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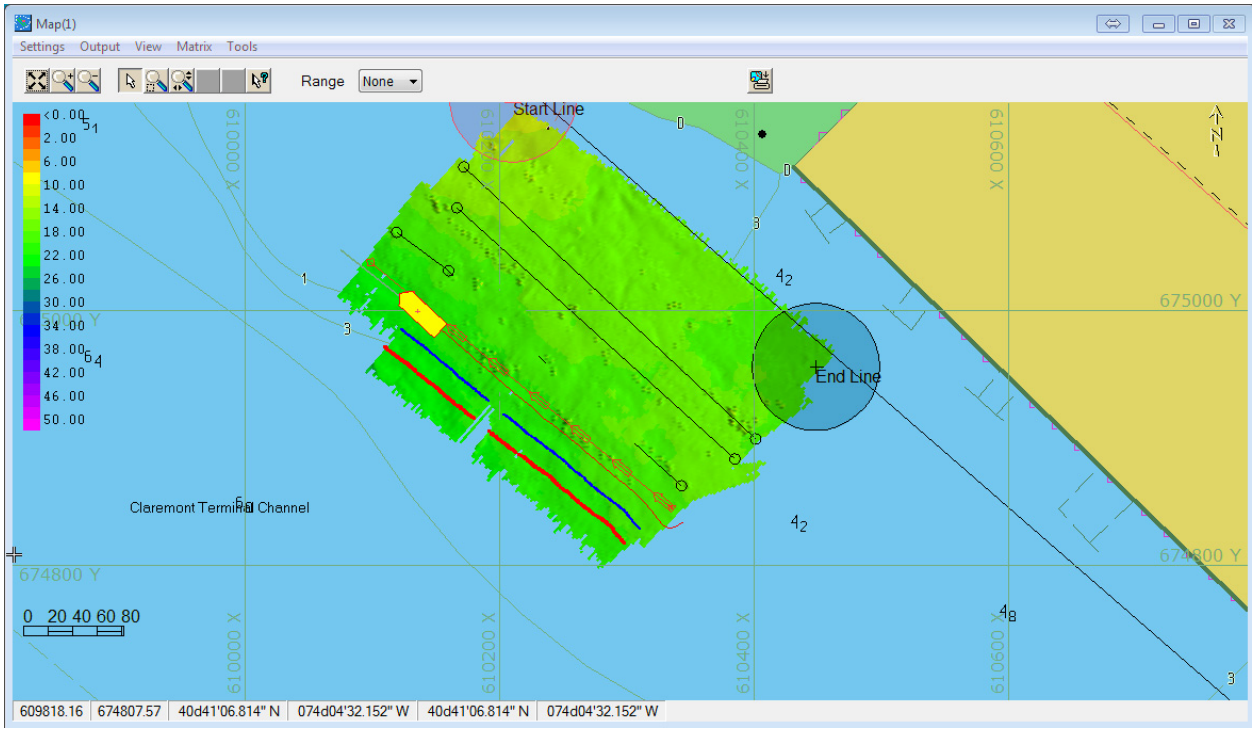
HYPACK® Adaptive Path Planning Tool—AutoLines.dll

by Vitad Pradith

“If you don't know where you are going, you'll end up someplace else.” — Yogi Berra

FIGURE 1. *HYPACK® Adaptive Path Planner in Action.*



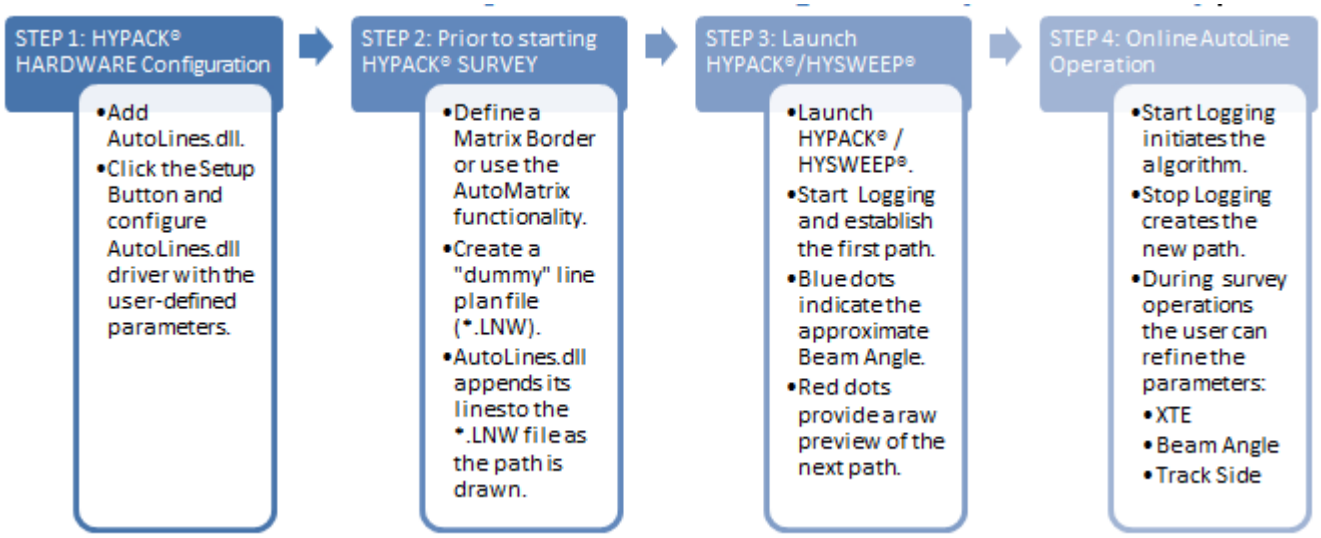
Traditional line planning for hydrographic surveys is typically mired in what I call the “hydrographic stew”. This stew can either follow an exact recipe or be used as a guideline with the chef adding their own accents. The provided ingredients in this particular example are your sensors, but are all ingredients the same? Likely not, as multibeam sonars come with different flavors (e.g. frequency, opening swath angles, etc). With this in mind, hydrographers are a conservative group and typically provide an overestimation of their survey line/mission plan in their mission to achieve a 100% ensonification of the seafloor. This well-intentioned, conservative mindset, however, can also increase the cost of doing work.

In our relentless pursuit toward making operations faster, cheaper, and <insert your own metric here>, HYPACK is pleased to provide another evolution to the surveying community that allows a new capability for the surveyor to adapt their platform’s overall survey plan according to their real-time swath coverage—AutoLines.dll. The initial impetus was provided by the autonomous community, but can be extended to the existing manned platforms as well (e.g. hydrographic vessels), especially in areas where seafloor depths vary widely.

Unmanned Vehicle Application (ASV/USV): The AutoLines driver has the capability to feed the next path to the Autonomy Module of the Unmanned Vessels. Injecting this information in real time allows the ASV/USV to position itself accordingly, thereby increasing the efficiency of operations avoiding unnecessary redundant coverage while maintaining 100% coverage for the duration of the unmanned surface vessel mission.

Manned Vehicle Application: Hydrographers can also leverage this capability on their survey vessels. This is especially true for larger hydrographic ships that can benefit from knowing where the next path will be. This not only facilitates more efficient and proactive operations, but also promotes safety.

Overview of the HYPACK® Adaptive Path Planning Process using the AutoLines Device Driver



1. **In HARDWARE, add the Autolines device driver** to your configuration.

FIGURE 2. Step 1: Adding the Autolines.dll Driver to the HARDWARE Profile.

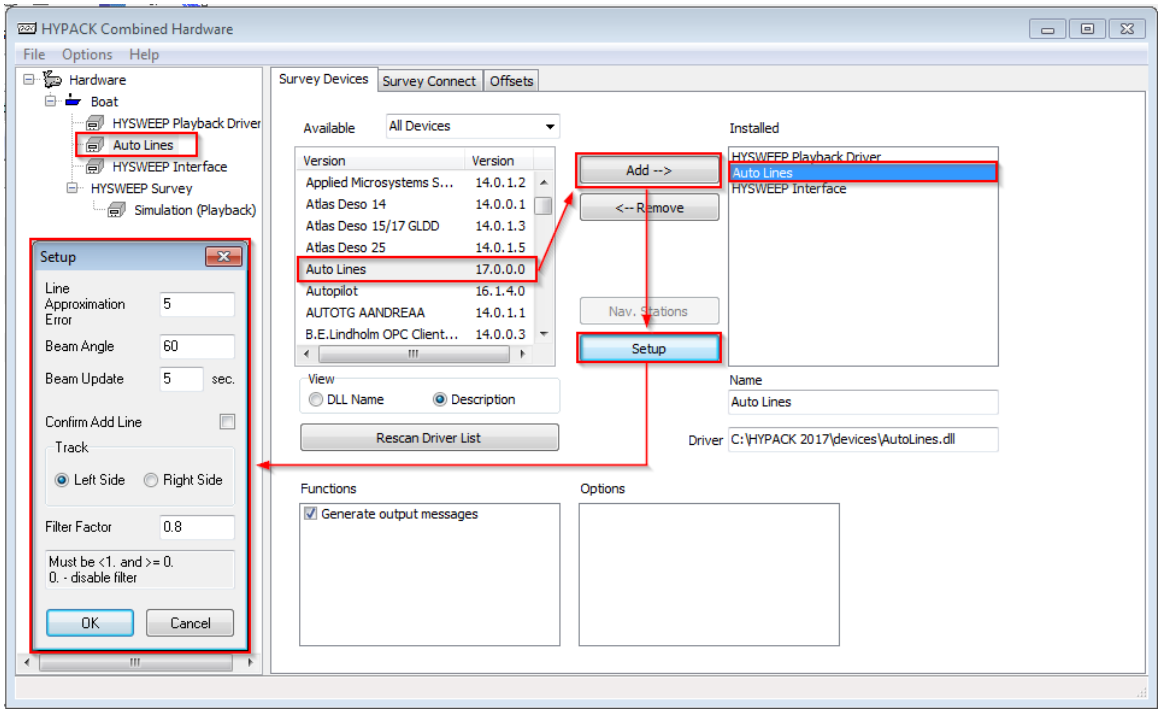
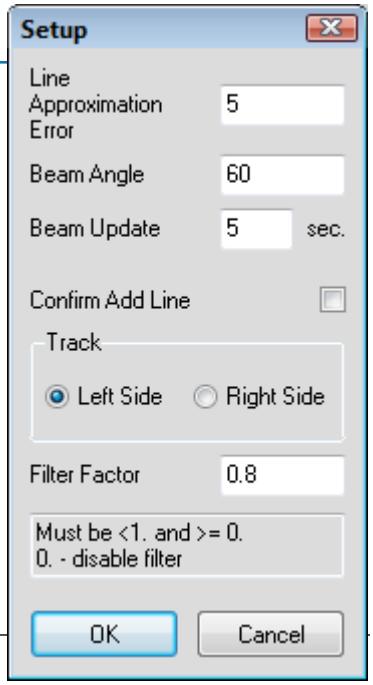


FIGURE 3. STEP 1 (continued): Configuring the AutoLines Driver with Initial Parameters.



Line Approximation Error: This value defines the allowable cross track distance, in survey units, from the projected line location (red) within which the new line must be drawn. (Adjustable in SURVEY.)

Figures 4 through 6 depict the results of this parameter.

Additionally, you can click [Line Preview] to preview the next line (drawn in green) before it is accepted and saved to the line plan.

Beam Angle: The multibeam angle, each side of nadir, is used together with the matrix coverage of that swath width, to calculate the next line position. Remember your goal is overlapping coverage to compensate for the outer beams. (Adjustable in SURVEY.)

NOTE: Shallower waters may limit the reach of the beam angle, which may result in data gaps or holidays. This has more to do with the physics and technical limitations of using multibeam sonar at these depth ranges where multibeam technology is less efficient.

Beam Update (sec): This value is dependent on the dynamics of the current survey line. A good question to ask is “how linear or sinuous do I think the survey path will be?” The Beam Update field is where you set how often you want to create a data point on a potential line segment. A shorter interval creates more red and blue data points, and a higher resolution survey line. The optimal interval will likely be trial and error based on the vessel type and operating conditions.

Confirm Add Line (Optional) prompts you to confirm whether you are satisfied with the created line. At any time while you are actively logging, the green line can be adjusted using the Line Approximation Error field *before* the line is created. This can help you fine-tune the next line before committing.

Track: Defines which side of the vessel the new line is to be drawn. (Soon to be modified to be “Port” and “Starboard”, rather than “Left” and “Right”.) Track designation automatically alternates as each new line is created, which facilitates boat surveying in alternating directions; however, if you are using a different pattern, you can manually set whichever side you want for the next line in SURVEY. (Adjustable in SURVEY.)

Filter Factor: Sets a low pass filter to smooth out any potential noise. The filter factor value is entered as a percentage (e.g. 0.80 means filter out 80% of the points in the line segment). You’ll notice an effect on the node spacing with higher percentage values.

Some examples describing the parameters are illustrated in the following figures:

FIGURE 4. *Using a 3 meter line approximation error (XTE) and 40 degree Beam Angle will closely follow (green line) the dotted red line.*

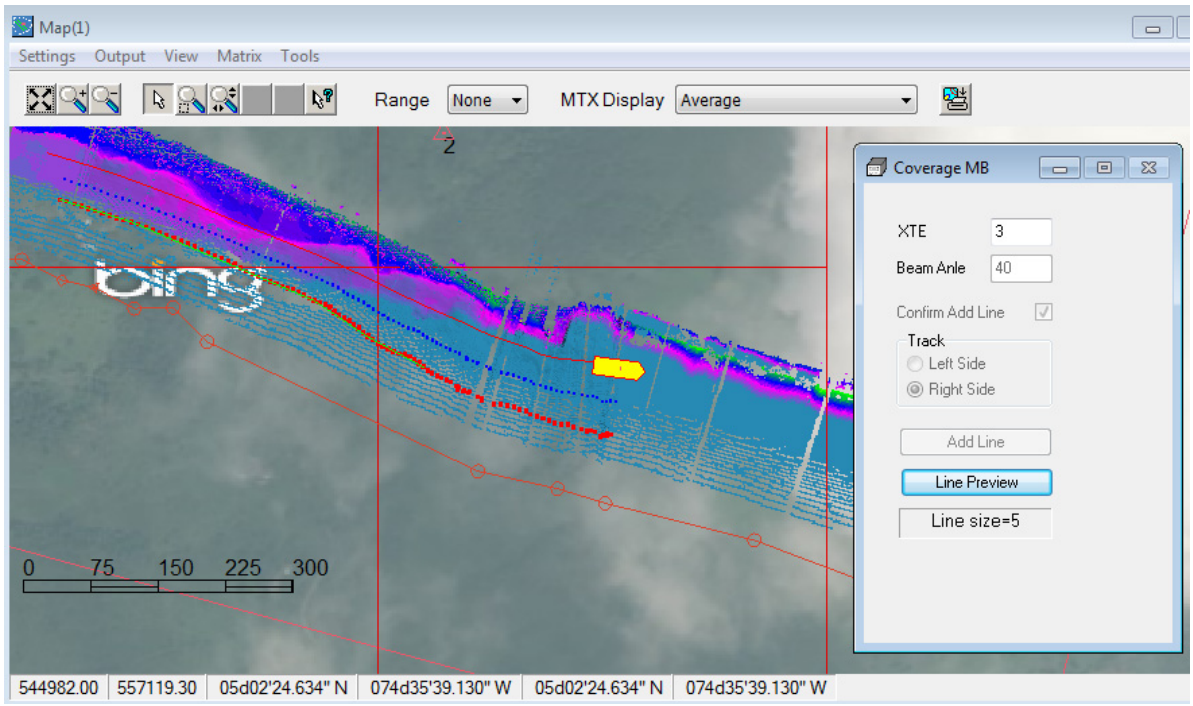


FIGURE 5. *Using a 20 meter line approximation error (XTE) and 40 degree Beam Angle will loosely follow (green line) the dotted red line.*

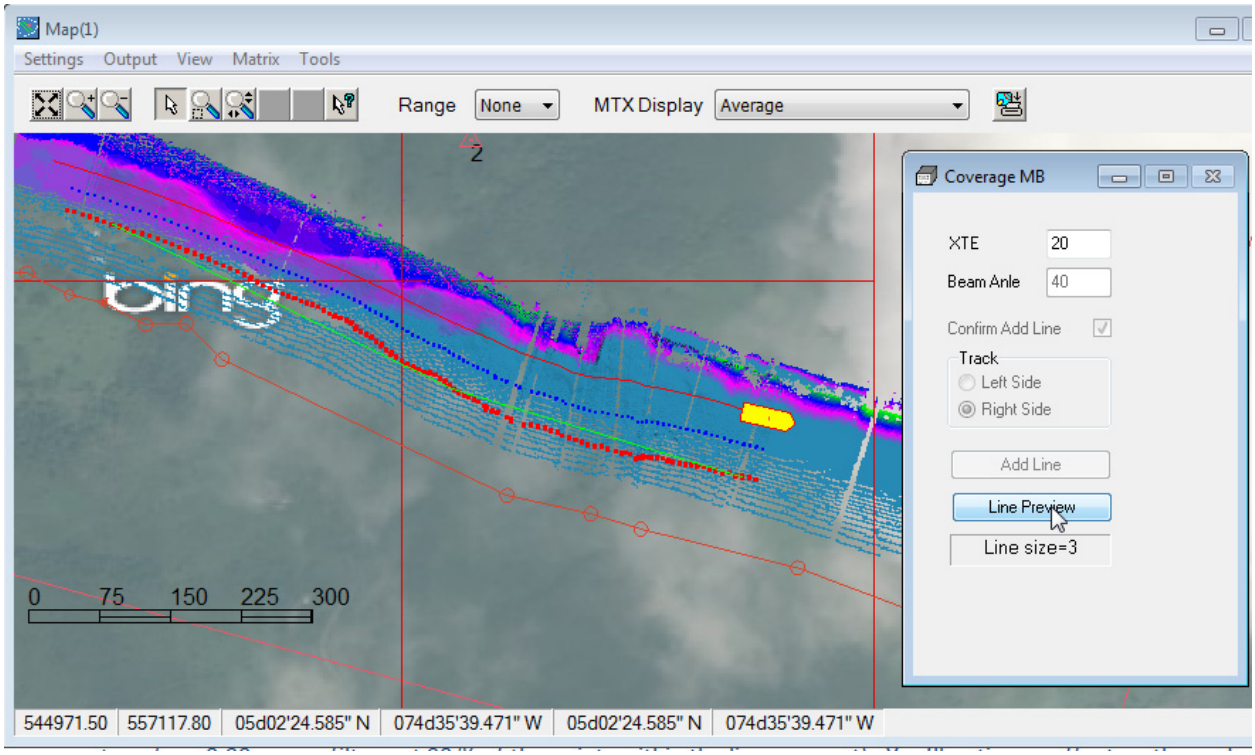


FIGURE 6. *Smaller allowable Line Approximation Error (XTE) values (e.g. setting a 3 meter XTE) will create lines with a higher resolution; however, this level of detail may not be practical for the survey vessel.*

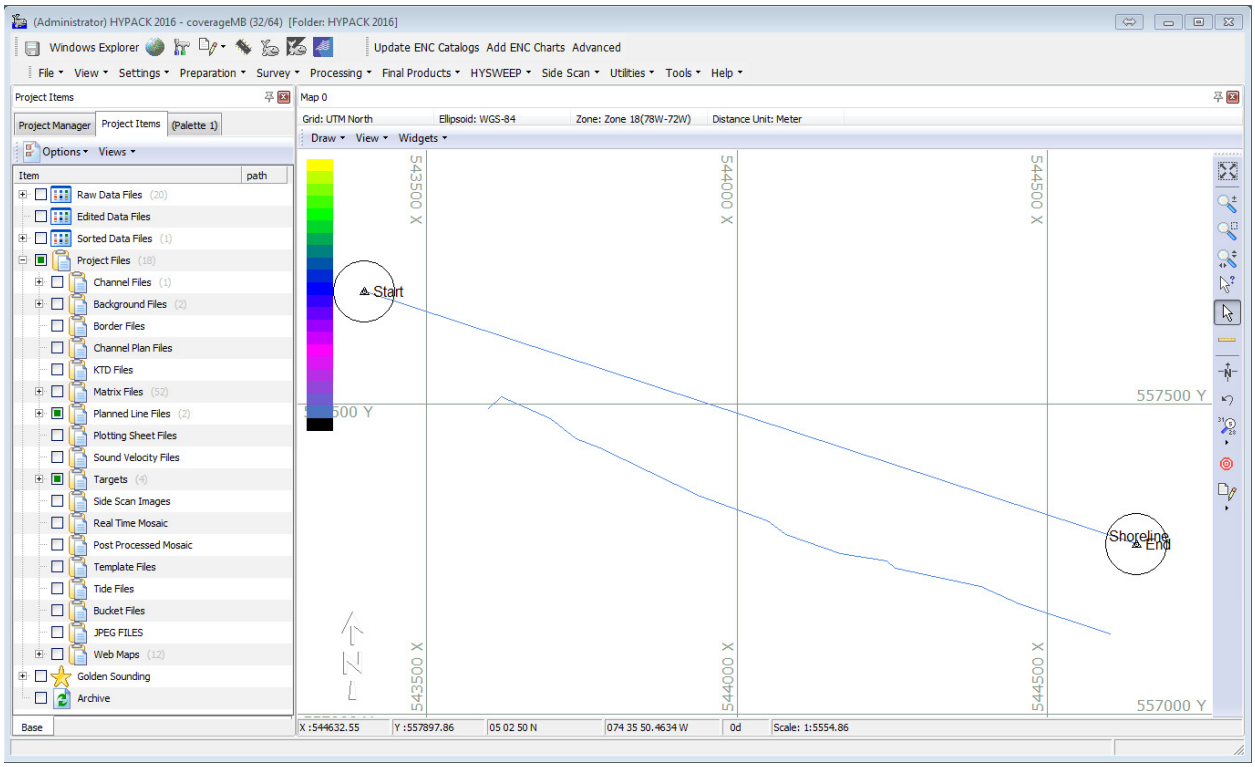


FIGURE 7. *The AutoLines driver in action once the operator begins to log data. The blue line represents the user-defined beam angle. Red represents a preview of the next line.*

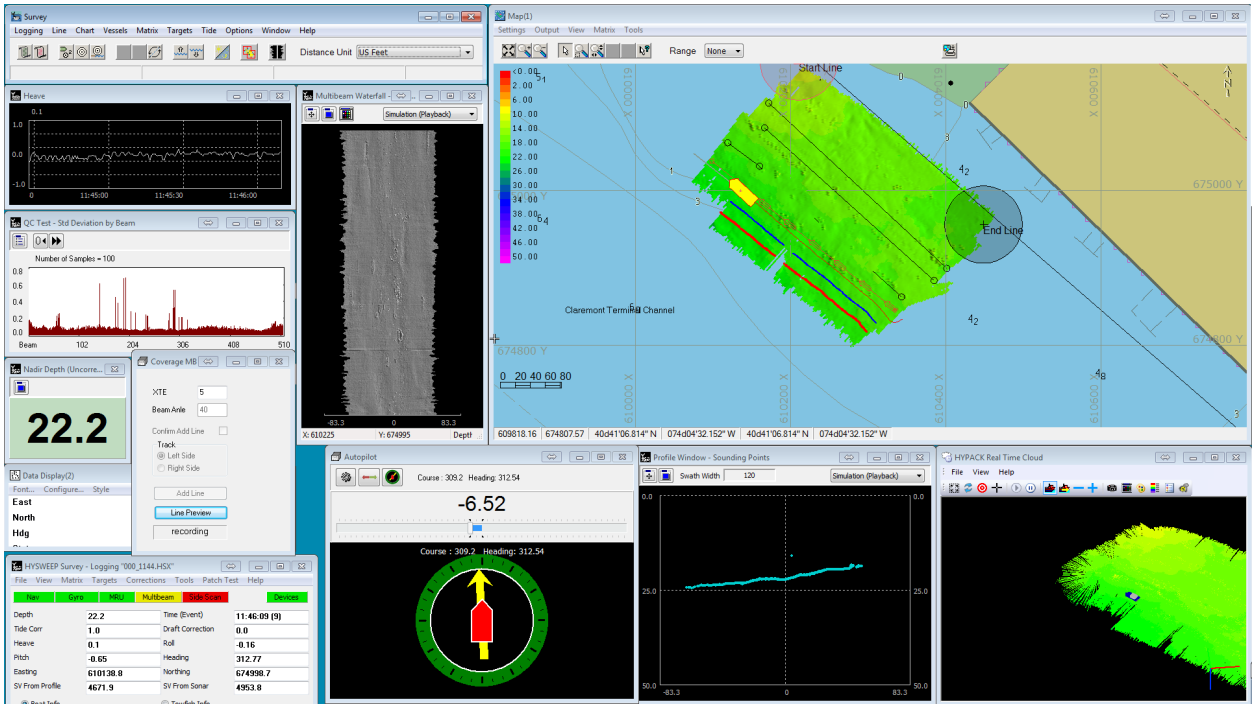


FIGURE 8. *Once you stop logging, the new line automatically draws on the screen and becomes the active line.*

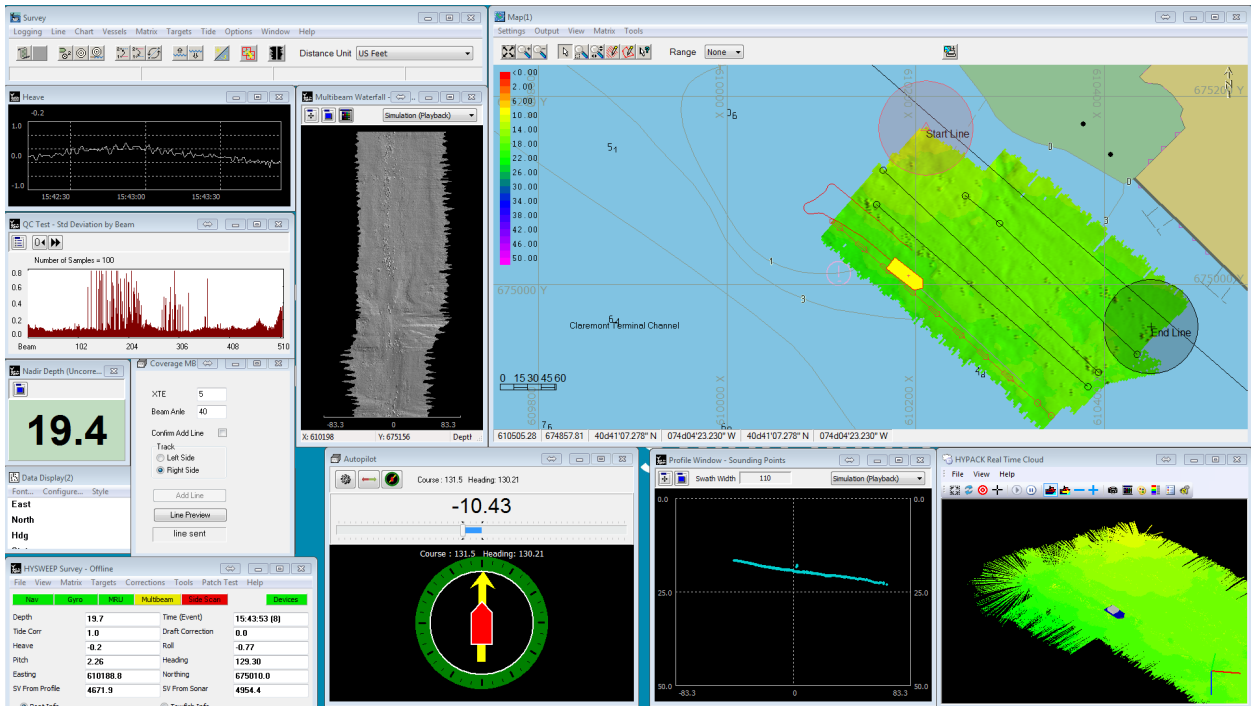


FIGURE 9. *Resulting Line Plan Created by the HYPACK® Adaptive Path Planner (AutoLines) Driver.*

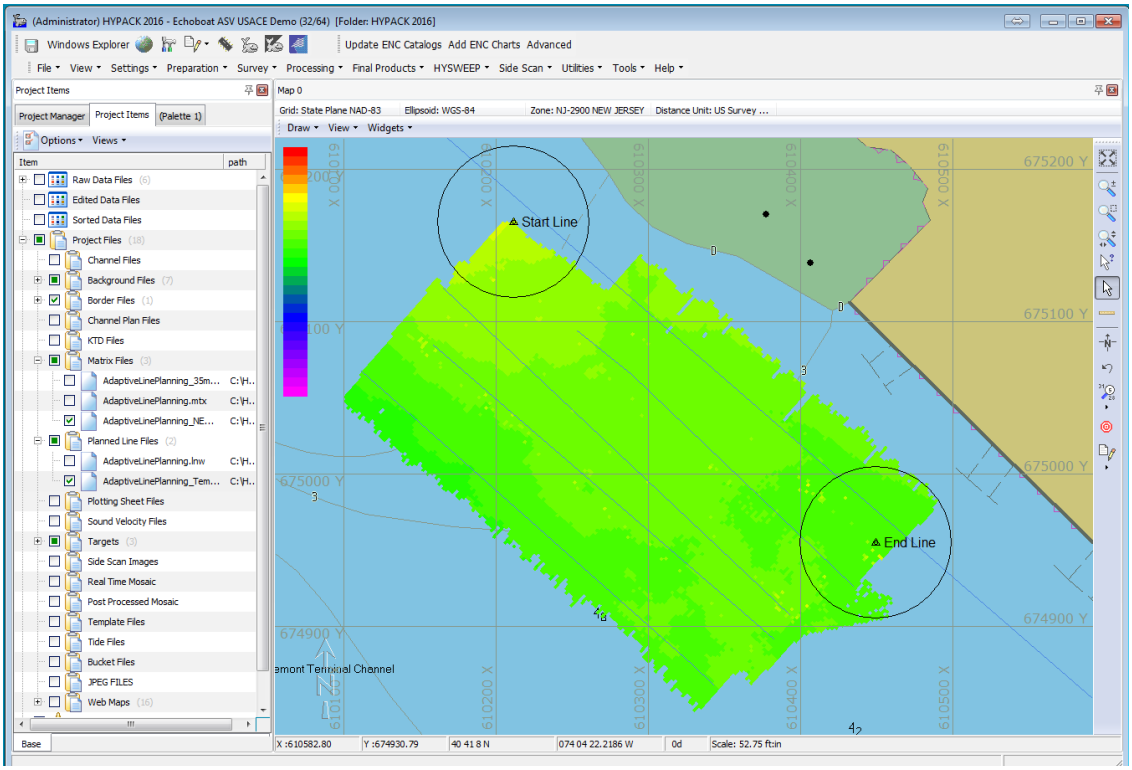
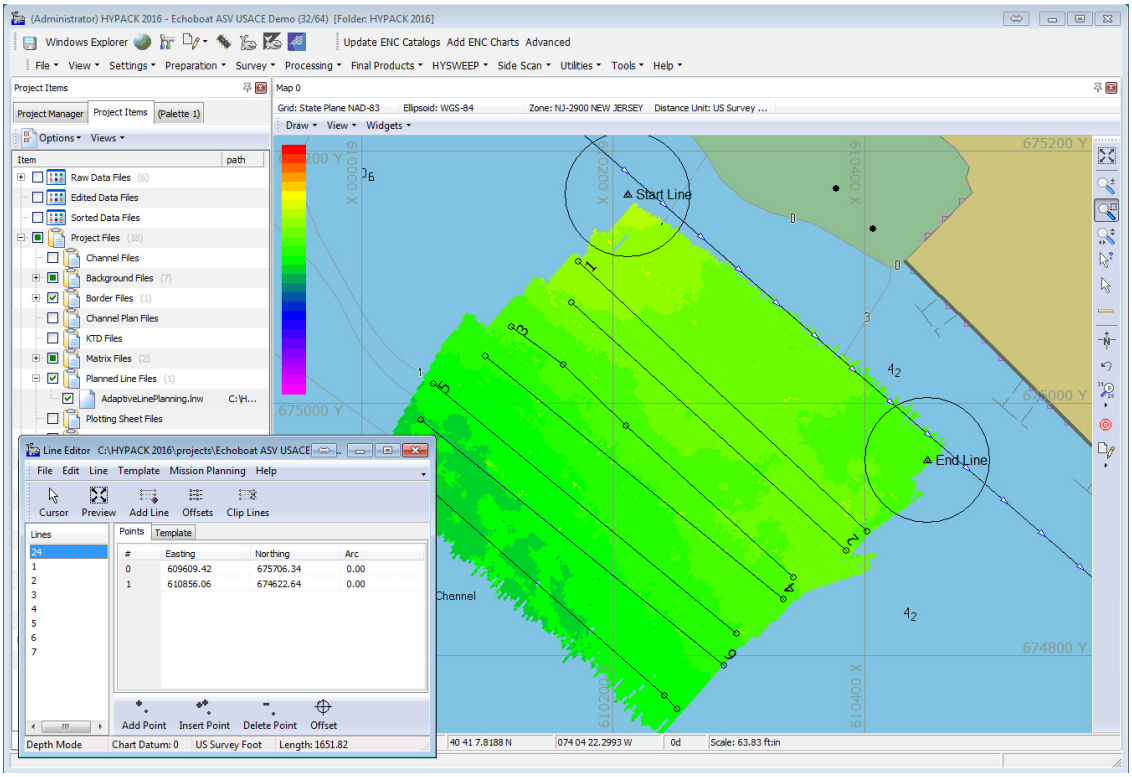


FIGURE 10. *Opening the Line (*.LNW) File After Completion.*



PUTTING IT ALL TOGETHER

There are many variables that can be modified. Going back to the stew analogy, much of this depends on who is doing the cooking and what they are given for ingredients, along with the time it takes to prepare the meal. In the end, you will end up with some sort of stew of some subjective quality, but perhaps an understanding of how certain ingredients can affect the whole can influence the decision-making process and make some very hungry people happy! This is the goal of the AutoLines driver. The ability to preview your next survey path allows you to be proactive and adapt the survey mission according to the data.

In summary, I have outlined the expected interaction between the operator and HYPACK® using the AutoLines functionality. Once the initial parameters have been set in the hardware profile and HYPACK®/HYSWEEP® SURVEY are launched the following occurs.

1. **Add a planned line (*.LNW) file with your initial survey line.** The driver appends new lines onto this file.
2. **Create a matrix file for your survey area.** Alternatively, you can enable the Auto Matrix capability in HYPACK® SURVEY.
3. **Configure the Autolines driver** in HARDWARE.
4. **Launch HYPACK®/HYSWEEP and Start Logging**. HYPACK® SURVEY draws red and blue dotted lines based on the Beam Angle, Filter Factor, and Beam Update values that you have set:
   - **Blue dotted line**: Visual indication of the Beam Angle.
   - **Red dotted line**: Raw Visual indication of the next path.
   - **Green solid line**: If the preview line is selected, a green line will draw a preview of the next line using the current parameters.
5. **Stop Logging and accept the proposed line created by the AutoLines algorithm.** If you selected “Confirm Add Line”, HYPACK® will ask if you want to save this line; otherwise, when logging is ended, a new line is created representing the next line.

   The aforementioned note warrants repeating:
   - **If Confirm Line box is unchecked**, you can only adjust the XTE (Line Approximation Error) until the end of line (i.e. stop logging).
   - **If Confirm Line box is checked**, you can adjust the line as much as you want until the next line is committed *even after you stop logging*.

In the future we hope to incorporate turn logic into the AutoLines capability, but in the interim, please do send me your questions, feedback, and suggestions!

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