AKAMINA

TECHNOLOGIES

WaveGen-Studio

Overview

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1 WAVEGEN-STUDIO

WaveGen-Studio is a feature-rich, powerful system designed for managing physical hydrodynamic studies. It combines the four components of data acquisition, wave synthesis, wave generation and wave data analysis in a seamless, intuitive graphical interface designed to allow users to easily manage even the most complex experiments. Each of the components can be included and configured individually. The WaveGen-Studio interface configured for all of the four components with the wave synthesis form displayed is shown below.
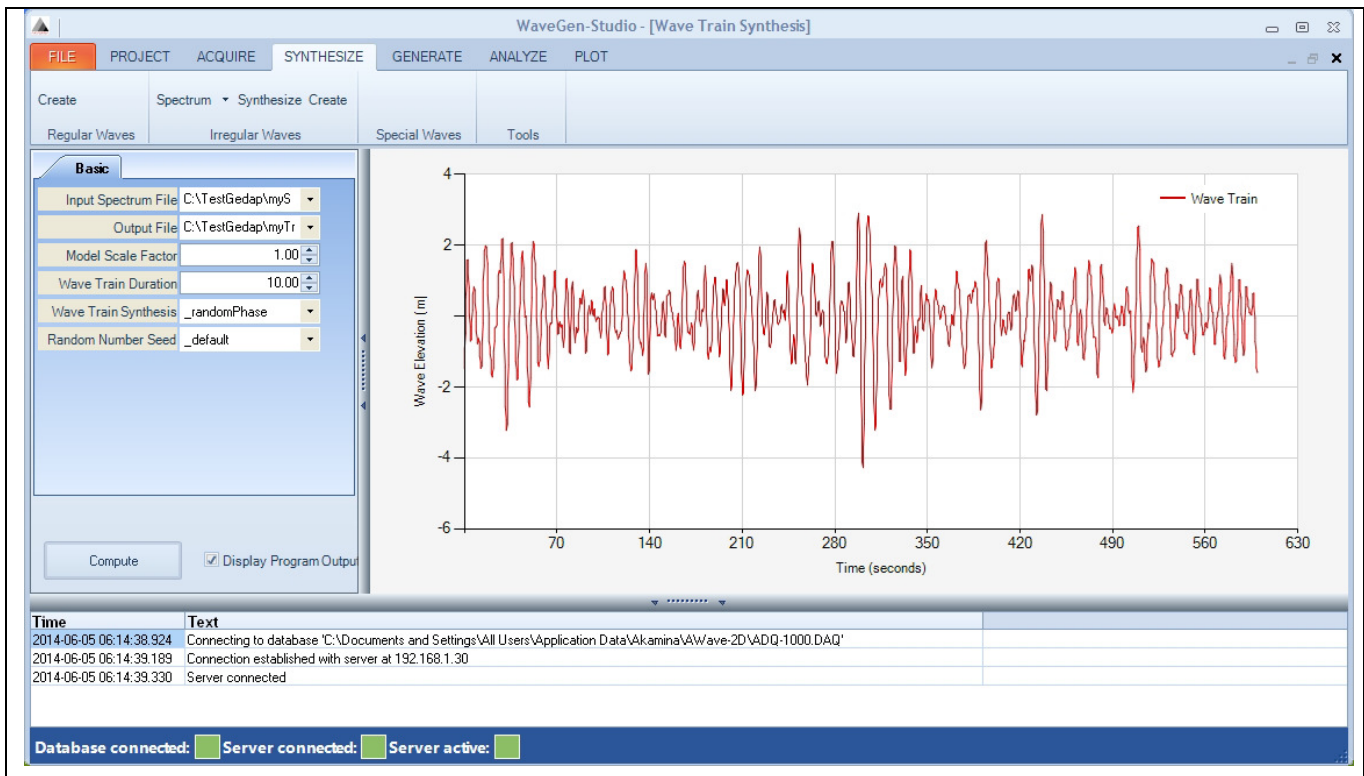

The system uses a network of connected servers to provide the necessary data acquisition and control capabilities. Data acquisition servers allow data to be acquired from sensors used in the study and control servers are used to control the electric or hydraulic actuators to generate waves.

Wave synthesis and wave data analysis with sophisticated plotting capabilities are provided by the National Research Council Canada's GEDAP system. GEDAP is a well-proven, complete software solution for physical modelling in hydrodynamic laboratories. Commonly used GEDAP programs have been integrated into WaveGen-Studio for interactive use. GEDAP programs, GPLOT and batch file processing are also available through the Windows Command Prompt.

WaveGen-Studio and GEDAP are designed to run on any PC running Microsoft Windows 7 or Windows 8 Operating System.

The figures below show an analysis-only configuration, a 2-D wave generation and analysis configuration with a combined data acquisition and control server and a 3-D wave generation system with two control servers and a single data acquisition server.

Figure 1: Data Analysis Interface

Figure 2: 2D Wave Generation with Operator's Interface and Data Acquisition Server
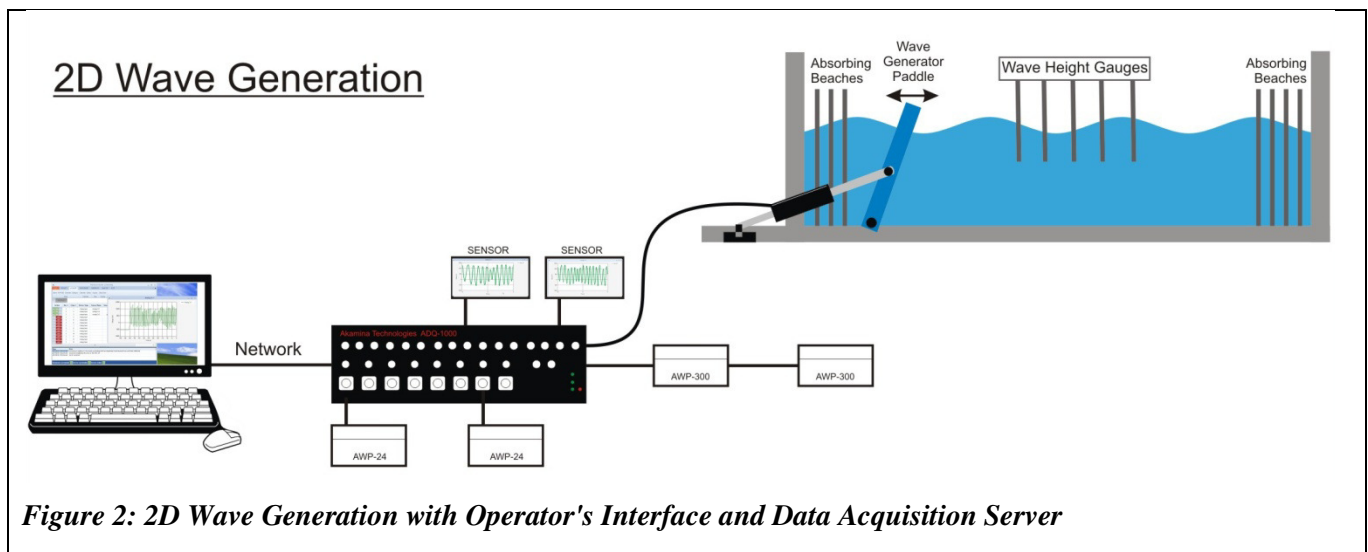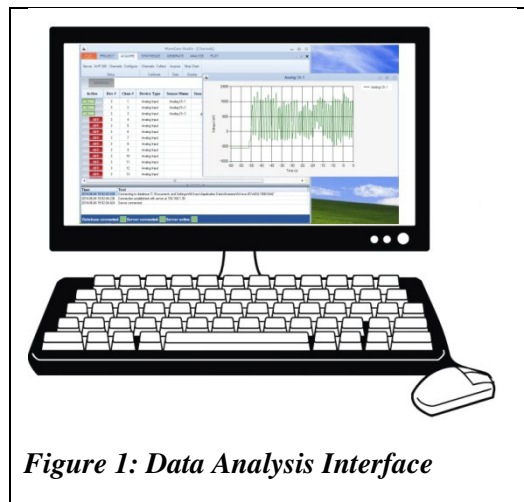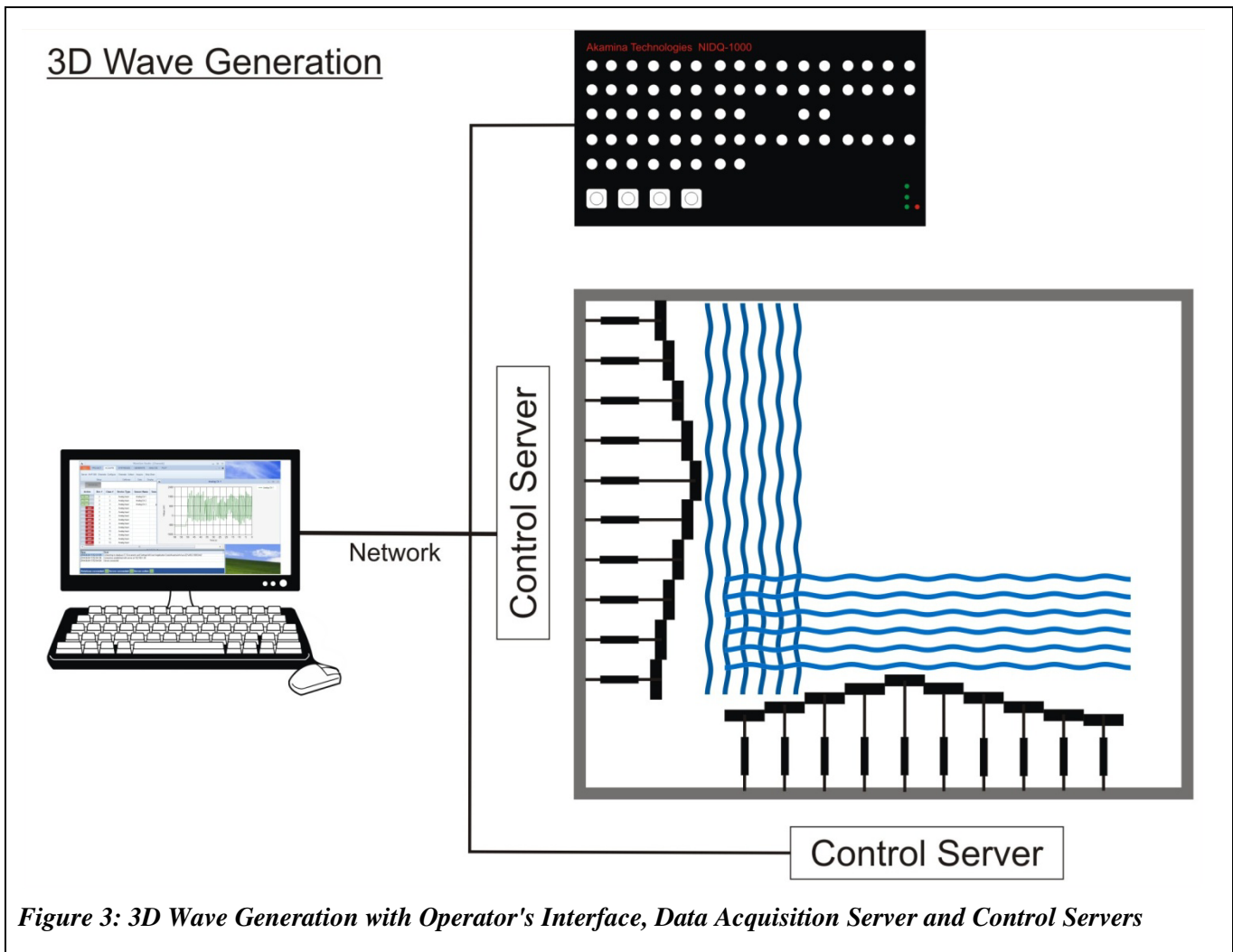
Figure 3: 3D Wave Generation with Operator's Interface, Data Acquisition Server and Control Servers

1.1 Data Acquisition

The data acquisition component of WaveGen-Studio allows data to be acquired from up to two data acquisition servers and any of the control servers for which the system has been configured. The data acquisition features include:

- Acquire data from any number of data acquisition server input channels at the selected sampling frequency.
- Acquire data from any number of control server input channels or derived data channels at the selected sampling frequency.
- Calibrate single channels or groups of channels.
- Display strip-charts with multiple channels per strip-chart in real-time.
- Synchronized data acquisition from any of the data acquisition or control servers.

1.2 Wave Synthesis

The graphical wave synthesis interface provides access to the GEDAP 2D and 3D wave generation packages. The interface allows spectra to be created, wave height time series to be derived and wave board drive signal files to be computed and loaded into controllers for wave generation.

Some of the capabilities of the wave generation software includes:

- regular, irregular and episodic wave generation,
- control over wave grouping characteristics and wave asymmetry factors,
- support for piston, hinged-flapper and combination modes of wave board articulation,
- support for elevated wave generators,
- dynamic calibration of wave generators to improve wave generation and
- spectral matching transfer functions to achieve a better match between desired and target spectra.

Target wave spectra can be specified using parametric models or by importing prototype wave spectra. Parametric models that are supported include: Pierson-Moskowitz, JONSWAP, Bretschneider, Ochi Double-Peak, Scott, TMA Shallow Water, Newmann, Mitsuyasu -Bretschneider (1971), and Mitsuyasu (1972). Wave trains can be synthesized from target wave spectra using the Fast Fourier Transform random phase, random Fourier Coefficient or random Fourier Coefficient with matched variance methods.

Users can also define their own spectra by entering the tabulated data in an ASCII file and importing that data into a GEDAP data file format. This wave spectrum file, now in GEDAP format, can be used in place of the parametric wave spectra used in the creation of irregular waves.

1.3 Wave Generation

Wave generation is the process of moving one or multiple actuators to generate waves. Wave generation with and without active wave absorption are supported. For 2D flume systems, a single controller provides closed-loop control of the position or velocity of the one or two actuators that power a wave board. For 3D basin systems, a bank of controllers provide closed-loop control of the position or velocity of the single actuator that drives each wave board. Both electric and hydraulic actuators are supported.

1.4 Wave Data Analysis

Wave data analysis is a suite of programs designed specifically for the analysis of 2D and 3D waves. The data analysis software includes a broad range of analysis tools including:

- time-domain: zero-crossing analysis, trend removal, peak detection and filtering,
- frequency-domain: wave reflection analysis, variance spectral density analysis, filtering, differentiation and integration,
- statistics: basic statistics, wave height data statistical analysis and probability density histograms, and
- miscellaneous: data scaling, sub-record selection, and resampling.

For 3D wave data analysis directional wave spectra can be computed using either the Maximum Entropy Method or the Maximum Likelihood Method.

2 SERVERS

The system uses a network of connected servers to provide the necessary data acquisition and control capabilities. Data Acquisition Servers allow data to be acquired from sensors used in the study and Control Servers are used to control the electric or hydraulic actuators to generate waves.

2.1 Data Acquisition Server

A Data Acquisition Server is used to acquire data from hardware. The hardware is typically analogue input hardware but it can include digital input and quadrature encoder input hardware as well. A Data Acquisition Server will often include the capability for analogue output and digital output. Analogue output can be used to provide a set-point signal that is connected to an external control system. Such a configuration would be used for generating waves when the wave generator is controlled by a controller that tracks a voltage signal.

Standard-speed servers are used to acquire data at up to 1,000 samples per second per channel; high-speed servers can go up to 10,000 samples per second per channel. Servers are configured for differential analogue input with 16 bit to 24 bit analogue-to-digital converters.

The following configurations of Data Acquisition Servers are available:

- ADQ-1000 – up to 32 differential input, 16-bit analogue input channels, 2 16-bit analogue output channels and 60 AWP-300 channels with sampling frequencies up to 1,000 samples per second.
- NIDQ-1000 – National Instruments CompactDAQ system with slots for up to 8 supported peripheral cards. Sampling frequencies up to 1,000 samples per second. Support is available for the following peripherals:
  - o NI 9205 – 16 differential input, 16-bit analogue input channels
  - o NI 9263 – 4 16-bit analogue output channels
  - o NI 9375 – 16 digital input, 16 digital output channels
  - o NI 9219 – 4-channel bridge input
- NIDQ-10000 – National Instruments PXIe system with slots for up to 8 supported peripheral cards. Sampling frequencies up to 10,000 samples per second. Support is available for the following peripherals:
  - o NI PXIe-6345/65/75 – 40/72/104 differential input 16-bit analogue inputs and 2 16-bit analogue outputs
  - o NI PXIe-6612 – 16 digital input, 8 digital output and 5 quadrature encoders
  - o NI PXIe-4330 – 8-channel bridge input

2.2 Control Server

A Control Server is used to provide closed-loop control for an actuator driving a wave board. Flume control servers support up to 2 hydraulic or 2 electric actuators. 3D wave generation control servers support up to 32 actuators per control server. Multiple 3D control servers can be used to provide closed-loop control over an arbitrary number of wave generators for large 3D facilities.

The flume control server is implemented on the ADQ-1000 Data Acquisition Server platform. This allows the flume controller to provide both closed-loop control of up to 2 hydraulic or 2 electric actuators as well as data acquisition. User configurable data acquisition is limited to those input channels that are not used by the controller.

3 GEDAP

GEDAP is a general purpose software package for the analysis and management of laboratory data. GEDAP is a well-proven system that has been developed over many years to satisfy a broad range of real-world project requirements with particular emphasis on random wave generation and data analysis in hydrodynamics laboratories. It can also be used for other applications including the analysis of full-scale data. GEDAP can greatly enhance the capabilities of most existing 2D and 3D wave generators.

GEDAP Features:

- Fully upgraded to run on any Windows 7 or Windows 8 PC 32-bit or 64-bit PC.
- Fully integrated modular package using a common data file structure and a common set of support routines.
- Allows users to add their own Fortran programs by taking advantage of more than 350 subroutines available in the various libraries.
- Includes automatic data tracking tools for quality assurance systems such as ISO 9000.
- Ancillary parameters, which are automatically stored in GEDAP file headers during data acquisition and analysis, can be easily retrieved for use in spreadsheets or plot labels.
- GEDAP programs can either be run interactively or in batch mode to analyse multiple sets of input data.
- Complete on-line documentation accessed by standard Web browsers.
- Comprehensive set of programs for unidirectional (2D) and multi directional (3D) wave generation in flumes, basins and towing tanks.
- All types of wave machines supported: piston, flapper, combinations of piston-flapper, dual-flap, etc.
- Dynamic calibration capabilities for accurate determination of wave machine response characteristics.
- Sophisticated wave machine compensation programs with extensive safety checks.
- Complete set of directional wave analysis programs.
- Reflection analysis programs for regular and random waves.
- Active absorption of waves reflected by test structures.

GEDAP programs are available in the following packages:

- Basic Data Analysis – a set of basic time-domain and frequency-domain programs for the analysis of data. Programs for filtering, integration, differentiation, and basis statistics are included in this package.
- Advanced Data Analysis – a set of advanced analysis programs for detecting and repairing noise glitches in files, advanced statistics, linear transformations, computing variance spectral densities, computing cross-correlations, and zero-crossing wave analysis are included in this package.
- 2D Wave Analysis – a set of analysis programs for the analysis of waves in wave flumes. Programs in this package include: reflection analysis, cross-mode analysis and spectral matching.
- 3D Wave Analysis – a set of programs for directional wave analysis using the Maximum Entropy Method and the Maximum Likelihood Method.
- 2D Wave Synthesis – a set of programs to synthesize waves for a wave flume. Programs in this package include: dynamic calibration of wave generators, synthesis of wave spectra using parametric models, synthesis of random wave trains for a target spectrum and wave machine drive signal creation. Control over spurious long-wave components and the generation of episodic waves are also supported.
- 3D Wave Synthesis – a set of programs to synthesize waves for a 3D wave basin. Programs in this package include: computation of various cosine-squared spreading functions, generation of long-crested wave trains and dynamic calibration of segmented wave generators.

3.1 GPLOT

GPLOT is an extensive interactive graphics package that allows GEDAP data files to be easily examined at any stage of the analysis process.

GPLOT Features:

- Interactive or batch mode operation.
- Automatic scaling and automatic axis labelling using information from the data file header.
- Choice of linear, logarithmic or probability axis scales.
- Choice of line patterns, line widths and colours for plotting curves.
- Various fonts are available for labelling plots.
- Support for embedded LaTeX commands in text strings for Greek characters, math symbols, accents, subscripts, superscripts, etc.
- Dynamic objects such as text strings, boxes, arrows, etc. that can be positioned with a mouse when designing plots.
- Multiple datasets per graph and multiple graphs per page with up to 262,144 points per dataset.
- Automatic generation of plot legends to identify the various datasets in a plot.

3.2 GEDAP Users

Some users of GEDAP include:

- Artelia, France
- Bassin d'essais des carènes, Paris, France
- Centro de Estudios de Puertos Y Costas Madrid, Spain
- Institute for Marine Dynamics, St. John's, Newfoundland, Canada
- Institute of Harbour and Marine Technology, Taichung, Taiwan
- Korea Research Institute of Ships and Ocean Engineering, Daejon, Korea
- Laboratoire National d'Hydraulique, Chatou France
- Marin, The Netherlands
- Offshore Technology Research Center, Texas A&M University, College Station, Texas, USA
- Queensland Government Hydraulics Laboratory, Brisbane, Australia
- Queens University, Kingston, Ontario, Canada
- University of British Columbia, Vancouver, British Columbia, Canada
- University of NSW, Australia
- US Army Coastal Engineering Research Center, Vicksburg, Mississippi, USA
- Coastal Engineering and Port Structure, CSIR, South Africa

4 SOFTWARE PACKAGING

WaveGen-Studio and GEDAP can be configured to support a diverse range of user requirements. Simple analysis-only workstations to fully configured operator interface workstations that support data acquisition, wave synthesis, wave generation and wave data analysis for 3D facilities are possible by selecting the desired set of functionality packages from the list below.

4.1 Data Acquisition

WaveGen-Studio and GEDAP functionality package options for data acquisition include:

ADQ-Basic – basic analogue input from a single Data Acquisition Server. This package includes the GEDAP Basic Data Analysis and GPLOT packages.

ADQ-Advanced – advanced data acquisition from a single Data Acquisition Server. Analogue I/O, digital I/O and quadrature encoder input are all supported. This package includes the GEDAP Basic Data Analysis, Advanced Data Analysis and GPLOT packages.

ADQ-Multiple – advanced data acquisition from two Data Acquisition Servers. Synchronized input and output of analogue and digital data are supported. This package includes the GEDAP Basic Data Analysis, Advanced Data Analysis and GPLOT packages.

The functionality matrix for the data acquisition packages are shown in the table below.

Package	# DAQ Servers	Input				Output		Analysis		
		Voltage	Digital	Encoder	Strain Gauge	Voltage	Digital	Basic	Advanced	Plot
ADQ-Basic	1	✔						✔		✔
ADQ-Advanced	1	✔	✔	✔	✔	✔	✔	✔	✔	✔
ADQ-Multiple	2	✔	✔	✔	✔	✔	✔	✔	✔	✔

GEDAP Software

Data Acquisition Package Functionality Matrix

4.2 Wave Generation

WaveGen-Studio and GEDAP functionality package options for wave generation:

- SYNTH-2D – wave synthesis and basic analysis for 2D wave generation (flumes). This package includes the GEDAP Basic Data Analysis, Advanced Data Analysis, 2D Wave Synthesis and GPLOT packages.
- SYNTH-3D – wave synthesis and basic analysis for 3D wave generation (basins). This package includes the GEDAP Basic Data Analysis, Advanced Data Analysis, 2D Wave Synthesis, 3D Wave Synthesis and GPLOT packages.
- AN-2D – wave analysis software for 2D wave analysis. This package includes the GEDAP Basic Data Analysis, Advanced Data Analysis, 2D Wave Analysis and GPLOT packages.

- AN-3D – wave analysis software for 2D and 3D wave analysis. This package includes the GEDAP Basic Data Analysis, Advanced Data Analysis, 2D Wave Analysis and 3D Wave Analysis and GPLOT packages.
- AGEN-MGMT-2D – wave generation operator interface for a flume wave generator controller.
- AGEN-MGMT-3D – wave generation operator interface for a segmented wave generator controller.
- AWA-2D – active wave absorption integrated with a flume wave generator controller.
- AWA-2D-3-Probe – active wave absorption in a wave flume using the 3-probe method with an external wave generator controller.
- AWA-3D – active wave absorption integrated with a segmented wave generator controller.

The functionality matrix for the wave generation packages are shown in the table below.

Package	Notes	2D Waves				3D Waves				Analysis		
		Synthesis	Generation	Analysis	Absorption	Synthesis	Generation	Analysis	Absorption	Basic	Advanced	Plot
SYNTH-2D		✔								✔	✔	✔
SYNTH-3D		✔				✔				✔	✔	✔
AN-2D				✔						✔	✔	✔
AN-3D				✔				✔		✔	✔	✔
AGEN-MGMT-2D			✔									
AGEN-MGMT-3D							✔					
AWA-2D	1				✔							
AWA-2D-3-Probe	2				✔							
AWA-3D	1				✔				✔			

GEDAP Software

Wave Generation Package Functionality Matrix

Notes:

1. Capability is available with Akamina Technologies Control Servers
2. Capability is available with any external controller

4.3 Package Licensing

The GEDAP Basic Data Analysis package and the GPLOT package can be installed and run on any number of PCs. All other packages are licensed to run on a named PC only.