Actran overview

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Information

- On computer at ULB (Linux), software is installed in /serveur/logiciels/actran/Actran_2021.1/

- To launch Actran VI:

> /serveur/logiciels/actran/Actran_2021.1/bin/actranvi

- You can download and install Actran student edition on your computer from:

https://www.mscsoftware.com/page/actran-student-edition

Actran general overview

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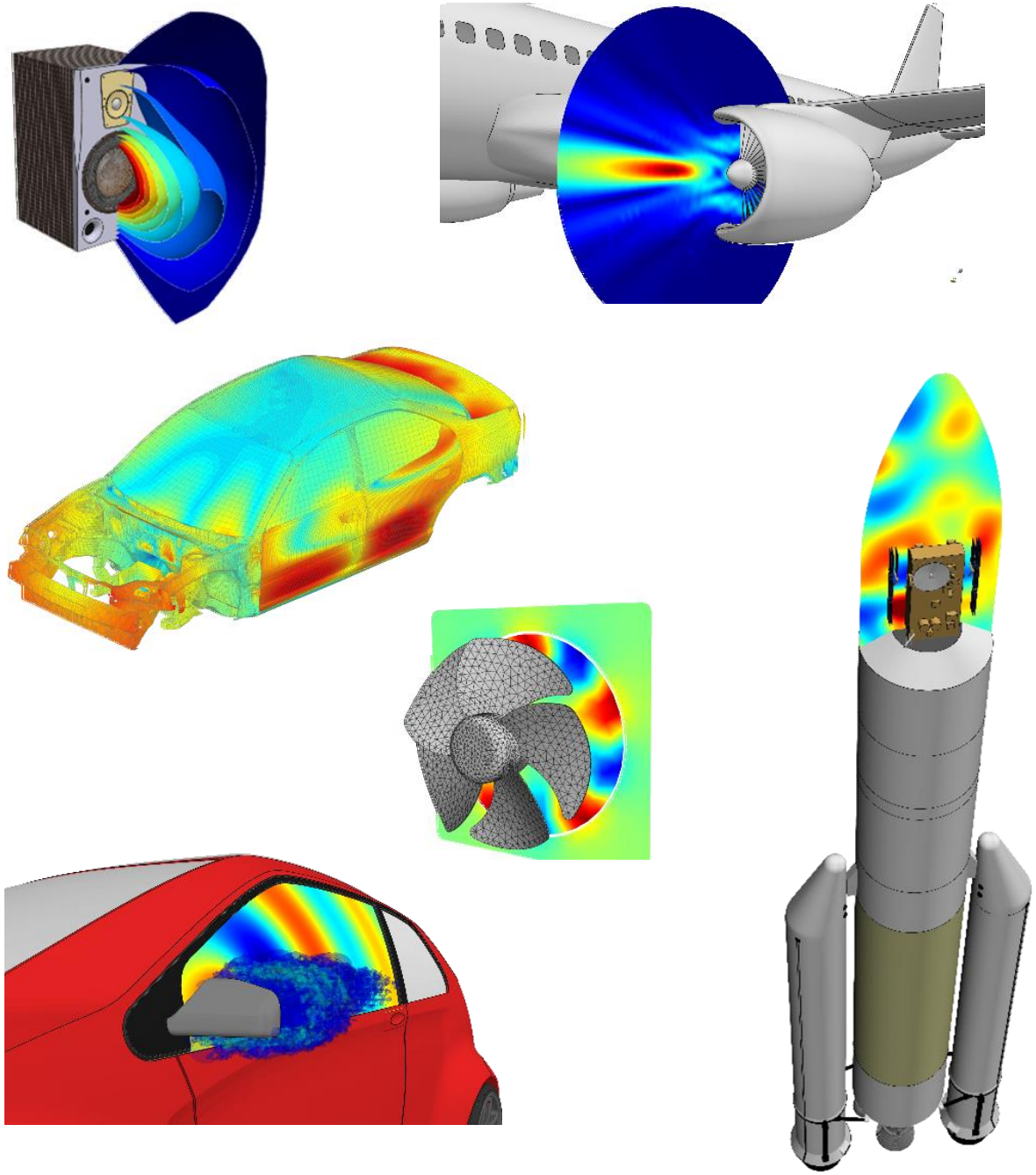
Introduction to Actran

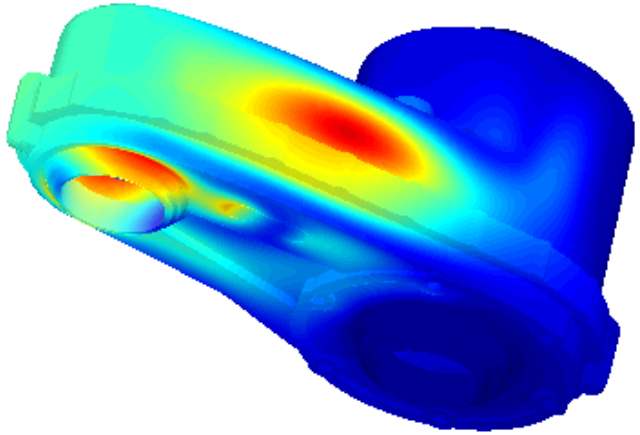
- Actran is an acoustic simulation software package:
  - Based on **Finite Element Method**
  - Able to solve **vibro-acoustic** and **aero-acoustic problems**
  - With efficient implementation and highly scalable solver

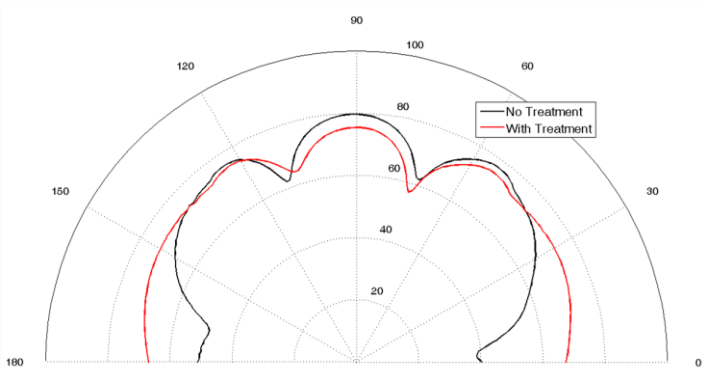
- Actran is:
  - Extensively used by engineers around the world for **various applications**
  - **Validated** against experiments
  - Supported by a team of **acoustic simulation experts**

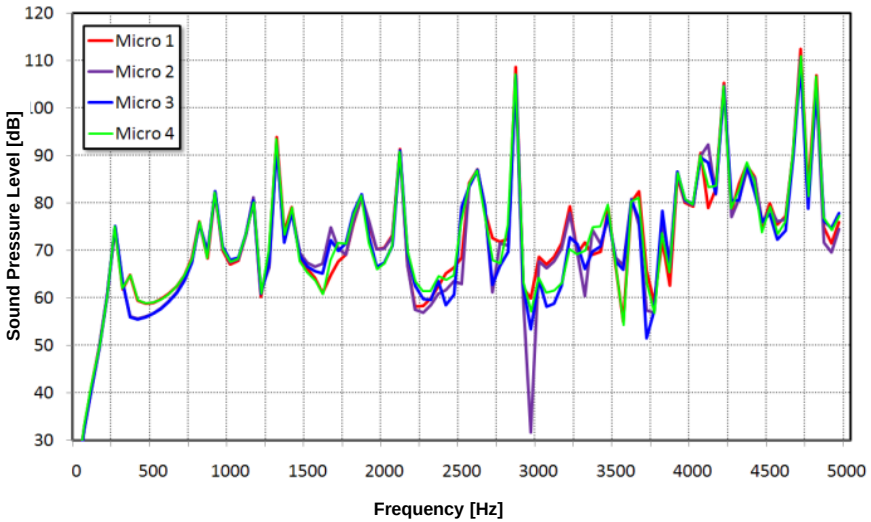


Typical engineering questions

- Noise prediction
  - Will there be a noticeable sound radiation?
  - What is the expected sound pressure level (SPL)?
  - What are the resonant frequencies (= acoustic modes)?
  - Will the sound change with operating conditions?
  - How about directivity?

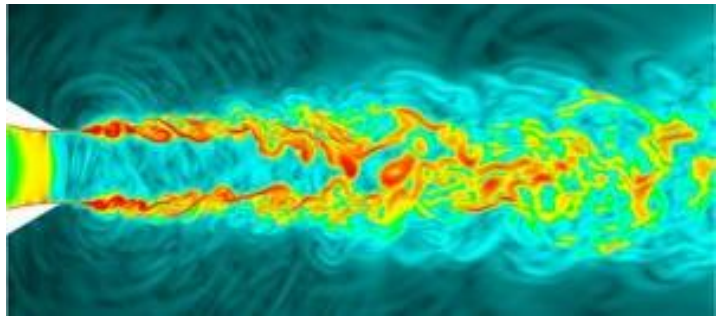






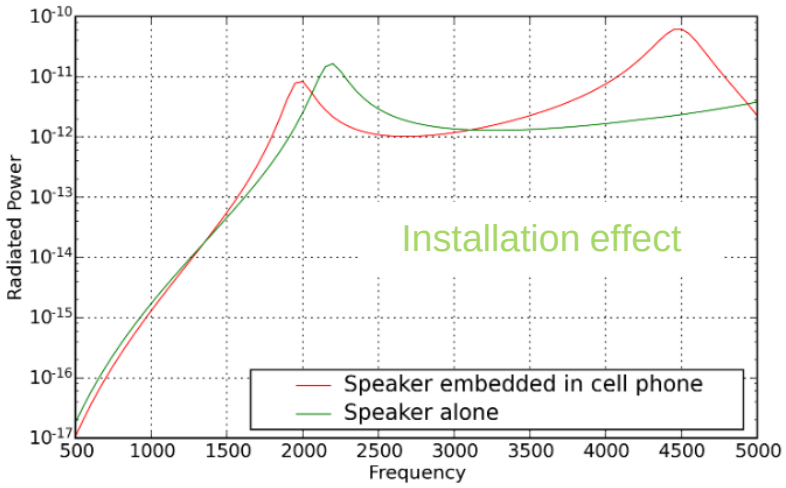
Typical engineering questions

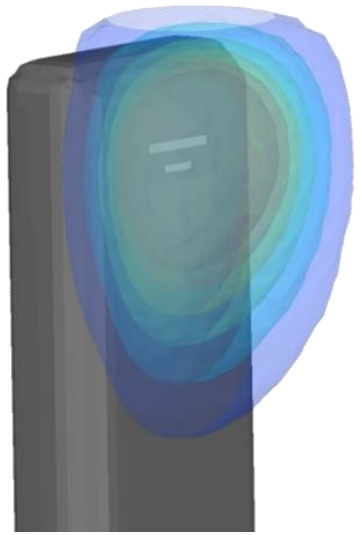
- Noise reduction - what can we do to reduce the noise?
  - Geometrical changes?
  - Decoupling of parts?
  - Decrease sources/excitation?
  - Absorbing materials?
    - Foams, trims, multi-layer composites
  - Change the flow conditions?

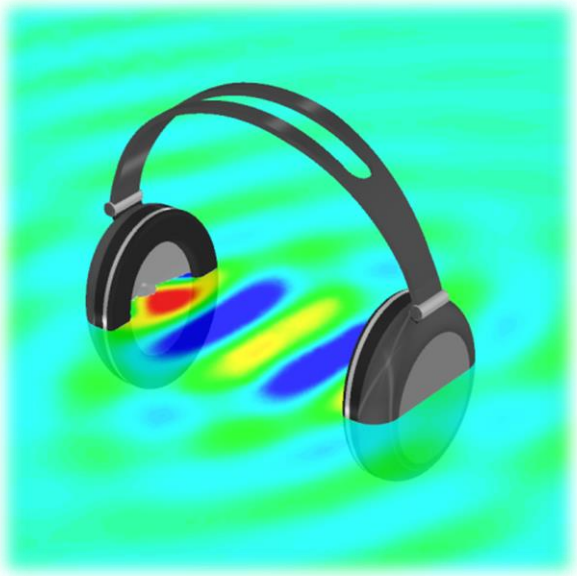


Typical engineering questions

- Sound is not always a problem!
  - Efficient radiation of HiFi components
  - Sound design of consumer products
  - Musical instruments
  - Sport cars







Ferrari exhaust line

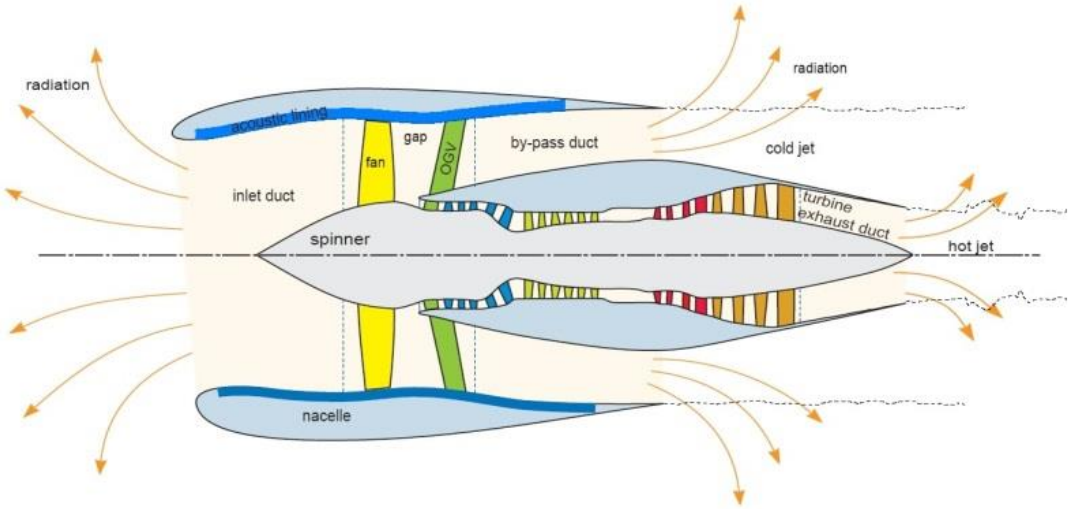
- Ferrari is using Actran to optimize the components of an exhaust line

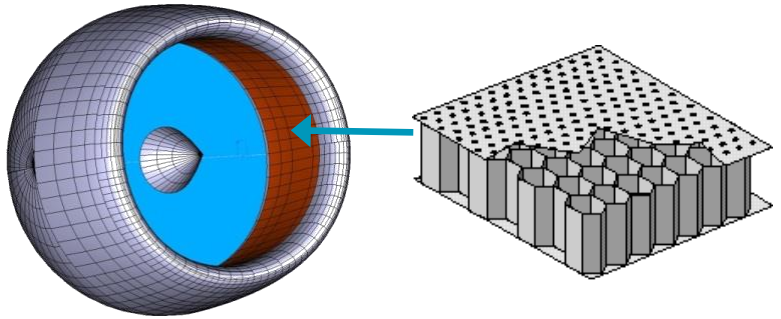
F12 Speciale

Aircraft nacelle acoustic treatments

- Compute the acoustic radiation from the turbo fan engine
- Design acoustic treatments
- Automated liner optimization program

Turbo fan engine in its nacelle

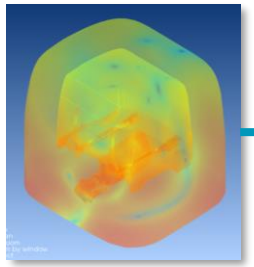




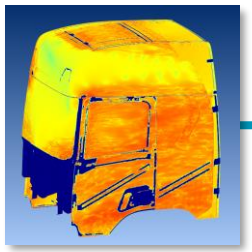
Auralisation of truck cabin noise

Reference (higher frequencies)

Airborne engine noise



Wind noise



Exhaust noise

Structure-borne noise

HP

Auralisation

Auralisation of truck cabin noise

Actran Organization

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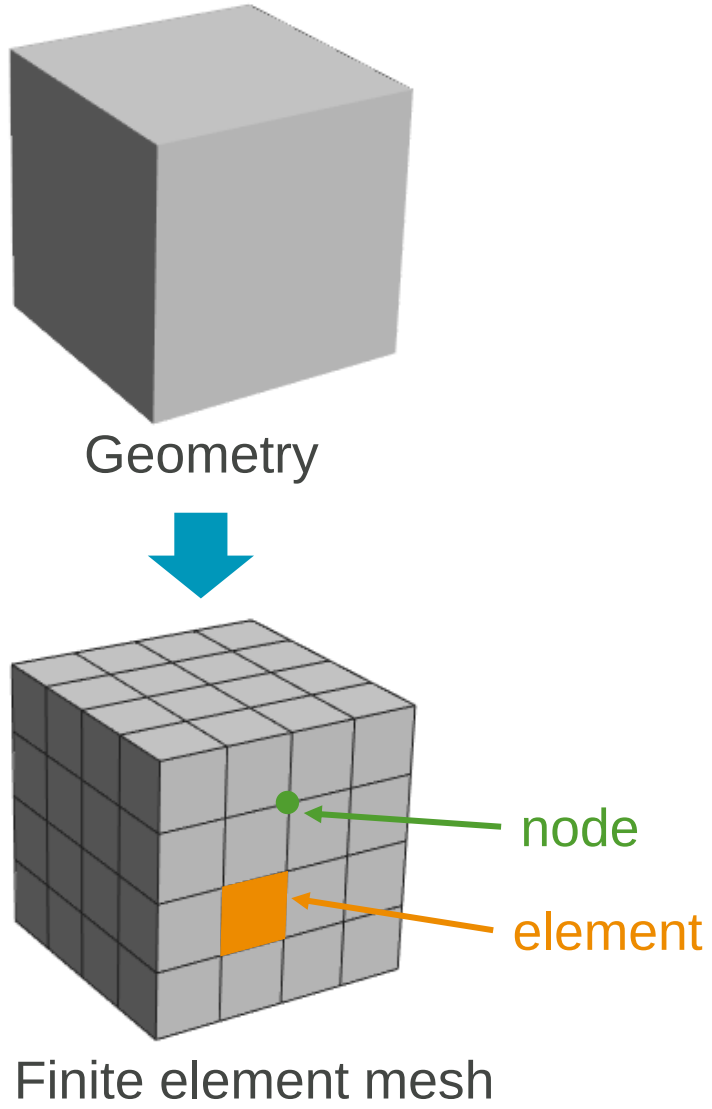
Actran is a solver

Finite element basics

- Actran is based on the finite element method
- Discretization of complex geometry in nodes and elements → finite element mesh
- Resolution of the system for all nodes according to the relationships between each node



Direct Frequency Response

- The vast majority of configurations are modelled using a **Direct Frequency Response** (DFR) analysis

- It computes:
  - the **response** of an **acoustic system**
  - to an **excitation** at the **specified frequencies**
  - for all finite element nodes

- The following equation system is solved by Actran:

$$(\mathbf{K} + i\omega\mathbf{C} - \omega^2\mathbf{M})\mathbf{x}(\omega) = \mathbf{F}(\omega)$$

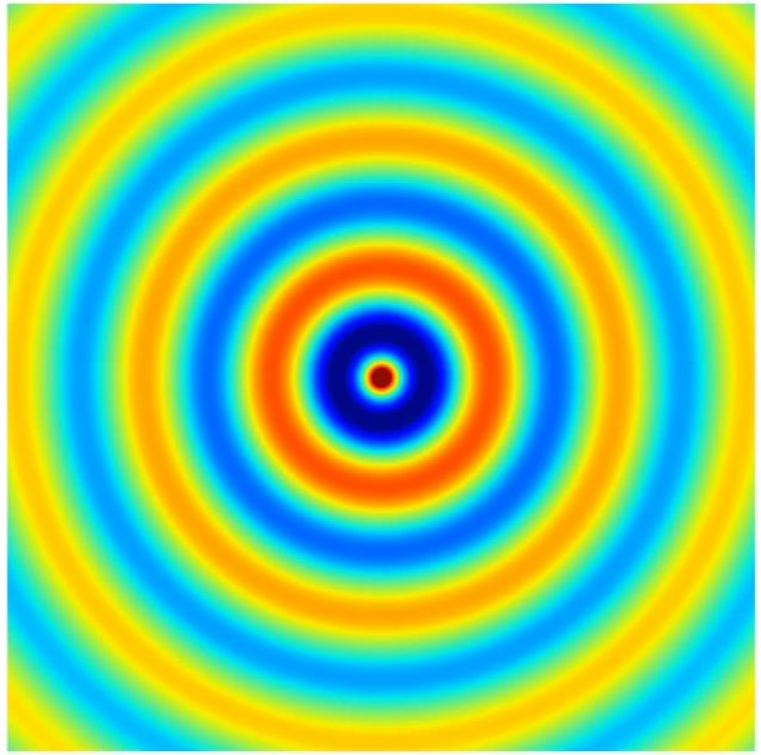
System Unknown Load

with
- Pulsation $\omega = 2\pi f$
- stiffness matrix **K**
- damping matrix **C**
- mass matrix **M**

Frequency response results (1/2)

- A Direct Frequency Response computes the response of an acoustic system **to an excitation at specified frequencies**
- The solution computed by a Direct Frequency Response at 1000Hz corresponds to the acoustic propagation of one or several excitations pulsating at 1000Hz
- Results are output in **frequency domain** (real and imaginary part)

- Example: frequency response of a monopole pulsating at 1000Hz (slow phase animation)

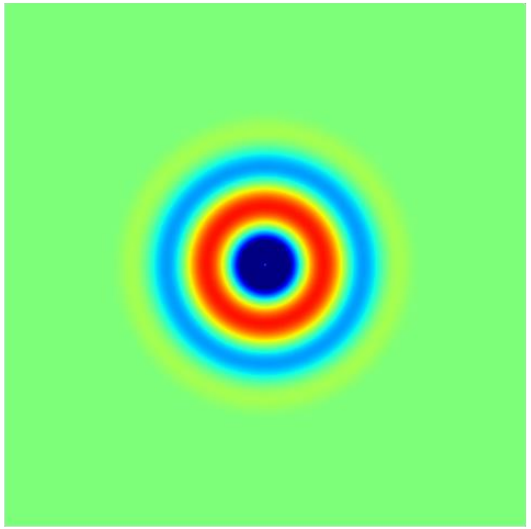


Frequency response results (2/2)

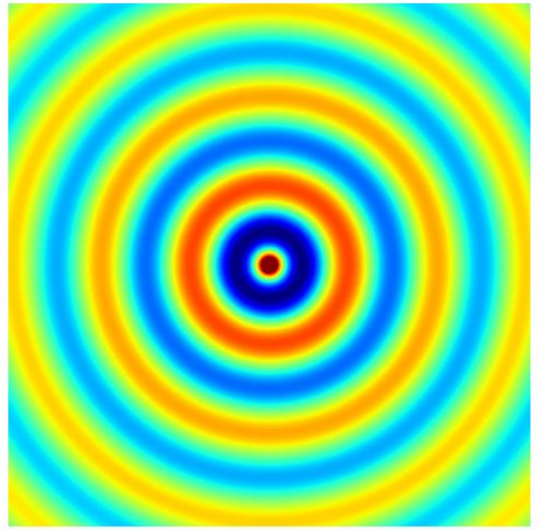
- Direct Frequency Response provides a **harmonic response** in frequency domain

- For a monopole pulsating at 1000Hz:
  - Equivalent to a source pulsating harmonically for an infinite amount of time
  - Effect of the monopole pulsation is fully propagated through space (no transition as for time domain simulation)

- **Time domain** simulation of a monopole pulsating at 1000Hz:



Pressure at t=1.8e-3s
(1.8 pulsations)



Pressure at t=0.02s
(20 pulsations)

Solution on the computation domain is equivalent to DFR results with phase=0

Actran Graphical User Interface

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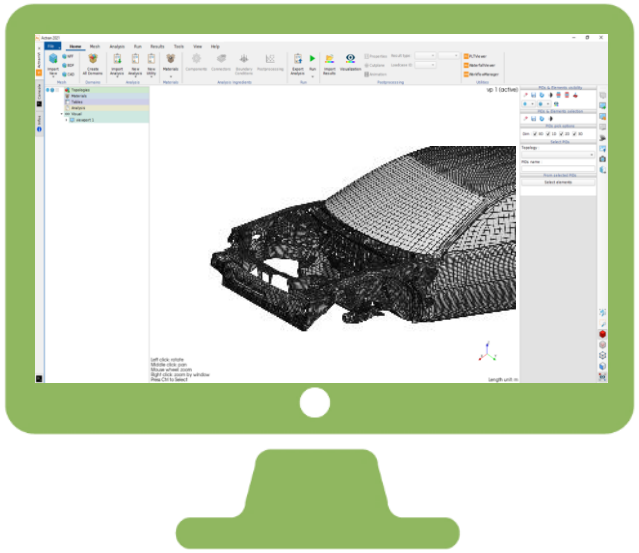
Actran is supported by a Graphical User Interface (GUI)

Model Set-up | Computation



ActranVI

Input
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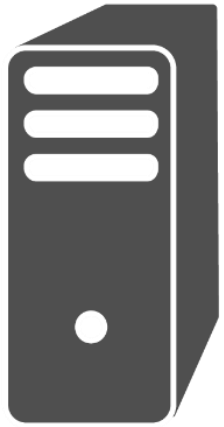
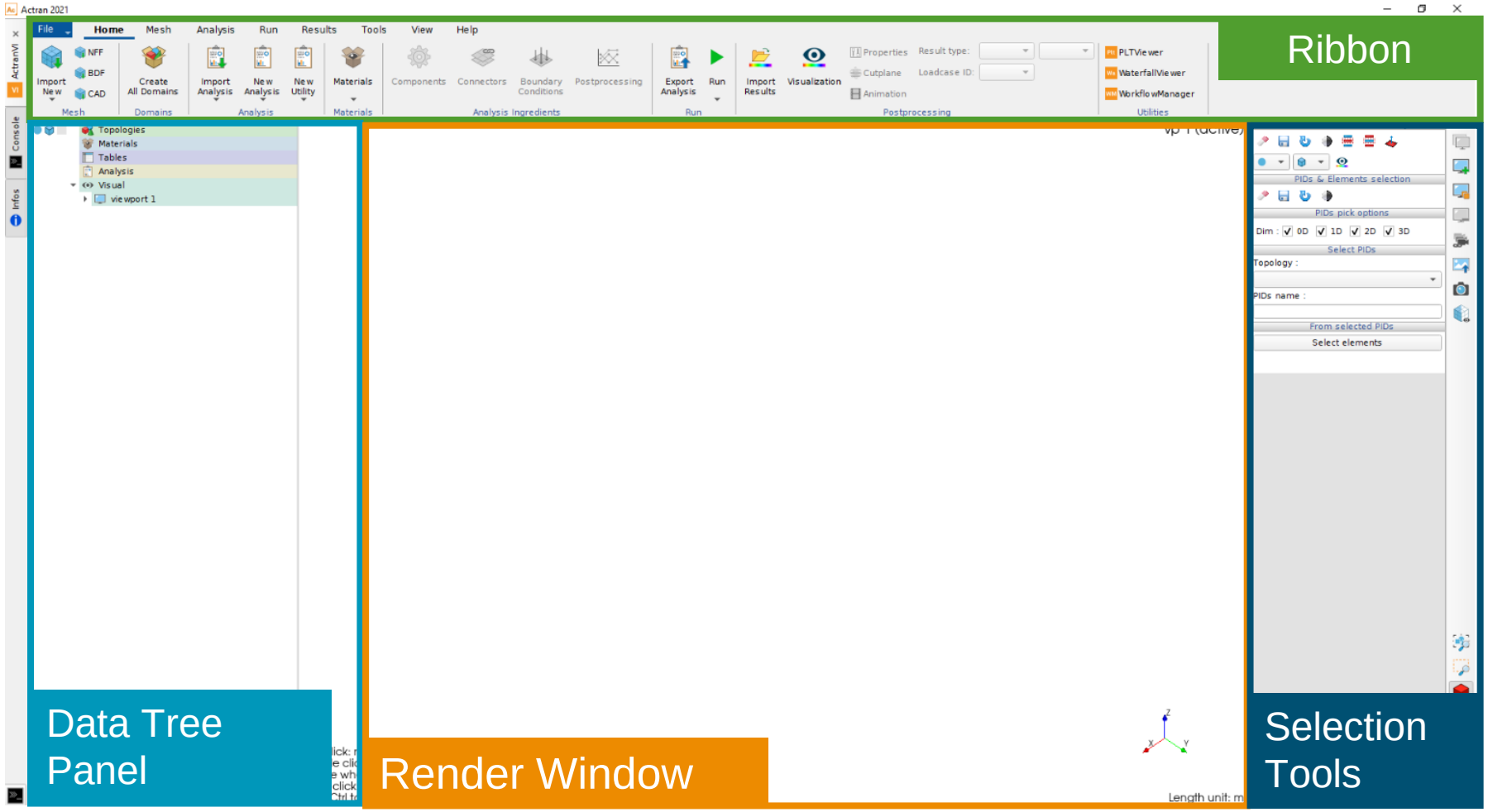


Ac Actran

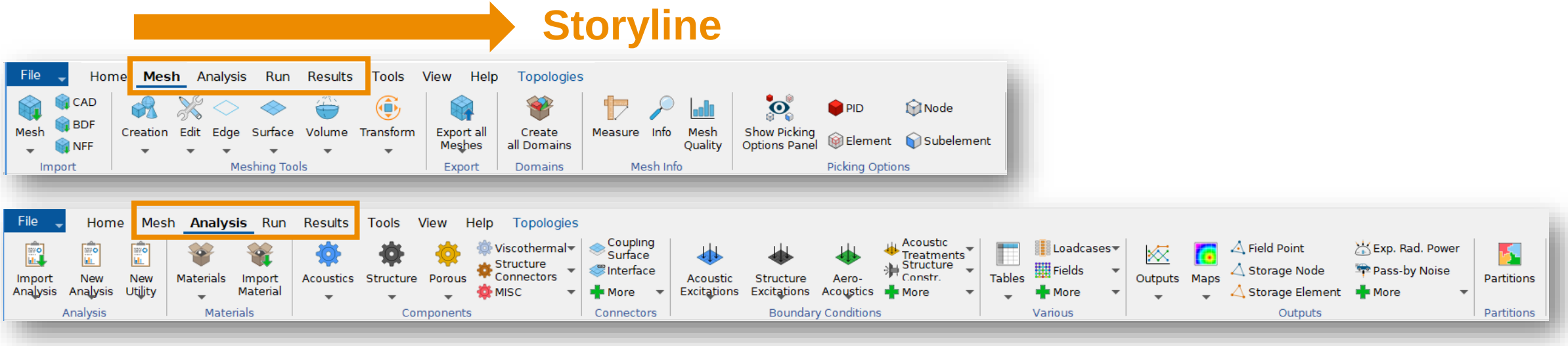
Solver

ActranVI overview



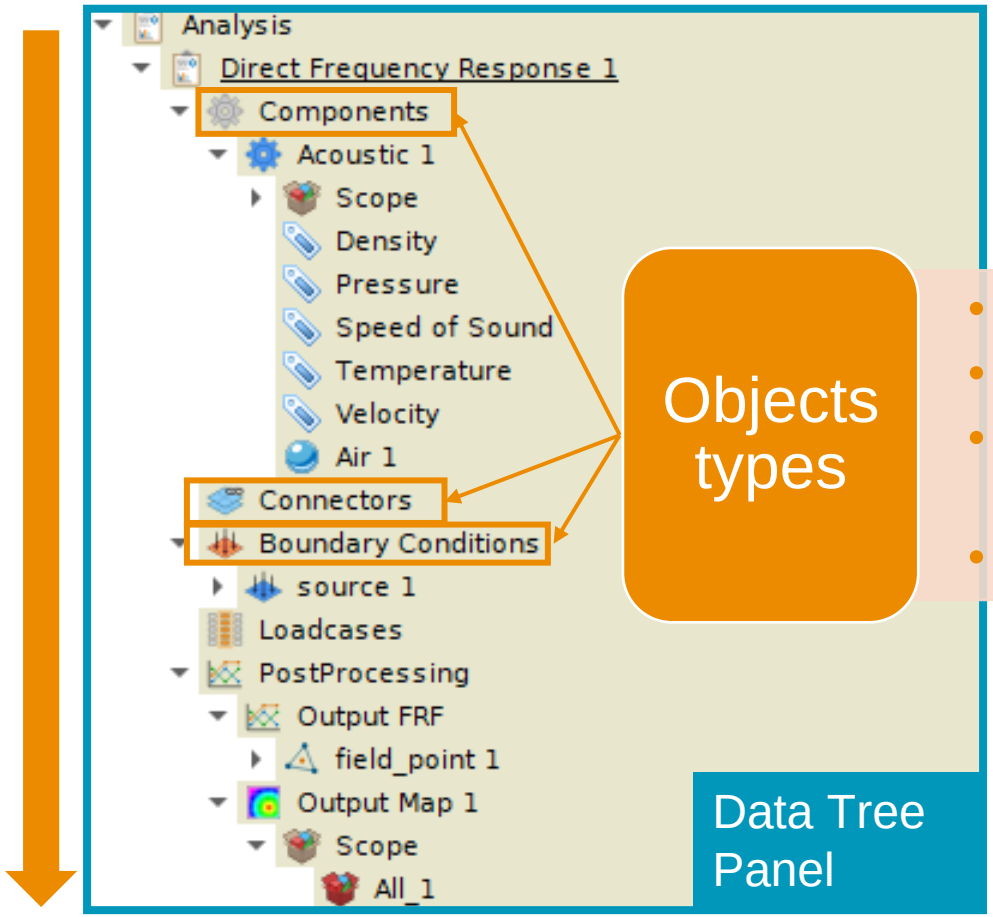
Ribbon

- **Complete** and **organized** layout
- **Guided analysis set-up** and **post-processing** operations using **ribbon storytelling**

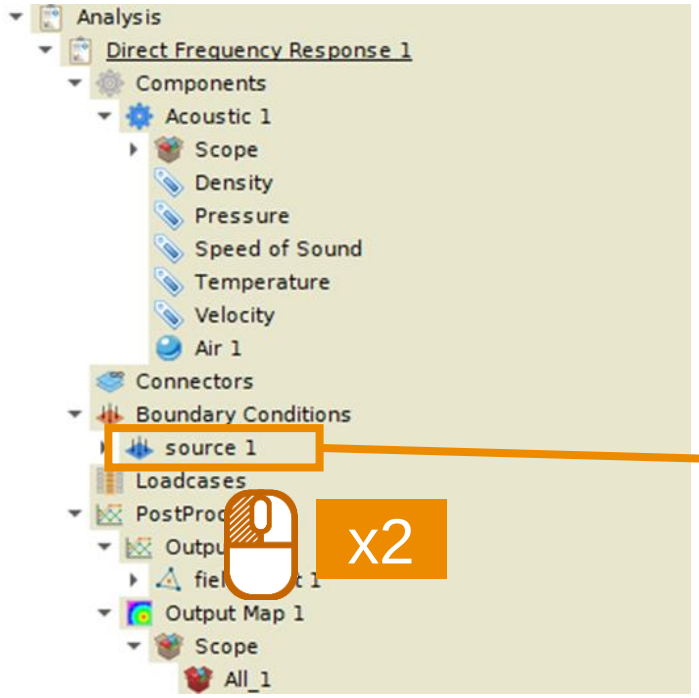


Actran analysis: data tree panel nodes

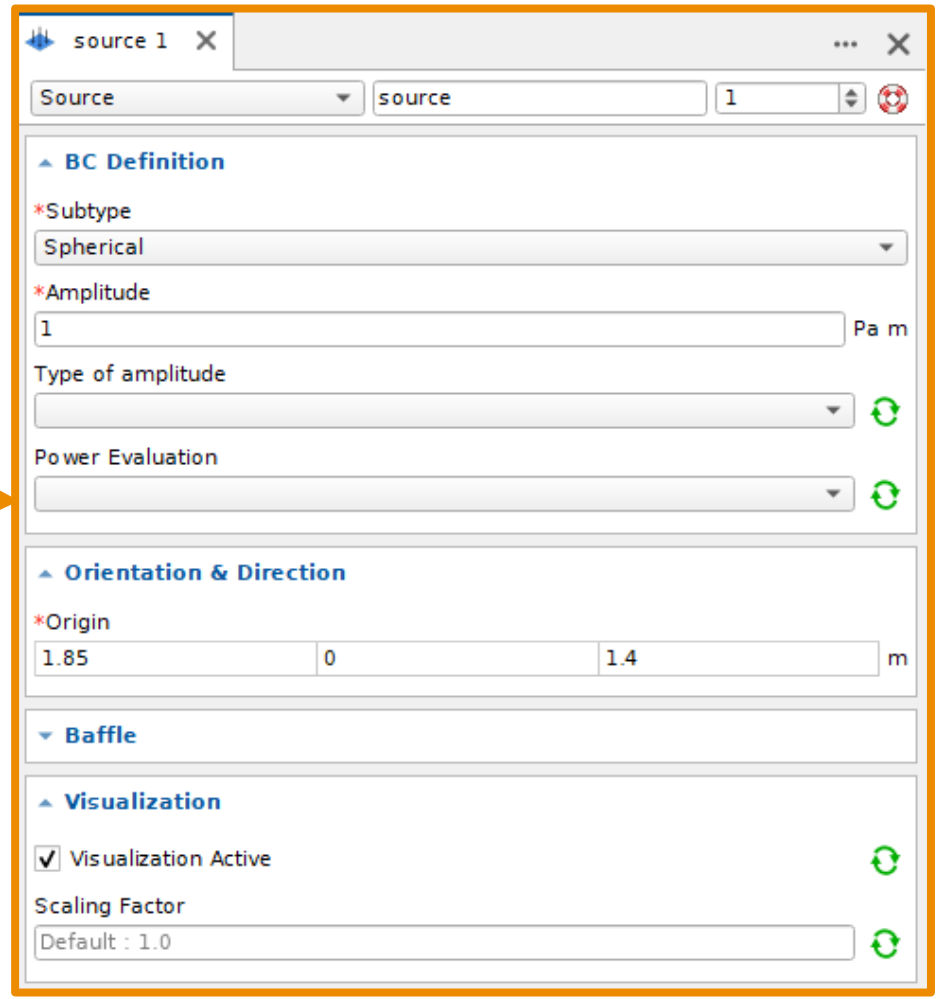
Direct Frequency Response Analysis parameters and objects



Actran analysis: edit objects properties



Double-click on a tree node to open the object properties window



ActranVI properties window

- Only parameters with * are mandatory
- Assigning a domain is always mandatory
- You can close or open any properties window anytime: input parameters will be taken into account

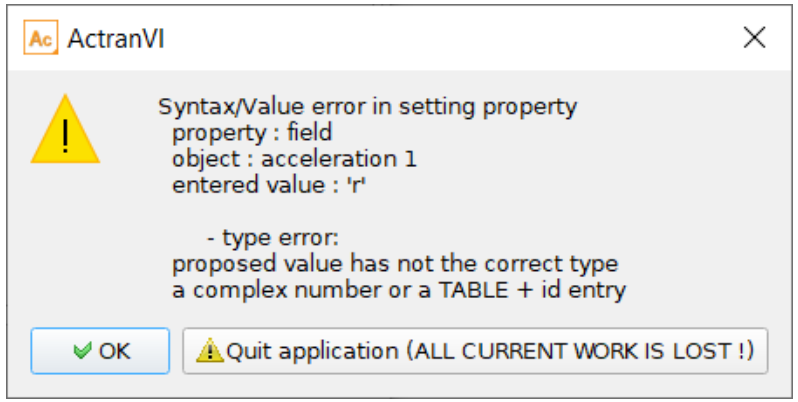
Errors in ActranVI

- You may come across error messages when pre-processing, running or post-processing a model

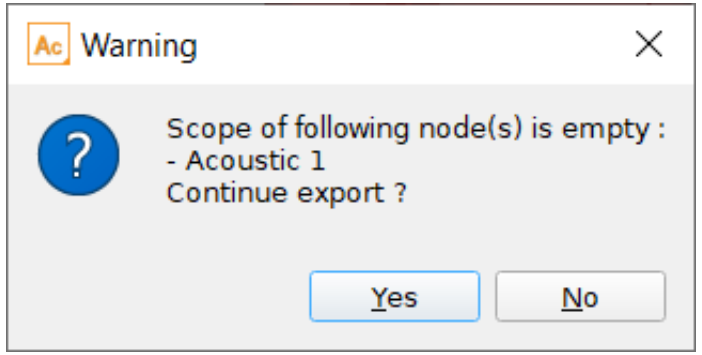
- **Read carefully** the error message and try to analyze what happens:
  - Is it a Warning or a Fatal message?
  - Can I find where the error is and correct it?

Examples

- Analysis pre-processing:



- Analysis export :



Actran concepts and inputs

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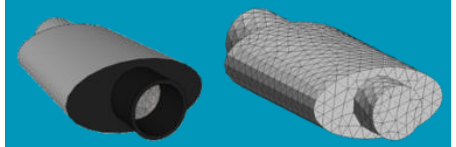
Actran concepts

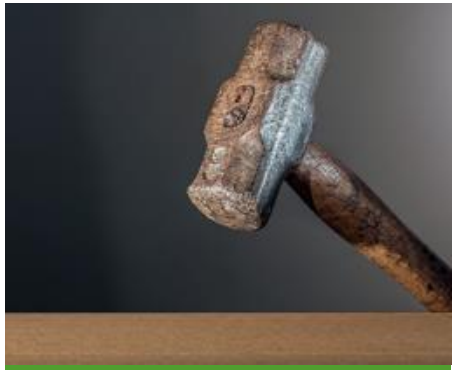
What information do we need to model a system ?



Meshed Geometry

Picture courtesy of Rieter Automotive

Materials



Excitations

$$\Delta p - \frac{1}{c^2}\frac{\partial^2 p}{\partial t^2} = 0$$

$$\underline{\underline{\sigma}} = \underline{\underline{c}}^{E}\underline{\underline{\epsilon}} - \underline{\underline{e}}\vec{E}$$

$$\vec{D} = \underline{\underline{e}}\underline{\underline{\epsilon}} + \underline{\underline{\varepsilon}}^{S}\vec{E}$$

…

Physical & Numerical Models

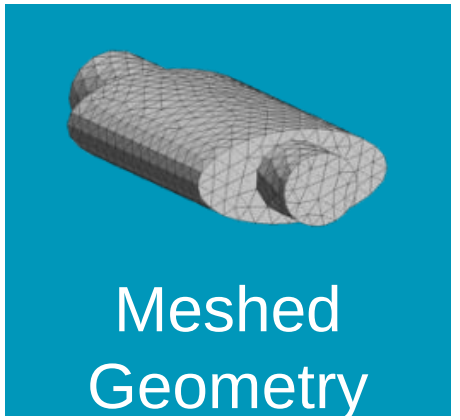
Outputs

$$Zx = B$$

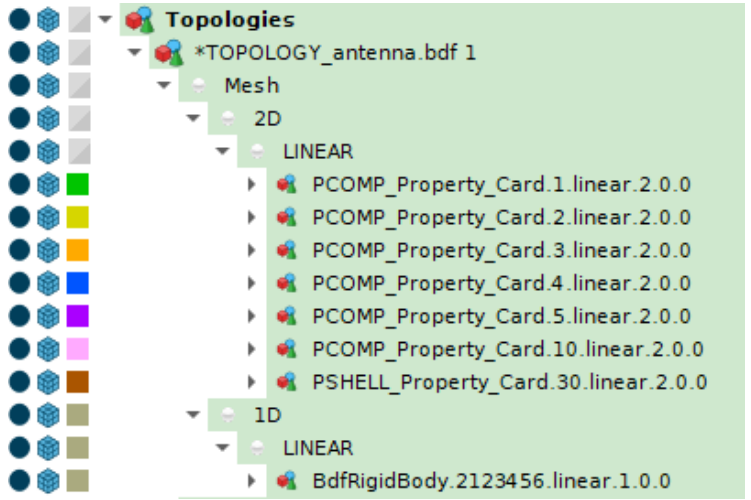
Solvers

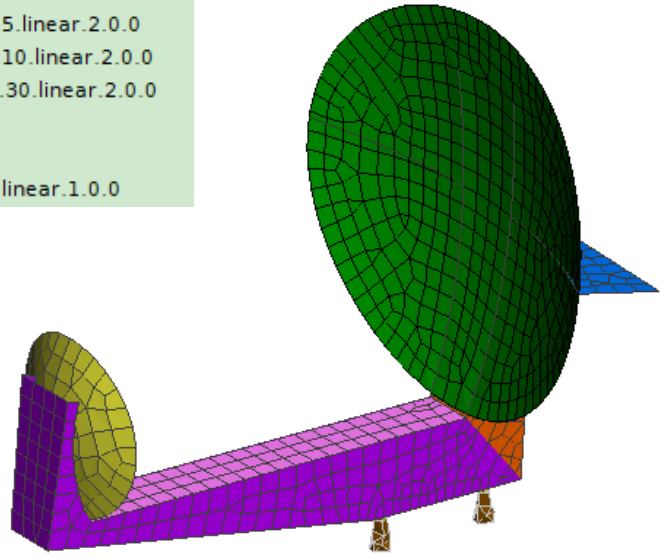
Actran concepts reflect such categories

Element set (also called PID)



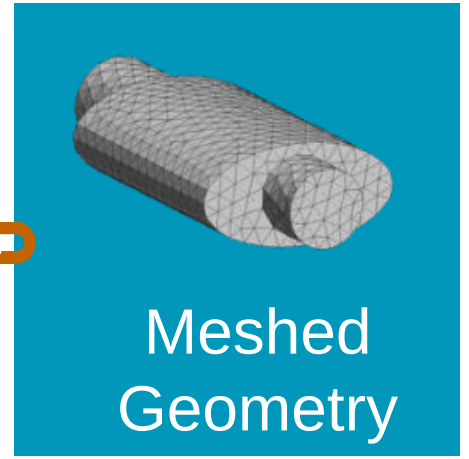
- An ***element set*** (or PID) is a group of finite elements:
  - Having the same dimension
  - Identified by a unique identification number
- A *topology* is separated in different *element sets* to be able to define the different parts of the model
- The *element set's* content depends on:
  - Either the structure of the mesh imported in ActranVI
  - Or the way the mesh was created in ActranVI

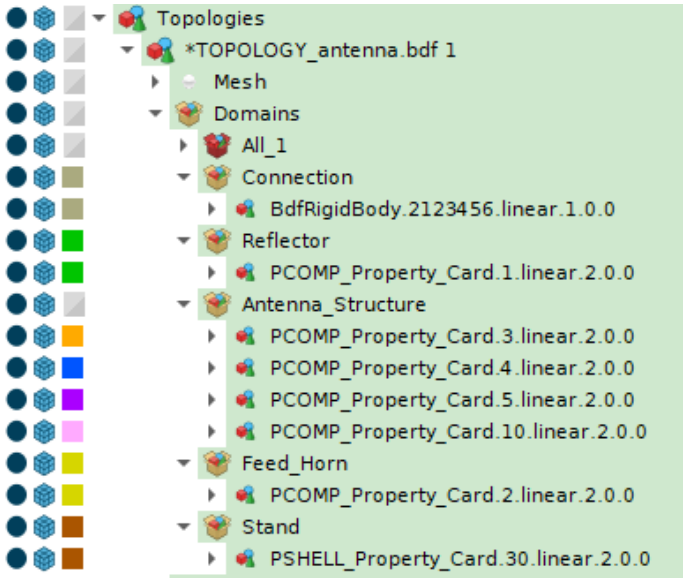


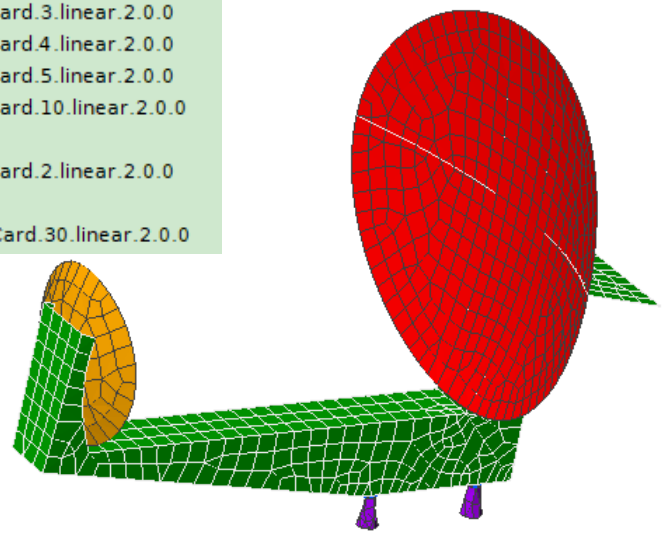


Domains

- A ***domain*** is a collection of *element sets*
  - Described by a domain name
- ***Domains*** are the **link** between the mesh and the Actran analysis
  - Used to group and organize *element sets* for complex meshes
  - For simple meshes, there can be one single element set per domain



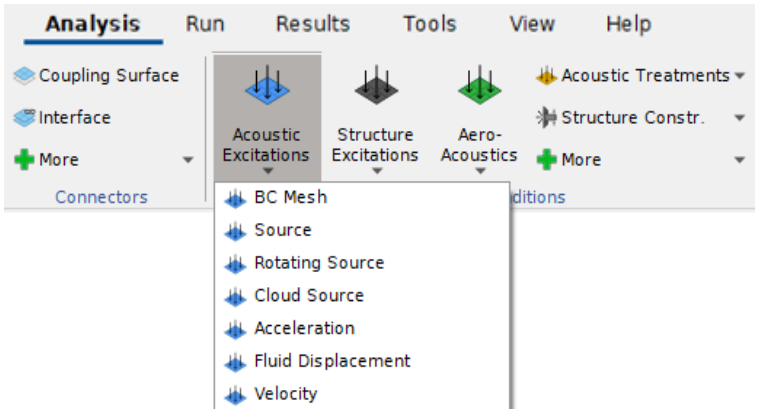


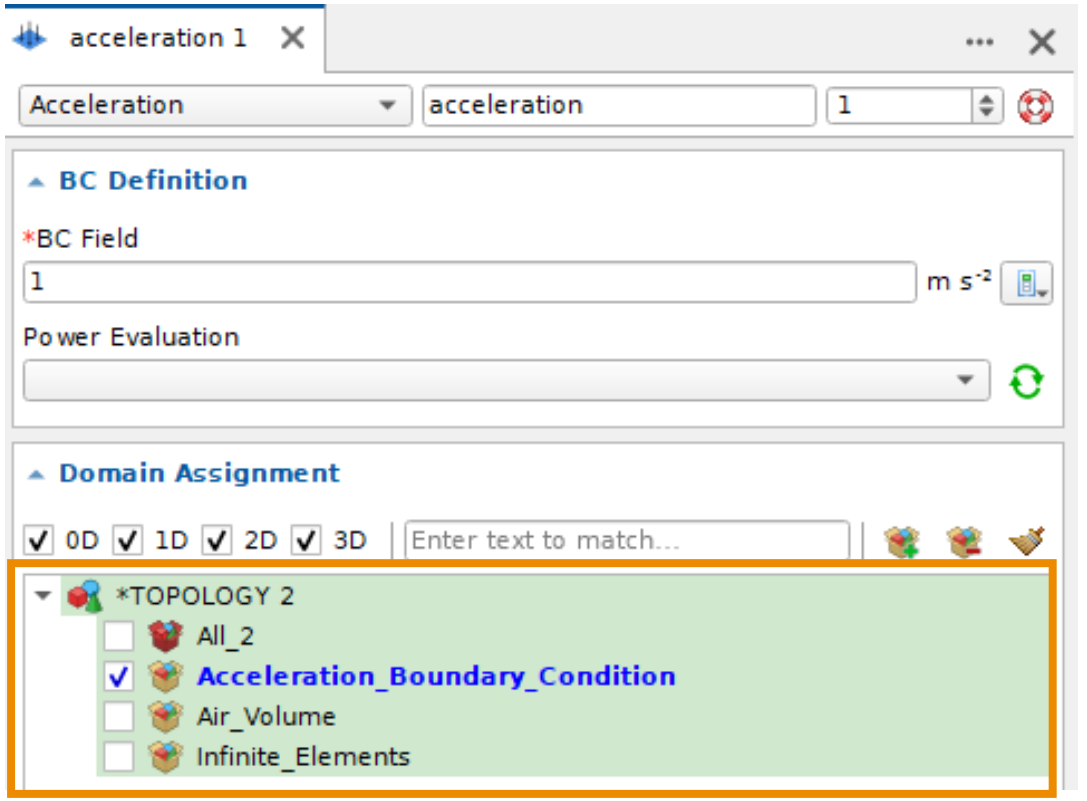


Boundary conditions

- A boundary condition characterizes a known restriction or an excitation on the finite elements

- Boundary conditions are linked to domains

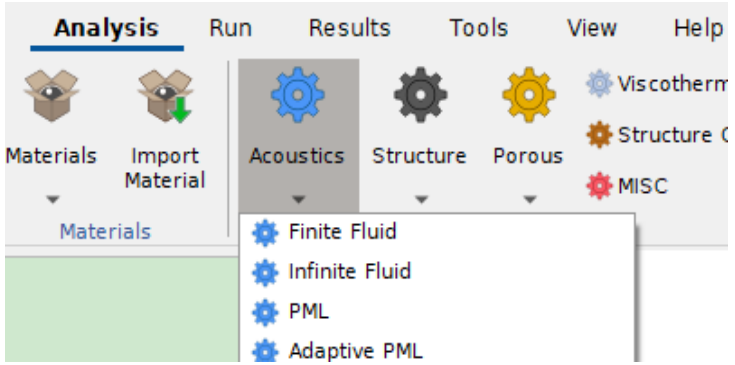




Components

- A ***component*** characterizes the numerical properties and the physical interpretation of a domain of finite elements
  - For instance: different components available for porous modelling, corresponding to different mathematical formulations

- ***Components*** are linked to a *material* and one or several *domains*

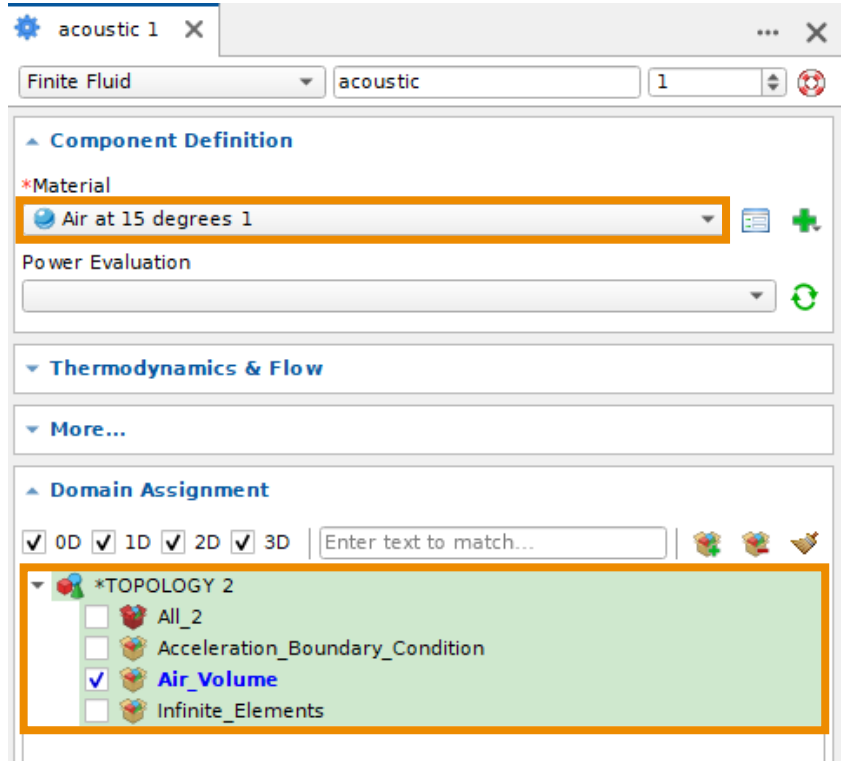


$$\Delta p - \frac{1}{c^2}\frac{\partial^2 p}{\partial t^2} = 0$$

$$\underline{\underline{\sigma}} = \underline{\underline{c}}^{E}\underline{\underline{\epsilon}} - \underline{\underline{e}}\vec{E}$$

$$\vec{D} = \underline{\underline{e}}\underline{\underline{\epsilon}} + \underline{\underline{\varepsilon}}^{S}\vec{E} \quad \dots$$

Physical & Numerical Models

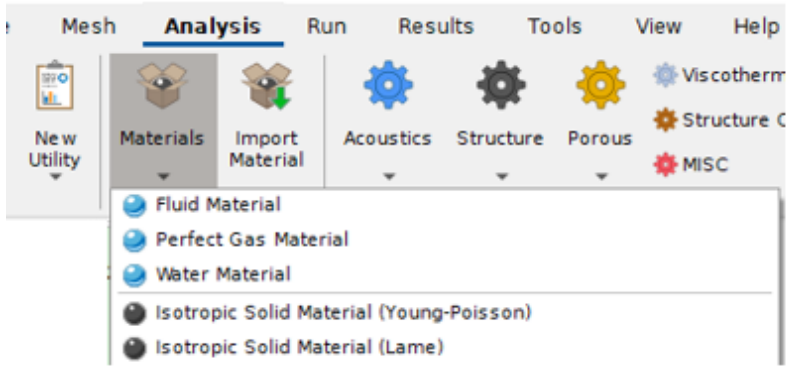


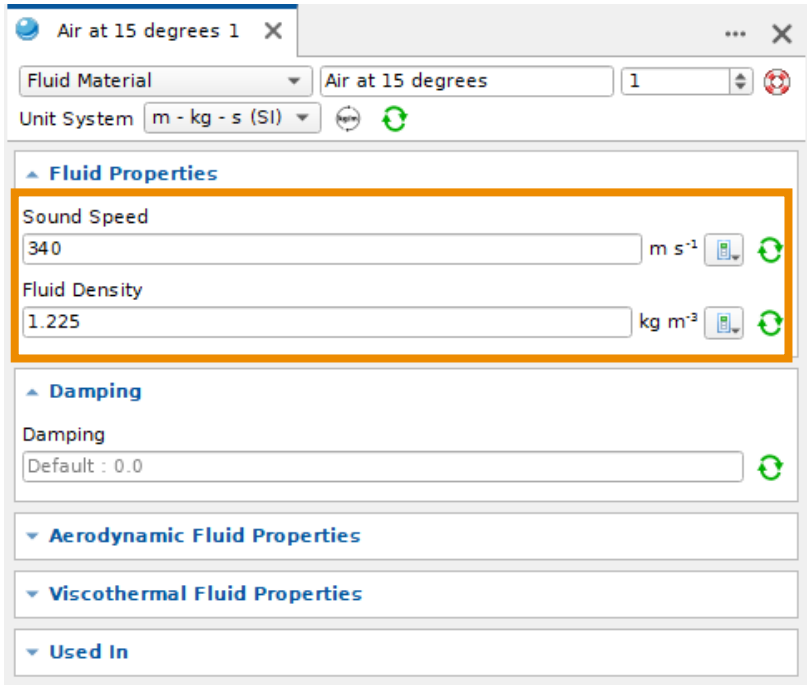
Materials

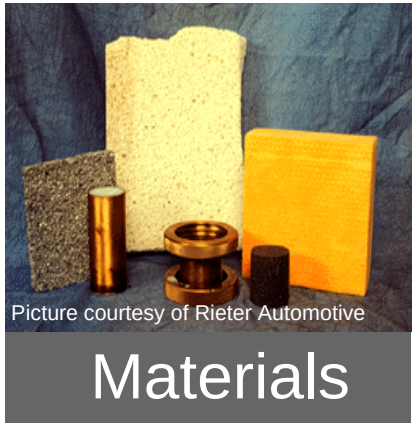
- A ***material*** describes the physical properties of a component

- A *material* has a **type** and a **list of properties**
  - Example of type:
    - Fluid
    - Isotropic Solid
  - Example of properties for a Fluid:
    - Speed of Sound
    - Density

NOTE ***One*** *material can be used in* ***several*** *components*







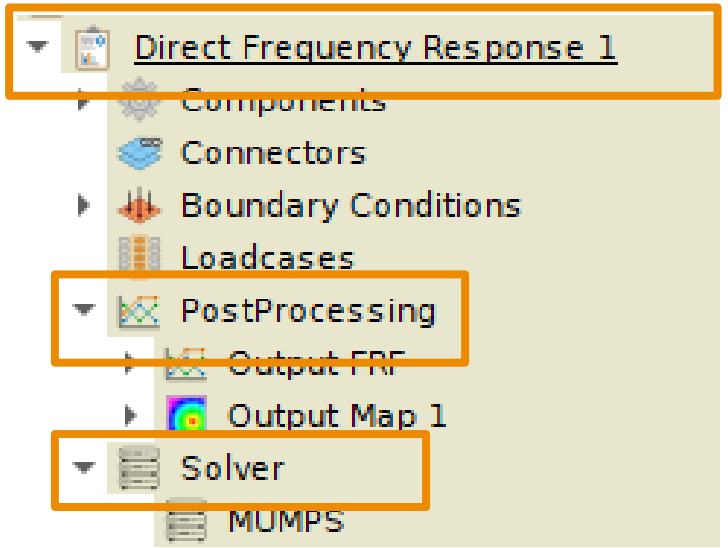
Analysis parameters

- An ***analysis parameter*** is any other parameter influencing the computation of the model
  - Frequencies to be solved
  - Post-processing indicators
  - Solver technology used

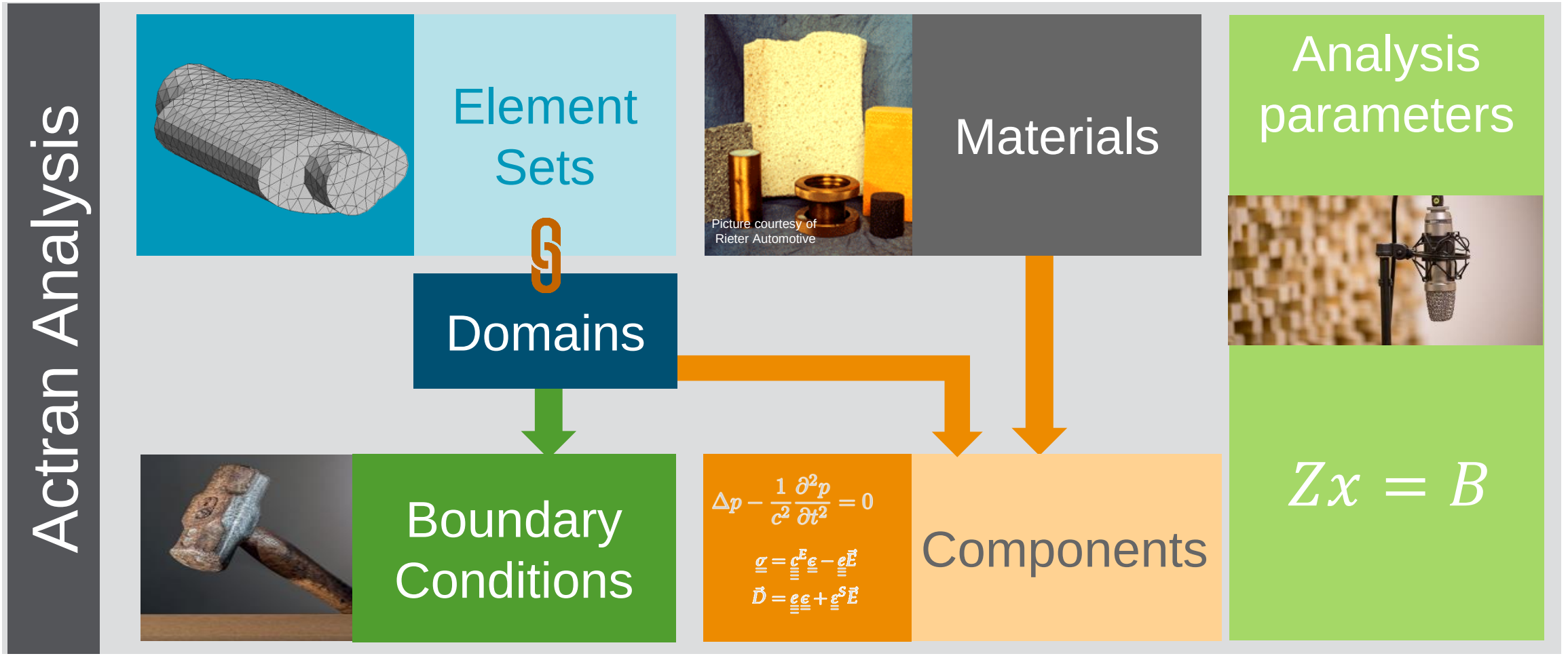
Outputs

$$Zx = B$$

Solvers



Actran concepts overview



Actran launch and outputs

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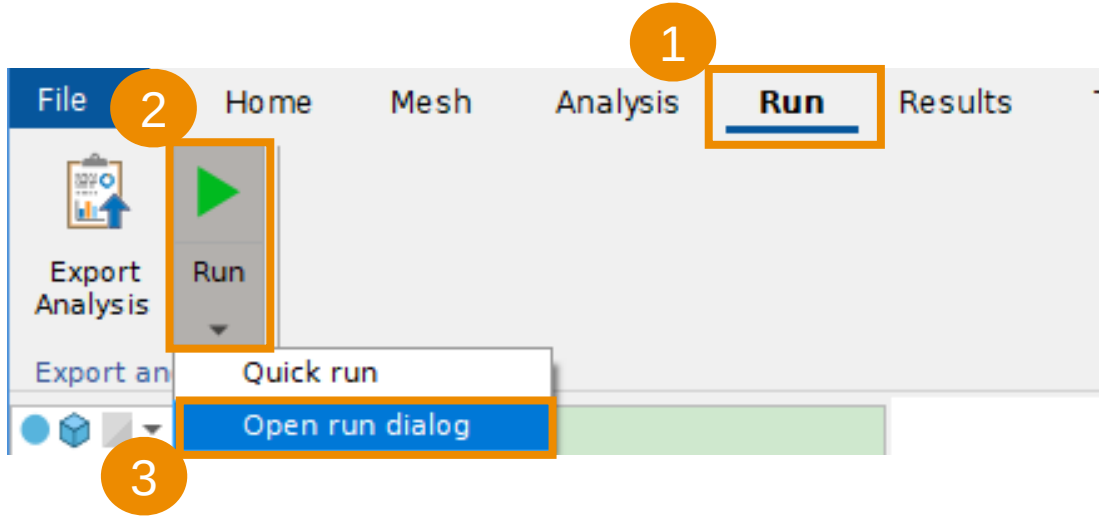
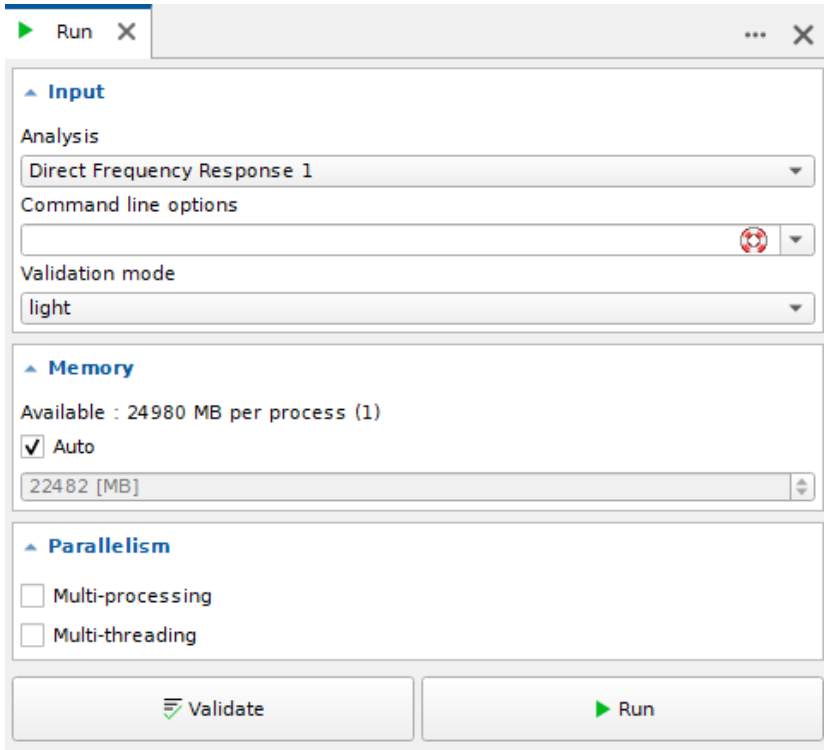
Launch the Actran analysis in ActranVI

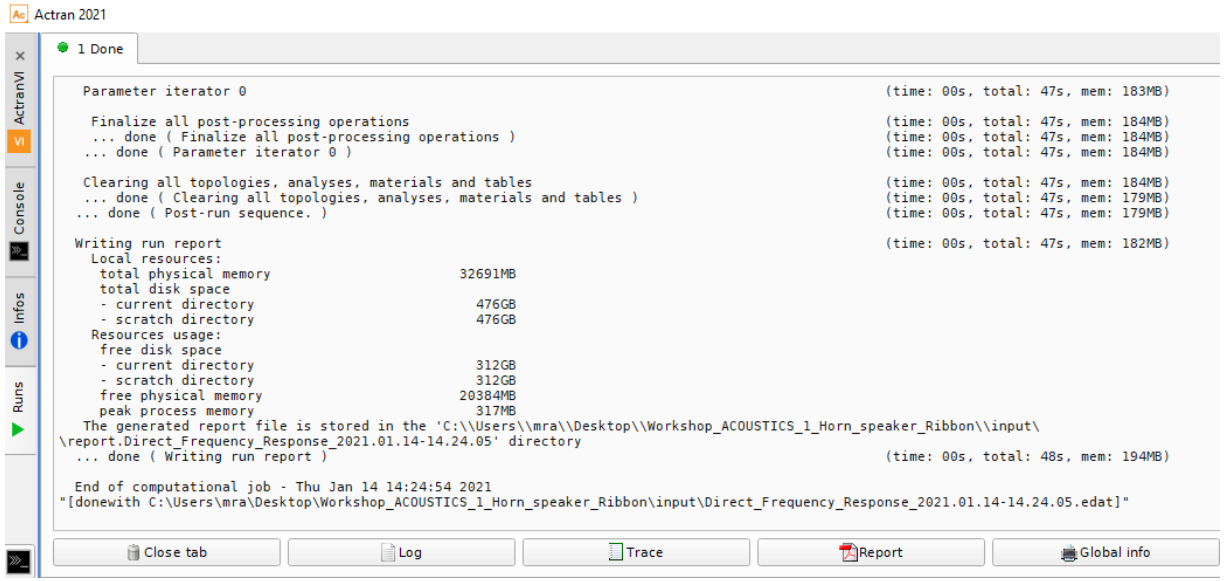




Information on computation process

- A window pops-up with information related to the different steps of the analysis:
  - The **command line** read by Actran
  - **Real-time information** about different steps involved in the computation
  - **Resource consumptions**
  - The warning or error messages (if any)

- This information can also be retrieved in the *.log file (in the report directory)



Actran output : FRF and Maps

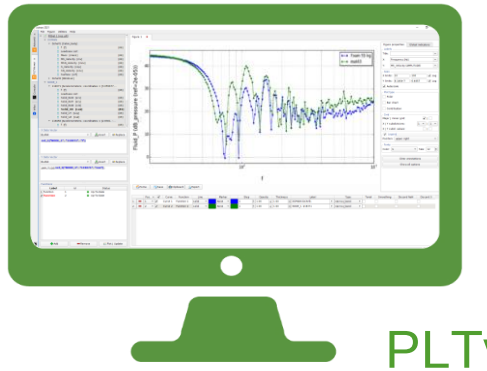
Computation | Post-processing

Ac Actran Solver

Frequency Response Function (FRF):
results at all the frequencies for a given node

*.plt

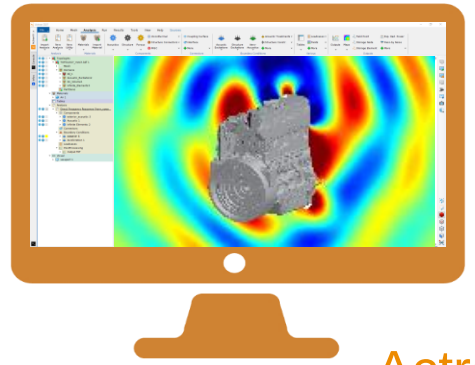
	100Hz	200Hz	300Hz		1000Hz
Node 1	974.74	794.66	523.86	…	507.21
Node 2	770.92	247.10	654.31	…	628.57
Node 3	473.51	875.77	300.71	…	22.66
…	…	…	…	…	…
…	…	…	…	…	…
Node 5877	946.14	147.55	787.7	…	49.2
Node 5878	174.06	498.23	23.63	…	98.28



PLTviewer

Maps: results at all the nodes for a given frequency

*.nff



ActranVI

Going further…

- Demo

Information

- On computer at ULB (Linux), software is installed in /serveur/logiciels/actran/Actran_2021.1/

- To launch Actran VI:

> /serveur/logiciels/actran/Actran_2021.1/bin/actranvi

- You can download and install Actran student edition on your computer from:

https://www.mscsoftware.com/page/actran-student-edition