FutureWaves™

User Manual

12 December 2019

Document # U001-003-RPT-002

RECORD OF CHANGES

Revision Number	Revision Date	Description	INITIALS
-	12/02/2019	Initial DRAFT	ML

Contents

Overview

This document serves as a guide for operating the FutureWaves™ system. FutureWaves™ is a system with the capability to measure, predict, and display the environmental and ship motion parameters needed for operators to safely conduct operations. The system provides accurate ship motion and wave forecasting for time scales of interest (~5 minutes) in up to sea state 5 and ship speeds of up to 10 knots.

System Description

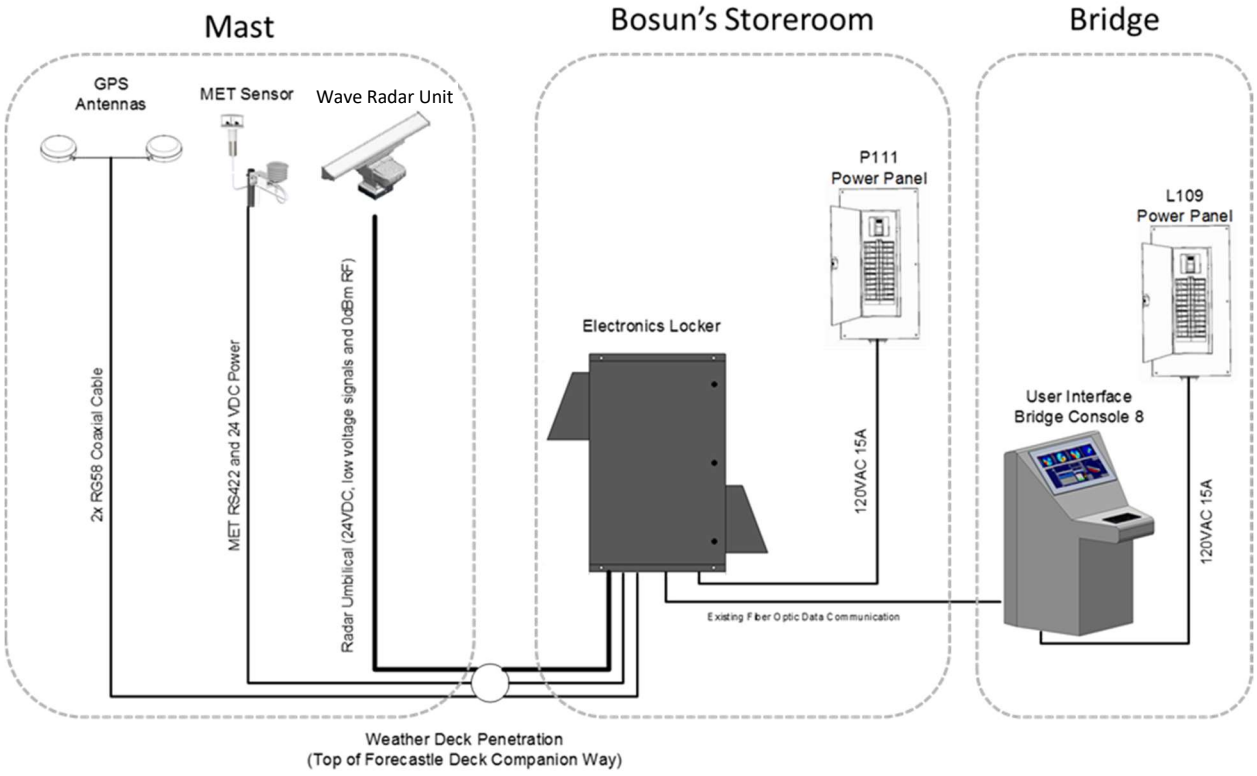


Figure 1: FutureWaves™ Components and Physical Layout

The major hardware subsystems of the FutureWaves™ system are:

- User Workstation [Bridge Console] – The User Workstation (UWS) is a ruggedized Intel PC running Windows 10 that provides the main interface for FutureWaves™. Detailed software description is in the following section.
- Primary Processing Unit (PPU) – The PPU is a ruggedized Intel PC running Linux Ubuntu 16.04. It performs the core algorithms of FutureWaves™ taking in sensor data and providing products to the UWS. The PPU is in the Electronics Locker located in the Bosun's Storeroom below the forecastle deck.
- Wave Radar Unit (WRU) – The WRU is the principal FutureWaves™ sensor for measuring the oceanic wave field. It is a modified marine navigation radar specialized for ocean surface return. Radar control and signal processing are performed by a

dedicated Radar Processing Unit (RPU) consisting of an Intel PC with Windows 10. The CORR is on the foremast and the RPU is also within the Electronics Locker.

- Ship Motion Sensor (SMS) – Real-time ship motion is provided to the system by an OXTS RT2502 IMU. The sensor uses accelerometers and gyros in conjunction with dual antenna GPS with L1 carrier-phase differencing. The SMS is located in the Electronics Locker and connects to the PPU via a direct Ethernet connection. GPS antennas are located on the foremast.
- Meteorological (MET) Sensor – Real-time environmental data (e.g. wind speed/direction, temperature) is provided to the system by a Gill® MetPak™ II Weather Station via a RS-422 serial connection to the PPU. The MET sensor is located on the foremast.
- Ethernet network switch – The processors are networked using a Dell PowerConnect 2816 16-port, high-performance Gigabit Ethernet switch also located within the Electronics Locker.

The three processor components (PPU, RPU, and UWS) are all Cincoze model DS-1002 high performance, fan-less, expandable computers. Hardware specifications are:

Dimensions:	227mm x 126mm x 261mm, 5.7kg
Power:	120W, 12-30VDC
Operating Temperature:	-10 to 76°C
Interface:	RS422, Ethernet
Processor:	Core i7-4770TE Haswell 2.3Ghz
Memory:	DDR3 1600 SO-DIMM- 16 GB
Primary Storage Drive:	mSATA SSD - 256 GB
Secondary Storage Drive:	2.5" Hard Drive - 2 TB

The interconnectivity of the components and the general physical layout are shown in Figure 1.

Operating instructions

Startup

1. Verify breakers are closed and power is available to the FutureWaves™ electronics locker via P111 and the FutureWaves™ Bridge console via L109.
2. At the bridge console, turn on power to the display then press and release the momentary power button located just under the console ledge. Login as user 'FutureWaves™' if prompted for a login.
3. Select the FutureWaves™ icon on the Windows Desktop and double click or press enter to start the FutureWaves™ Graphical User Interface (GUI). Once the GUI starts, the display should appear as shown in Figure 2.

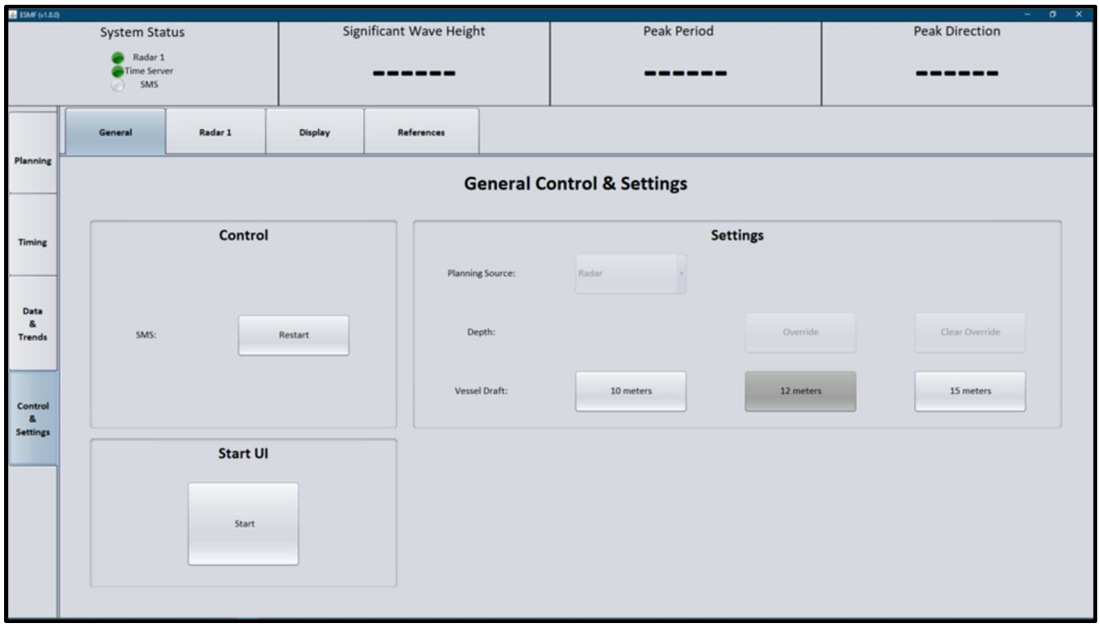


Figure 2: Initial Display - **General Tab**

4. (Refer to Figure 3) Find the *System Status* on the upper-left corner of the display. If the 'SMS' indicator is grey and all other indicators are green, then the system is ready to start receiving data. Press the 'Start' button.

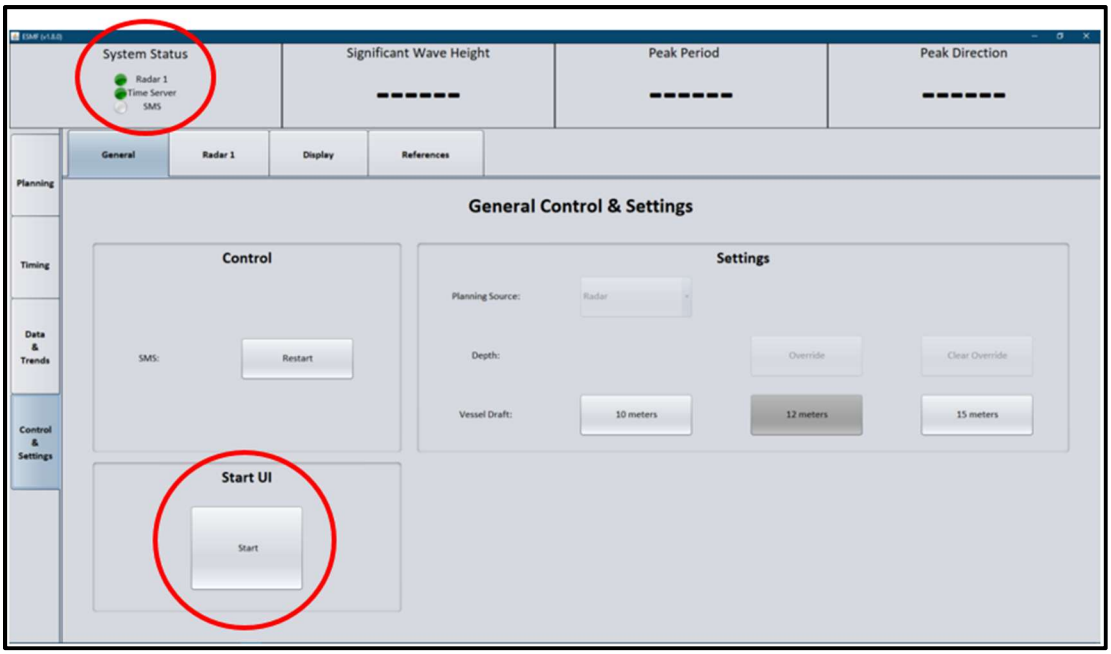


Figure 3: Location of the *System Status* and 'Start' Button on the **General Tab**

5. It may take the system up to 60 seconds to completely initialize after clicking 'Start'. Once the initialization process is complete, the 'Start' button will become disabled and replaced with a faded 'Ready to transmit' text. Additionally the 'Planning Source' and 'Depth' settings will become enabled.
6. (Refer to Figure 4) The next step is to start the radar. Click **Radar-1** on the upper horizontal tabs. Look at the *Radar Control* section on the right half of the display. The 'Transmit Power' should be 'Off' because the radar is not transmitting. The 'Ready Status' indicator should indicate green if the radar subsystem is ready to begin transmitting.

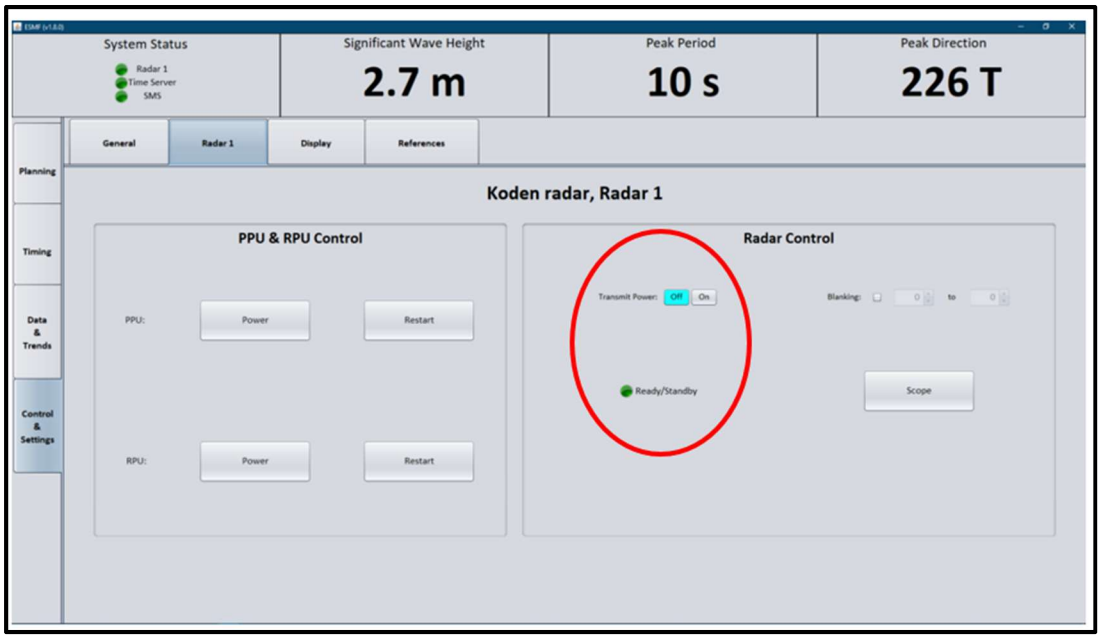


Figure 4: Location of the 'Transmit Power' buttons and 'Ready Status' indicator in the *Radar Control* section of the **Radar-1 Tab**.

7. Visually verify the radar is clear of any obstructions then click the Transmit Power 'On' button. This will energize the unit and begin rotating the antenna.
8. (Refer to Figure 5) To verify nominal operation of the radar and RPU, open the Sensor Scope by pressing the 'Scope' button. You will see the text 'Connecting…' as it tries to connect to the network. It may take up to 2 minutes for the radar scope to connect.

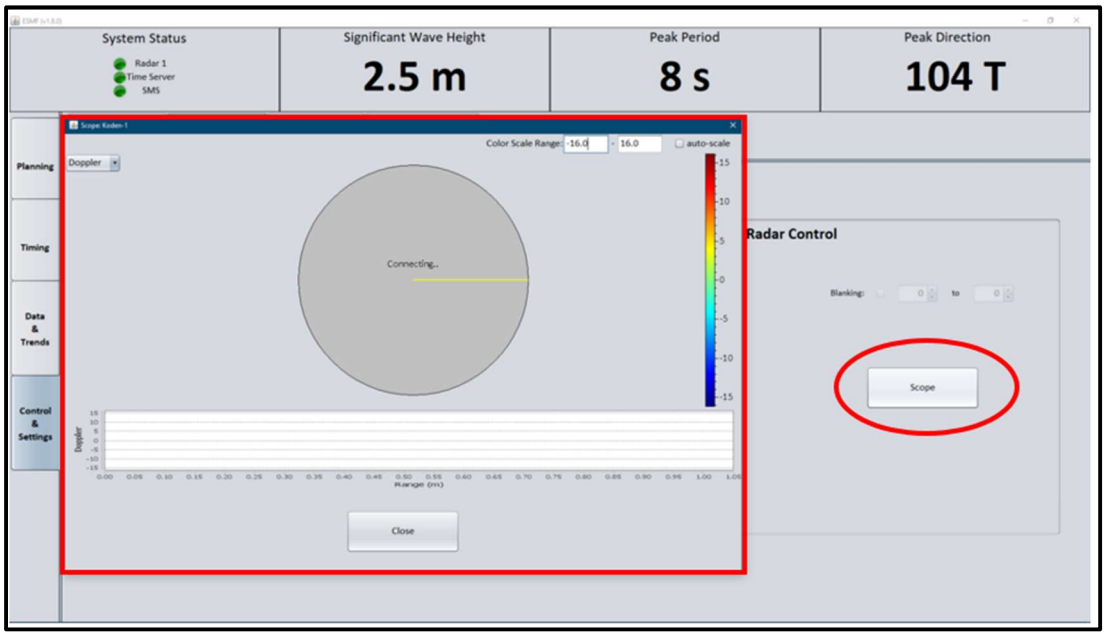


Figure 5: Locate 'Scope' Button and the show Radar Scope connecting in the **Radar-1 Tab**.

9. (Refer to Figure 6) Once the 'Connecting...' text is no longer displayed, the radar scope is connected and should be displaying data. Select 'SNR' from the drop-down on the upper-left of the dialog. Reflections in the scope should appear similar to that in Figure 6, depending on objects nearby. If the scope is not showing any data (solid grey), the RPU may not have completed its startup cycle.

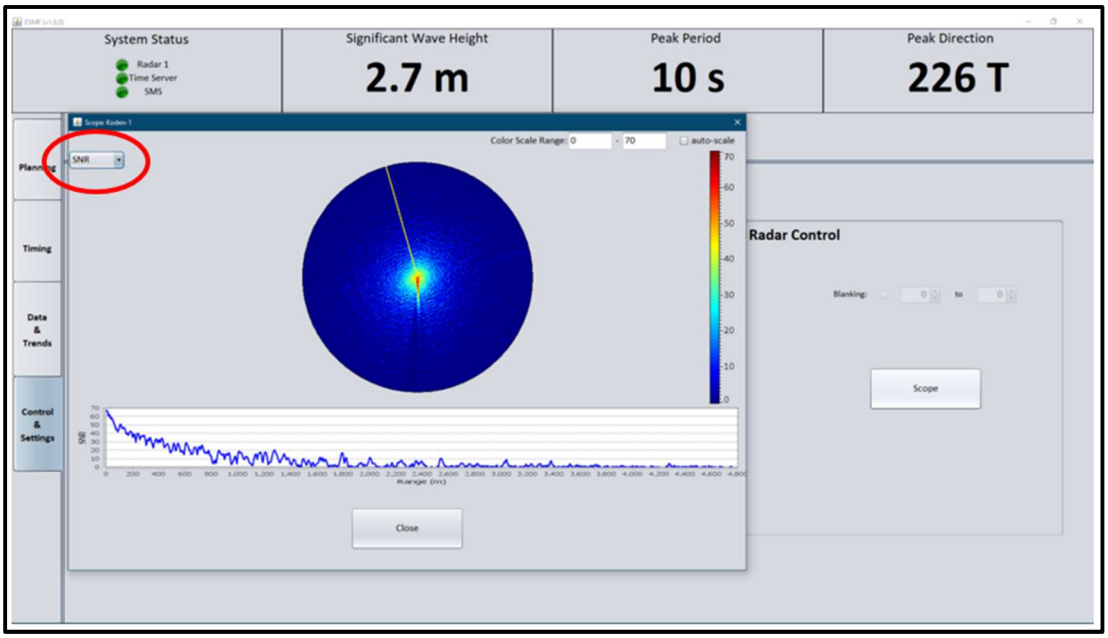


Figure 6: Locate the 'SNR' Button and show the Radar Scope displaying data in the **Radar-1 Tab**.

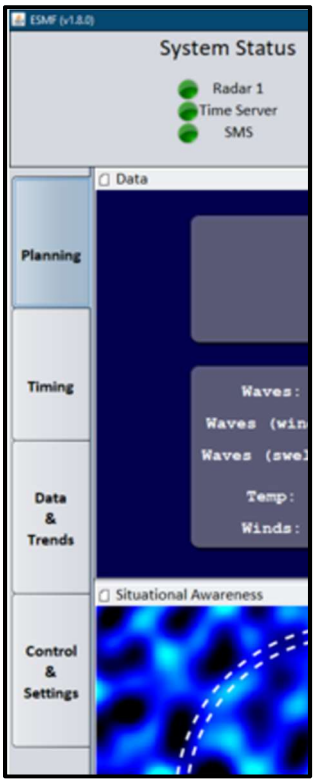
10. After verification of radar operation, exit the scope window by selecting 'Close'. The radar scope requires a lot of network bandwidth to function and can impact normal operations if left running. The radar data scope should only be used intermittently and not left operating continuously. Stopping the radar scope will pause updates to this display, but ***does not*** stop radar transmissions. The radar and FutureWaves™ will continue to function when the scope is stopped. To stop radar transmission the 'Transmit Power' must be switched to 'Off'.
11. FutureWaves™ is now in normal operating mode and has begun to collect data. After about three (3) minutes the ocean wave spectra [2DPS] should become visible on the planning tab and timing forecast should be ready shortly after that.

Normal Operations

The top of the FutureWaves™ display shows overall system status and current forecast at all times. This is shown in Figure 7.

Figure 7: FutureWaves™ Header

Aligned along the left edge of the display, the four function tabs for the FutureWaves™ GUI are ***Planning***, ***Timing***, ***Data & Trends***, and ***Control & Settings.*** This is shown in Figure 8.



Planning

The 'Planning' tab is used for assessing directional wave energy spectra and impacts on vessel motion.

Timing

The 'Timing' tab displays detailed statistics of current ocean conditions, motion forecasts, and *timing* information related to the current motion forecast.

Data & Trends

The 'Data & Trends' tab is used to display measured parameters and their trends.

Control & Settings

The 'Control & Settings' tab is used control the radar and other FutureWaves™ components. It is also used to load in a buoy file, override the depth, choose a vessel draft, change display settings, and view references. For diagnostic purposes, it can also be used to collect information about how the system is behaving.

Figure 8: The four function tabs of FutureWaves™

Planning

The ***Planning*** panel is used for assessing directional wave energy spectra and impacts on vessel motion. The wave data is fed to a Course/Speed Recommendation Module (CSRM) which shows expected vessel motions for varying course/speed. The ***Planning*** panel shows 6 separate panels by default as shown in Figure 9.

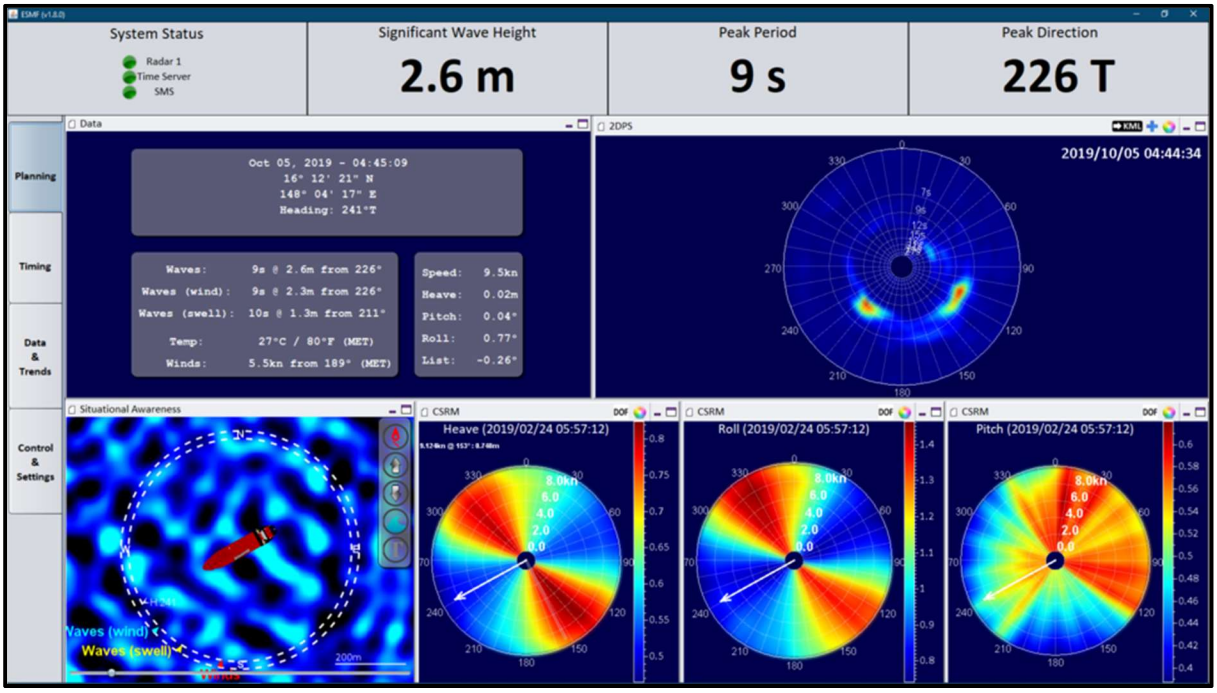


Figure 9: The ***Planning*** panel

Each panel can be independently moved within the tab, maximized to fill the entire tab, or minimized. When a panel is minimized, the other panels will automatically adjust to fill the newly available space.

The 6 panels of the ***Planning*** panel are:

- Data readout
- Two-dimensional power spectrum (2DPS)
- Situational Awareness
- Course & Speed Recommendation based on Heave
- Course & Speed Recommendation based on Roll
- Course & Speed Recommendation based on Pitch

Data Readout

The **Data readout** panel provides a text summary of the current forecast and some sensor data. This is shown in Figure 10.

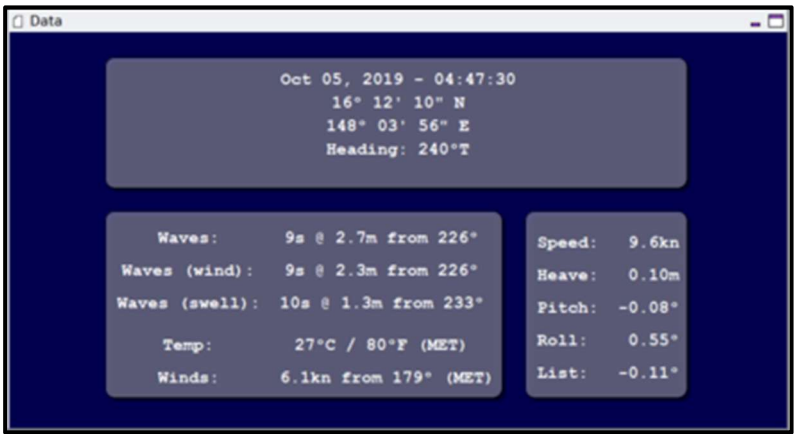


Figure 10: The **Data Readout** panel

The readout information displays the following:

- The date and time displayed is the current system time, **not** the time of the current forecast
- Position and heading as computed by the FutureWaves™ Ship Motion Sensor (SMS)
- Forecast combined seas and the forecast contributions from wind waves and swell waves updated approximately every 90 seconds to 2 minutes.
- Temperature and wind speed and direction from the FutureWaves™ meteorological sensor updated every second.
- Current ship motion data updated 10x per second.

The 'Waves' line describes the Significant Wave Height (SWH). SWH is the "combined seas" describing the total contributions from both wind generated waves and swell waves. The wind and swell contributions are combined as follows:

$$SWH = \sqrt{w^2 + s^2}$$

Where:

w is the wind wave contribution

s is the swell wave contribution

The Significant Wave Height, the period and direction associated with the primary wave contributor is what is displayed on the Waves line and in the FutureWaves™ banner area.

Situational Awareness

The **Situational Awareness** panel displays a top-down view of the vessel and surrounding wave field as it moves in real-time. This is displayed in Figure 11.

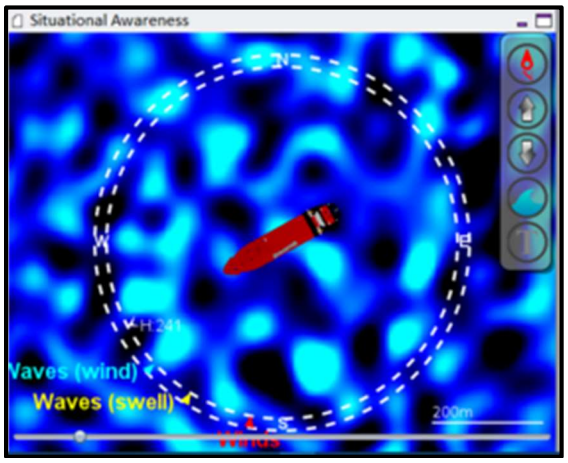


Figure 11: The **Situational Awareness** panel

The horizontal scroll bar at the bottom of the **Situational Awareness** panel can be used to zoon in and out of the display. The display can also be customized using the buttons on the right side of the panel.

 Orient display with True North up

 Orient display with ship Bow up

 Orient display Bow down

 Toggle drawing the wave field background

 Toggle drawing own ship track history.

If the system is configured as a connected, multi-ship system, then both ships will be drawn in the center of the display with standard fenders and lines connecting the two ships.

When the **Situational Awareness** panel is maximized, the data readout information is displayed on the left-hand side of the panel as shown in Figure 12.

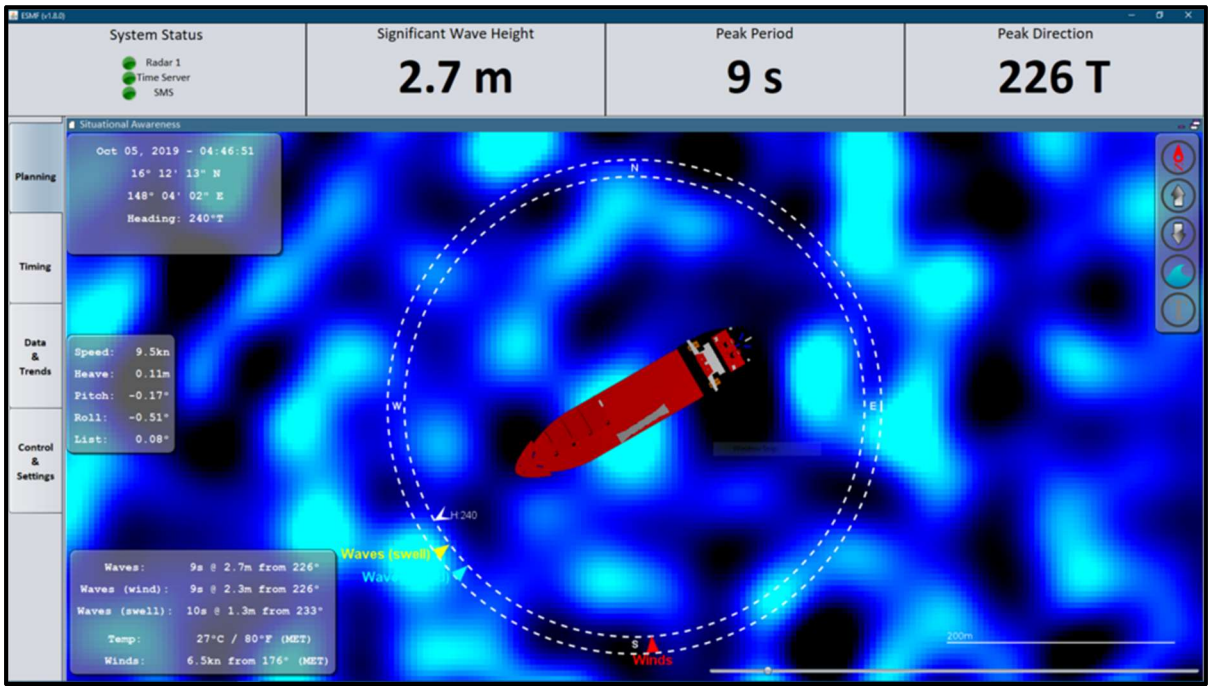


Figure 11: The **Situational Awareness** panel when maximized

Two Dimensional Power Spectrum (2DPS)

The **2DPS** panel displays a 2DPS either calculated from current radar data or from a NOAA forecast spectra obtainable by download from NOAA NCEP. This is displayed in Figure 12.

The graph shows the wave energy surrounding the ship. The distance from the center represents the wave period: the outermost edge represents 4 second periods, while the inner ring is 27 seconds. Whereas significant wave height provides an average value for the highest 1/3 of all waves, the 2DPS provides more detail. It shows wave energy from all directions at many different frequencies.

The time displayed in the upper right corner is the time that the last forecast was received. When updating normally with live radar data, the power spectrum attempts to update as often as the system processor can support. The current system should refresh roughly every minute or so.

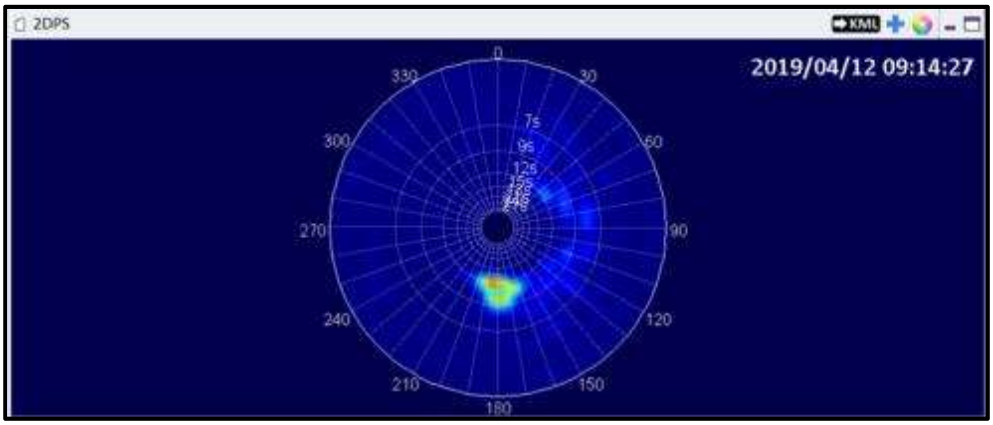


Figure 12: The **2DPS** panel

If more than 3 minutes elapses without a fresh forecast, an indicator immediately below the forecast valid time is displayed (view Figure 13). The time late indicator will periodically update the forecast age until a new forecast is received. When a new valid forecast is received, the time late indicator is removed automatically.

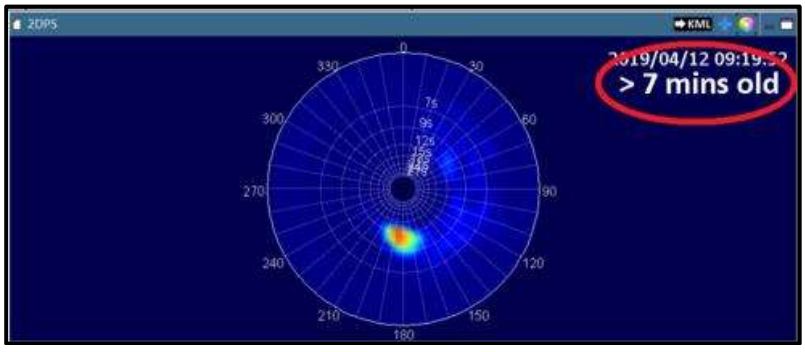


Figure 13: The **2DPS** panel with an old time indicator

Spectral Wave Bulletins

The **2DPS** display can display forecasts published as *spectral wave bulletins*. This allows users to easily visualize wave forecasts more than a week in the future. NOAA calculates wave spectra forecasts for several ocean locations several times per day. For instance the Beryl A AWS platform (station 63110) forecast. (http://polar.ncep.noaa.gov/waves/WEB/multi_1.latest_run/plots/multi_1.63110.bull)

The buoy nearest Tanapan harbor is bulletin id 52211.

To display a wave bulletin, first download a wave bulletin from the NOAA site and upload it into FutureWaves™ using the USB hub provided. The connection is located underneath the display shelf next to the display power switch. Move to the **General tab** inside the ***Control & Settings Panel***. Select 'Buoy' from the drop down box next to 'Planning Source' in the *Settings* section (refer to Figure 14). If file extension is not ".bull", then select 'All Files' from 'Files of Type'. Once you have selected a wave bulletin, click 'Open'.

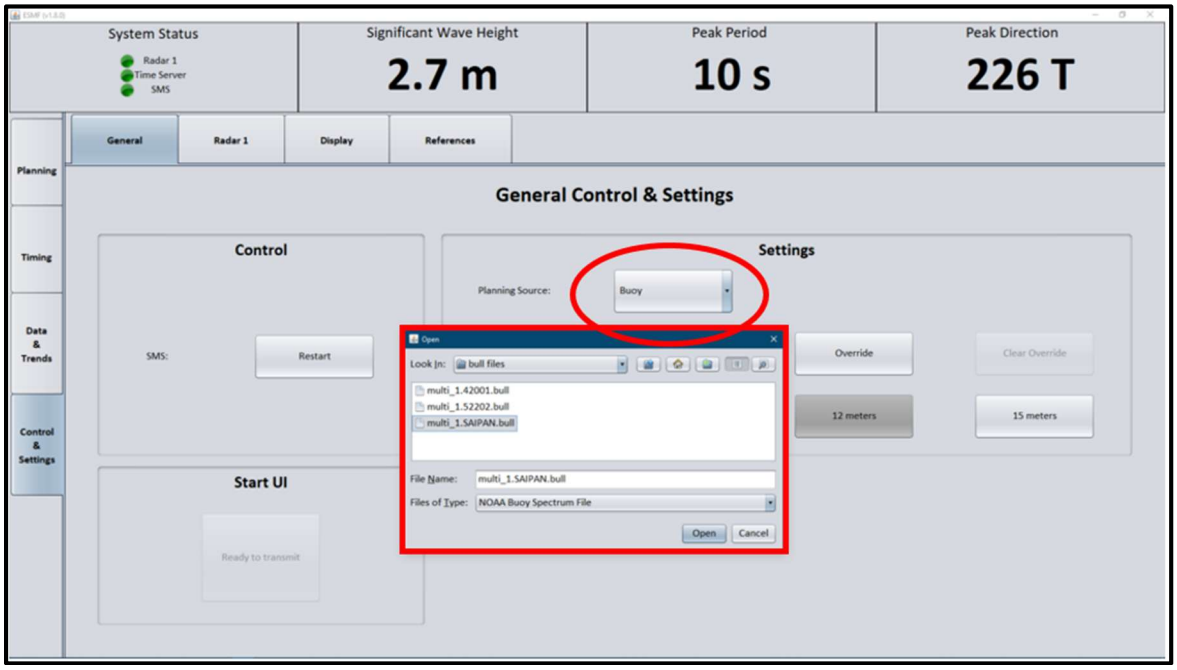


Figure 14: Selecting 'Buoy' as the 'Planning Source' in the **General Tab** in the ***Control & Settings Panel***

Return to the ***Planning*** panel. Once loaded into FutureWaves™, each forecast contained within the bulletin is selectable from a dropdown that will appear in the upper-right corner of the **2DPS** display. "NOAA BUOY" is displayed below the drop down. The forecast reference time is displayed in the center of the panel and the position of the forecast is displayed in the upper-left corner. This 2DPS displaying a wave bulletin forecast is displayed in Figure 15.

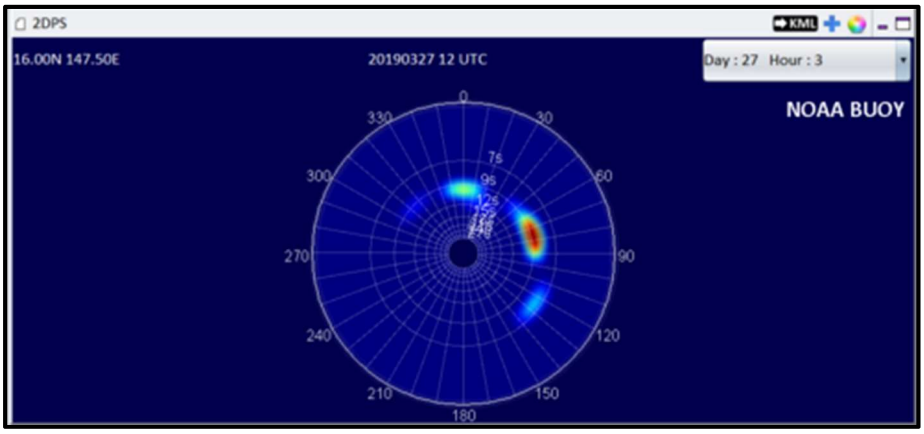


Figure 15: **2DPS** displaying a wave bulletin forecast

The course and speed recommendations in the **CSRM** panels are also calculated using the wave bulletin. When a 'Day and Hour' is selected from the **2DPS** dropdown, both the **2DPS** and the **CSRM** panels will update (refer to Figure 16). To verify, you should see that the timestamps on the **CSRM** panels match the 'Day and Hour' selected from the **2DPS** drop down box.

Note that the summary data in the FutureWaves™ header still reflects the live radar system.

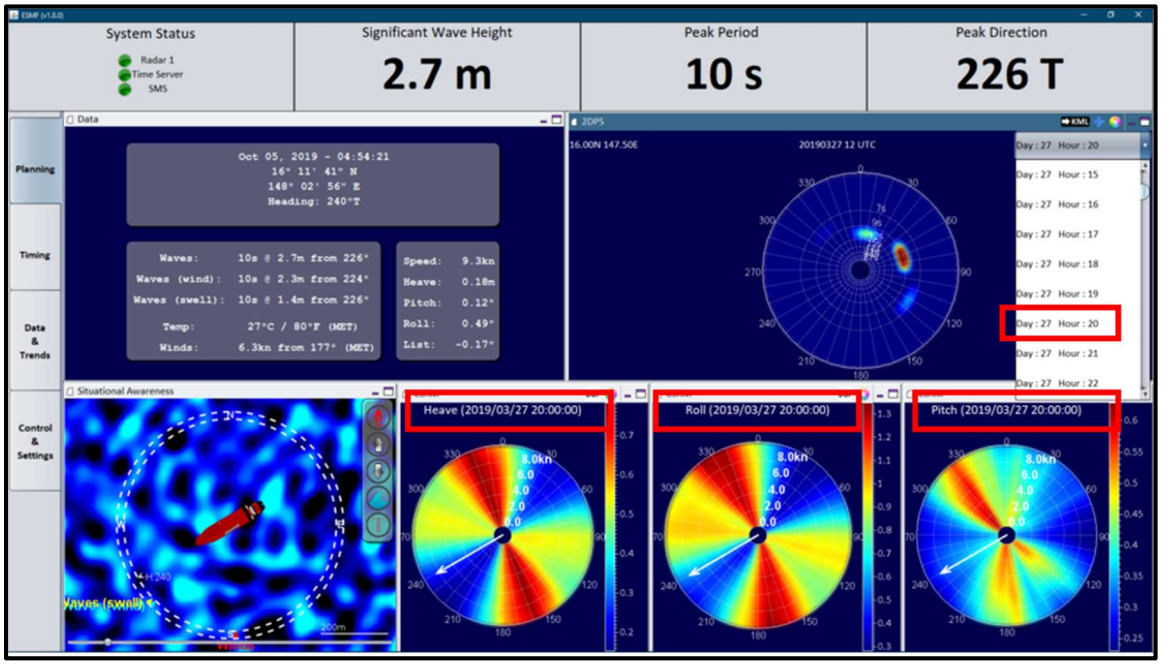


Figure 16: **2DPS** dropdown also updates the **CSRM** panels with the wave bulletin data

The 2DPS can also 'pop-out' a new 2DPS panel by selecting the '+' icon on the upper-right corner of the 2DPS frame. The pop-out display is always of the live radar feed.

Timing

FutureWaves™ provides a unique wave and vessel motion prediction capability that can have significant impact on complex operations. Operators receive detailed knowledge of current ocean conditions and are also provided critical *timing* information during execution. The ***Timing Panel*** is used to indicate phase-resolved timing of waves and the resultant vessel motions. Features include the *Operational Forecast* and *Micro-Forecast* panels, as well as the Situational Awareness panel. This is shown in Figure 17.

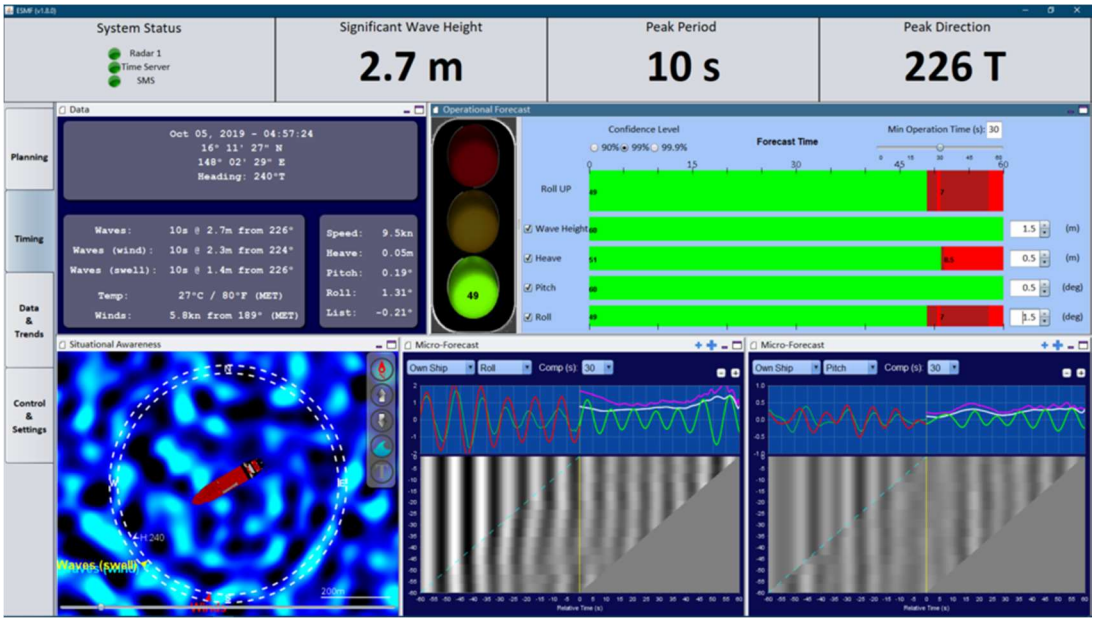


Figure 17: ***Timing Panel***

The *Operational Forecast* is a user configurable tool which provides operational views of operability based on thresholds for predicted wave heights and vessel motions. The *Micro-Forecast* displays are used to evaluate the phase-resolved forecast as it is being generated in order to determine quality and confidence of the Operational Forecast.

Operational Forecast Panel

The Operational Forecast Panel is displayed in Figure 17.

Figure 17: **Operational Forecast Panel**

User settings include:

- Thresholds for Wave Height, Heave, Pitch, and Roll at origin point (usually CG). The thresholds represent **peak-to-peak amplitude** of the parameter.
- Minimum Operation Time needed to perform an operation (e.g. a crane lift)
- Confidence Level
- Roll-up of threshold parameters to consider for Go/No-Go condition

In the above example Wave Height and Pitch are being 'rolled-up' to provide the conditions for the Go/No-Go stoplight.

- **Green** indicates no limits (thresholds) are currently exceeded **and** the Minimum Operating Time is also met.
- **Yellow** can only follow a Green condition and indicates that parameters are still below thresholds but that there is less than the Minimum Operating Time left to complete the operation
- **Red** indicates a threshold is exceeded and the number of seconds until it clears.

The Roll-Up and Forecast bars indicate similar conditions. The numbers in the bars represent the number of seconds (length) of this section of the forecast bar.

- **Green** indicates no limits exceeded at the bar forecast time **and** no expected limits exceeded for at least Minimum Operating Time seconds.
- **Dark Red** indicates a threshold is exceeded and the number of seconds the threshold is expected to be exceeded.

If a threshold is **not** currently exceeded, but it's expected to happen in less than the Minimum Operating Time:

  - **Yellow** if this happens after a green section.
  - **Red** if this happens after a dark red section.

The Roll-Up is the combination of the selected (check-boxes on the left) forecast parameters.

The Confidence Level is used to select how much system error to include in computing threshold exceedance. A higher confidence level means more conservative limits to meet operating conditions.

Micro-Forecast Panels

The Micro-Forecast panel provides detailed information on each time-domain forecast produced by the system. The panel can be 'popped-out' by clicking on the smaller '+' on the upper right. Clicking the large '+' provides a pop-out with additional signal-processing information. An overview of the Micro-Forecast Panel is displayed in Figure 18.

FutureWaves™ generates a new time-domain forecast of incoming waves and the resultant vessel motions as often as possible with the processing resources available. The limiting processing component is typically the algorithm which computes amplitudes and phases of the discretized ocean wave-field components. This component is referred to as the 360o spectral extractor (SE360). As it begins a new processing cycle (typically every ~1.5 secs in the current system), SE360 uses any new radar data collected since the last processing cycle, and combines it with previously collected data as required to compute the desired wave components. These wave components are then used to compute the forces imparted on the vessel. As each forecast is updated, new motion predictions are also computed. Since new data is introduced with each update, the predictions can vary. If the radar measurements and corresponding ocean wave velocities are consistent then the results of each forecast should also be consistent. The Micro-Forecast displays previous forecasts in a waterfall so that they can be compared to the more recent forecasts.

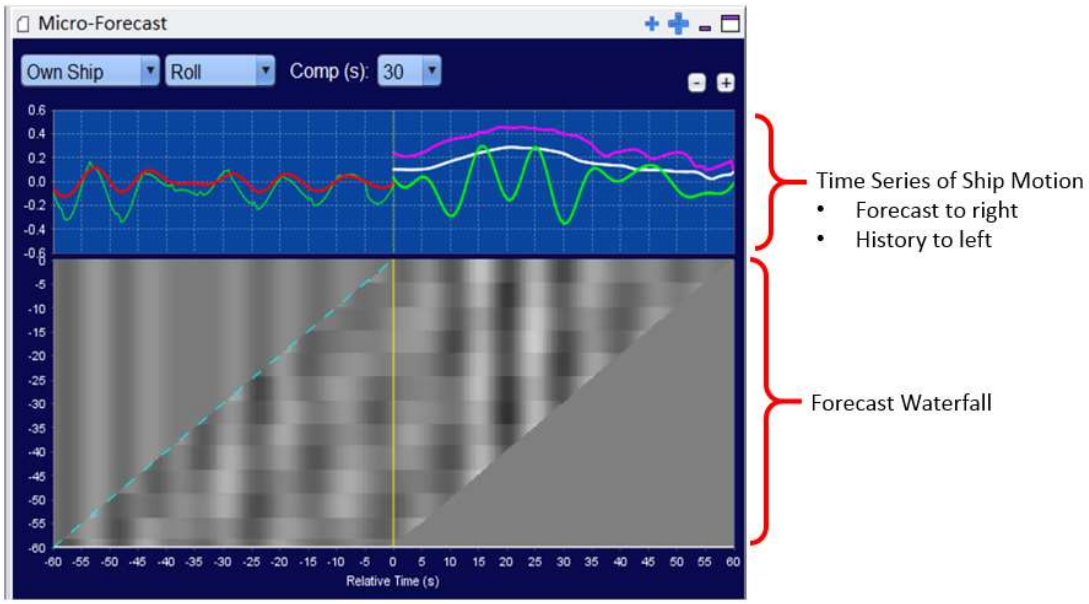


Figure 18: **Micro-Forecast Panel** Overview

The ship motion time series shows the current forecast output as the green-line going from the center to the right in the Time Series plot. In Figure 19, the forecast is for the 'Roll' motion of' Own Ship', as indicated by the blue-circled drop-down menus.

Figure 19: **Micro-Forecast Panel** Example Part 1

The green-line to the left is what the system predicted for a time, as selected by yellow-circled drop-down menu, before the motion occurred. In this example it is set to the 30-second prediction. Since this value can change with each subsequent system forecast output, if forecast-to-forecast values are inconsistent there will be discontinuities in this line. This area to the left of the time-domain plot also shows what was measured for the selected ship motion of interest by the ship motion sensor (SMS) as the red-line. Comparing the red-line to the green-line in this section of the display provides one assessment of forecast performance.

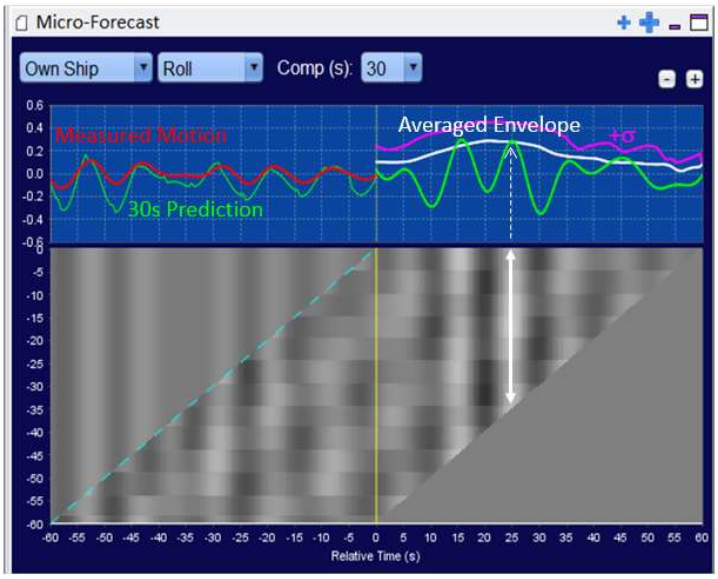


Figure 20: **Micro-Forecast Panel** Example Part 2

The additional white and purple lines on the right on the Time Series plot in Figure 20 depict statistics of the predictions produced up to that point in the forecast timeline. The white-line is a plot of the average value of the signal envelope for each forecast at the point in the time series. For this example, the white-vertical-double-arrow-line in the figure, which is not plotted by the system but is annotated here for explanatory purposes, represents all the predictions produced up to 'now' for a time 25s into the future. The white-dashed arrow points to the plotted white-line at 25s in the prediction window, and this plotted white-line is an estimate of the predicted roll 25s from 'now'. Since we are averaging values for times along the prediction window, we also have a variation of these values which is indicated by the plotted purple-line. The purple-line represents one standard deviation added to the average value. If predictions are consistent from forecast-to-forecast, the purple-line is closer to the white-line. When a confidence level is chosen in the *Operational Forecast* panel, this is selecting the factor for adding sigma to the predicted values to minimize probability of exceeding a threshold.

As each new forecast is produced, previous forecasts are plotted ‘on edge’ below the new forecast in the Forecast History display section. Peaks in the time series appear as brighter values in the history and troughs as darker values. As new forecasts stack up in the history, if a peak or trough is consistent from forecast-to-forecast, then the history graphic will demonstrate this consistency as vertical stripes. If they are inconsistent, the graphic will appear ‘spotty’. When the system is performing well, this graphic is referred to as the ‘zebra’, if it is not it is the ‘cheetah’.

In Figure 21, the section on the left of the vertical yellow-line, the ‘now’ line, is used to show what the measured motion was for the prediction times. Since measured motion does not change once measured, this section always has a zebra above the forecast history.

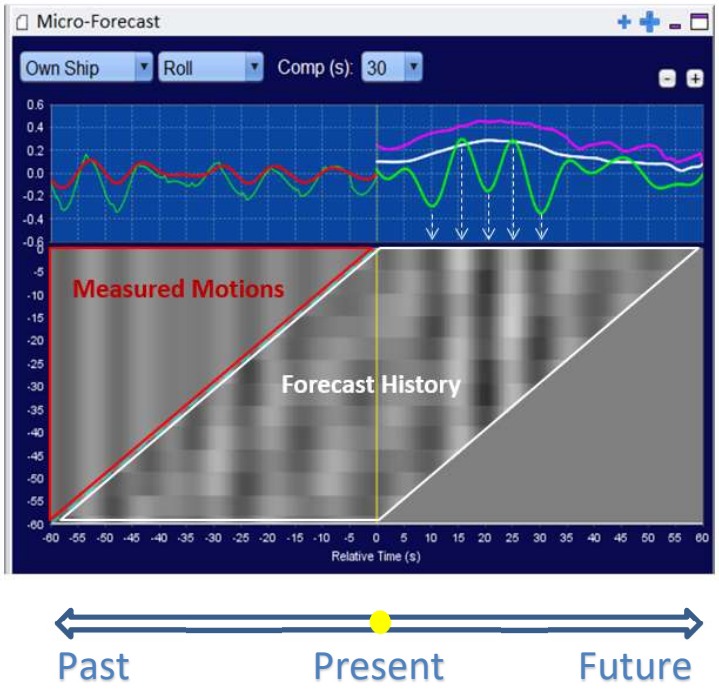


Figure 21: **Micro-Forecast Panel** Example Part 3

This can be very useful in seeing a timing-lag issue with the forecast. As the time progresses the 'zebra' lines will march in to line up with the measured motions as shown in Figure 22.

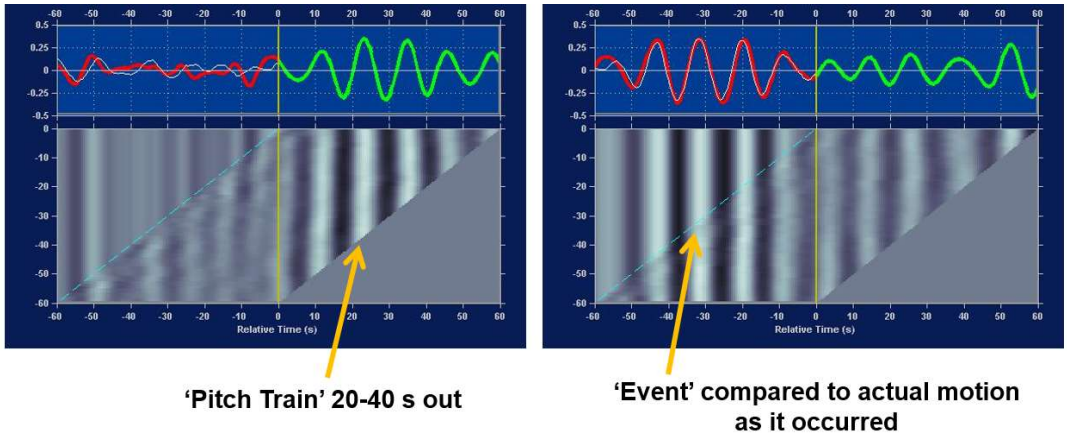


Figure 22: **Micro-Forecast Panel** Example Part 4

Even more detailed signal-processing information can be displayed in a pop-out window by clicking the large '+' circled in red in Figure 23 or by clicking the maximize button.

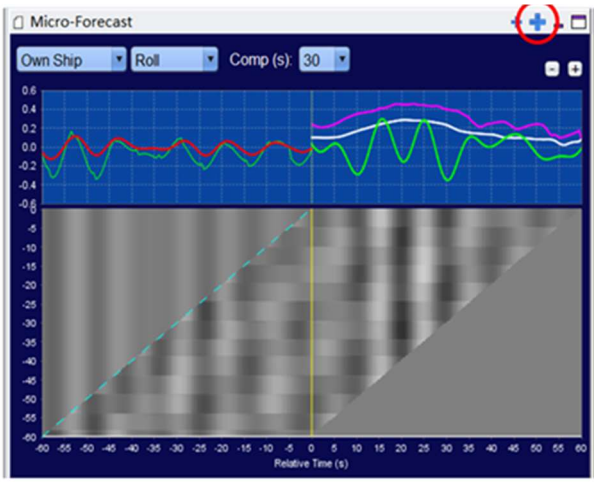


Figure 23: **Micro-Forecast Panel** Example Part 5

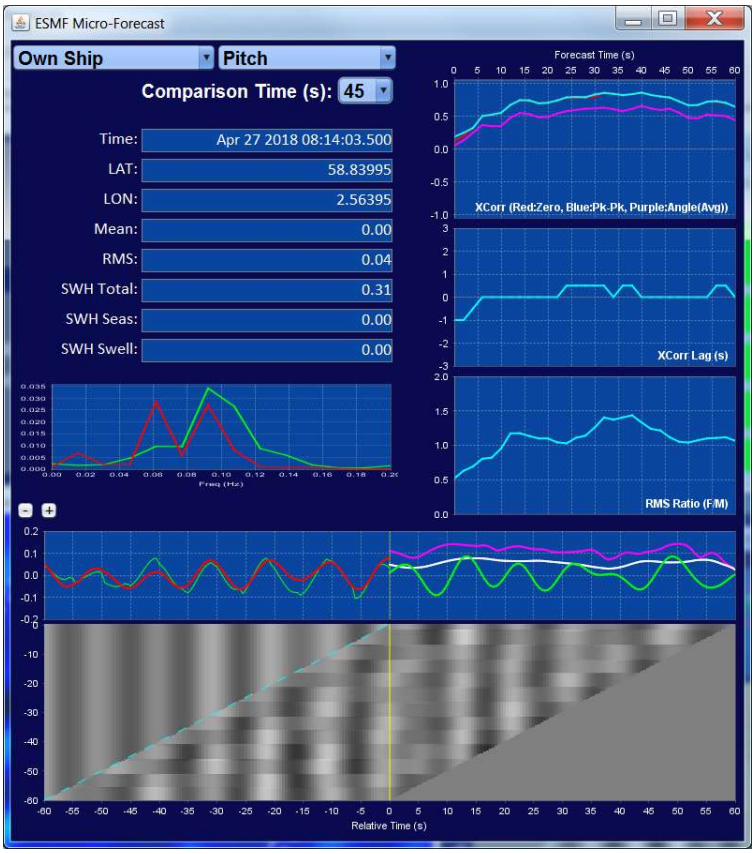


Figure 24: **Micro-Forecast Panel** Maximized

This display contains all the features of those just described but includes additional data on the cross-correlation and average-angle measurements of the predicted signal as compared to the measured motion signal.

The plots include the frequency response of both signals, the cross-correlation lag applied for the peak correlation computation, and the RMS ratio of the predicted signal compared to the measured signal across the forecast time line.

In Figure 24 the measured signal (red) is showing a response in pitch that the predicted signal is not capturing. The predicted signal is also higher than the measured signal which is also shown in the RMS ratio plot.

Data & Trends

The ***Data & Trends*** panel is used to display measured parameters and their trends. This is displayed in Figure 25. Three of the listed parameters can be plotted. Max values over a two-minute window are depicted by the red line and the white line depicts the two-minute average of the single significant amplitude (SSA).

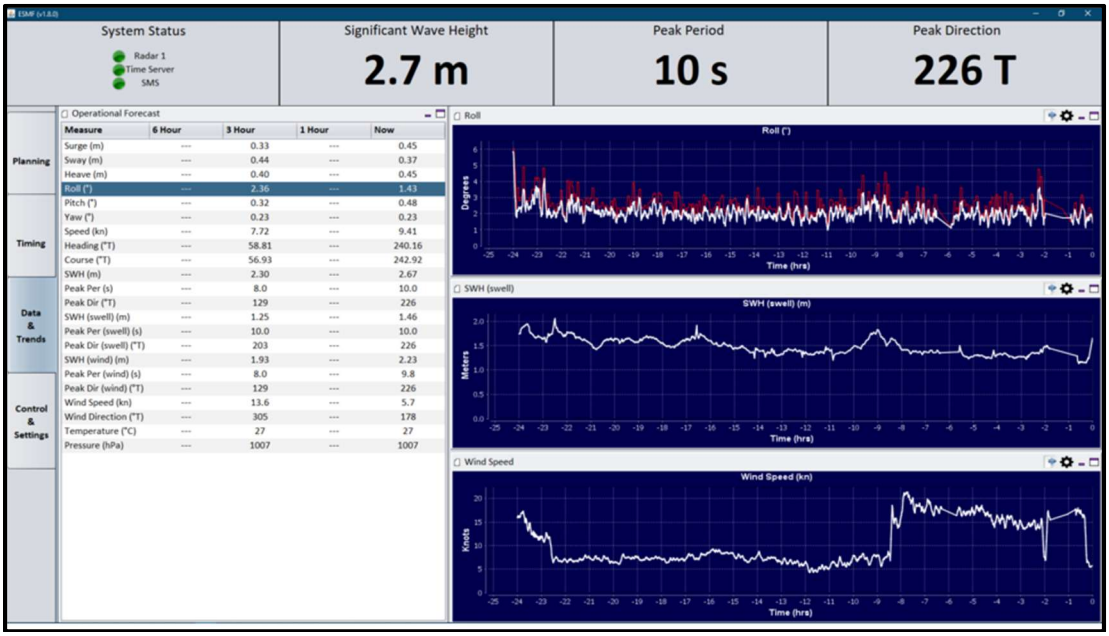


Figure 25: ***Data & Trends*** panel

Note that some of the columns do not have data entries. This may happens if a trend was not recorded at the exact time specified in the column header. However, if you display the parameter on the graph you will see that the system does in fact have a 24-hour trend associated with that parameter.

To add or replace a graph with a new measured parameter:

1. Select the X-Y plot that will contain the information
2. Click on the table row containing the desired parameter.

All of the currently available history for the selected parameter will appear in the graph.

Control & Settings

The ***Control & Settings*** panel is primarily for the user to

1. Control the radar and other FutureWaves™ components
2. Set settings for the system and the FutureWaves™ display.
3. Collect information about how the system is behaving

Aligned along the top edge of the ***Control & Settings*** panel are four tabs: **General, Radar 1, Display,** and **References.** This is shown in Figure 26.

Figure 26: The four upper tabs of the ***Control & Settings*** panel

General

The General tab is used for general control and settings, such as the 'Start' button that connects the GUI to the FutureWaves™ network.

Radar 1

The Radar 1 tab is used to monitor and control the radar, as well as the PPU and RPU associated with that radar. Note that in a multi-radar system there would be a **Radar-2** tab to monitor and control the second radar, as well as the PPU and RPU associated with that second radar.

Display

The Display tab is used to change the display settings on the FutureWaves™ Display.

References

The References tab is used to view seas and forecast tables as a reference and collect information about how the system is behaving.

General Tab

The General Tab is broken up into three subsections: ‘Start UI’, ‘SMS’, and ‘Settings’. This is displayed in Figure 27.

Figure 27: The **General Tab** in the ***Control & Settings Panel***

Start UI

This section contains one button that is labeled ‘Start’ when the GUI is first launched. Clicking this connects the GUI to the FutureWaves™ network so that it can begin receiving data. Once the system is connected, this button becomes disenabled and the text reads ‘Ready to transmit’.

Control

This section contains one button labeled ‘Restart’ that restarts the Ship Motion Sensor (SMS) located in the Equipment locker

Settings

The ‘Planning Source’ was briefly discussed in the ***Planning*** panel section. This setting controls the source of what is displayed 2DPS and the CSRM. The default is to have it set to ‘Radar’, which sets the source to be the live radar feed. When the user selects ‘Buoy’, the source changes to be the selected wave bulletin. Note that for the multi-radar system the ‘Radar’ option is replaced with ‘Radar Combined’, ‘Radar 1’, and ‘Radar 2’ options. That sets the source to be from the combined radar system, only the first radar, or only the second radar, respectively. Also note that this dropdown will be disabled until the system is connected to the FutureWaves™ network.

The ‘Depth’ section displays the depth and allows the user to override this depth. If the depth is not currently overridden, the ‘Clear Override’ button will be disabled. To override the depth, select ‘Override’, enter in a depth, and click ‘Ok’ (refer to Figure 28). At this point the ‘Clear

Override' button will become enabled. You may see a "overriding to ____ m .." label in place of where the depth was as it waits for the system to accept the depth override request. This may take up to 60 seconds. Once the depth has been successfully overridden, the new depth will be displayed.

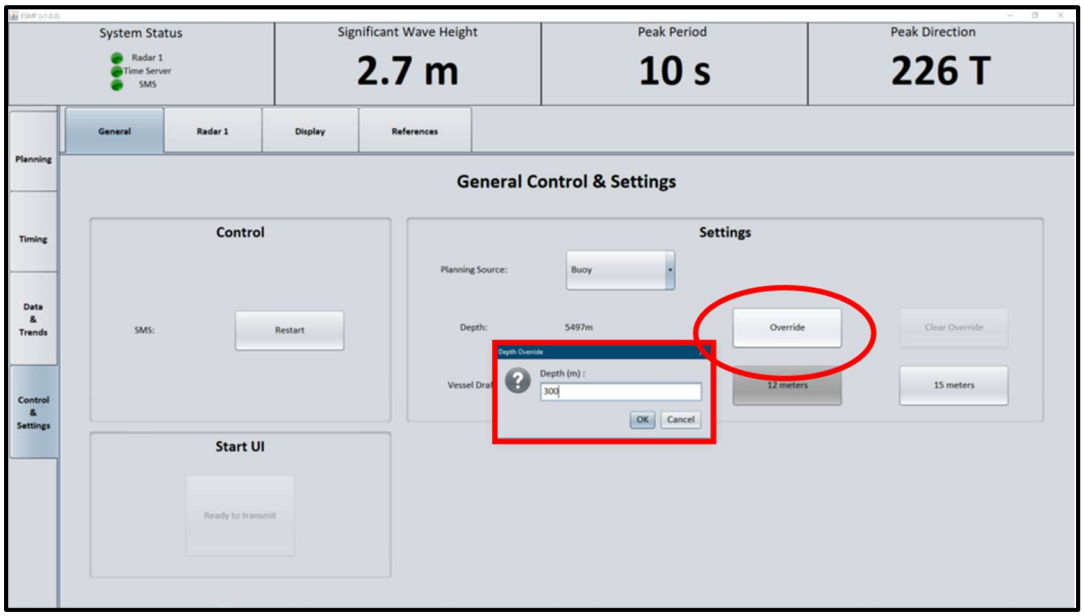


Figure 28: Overriding the depth in the General Tab in Control & Settings

To clear a depth override, simply click the 'Clear Override' button, as shown in Figure 29. At this point the 'Clear Override' button will become disenabled. You may see a "retrieving depth…" label in place of where the depth was as it waits for the system to accept the clear override request. This may take up to 60 seconds. Once the override has been successfully cleared, the current depth will be displayed.

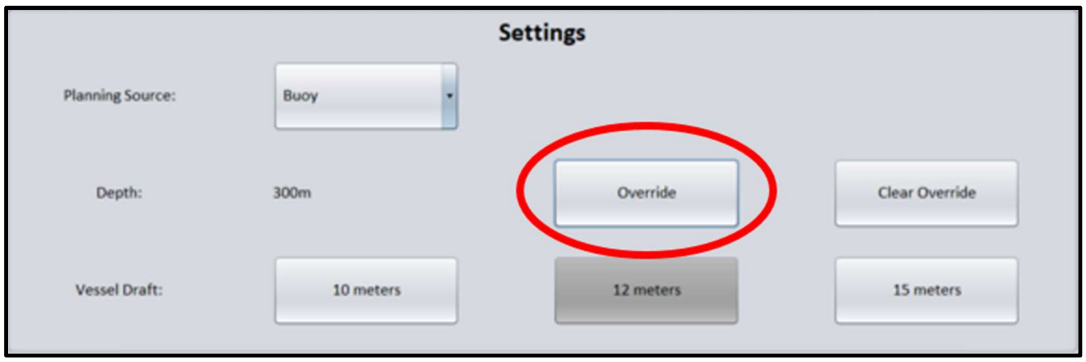


Figure 29: Clearing depth override in the General Tab in Control & Settings

The selected 'Vessel Draft' sets the ship database that is used in the system. Ship motion forecasts are sensitive to vessel draft. Select the draft closest to your actual draft to get the best forecast.

Radar-1 Tab

The Radar-1 Tab is broken up into two subsections: 'PPU & RPU Control' and 'Radar Control'. This is displayed in Figure 30.

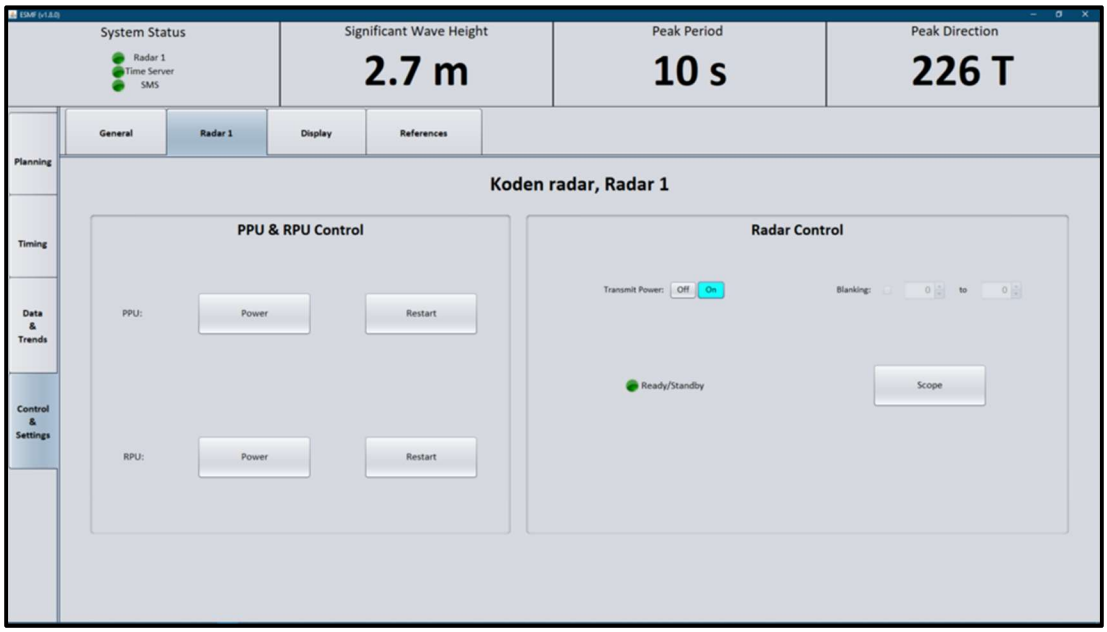


Figure 30: The **Radar-1 Tab** in the ***Control & Settings Panel***

PPU & RPU Control

Cycle power to and restart the RPU and PPU in the Equipment Locker. If the component in off, 'Power' will turn the component on. Clicking 'Power' again will turn the component off. If you 'Power' or 'Restart' a component, the lights on the System Status in the FutureWaves™ Header may change. After performing a 'Power' or 'Restart' on a component, it is recommended that you wait at least 10 before perform another 'Power' or 'Restart'.

Note that if you 'Power' or 'Restart' the PPU, it is recommended that you close the GUI and start it back up again.

Radar Control

The Radar control section was mostly covered in the Startup section. This is used to check the radar status, turn the radar transmit power on and off, set a radar blanking region, and open the radar scope. The radar blanking region interrupts the radar transmission between the angles provided. Two items of note:

1. The blanking regions can be set only when the radar transmit is off.
2. Extensive use of this feature can shorten the life-span of the radar because it actually turns the radar off every rotation.

Display Tab

The Display Tab is controls whether warnings are displayed when performing 'Power' and 'Reset' operations and the units displayed in the GUI. This is shown in Figure 31.

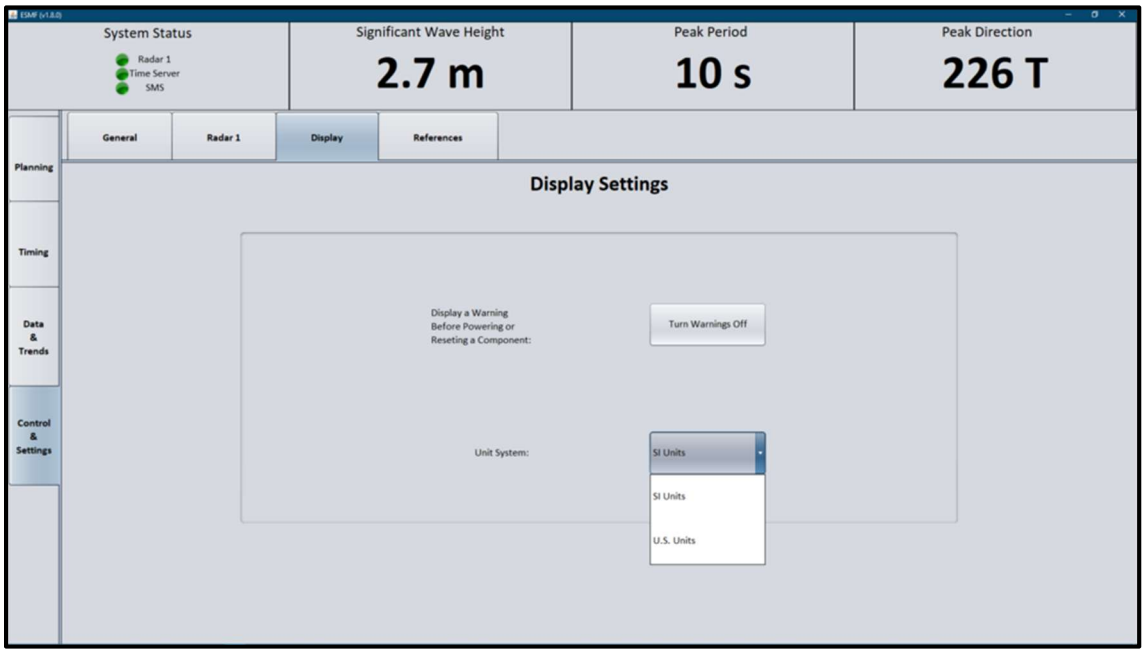


Figure 31: The **Display Tab** in the ***Control & Settings Panel***

Turn Warnings Off/ Turn Warnings On

By default, each time the user does a 'Power' or 'Restart' to the PPU, RPU, or SMS through the GUI, a confirmation dialog appears asking to confirm the operation. This button gives the user control over whether these warnings are displayed. By clicking the 'Turn Warnings Off', it will turn these warnings off.

Unit System:

This changes the units displayed on the GUI. By default the system is set to SI Units. The other option is US Units. The current capability of the units change is limited. This dropdown will toggle the units between meters/feet in the following sections: The Data Readout on the ***Planning*** and ***Timing*** panels (see Figure 32), the Situational Awareness on the ***Planning*** and ***Timing*** panels (see Figure 33), the Trends panel (see Figure 34), and the FutureWaves™ header (see Figure 34).

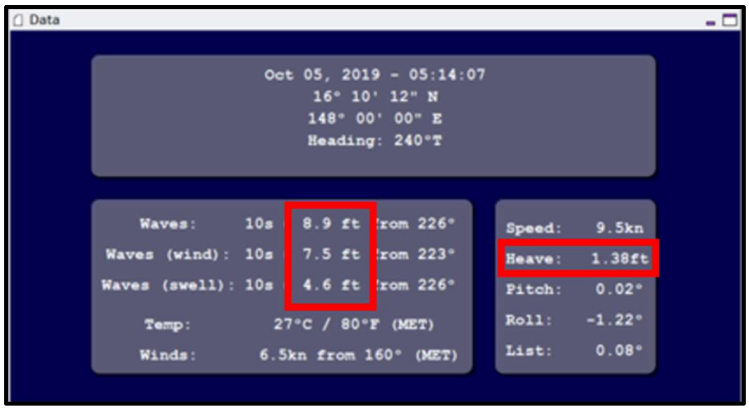


Figure 32: Unit changes on Data Panel

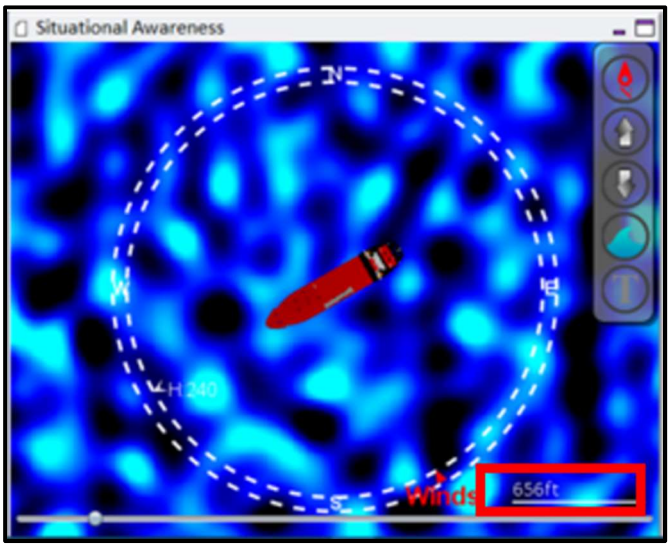


Figure 33: Unit changes on Situational Awareness Panel

Figure 34: Unit changes on Header and TrendsPanel

References Tab

The References tab is used to view seas and forecast tables as a reference and collect information about how the system is behaving. This is displayed in Figure 35.

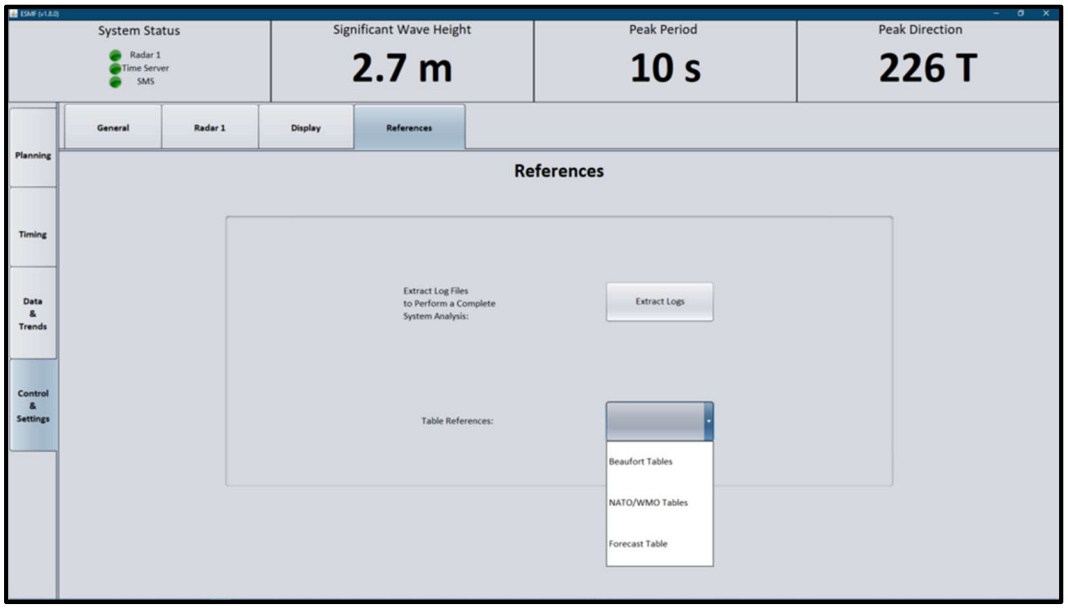


Figure 35: The **References Tab** in the ***Control & Settings Panel***

Extract Logs

As FutureWaves™ runs, the PPU creates log files with important information about how the system has behaved over time. For the diagnostic purposes, the user may be asked at some point in the future to extract these log files to a file to then send to other personnel. This can simply be done through the Extract Logs feature on the References tab.

Clicking the 'Extract Logs' button will open up the frame displayed in Figure 36. The 'File Path' section prompts the user to enter a file path for the file to be created. Use the '…' buttons to the right to open a file chooser window. Please be sure to append "*.tar" to the end of the filename that is chosen.

The 'Select All' option is selected by default. This tells the system to collect all the files on the system. When this is selected, the 'Start Date' and 'End Date' options are disabled.

'Extract' will start the extraction process.

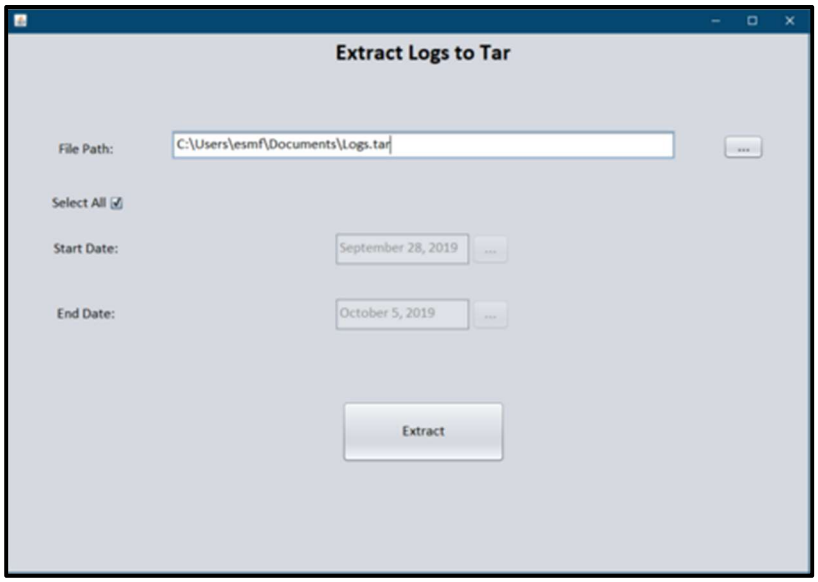


Figure 36: Extract Logs Dialog in **References Tab** in the ***Control & Settings Panel***

Depending on how large the log files are on the system, 'Select All' can create a larger file than necessary. Deselecting 'Select All' will enable the 'Start Date' and 'End Date' sections (see Figure 37), which will tell the system to collect information only between the given certain date range. This will almost always create a smaller file, but is usually much slower because it requires the system to check the date on each log statement. If you are asked to extract the logs by other personnel, they will inform you on which options to choose.

To enter a date, click on the right '…' icon. This will open a calendar through which you can select the date. Note that if you only want one day of information, enter that day into both the 'Start Date' and 'End Date'.

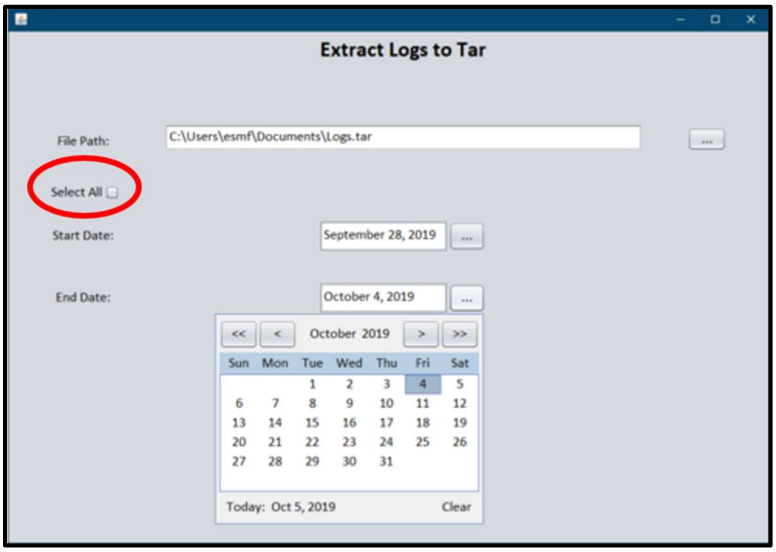


Figure 37: Choosing Data range in Extract Logs Dialog

The next step is to click the 'Extract' button to begin the process. You will see this button replaced by a progress bar and text at the bottom with a short description about the stage of the extraction process (see Figure 38). Once the extraction process has completed, the user will see a success dialog box as shown in Figure 38. You may also minimize the frame and continue viewing the main FutureWaves™ GUI. You will be notified once the log extraction has completed. You may cancel this extraction at any time by exiting out of the frame, but you will be asked to confirm the cancelation of this operation. If any issues occur with the log extraction process, a warning will appear saying that the extraction failed. Contact FutureWaves™ personnel if this occurs.

Figure 38: Successfully extracted logs and progress bar

Table References

View the Beaufort, NTA/WMO, and Forecast tables as references.

Shut Down

To completely shutdown the FutureWaves™ system (Refer to Figure 39):

1. Move to the **Radar-1** tab in the ***Control & Settings*** Panel
2. In the *Radar Control* section, click the 'Transmit Power' 'Off' button
3. In the *PPU & RPU Control* section, power off the RPU by pressing the 'Power' button next to the 'RPU' label.
4. In the *PPU & RPU Control* section, power off the PPU by pressing the 'Power' button next to the 'PPU' label.
5. Close the FutureWaves™ application using the X in the upper right.

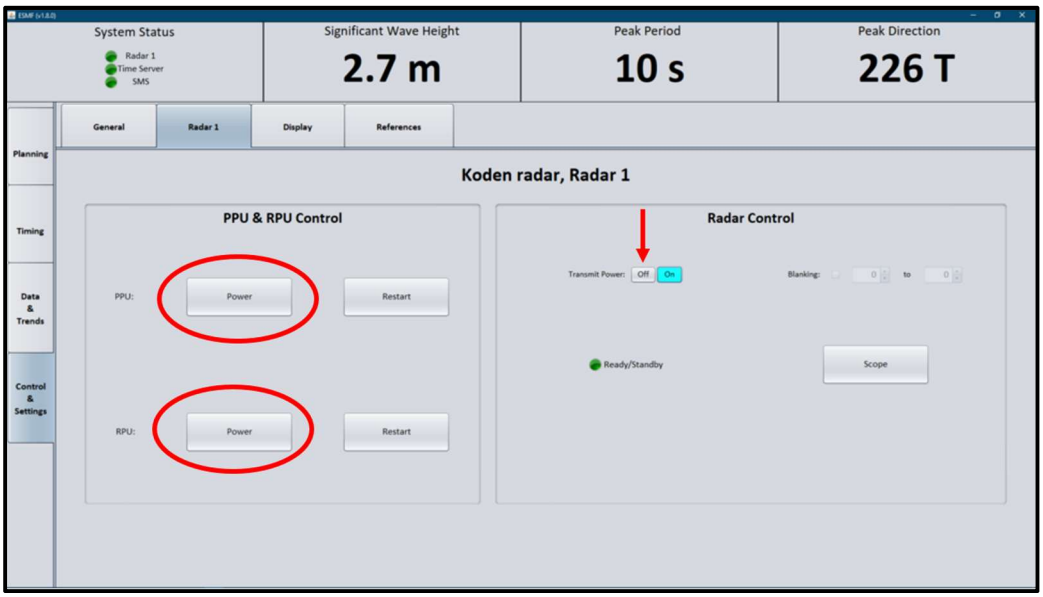


Figure 39: The steps to shutting down the FutureWaves™ system labeled.

6. Shutdown the FutureWaves™ bridge console using the Windows Shutdown function or press and release the momentary power button located just under the console ledge. Turn off the FutureWaves™ display.

Data Handling

The FutureWaves™ system is built upon the Gravity system architecture, which includes an archiving tool that will be the main data collection mechanism. Data are moved within the FutureWaves™ system using a publish/subscribe paradigm. An archiving instance subscribes to data products which are desired for archiving, and writes them to file as they are published to the system. Through this process, any user with access to the FutureWaves™ system can archive any desired data products. The archiving GUI interface allows management of the archiving features and selection of desired data products. Archived files include a time stamp in their name, which indicates the date and time for which the data log began.

Maintenance and Troubleshooting

Detailed maintenance and troubleshooting can be found in the System Technical Manual. For initial steps please fill out the System Information Data Form (Appendix C – System Information Data Sheet) as soon as possible and forward to FutureWaves@aphysci.com.

Personnel Safety

All persons are required to follow all required shipboard safety procedures at all times. The Ship's Master and crew are responsible for the safety of all personnel aboard; their rules and instruction in such matters are to be followed by all hands. Spare no effort to avoid accidents, the consequences of which are generally worse at sea. Man overboard, fire, flooding and significant injuries should be reported immediately to the bridge officer on watch. Bring any unsafe condition to the attention of ship's crew at once. Follow all rules about use of work vests, lifelines, hard hats, proper footwear, etc.

Appendix A - QuickStep

Startup

1. Verify breakers are closed and power is available to the FutureWaves™ electronics locker via P111 and the FutureWaves™ Bridge console via L109.
2. At the bridge console, turn on power to the display then press and release the momentary power button located just under the console ledge. Login as user 'FutureWaves™' if prompted for a login.
3. Select the FutureWaves™ icon on the Windows Desktop and double click or press enter to start the FutureWaves™ Graphical User Interface (GUI). Once the GUI starts, the display should appear as shown in Figure A1.

Figure A1: Initial Display - **General Tab**

4. (Refer to Figure A2) Find the *System Status* on the upper-left corner of the display. If the 'SMS' indicator is grey and all other indicators are green, then the system is ready to start receiving data. Press the 'Start' button.

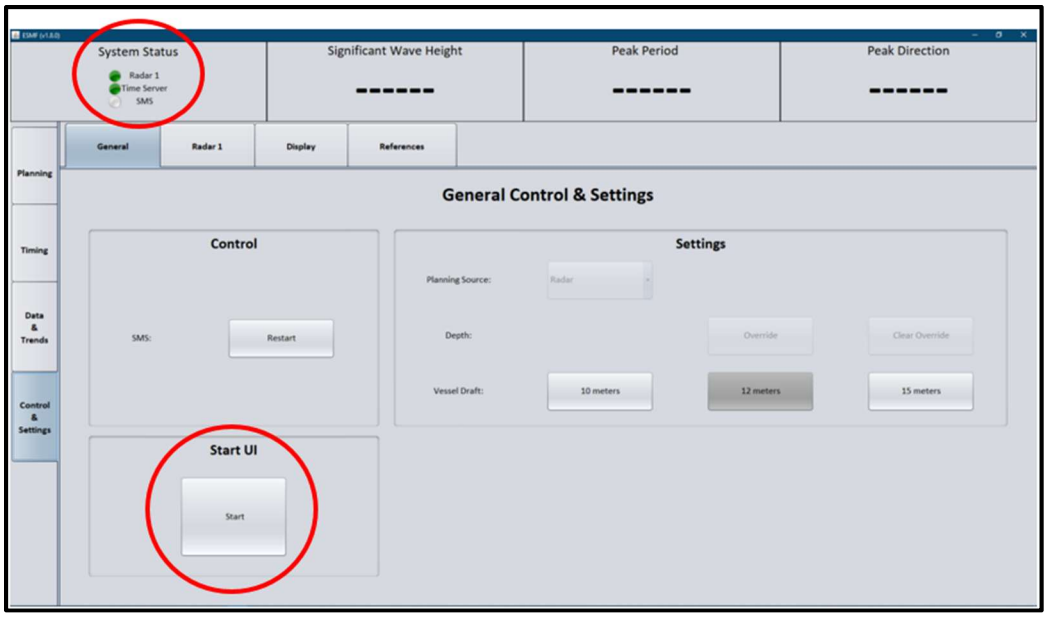


Figure A2: Location of the *System Status* and 'Start' Button on the **General Tab**

5. It may take the system up to 60 seconds to completely initialize after clicking 'Start'. Once the initialization process is complete, the 'Start' button will become disabled and replaced with a faded 'Ready to transmit' text. Additionally the 'Planning Source' and 'Depth' settings will become enabled.
6. (Refer to Figure A3) The next step is to start the radar. Click **Radar-1** on the upper horizontal tabs. Look at the *Radar Control* section on the right half of the display. The 'Transmit Power' should be 'Off' because the radar is not transmitting. The 'Ready Status' indicator should indicate green if the radar subsystem is ready to begin transmitting.

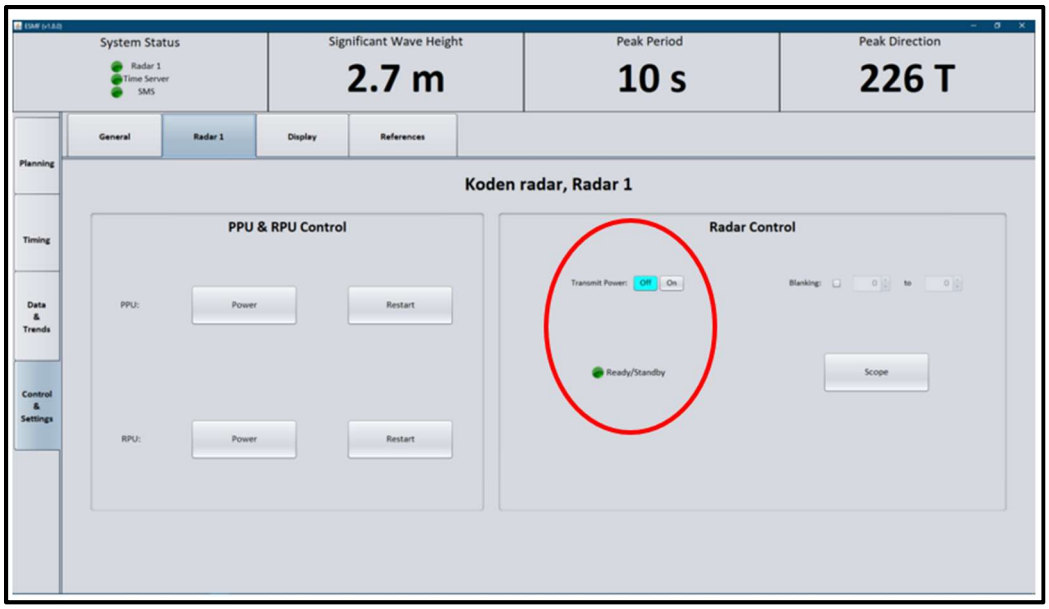


Figure A3: Location of the 'Transmit Power' buttons and 'Ready Status' indicator in the *Radar Control* section of the **Radar-1 Tab**.

7. Visually verify the radar is clear of any obstructions then click the Transmit Power 'On' button. This will energize the unit and begin rotating the antenna.
8. FutureWaves™ is now in normal operating mode and has begun to collect data. After about three (3) minutes the ocean wave spectra [2DPS] should become visible on the planning tab and timing forecast should be ready shortly after that.

Shutdown

To completely shutdown the FutureWaves™ system (Refer to Figure A4):

1. Move to the **Radar-1** tab in the ***Control & Settings*** Panel
2. In the *Radar Control* section, click the 'Transmit Power' 'Off' button
3. In the *PPU & RPU Control* section, power off the RPU by pressing the 'Power' button next to the 'RPU' label.
4. In the *PPU & RPU Control* section, power off the PPU by pressing the 'Power' button next to the 'PPU' label.
5. Close the FutureWaves™ application using the X in the upper right.

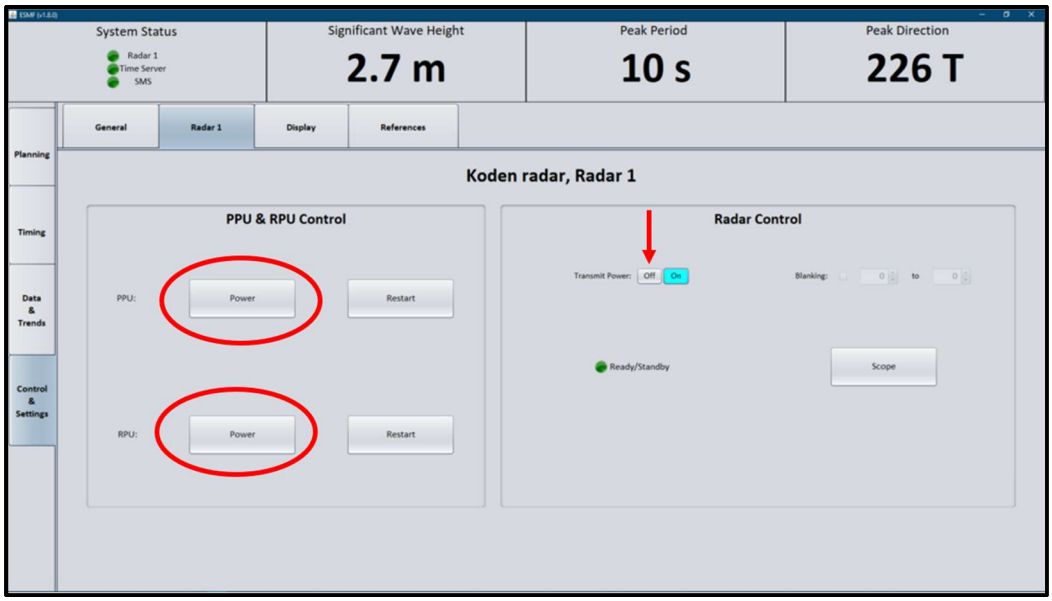


Figure A4: The steps to shutting down the FutureWaves™ system labeled.

6. Shutdown the FutureWaves™ bridge console using the Windows Shutdown function or press and release the momentary power button located just under the console ledge. Turn off the FutureWaves™ display.

Appendix B – Frequently Asked Questions

Why is the FutureWaves™ heading different from the ships Gyro?

FutureWaves™ derives ship heading from the ship motion as measured by the FutureWaves™ Ship Motion Sensor. This sensor can drift off course, especially when the ship is at anchor, pier-side, or stationary for an extended period.

If the heading is off by more than 2 degrees, reset the SMS sensor once the ship is underway and on a steady heading. It can be reset at any time, but the ship should remain on a steady course for 15 minutes after an SMS reset.

Why is the FutureWaves™ system unable to display any position?

FutureWaves™ will not display any position or ship motion data until it achieves a 'heading lock'. Even when good satellite data is available, if FutureWaves™ can't determine a heading, then no data is sent. This is to guard against providing incorrect forecasts.

Why is the depth displayed in FutureWaves™ different from the Fathometer?

A couple of reasons. The main takeaway is to never use this value for navigation or as a reference for water under the keel. This value is only used to improve the accuracy of a wave forecast in shallow water.

The depth displayed in FutureWaves™ is a value read from a file. The ship position is used to look up a value from the file. The file only contains data at approximately 1/10 degree resolution, so many small features picked up by the fathometer may be missed by FutureWaves™.

A change in FutureWaves™ depth will reset the wave forecast, so there is a check to prevent this from changing too often. Even in a rapidly changing environment, the depth will never update more often than every 60 seconds. Additionally, since it is used solely to improve the accuracy of the forecast in shallow water, the system may stop updating the depth value entirely if the water depth is greater than 2000 m.

Finally, the depth displayed is the total water depth, from the surface to the bottom. It is not depth under the keel.

Why does the Ship Motion Sensor pitch/roll differ from my Clinometer?

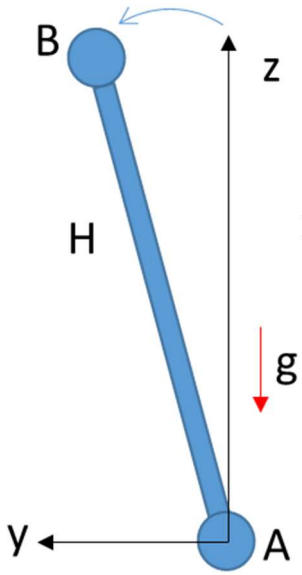
Short answer: A Clinometer is not a roll sensor.

Long answer:

A clinometer measures the direction of maximum acceleration.

- For static systems, this aligns with the gravity vector and gives you the incline.
- For dynamic (accelerating systems) a clinometer does not measure the pose of the body — only the angle of the acceleration vector

When measuring at a height above the center of rotation, you get acceleration due to the rotational motion and the moment arm. Given a system with a center of gravity at position A, the sway acceleration at B for a roll angle (θ) around the point A at a frequency (ω) is:



$$\ddot{y} = \omega^2 \theta H$$

Measured direction φ of maximum acceleration for inclinometer at A:

$$\varphi_A = \theta$$

Measured direction φ of maximum acceleration for inclinometer at B:

$$\varphi_B = \theta + \operatorname{atan}\left({}^{\ddot{y}}/_{g}\right) \cong \theta + {}^{\ddot{y}}/_{g} \cong \theta\left(1 + \omega^2 {}^{H}/_{g}\right)$$

For a 8s period with H=20m we get:

$$\varphi_B = 2.26\theta$$

The FutureWaves™ ship motion sensor readings are corrected to motion at the ship Center of Gravity.

Appendix C – System Information Data Sheet

FutureWaves™ System Information

Please collect the following information to assist in FutureWaves™ system troubleshooting.
Note: The locations of the above system parameters are indicated on the next page in Figure C1 and Figure C2.

Current date/time:

	Parameter	Value	Notes	Nominal Value
1	Radar 1 Status Indicator		Red or Green	Green
2	Time Server Status Indicator		Red or Green	Green
3	SMS Status Indicator		Red or Green	Green
4	Significant Wave Height			0.1 – 5 m
5	Peak Period			4 – 25 s
6	2DPS Date and Time			Within 3 min of current time
7	CSRM Date and Time			Within 3-5 min of current time
8	Does 2DPS have a message indicating “>X minutes old”?		Yes or No	No
9	If 9 is yes, what is X?			
10	Is Ship Motion Data (Speed, Heave, Pitch Roll and List) in the Data Pane Updating?		Yes or No	Yes
11	Is the Ship Heading Updating?		Yes or No	Yes
12	Does the FutureWaves™ Heading Match the Ship’s Heading?		Yes or No	Yes
13	Is the Ship Under Way?		Yes or No	Yes
14	What is the Ship Speed?		In Knots	>0

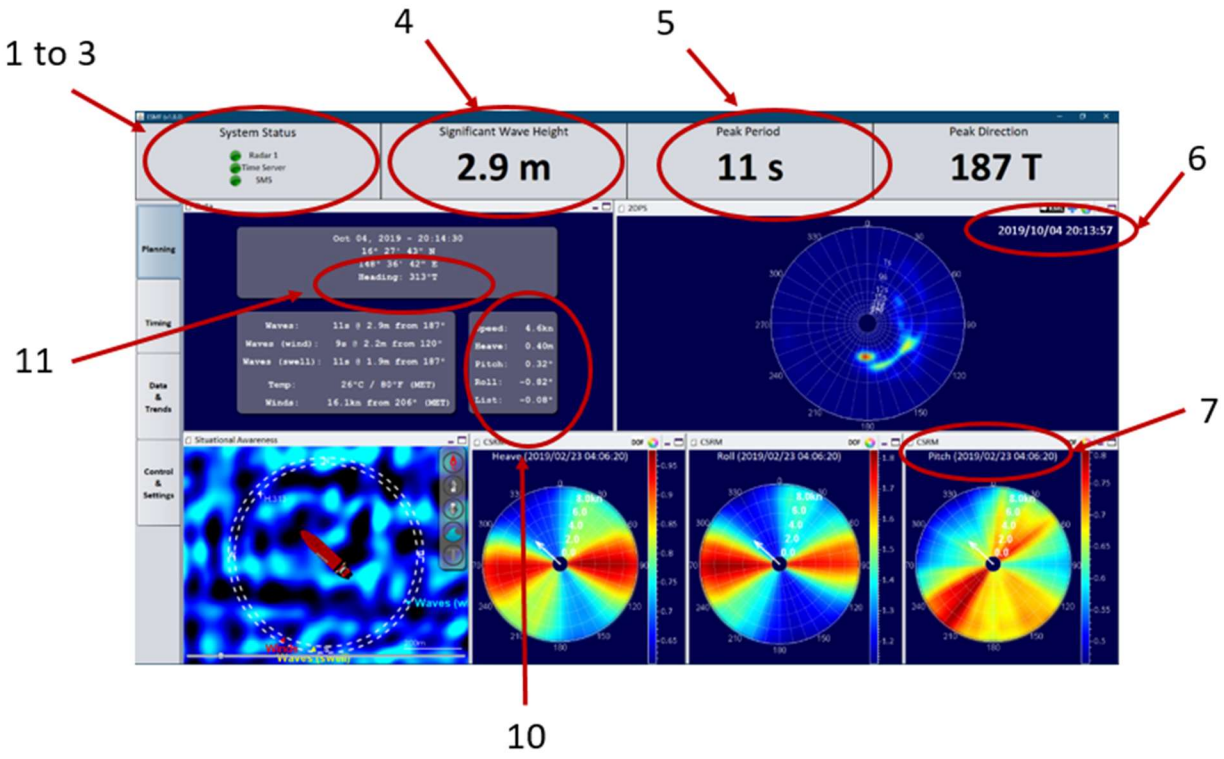


Figure C1. Locations of System Parameters 1 through 7, 10 and 11

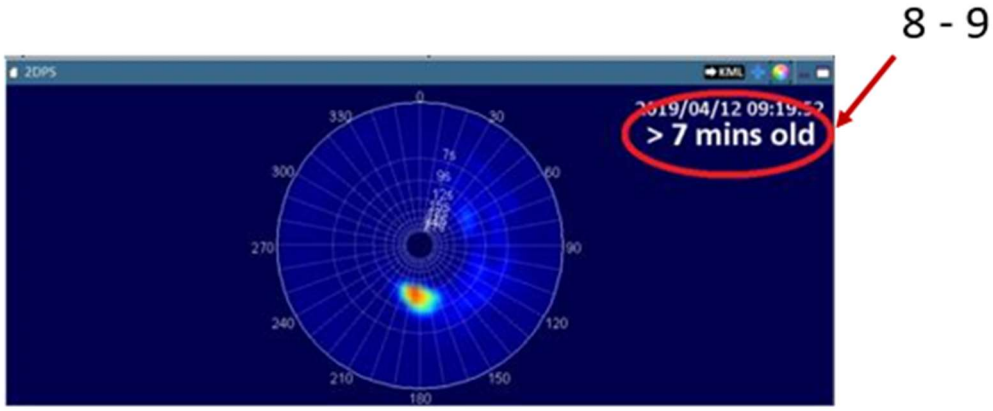


Figure C2. Locations of System Parameters 8 and 9 (if present)

Appendix D – EU Declaration of Conformity

EU Declaration of Conformity No. 001

We,

Applied Physical Sciences Corp.
475 Bridge St.
Groton CT, 06340 USA

declare under our sole responsibility that the product,

FutureWaves Wave-i 1.00

manufactured by,

Applied Physical Sciences Corp.
475 Bridge St.
Groton CT, 06340 USA

is in conformity with the provisions of the European Community Directives, including the latest amendments, as shown below.

Presumption of conformity is based on the application of the harmonized standards, normative documents or other documents and, when applicable or required, a European Community notified body certification, as shown below.

Directive 2014/53/EU

- **ETSI EN 303-135 V2.1.1**
- **ETSI EN 301-843 V2.2.1**
- **EN 62311**

Quality Assurance, Testing, and EU-Type Examination performed by Notified Body,

TIMCO Engineering, Inc.
849 NW State Road 45
Newberry, Florida 32669 USA
1-352-472-5500

EU Authorized POC:

GAMIC mbH
Roermonder Str. 151
52072 Aachen, Germany
Phone: +49 241 88911-0
Email: info@GAMIC.com

David Horne
Sr. Vice President / Business Manager

Appendix E – FCC Regulation Statements

FCC ID – 2AUE82019

Equipment Product Code – WAVE-I-100

FCC Part 15.19 Warning Statement- (Required for all Part 15 devices)
THIS DEVICE COMPLIES WITH PART 15 OF THE FCC RULES. OPERATION IS SUBJECT TO THE FOLLOWING TWO CONDITIONS: (1) THIS DEVICE MAY NOT CAUSE HARMFUL INTERFERENCE, AND (2) THIS DEVICE MUST ACCEPT ANY INTERFERENCE RECEIVED, INCLUDING INTERFERENCE THAT MAY CAUSE UNDESIRED OPERATION.
FCC Part 15.21 Warning Statement-
NOTE: THE GRANTEE IS NOT RESPONSIBLE FOR ANY CHANGES OR MODIFICATIONS NOT EXPRESSLY APPROVED BY THE PARTY RESPONSIBLE FOR COMPLIANCE. SUCH MODIFICATIONS COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.

The antenna gain used with this transmitter should be 28 dBi or less and all persons should maintain a minimum safety separation distance of 35cm while functioning properly.