# ENHAnCE
## Featuring Engineering

# D3.3. "Computational platform (Open Access) for computing Lamb-wave simulation and interaction with typical damage cases"

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# 1. Introduction

This deliverable aims to provide a graphical interface where a user can play on specific parameters to observe time wave signals in an elastic plate. For intellectual property reasons, we will settle for an isotropic material where the information is accessible. This file explains how to install and use the Matlab GUI. The last part of this file will explain the theoretical background of the GUI, as well as the central hypothesis.
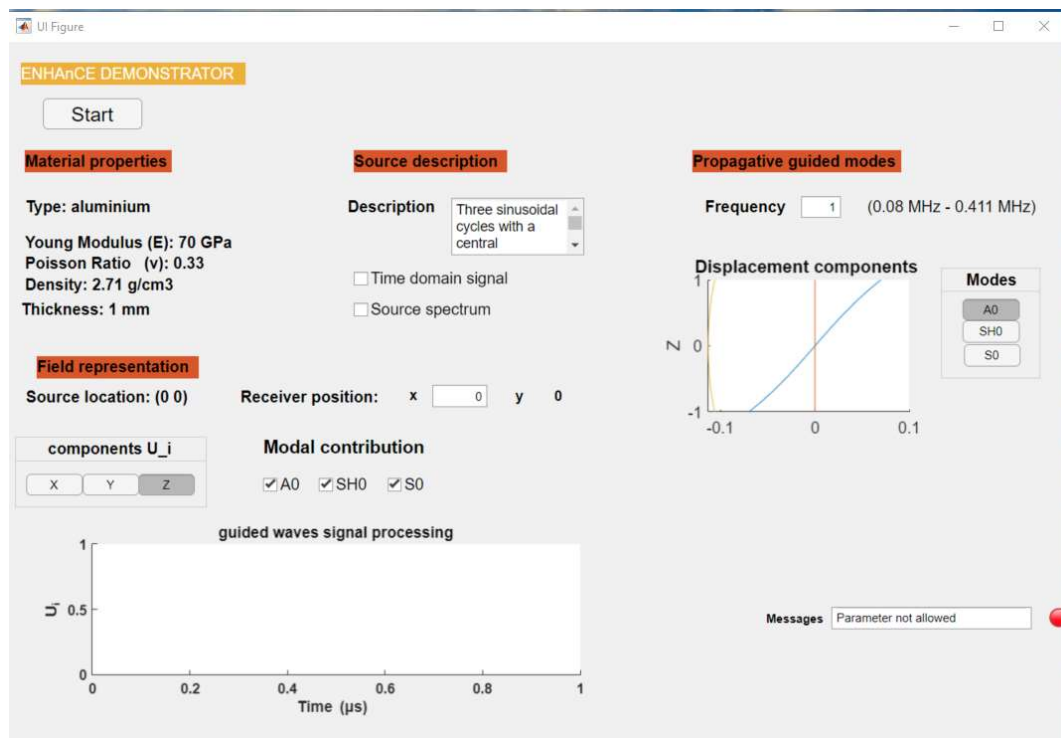


*Figure 1: Matlab GUI for wave propagation in aluminum material.*

# 2. Installation

### 2.1 The folder components

The folder "**ENHANCE_deliverable**" will contain the following files:

- **Signal_temporel_gaussien.m** : used to generate the time domaine signal.

- **Farfield.m** : used to evaluate the farfield displacement in the frequency domain.

- **ENHAnCE_software_exploited.m:** the first installation method

- **ENHAnCE_software_mlappinstall:** the second installation method with Matlab App.

- **ModeITN:** the guided waves data computed for all the useful frequencies of the source ( DO NOT DELETE ).

### 2.2 Run from the .m file

Open the **ENHAnCE_software_exploited.m** by double clicking on it. The Matlab current folder should be the **ENHANCE_deliverable folder.** In the editor view, run the program. The GUI will appear in a new window.
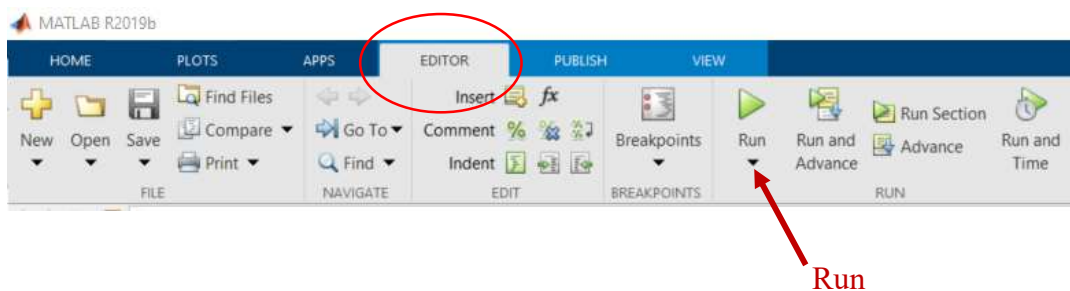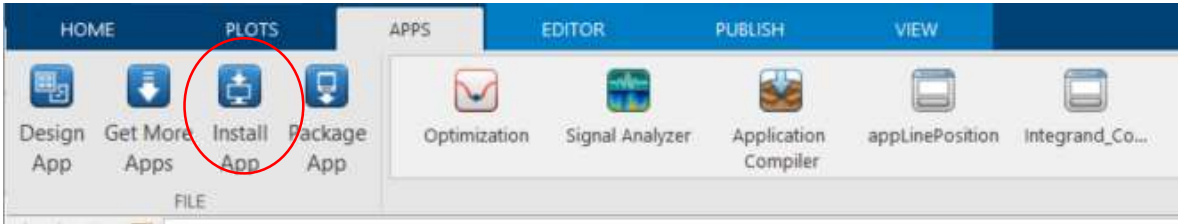


*Figure 2: First method configuration*

### 2.3 Run from Matlab App

- Step 1: Select the APPS view in matlab
- Step 2: Click on install App and select the file **ENHAnCE_software_mlappinstall** in the appropriate folder.

The GUI will appear like in the figure 1.

# 3. Description of the GUI

The GUI is composed of 4 main sections:

- **Material properties**: the aluminium properties as described.

- **Source description**: a 3-cycle sinusoidal signal with a central frequency of 100 kHz has been used. The windowing method is Gaussian. Click on the "Time domain signal" or "Source spectrum" to see the time domain source signal and the source spectrum, respectively.

- **Propagative guided modes:** a specific band of the source spectrum will be used in the field representation at the receiver position. The fundamental guided modes in this frequency range are A0, SH0, and S0. These modes are the basic lamb modes in the wave theory literature. In this part, select the frequency and the mode to visualize.
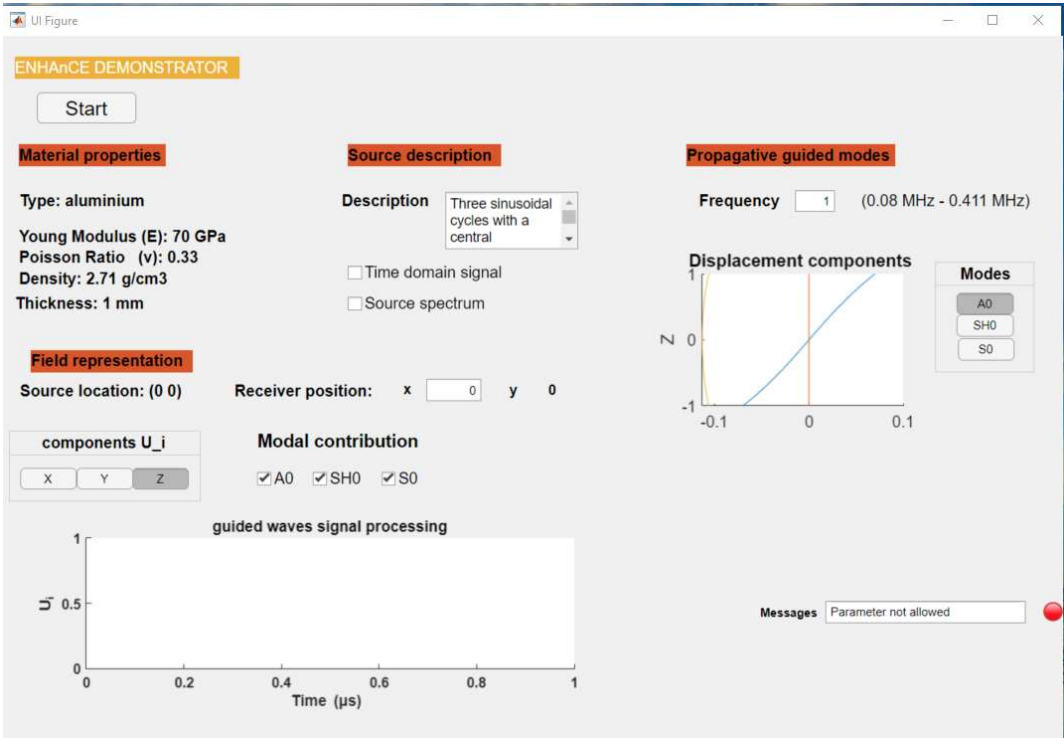
- **Field representation:** here the wave at the position of the receiver is given. You can select the position of the receiver and the components to see. The mode contribution at the point can be seen by clicking or unclicking the "modal contribution button".

# 4. Theoretical background

- The source signal is a tree sinusoidal cycles with a central frequency at 100 kHZ. The time windowing is Gaussian (select "Time domain signal"). The fast Fourier transform (**fft**) is performed to get the main frequencies of source (click on "Source spectrum"). The guided modes are calculed for all the main frequencies. Theses modes can be seen in the "propagative guided modes" at a given frequency.

- Once the modes are known, we will find each mode contribution at the receiver point M. An **integral representation formula** is used for the propagation. This formula is given below (see **chap 3 [1]** ) :

$$u(M,\omega) = \frac{1}{\sqrt{2\pi}} \int_{\mathbb{R}} \sum_{k \leq N} A_k(\xi;\omega) \, \hat{\mathcal{U}}_k^+(\omega,\xi,z) e^{i\beta_k(\xi)x} e^{i\xi y} d\xi$$

For simplification, we did this hypothesis:

$$A_k(\xi;\omega) \, \hat{\mathcal{U}}_k^+(\omega,\xi,z) = A_k(\xi;\omega=\omega_0) \, \hat{\mathcal{U}}_k^+(\omega=\omega_0,\xi,z)$$

It's meens we have build the source to satisfy the above conditions.

- Knowing the contribution of all the mode for all the valuable frequencies lead to an inverse Fourier transform (**ifft**) to get the time domain signal. The following graph summarizes the adopted methodology.
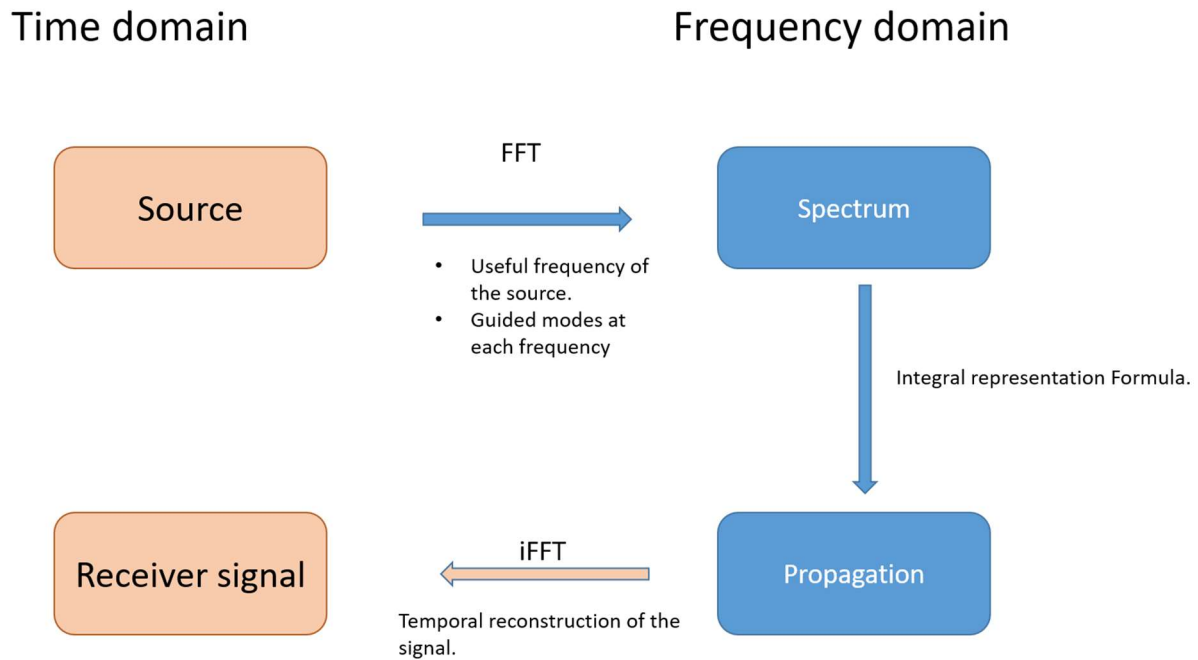
*Figure 3: methodology for guided waves modelling*

# 5. Conclusion

This deliverable presents a graphical user interface designed for academic use, allowing users to manipulate specific parameters and observe time wave signals in an elastic plate. The tool enables the selection of receiver positions to visualize mode separation, facilitating the identification of individual modal contributions. While more advanced simulation methods exist at the CEA for wave propagation in composite materials, limitations related to intellectual property precluded their use. Consequently, we developed this tool specifically for studying isotropic aluminum plates.

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# Reference

[1] Tjandrawidjaja, Yohanes. « Some contributions to the analysis of the Half-Space Matching Method for scattering problems and extension to 3D elastic plates ». These de doctorat, Université Paris-Saclay (ComUE), 2019. https://www.theses.fr/2019SACLY012.

[2] Barras, J., & Lhémery, A. (2022). Modal pencil method for the radiation of guided wave fields in composite plates of finite size. *NDT & E International*, *126*, 102598.
https://doi.org/10.1016/j.ndteint.2021.102598