



CIVA
N·D·E 2023

NDT Software for Simulation and Analysis



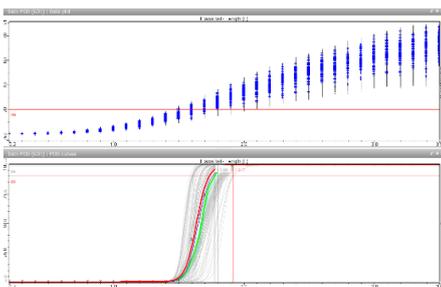
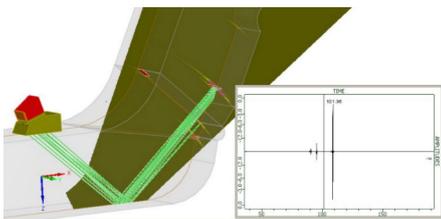
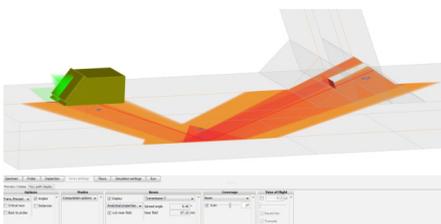
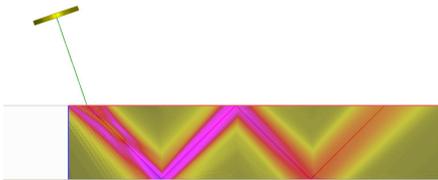
CIVA is the expertise platform which includes modeling, imaging and analysis tools, assisting in the design and optimization of inspection and monitoring methods and the prediction of their performances for realistic configurations.

CIVA simulates Ultrasonic Testing (UT), Guided Waves Testing (GWT), SHM by Guided Waves, Eddy Current Testing (ET), Thermographic Testing (TT) Radiographic Testing (RT) and Computed Tomography (CT).

EXT·N·D·E

CIVA UT

Available in English, French, German, Spanish, Russian, and Chinese



- CIVA UT at a glance:
- Beam simulation
 - Zone coverage with Ray Tracing
 - S-scan inspection simulation
 - POD curve in CIVA

Many capabilities to simulate realistic NDE situations:

CIVA Ultrasound gives you the ability to simulate the whole inspection process (**pulse echo, tandem or TOFD**) with a wide range of probes (**conventional, Phased-Arrays or EMAT**), components (from simple shapes to complex 3D CAD geometries), and defects (calibration holes, planar defects, crack-like defects, volume flaws, even inclusions). The component can be homogeneous or made of several parts or several layers (e.g. cladding). Materials available are not only **metallic** ones but can also be, for instance, **fiber composites** or granular composites (e.g. concrete).

Innovate with Phased-Arrays probes:

CIVA includes sufficient features to design PA probes and simulate **classical and advanced PA settings** (focusing, sectorial scanning, linear scanning, TFM, SAUL, advanced electronic scanning). CIVA includes a **delay law calculator** from which you can export the computed data (focal laws and index points).

Shift up a gear with CIVA:

Thanks to its dedicated environment and a lot of “ready to define” configurations, to create a configuration in CIVA is a matter of minutes, if not seconds! Mostly based on semi-analytical models, CIVA simulations are also intrinsically **fast**, which opens the door to intensive **parametric and sensitivity studies**.

Finite Elements models now integrate CIVA to manage the most complex configurations.

UT simulation tools include:

- **“Beam computation”**: Ultrasound Beam propagation simulation (flaw-free configurations)
- **“Inspection Simulation”**: Predicts echoes from beam interaction with defects or specimen boundaries
- **“Sensitivity coverage”**: To compute sensitivity maps for a given scan plan

The calculations can account for **multiple skips** in the component and **mode conversions** with Longitudinal and Shear waves. An advanced **ray tracer** is connected to the CIVA simulation modules. It displays the different wave modes propagated and reflected, and can help **evaluate at a glance the covered area** with the defined settings for a given scan plan. Results are provided as classical UT data (**A-Scan, Echodynamic curves**) or **more advanced images (B-Scan, C-Scan, S-Scan, E-Scan, etc.)** that can be **reconstructed in the 3D view** and superimposed on the work piece, facilitating an optimal understanding of physical phenomena. All analysis features available to process acquisition data (described on the next pages) are also available for simulation results. CIVA UT also includes **metamodels** and statistical plots providing very powerful tools to perform extensive sensitivity analysis studies on the influential parameters. CIVA can also compute **POD curves** (Probability Of Detection).

Discover more about the UT module at:
<http://www.extende.com/ultrasonic-testing-with-civa>

CIVA 2023 | UT MODULE Features list

Basic features

- Parametric geometries (planar, cylindrical, spherical, conical), 2D CAD editor
- Isotropic materials (with database), attenuation laws
- Industrial probes library
- Conventional UT probe descriptors (immersion, contact, straight beam, angle beam) with several crystal shapes (rectangular, cylindrical, elliptical), focused probes, with pressure or shear polarization
- Dual-Elements probe, 1D Array probes (linear and annular arrays)
- Planar defects, calibration holes (FBH, SDH, etc.), spherical porosities and inclusions
- TOFD, Tandem
- 1D and 2D (raster) scanning
- Ray tracing, beam computation, zone coverage sensitivity maps and inspection simulation
- DAC, TCG
- Bulk wave computations (Longitudinal and Shear Waves)
- 2D and 3D computation

Advanced features

- Heterogeneous and multi layered structures
- Weld (butt, bimetallic, Tee) and nozzle geometries with templates
- 3D CAD import
- Anisotropy, structural noise, polycrystalline model, composite model
- 2D advanced PA probes (Matrix, Dual Matrix Array, Sectorial, Flexible, Daisy probes... And even custom probes!)
- EMAT probes (single and Multi-Elements)
- Advanced Delay law calculator (beam focusing, beam steering, sectorial scanning, multi shots, dynamic delay laws)
- Advanced PA settings (electronic scanning, FMC-TFM, PWI-TFM, Classic or PCI-Like reconstruction, ATFM, SAUL, DDF)
- CAD-contour and branched defect profiles
- Multi-skip Inspection Simulation
- Complex and robotic scanning patterns
- Geometrical echoes computation
- Assistant for nozzle inspection optimization
- Mode conversions
- Modes identification
- Parametric studies (variation over 1 or more parameters) and sensitivity studies with metamodels
- PoD curves computation

Analysis features

- All the features of CIVA UT Analysis module! See details on page 5

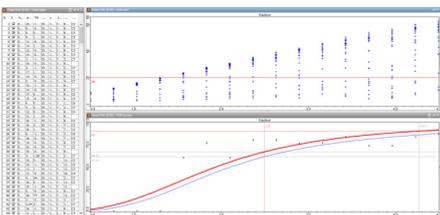
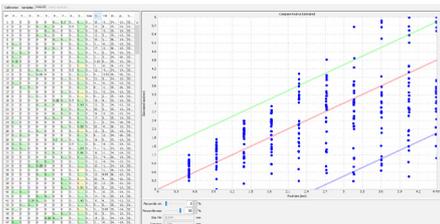
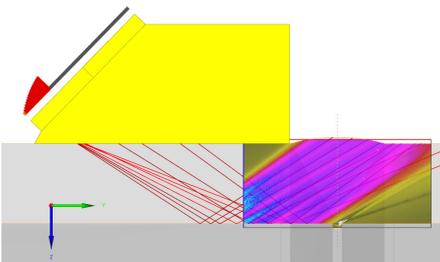
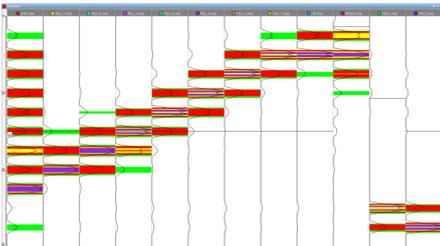
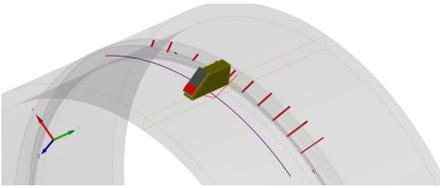
Optional features

- CIVA ATHENA2D (coupling CIVA and ATHENA2D FEM simulation from EDF)
- CIVA FIDEL2D (coupling CIVA and FIDEL2D Finite Difference code from AIRBUS for advanced composite simulations)
- CIVA Script (to drive and automate CIVA simulations and analysis using custom scripts, such as Python or Matlab ones)
- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)



CIVA AUT Pipeline

Available in English, French, and Chinese



- CIVA AUT Pipeline at a glance:
- Girth weld UT inspection model
 - Calibration strip chart
 - Zone coverage
 - Sizing Accuracy graph
 - POD curve

Simulation for efficient weld inspections and performance demonstrations:

This dedicated simulation tool has been designed for **Oil & Gas** stakeholders to support pipeline project validation as well as to optimize inspection performance and reliability.

Support project specific validations and reduce costs:

With CIVA AUT Pipeline, you can address the standard "**Zonal Discrimination Method**" (ZDM) approach or the latest "**Total Focusing Method**" (TFM) for pipeline girth welds inspections. You can easily define the different channels and verify the relevance of the calibration mock-ups and the Phased-Array setup. You can **rank the essential variables** according to their importance on the UT signals. You can perform **sensitivity analysis** and explore numerous inspection scenarios. You can build Sizing Accuracy and POD indicators. While all these stages usually require heavy preparation and experimental campaigns, modelling can **limit the experimental trials to a reasonable sample set**.

Optimize inspection set-up:

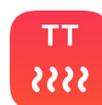
Besides the tools provided to evaluate inspection performance, CIVA AUT Pipeline also includes **field mapping**, **zone coverage**, and **flaw response simulation** tools to work on the inspection technique itself. You can **design** the most relevant transducer characteristics (element size, wedge, frequency, etc.), **optimize** Phased-Array setups (number of elements per channel, focal laws), and adjust probe positions and acquisition gates to increase performance (detectability, sizing, positioning) and reliability.

CIVA AUT Pipeline includes a **dedicated set of modules** to quickly enter the project parameters (weld configuration, probe selection, channel definition), and **guides you through the different steps** of a performance demonstration:

- **AUT Calibration:** Channels definition and calibration mock-up simulation to verify the relevance of a set-up and visualize the beam coverage of different weld zones
- **AUT Sensitivity:** Parametric study on the essential parameters and evaluation of their influence through many potential scenarios in a "real-time" analysis environment powered by metamodels
- **AUT Sizing:** Sizing accuracy evaluation through true versus predicted flaw size graphs
- **AUT POD:** Probability of Detection curves analysis, versus flaw size or other parameters, for one or several channels

The "generic" Beam Computation, Sensitivity coverage and Inspection simulation tools of CIVA UT are also available in CIVA AUT Pipeline for **girth weld modelling**. These tools will let you work on transducer selection, focal law definition and calculation, and **designing and optimizing** your inspection techniques or qualification mock-ups.

Discover more about the AUT Pipeline module at:
<http://www.extende.com/aut-pipeline-testing-with-civa>



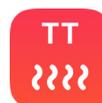
CIVA 2023 | AUT PIPELINE MODULE Features list

Basic features

- Parametric girth weld geometries
- Isotropic materials (with database)
- Contact Linear PA or Single Element probes
- Pulse parametric waveforms
- Circumferential scanning
- Zonal Discrimination or Total Focusing Method
- Available channels for ZDM: Fill, Hot Pass, Cap, Root, Volume
- Calibration reflectors: Flat Bottom Hole for Fill, Hot Pass and Volume channels, rectangular notch for Cap and Root channels
- Multi-channels integrated simulation and data management
- Strip chart on calibration mock-ups
- Sensitivity analysis through parametric studies on rectangular target flaw response in the weld

Advanced features

- Multi-parametric sensitivity analysis through the following essential variables: Pipe thickness, Probe standoff, Steel velocity, Flaw dimensions, depth and tilt angle
- 1D and 2D parametric analysis viewers
- Metamodel generation to enhance sensitivity analysis sampling
- Sobol indices diagram to rank essential variables impact
- Parallel plot for multi-dimensional parametric analysis
- Sizing accuracy curves
- Sensitivity analysis of sizing errors
- POD curves computation for one or several channels
- 2D Heat maps POD
- Beam and Sensitivity Coverage simulation tools for custom probe and channel set-up and optimization
- Complete Inspection Simulation channel per channel on various flaw types: rectangular, elliptical, branched flaws, porosities, inclusions



CIVA UT Analysis

Available in English, French, German, Spanish, Russian, and Chinese

Display acquisition data in 3D:

Data is displayed as **classical UT data** (A-Scan, Echodynamic curves) or more **advanced images** (B-Scan, C-Scan, S-Scan, E-Scan, etc.). Connected with a description of the acquisition parameters (component, probe, scanning, etc.), data can be displayed in the **specimen frame** and **exported in the 3D view** with the **“one click 3D view”**, which provides a quick and easy understanding of the indication’s location.

Fast, efficient and customizable analysis:

Within a user-friendly environment offering a complete toolbar, you can easily and quickly extract interesting information thanks to the graphical definition of a custom region of interest (ROI) from which **one-click tools** such as **“-xdB contour”** or **Segmentation** help to analyze the signal (amplitude, position of detection, time of flight), and then **locate and size indications**. Segmentation even makes groups **automatically show in the 3D display**. You can customize your use of CIVA UT Analysis to drastically reduce repeatable actions, have a convenient environment, and **automate most of your analysis procedure!** Give a name to some of the actions you currently do and recall it for a similar file to have a consistent process, avoid errors, save time and put your efforts on the real work of analysis!

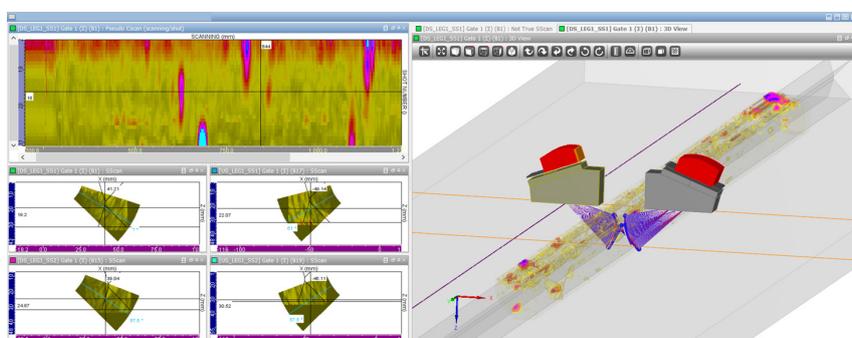
Relevant information (amplitude, position, size...) is included in an **indication table** in one click. Columns of this indication table can be selected and sorted among a complete list of available data. In one click, this indication table can be **exported in CSV format** or as a **PDF** or **HTML report**.

Advanced analysis tools link with simulation tools:

To help with the diagnosis, multiple functionalities are available: a wide range of **signal processing methods** (classical, such as filters or advanced options). If you use the latest techniques like **TFM** (Total Focusing Method), you can make appropriate reconstructions, and even redraw the surface of your specimen in one click. You can also benefit from simulation tools in CIVA UT to easily compare your simulation and acquisition data on the same page for assessment. Even if you do not have the UT simulation module of CIVA, CIVA UT Analysis offers a **“simulation on acquisition”** feature, based on the prediction you want to test (planar defect) to confirm or disprove a conclusion by simulation of a given Region of Interest.

Beam Calculation and Delay laws export (optional):

It is possible to include in your CIVA UT Analysis package, the **beam computation** module of CIVA (simulation), described in the previous part. With this option, you will be able to **load and compare simulation files with acquisition files**. The **delay laws calculator** also provides the possibility to export in *.raw and *.pte ASCII files both delay laws and index point’s data.



Analysis toolbar

Multi-Channel acquisition data displayed in 3D view

Discover more about the UT Analysis module at:
<http://www.extende.com/ultrasonic-testing-analysis-with-civa>

CIVA 2023 | UT ANALYSIS MODULE Features list

Basic features

- Classical images (A-Scan, B-Scan, C-Scan, D-Scan...)
- PA images (S-Scan, E-Scan...)
- Amplitude measurement and calibration
- Distance measurement (3D), surface measurement
- TOFD calibration, lateral wave linearization and deletion
- Customizable analysis banner
- Report in PDF, HTML or export as CSV
- Delay laws calculator (includes management of electronic scanning)
- Display in amplitude, depth or time of flight

Advanced features

- 2D scan images reconstructed in the 3D view (simple or CAD specimen) considering material and geometrical influences
- Multi-channel data files with data merging
- Hysteresis correction
- 3D evolved ray tracer with time of flight connection
- Layout definition and back-up
- DATA eraser
- Complete traceability of actions modifying data
- Acquisition gates addition, modification and synchronization
- One-click amplitude histogram with mean values, max, etc.
- “-x dB” automatic contour (also added in report)
- Signal processing (filters to wavelets or split spectrum...)
- TCG (Time Corrected Gain)

Cutting-edge features

- One-click segmentation with 3D representation
- One-click 3D full DATA export
- UT Simulation on defects in a ROI
- Customization of analysis layout, indication table fields, thresholds, analysis operators
- Automation of analysis procedures
- TFM reconstructions and surface reconstruction, Classic or PCI-Like reconstruction, TFM profiler

Optional features

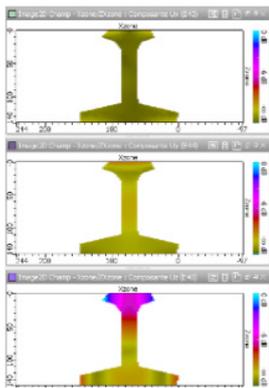
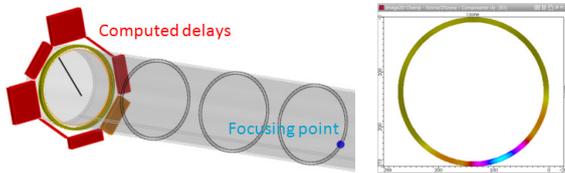
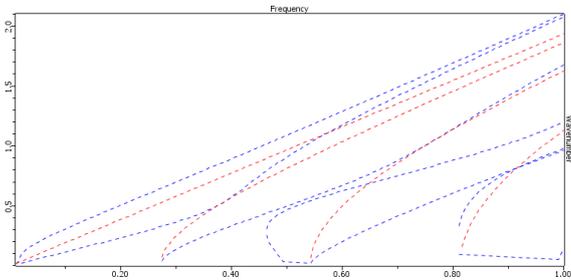
- UT Beam simulation
- Load CIVA inspection simulation files in the analysis environment
- Delay laws export

Accepted formats: EddyFi systems (M2M brand: Gekko, Panther, MultiX), Olympus data (opd, oud, rtd and X3 format up to version 5.9), Prelude and TFM data from TPAC, Sonatest UT data, Zetec text exports
Plug-In proposed to load other data file formats and to customize analysis tools

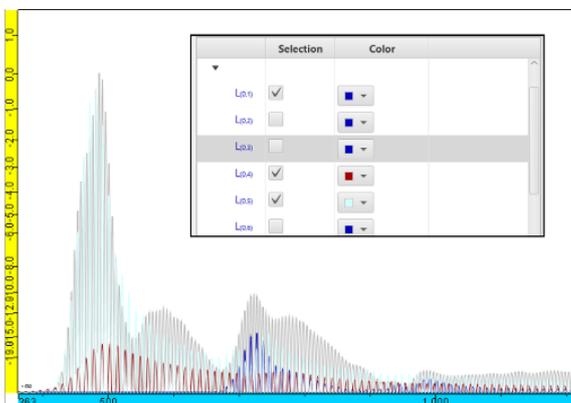
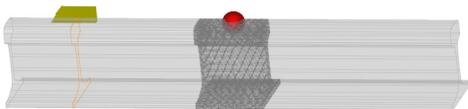


CIVA GWT

Available in English, French, German, Spanish, Russian, and Chinese



- CIVA GWT at a glance:*
- Dispersion curves
 - Delay laws computation and associated Beam computation
 - Beam radiated in a rail
 - Inspection Simulation on a flawed rail and associated A-scan



Echo computations with Guided Wave testing:

CIVA Guided Wave Testing computes the echoes obtained from **flaws** or geometrical changes (perpendicular to the inspection direction) with one transducer exciting the full section. Parametric discontinuities are available (**groove, section transition or weld**), but it is also possible to **draw a geometrical discontinuity** in the 2D CAD editor of CIVA.

Dispersion curves in many component geometries, from simple to complex profiles:

A 2D CAD editor lets you define a **2D CAD profile** for which CIVA GWT is able to compute the dispersion curves, beam radiated by a probe and inspection simulation. This editor is useful in order to define the section of a rail track for instance.

A large variety of probes taken into account:

The Inspection Simulation and Beam Computation modules consider a large range of probes. **Piezo-electric** and **Magnetostrictive probe types** can be easily modelled by defining their geometry and the direction of excitation and the pulse waveform. Probes with **wedges** can be also simulated, as well as **EMAT probes** (requires CIVA ET).

GWT simulation tools include:

- **“Modes computation”**: Dispersion curves computation on plates, pipes (potentially filled with fluid, coated or buried) or 2D CAD profiles
- **“Beam computation”**: Computation of the modes radiated by a probe and field profile (energy distribution among modes, displacement and stress map over the profile)
- **“Inspection Simulation”**: Multiple defects and/or geometrical discontinuities

The modes computation gives modes that may propagate in the structure as well as their stresses and displacements profiles. The beam computation displays the beam radiated by a probe in a structure, and the energy distribution among the existing modes. The inspection simulation estimates the obtained echoes with the modal contributions.

CIVA GWT also includes metamodels and statistical plots providing very powerful tools to perform extensive sensitivity analysis studies on the influential parameters.

Discover more about the GWT module at:
<http://www.extende.com/guided-wave-testing-with-civa>

CIVA 2023 | GWT MODULE Features list

Basic features

- Dispersion curves computation on plates and pipes (phase velocity, group velocity, wavenumber, wavelength)
- Modes computation in 2D and 3D (Symmetric modes, Antisymmetric modes, SH mode, Longitudinal mode, Torsional mode, Flexural mode)
- Computation of the beam radiated by a probe including:
 - Energy distribution between the modes
 - Displacement color chart in the profile
 - Stress color chart in the profile
- Beam computation for single-element probe
- Beam computation on a pipe with array of annular probes
- Attenuation associated with a guided mode
- Piezo-electric and Magnetostrictive probes with a selected solicitation direction

Advanced features

- Homogeneous or multilayered plates
- Coatings
- Pipes filled with fluid, buried pipes
- Dispersion curves for homogeneous or heterogeneous 2D CAD profiles
- Dispersion curves for plates and tubes made of anisotropic materials such as composites
- Beam computation for Phased-Array probe
- Delay laws computation in pipes
- EMAT probe simulation
- Echo computation due to transverse defects (thin, rectangular or semi-elliptical sections) in planar, groove, weld, section transition and 2D CAD junction specimen geometries
- Echo computation in tubes and 2D CAD profile specimens (such as a rail) with defects such as planar flaws, branched crack or volumetric defects (parallelepipedic, 3D CAD, spherical, etc.)
- Echo computation due to geometrical changes in groove, weld, section transition and 2D CAD junction
- Pulse-Echo or Pitch-Catch mode (transmission or reflection)
- Analysis of the modes involved in the A-Scan signal
- Parametric studies (variation over 1 or more parameters), sensitivity studies, metamodels
- POD Curves computation

Optional features

- CIVA Script (to drive and automate CIVA simulations and analysis using custom scripts, such as Python or Matlab ones)
- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)

Simulation to help industrial deployment of Structural Health Monitoring by Guided Waves:

Thanks to CIVA simulations, you can easily define **virtual prototypes** of instrumented structures to **try many scenarios** (type of sensors, number and location of sensors, etc.) at a low cost before real implementation. A solid performance demonstration is also required to evaluate the robustness of the SHM technique and assess its real benefits for your predictive maintenance strategy. With CIVA, thanks to a dedicated and **application-oriented user-interface**, you can monitor many **influential parameters** (specimen properties, flaw size and locations, sensors) and easily perform **sensitivity and POD studies** that will credit your choices.

Imaging tools to enhance detection techniques:

SHM provides a lot of data, but it is often difficult to go from data to diagnostic. Beyond the traditional base line subtraction technique, CIVA includes **imaging tools** to enhance your capacity to detect and characterize an indication for many scenarios. It also provides insights to **visualize and understand sound waves paths**.

Fast simulations:

Thanks to its **optimized FEM technique** relying on high-order elements built from a **fully automated parametric mesh**, CIVA SHM by Guided Waves shows very competitive performances, generally **faster with more than a factor 100 compared to traditional Finite Element software**, and has very low requirements in terms of RAM, which makes this tool really affordable for engineers for **massive simulations in an industrial context**.

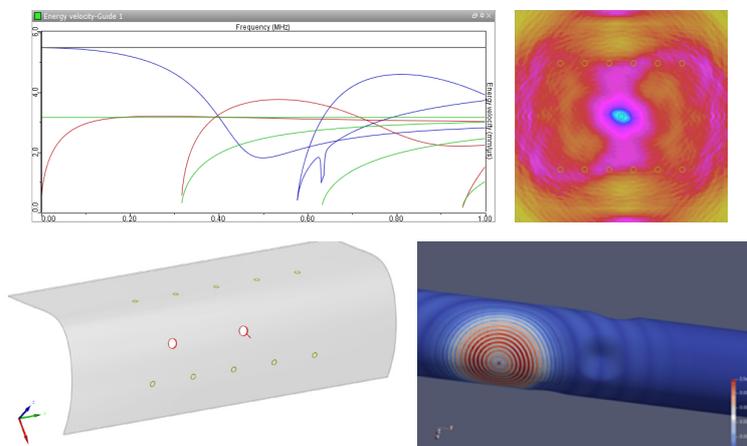
CIVA SHM simulation tools include:

- **“Modes computation”**: Dispersion curves computation for the Guided Waves modes in plates and pipes (potentially multi-layers and anisotropic)
- **“SHM Simulation”**: Compute the signals received on each sensor and for each firing sequence

Specimens can be **metallic or composite** plates or tubes, possibly **multi-layers, curved**, elbows, with a stiffener or an external sleeve. Attenuation can be accounted for. **Several defects** can be simulated (delamination, hole, hole with crack, vertical crack, solid inclusion, corrosion / erosion or bump profiles). Sensors can have thin circular shapes such as typical Piezo-Electric patches, but also custom shapes and loading profiles. From the raw signals obtained on each sensor, **imaging reconstruction** algorithms are available to process them, and provides a **tomographic image** of the defect impact displayed on the specimen 3D view. A *.vtk export enables visualizing snapshots of Guided Waves propagation to help understanding. CIVA SHM also includes **metamodels** and statistical plots providing very powerful tools to perform extensive **sensitivity analysis** studies on the influential parameters.

CIVA SHM at a glance:

- Dispersion curves
- 3D view with an instrumented panel
- Tomographic reconstruction of a defect signature
- Field snapshots visualization



Discover more about the SHM module at:

<http://www.extende.com/structural-health-monitoring-with-civa>



CIVA 2023 | SHM MODULE Features list

Basic features

- Parametric geometries (planar or cylindrical)
- Isotropic materials (with database)
- Classical PZT circular patch with radial or normal loading profiles
- Pulse parametric waveforms
- Circular or grid sensor distributions on the specimen
- Custom or Round Robin scanning technique
- Hole, delamination, hole with crack, vertical crack
- Automatic mesh
- Dispersion curves calculation
- 3D computation of guided modes in the component
- Raw signals display and export
- Local fields of displacement and stress can be extracted in *.txt files
- Baseline subtraction post-processing

Advanced features

- Multi-layered structures with stiffener or external sleeves
- Curved panel profiles, elbows
- Anisotropic material (such as composite)
- Custom sensors shape and loading profiles by *.txt import
- Custom pulse waveform by *.txt import
- Attenuation
- Custom sensors layout on the specimen
- Solid inclusions, complex erosion / pitting / bump profiles
- Symmetric and antisymmetric modes identification
- Reconstruction algorithms for tomographic image superimposed on the 3D specimen view
- Parametric studies (variation over one or more parameters) and sensitivity studies with metamodels
- POD curves computation
- *.vtk export for snapshots of Guided Waves propagation visualization and mesh information in a VTK viewer such as the freeware Paraview

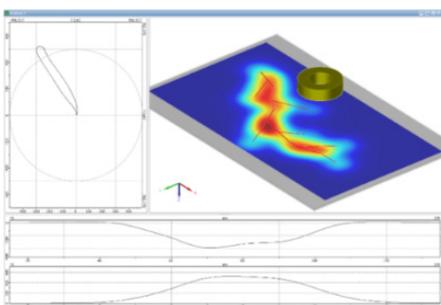
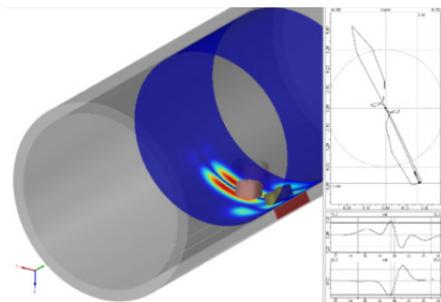
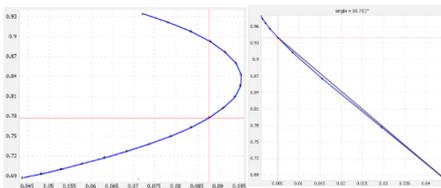
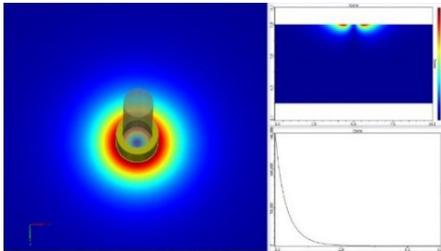
Optional features

- CIVA Script, (to drive and automate CIVA simulations and analysis using custom scripts, such as Python or Matlab ones)
- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)



CIVA ET

Available in English, French, German, Spanish, Russian, and Chinese



CIVA ET at a glance:

- Field simulation
- Impedance diagram
- Lift-off signal rotating probe
- Surface probe inspection simulation with C-scan views and impedance plane

Easy and fast simulations of tube and surface inspections:

CIVA Eddy Current offers a dedicated environment to easily and quickly simulate typical inspection setups from **planar surfaces and tube inspection configurations** including various types of defects (Longitudinal or transverse notches, grooves, holes, semi or quarter elliptical flaws, fretting wear) to more complex parametric or 2D CAD geometries with an infinite transverse defect. Surface inspection of **fastened plates** (including rivets) can also be defined. A module dedicated to **Steam Generator inspection** modeling lets you define advanced configurations with bobbin probes, including **support plates, antivibration bars**, wears, deposits, tube section bending, **expansions and distortions**.

Variety of Eddy Current probes and techniques available:

CIVA includes an extensive library of probe types, such as conventional surface probes with **various coils shapes** (cylindrical, rectangular, spiral, racetrack, meander, D) and also advanced sensors such as **Eddy Current Arrays** or **orthogonal wound arrays** (“+Point“-like design). For tube inspections, in addition to conventional **bobbin or encircling coils, rotating probes** with one or several elements can be created, including the “Rototest” probe design commonly used for bore inspections. Sectorial coils are also available, as well as the X-probe like sensor. **Ferrite cores** of various shapes (cylindrical core, cap, U-Yoke) can be defined, a shielding ring can be also included. Specific set-up using **GMR-like sensors** (Giant Magneto Resistance) can also be simulated, as well as the **Remote Field Testing** technique for ferromagnetic tube inspections. **Pulsed Eddy Current** is now also available.

Multi channels simulation:

CIVA lets you simulate several acquisition modes in a single file: absolute or differential reception modes, double function or separate transmit/receive modes, single or several frequencies.

ET simulation tools include:

- **“Field computation”**: Electromagnetic field and Eddy Current distribution (flaw-free configurations)
- **“Impedance and lift-off diagram” graphs**
- **“Inspection Simulation”**: Defect response simulation

The field simulation tool provides access to a precise evaluation of the action zone and Eddy Current penetration with a given probe, while impedance and lift-off diagrams helps to define operating settings (frequency, calibration, etc.). The inspection simulation module can predict the signal response with different types of outputs: **C-Scan** views, **impedance plane** curves, X/Y “temporal” channels (or Real/Imaginary part) Amplitude/Phase. Simulations are **fast**, which allows intensive **parametric and sensitivity** studies. Experimental data can be loaded through *.csv files import. CIVA ET also includes **metamodels** and statistical plots providing very powerful tools to perform extensive sensitivity analysis studies on the influential parameters. CIVA can also compute **POD** curves (Probability Of Detection).

Discover more about the ET module at:

<http://www.extende.com/eddy-current-testing-with-civa>



CIVA 2023 | ET MODULE Features list

Basic features

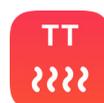
- Parametric geometries (planar, cylindrical)
- Conductive materials (with database)
- Conventional surface probes editor (with various shapes)
- Ferrite core (cylindrical core, C and E pot, U-Yoke)
- Tube inspection probes (bobbin coil, encircling coil, sectorial coil, rotating coil)
- Notch defects (longitudinal, transverse) with rectangular, semi or quarter-elliptical shape, Flat Bottom Holes, grooves
- 1D and 2D (raster) scanning
- Field calculation and inspection simulation
- Impedance diagram vs frequency
- Lift-off signal computation
- 2D axisymmetric and 3D computations
- Multi-channel simulation with different operating modes (absolute, differential, double function or separated Transmit / Receive) and frequencies

Advanced features

- Multi-layer planar configurations with/without rivet
- Complex parametric geometries (fastened plate, weld profiles, blade root) or 2D CAD geometries, with "infinite" transverse defect
- Linear ferromagnetic properties in tubular configurations
- Remote Field Testing
- Eddy Current Arrays (surface probes), X-Probe-like sensor (in tubes)
- Orthogonal wound probe ("Point"-like design with ferrite core)
- Rototest-like probe (with D shape ferrite pot)
- EMAT probes (single and multi-elements) for coupling with CIVA UT and CIVA GWT
- GMR (Giant Magneto Resistance)
- Pulsed Eddy Current
- Electrical parameters of ET system (generator, cable, probes)
- Fretting wear, notches and drilling complex profiles in tubes
- Parametric studies (variation over 1 or more parameters), sensitivity studies, metamodels
- POD curves computation
- Channels combination and frequency mixing
- Analysis of experimental data through an import with a *.csv file

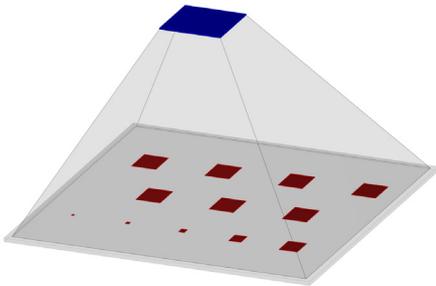
Optional features

- CIVA Script (to drive and automate CIVA simulations and analysis using custom scripts, such as Python or Matlab ones)
- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)



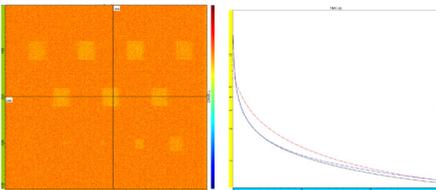
CIVA TT

Available in English, French, Russian, and Chinese



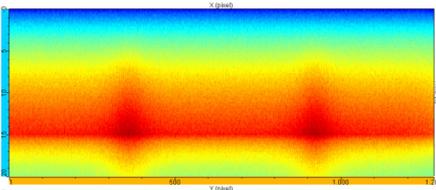
Optimize infrared thermographic testing with simulation:

Through simulation in CIVA, you can easily compare a **large variety of optical heating** techniques (Flash, Transient, Lock-In, etc.) to improve inspection regarding many scenarios, **maximize temperature contrasts and defect detectability**. Change specimen and flaw characteristics, modify environment properties, define your thermographic inspection technique, and repeat these steps to generate **thermal images and data**. Analyze them directly with CIVA tools or export the results for further post-processing.



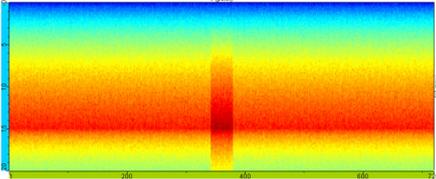
Evaluate influential parameters:

CIVA TT allows you to evaluate the impact of specific thermal parameters related to the **environment** (such as emissivity and environment temperatures) and to the **technique** (detector position in reflection or transmission mode, excitation type, power and heating time). Study the **reliability** of your thermographic inspection regarding various specimens and flaws (geometry type and dimensions, positions and orientations, materials). Perform **parametric studies** to focus on the influence of one parameter or a combination of several ones.



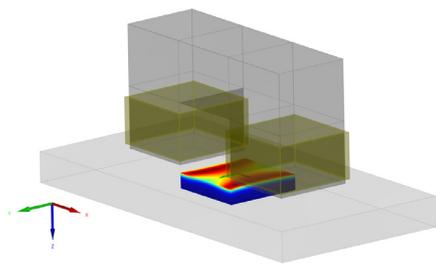
Fast and easy simulations:

Thanks to a **dedicated** and **user-friendly interface**, you can easily and quickly define your own configuration: selection of the inspected specimen, definition and positioning of the source and the detector, specification of the environment, insertion of one or several flaws. In addition, the computations are fast ; in a couple of seconds or minutes, the configurations will be created and computed, all you need to do is analyze the results!



CIVA TT includes:

- **“Induction Heating computation”**: Computes power density maps induced by the inductor in a conductive component
- **“Optical Thermographic Inspection Simulation”**: Computes the thermogram obtained when simulating the inspection of a specimen with flaws heated by lamps



Specimens are planar with homogeneous or multilayer structure. Lots of materials can be loaded from the CIVA database, or even be created by yourself if needed. Flaws are inclusions with parametric shapes (planar or cylindrical) or customizable 2D CAD profiles. Lamps are used as source with **many excitation types** available (impulse, ramp, step, crenel and sinusoidal).

CIVA TT at a glance:

- Thermogram of a composite plate and associated time signal curves for different positions
- Propagation of thermal wave in front and side views
- Induction Heating power density in a metallic block

Typical thermal images are provided such as **thermograms** (time domain or frequency domain such as Pulse Phase Thermography), cross-section along 1 axis, characteristic time signal curves with various representations (linear or log scale), FFT, geometrical views. CIVA TT also includes **metamodels and statistical plots** providing very powerful tools to perform extensive sensitivity analysis studies on the influential parameters.

Discover more about the TT module at:

<http://www.extende.com/thermographic-testing-with-civa>



CIVA 2023 | TT MODULE Features list

Basic features

- Parametric planar geometries
- Isotropic materials (with database)
- Lamp sources with impulse, ramp, step, crenel and sinusoidal excitations
- Power / energy and heating time parametric definition
- Reflection and transmission modes
- Definition of main detector parameters (dimensions, resolution, focal distance)
- Inclusion with planar and cylindrical shapes
- Automatic mesh
- Thermal wave computation in 2D
- Typical thermal images as thermogram, 1D cross-sections, temporal transient signal, Phase or Amplitude thermogram in Frequency domain

Advanced features

- Multi-layered structures
- Complex detectors defined by equation or data calibration import
- Environment properties consideration
- 2D5 CAD flaws
- Tilted flaws
- Mesh optimization
- Various time domain representations (log-log, lin-log, log-lin), FFT curves
- Data export in *.txt files
- Parametric studies (variation over 1 or more parameters) and sensitivity studies with metamodels
- Differential Digital Level signals with / without defect
- Power density induced by Eddy Current computation for induction thermography

Optional features

- CIVA Script (to drive and automate CIVA simulations and analysis using custom scripts, such as Python or Matlab ones)
- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)



CIVA RT - CT

Available in English, French, German, Spanish, Russian, and Chinese

Direct and scattering radiation modelled in one single simulation:

The CIVA RT simulation module lets you simulate a full radiographic inspection by taking into account the radiation produced by X-ray, Gamma ray and high energy sources.

CIVA RT can predict images related to standard **films**, **flat panel detectors**, **image plates**, etc. with a wide range of components (including 3D CAD geometries), and **defects** (rectangular defects, crack-like defects, inclusions, porosities and even 3D CAD flaws).

In addition to these options and in order to be as close as possible to real radiographic shots, a standard library of **IQI** is proposed (wire type, double wire, plaque penetrameters...). The IQI can be positioned from the source or film side. The component can be homogeneous or **heterogeneous** (made of several parts or several layers). The material is defined from an available database including more than **110 elements and alloys**, with the associated cross-section data.

A quick set-up, a lot of results:

From the simplicity of the CIVA interface, the user can easily and quickly set their configuration up: selection of the part to be inspected, definition and positioning of the source and the detector, insertion of one or several flaws, definition of calculation options. Users can visualize the detector responses (**optical density or Gray levels**), as well as the incident dose in Gray or the deposited energy on the detector in keV.

Detectability criteria are integrated in CIVA in order to provide with automatic detectability threshold based on a signal to noise ratio and comparison between images with flaw and without flaw, which especially opens up the possibility to realize **POD studies** (Probability Of Detection).

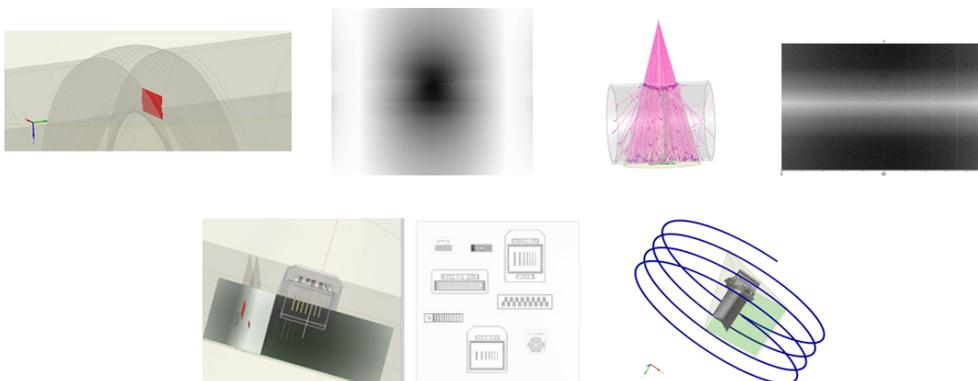
CIVA RT also includes **metamodels** and statistical plots providing very powerful tools to perform extensive **sensitivity analysis studies** on the influential parameters.

Reconstruction of simulated and experimental tomographic data:

CIVA lets you **simulate Computed Tomography**, and also import real data that can be further processed and reconstructed using the available algorithms: **FDK** (analytic), **PixTV** (iterative) or **SART** (complex CT scan). RT **linear scan** applications can also be simulated.

CIVA CT is a simulation tool for a realistic modeling of the X-ray image formation, including photon attenuation and scattering processes, and the modeling of various X-ray sources and detectors.

In order to perform a CT reconstruction, an arbitrary number of steps and shot positions must be defined. Then, CIVA will run the RT simulation for all the projections. It includes the simulation of **circular**, **helical**, or **complex** and robotic trajectories.



Discover more about the RT - CT module at:
<http://www.extende.com/radiographic-testing-with-civa>

CIVA 2023 | RT - CT MODULE Features list

Basic features

- Calculation of the direct radiation
- Basic images as “Optical density” or “Grey level images”
- Library of parametric geometries of specimens
- X – Y – High energy sources
- Detectors: Films – CR – DR
- Import and export of Tiff images, export in Raw format file
- Extensive material libraries
- Source blurring
- Detector’s noise
- Library of IQI

Advanced features

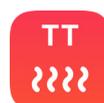
- Calculation of the scattered radiation
- Build-Up image
- Possibility to take into account the global FTM blurring
- Parametric studies (variation over one or more parameters), sensitivity studies, metamodels
- Flat-field correction
- *In the case of the purchase of the CT Module:*
- Bridge with ImageJ freeware for advanced image analysis
- Circular tomographic scanning
- Reconstruction with FDK or PixTV algorithm for circular scanning

Cutting-edge features

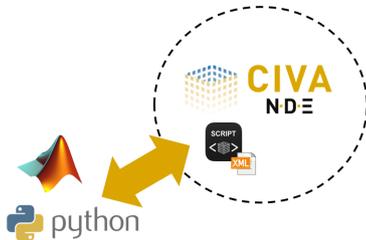
- Detectability criteria
- POD
- Back scattering radiation can be modeled to evaluate the impact of the environment
- Linear Scan
- *In the case of the purchase of the CT Module:*
- Possibility to realize a short scan
- Helical tomographic scanning
- Reconstruction with FDK algorithm for helical scanning
- Complex / Robotic tomographic scanning
- Reconstruction with SART algorithm for complex scanning
- Reconstruction with PixTV algorithm for circular scanning
- Reconstruction parallelized on GPU

Optional features

- CT Module
- CIVA Script (to drive and automate CIVA simulations and analysis using custom scripts, such as Python or Matlab ones)
- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)



CIVA Script



CIVA Script at a glance:

- Drive CIVA models through XML scripts and Python / Matlab routines

CIVA Data Science at a glance:

- Train classification algorithm and visualize 2D plots, parallel plots and confusion matrices

Automate your calculation and analysis loops:

In a simulation project, the time-consuming part is often not the computation itself, but the operations needed to run and analyze simulations one after the other. This can take a lot of time, especially for **large-scale studies**. With CIVA Script, you can automate extensive calculation sequences and extract results of interest without opening the user interface!

Optimize your simulation model:

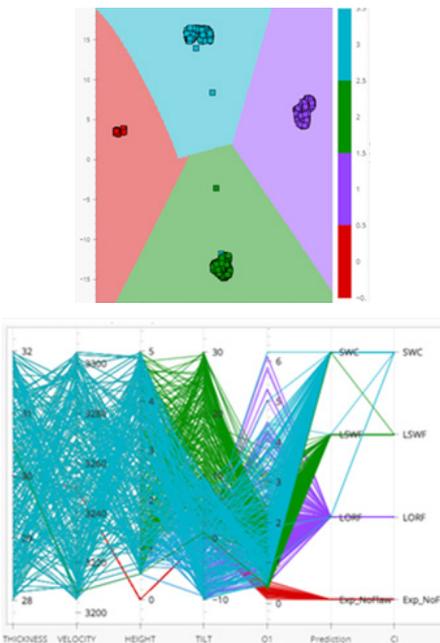
Design, optimization, or characterization studies often rely on iterative loops. In a simulation context, it means that you first need to analyze results before launching new computations. With CIVA Script, you can define your analysis criteria, your target result, and then create your **iteration loops** that will monitor CIVA parameters depending on previous analysis results and converge to an optimal result faster!

Customize post-processing of your simulation results:

CIVA provides results in a NDE oriented analysis environment, but you might want to adapt the analysis results to your application context. With CIVA Script, you can export full simulation "raw" data and use your own programming tools and languages (such as Python) to define your **dedicated post-processing operations**.

CIVA Data Science

Available in English, French, and Chinese



Data management for Machine Learning assisted diagnostics:

A real use of "AI" in NDE suffers from the difficulty to get sufficient and relevant data to train algorithms. **Simulation can overcome this situation by efficiently and massively providing relevant data sets.**

Train and Evaluate classification and detection prediction models:

Parametric simulations in CIVA will let you build relevant databases for aided diagnostics strategies. CIVA Data Science will then provide you with the tools to **manipulate databases** of simulated data but also experimental data, useful to capture experimental noise and artefacts and include it in the training data set.

From this database, you will define different relevant extraction criteria allowing you to design and test **classification and detection** algorithms. This is connected to CIVA Script, so that the user can try and test different **custom output criteria thanks to Python scripts**.

CIVA Data Science includes different Scaler, Projection, and Classifier algorithms with relevant visualization maps and graphs such as 2D plots, parallel plots, and confusion matrices to set up training parameters.

Once the diagnostic model is trained, you can try it on an external experimental database imported beforehand into CIVA Data Science and check its efficiency.

Discover more about the Script and Data Science modules at:

<http://www.extende.com/going-further-with-civa-script>

<http://www.extende.com/ai-for-nde-with-civa-data-science>



CIVA 2023 | SCRIPT MODULE Features list

Basic features

- Run simulations from an external launcher
- Monitor CIVA parameters modifications and variations, then extract data with an XML script
- Python and Matlab readers provided to read CIVA simulations binary outcomes
- Use your own programming language, such as Python, to post-process data and manage your loops of simulations through the XML script file
- Customize extraction criteria from parametric studies thanks to Python scripts

Optional features

- CIVA Data Science (to process data for Classification and Detection Machine Learning algorithms)

CIVA 2023 | DATA SCIENCE MODULE Features list

Basic features

- Build databases from CIVA parametric studies and / or acquisition data files
- Generate metamodels from available data
- Merge different databases together
- Customize NDE extraction criteria thanks to Python scripts
- Notebook environment to manage Python scripts
- Classification algorithms including different projection algorithms (UMAP, PCA) and different classifiers (SVM, Ridge, Naïve Bayes)
- Visualization maps: 2D plots, Parallel plots, and Confusion matrices
- Outliers' detection algorithms

Requirements

- CIVA Data Science requires CIVA Script



Hardware & Software Requirements

General specifications

- 64 bits OS == Windows 10 or Windows 11
- Graphic Resolution == 1920 x 1080
- **No 4k screen type**
- CIVA shall be installed at the root of a disk, >= 256 Gb if on a System disk, >= 128 Gb if on a dedicated disk
- Read / Write rights are necessary in the CIVA directory (but the cache can be moved, contact us in this case)
- USB port for Hardware dongle (but a Software license key is proposed by default)

Comfortable configuration*

- 8 physical cores (i7/i9 types)
- RAM >= 32 Gb
- Dedicated graphic card (also for laptop)

* *Minimal configuration to smoothly run parametric or POD studies, as well as the AUT Pipeline, GWT, SHM, CT, Data Science, and SG-Tube modules*

* *Most simulations and processing will be compatible with this configuration ; several "extreme" use cases and modules could be more demanding*

Optimal configuration**

- > 8 physical cores
- RAM >= 64 Gb (128 / 256 Gb can be necessary for several specific configurations and codes)
- SSD Hard Drive >= 500 Gb
- Dedicated graphic card (also for laptop)

** *An efficient use of the CT module requires this configuration (or at least the comfortable one), and can also require GPU processor for CT reconstructions (GPU is only useful in CT), "CUDA" type with the following computations capacities: 3.5 <= version <= 9.0 (information available at http://en.wikipedia.org/wiki/CUDA#Supported_GPUs)*

CIVA software is used in more than 40 countries worldwide



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