Figure 3 Terminal Window

9. Planning

This is the place to plan a deployment. Click the icon from tool bar to open **Planning** window and start planning. The planning steps will guide the user through the procedure of how to configure the instrument for a deployment. An ADCP is not required during planning. But you the user can check the ADCP configuration is an ADCP is connected to the PC.

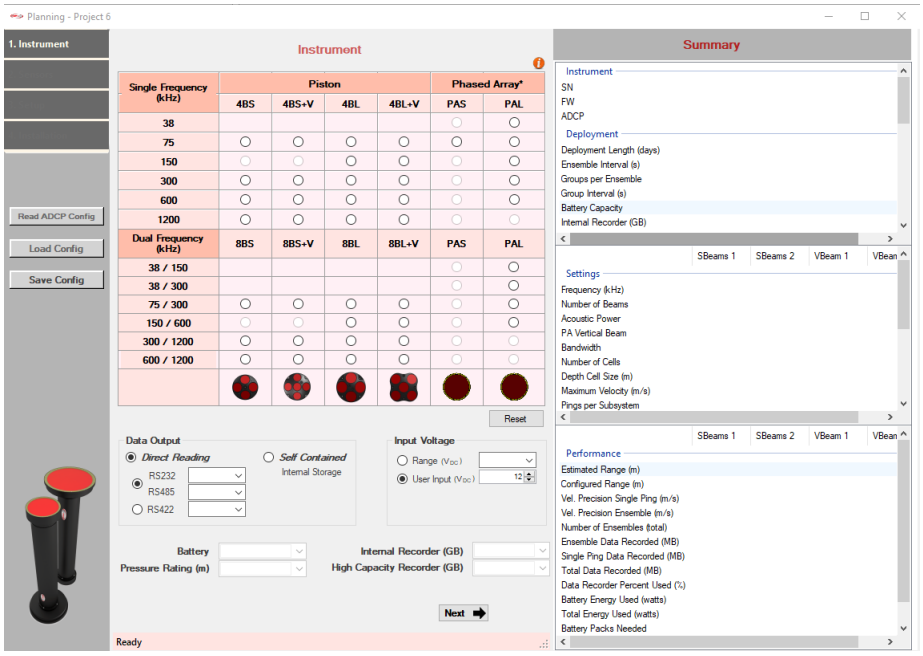


Figure 4 Planning Window

The Planning window (Figure 4) is organized into three parts: the control panel in the left that has three planning step buttons, three function buttons and a picture of the selected instrument the user is working on; in the middle of the window is content of the settings parameters of each step; the right column is the Summary of the configuration and the predicted performance of the settings. Any changes of the settings in each step will be reflected in the Summary.

9.1 Planning Steps

Step 1. Instrument

The first step of Planning is to choose an ADCP from the instrument table for the deployment. The instrument table consist of all the RTI ADCP3 products that are designed and developed to operate from a frequency range of 38 kHz to 2.4 MHz with single and dual frequency mode of operation, transducer type can be piston or phased array, size can be large or small. The information button icon on the right top corner of the table explains the names of the instruments (Figure 5).

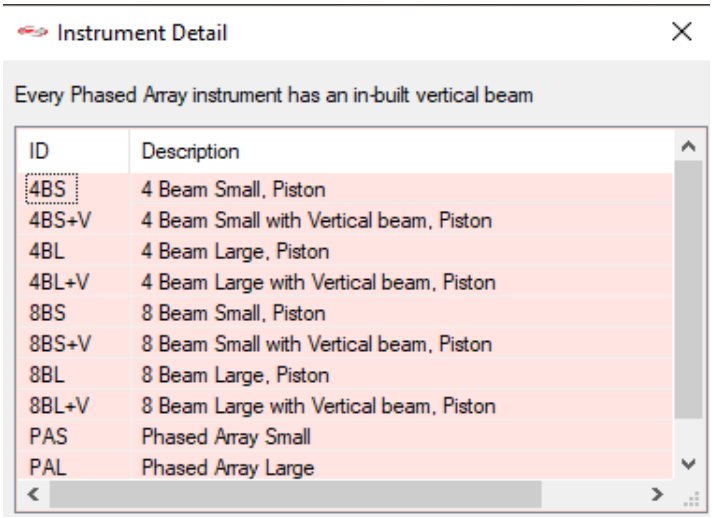


Figure 5. Instrument Description

After selecting an ADCP from the table, the ADCP information such as subsystems, frequency, transducer type etc. and the default ADCP settings along with the predicated performance results will be shown in the Summary column on the right side of the window (Figure 6). On the Instrument page, the user can also setup other hardware parameters like battery, pressure rating, input voltage, the internal recorder size and does it have the high capacity recorder or not.

For Direct Reading applications, the user also need to select how to output data from ADCP to PC by choosing from RS232/RS485 port and RS422 port. For Self-Contained applications, the data collected by ADCP will be saved on the SD card inside of the ADCP and there is no data output to PC.

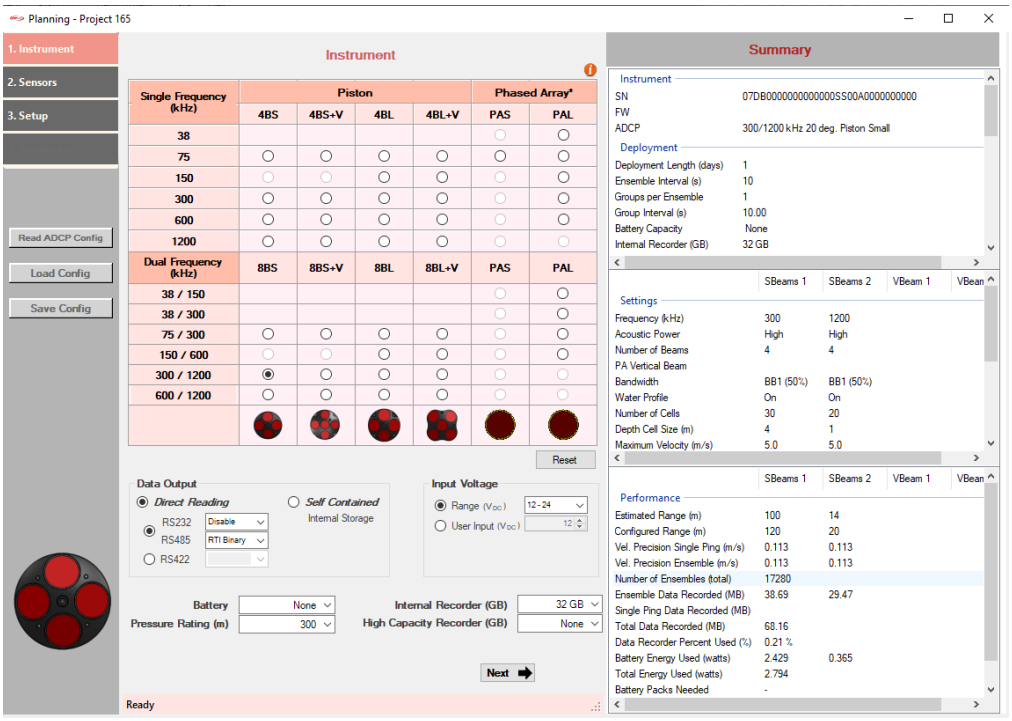


Figure 6. Planning Window - Instrument Page

After done with the instrument, click **Next** button or click the **2. Sensors** button on the left side of the window to go to next step - **Sensors** page.

Step 2. Sensors

The second step is to set up sensor source and environmental parameters for the deployment.

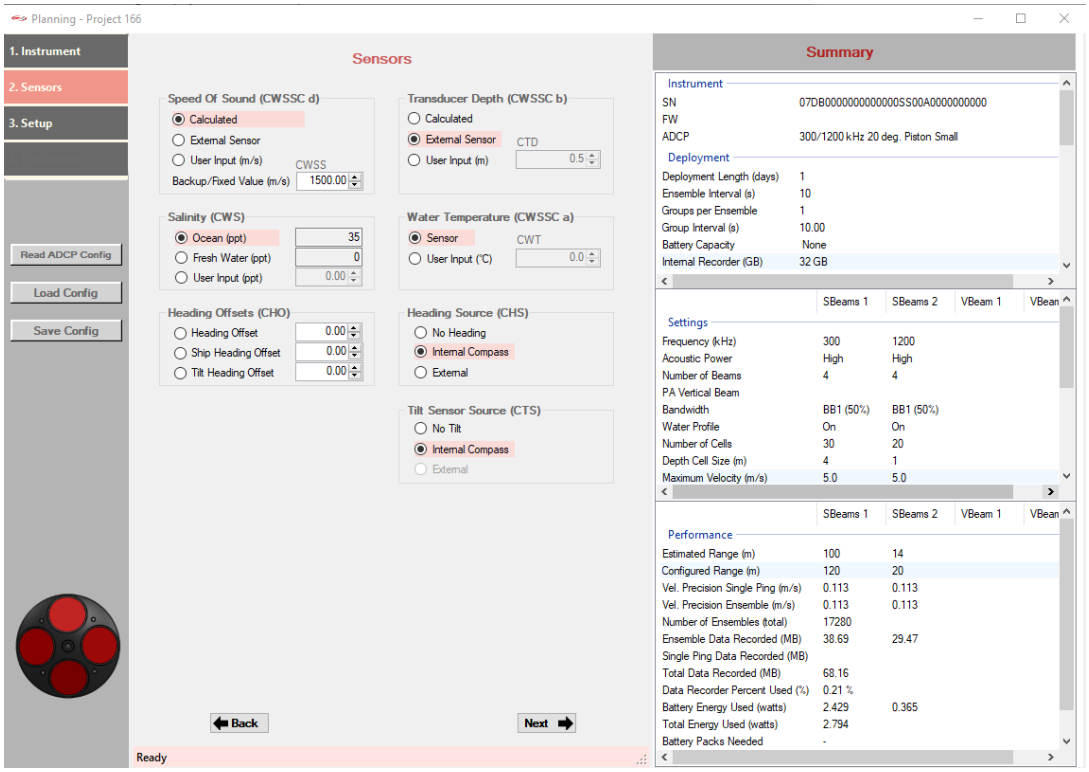


Figure 7. Sensors Page

Speed Of Sound: Sets the speed of sound value used for ADCP data processing. The speed of sound values is used by ADCP to scale velocity data, depth cell size and range to the bottom.

- Calculated: ADCP calculates speed of sound using the values of measured transducer depth, water temperature and salinity. The following equation is used to compute the speed of sound:

  $C = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.01T) * (S - 35) + 0.016D$

  Where:

  T is the temperature in ºC
  S is salinity in parts per thousand (‰)
  D is the depth in meters

- External Sensor: using an external device for the value of speed of sound.
- User Input: a fixed value of speed of sound (in meters per second) input by the user.

The Backup / Fixed value is necessary in the situations when none of the three above options is available.

Transducer Depth: Sets the way how to get ADCP transducer depth.

- Calculated: ADCP calculates transducer depth using the values of the built-in pressure sensor (if presents). If a pressure sensor is not available, the ADCP uses the CTD command setting.
- External Sensor: uses an external pressure sensor for the calculation of transducer depth.
- User Input: uses the user input value (in meters) from CTD command for the transducer depth.

Salinity: Sets the water salinity value.

The salinity of 0 is for fresh water, 35 for ocean or saltwater, or any other user-input value between 0 and 35 ppt.

Water Temperature: Sets the water temperature value.

It can the readings from a sensor or a user input values saved in the CWT command.

Heading Source: Selects the heading source for ENU transformations.

- No Heading: means there is no heading data available.
- Internal Compass: the heading data is from an internal compass reading.
- External: ADCP will use the heading data obtained from an external GPS's $xxHDT string.

Tilt Source: Selects the tilt source for ENU transformations.

- No Tilt: no tilts.
- Internal Compass: uses the tilt data from an internal compass reading.

Heading Offsets: Sets the heading offsets.

- Heading Offset (+-180 deg): the offset that is used to correct the heading that ADCP has either from ADCP's PNI compass or from user's GPS heading. This offset will be added to the compass or GPS heading prior to being used within the system and then output.
- Ship Heading Offset (+-180 deg): system to ship heading offset. This will align the instrument axes and the ship axes.
- Tilt Heading Offset (+-180 deg): system to PNI compass tilt heading offset. This will align ADCP Beam 0 and the PNI compass tilt axes.

Which offset to use and how to use these offsets depends on the real applications. Following are the applications that show how to set these offsets:

Application 1. Uses PNI compass for magnetic north (SC or DR).

In this application, all these offsets should be set to 0 (ZERO). The PNI heading will be the heading that will be used in system data processing and outputting.

Application 2. Same as Application 1 but need to correct declination.

In this case, use Heading Offset for correcting the declination.

Application 3. PNI compass is not aligned with ADCP Beam 0.

In this case, use Tilt Heading Offset to align PNI compass tilt axes and ADCP axes.

Application 4. Uses external heading devices either GPS or GYRO for heading.

In this case, use Heading Offset to line up ADCP instrument to North.

Application 5. ADCP is mounted on a ship but not aligned.

In this case, use Ship Heading Offset to line up ADCP instrument axes and the ship axes.

Step 3. Setup

The last step is to set up the ADCP parameters for the deployment such as ensemble interval, bandwidth, water profile pings and bottom track pings. A predicted performance of the setting is calculated based on the parameter values chosen by the user. The question mark will refer to "Rowe Technologies Grouping Scheme" and the two pinging schemes. The green check sign tells the user that the settings are a valid setup, while the red cross sign indicates the setup is not valid.

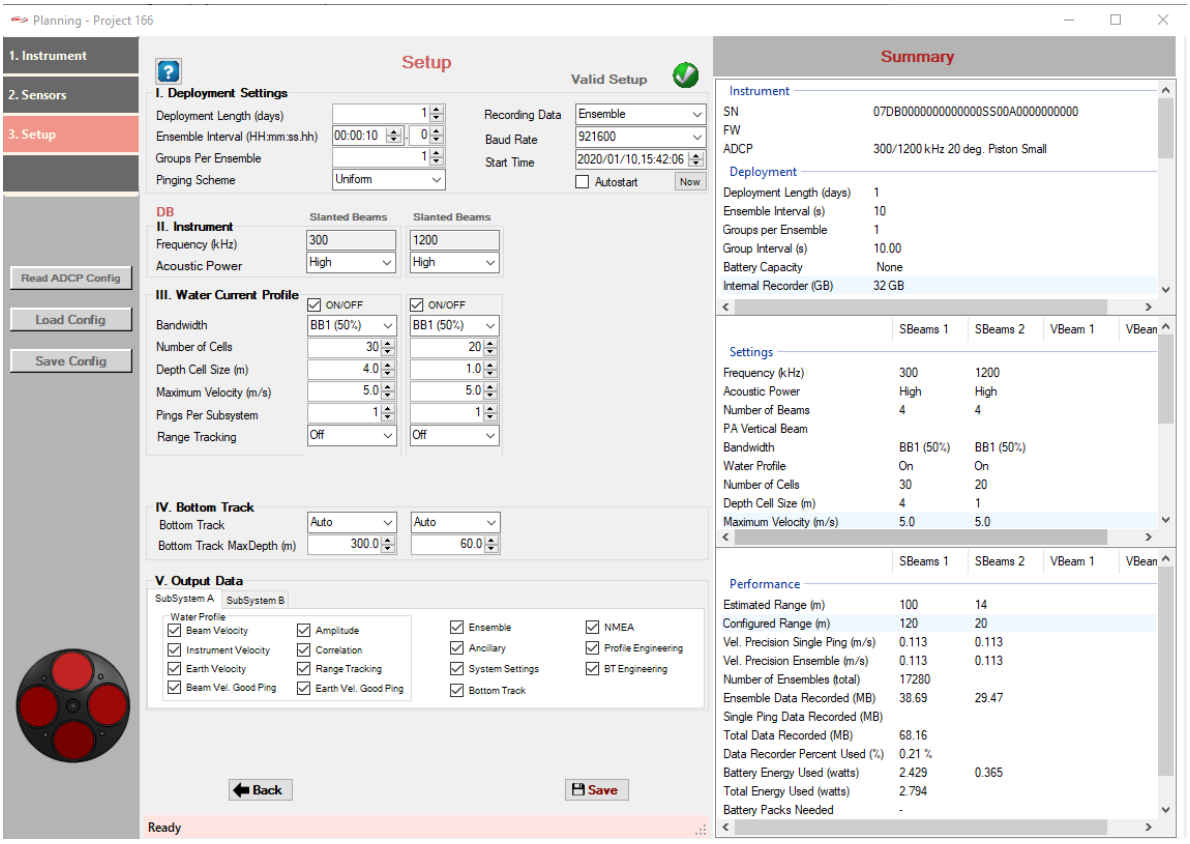


Figure 8. Setup Page

I. Deployment Settings

- **Deployment Length (days)**: the number of days the deployment will last.
- **Ensemble Interval**: the time interval (in seconds) between data ensembles. It's in the format of *HH:mm:ss.hh*.
- **Groups Per Ensemble**: the number of subsystem groups in one ensemble.
- **Pinging Scheme**: how the pings will be organized either using Uniform Group Pinging or using Burst Group Pinging.
- **Recording Data**: to record data in the format of Ensemble, Ensemble and Single Ping, or No Recording.
- **Baud Rate**: choose the serial port baud rate for outputting data from ADCP to user PC. This value will be used to compute the data output time.
- **Start Time**: the first ping time, i.e., the time to start pinging. You can click the **Now** button to use current computer time.

II. Instrument

This part shows instrument subsystem frequencies of the selected instrument and the acoustic power that is associated with each frequency. The frequency cannot be changed, it is for display purpose only. There are five options for the acoustic power for each frequency: "High", "Medium 1-3" and "Low".

III. Water Current Profile

This is the place to setup parameters for water current profile pings including bandwidth, bin number, bin size, maximum velocity, number of pings per subsystem, and to on/off range tracking. For each subsystem, the user can choose to turn on and off the water current profile ping by checking/unchecking the ON/OFF checkbox on top of each frequency.

- Water Profile **ON/OFF**: to turn ON / OFF water current profile ping for each frequency. In the column of each frequency's setup, if the ON/OFF checkbox is checked, the water profile ping for that frequency is turned on, and all the water profile ping parameters in that frequency's column will be enabled, otherwise, all the water profile ping parameters for that frequency will be disabled.
- **Bandwidth**: the bandwidth of water profile ping. There are six options of the bandwidth:
    - Broadband 1 (BB1): 50 % of the frequency
    - Broadband 2 (BB2): 25 % of the frequency
    - Broadband 3 (BB3): 12.5 % of the frequency
    - Broadband 4 (BB4): 6.25 % of the frequency
    - Broadband 5 (BB5): 3.125 % of the frequency
    - Narrowband (NB): 6.125 % of the frequency
- **Number of Cells**: the number of cells.
- **Depth Cell Size (m)**: the vertical size of individual cells in the profile, in meters. A larger cell size transmits more energy for a given power level.

- **Maximum Velocity (m/s)**: the maximum current velocity (5.0 m/s by default) can be measured in the profile.
- **Pings Per Subsystem**: number of pings in each subsystem to be averaged together in the ensemble before output.
- **Range Tracking**: water profile range tracking.
    - Off: turn water profile range tracking off.
    - On: turn water profile range tracking on, set the first bin and last bin that are used to look between for a valid amplitude target. Search window is between First Bin and Last Bin.

IV. Bottom Track

To setup the bottom track ping parameters for each frequency.

- **Bottom Track**: to set up bottom track mode for that frequency
    - On: bottom track is ON
    - Off: bottom track is OFF
    - Auto: the system will automatically switch between ON and OFF depending on the measurements and the physical environment of the bottom.
- **Bottom Track Max Depth (m)**: set the maximum depth in meters to search for the bottom. Set up appropriate of this value will reduce the amount of time in the search algorithm.

V. Output Data

To choose what kind of data the user wants to include in the data ensemble that will be outputted by ADCP. In the RTI binary format, these data types will be stored in the specific part of the RTI data ensemble identified by its unique 7 digits ID in the format of E0000XX. Usually the default setup is good unless you want to have a smaller size of the data ensemble to save the recorder space.

1) Water current profile data
    - Beam velocity (E000001)
    - Instrument velocity (E000002)
    - Earth velocity (E000003)
    - Amplitude (E000004)
    - Correlation (E000005)
    - Beam velocity good ping (E000006)
    - Earth velocity good ping (E000007)
    - Range tracking (E000015)

2) Bottom track data
    - Bottom track (E000010)
3) System settings and ancillary information of ensemble
    - Ensemble (E000008)
    - Ancillary (E000009)
    - System setup (E000014)
    - NMEA (E000011)
4) Engineering data
    - Profile engineering (E000012)
    - Bottom track engineering (E000013)

9.2 Predicted Performance

The Summary section of Planning reflects the current user settings for a deployment and the predicted performance of the deployment based on the settings. Any changes of the instrument and parameter values in the planning will result in the refresh of the Summary contents. It's recommended that you to keep checking the performance results during planning, to make sure the configuration of the ADCP better serves your goal of deployment.

The following content items are for water current profile pings.

- **Estimated Range (*m*):** the default profiling range for each frequency based on typical setup (bandwidth, acoustic, bin size and bin number).
- **Configured Range (*m*)**: the user configured range for each frequency, equals to bin size times number of bins.
- **Vel. Precision Single Ping (*m/s*)**: velocity standard deviation of single ping
- **Vel. Precision Ensemble (*m/s*)**: velocity standard deviation of ensemble
- **Number of Ensembles (total)**: the total ensemble that will be collected during the deployment
- **Ensemble Data Recorded (*MB*)**: the recorded ensembles in MB on the SD card. This is the space that will be needed to save the recorded ensembles on the ADCP SD card.
- **Single Ping Data Recorded (*MB*)**: the single ping data recorded (MB) on the SD card
- **Total Data Recorded (*MB*)**: the total data recorded (MB) on the SD card including ensemble data and single ping data
- **Battery Energy Used (*watts*)**: the batter energy in watts will be used for the entire deployment if battery is the only power supply.

- **Total Energy Used (*watts*)**: the total energy in watts will be used for fulfilling the length of the deployment. This includes electric energy and acoustic energy that will be used during the deployment.
- **Data Recorder Percent Used (%)**: the percentage of space that will be used by the collected data on the SD card
- **Battery Packs Needed**: how many battery packs are needed for the deployment if battery is the only supply.

9.3 Button functions

There are three button functions the user can use in planning of the deployment:

- **Read ADCP Config**: if your computer has connected to an ADCP vis a serial port, this button can be used to check the ADCP information and settings. When clicked the button, the software will first try to connect to the ADCP by checking all available serial ports and baud rates, if successfully connected to the ADCP through a serial port, the program will read ADCP information such as serial number, firmware version, system frequency and transducer type along with the settings of ADCP and display them in the Summary.
- **Load Config**: Load an existing deployment configuration from a file saved on PC and display the settings in all the three pages of Planning.
- **Save Config**: save the current settings to a file.

10. Deploy

The procedure of deploying an instrument. The Deploy function needs the ADCP to be connected to the PC. Click "Connect" icon to connect to ADCP by selecting correct serial port and baud rate (Figure 2). After connected to ADCP, the "Deploy" 

button icon will be enabled. Click it to open Deployment page (Figure 9).

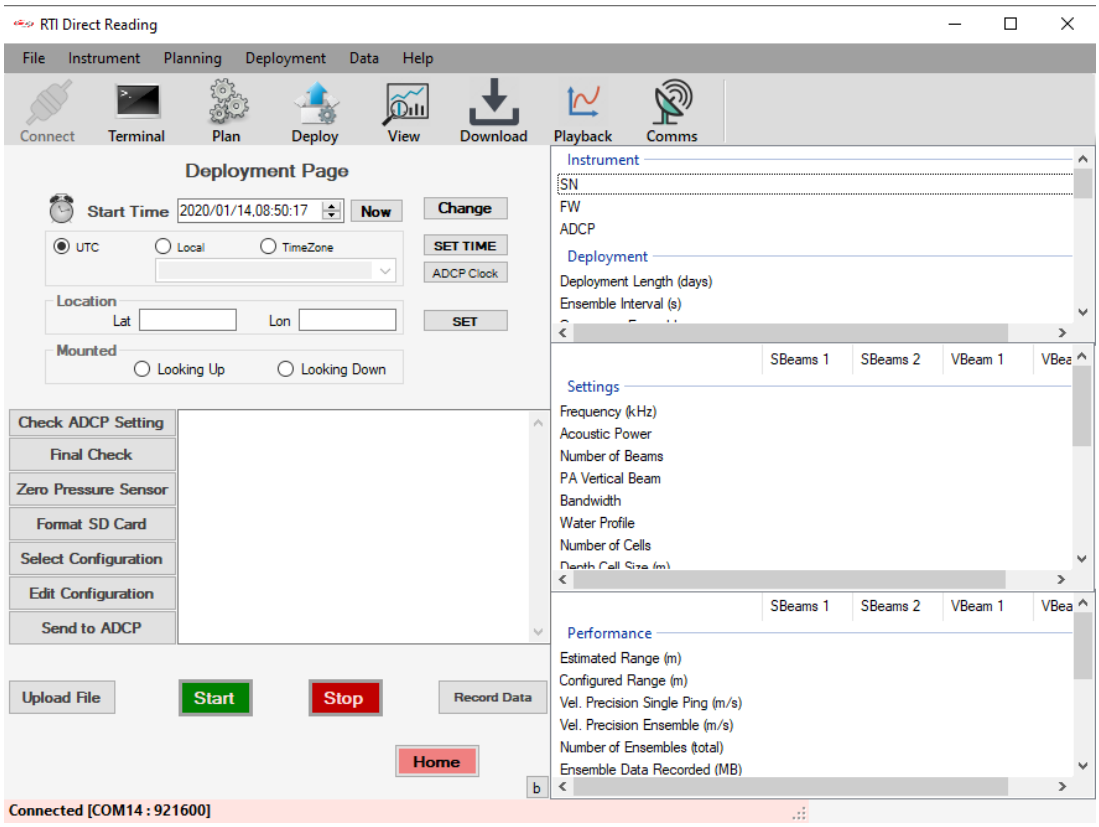
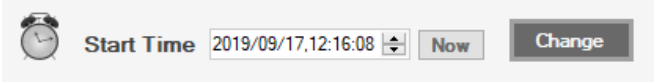


Figure 9. Deployment Page

- Set **Start Time** of pinging, i.e. the first ping time. By default, it will show the user's computer clock time when the Deployment page is open. Adjust the time to the desired deployment start time. Click "**Now**" button will set the time to the current computer time. After set or changed the start time, click "Change" button to set the start time on ADCP.



- **Set Time**: to set ADCP clock. The user can set the ADCP clock to UTC time, Local time or any Time Zone time choosing from the dropdown menu. After selected, click "**SET TIME**" button to set the clock on ADCP. The result will be shown in the message box underneath (Figure 10). The "ADCP Clock" button allows the user to check what the current clock time on ADCP. This will read ADCP time and show it in the message box (Figure 10).

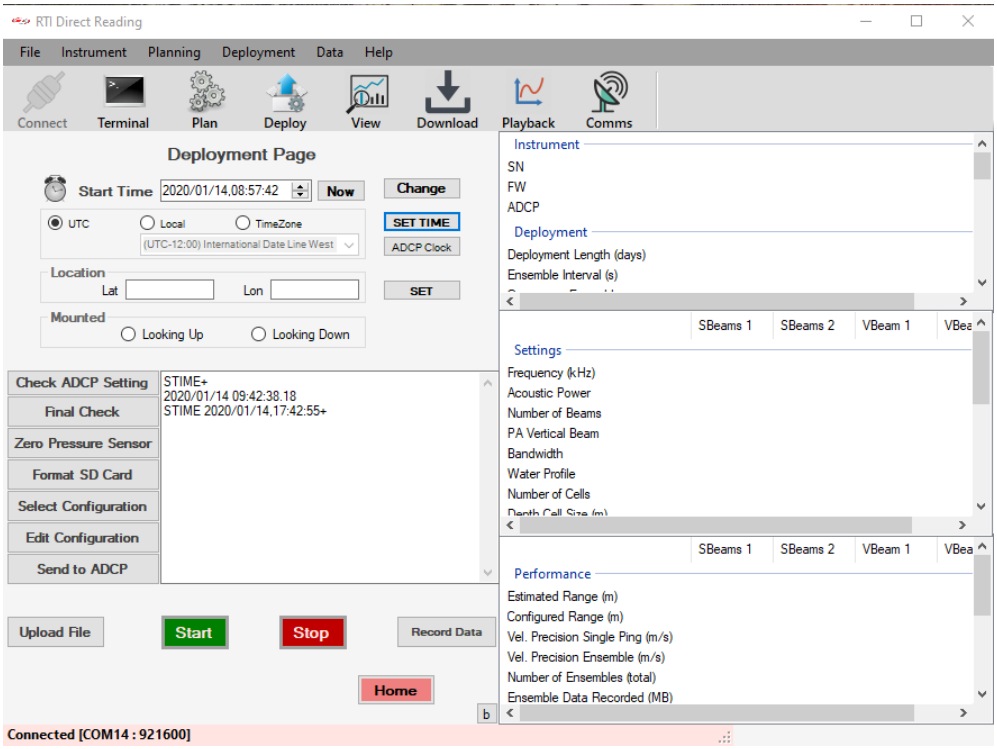


Figure 10. Deploy Message Box

In the message box, it first shows ADCP time as a result of clicking "ADCP Clock" button, it then shows the result of clicking the "SET TIME" button which sets ADCP clock to UTC time.

- **Location**: set the latitude (-90 ~ 90 degree) and longitude (-180 ~ 180 degree) of the deployment location.
- **Mounted**: the orientation of how the instrument mounted.
- **Check ADCP Setting**: this is the same as in the Planning, it will read ADCP information and settings and show them in the summary column (Figure 11).

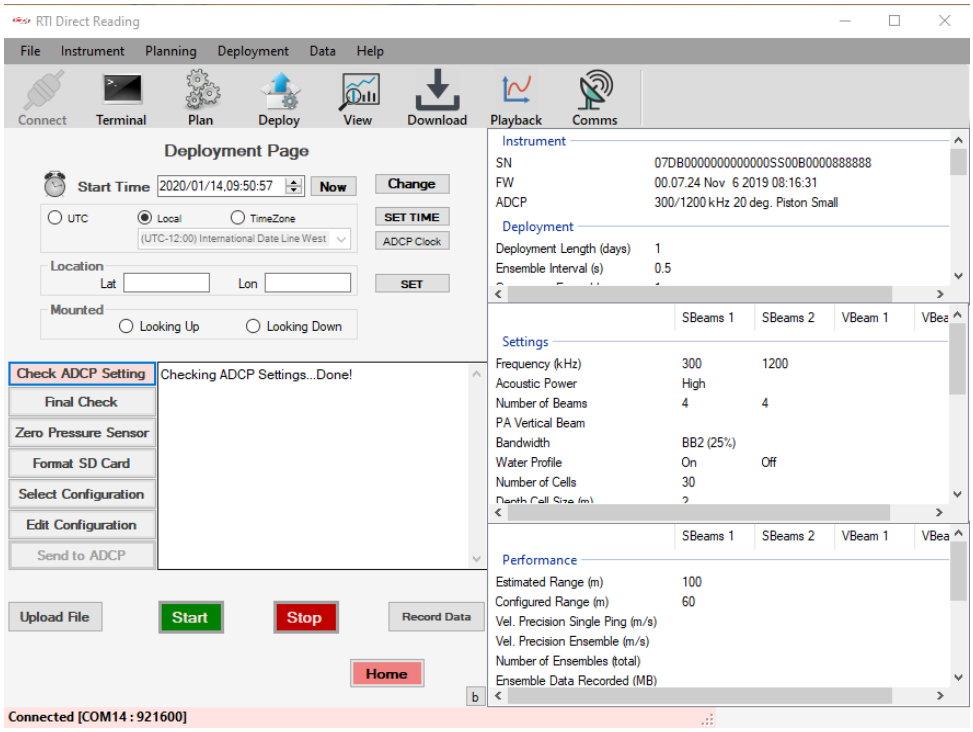
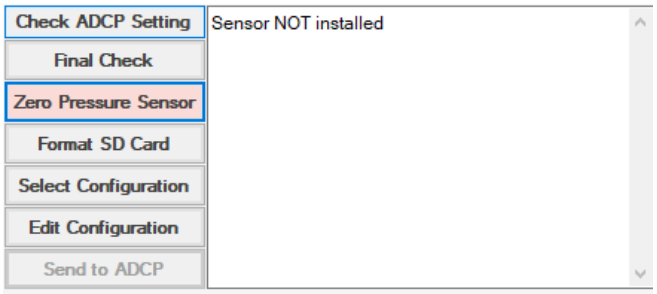


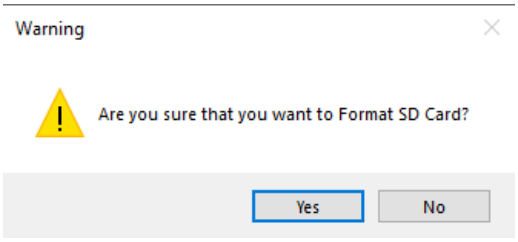
Figure 11. Deploy – Check ADCP Setting

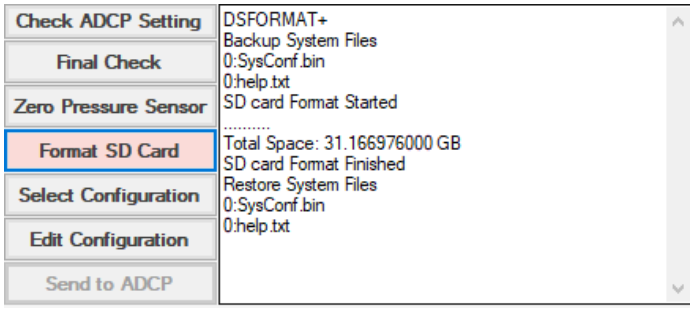
- **Final Check**: before any deployment, it is strongly recommended to undergo a diagnostic test to ensure that the various components are working as intended. This will check ADCP information, pressure sensor, temperature sensor, compass, international recorder, beam check, transmitter and receiver test, sample pinging test etc. (not implemented)

- **Zero Pressure Sensor**: this will first check if the pressure sensor is installed in the instrument, if it is installed, it will set the pressure value to ZERO. Otherwise, it will show "Sensor NOT installed" in the message box.



- **Format SD Card:** this will delete all the data files stored on the SD card of the ADCP to make spaces for the new deployment. There will be a warning message to ask the user if she/he really want to do this. Make sure you downloaded all the data files from the ADCP to your PC before clicking the "Yes" button to avoid losing your data. And be patient to wait until it finished formatting the card.





- **Select Configuration:** select a deployment configuration from an existing configuration file on the computer. The Configuration file is in JSON format. After loading the configuration file, the configurations will be shown in the summary column on the right (Figure 12).

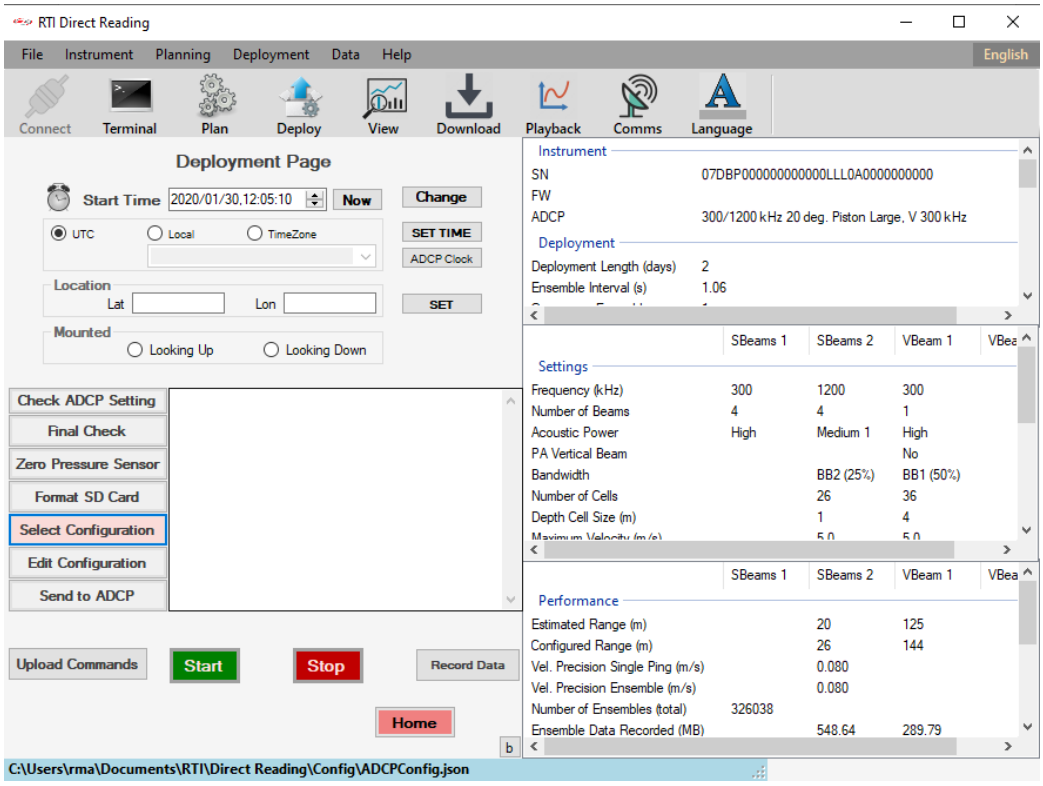


Figure 12. Select Configuration

- **Edit Configuration:** this will allow the user to make changes of the configuration, click the "Edit Configuration" button will direct the user to the **Planning** window (Figure 13) Setup page with the selected configuration. After edition, the user can save the edited configuration to the same file or save it to a new file. After edition, the user needs to go back to the Deploy page to load the edited configuration to the deploy page.

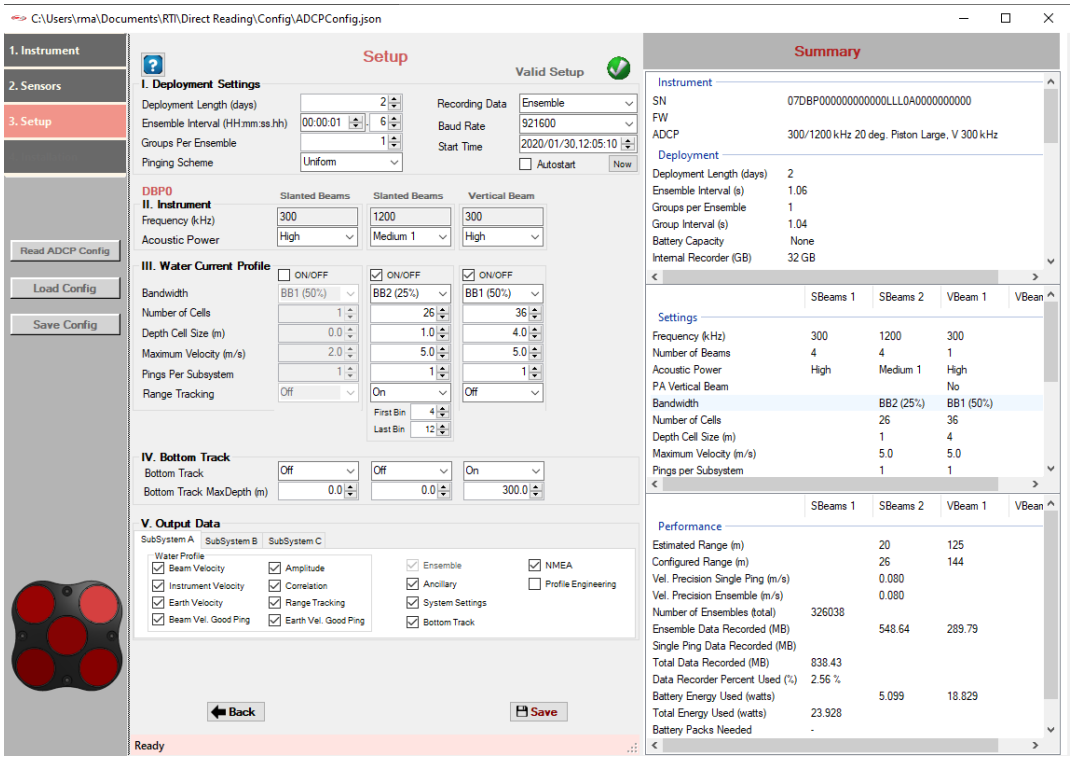


Figure 13. Edit Configuration in Planning window

- **Send to ADCP:** when the user is satisfied with the configuration showing on the Deployment page, the user can click "Send to ADCP" button to send the configuration / commands to ADCP. The Message Box will tells if it is successfully sent to ADCP (Figure 14) or an error message if it failed.

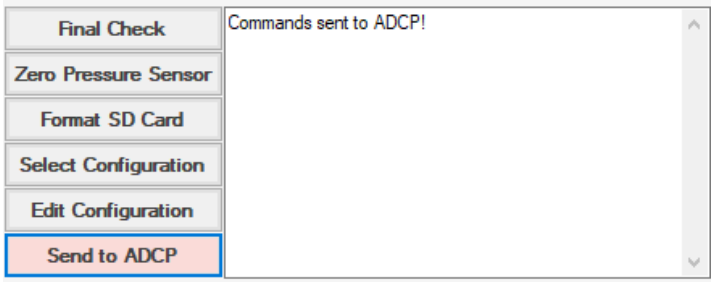


Figure 14. Configuration was sent to ADCP

- **Start:** click the Start button to start pinging / deployment. If the "Start Time" hasn't arrive, ADCP will in sleep mode and it will show how much time left in the format of ddd hh:mm:ss as shown in Figure 15.

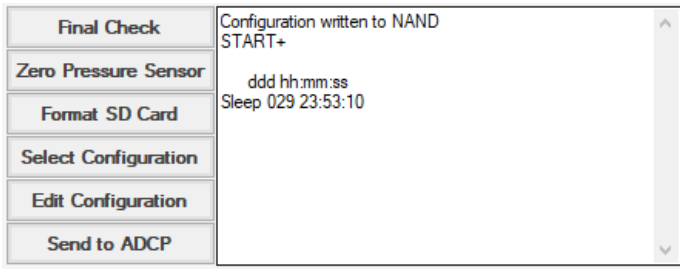


Figure 15. System started but in sleep mode

The ADCP will immediately start pining if the scheduled Start Time is current or in the past, the user will see the outputting data in the message box (Figure 16). Now, the user can click the "View" icon to open the Display window to see the live data display (Figure 17). Keep the "Deployment Page" open if it is pinging to keep receiving data from ADCP. The user can switch to Terminal window also when ADCP is pinging in order to continue receiving data.

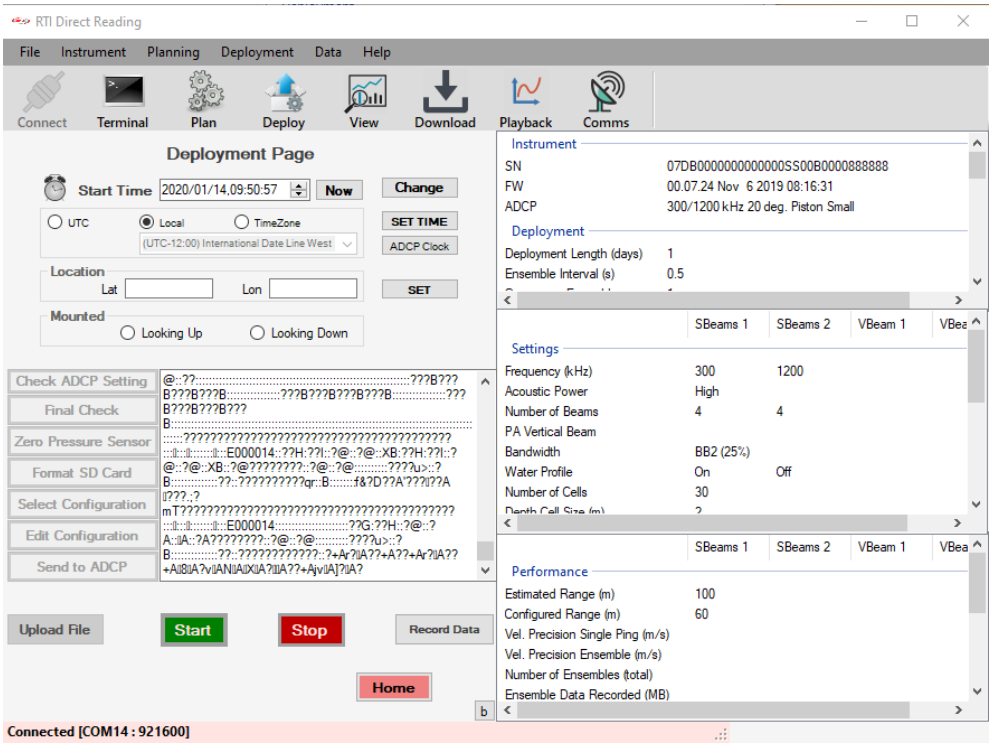


Figure 16. System started pinging

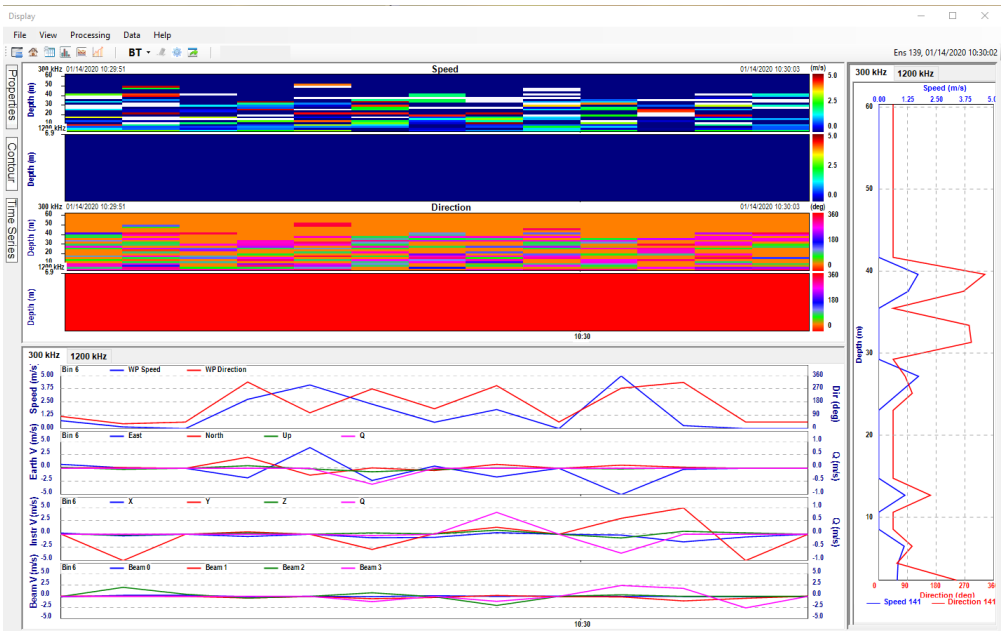


Figure 17. Live data

- **Stop:** to stop ping (Figure 18).

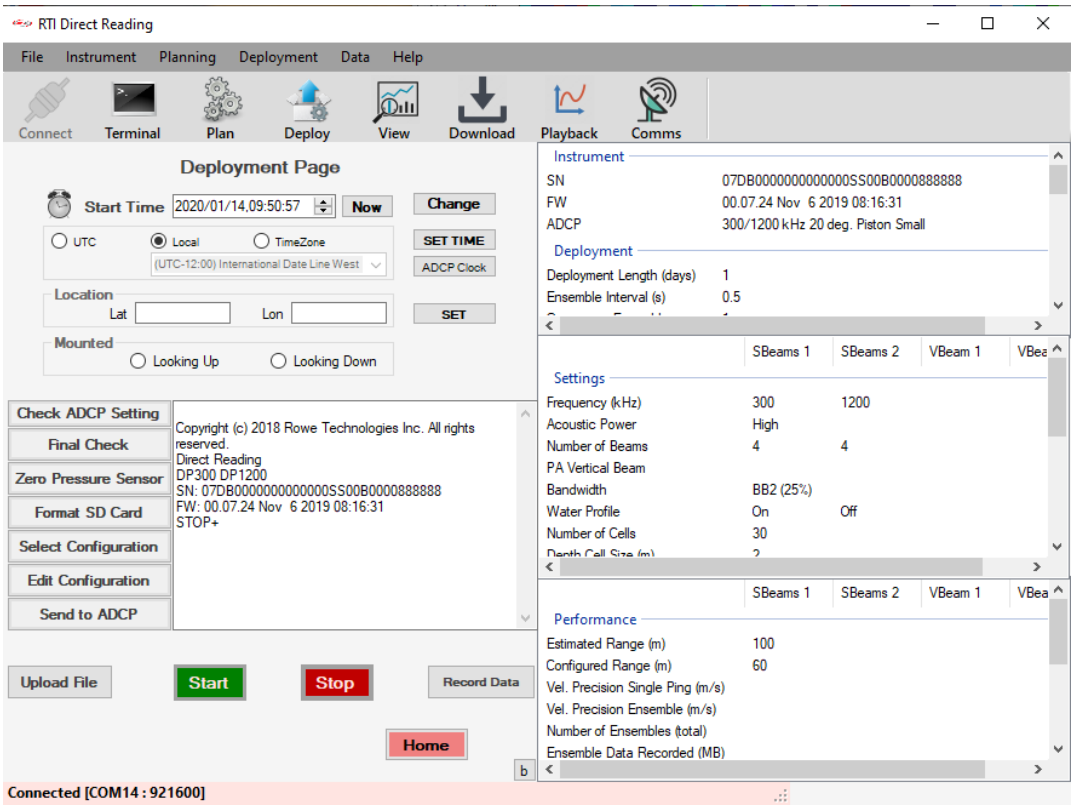


Figure 18. Stop pinging

- **Record Data**: to save data to PC when ADCP is pinging (Figure 19). Data will be saved in the "\Documents\RTI\Direct Reading\Data" folder. Click it again to stop recording.

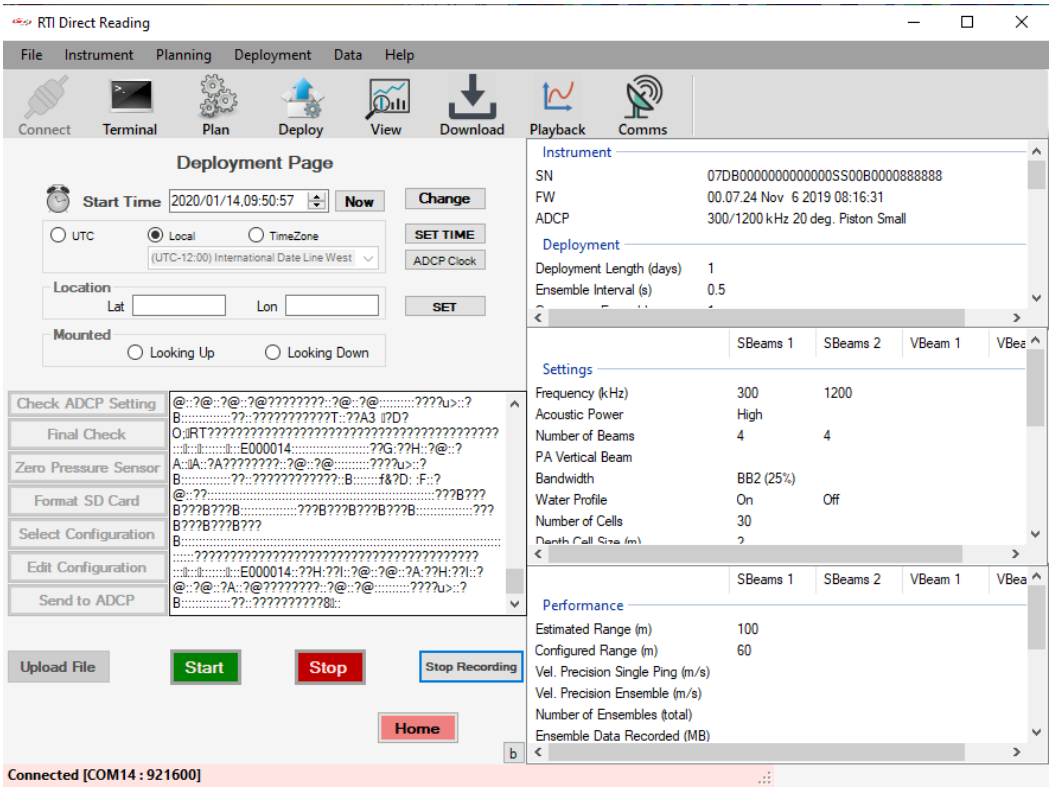


Figure 19. Recording data on PC

- **Upload Commands**: to upload command file to ADCP. this is for experts only.

- **Home**: go back to the program Home page.

11. Download

To download data from ADCP. The 

icon will be enabled if it is connected to ADCP, click it will direct the user to the **Download** page (Figure 20).

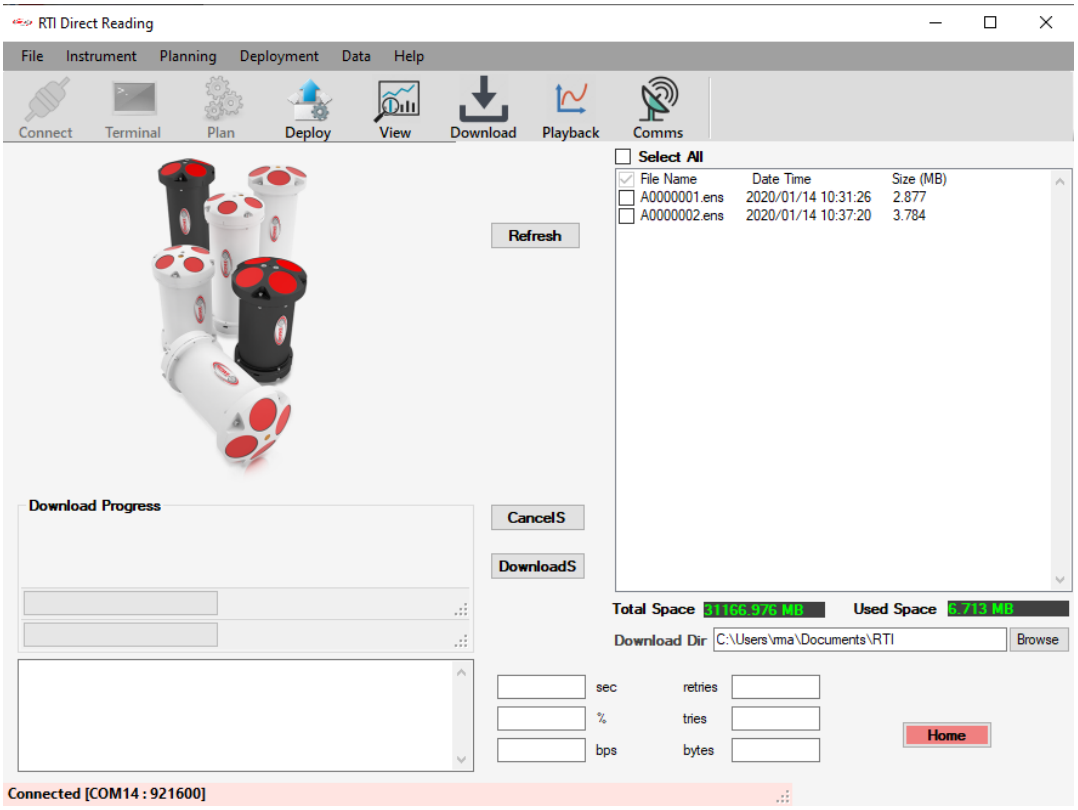


Figure 20. Download page

The user can choose the files to download by checking the boxes in front of the file name or select all the files to download. The "Download Progress" box will show the downloading progress (Figure 21).

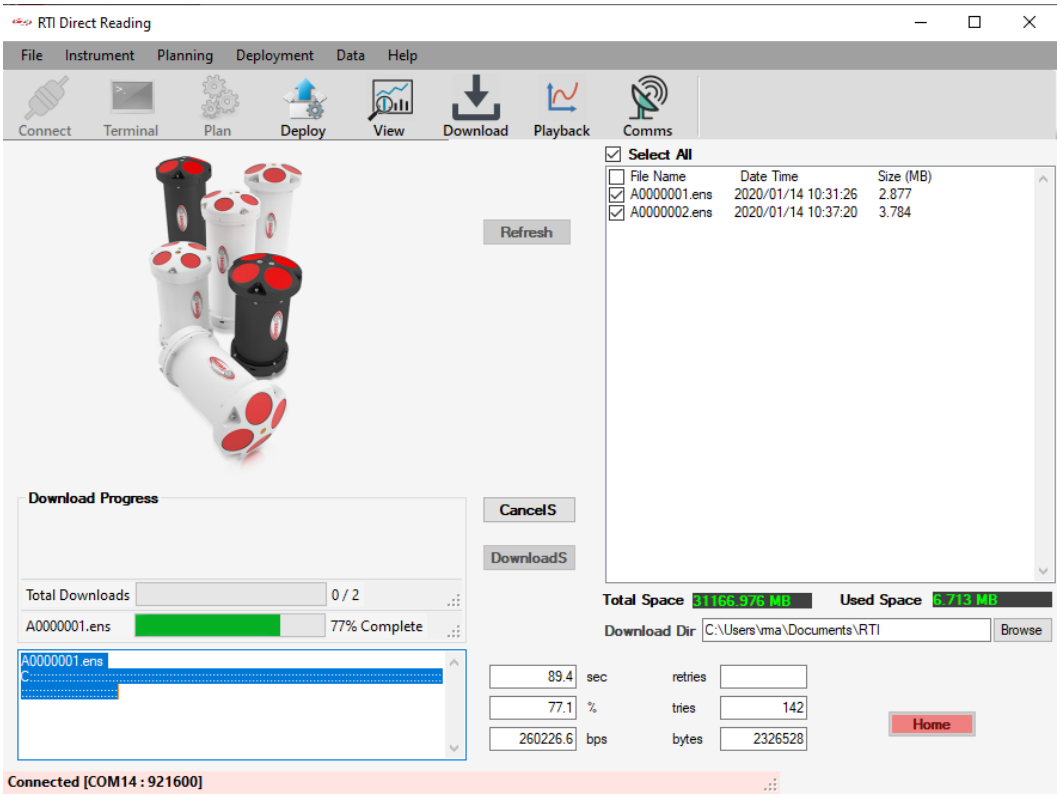


Figure 21. Downloading

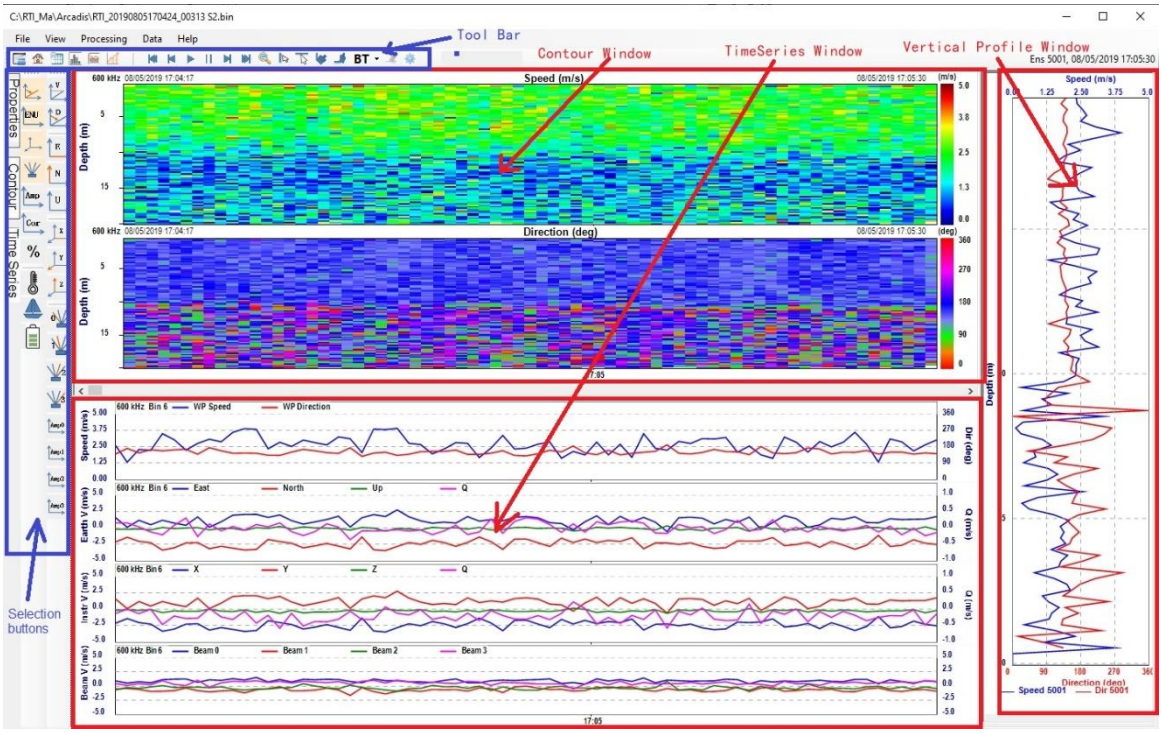
12. Playback

Playback is designed for displaying and post-processing the data from a file.

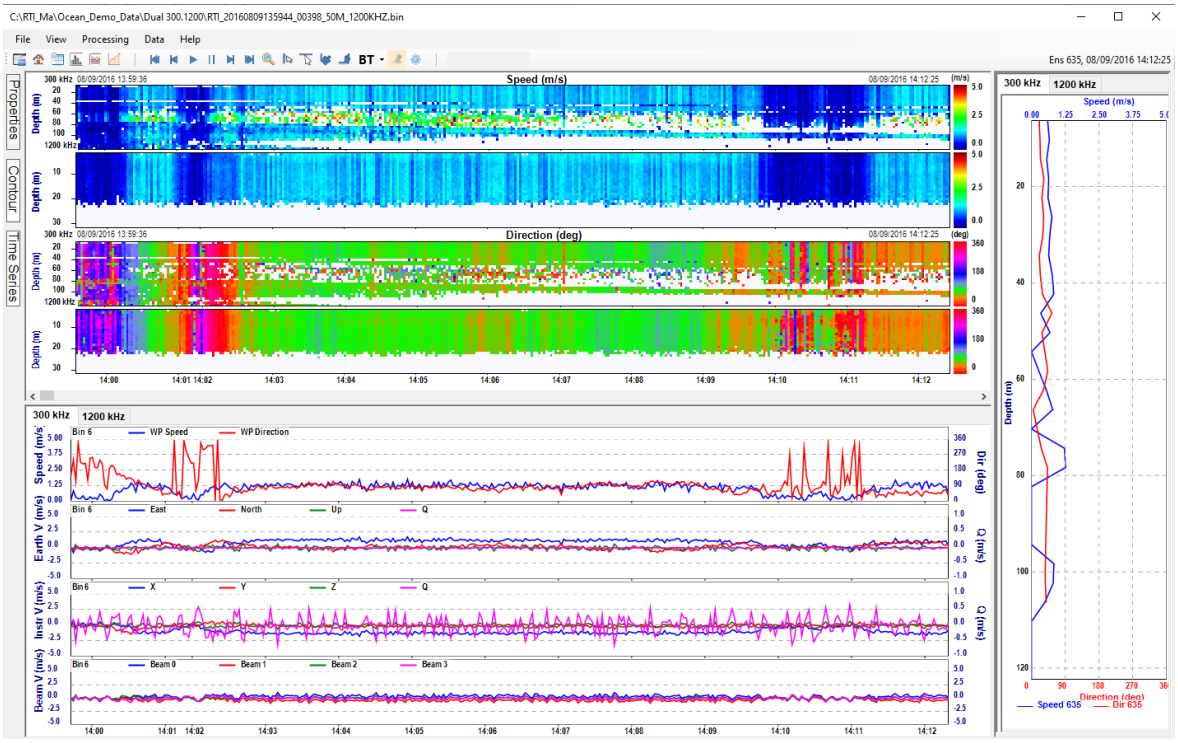
12.1 Main page

The **Display** user interface can be started by clicking the **Playback** icon from tool bar or by choosing **Data > Playback** from the main menu on the top of the home page. After loading the selected data file to the program, the Display window will show up (Figure 22). The user can open more than one **Display** window for loading different data files to view or compare at the same time. Just click the **Playback** icon from the home page to open a new **Display** window.

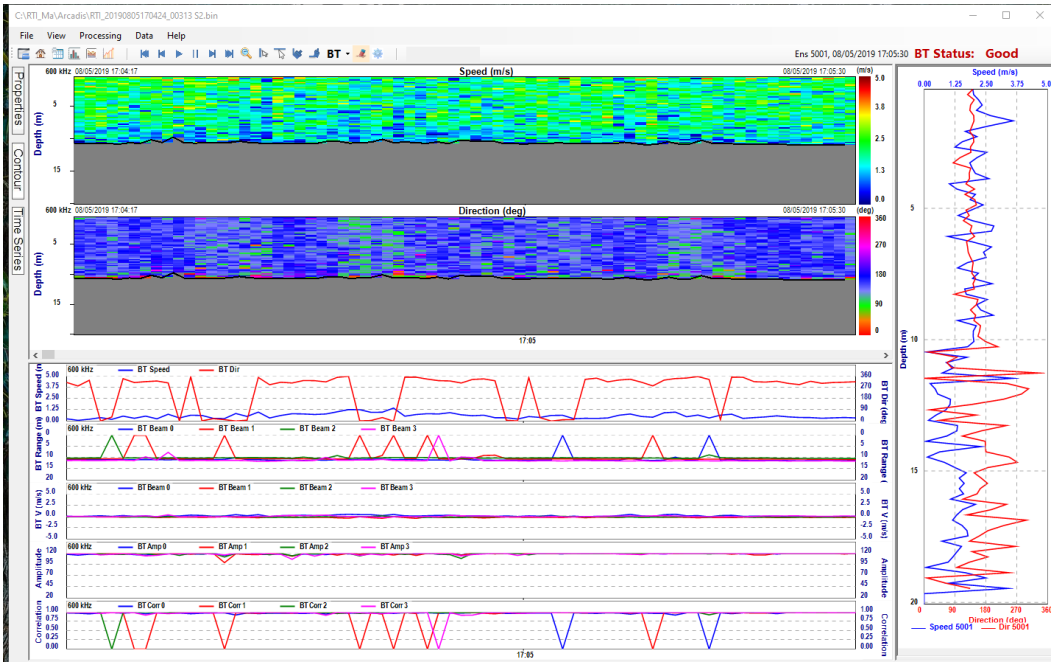
There are five main parts of the display window: the Tool Bar on the top of the window, the Selection Buttons on the left side of the window, and the three plotting areas are in the middle and right. The three plotting areas are Contour Plotting Area, TimeSeries Plotting Area, and the Vertical Profile Plotting Area as shown in Figure 22 (a). For dual frequencies, the two frequencies are both shown in the Display as shown in Figure 22 (b). When BT is turned ON, the boat speed and velocity will be subtracted from the raw data, and the TimeSeries window will be bottom track data plots such as boat speed and direction, BT range, BT velocity (Beam/Earth/Instrument), Amplitude, Correlation etc. Figure 22 (c).



a) Single frequency



b) dual frequency



c) BT is ON

Figure 22. Display user interface

- **Tool bar**: contains buttons  to switch between pages including the **Home** page  , plain text **Data** page  , **Contour** page  , **Timeseries** plot  page and **Vertical profile** display page  . The **Open file**  button allows user to open a different data file.

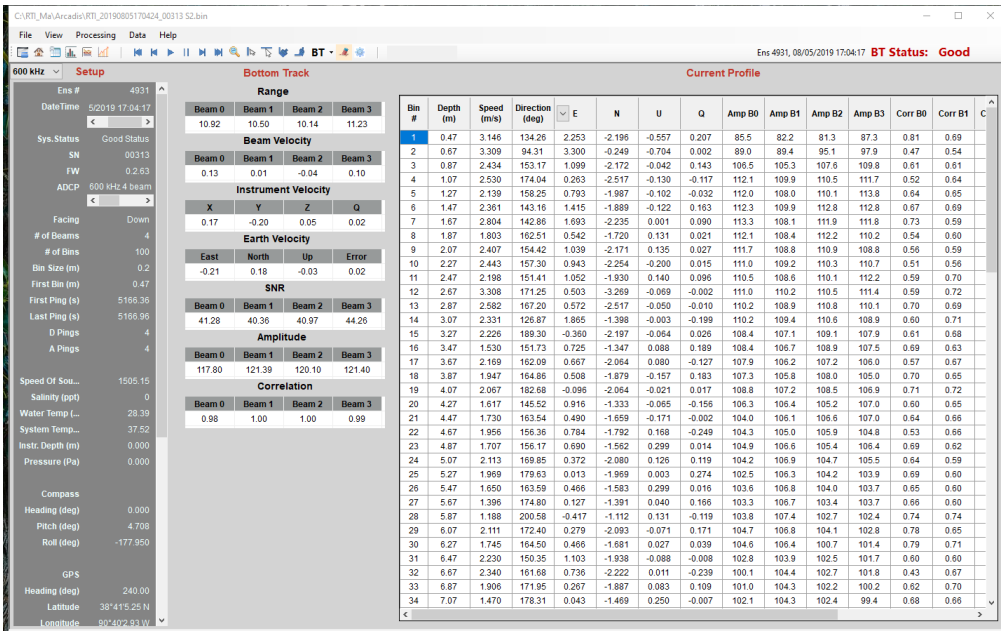


Figure 23. Data Page

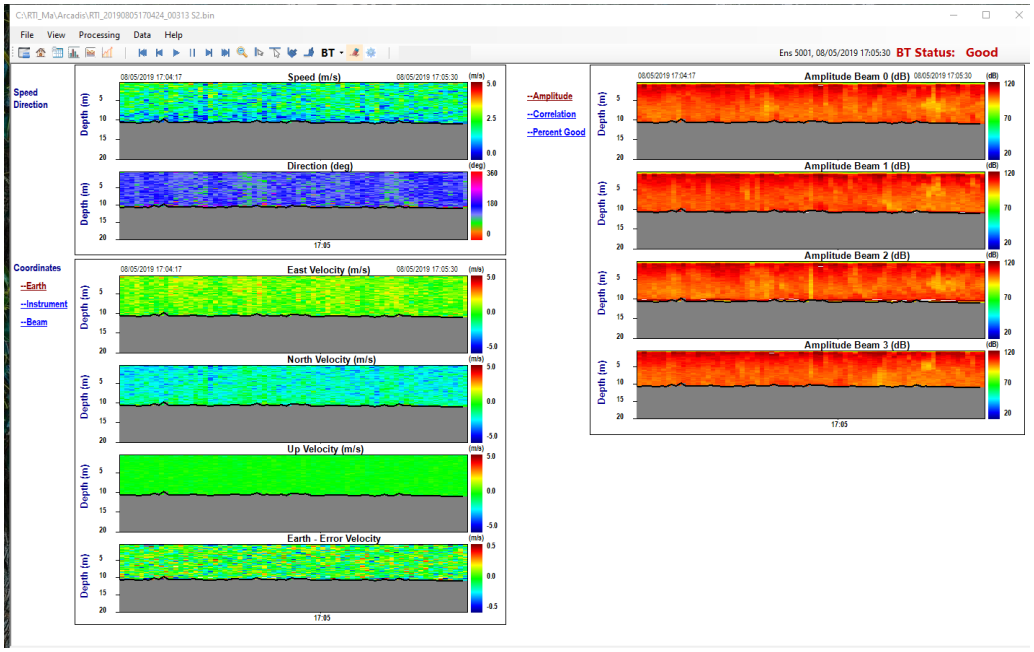


Figure 24. Contour Page

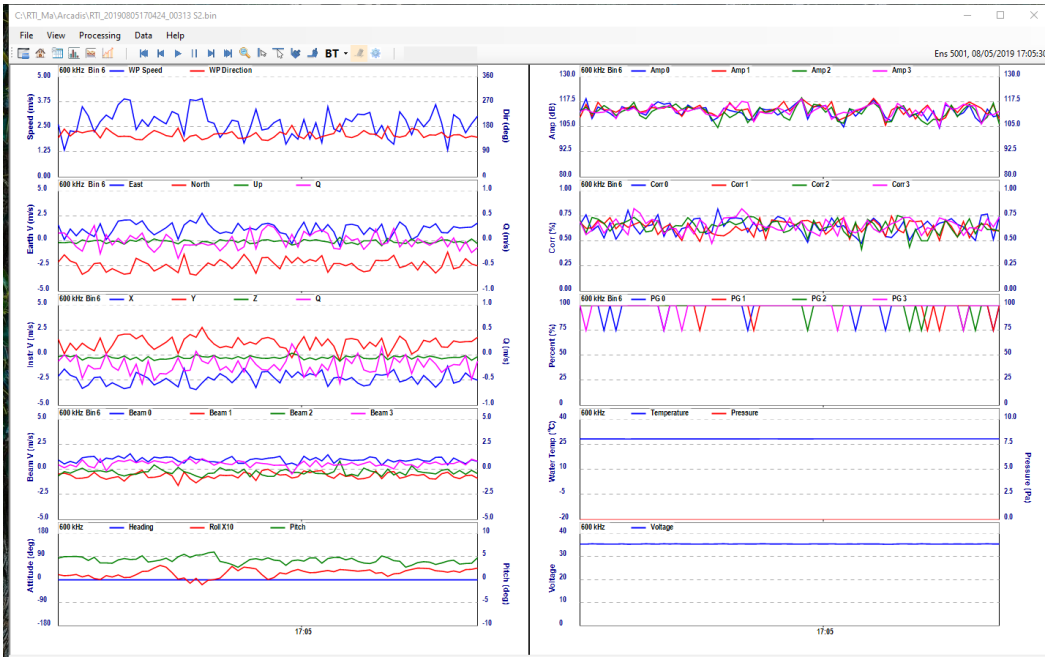


Figure 25. TimeSeries Page

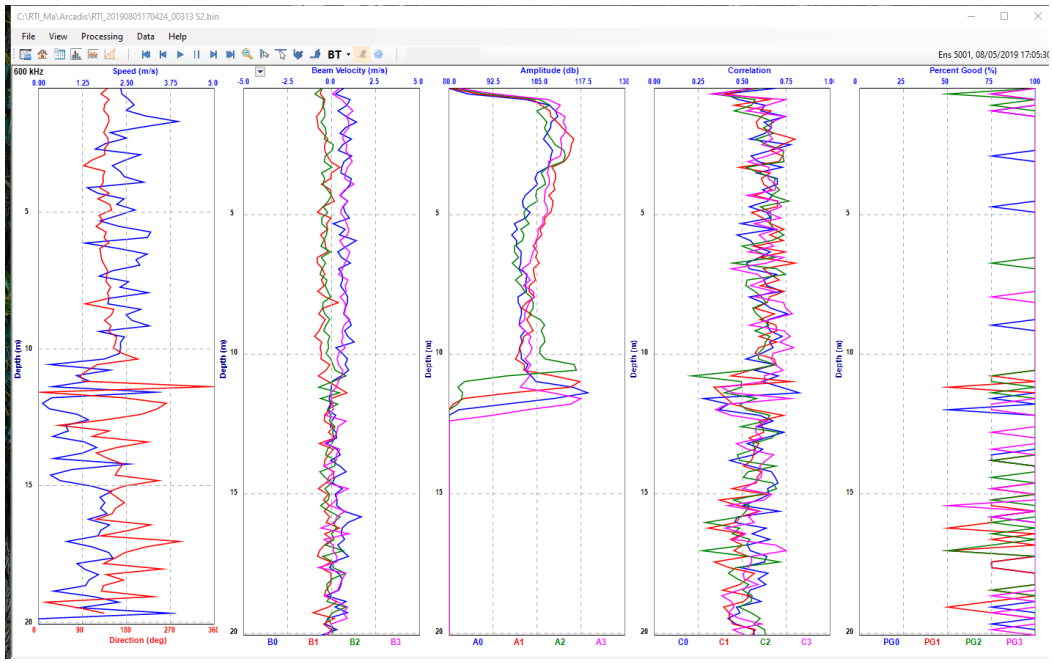


Figure 26. Vertical Profile Page

- **Control bar**: contains buttons  to play with data includes Play / Pause, step forward / backward, First / Last ensemble; Zoom out, pick / unpick ensemble, pick /unpick timeseries, Select bottom track reference, Mark bad below bottom, and change setting parameters.

    - **Zoom In**: You can select an area on the contour plot to zoom in that area. To do this, put your mouse on the spot on the contour plot, hold the mouse button and drag the mouse. You will see a rectangle on the contour plot. Hold the mouse key and drag the rectangle to select the area you want to zoom in and release the mouse key. The selected area will be zoomed in and shown in the plot window (Figure 27). Click the magnifier icon  to zoom it out.

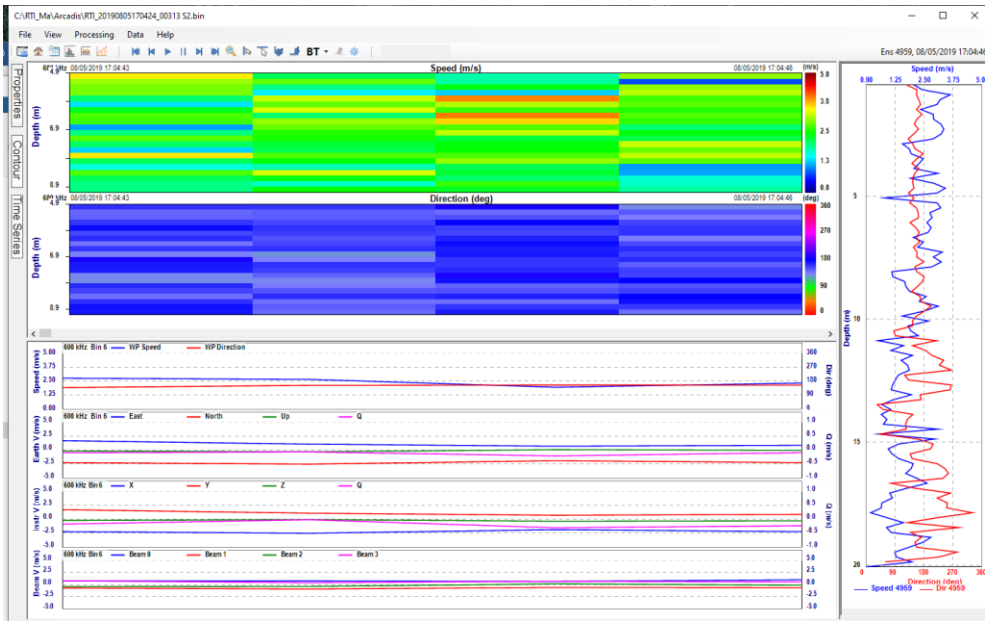


Figure 27. Zoom In

- **Pick Ensemble** : pick ensembles from the contour image. The picked ensembles will be shown on the Vertical Profile Window. Click the button from the tool bar to enable ensemble picker. You will see a white vertical line on the contour image, move the white line to the ensemble on the contour plot then click. That ensemble will be selected, and the profile file of the ensemble will be shown in the Vertical Profile Window on the right (Figure 28). You can select as many ensembles as you can. Click the button to clear the selected ensembles. Unclick the button to disable ensemble picker.

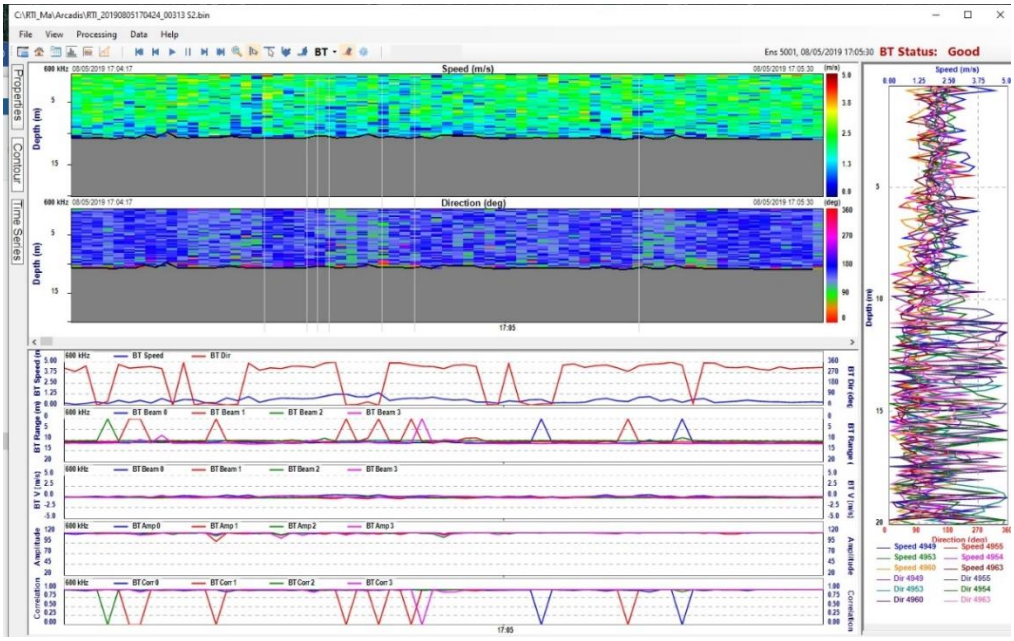


Figure 28. Ensemble Picker

- **Pick TimeSeries** : pick different bins from the contour plot and show timeseries of the picked bins on the TimeSeries plots (Figure 29). You can only select bins from one contour plot. In doing so,

  First, click button to enable timeseries picker.

  Second, click "Contour" button on the left and select only one item, for example Speed , from the contour item buttons.

  Third, click "TimeSeries" button on the left to unselect all the item buttons from the first column, then select the same item (Speed) on the second column. This way, both the Contour Area and the TimeSeries Area of the home page will only show Speed plots.

  Fourth, now you will see a white horizontal line on the Speed contour plot. click will select that bin data, the selected bin timeseries plot will be shown in the TimeSereis Plotting Area. Move mouse on the contour to different depth to select more bins. Figure 29 shows the result of the selected bin timeseries plots.

  Click button on the tool bar to clear the selected timeseries plots. Unclick button to disable TimeSeries Picker.

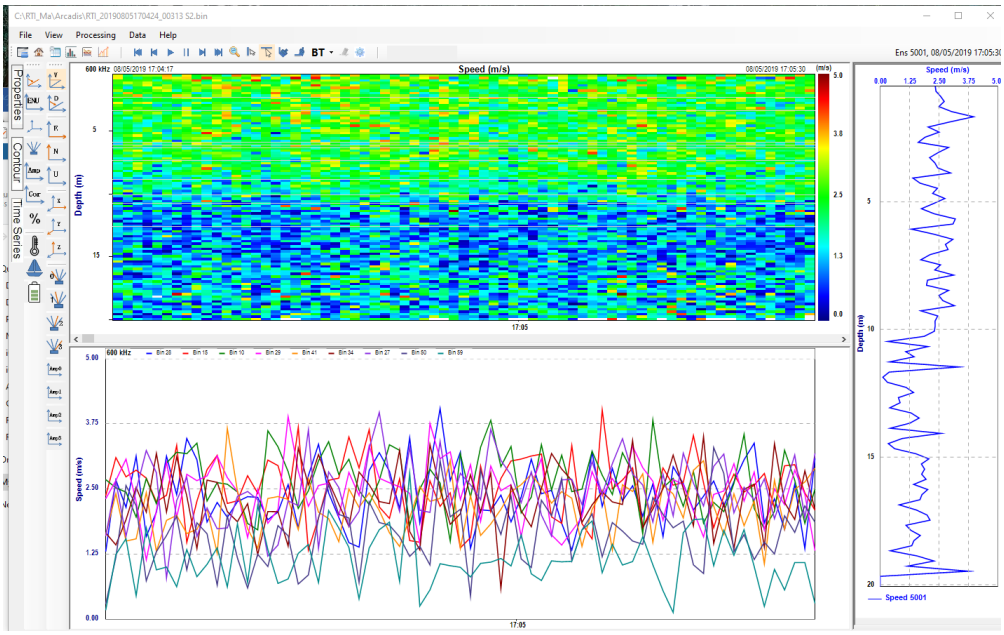


Figure 29. Timeseries Picker

- **Bottom Track Reference** BT: the reference to calculate boat velocity. It has four options:
    - None: no reference
    - BT: use speed and direction collected by ADCP bottom track data
    - GPS VTG: use the speed and direction measured by external GPS VTG data string.
    - GPS GGA: use the speed and direction measured by external GPS GGA data string.

  Water current meter mounted underneath the vessel hull will measure the water speed and direction relative to the vessel, i.e. the vessel speed through water. However, what the navigation crew typically is interested in is the net ocean current speed and direction relative to ground. This is obtained by connecting the vessel Gyro and DGPS and subtract the vessel speed over ground from the peed through water value. What RTI Direct Reading software does, is to collect real-time "raw" current profile data and heading, pitch, roll from ADCP with speed and heading data from external inputs like DGPS/Gyro. The corrected values, or difference between the two, represent the net ocean current relative to ground.

  In RTI DR software, when BT is ON, the vessel velocity will be taken off from the ocean current speed and velocity display. The user can also choose what reference (None, BT, GPS VTG, GPS GGA) he/she will use to calculate the vessel velocity.

- **Mark Bad Below Bottom** : the current data collected by ADCP usually are bad or not valid bellow the bottom depth, so, the user can choose to show or

not show the bad data below bottom line when analyzing the data. This can be done by turning ON and OFF the "Mark Bad Below Bottom" button in the tool bar. It requires the to turn on the BT button first in order to use the "Mark Bad Below Bottom" button. When  is ON, it's clear to see the bottom line and the real ocean current data.

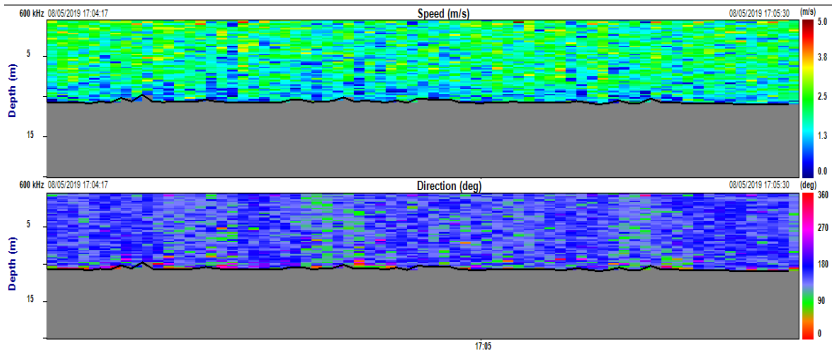


Figure 30. Bottom Track is ON

- **Display Settings**  : to set up some parameters for post processing data.

- **Left-Side Buttons**: there are three buttons on the left-side of the window:
  - **Properties**: show some properties of the data such as ADCP frequency (s), serial number, firmware version, subsystems, datetime, ensemble number, environmental information and ADCP configurations.

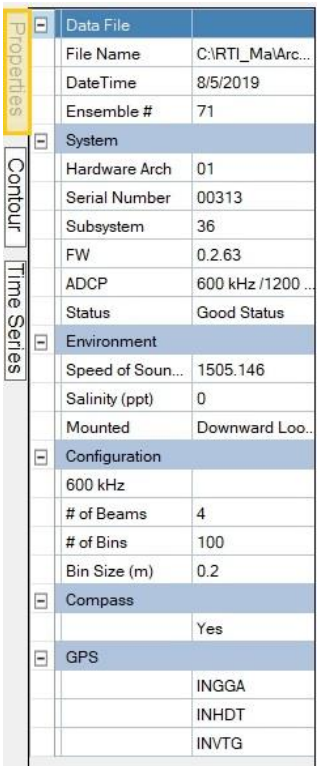


Figure 31. Properties Button

- **Contour**: the button items that the user can choose to be shown in the Contour Plotting Area. i.e. select which contents you want to see in the contour plotting area. Please note, the contents in the vertical profile window will also change if the contour plotting area contents change. The selectable contour items are as follow:
    - Speed / Direction
    - Coordinates velocity
        - Earth Coord (ENUQ)
        - Instrument Coord (XYZQ)
        - Beam Coord (B0, B1, B2, B3)
    - Amplitude
    - Correlation
    - Good Ping

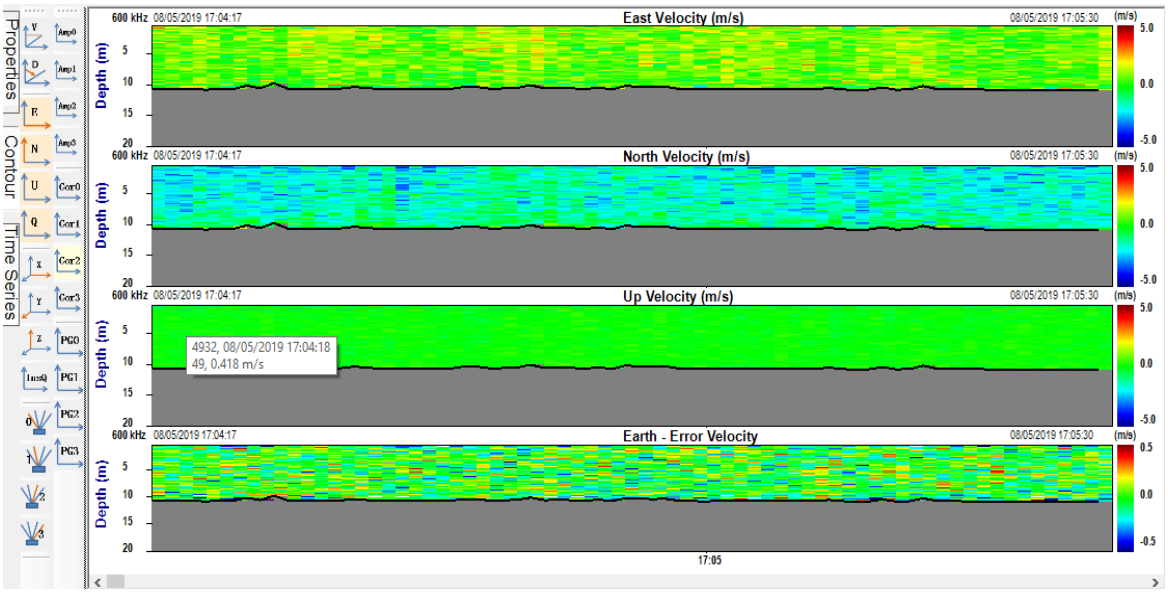


Figure 32. Select items to be shown in the Contour Plotting Window

- **TimeSeries:** select the button items to be plotted in the TimeSeries Window. The contents of this button will be different when BT is ON and OFF, so does the TimeSeries plotting window.
  - BT is OFF: this will show water current profile data (Figure 33). The data contains boat speed and boat velocity.
    - Speed/Dir
    - Velocity (Earth/Instr/Beam)
    - Amplitude
    - Correlation
    - HRP
    - System information such as water temperature and pressure
    - Battery voltage

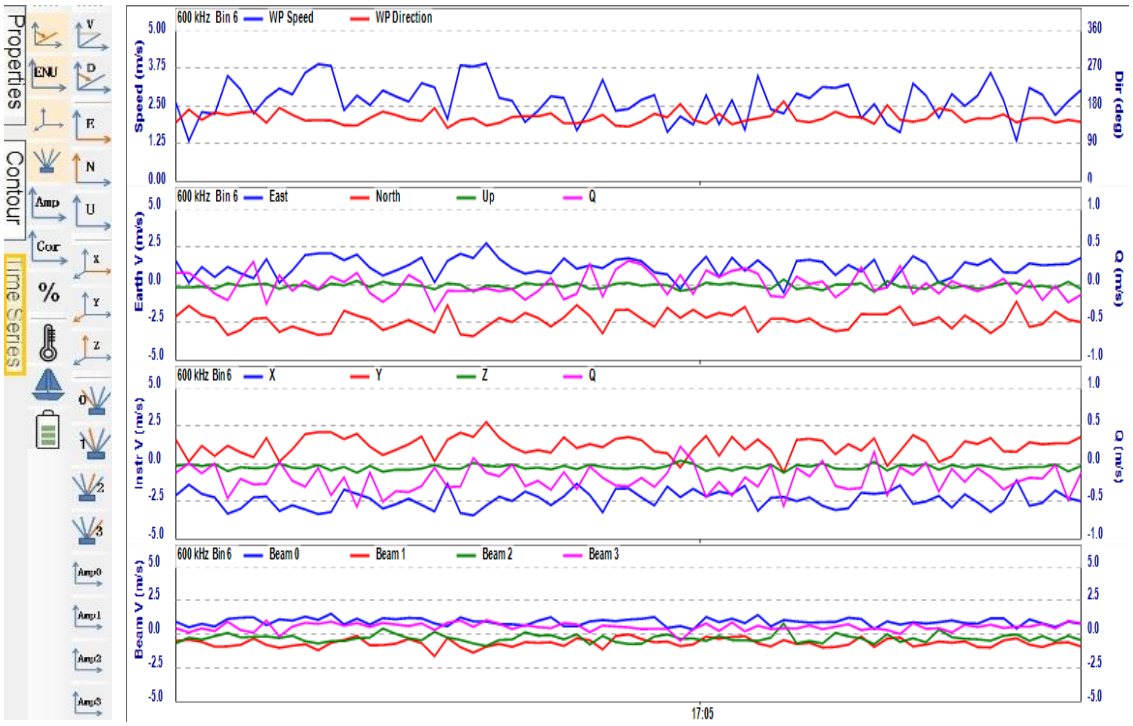


Figure 33. TimeSeries Button when BT is OFF and TimeSeries plots

- BT is ON: this will show the ADCP bottom track data (Figure 34)
  - BT Speed/Dir
  - BT Range
  - BT Velocity (Earth/Instr/Beam)
  - Amplitude
  - Correlation
  - SNR
  - HPR

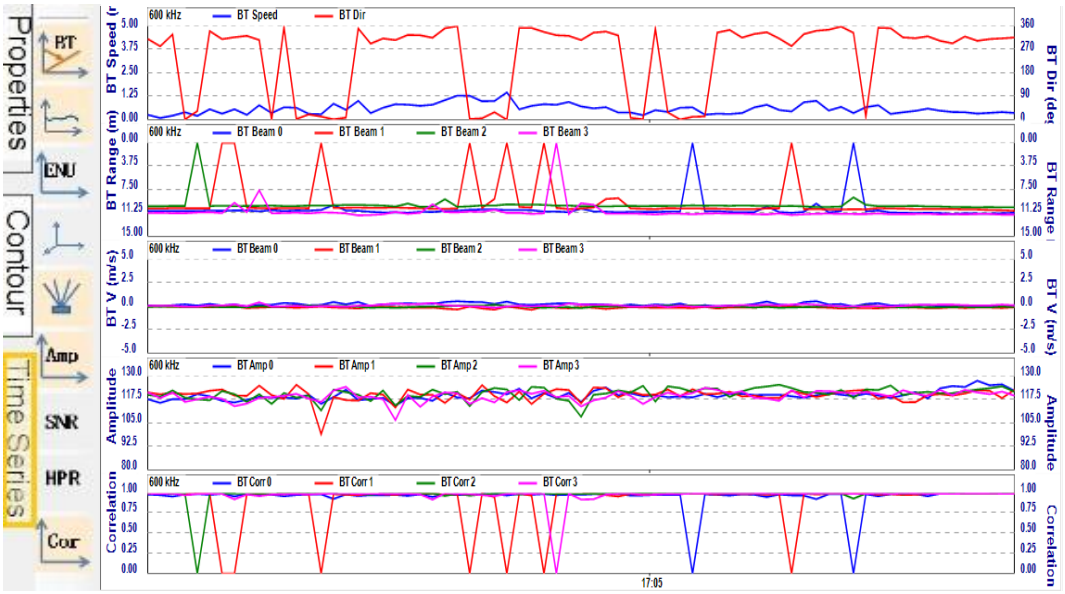


Figure 34. TimeSeries Button when BT is ON and TimeSeries plots

- **Contour window**: the color-filled plots of data. The default display in Contour window is Speed and Direction but user can choose whatever data he / she wants to view from the extended **Contour** selection buttons on the left side of the **Display** window.
- **Timeseries plot window**: the timeseries plots of data. The default timeseries plots in the Timeseries plot window are Speed and Direction, Earth Velocity, Instrument Velocity and Beam Velocity, similarly, user can choose other data by clicking the buttons in the extended **Timeseries** selection buttons on the left side of the **Display** window. The Timeseries plot window can only display up to four timeseries plots, if it is more than four plots, the oldest plot will be removed from the window. For dual frequency, each frequency has a tabpage in the Timeseries plot window.
- **Vertical profile**: the vertical profile of data plots. The content of vertical profile display depends on what kind of data you chose in the Contour window. It is only the vertical plot of the same data in the contour window. For dual frequency, each frequency has a tabpage in the Vertical Profile window.
- **Properties button**: Properties button contains the information about the data and the instrument that collected the data (Figure 35).

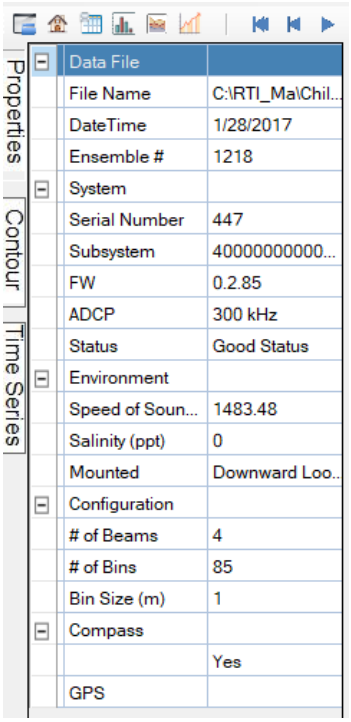


Figure 35. Properties button contents

- **Contour button:** contains the buttons (Figure 36) that for selecting what kind of data will be showing in the Contour window. The plots are organized into the following display groups:
    - Speed and Direction
    - Three coordinate system velocity:
        - Earth coordinates: **E**ast, **N**orth, **U**p
        - Instrument coordinates: X, Y, Z
        - Beam coordinates: Beam **0**, Beam **1**, Beam **2**, Beam **3**
    - Error velocity
    - Amplitude (4 beams)
    - Correlation (4 beams)
    - Percent Good (4 beams)

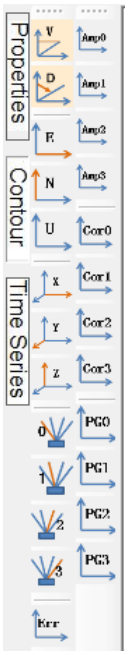


Figure 36. Contour data selection buttons

When you click any of the contour buttons, a popup window (Figure37) will show up to let you choose the depth or the bin you want to plot.

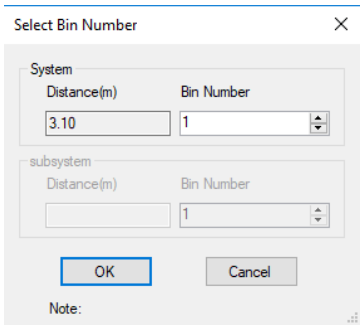


Figure 37. Select Bin window

- **Timeseries button:** contains the buttons (Figure 38) that for selecting what kind of data will be showing in the Timeseries plot window. The default selections include four buttons (as shown in yellow in Figure 38): Speed and direction, ENU (earth) coordinates velocity, XYZ (Instrument) coordinates velocity, and beam coordinates velocity.

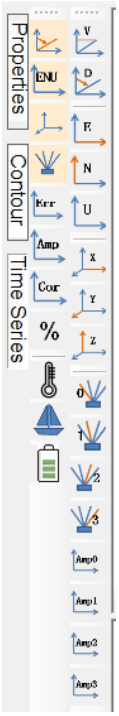


Figure 38. Timeseries data selection buttons

The Timeseries buttons are organized into two columns: the left column buttons are the data type you want to plot in the timeseries plot window; the right column buttons are used in conjunction with the **Timeseries Picker** button to select particular data point from the contour plot to be plotting in the timeseries. To use the second column buttons, you first enable **Timeseries Picker** button from the Control bar by clicking it, second, you choose the buttons from the second column of Timeseries, third, use your mouse to click on any spots on the contour plot to select the data point you want to see, the timeseries lines will be shown in the Timeseries plot window. Figure 39 shows an example of the results. Click the **Clear Timeseries Picker** button to clear the selected timeseries plots.

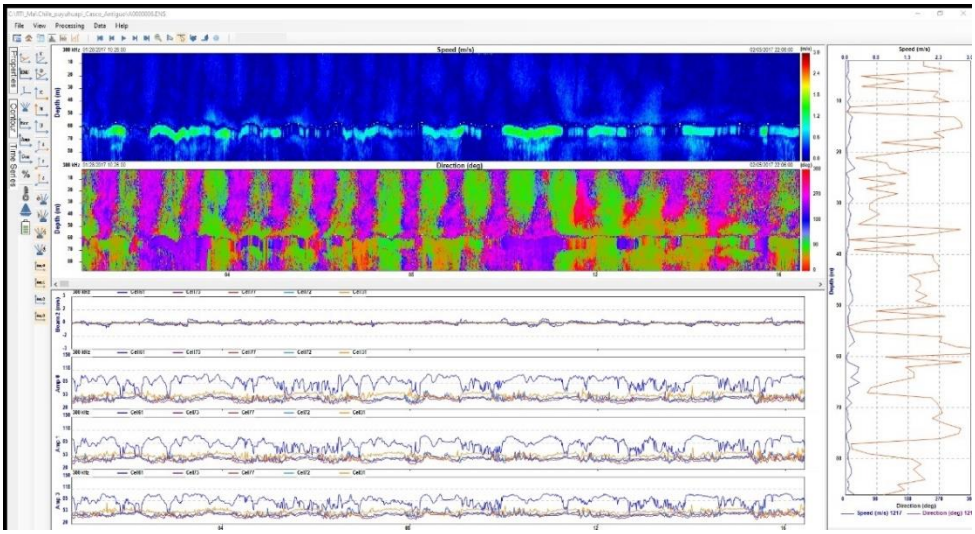


Figure 39. Timeseries picker example

12.2 Data page

Click  button from the **Tool bar** menu to switch to **Data Page** (Figure 40). If it's dual frequency or more than one frequency, the dropdown menu on the left top will allow you to switch between different frequencies (Figure 41).

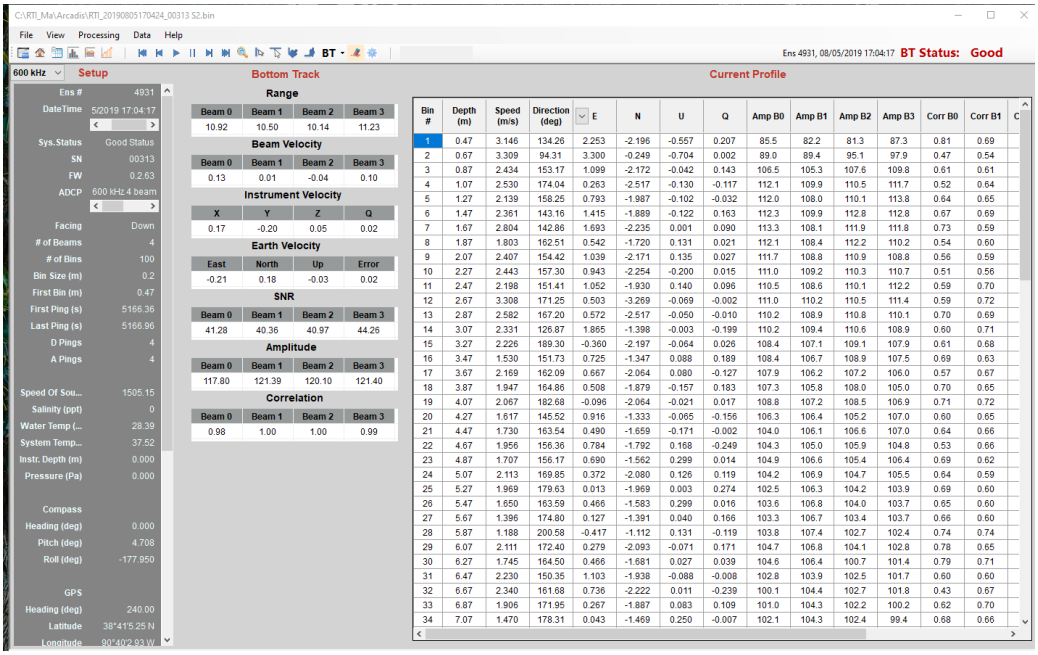


Figure 40. Data Page – Single Frequency

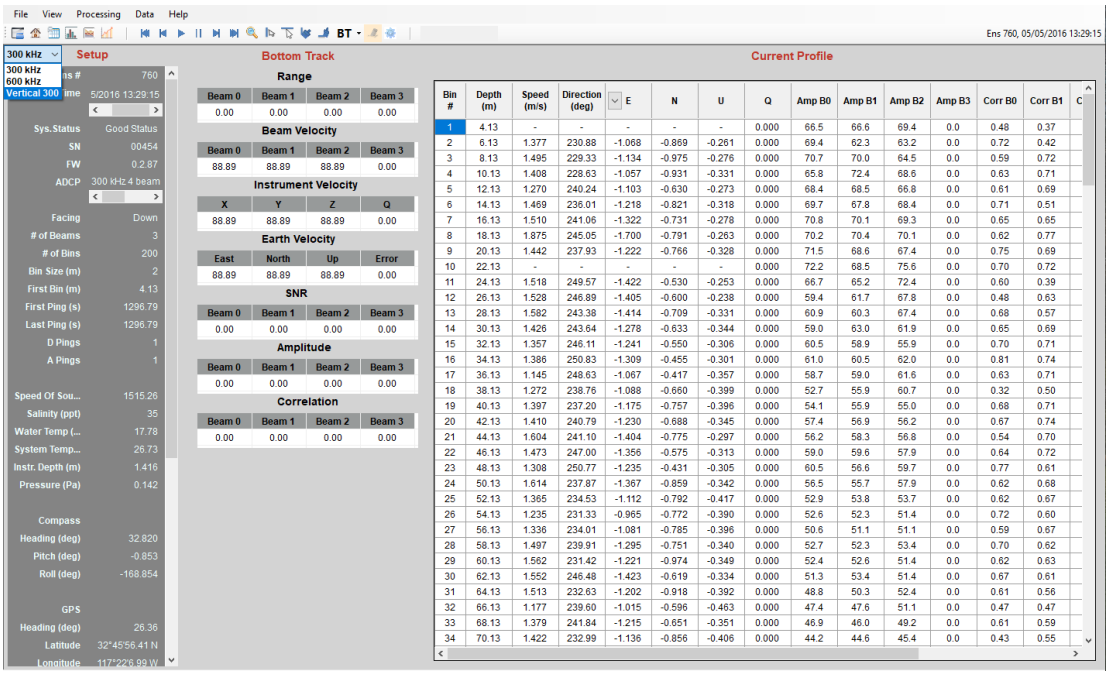
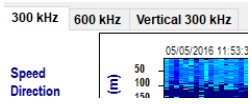


Figure 41. Data Page – Multiple Frequency

12.3 Contour page

Click **Contour** page button from the **Tool bar** menu to switch to **Contour Page.** Figure 42 and Figure 43 show the contour page when BT is off and when BT is on, respectively. There are four areas on the page: the *Speed and Direction* part on the left top showing the *Speed and Direction* plots, the Coordinates area on the left bottom showing velocities of three different coordinates (Beam, Earth, Instrument), the right column shows the Quality Control (QC) parameter (Amplitude, Correlation and Percent good) data. If it's dual frequency or has vertical frequency data, each frequency will have a tab page, you can use the tab page buttons



on to top of the *Speed and Direction* area to choose the frequency you want to look. For vertical frequency, there are only three plots on the page: Beam 0 Velocity, Beam 0 Amplitude and Beam 0 Correlation as shown in Figure 44.

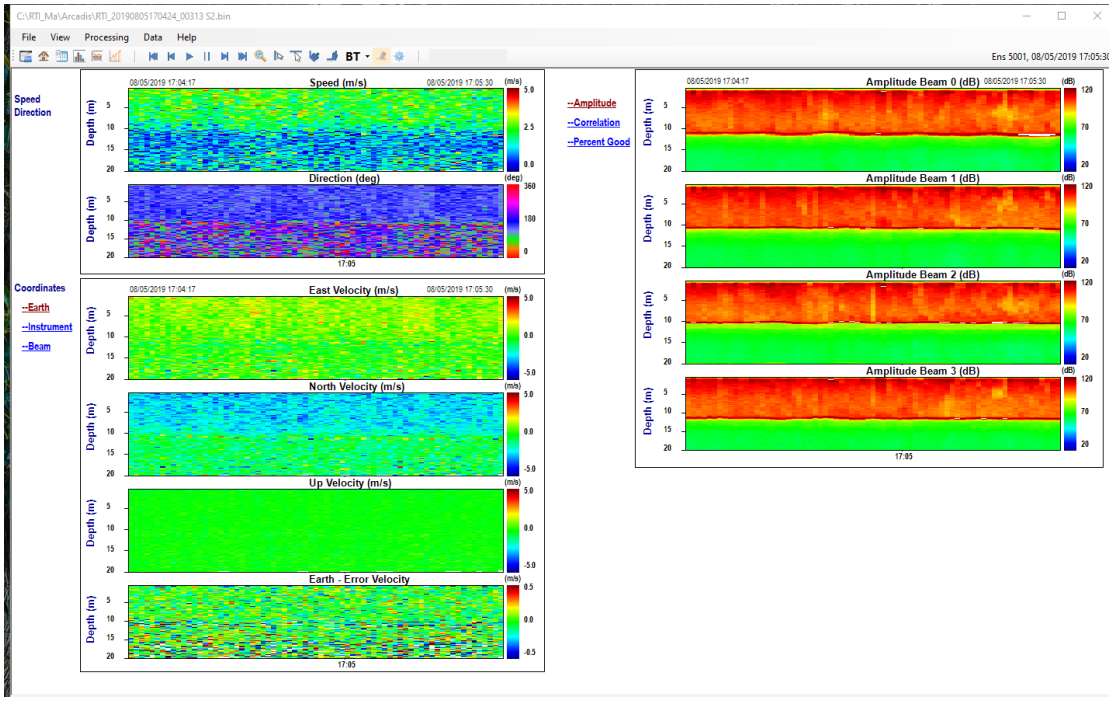


Figure 42. Contour Page with BT is OFF

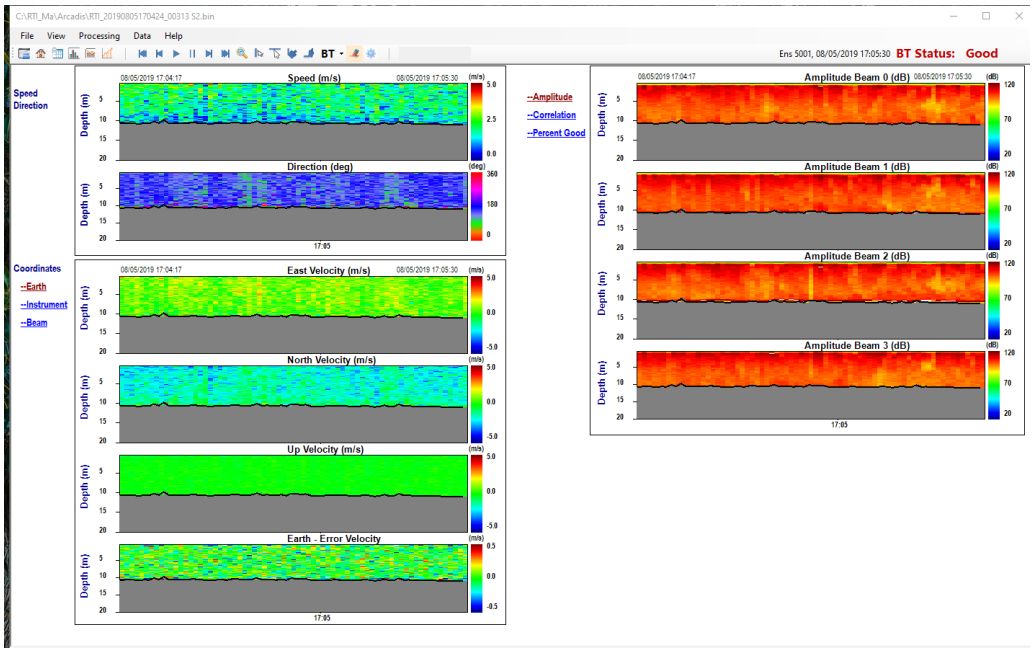


Figure 43. Contour Page with BT is ON

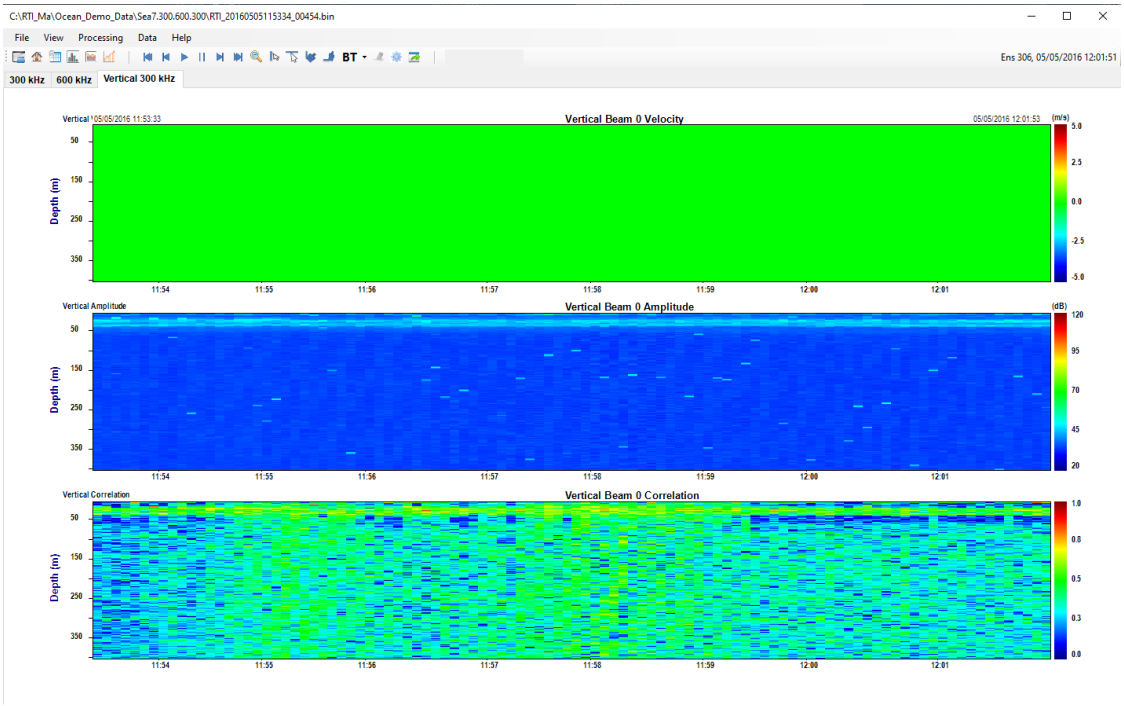


Figure 44. Vertical beam contour page

12.4 Timeseries page

Click **Timeseries** page button from the **Tool bar** menu to switch to **Timeseries Page** (Figure 45). Similarly, for dual frequency data, click the tab page buttons to switch between frequencies.

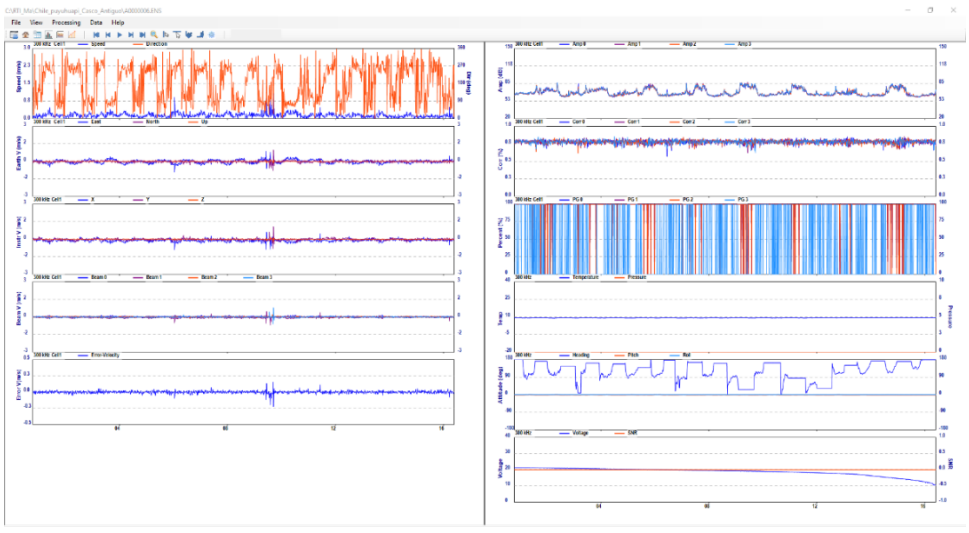


Figure 45. Timeseries page

12.5 Vertical profile page

Click **Vertical profile** page button from the Tool bar menu to switch to **Vertical profile** Page (Figure 46). If it's dual frequency data, the second frequency data plots will be shown below the first frequency plots (Figure 47). For the third column of Velocity, there are three coordinates the user can choose: ENU, XYZ and Beam.

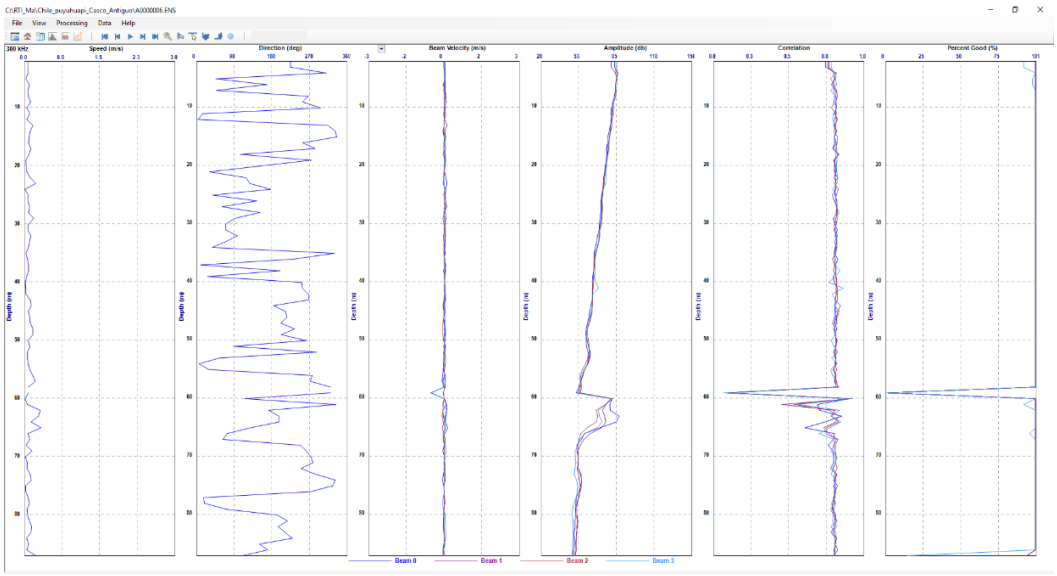


Figure 46. Vertical Profile page – Single frequency

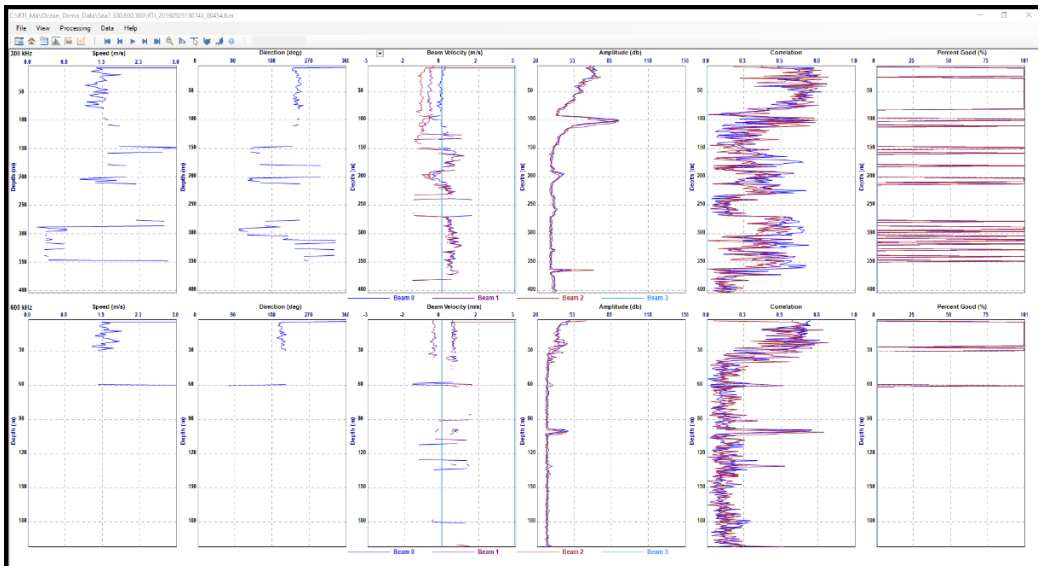


Figure 47. Vertical Profile page – Dual frequency

13. Live Data View

After deployed the system and Started pining, you can open the View page to see the live data received from the ADCP by clicking the 

icon from the tool bar. They are the same pages as the pages in **Playback** display but with the live data (Figure 48).

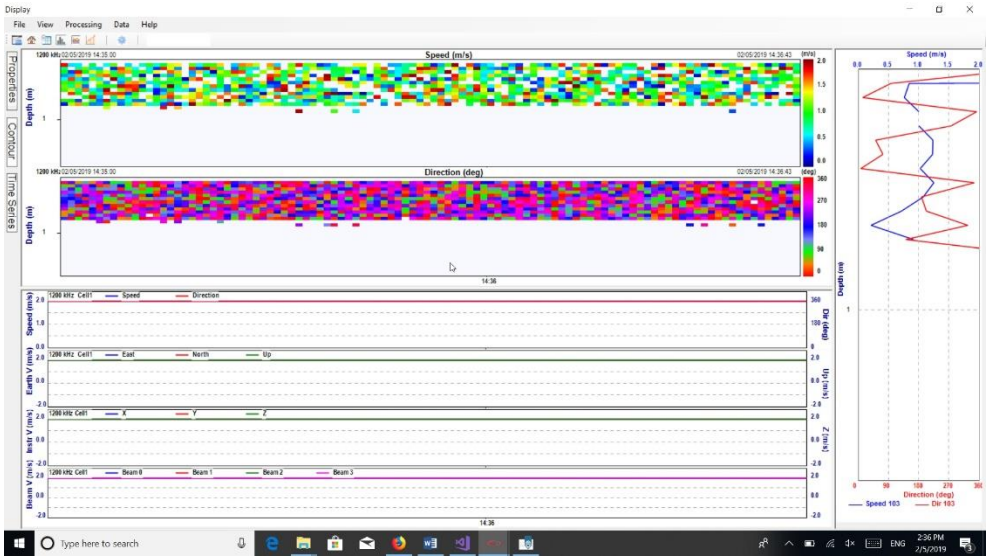


Figure 48. Live data view

14. Communication

The **Communication** window is a place for the user to change the serial baud rate on ADCP. Click 

icon in the tool bar to open the Communication window (Figure 49).

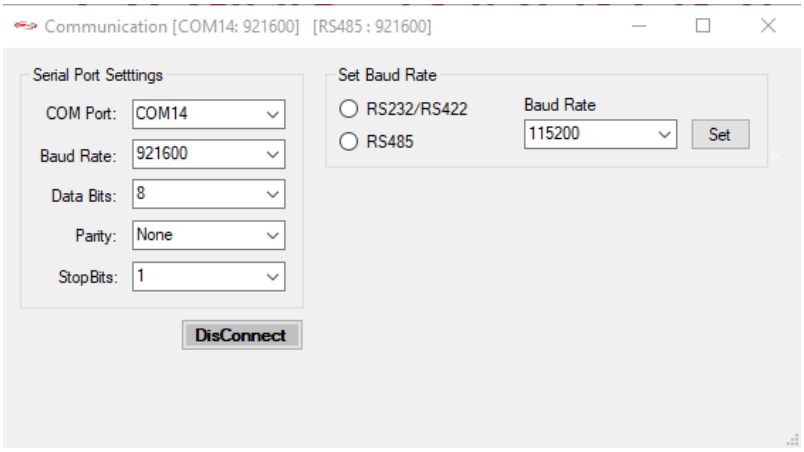


Figure 49. Communication Window

The “Serial Port Settings” group box shows the COM port and baud rate that are currently in use, the “Set Baud Rate” group box is to let the user to select the port (either the RS232/RS422 port or the RS485 port) to change and what baud rate it will be. The title of the window shows the current settings of the COM port and baud rate.

After clicking the “Set” button, the selected port (either RS232/RS422 or RS485) will change its baud rate to the value you choose. If you are connecting to ADCP using this port, you need to reset its baud rate in the left “Serial Port Setting” box and reconnect to it.

15. Instrument

This includes operations of the instrument such as System Check, Compass Cal and Upload Firmware.

- **System Check**: before any deployment test it is strongly recommended to undergo a functionality test to ensure that the various components are working as intended. Figure 50 shows an example of the test result. The warning information is in Yellow and any information in Red means something wrong with that component and needs attention.

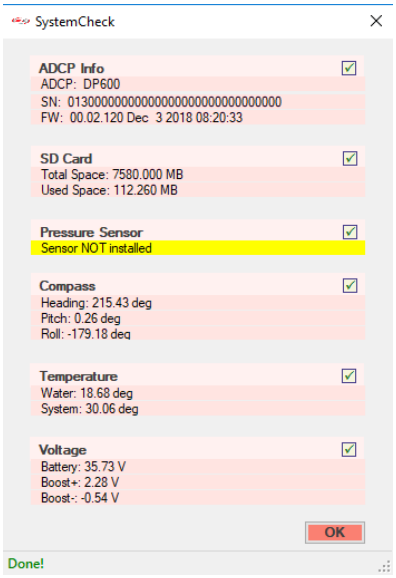


Figure 50. System Check

- **Compass Calibration**: this starts the Compass Calibration user interface that allows perform an on-site 2D or 3D calibration of the instrument compass to remove the effect of Hard-iron objects.

- **Upload Firmware**: to upload new firmware to the instrument. When uploading the firmware, check to ensure that the firmware you are intending to upload is compatible to your instrument hardware, and the most recent version of the application software s also used. Incompatible firmware loads will be detected by application.

    1. Download the appropriate firmware from RTI website to your computer.

2. Click on Upload Firmware, select the firmware on your computer that you downloaded
3. This will result in the file being transferred to the instrument and a progress bar will be displayed (Figure 51)

Figure 51. Upload Firmware