BESA Research 7.0

The most comprehensive signal processing toolbox for EEG/MEG source localization, classic ERP/ERF and brain connectivity analysis

international edition

Welcome to BESA Research 7.0

We recommend that you read this document carefully before installing, configuring, and using the product. The document contains firstly the Safety Instructions and Installation Instructions. The Getting Started Guide explains the most important things you need to know to get going.

Finally, the Quick Reference and Interaction with Other Programs sections provide additional important information on program usage.

We strive to bring you the latest methods for advanced EEG and MEG analysis in a user-friendly and optimized implementation.

Dr. Tobias Scherg
CEO / General Manager

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Safety Instructions

Intended Use

- BESA Research 7.0 is intended for the Use (MDD 93/42/EEC)
  - For Human Beings
  - And NOT for Animal Beings
- BESA Research 7.0 is a software-only product compatible with personal computers running under a Windows operating system.
- The purpose of BESA Research 7.0 is to assist in the analysis of EEG and MEG data by providing tools for the following analysis steps:
  - Raw data review
  - Data pre-processing
  - Artifact rejection and correction
  - Data averaging and ERP analysis
  - 2D and 3D Mapping
  - Source analysis
  - Time-frequency analysis

- BESA Research 7.0 is intended to be used as an additional tool for the clinical evaluation of data for the purpose of analyzing epileptiform EEG and MEG data.

- BESA Research 7.0 does not replace the routine EEG data evaluation as specified by the national and international societies for Clinical Neurophysiology.

- Surgical decisions must not be based solely on the evaluation results of BESA Research 7.0. All clinical decisions must be based on combining and comparing these results with all available clinical findings, including standard EEG or video-EEG evaluation, neuropsychological examinations, and independent imaging methods.

- BESA Research 7.0 is intended to be run independently of the EEG and MEG acquisition and review programs of other manufacturers.

- BESA Research 7.0 must not be used as monitoring software for vital human functions, for example, in:

  – Intensive care units
  – Neurosurgical units

Intended User

- The intended user is a physician who is neuroscience professional with a thorough understanding of the mechanisms underlying the generation of electrophysiological potentials in the human brain. He or she is expected to be literate in the usage of computer programs in the Windows environment.

- Results from working with the following module: **Source Analysis** shall only be used for diagnostic purposes if created by an experienced neurologist with profound knowledge concerning the methods used in said application areas.

- BESA Research 7.0 is only to be used by appropriate trained specialist personnel who also have an understanding of English sufficient to enable them to read the Getting Started Guide and operate the software.

- Users of BESA Research 7.0 must consider the national requirements for EEG and MEG evaluation independently of the manufacturer's liability.

- The BESA GmbH assumes no liability for unauthorized access to this product or unauthorized use. Children, layman and patients shall not use the product.

Product Classification

BESA Research 7.0 is a product for analyzing neurophysiological data that may be used in the field of scientific research, and for providing assisting information supporting the diagnosing of disorders in neural processes by analyzing such data. According to MDD 93/42/EEC Article 1, the product is intended to be used for human beings for the purpose of: investigation, replacement or modification of the anatomy or of a physiological process.

GMDN collective term: CT112 (Software, application program)

According to **MDD 93/42/EEC (as amended)**, Annex IX, rule 10, Indent 3, BESA Research 7.0 is a **Class IIa** software product for the review and analysis of neurophysiological data stored on computer disk with the following properties:

1.1 Duration of application: short term

1.4 Active medical device

1.6 Active device for diagnosis

BESA GmbH is not liable for the use of the software beyond the intended purpose.

According to safety classifications in IEC 62304:2006/AMD1:2015, BESA Research is a Class A product (class A: the software system can contribute to a hazardous situation which does not result in unacceptable RISK after consideration of risk control measures external to the software system): It is a pure data analysis software, no physical devices are being

controlled or driven by BESA Research 7.0, nor is any active feedback provided to the patient. Any direct physical damage to the subject can therefore be excluded.

Patient Environment

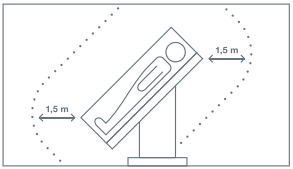
According to **DIN EN IEC 60601-1:2005**, BESA Research does not affect the possibility of using any computer within patient environment. Other programs or hardware connected to the computer (third party equipment) may not be suitable for use within the patient environment.

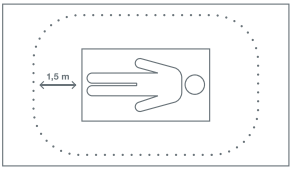
If the product is installed on a PC or Notebook within the patient environment, the PC/Notebook must conform either

a. to DIN EN IEC 60601-1 medical PC or
b. must be isolated from the patient by Means of Protection (IEC 60601-1 3rd Edition) e.g. by an isolating transformer fixed at the PC, or mobile isolating devices for notebooks.

Please note: It is User's responsibility to ensure the safety of combined medical-non-medical-devices (whether in institutes, clinics or practitioners' location).

If the product is installed on a PC or notebook within the patient environment, the PC or notebook must either conform to DIN EN IEC 60601-1 medical PC or must be isolated from the patient by means of protection (IEC 60601-1 3rd Edition), for example, using an isolating transformer fixed to the PC or mobile isolating devices for notebooks.





System Requirements

BESA Research 7.0 is designed to be used for the following hardware / OS:

- Windows® 10 – 64 bit (Touch not supported)
- Windows® 8.1 – 64 bit (Touch not supported)
- Windows® 7 – 64 bit
- Processor: minimum 2 GHz
- RAM: minimum 4 GB
- Display resolution: minimum 1280 × 1024 pixels
- Graphics card supporting OpenGL 2.0 with 16 MB RAM or more

Disposal Information

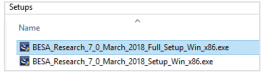
The BESA license key and the box must be disposed of according to the national guidelines on environmental protection.

Installation Instructions

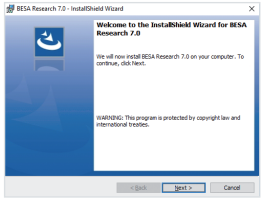
To install BESA Research, you need to have administrator privileges on your computer. The figures below are taken from an installation on a computer with the Windows 10 operating system. On other operating systems, the appearance will slightly differ.

1. Please insert the installation USB stick into your computer. Browse to the Setups folder. If you have downloaded BESA Research 7.0 from our website, browse to the Downloads folder.

2. Run **BESA_Research_7.0_March_2018_Full_Setup_Win_x86.exe** for the full setup, or **BESA_Research_7.0_March_2018_Setup_Win_x86.exe** for the reduced setup without age-appropriate template head models.

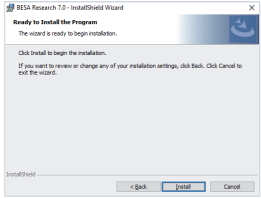


3. The installation wizard starts and the welcome screen is displayed. Press the **Next** button.

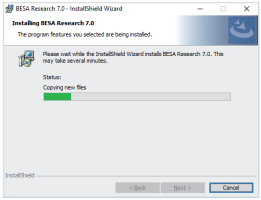


4. Please read the license agreement. If you accept it, select **I accept the terms in the license agreement** and press the **Next** button.

5. BESA Research 7.0 is now ready for installation. Press the **Install** button.

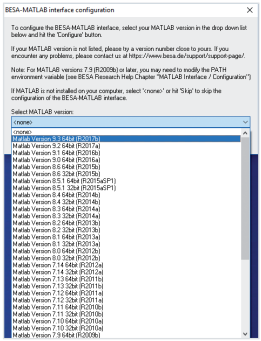


6. BESA Research 7.0 is now being installed on your computer.



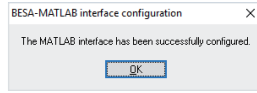
7. Towards the end of the installation process, a dialog window opens to perform the setup of the MATLAB interface.

   Important note:
   The corresponding dialog window might open in the background (behind the InstallShield Wizard window). In this case, please bring it to the foreground by selecting the BESA icon from the taskbar.

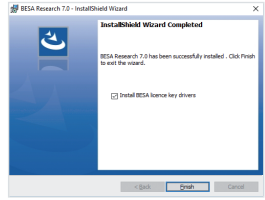


8. In the dropdown menu select the MATLAB version that is installed on your computer and press the **Configure** button. If MATLAB is not installed, press the **Skip** button.

9. Confirm the message box on the successful MATLAB interface configuration by pressing the **OK** button.

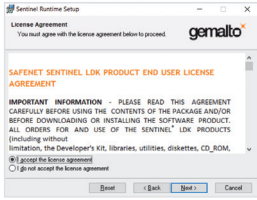


10. Installation of BESA Research is now complete. You have the option to install **Sentinel HASP dongle drivers**. Unless they are already installed, please make sure the box **Install BESA license key drivers** is checked and proceed by pressing the **Finish** button.

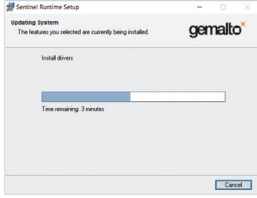


11. Next, the **Sentinel Runtime Installation Wizard** opens. Press the **Next** button to continue.

12. Please read the SafeNet license agreement. In case you accept it, select **I accept the license agreement** and press the **Next** button to continue.



13. Installation of the drivers and system update may take a few minutes.



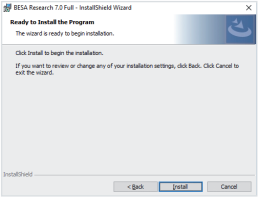
14. The installation of the Sentinel Runtime is now complete. Press the **Finish** button.

15. In case that the reduced setup was installed (without age-appropriate template head models), continue with step **21** below.

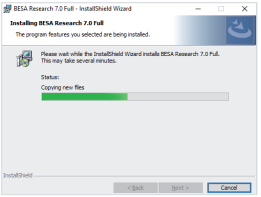
16. After a few moments, a second setup will open automatically for installing the age-appropriate template head models.

17. Please read the license agreement. If you accept it, select **I accept the terms in the license agreement** and press the **Next** button.

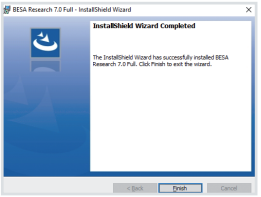
18. The age-appropriate template head models for BESA Research 7.0 are now ready for installation. Press the **Install** button.



19. Age-appropriate template brain models are now being installed on your computer.



20. The installation is complete. Exit the installation by pressing the **Finish** button.



21. **Settings of BESA Research 6.0 or 6.1:** If you have used BESA Research 6.0 or BESA Research 6.1 before and you want to use e.g. your settings or user montages in BESA Research 7.0, please proceed as follows. Note that the following directories are default locations for an installation on Windows 10. For an update from BESA Research 6.0, replace Research_6_1 with Research_6_0 in the description below.

    - If required, copy the **user montages and scripts** from the **\Users\Public\Public Documents\BESA\Research_6_1** folder to the **\Users\Public\Public Documents\BESA\Research_7_0** folder.

    - If required, copy the **settings** from the **This PC\Documents\BESA\Research_6_1\Settings** folder to the **This PC\Documents\BESA\Research_7_0\Settings** folder.

22. Connect the BESA license key (USB key) directly to your computer or a server and wait until Windows completes the configuration of the USB device. If you are having trouble with this step, please find more details in the **BESA License Key Manual**.

23. **Check for updates:** After first starting BESA Research, and from time to time in your daily use, check if there are program updates available. You can do this by selecting the **Help → Check for Updates in BESA Research** menu item (internet connection required).

Getting Started

The MATLAB Interface of BESA Research

BESA Research 7.0 features a direct interface to MATLAB. During program installation, you will be asked which MATLAB version is installed on your computer, so that the interface gets configured correctly.

Note: For MATLAB versions 2009b and higher, you may need to modify your PATH environment variable on your computer. A detailed instruction is given in the BESA Research program help (**Help → Help Topics → Chapter MATLAB → Configuration**), or on the BESA Wiki page (call up **http://wiki.besa.de** and search for "How do I configure the Matlab interface").

More information on the MATLAB interface and its features is provided by the following resources:

- **BESA Research program help** chapter MATLAB contains information on how the MATLAB interface works, how it can be configured, and what kind of data can be exchanged.

- The website **http://www.besa.de** provides sample MATLAB scripts and more information on toolboxes that can utilize the MATLAB interface of BESA Research.

- The BESA Wiki (**http://wiki.besa.de**) provides information about several aspects of the Matlab interface.

Program Modules and Feature Overview

BESA Research is distributed in several different module configurations. The figures on the following page illustrate these for the configurations Basic, Standard, and Complete, with the optional MEG module.

The BESA Research Folder Structure

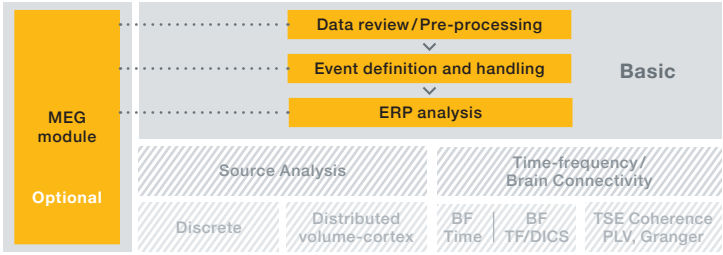
BESA Research generates the following default directories on your computer:

- The **installation folder** contains the executable programs of BESA Research. By default, the **BESA\Research_7_0** subfolder of your default **Program Files (x86)** folder is used for the installation.

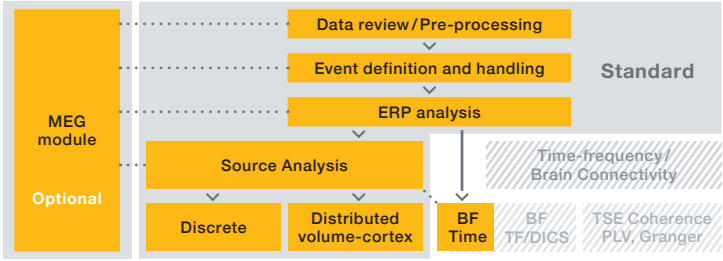
- **Example data, montages, scripts and the BESA Research initialization file BESA.ini** are located in the **BESA\Research_7_0** subfolder of the **Public Documents** folder. The default location of the Public Documents folder is:

  – **C:\Users\Public\Public Documents**

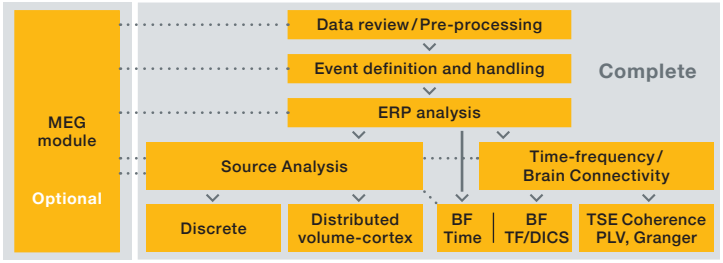
You can change the above default locations by modifying the initialization file **BESA.ini**. Please refer to the BESA Research Help chapter in the program help (**Help → Help Topics → Chapter Special Topics → The initialization file: BESA.ini**).



Basic: Includes tools for: Data review, Pre-processing, Mapping; Artifact / Event handling, Spectral analysis; ERP analysis



Standard: Additional tools for: Discrete source analysis (dipoles, regional sources); Distributed source imaging (volume and cortex), Beamformer (BF), Bayesian source imaging, EEG-fMRI, Brain Connectivity



Complete: More tools for: Time-frequency analysis, TSE, ITPL; Coherence, PLV, Granger causality, PDC, DTF; Beamformer (BF), DICS

Configuring BESA For My Own Needs

Review: BESA Research 7.0 is available in the standard review layout, or in a layout optimized for clinical use, where pattern search and event review options are optimized for clinicians. To switch between these, use the menu entry **Options → Open "Reset Settings" Dialog** and then select **Set Options for EEG Review** at the bottom of the dialog box.

Data file readers: BESA Research 7.0 supports a large amount of data formats. For some of them, additional readers need to be installed. Please refer to **http://www.besa.de/downloads/data-readers/** for a list of available data readers.

Hot keys: Many functions can be achieved by using the keyboard. In the review window, these hot keys are fixed. In Source Analysis and the Montage Editor, you can define your own hot keys. A list of common hot keys is provided in the Quick Reference section below.

Batches: For most analysis steps, batch commands are available. Pre-defined batches for typical analysis tasks are also provided, and can be assigned to function keys. To do this, press the **Shift** key and the function key of choice; then select the batch that will be run when you press that function key.

Run any batch by pressing the **BAT** push button in the review window, or define a batch by **Shift-click** on that button. The pre-configured assignments are listed in the Quick Reference section below.

Tutorials and Help

For an introduction on how to use BESA Research 7.0, please refer to the following sources:

- **BESA Wiki:** The BESA Wiki offers help on many aspects of BESA usage, from typical FAQs to recipes on how to achieve complex goals with BESA. Simply visit **wiki.besa.de** and type your question, or browse through the content.

- **Youtube channel:** The BESA GmbH Youtube channel holds condensed workshop talks and other informative material on how to use the BESA Research software.

- **BESA Program Help:** All features of BESA Research are described in the program help. It can be started from the menu item **Help → Help Topics**.

- **BESA Research Tutorials:** These tutorials provide hands-on step-by-step examples on specific types of data analysis. The tutorials use the BESA Research example data that is installed with the software. In addition to the material provided in this package, please also refer to our website **www.besa.de**. In the **Tutorials** section, tutorial material is available as **.pdf** download.

- **BESA Research Support:** If you have any program-related questions that are not answered by the material mentioned above, please send us an email through our web-interface here: **http://besa.de/contact/support/form.php**.

You can request additional documents related to the instructions for use in printed paper form at no additional cost.

Quick Reference

a. Data Readers

BESA Research 7.0 supports most major EEG and MEG file formats. This document gives an overview of the EEG data formats available. The most common ones are part of the standard installation. Many other formats can be added from the Utilities folder in the installation directory (*). The full list of all supported formats, as well as the latest installers for the various file formats, is available on:
http://www.besa.de/downloads/data-readers/

If your file format cannot be found in this list, please contact us via our support form:
http://besa.de/contact/support/form.php

Supported EEG data formats

• BESA / FOCUS high compression format	.foc .fsg
• BESA new data format	.besa
• BESA ASCII (avr + multiplexed format)	.avr .mul
• FOCUS (1.x binary), EEGFOCUS (2.x binary)	.foc .fsg
• Alpha-Trace (alpha-trace medical software)	.alp
• ATES*	
• BDF (BioSemi)	.bdf
• Beekeeper64 (Telefactor)	.eeg .dat
• Bio-logic (CEEGraph)*	.eeg

• BrainAmp / Brain Vision (Brain Products)	.eeg .vhdr
• BrainLab (Schwarzer)	.sig
• BrainStar (Schwind Medizintechnik)	.eeg
• Compumedics (ProFusion EEG 4, installation required)*	.sdy
• DCmes, PolyDC (MES)	.dat
• Deltamed (Coherence)*	.eeg
• Deltamed (Neurofile)	.eeg
• EBNeuro (Galileo.NT and Galileo.NET 3.5)*	.gnt, .set
• EDF (European Data Format) and EDF+	.edf
• EEProbe (ANT)	.cnt
• Electrical Geodesics, Inc. (EGI)	.raw .ses
• EGI MFF*	.xml
• ERPSS	
• g.Tec (Guger Technologies)	.hdf5
• Galileo (EBNeuro, installation required)*	.nt
• Generic Reader (any simple binary or ASCII formats; see BESA Program Help)	
• Grass-Telefactor (TWinREF)*	.ref
• InstEP*	.c .is .ia
• Konstanz file format*	.raw .sum
• MANSCAN interchange format (SAM)*	.mbi
• Medtronic*	.wg1

• MEF (Multiscale Electrophysiology File 2.0)	.xml
• Micromed*	.trc
• Neuralynx	.ncs
• NeurOne	
• Neuronic*	
• NeuroScan	.cnt .avg
• NeuroScan CURRY version 7	.dap
• NexStim	.nxe
• Nicolet (Nicolet Biomedical Inc.)*	.eeg
• NicoletOne/Nervus (Nicolet Biomedical Inc., installation required)*	.e .eeg
• Nihon Kohden EEG 1100/1200/2100	.eeg
• Phoenix II (EMS) *	s*.0 s*.1…
• Stellate Systems (Harmonie, installation required)*	.sig
• Stellate Systems (Monitor)	.eeg
• Vangard (LaMont Medical Inc.)*	B****, no ext.
• XLTEK	.eeg .erd

* Install this reader using **Install Additional Readers.htm** in the **Utilities\Additional Readers** installation sub-folder.

If files are in one of these formats, they can be read directly and conversion is not required.

BESA Research also has a new, flexible interface for importing ASCII files which can be used in conjunction with the ASCII export functions of your software.

Any EEG format can be converted to the compressed BESA binary format, ASCII format, EDF+ or simple binary format.

For more information please submit your support request here: **http://besa.de/contact/support/form.php**.

b. Frequently Used Hotkeys

Review window

Paging and navigation	
A	Turn on automatic paging
B / N	Page a half page back / forward
<space>	Page to next screen
<Bcksp>	Page a whole page back
<tab>	Go to next tag
Shift-<tab>	Go to previous tag

File I/O	
Ctrl-L	Load coordinate files
W	Write data (export data)

Event handling and viewing	
T	Tag an event (if cursor set)
Ctrl-D, <del>	Delete the current event (if cursor set)
S	Show the selected view

Data analysis and viewing	
Ctrl-E	Toggle between artifact correction and original data
F	Calculate FFT spectrum of the marked data block
R	Run a batch
Ctrl-R	Run last-used batch on current file only
Shift-R	Open the batch editor
V	View coordinates of sensors
Shift-V	View coordinates of all sensors including MEG

Source Analysis and Montage Editor: See the hotkey table under the menu item **Options → Hot Keys** in these windows. In the dialog that appears, change or define hot keys for many actions.

c. Batches

Batches and montages can be assigned to function keys. Function keys **F2–F8** can be used to store batches. Function keys **F9–F12** can be used to store montages that are frequently used. The assignment is user-specific.

To set a batch, press **Shift+<Function key>**. A selector box opens from which the batch of choice can be selected.

For clinical use, batches and montages can be auto-set by using the option **Options → Open "Reset Settings" Dialog**, and selecting **"Set Options for EEG Review"** in the dialog. In that case, function keys are assigned as follows:

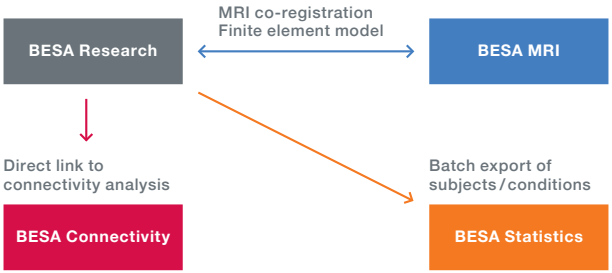
Key	Set montage to	Set filter	Default block around cursor
F2	**BiHL** - bipolar mixed	HP: 0.53 Hz fw / TC 0.3 s	-250 ms : +150 ms
F3	**Av33** - average ref. a10	HP: 2 Hz zp – 35 Hz zp	-250 ms : +150 ms
F4	no change in montage	HP: 4 Hz zp – 30 Hz zp	-150 ms : +90 ms
F5	no change in montage	HP: 5 Hz fw – 40 Hz zp	-250 ms : +150 ms
F6	Action: Convert tags to triggers 41-45 and average		
F7	Action: Fit sources to 1st spike onset & peak (Sp1)		
F8	**TR –Temporal Region**	HP: 3 Hz fw – 20 Hz zp	-500 ms : +500 ms (Seiz.)

Montage function keys are then assigned as follows:

Key	Set montage to	Modify association by
F9	**Av33** - average ref. a10	pressing Shift + F9 to associate key with current montage
F10	**BiHL** - bipolar mixed	pressing Shift + F10 to associate key with current montage
F11	**TR - temporal sources**	pressing Shift + F11 to associate key with current montage
F12	**FR - frontal sources**	pressing Shift + F12 to associate key with current montage

Interaction With Other BESA Programs

BESA Research integrates with the other BESA Research programs BESA MRI, BESA Connectivity, and BESA Statistics for MRI co-registration and FEM, brain connectivity analysis, and statistical analysis.



To start **MRI co-registration**, use the menu **File → MRI Coregistration** in the BESA Research main program. After co-registration, the MRI images and – if applicable – the FEM will automatically be available in BESA Research.
For **BESA Statistics**, use batch commands to automatically export data in the right format, whether source waveforms, volume images, signal or time-frequency data. If you work with sensor data or discrete sources, add one file that details the channel configuration to the data export folder (either using **File → Save Solution in Source Analysis, or File → Head Surfact Points … → Save All Files in Head Coordinates**).
Start **BESA Connectivity** directly from the Coherence dialog.

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CE 0197

The CE marking certifies that this product fulfills the essential requirements of the Medical Devices Directive MDD 93/42/EEC. The number 0197 represents the identification number of the Notified Body.

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Document name BESA Research 7.0 – Booklet / int. edition
Revision number 002
Revision date 15 March 2018