MakaiPlan Pro

Installation Planning & Simulation Software

MAKAI OCEAN ENGINEERING, INC.
ISO9001:2008 Certified

MakaiPlan Pro is a software for planning and simulating at-sea submarine cable installations. It is an extension of the most popular, industry-standard software for submarine cable route planning and engineering, MakaiPlan. Ship plans from MakaiPlan Pro feed into MakaiLay, the world's #1 submarine cable installation software. This brochure describes the features of MakaiPlan Pro, how it works, and why it pays to join the hundreds of users of the Makai cable software suite.

- 3D Cable Lay Simulations
- Simulated Currents
- Cable Ship Plans
- Detailed Pre- and Post-Lay Analysis
- Operator Training
- Feasibility Studies
- Cost Estimating

Makai**Plan Pro**

MakaiPlan Pro enables powerful and precise 3D, dynamic simulations of submarine cable installations. Cable operators can quickly simulate an entire cable lay in advance and in the office at up to 50 times faster than real-time. An entire trans-oceanic lay simulation can be completed in one day. MakaiPlan Pro is an extension of the successful cable route planning software, MakaiPlan and also includes all the planning features of MakaiPlan.

The primary benefit of MakaiPlan Pro is to give the cable operators a deep understanding of the expected cable behavior during their particular lay. Investing the time to know what to expect before going to sea is a cost effective way to avoid expensive delays and major risks to the cable during installation. A detailed simulation helps operators understand and plan for the impact on the cable of dynamic situations such as vessel starts and stops, repeater deployments, strong cross-currents, and sharp alter-courses.

Once simulations are performed, in which the cable is laid on course and with acceptable bottom slack or tension, MakaiPlan Pro can create a detailed Ship Plan which will be used to provide navigation and cable payout instructions during installation. MakaiPlan Pro can also be used for feasibility studies and trade-off analyses (e.g., equipment used vs. costs vs. accuracy achieved), training cable engineers, and for pre-lay and post-lay analysis.

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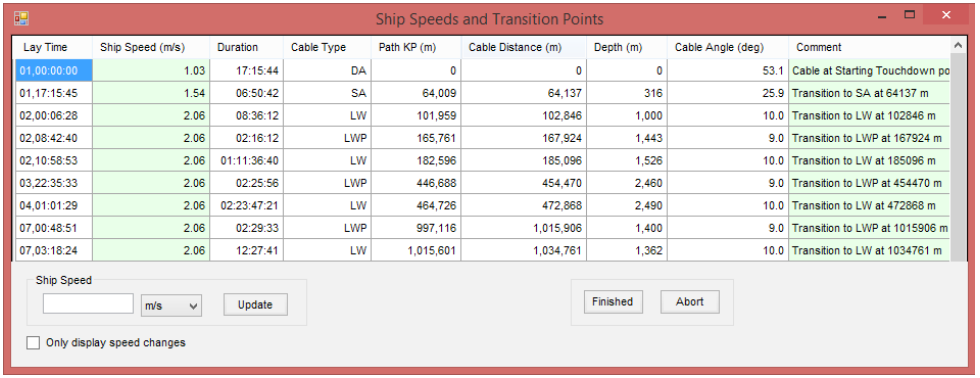
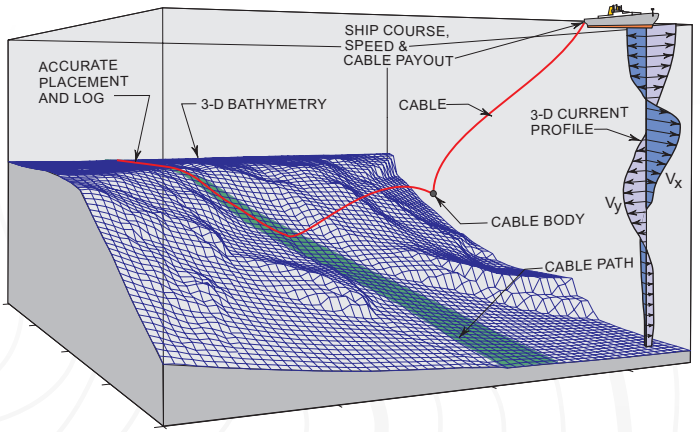
Preliminary Ship Plan

MakaiPlan Pro has the tools to generate a preliminary ship plan: a detailed set of ship and cable payout instructions for installing the cable along a given submarine cable route. The Ship Plan is similar to a Route Position List (RPL) except that it is surface oriented and defines ship movements and cable payout instructions. MakaiPlan Pro can generate a preliminary Ship Plan quickly and automatically based on simple steady-state approximations to the cable installation process. This provides a first-cut at a Ship Plan, which is then refined and improved based on detailed dynamic simulation results.



Lay Time	Ship Speed (m/s)	Duration	Cable Type	Path KP (m)	Cable Distance (m)	Depth (m)	Cable Angle (deg)	Comment
01,00:00:00	1.03	17:15:44	DA	0	0	0	53.1	Cable at Starting Touchdown po
01,17:15:45	1.54	06:50:42	SA	64,009	64,137	316	25.9	Transition to SA at 64137 m
02,00:06:28	2.06	08:36:12	LW	101,959	102,846	1,000	10.0	Transition to LW at 102846 m
02,08:42:40	2.06	02:16:12	LWP	165,761	167,924	1,443	9.0	Transition to LWP at 167924 m
02,10:58:53	2.06	01:11:36:40	LW	182,596	185,096	1,526	10.0	Transition to LW at 185096 m
03,22:35:33	2.06	02:25:56	LWP	446,688	454,470	2,460	9.0	Transition to LWP at 454470 m
04,01:01:29	2.06	02:23:47:21	LW	464,726	472,868	2,490	10.0	Transition to LW at 472868 m
07,00:48:51	2.06	02:29:33	LWP	997,116	1,015,906	1,400	9.0	Transition to LWP at 1015906 m
07,03:18:24	2.06	12:27:41	LW	1,015,601	1,034,761	1,362	10.0	Transition to LW at 1034761 m

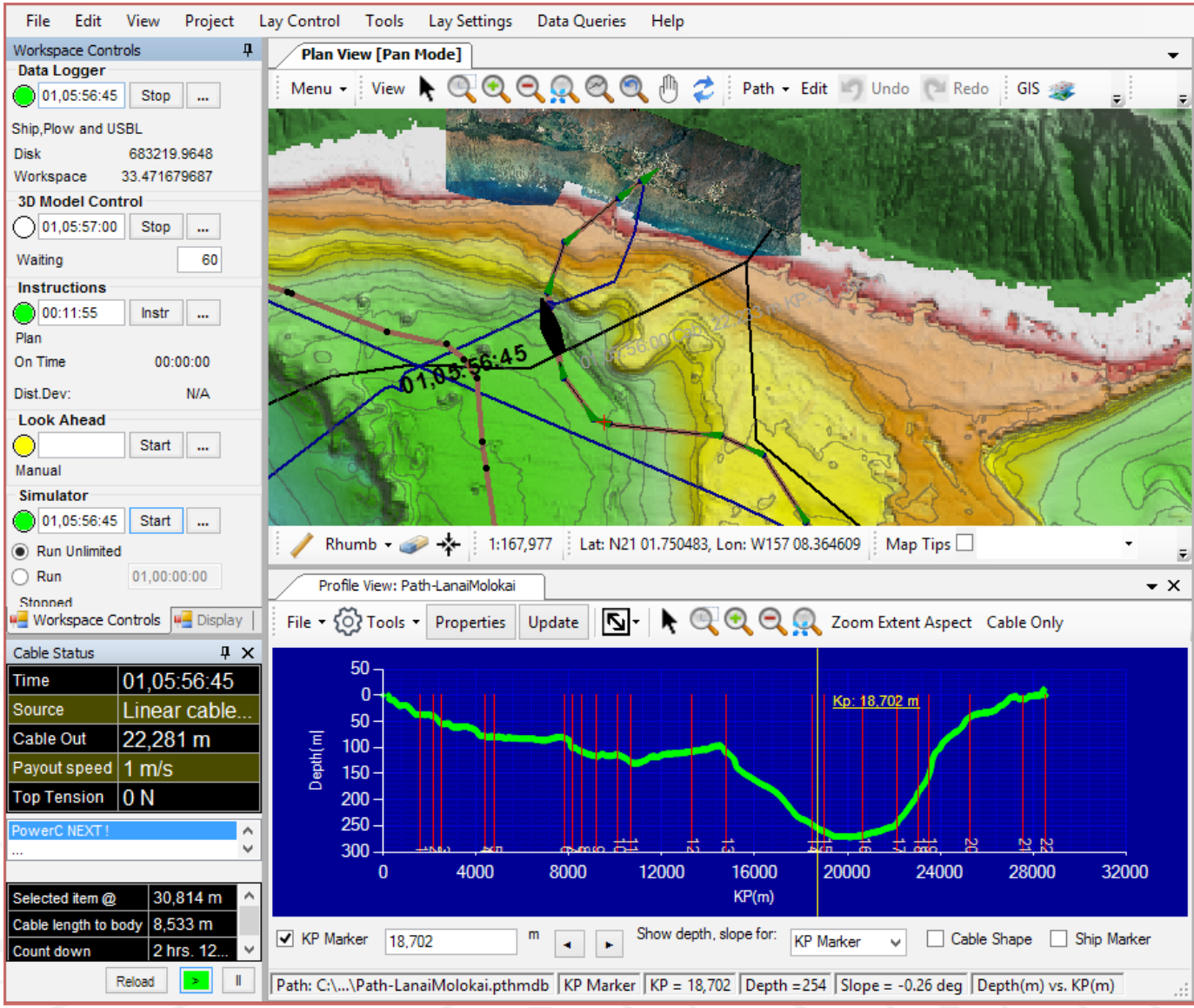
Above: MakaiPlan Pro automatically creates a Preliminary Ship Plan based on Steady-State approximations which is later refined by running detailed dynamic simulations



Right: MakaiPlan Pro uses a rigorous and thoroughly validated 3D dynamic model of the cable in its simulations. This same cable model also powers the MakaiLay software, which has been used to accurately install more than 400,000 km of subsea cable.

Cable Lay Simulations

MakaiPlan Pro includes a state-of-the-art cable installation model that can quickly and accurately compute the cable shape and movement during a submarine cable lay. MakaiPlan Pro's cable model computes the complex, three-dimensional, dynamic shape of the cable between the ship and the touchdown under nearly any sequence of ship movements and cable payout. The model also takes into account cable type changes and inline cable bodies as well as changing bottom bathymetry and ocean currents. Makai's model has been rigorously tested and calibrated at-sea. As a result, the cable touchdown conditions – location, slack/tension and even bottom dragging – can be computed accurately. During a simulation, MakaiPlan Pro allows users to fully visualize the dynamic installation process in 3D and provides detailed numerical output of all the relevant parameters affecting the lay.


File Edit View Project Lay Control Tools Lay Settings Data Queries Help
Workspace Controls
Data Logger
01,05:56:45 Stop ...
Ship,Plow and USBL
Disk 683219.9648
Workspace 33.471679687
3D Model Control
01,05:57:00 Stop ...
Waiting 60
Instructions
00:11:55 Instr ...
Plan
On Time 00:00:00
Dist.Dev: N/A
Look Ahead
Start ...
Manual
Simulator
01,05:56:45 Start ...
Run Unlimited
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Stopped
Workspace Controls Display
Cable Status
Time 01,05:56:45
Source Linear cable...
Cable Out 22,281 m
Payout speed 1 m/s
Top Tension 0 N
PowerC NEXT !
Selected item @ 30,814 m
Cable length to body 8,533 m
Count down 2 hrs. 12...
Reload
Plan View [Pan Mode]
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Rhumb 1:167,977 Lat: N21 01.750483, Lon: W157 08.364609 Map Tips
Profile View: Path-LanaiMolokai
File Tools Properties Update Zoom Extent Aspect Cable Only
Kp: 18,702 m
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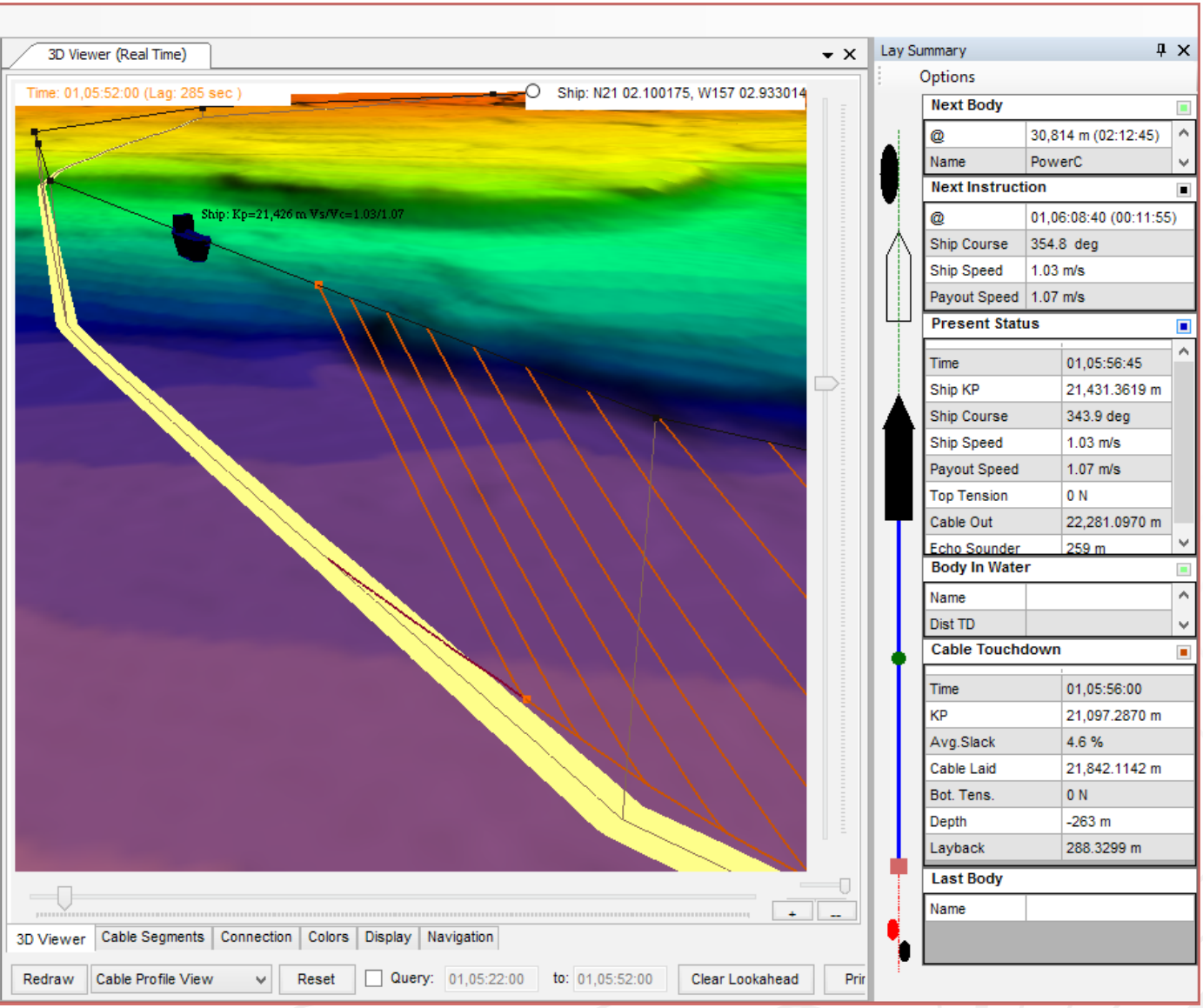
Path: C:\...\Path-LanaiMolokai.pthmdb KP Marker KP = 18,702 Depth =254 Slope = -0.26 deg Depth(m) vs. KP(m)



A screenshot of MakaiPlan Pro, showing the Plan View (top left), the Profile View (bottom left), the 3D Viewer (right), Lay Summary (far right) along with other controls and information about the simulated lay in progress.

Refining the Installation and Ship Plan

With MakaiPlan Pro, the cable installation can be simulated in detail and refinements can be made to the preliminary Ship Plan. With the aid of a dynamic 3D simulation of the lay, operators can look at the entire installation, minute-by-minute, and observe the slack or tension at the seabed, and the position of the cable along all portions of the route. This analysis can be accomplished at up to 50 times faster than real time. Every single event during installation (repeater touchdowns, alter-courses, splices, slowdowns and stops, etc.) can be graphically and numerically reviewed. Adjustments can be incorporated into the Ship Plan to compensate for these dynamic events and make sure the cable is properly installed as specified by the Route Position List.

MakaiPlan Pro includes a feature called Look Ahead, which enables the operators to look into the future and determine the impact on the cable lay for a given set of actions. This allows operators to quickly test "what if" scenarios and decide on the best plan forward. This tool is very useful for in-office simulations to properly modify and optimize the ship plan, and is also a critical tool for resolving unexpected situations at-sea.

With MakaiPlan Pro, users can make all the mistakes in advance on the simulator when they can be easily corrected and before they become costly at-sea disasters.

Feasibility Studies

Simulations produced by MakaiPlan Pro can be used to determine the feasibility of the given cable installation, taking into account ship and other equipment limitations as well as the expected environmental conditions. Simulations can be run to include typical at-sea instrument and operator errors. Instruments errors such as GPS position errors, cable length measurement errors and errors in the knowledge of the ocean currents and bathymetry can be easily incorporated in the simulations. Operator errors, such as how well the helmsman and cable engine operators can follow the instructions, can also be incorporated in the simulation. Using these results, an error budget analysis can be produced which will aid in determining the factors that are limiting the operation.

These computer simulations realistically reproduce actual at-sea lay conditions and allow the planner to estimate the probability of success to achieve the desired cable touchdown positions and the cable slack (or tension) at the seabed.

Equipment Selection

MakaiPlan Pro simulations can be used to quantify the effect of each instrument on the cable lay speed and accuracy. Makai can simulate DP systems, GPS, cable engines, Acoustic Doppler Current Profilers (ADCP - to measure ocean currents in real-time), and the use of transponders attached to the cable. MakaiPlan Pro can assist operators in objectively answering questions such as:

- Will a more expensive ADCP with longer range meaningfully improve my installation accuracy?
- Do I need to use transponders attached to the cable to meet the required installation accuracy?
- How does the installation speed affect my placement accuracy?
- Do I need a DP vessel?

Answering these questions allows the operator to present the client with a trade-off analysis of equipment costs vs. accuracy achieved and risk minimization. This analysis is objective and backed up by rigorous modeling results, making it much easier to convince project management of the need for having the right equipment on board.

Cable Engineer Training

MakaiPlan Pro is very similar in operation to MakaiLay – Makai's at-sea cable monitoring, logging, navigating and controlling software. Operators can run entire cable installations prior to going to sea in order to become familiar with the software, cable installation concepts, and the details of a particular lay. This training prepares them to run successful at-sea lay operations.

Post Installation Analysis

MakaiPlan Pro can be used to simulate in detail a cable installation after the installation has been completed using the installation logs. As-laid cable paths can be refined and potential seabed problems can be identified. Post installation analysis is valuable in analyzing at-sea problems that might have occurred, identifying possible premature failure locations, and creating a good as-laid record of the installation.

Route Engineering

As with all of Makai's cable software, MakaiPlan Pro is built on a Windows GIS platform.. This enables a precise placement of the cable on the seafloor, as well as the ability to import other GIS data such as cable databases, marine protected areas, and more. MakaiPlan Pro contains all the route planning and engineering goals of MakaiPlan and enables users to collaboratively design a cable path with cable engineers, owners, surveyors, and installers, all sharing a unified view of the project data. See Makai's brochure on MakaiPlan for more details.

Power Module

The optional Power Module for MakaiPlan Pro includes a collection of tools that were developed for addressing specific issues faced by submarine power cables during installation. Power cables are heavier and more rigid than fiber optic cables. Their longevity can be severely compromised if they are not installed with the correct tension on the seabed. Thus, a successful power cable installation requires more careful planning and monitoring.

Fiber Optic Cables versus Power Cables

While fiber optic cables are installed with slack on the seabed, power cables have to be installed with some residual tension to avoid a bend radius smaller than the Minimum Bend Radius (MBR) recommended by the manufacturer, which could kink and damage the cable at the touchdown (as seen in Figure 1 below).

On the other hand, high bottom tension results in cable suspensions on the bottom. As shown in Figure 2, at these seafloor contact points, large reaction forces and small bend radii are common, thereby reducing the life expectancy of the cable due to increased wearing and chafing.

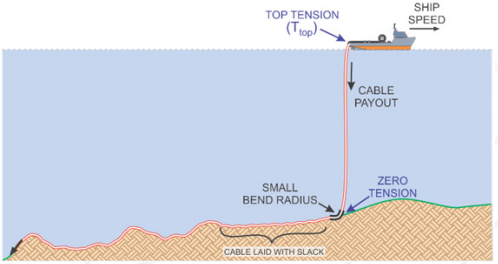


Figure 1: Too little bottom tension or bottom slack will cause excessive bending of the cable.

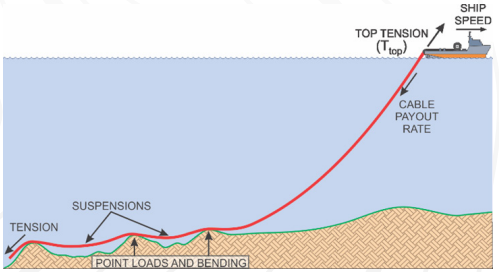


Figure 2: Too much bottom tension will create spans on the bottom creating heavily loaded contact points.

To maximize the life expectancy of the cable, the power cable installer must accurately lay the cable with low values of bottom tension to avoid cable suspensions, but at the same time maintain a small amount of tension at the touchdown to maintain bend radii above the MBR. The bottom tension and cable touchdown location can be accurately managed using MakaiPlan Pro Power and MakaiLay Power, both of which have the capability to accurately model the 3D cable shape, touchdown location, and tension on the seabed during a lay.

Heave Analysis Tool

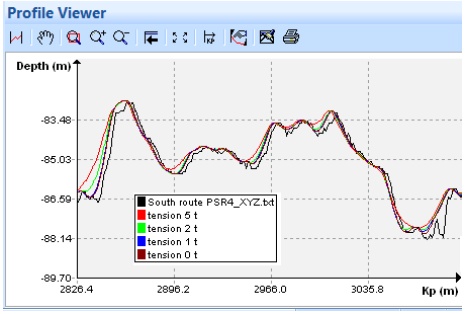
As a ship heaves up and down with the waves, cable tension and bend radius of the cable catenary can be impacted, potentially damaging the cable. To simulate these effects on the cable, a Heave Analysis tool comes with the Power modules for MakaiPlan Pro and MakaiLay. This tool enables users to perform analyses for different sea states and lay conditions to ensure that tensions and bend radii are within allowable limits during the installation. Users can import the vessel RAOs and impose wave spectra to create realistic ship motions (heaving, pitching, etc.) and then analyze the impact on cable tensions and bend radii. The tool can be used in office to design a safe lay with MakaiPlan Pro, or at-sea with MakaiLay to make fast decisions about the lay as conditions change and contingencies arise.

Span Analysis Tool

Using this tool, cable engineers can calculate the true shape of the cable on the seafloor when different tensions are maintained on the cable. The model accurately calculates the resulting free spans, the reaction forces on the cable at the seafloor, bend radii, and shear forces and moments along the suspended cable. The tool can provide the cable engineer with values of the bottom tension that need to be maintained during installation in order to avoid excessive spans on the seafloor. The Span Analysis tool comes with Power modules for MakaiPlan Pro and MakaiLay.

Auto-Tension Tool

Auto-Tension is an extension of the Look-Ahead module which allows the users to vet and optimize future ship instructions. Using the Auto-Tension tool, users can automatically generate future cable pay-out instructions that will maintain a desired bottom tension during the installation.



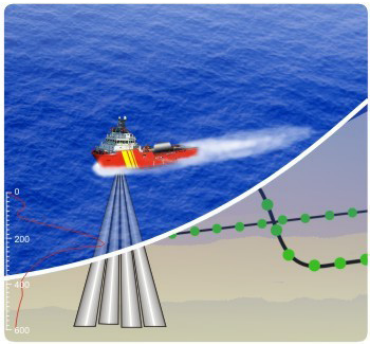
The Span Analysis tool enables engineers to easily analyze the entire cable route for regions of potential spans, based on the likely residual tensions of the cable as installed on the seafloor. Span Analysis comes with the Power modules for MakaiPlan Pro and MakaiLay.

Top-Angle Measurement Input

In shallow waters, the top cable angle or the departure angle measured at the cable over-boarding point is sensitive to the changes in tension at the cable touchdown point. Top angle measurements can now be used as an input to the Makai's real-time cable model to calculate the cable shape, touchdown position and bottom tension.

Seismic Module

The optional Seismic module addresses the needs of the seismic Industry for the accurate planning, installation, and retrieval of Ocean Bottom Cables (OBC) in mid- and deep waters. OBCs often have transponders along their length, which can provide accurate position measurements at points along the cable. By inputing data from these transponders, the accuracy of Makai's cable model can be significantly improved in-turn providing higher placement accuracy of the cable on the sea floor. This is of particular importance for OBC installations where transponders are placed at regular intervals along the arrays. Contact Makai for more information about our purpose-built Seismic software products.



Repair Module

The Repair Module is a collection of tools and features that will help the operator during cable recovery and repair operations. It can simulate grapnel dragging, installing cables with buoy assemblies attached at the end, and recovering previously laid cables.

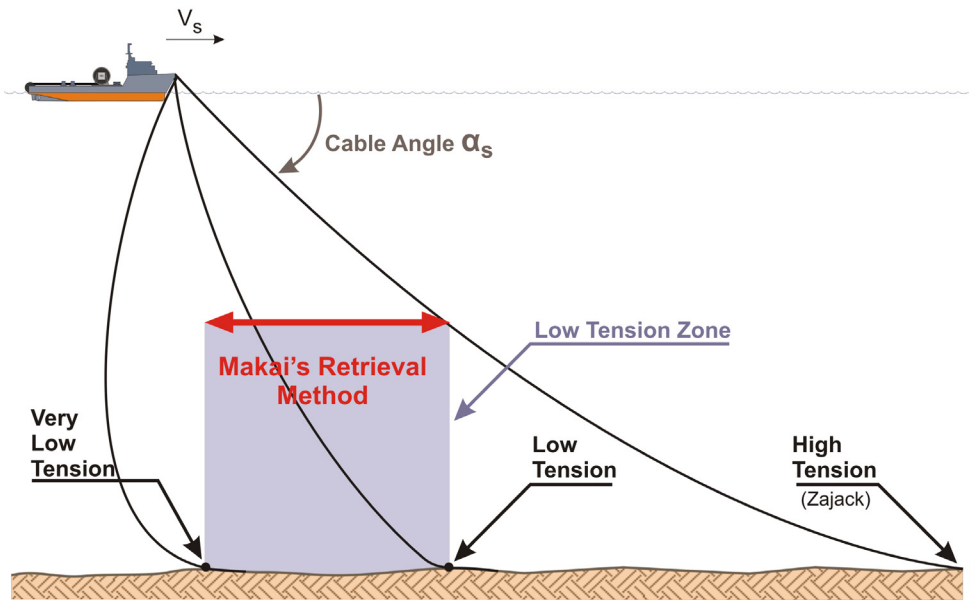
Cable Recovery Operations

The user can load the information about previously installed cables and then model the recovery of that cable using the Repair Module. Just like a regular installation, the cable model takes into account all the instrument measurements and provides a real-time catenary of the cable while it is being recovered.

Maintaining a desired working load of tension during retrievals is crucial to:

- Maintain safe working conditions which mitigate the risk of cable breakage;
- Prevent damaging the cable by excessively dragging along the seabed;
- Ensure that cable is not being retrieved at zero tension in which case it will become snagged on any bottom outcrops present. By using the cable model, a repair operator can accurately monitor the bottom tension and can consequently recover cable at a much faster rate with confidence that the cable will be recovered with the proper amount of tension.

The Repair Module includes a Recovery Shape Calculator to calculate and display the cable shape in the water column as it is being recovered in steady-state conditions.



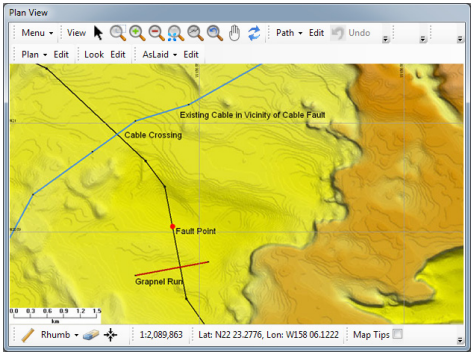


Figure 3 (above): Users can create grapnel routes easily by clicking and selecting route points on the plan view. Then can them select the grapnel assembly and simulate the grapnel dragging on this route.

Left: Comparison between conventional retrieval and retrieval using Makai's cable model. With the confidence of knowing the bottom tension, the installers can increase the retrieval rates and maintain lower tensions.

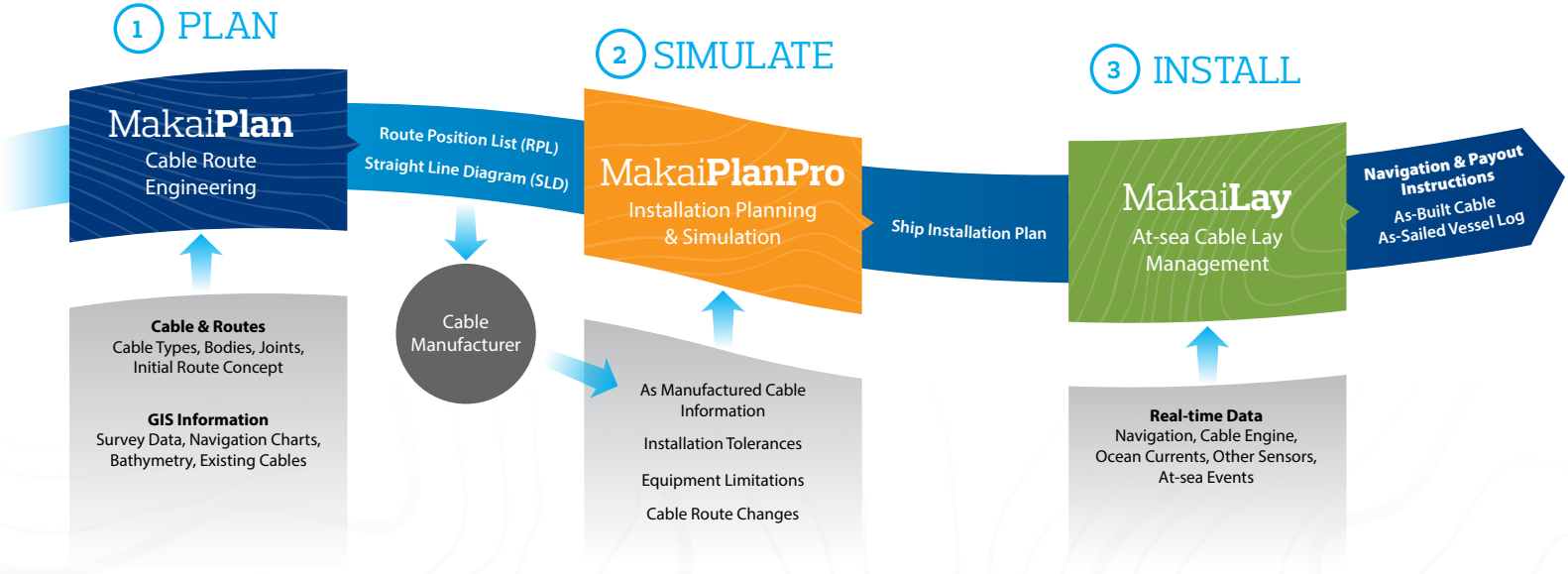
Grappling Operations

The Repair Module allows the users to simulate lowering, landing, and dragging of the grapnel assembly. Users can define the grapnel assembly and grapnel route separately. When a new grapnel run is started, the user can quickly draw the route on plan view (Figure 3) and calculate the depths along the route from the bathymetry data. An existing grapnel assembly can be reused or a new one can be created. The Repair Module also includes a tool to estimate the grapnel rope length that is required to ensure that the grapnel is being dragged on the bottom to hook the cable to be repaired. The user can specify the ship speed, water depth, and estimated currents to be used in the rope length calculation.

Buoy Operations

The Repair Module allows the users to create buoy assemblies and to append them to the regular cable assemblies. This allows users to continue the simulations when the cable is being buoyed off. The Repair Module also includes a tool to estimate the buoy size to ensure that it can carry the weight of the catenary when buoyed off. The user can specify the water depth and estimated currents to be used in the buoy selection calculation.

Cable Planning, Simulation, and Installation Process



Seamless Transition from Plan to Lay

MakaiPlan Pro is an extension of MakaiPlan, the industry-standard software for cable route engineering. MakaiPlan Pro's Ship Plans feed directly into MakaiLay, the world's #1 subsea cable installation software, which has been used by over 75% of the world's cable ships to accurately install more than 400,000 kilometers of cable on the seabed. This software suite enables seamless flow of information along the lifecycle of any cable project.

The Creators of MakaiPlan Pro

MakaiPlan Pro was created by Makai Ocean Engineering, Inc, a diversified ocean engineering firm with over 25 years' experience in the subsea cable industry. At Makai we pride ourselves on excellent customer service and technical support. We are an ISO 9001:2008 certified business and use strict quality control methods to ensure the highest quality of submarine cable software products and services.

Contact one of our engineers today

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