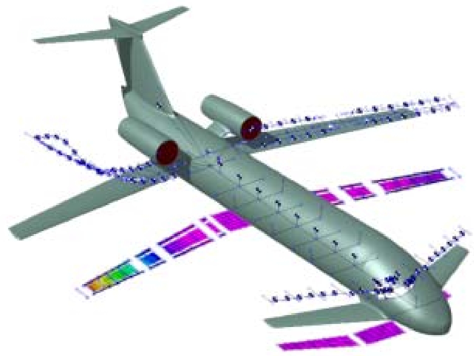
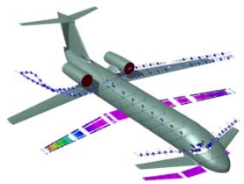
Basic course on NeoCASS



NeoCASS 2.2.809

July 2018

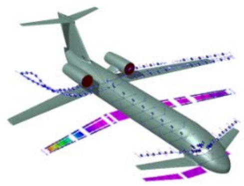
Outline



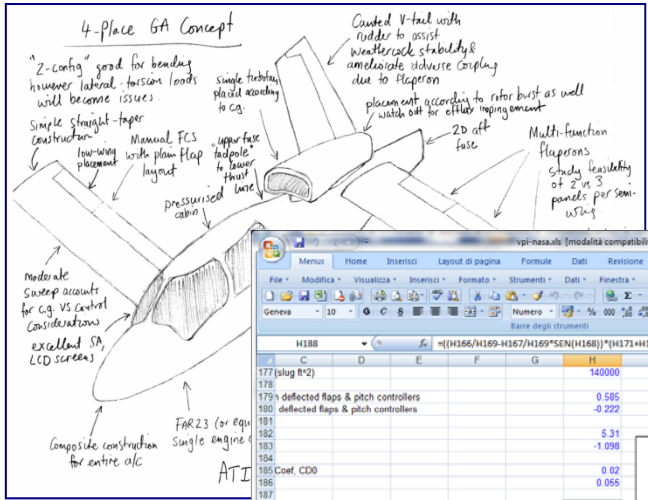
Conceptual design phase

Concerning aircraft, it is the first design step, which involves sketching up a variety of possible aircraft configurations that meet the required design specifications. The adopted tools typically have to be:

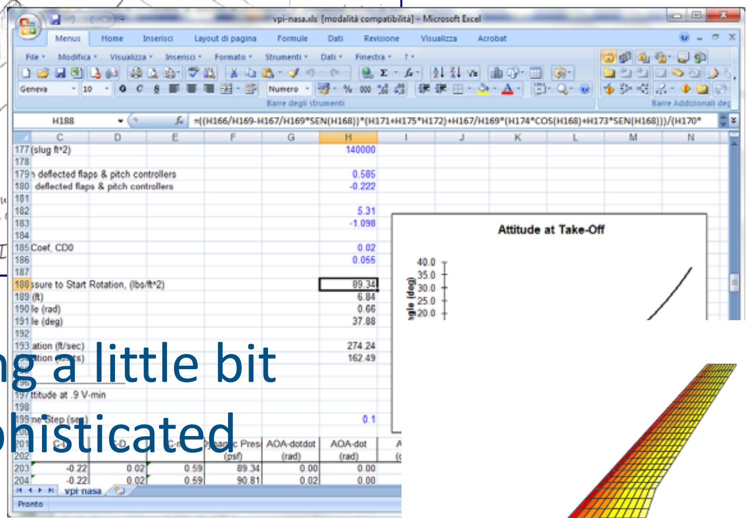
- Simplified (low fidelity) so to be quick
- Suitable for iteration



Typical conceptual design tools

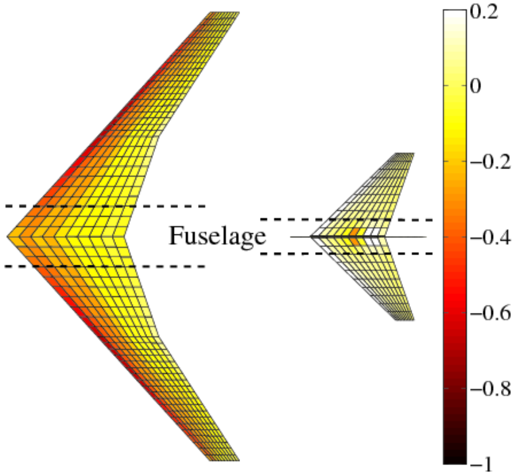


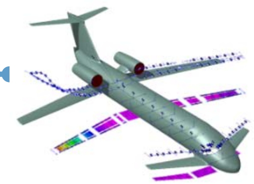
Typical Catia's V0.0 model for conceptual design



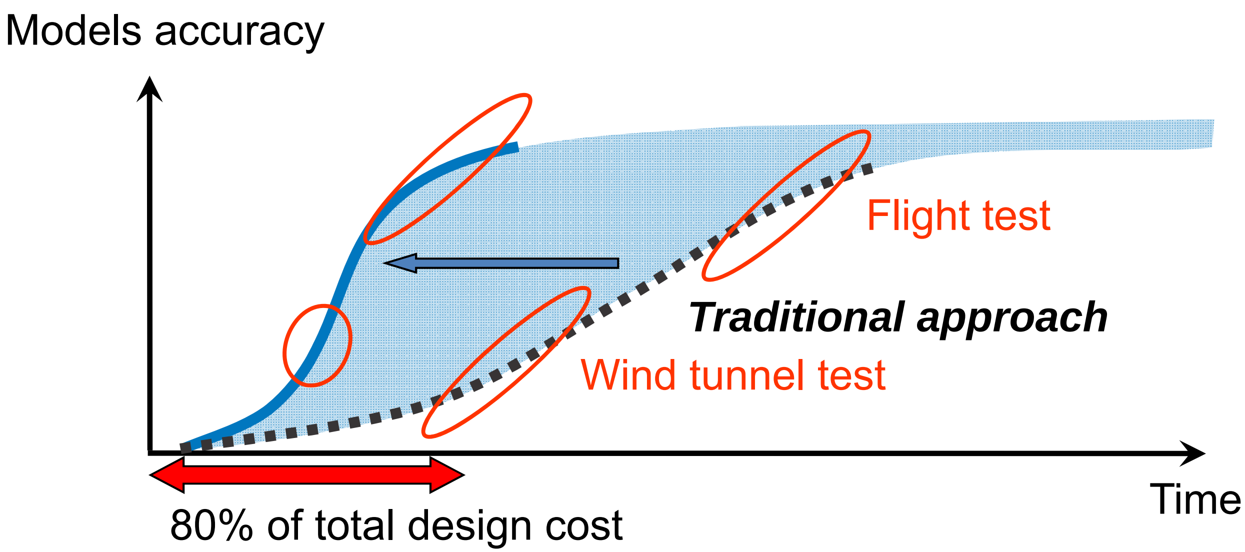
The Bill Gate's contribution to the conceptual design

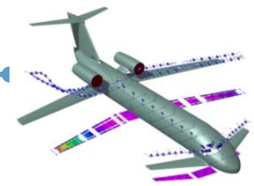
Something a little bit more sophisticated





Conceptual design *cost*

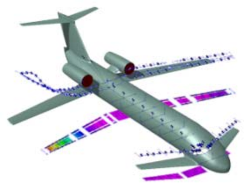




Conceptual design *limits*

The simplified methods used in the early phases of design do not give sufficient fidelity, which may result in mistakes which are costly to correct later in the design cycle. Some examples pertaining to the Flight Control System are:

- **DC-9**: unexpected pitch-up and deep stall of T-tail lead to costly redesign;
- **DC-9-50 & MD-80**: inadequate directional stiffness at high angles of attack in sideslip; adoption of low-set nose strakes;
- **SAAB2000**: larger than expected wheel forces caused delay in certification; costly redesign of elevator control system;
- **Boeing 777**: missed horizontal tail effectiveness led to larger than needed horizontal tail.



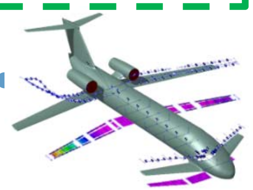
Conceptual design *limits*

SimSAC: ***Sim***ulating Aircraft ***S***tability ***a***nd ***C***ontrol Characterist in Conceptual Design
Coordinator: Prof Arthur Rizzi, KTH, 17 partners
Duration: Nov 2006 – June 2010

SimSAC'c goals:

- Bringing **Adaptive-Fidelity** Aerodynamic Tools to Aircraft Conceptual Design;
- Fully **parametric geometry** modelling;
- Introducing *a flavor of* **aeroelasticity** at the Conceptual Design stage.

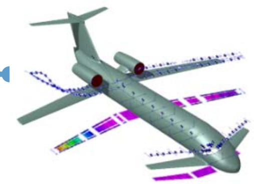
POLIMI's contribution



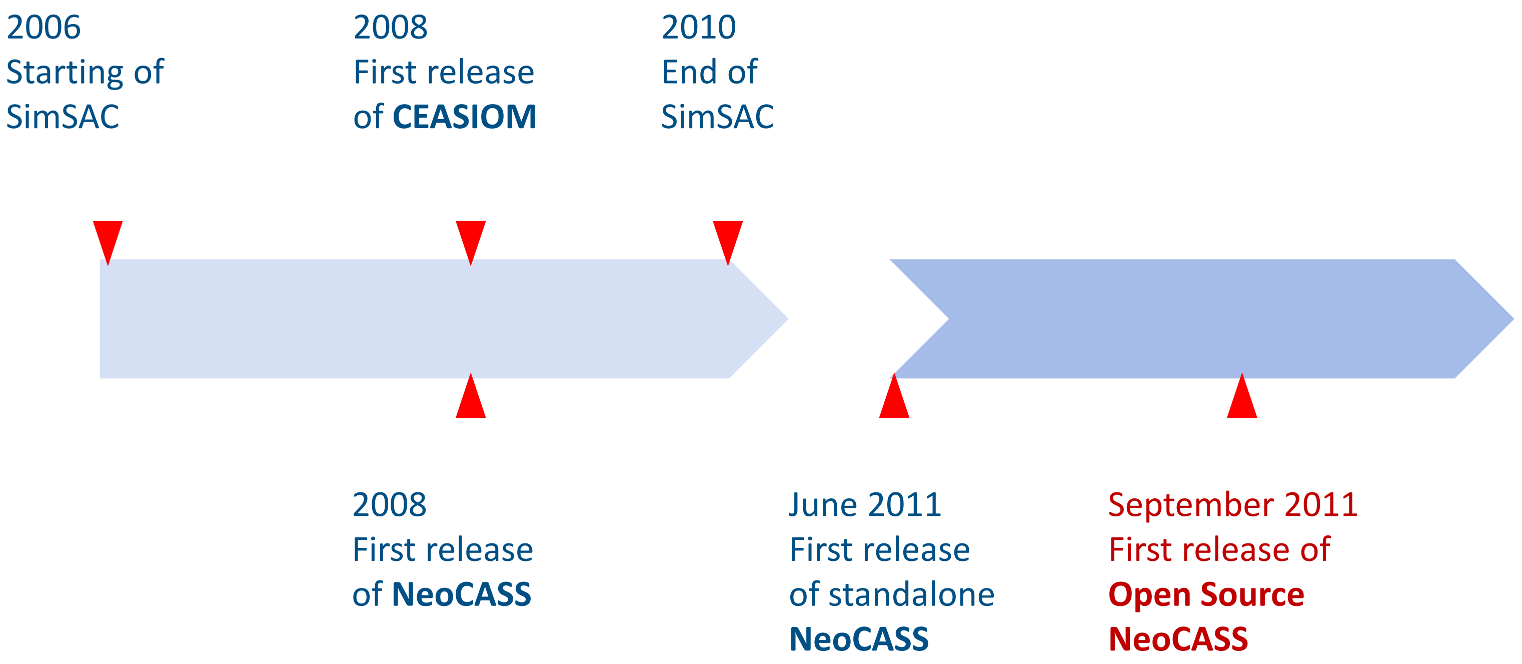
SimSAC's outcomes

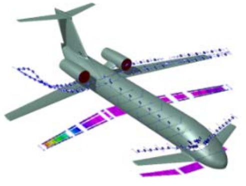
The main outcome of SimSAC project was a Matlab-based environment for aircraft conceptual design called **CEASIOM**.

- It includes the following modules:
  AcBUILDER: Graphic Pre-processor
  AMB: aerodynamics
  NeoCASS: aeroelasticity
  SDSA: flight dynamics
- It is distributed by CFSEngineering under GPL license (www.ceasiom.com)



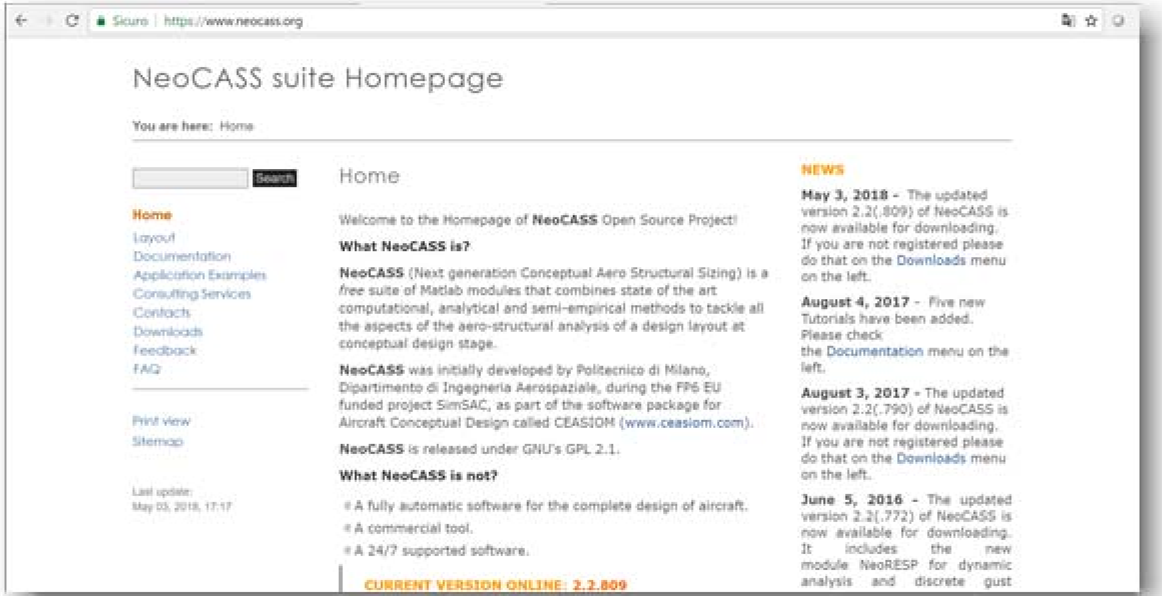
NeoCASS Roadmap

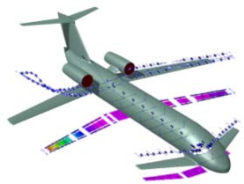




NeoCASS core team and contributors

Sergio Ricci
Luca Cavagna
Andrea Da Ronch
Alessandro Scotti
Lorenzo Travaglini
Luca Riccobene
Alessandro De Gaspari
Federico Fonte
Roberto Garotta
Francesco Toffol
Luca Marchetti

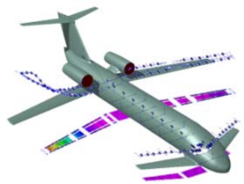




NeoCASS development goals

The main requirements considered during the development were:

- More realistic estimation of structural mass
- A simplified, but realistic for conceptual level, structural model of full aircraft
- Static (divergence, elastic trim, flexible stability derivatives) and dynamic (flutter, gust response) aeroelastic capabilities
- Interfaced with higher fidelity modules



NeoCASS Overview

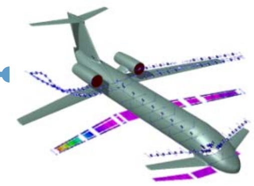
Step by step NeoCASS sequence of operations:

1. Input of **Aircraft Geometric description** and **technological** solutions from AcBuilder module through XML file
2. Input of **Sizing Mode** (certification rules, user-defined)
3. Initial structural sizing

GUESS

4. Structural Analysis
5. Aeroelastic analysis, including MDO
6. **Output:** vibration modes, trimmed elastic aircraft, aeroelastic derivatives, flutter boundaries, divergence speed, aileron reversal, corrected inertia properties

SMARTCAD



NeoCASS overview

NeoCASS (**Ne**xt generation **C**onceptual **A**ero-Structural **S**izing **S**uite) is a collection of Matlab® analysis modules for:

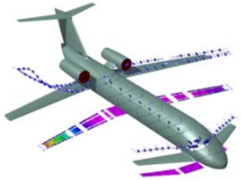
- Initial aircraft structural sizing;
- Modal analysis;
- Linear/non-linear static analysis;
- Aeroelastic analysis (static aeroelasticity, flutter);
- ‘Flexible’ Aerodynamic stability derivatives.

connected with tools for:

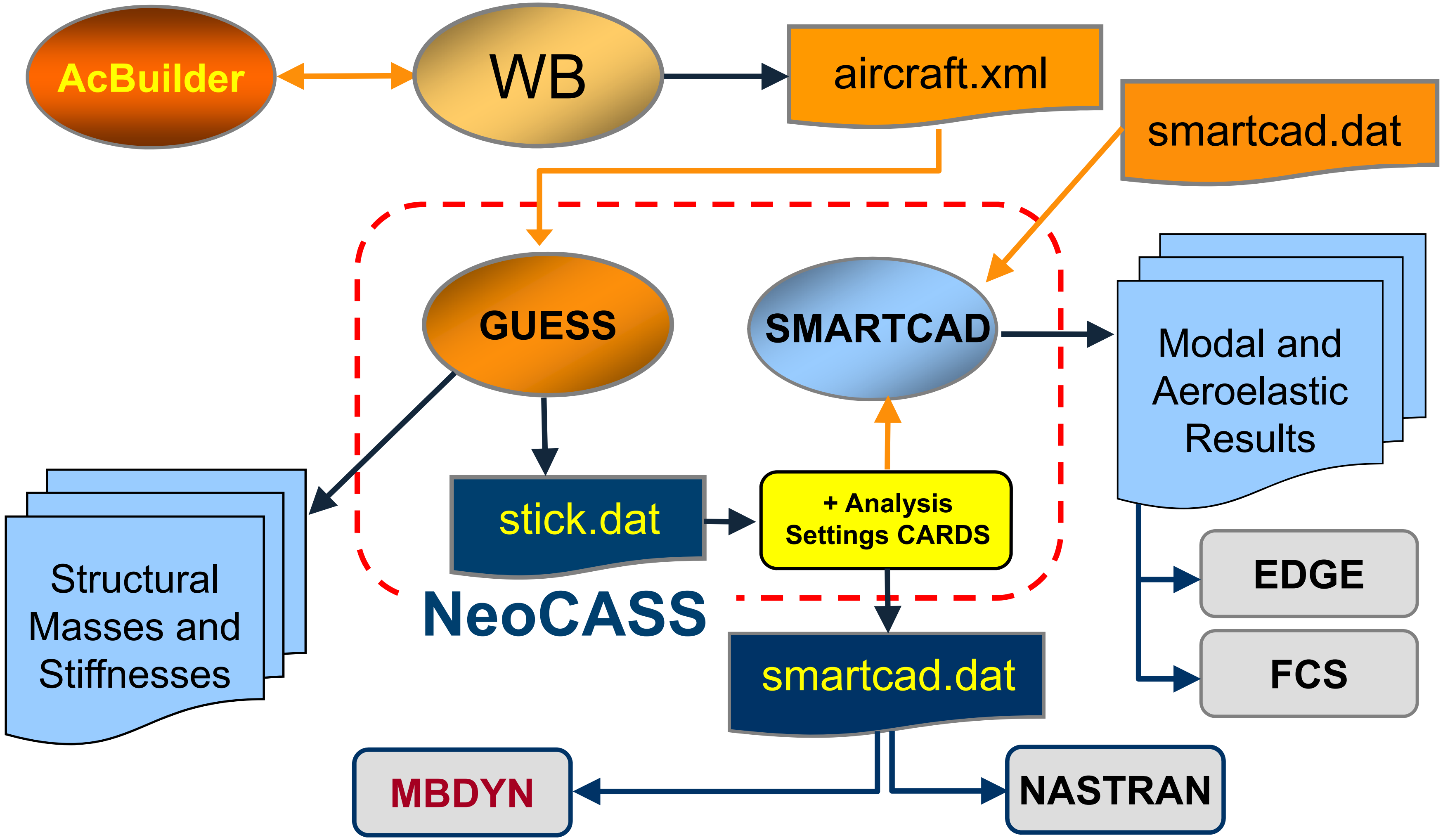
- Spatial coupling (MLS and RBF);
- Aerodynamic analysis (internal VLM/DLM);
- MDO.

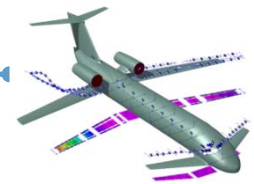
interfaced to:

- External codes (Edge-FOI, MSC/NASTRAN, others);



NeoCASS architecture

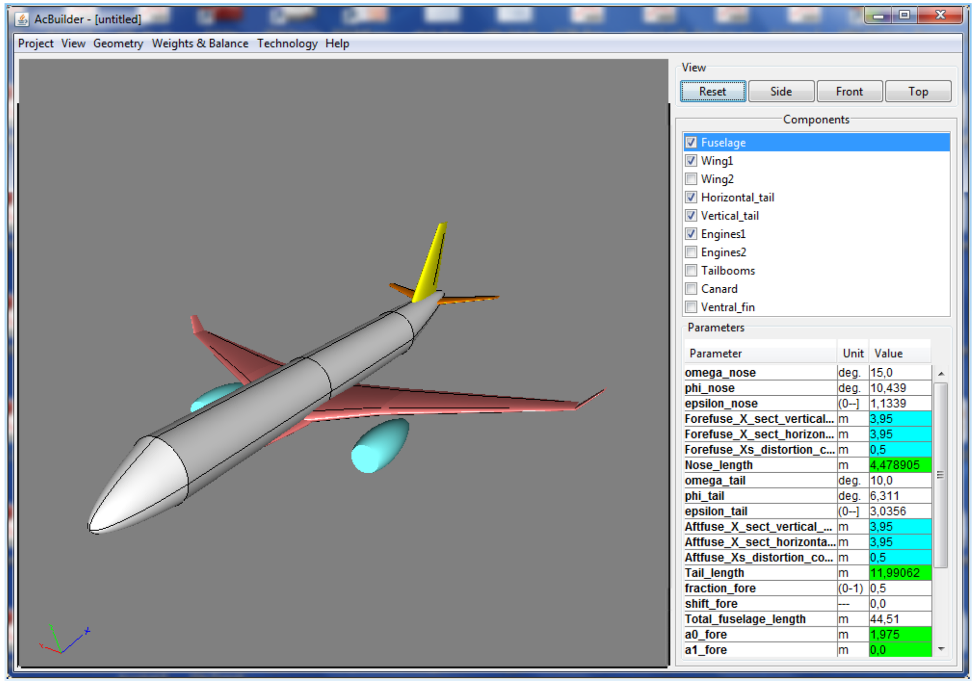




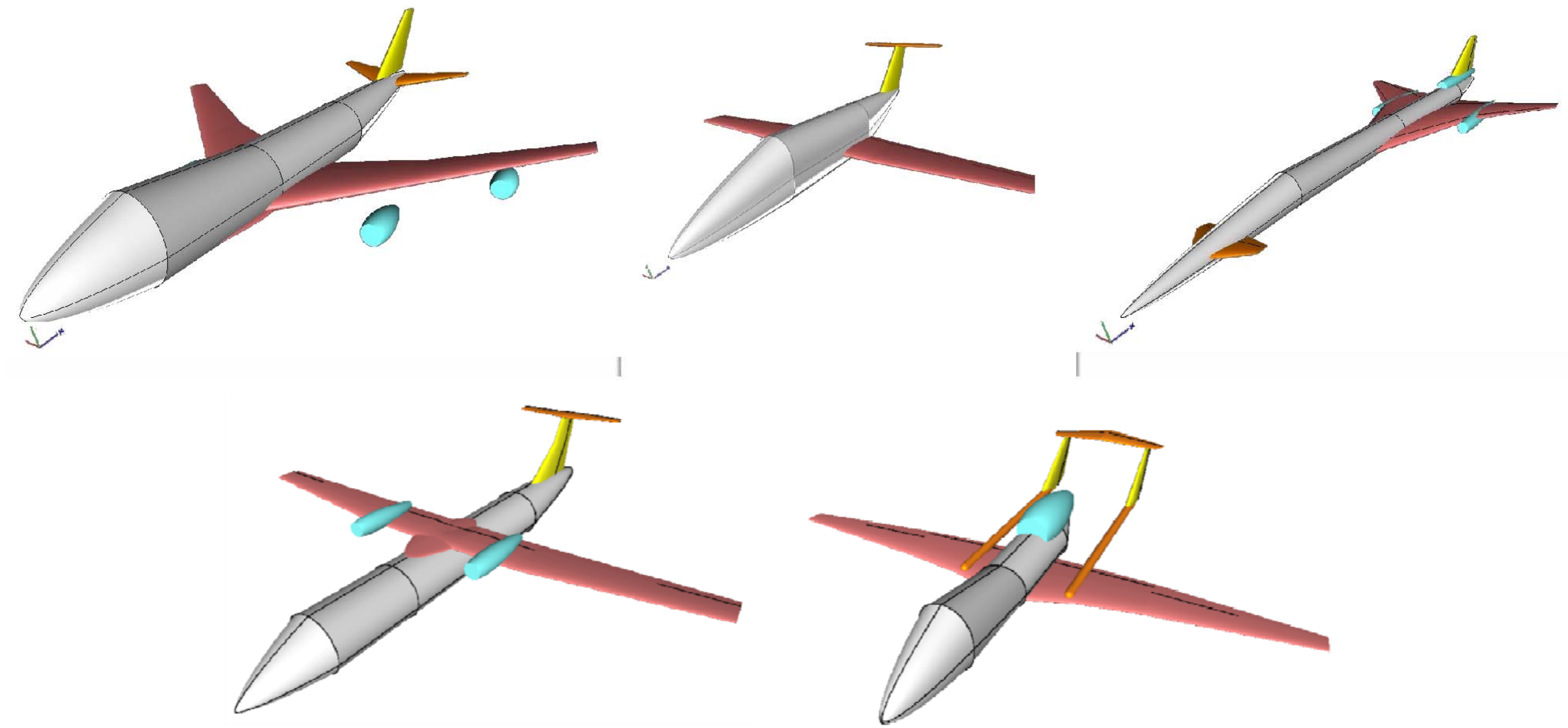
AcBuilder module

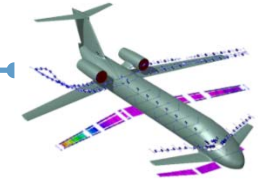
AcBuilder (Aircraft Builder) is:

- A graphical editor to prepare the aircraft XML file requested by NeoCASS and other modules of Ceasiom.
- The standard pre-processor for **NeoCASS**.



Different layout available





GUESS: a module for the initial sizing

GUESS (**G**eneric **U**nknowns **E**stimator in **S**tructural **S**izing)

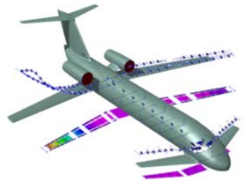
Why the need for a 'GUESS' initial sizing?

- Since the weight estimating formulas are based on existing aircraft, their application to unconventional configuration (i.e., canard aircraft) is difficult;
- The impact of advanced technologies and materials cannot be assessed in a straightforward way.

GUESS enhances the NASA-PDCYL code by Ardema [1] with:

- Sizing of complete aircraft based on certification rules;
- Calculation of torsional and shear structural properties through semi-monocoque theory;
- Non-conventional aircraft.

[1] Ardema A. et al. Analytical Fuselage and Wing Weight Estimation of Transport Aircraft, NASA Technical Memorandum 110392)



GUESS : a module for the initial sizing (contd)

The total amount of load-bearing structural weight is determined on:

- Real material properties
- Real aircraft layout (conventional or not)
- Real load conditions

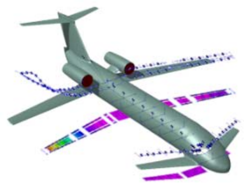
Two methods implemented:

- **Rigid aircraft**: force method, single mass configuration;
- **Elastic Aircraft**: displacement method, multi mass confs, non conventional architecture.

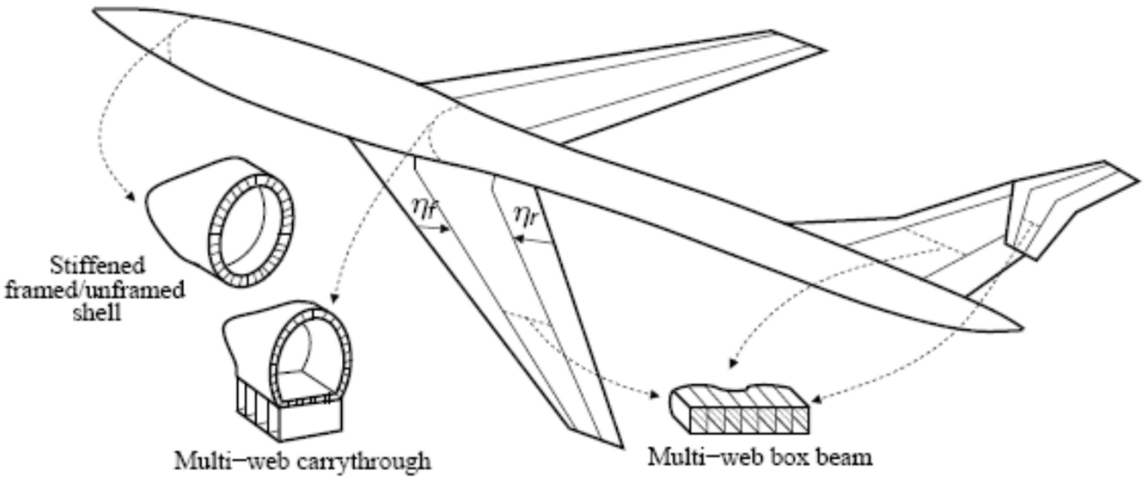
Once loads are determined on rigid aircraft (using VLM-based aerodynamics), **GUESS** sizes each component section by section.

Limits:

- No aeroelastic effects considered;
- Fully-stressed sizing based on max. stress and/or instability loads (local-global) and isotropic materials.



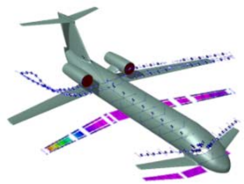
Structural layout



Structural layout adopted by **GUESS**:

- Multi-web structure for lifting surfaces and carrythrough component;
- Stiffened framed-unframed shell for fuselage;
- A typical wingbox section (available since version 2.0 of **NEOCASS**)

Once computed the structural weight, the total weight is obtained by summing up the non structural weights resulting from **W&B** module.



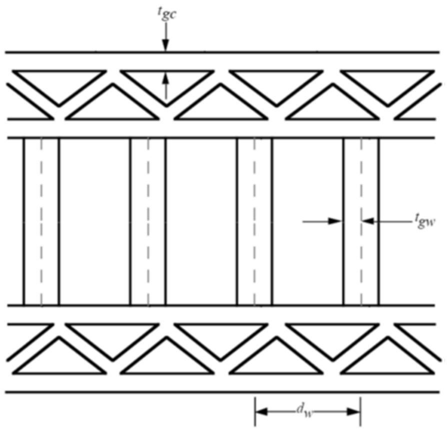
Lifting surfaces sizing

Features:

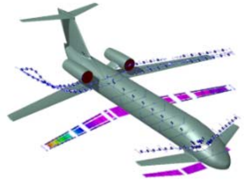
- The minimum amount of material is determined for each section
- **GUESS** adopts different concepts of multi-web box beam with span-wise webs
- Each concept is analitically proportioned to maximize different performances (buckling, minimum gage,…)
- A regression takes into account secondary structural weight (joints, fasteners, landing gear support, bulkheads, high lift devices…)

K_{con}	*Covers*	*Webs*
1	Unstiffened	Truss
2	Unstiffened	Unflanged
3	Unstiffened	Z-stiffened
4	Truss	Truss
5	Truss	Unflanged
6	Truss	Z-stiffened

Lifting surfaces structural concepts



Sketch of the wing concept



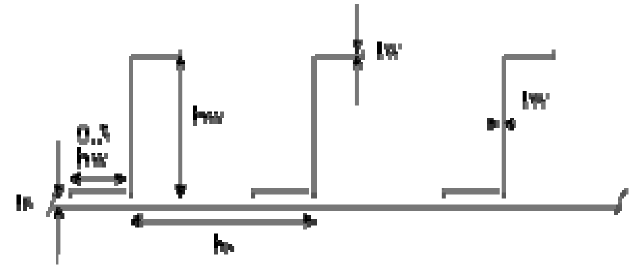
Fuselage sizing

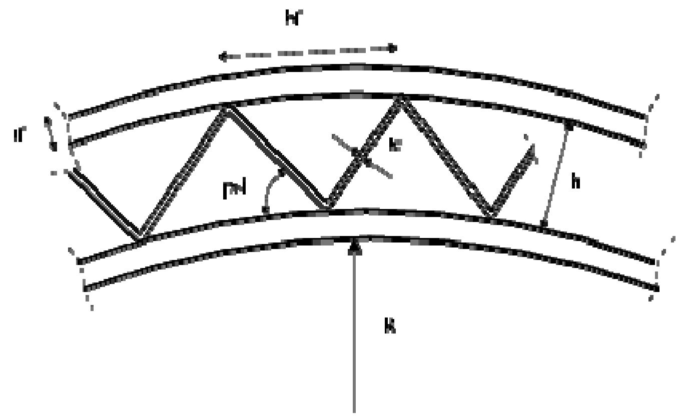
Features:

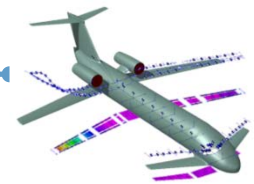
- **GUESS** adopts different concepts of stiffened shells with/without frames
- A regression takes into account secondary structural weight (flooring, pressure webs, …)

K_{con}	***Description***
1	Simply stiffened shell, frames sized for minimum weight in buckling
2	Z-stiffened shell, frames best buckling
3	Z-stiffened shell, frames buckling-minimum gage compromise
4	Z-stiffened shell, frames buckling.pressure compromise
5	Truss-core sandwich, frames best buckling
6	Truss-core sandwich, no frames
7	Truss-core sandwich, no frames, buckling-minimum gage-pressure compromise

Fuselage structural concepts



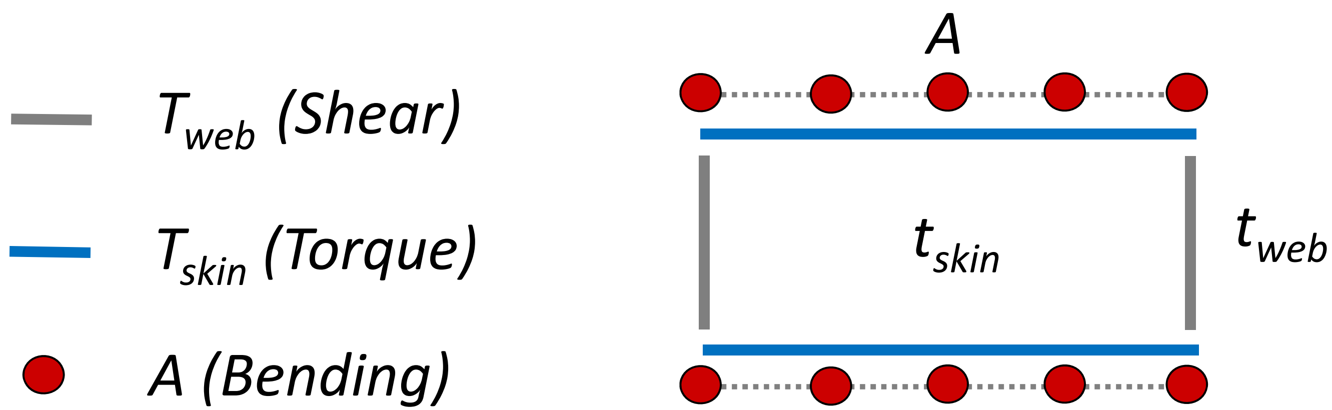


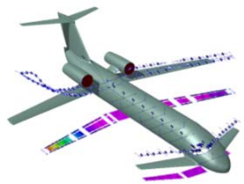


The NEW wingbox structural layout for lifting surfaces

- Implements semi-monocoque concept.
- Three main design variable adopted during initial sizing with Guess.
- Possible generalization up to 10 design variables during MDO.
- Strength and stability constraints taken into account during initial sizing.

New Wingbox Section Model (kcon=9)

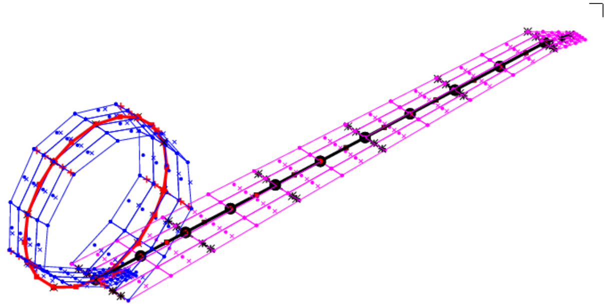


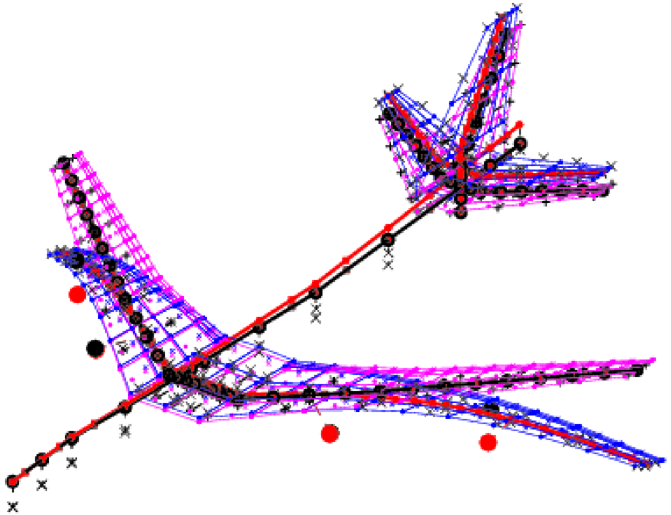


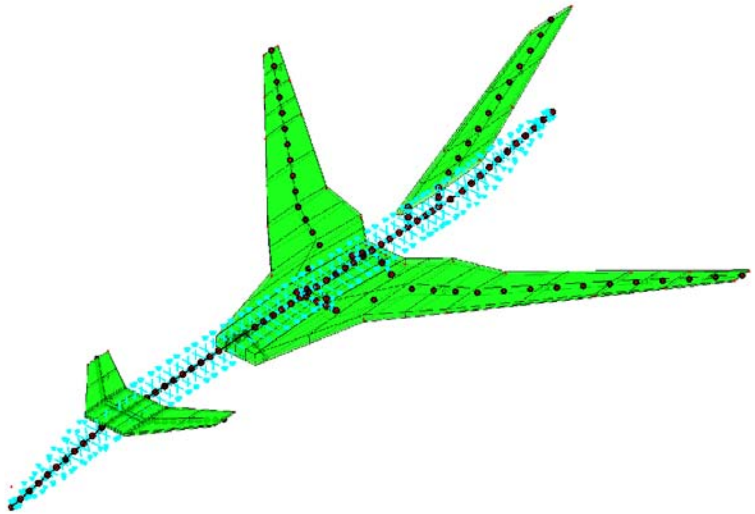
Structural models in GUESS

Two kind of structural models available:

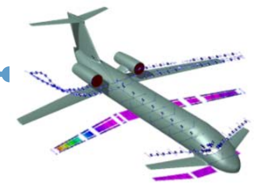
- Three nodes linear-nonlinear beam [2]
- Equivalent plate
- Hybrid models





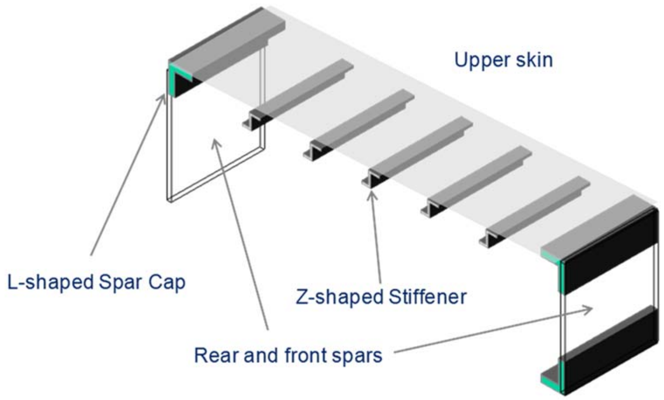


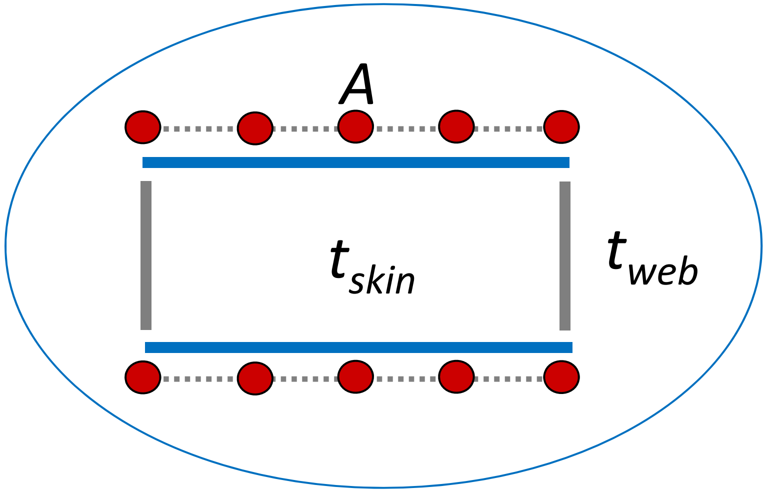
[2] Ghiringhelli, G. L., Masarati, P., and Mantegazza, P., "*Multibody Implementation of Finite Volume C0 Beams*" **AIAA Journal**, Vol. 38, No. 1, January 2000.



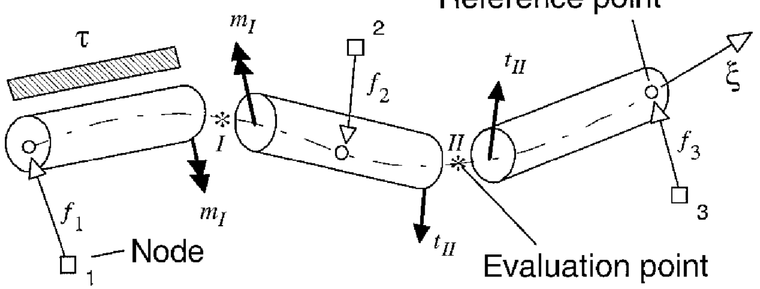
The NEW wingbox structural layout for lifting surfaces

The stick model is obtained by condensing a **physically-based** model of the wingbox, sized through a local optimization run section by section.

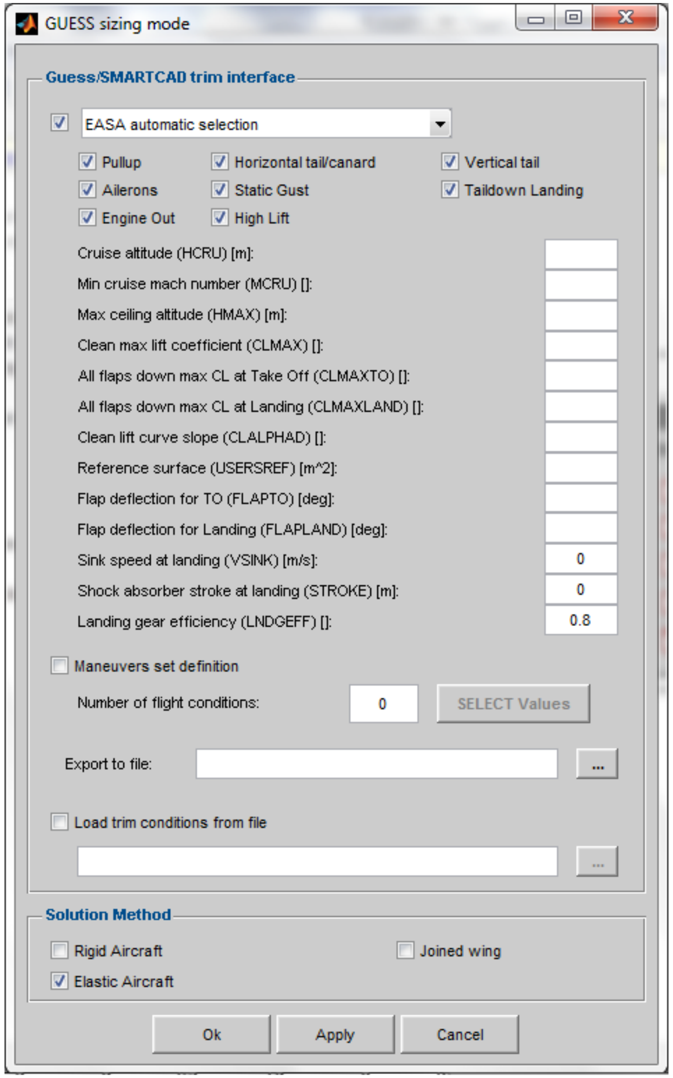




GUESS Design Space

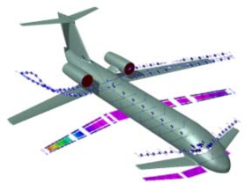


GUESS sizing Loads

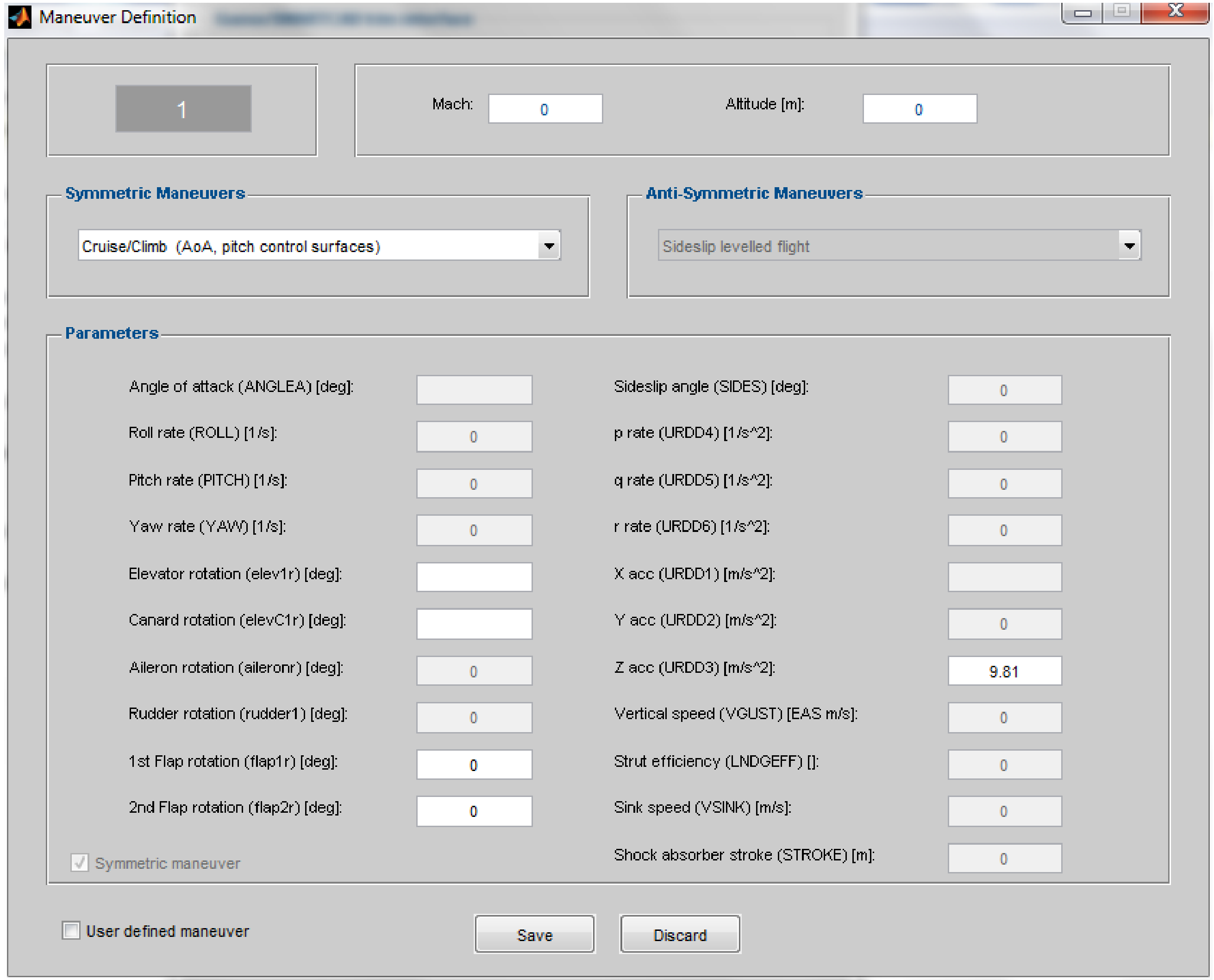


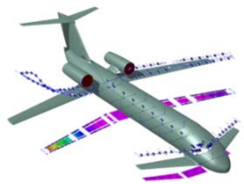
The sizing loads are defined **automatically** based on certification rules or **provided by the users**.

They are formulated in terms of frozen maneuvers used to trim the aircraft

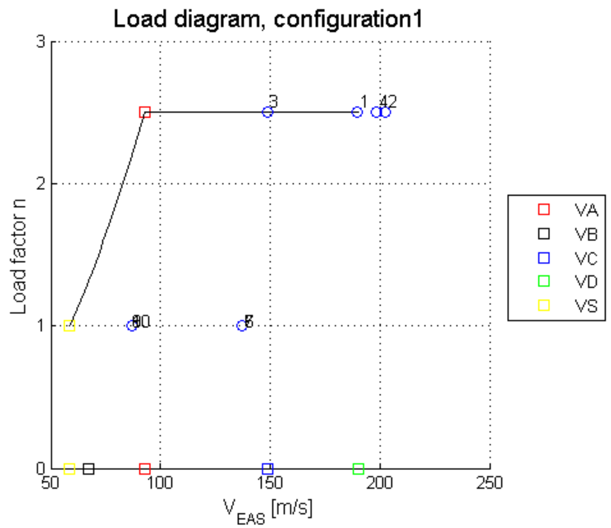


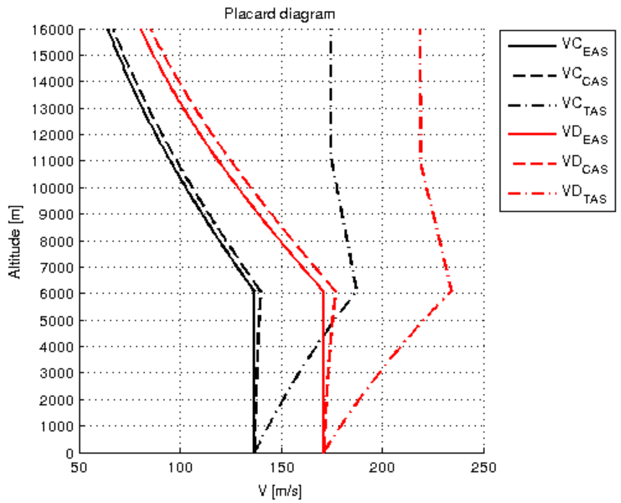
GUESS sizing Loads





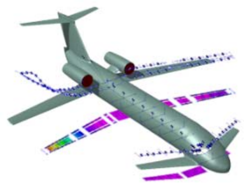
GUESS sizing Loads





Different mass configurations, combining different values of pax and fuel, can be used and related to different maneuvers.

ID	Type	Mass conf.	Mach	V [KEAS]	Z [ft]	Nz
1	Cruise @Vc	MTOW	0.484	320	0	1
2	Nz max @Vc	MTOW	0.484	320	0	2.5
3	Nz max @Vc	MZFW	0.484	320	0	2.5
4	Nz min @Vc	MTOW	0.484	320	0	-1
5	Nz max @Vd	MTOW	0.605	400	0	2.5
6	Nz max @Va	MTOW	0.36	235	0	2.5
7	Nz max @Vc	MZFW	0.81	320	25918	2.5
8	Nz max @Vc	MTOW	0.81	320	25918	2.5
9	Cruise (β=20°) @Vc	MTOW	0.484	320	0	1
10	Static Gust @Vc	MZFW	0.484	320	0	3.1



GUESS Overview

The total amount of load-bearing structural weight is determined on:

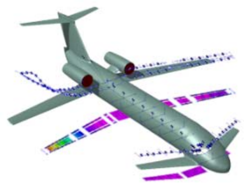
- ✓ Real material properties
- ✓ Real aircraft layout (conventional or not)
- ✓ Real load conditions

Both Forces (rigid) and Displacements (deformable) approaches implemented for structural sizing.

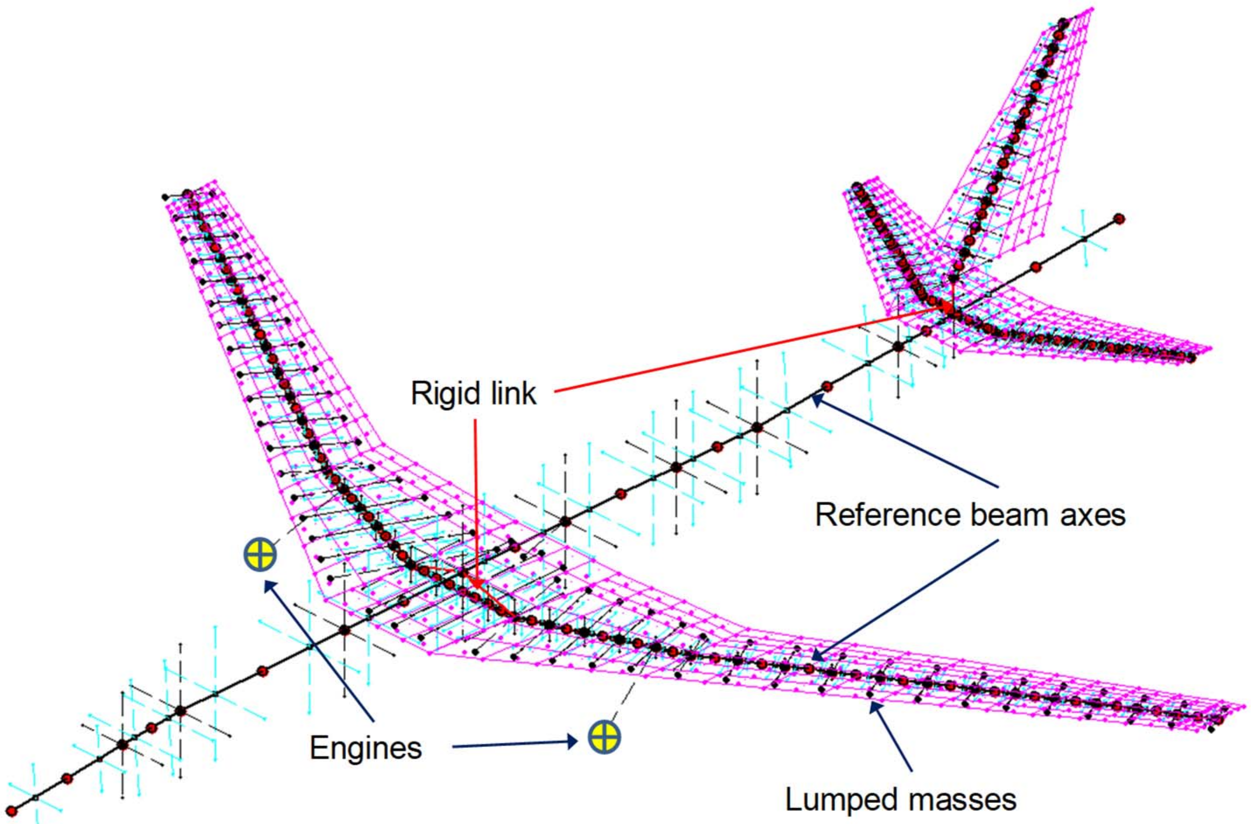
Once loads are determined on aircraft using VLM-based aerodynamics, **GUESS** sizes each component section by section, using fully-stressed design based on max. stress and/or instability.

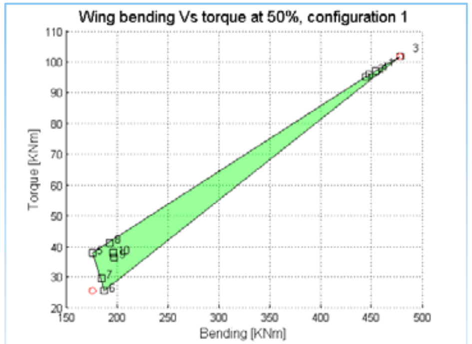
Limits:

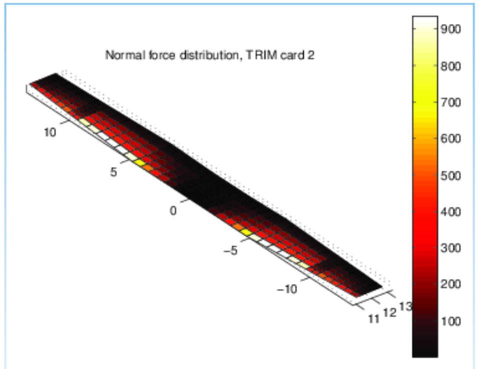
- ✗ No aeroelastic requirements explicitly considered during sizing
- ✗ Isotropic materials.

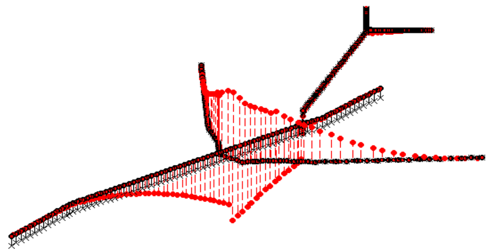


GUESS Outputs

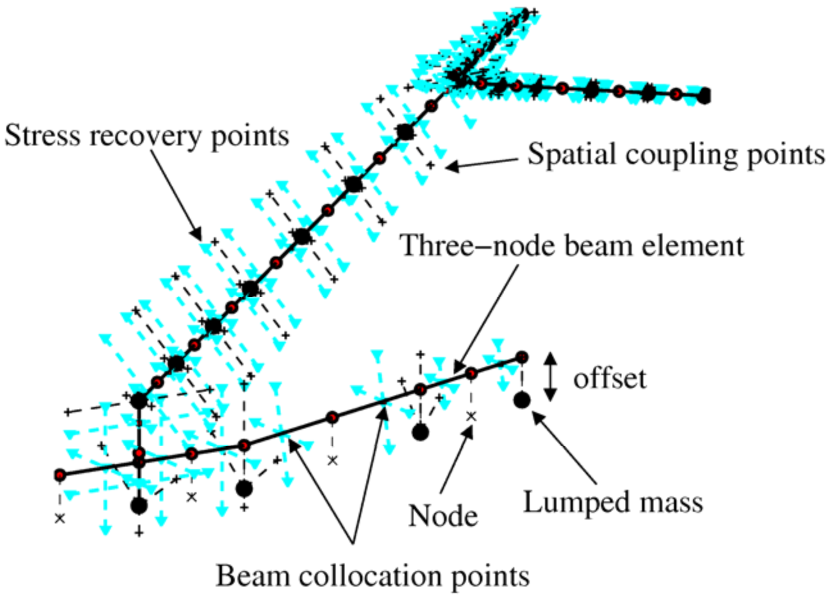


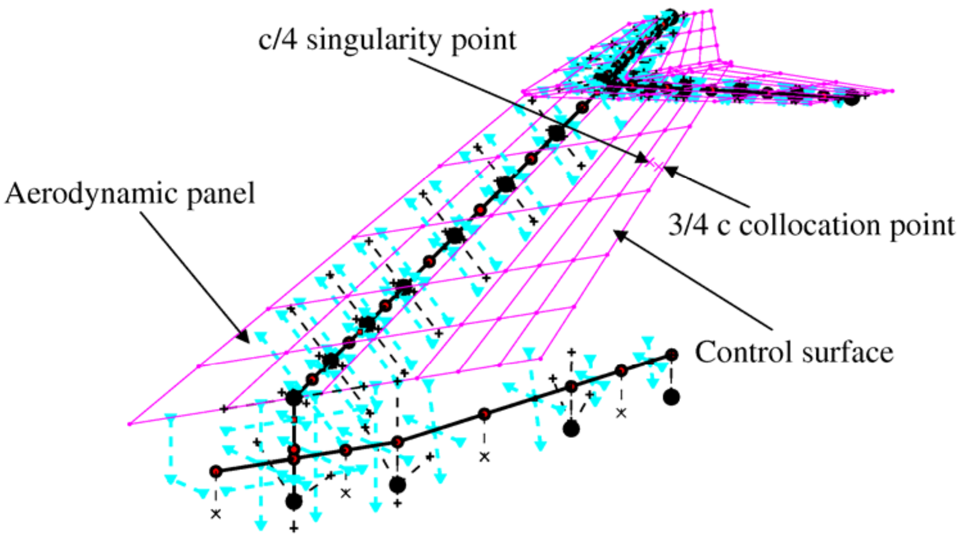






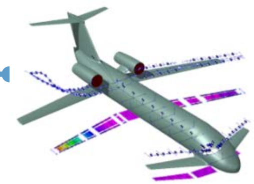
GUESS: automatic stick model generation





Items automatically generated:

- Stick model and mechanical properties;
- Stress-recovery points;
- Extra-nodes for Fluid-Structure coupling.

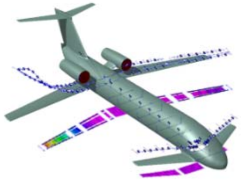


The NEW wingbox structural layout for lifting surfaces

- Two optional parameters can be included into XML file to specify (for each lifting surface) the stiffeners and ribs pitch.

```
user_input.material_property.wing.spitch
user_input.material_property.wing.rpitch
```

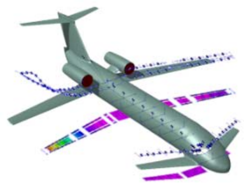
- If not included, the code automatically defines ribs pitch=0.55 m and stiffeners pitch comprised between .16 and .17 m.
- **IMPORTANT**: to select option kcon=9 the Matlab Optimization Toolbox must be installed on the computer running **NeoCASS**.



SMARTCAD overview

SMARTCAD (***S****implified* ***M****odels for* ***A****eroelasticity in* ***C****onceptual* ***A****ircraft* ***D****esign*)

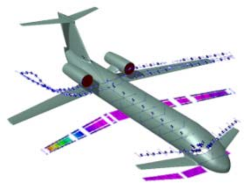
- **Input**: ASCII files derived from NASTRAN® formats. Why?
  - ✓ Platform independent;
  - ✓ To avoid wasting time to define and learn a new format;
  - ✓ Commercial pre/post-processors can be used to visualize the model and results;
  - ✓ **SMARTCAD** can be almost easily bypassed in favor of NASTRAN® without precluding the overall functionality of CEASIOM design tool;
  - ✓ The comparison with the validated commercial code is then straightforward.



SMARTCAD overview

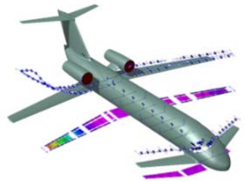
Once available, the aeroelastic model can be processed by **SMARTCAD** to compute:

- Static aeroelasticity;
  - ✓ Divergence speed;
  - ✓ Deformable trimmed configuration;
  - ✓ Flexible stability derivatives.
- Dynamic aeroelasticity;
  - ✓ Flutter diagram (*V*-g plot);
  - ✓ Flutter envelope.
- MDO, to improve any of the aeroelastic responses by changing the structural properties initially estimated by **GUESS**.



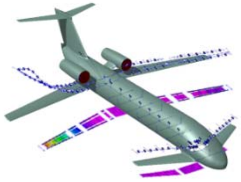
SMARTCAD: static aeroelastic problem formulation

- NASTRAN-like formulation (mean axes formulation, to nullify the inertial coupling and a quasi-steady approximation for aerodynamic forces);
- Control surface mechanical stiffness and damping are neglected:
- Six reference conditions have to be defined in order to correctly couple the reference motion and the structural one;
- In case of multi-control surfaces linear constraints are introduced to reduce the total number of degrees of freedom for trimming;
- Typical results: deformable/rigid stability derivatives, free flying aircraft trimmed configuration, divergence speed.

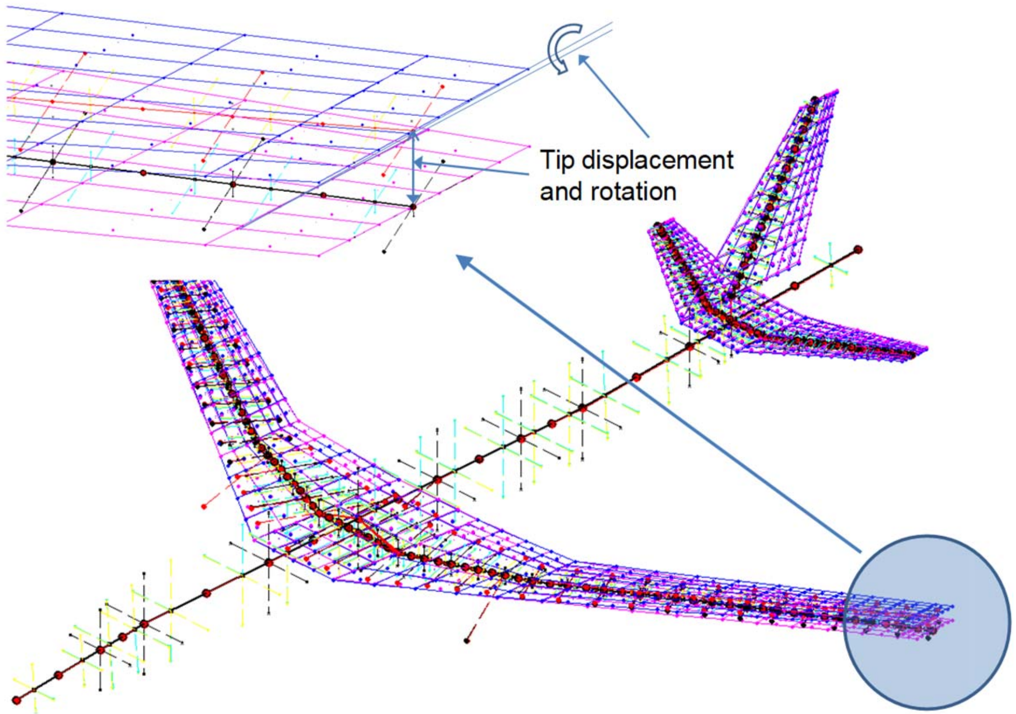


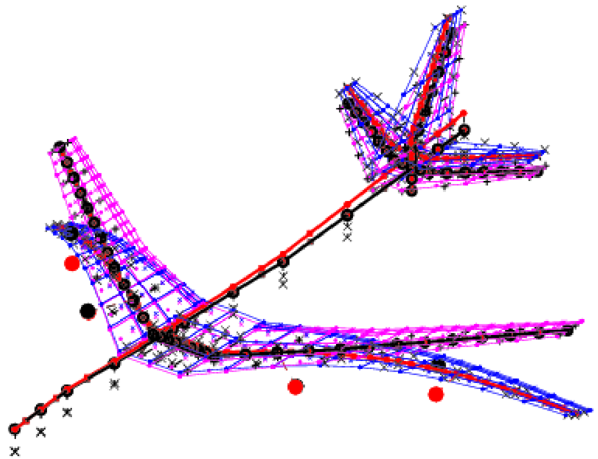
SMARTCAD*:* linearized flutter analysis

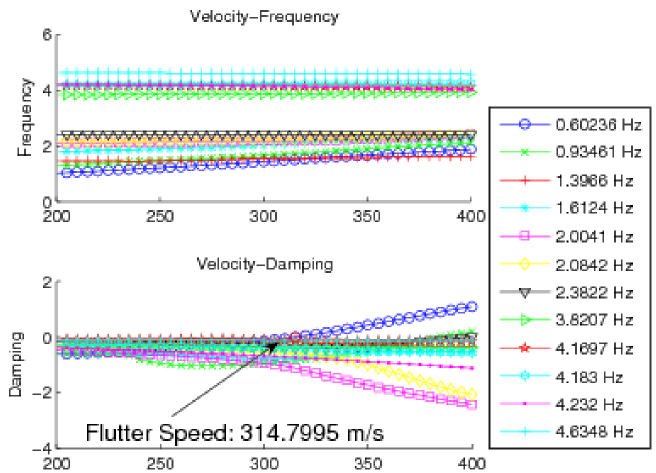
- Typical assumptions based on assumed structural shapes, the availability of an aerodynamic transfer matrix H_{am} and the Laplace domain s; static corrections available (T-Tail).
- The flutter system of equations is solved in a continuative way, i.e. as a nonlinear algebraic system of equations with the eigenvalue and the eigenvector as unknowns.
- Particularly suitable for optimization purposes since it unifies analysis and sensitivity calculation in a very effective way.
- Eigenderivatives come from the solution of a linear system of equations determined by differentiating the nonlinear equations with respect to a structural parameters.
- The coefficient matrix to be used is the same as the one used for the flutter-tracking process but with a different right hand side.



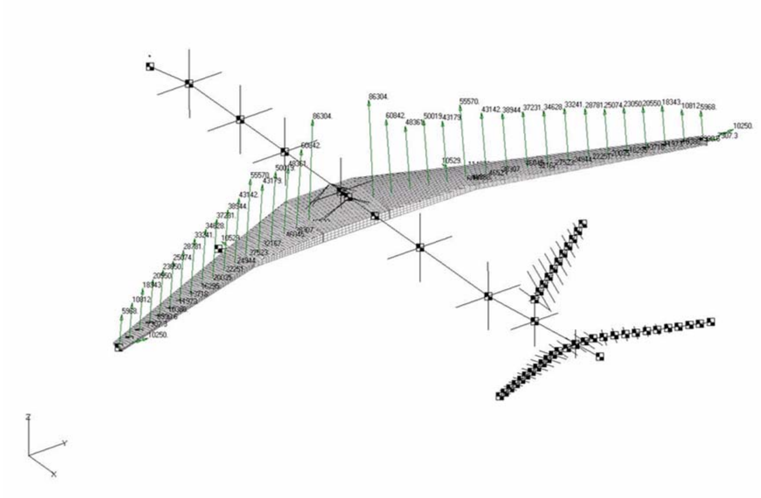
SMARTCAD Outputs



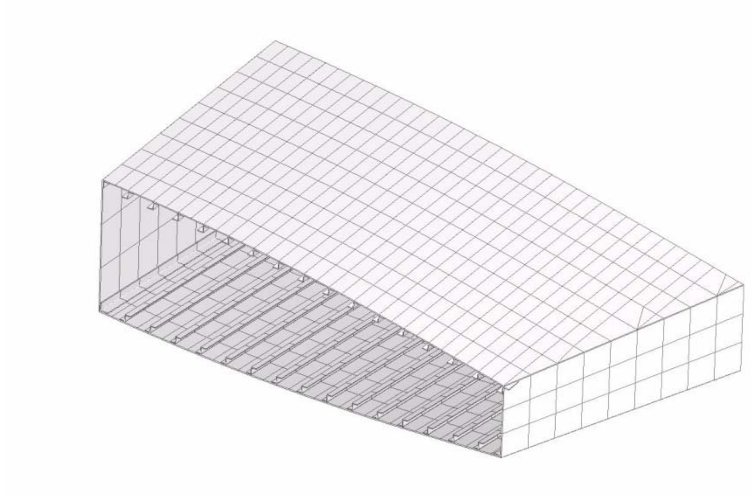




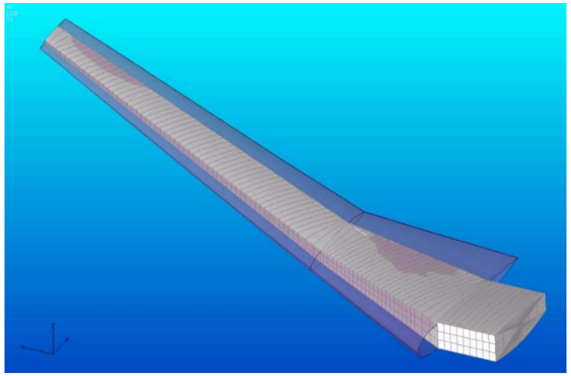
Examples: advanced regional aircraft



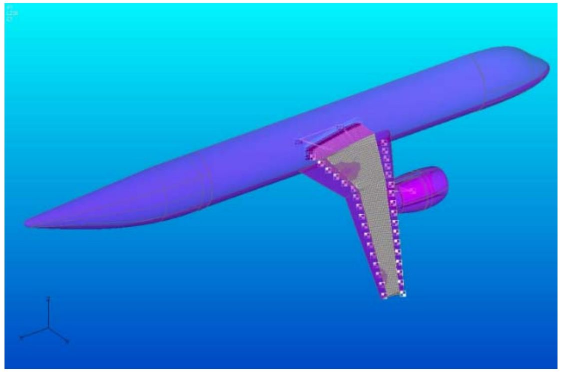
Hybrid model



3D model of the wingbox

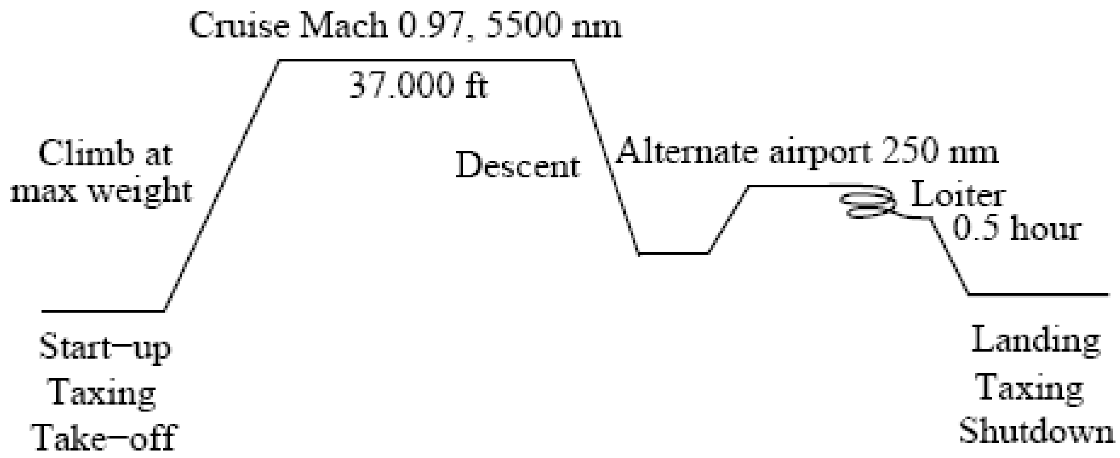


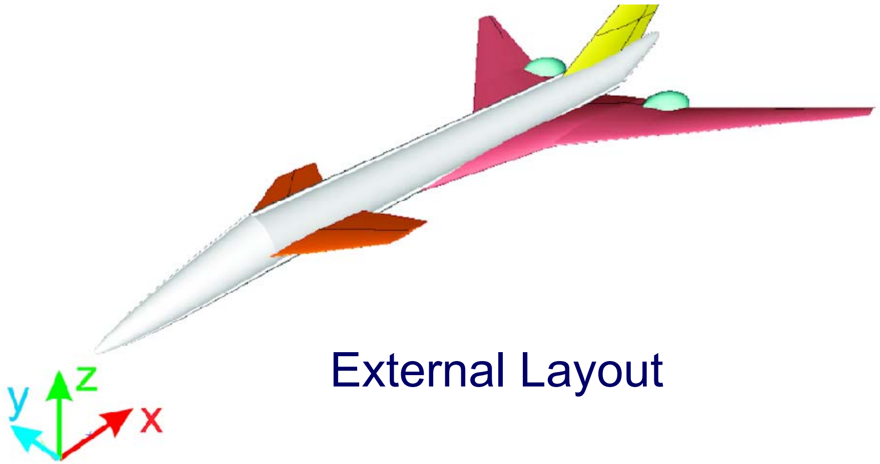
Details of the wing



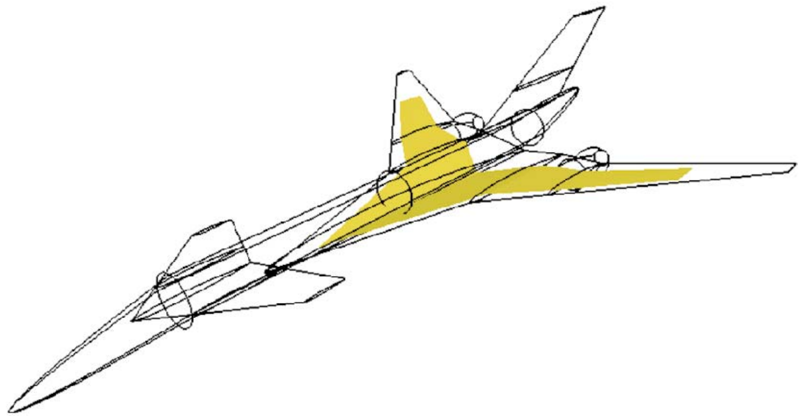
Half body with embedded wbox

Examples: Transonic cruiser (TCR)



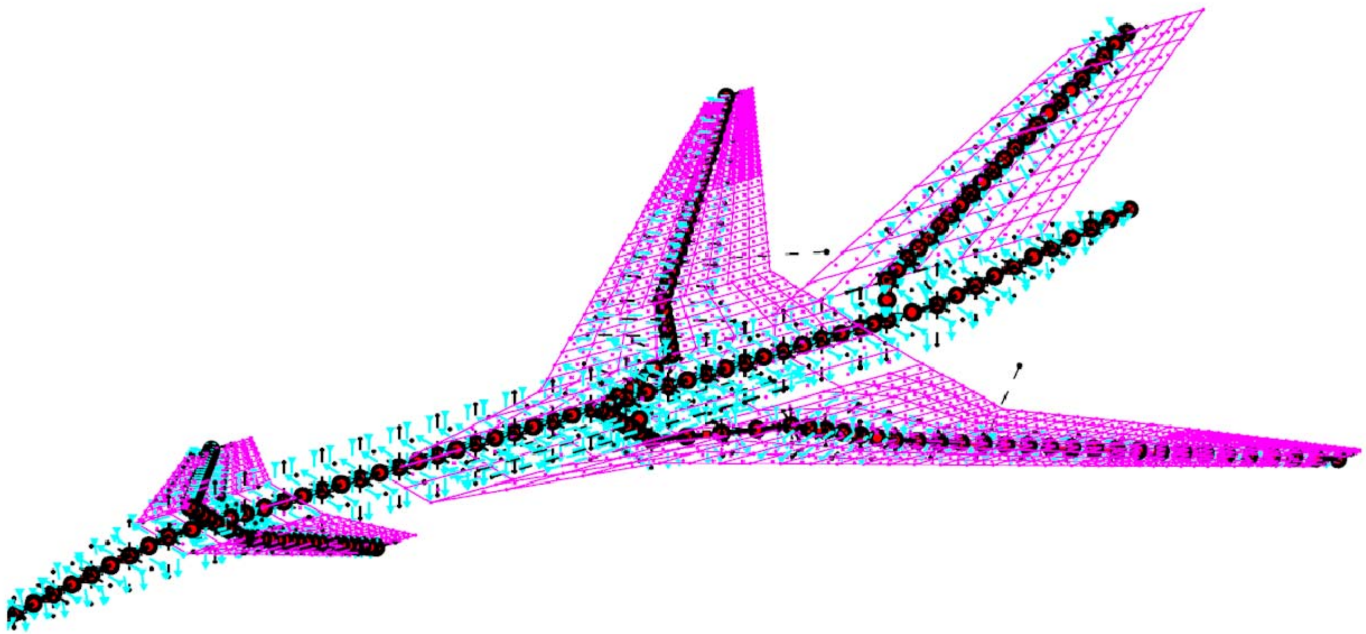


External Layout



Fuel distribution

Examples: Transonic cruiser (TCR)

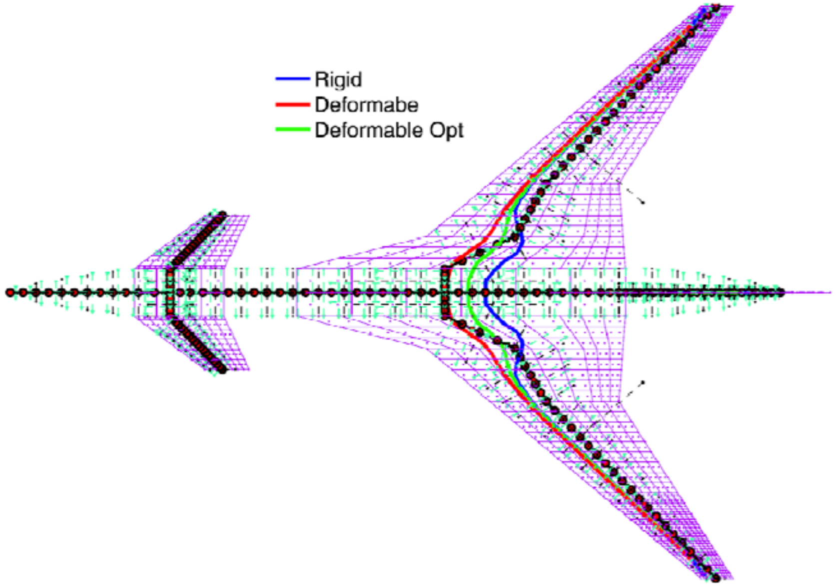


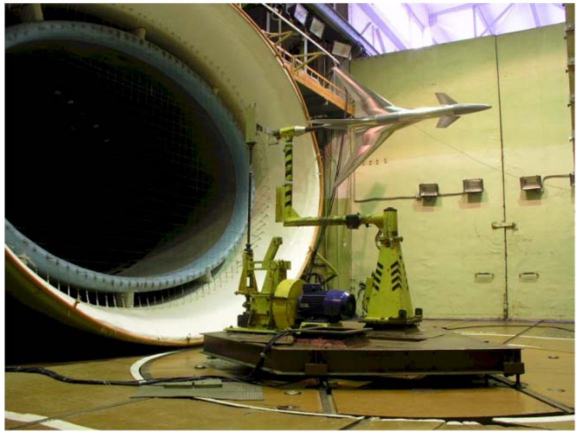
The complete aeroelastic model

Cavagna L., Ricci S., Travaglini L.: *NeoCASS: An integrated tool for structural sizing, aeroelastic analysis and MDO at Conceptual Design Level*, Progress in Aerospace Sciences, Vol. 47, N. 8, 2011, p. 621-635, doi:10.1016/j.paerosci.2011.08.006.

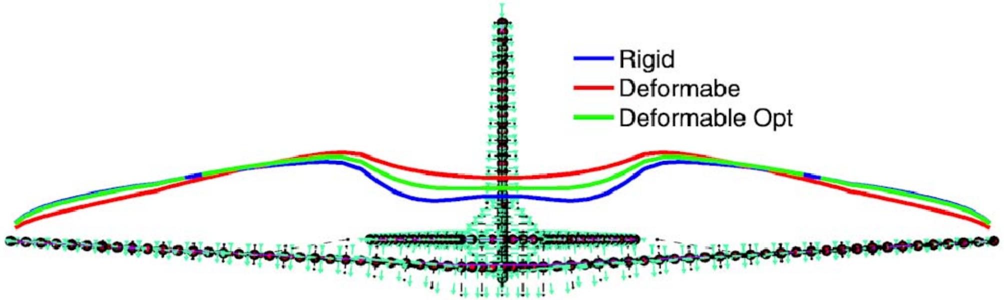
Examples: Transonic cruiser (TCR)

Wind tunnel model



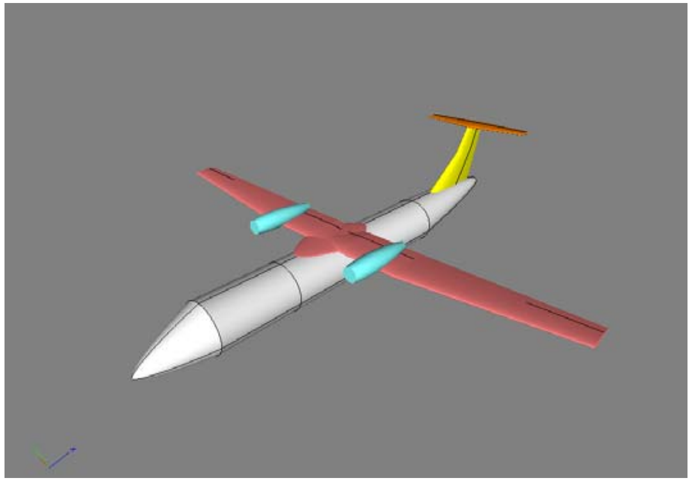


Testing at TsAGI

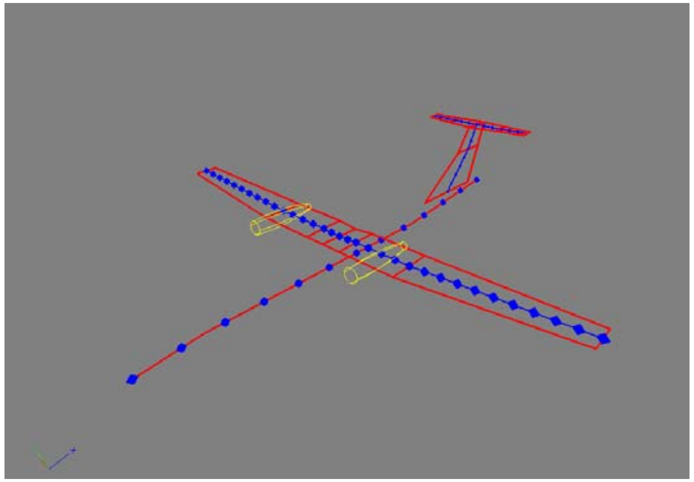


MDO results

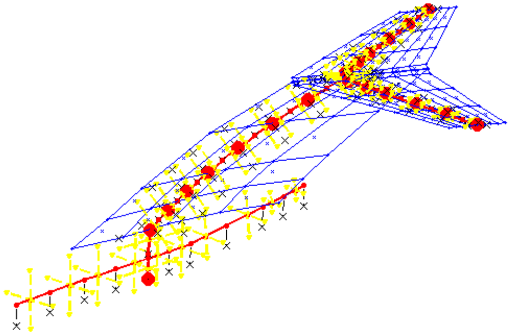
Examples: Twin Prop optimization

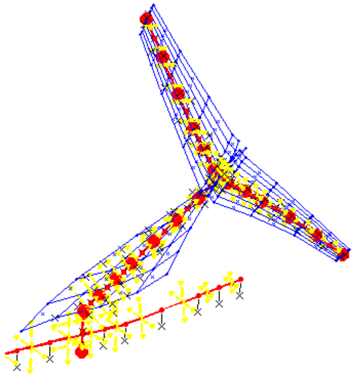


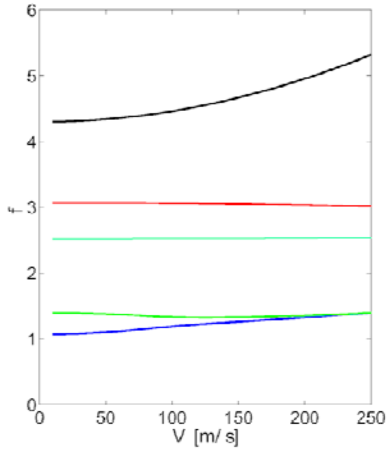
External Layout

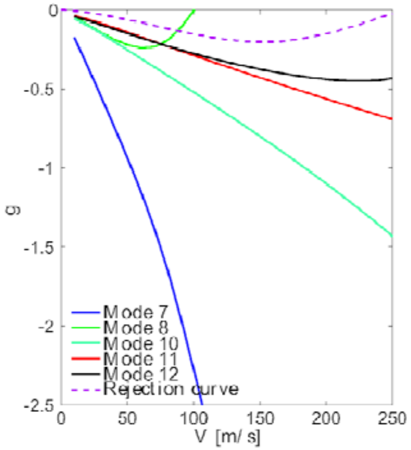


Structural model

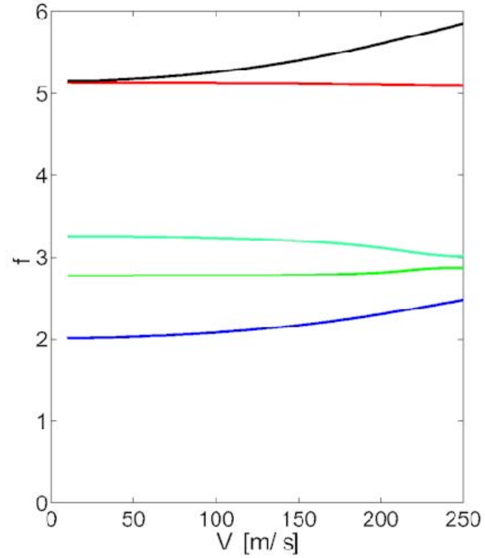


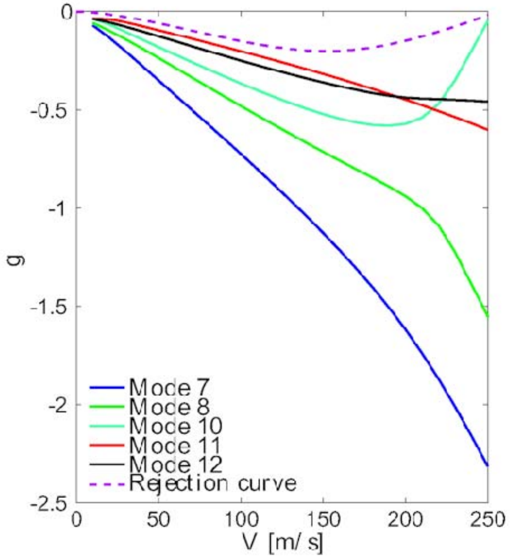




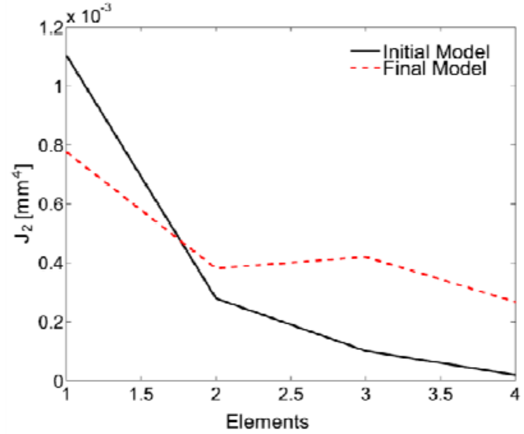


Examples: Twin Prop optimization

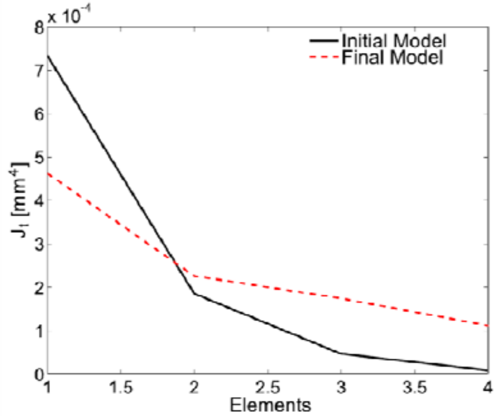


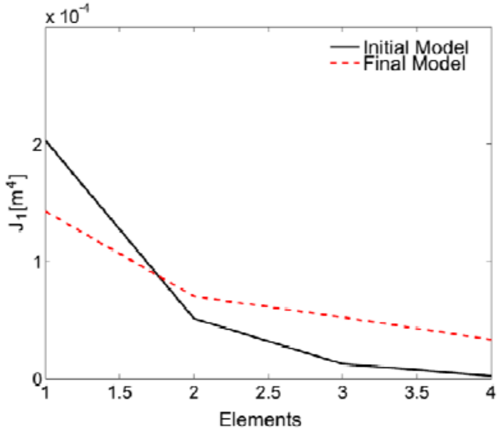


Final V-g plot



In plane bending stiffness

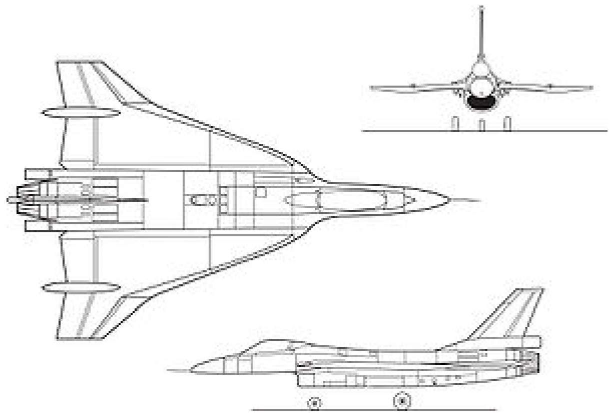




Torsional stiffness Out-of plane bending stiffness

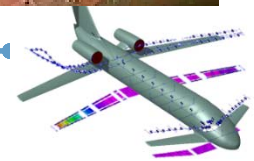
Examples: F16XL structural model generation

Inputs used: data available on public literature



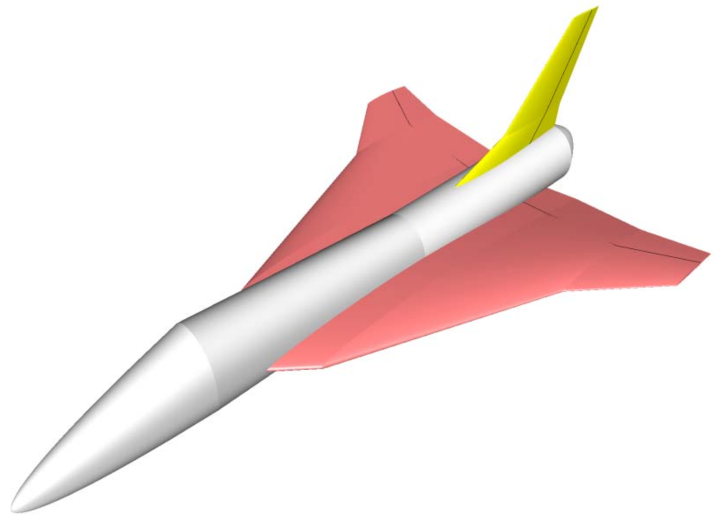
General characteristics
Crew: One or Two
Length: 54 ft 2 in (16. 51 m)
Wingspan: 34 ft 3 in (10. 44 m)
Height: 17 ft 7 in (5. 36 m)
Wing area: 633 ft² (58. 8 m²)
Empty weight: 22,000 lb (9,980 kg)
Loaded weight: 48,000 lb (21 800 kg)
Max takeoff weight: 48,000 lb (22,000 kg)
Powerplant: 1× General Electric F110-GE-100
Dry thrust: 17,155 lbf (76. 3 kN)

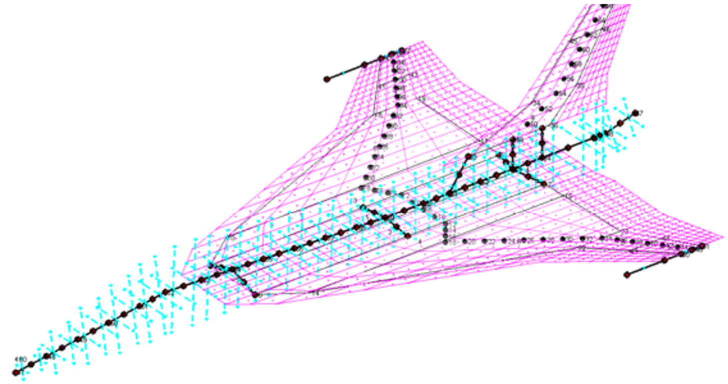
NASA-TM 104264 *Ground Vibrations and Flight Flutter Tests of the Single-Seat F16XL with a Modified Wing*, D.F.Voracek, June 1993



Examples: Examples: F16XL structural model generation

- VLM aerodynamic model for loads
- Aeroelastic Trim, free-free condition
- Stiffnesses ad masses distribution from NeoCASS suite (www.neocass.org)
- Hybrid model: lifting surfaces with linear equivalent plate, fuselage with linear beam model
- No aerodynamic model for fuselage
- Inboard flaperon used as trim surface (pitch)
- MASS configuration = 12196 kg
- Updating after initial sizing to improve numerical vs. experimental frequency matching

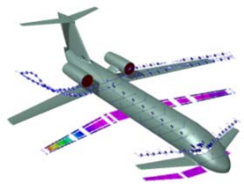




Examples: Examples: F16XL structural model generation

	Measured [Hz]	Hybrid [Hz] GUESS sizing	Hybrid [Hz] after updating
1st bending (symmetric)	7.98	17.48	7.98
1st bending (anti-symmetric)	10.79	18.73	8.13*
1st bending fin	12.48	26.39	12.48
1st torsion (symmetric)	13.70	54.77	13.70

* Mode not included in the updating process



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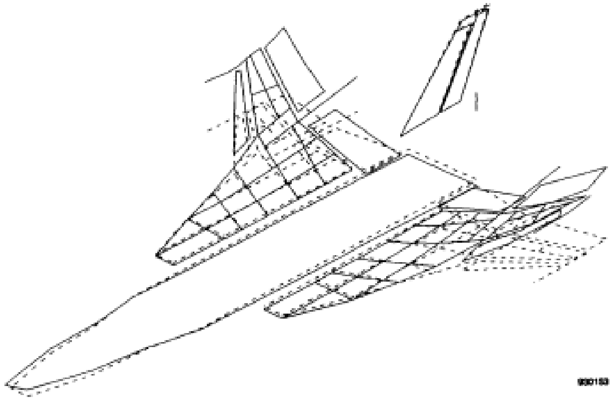
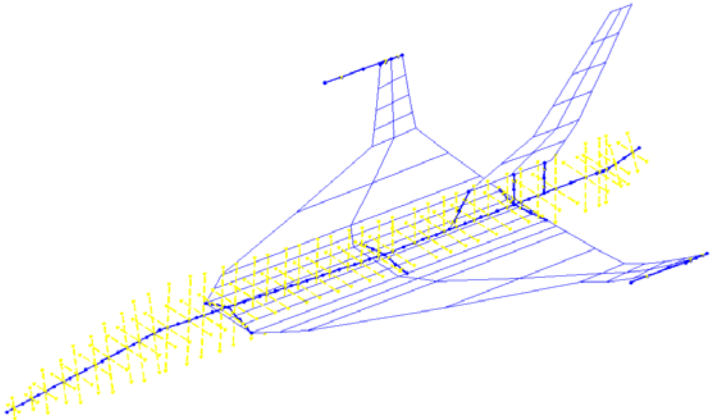
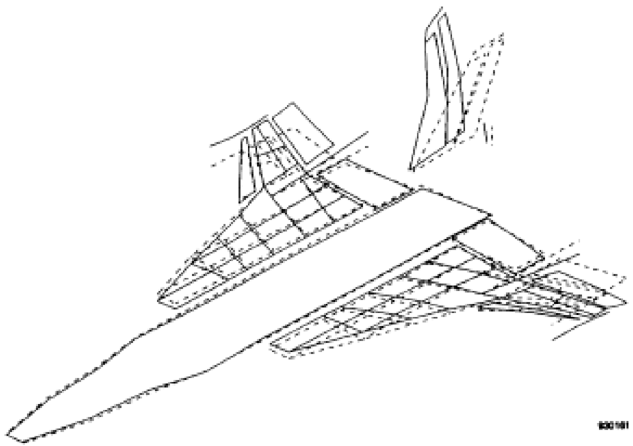


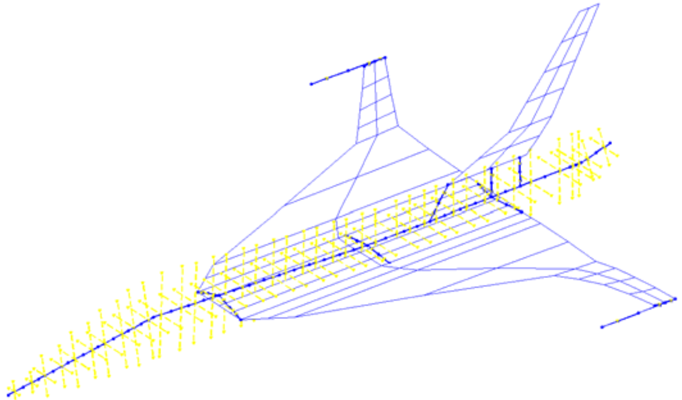
(a) Baseline, 7.98 Hz.



First bending symmetric

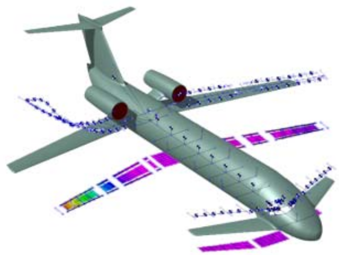


(a) Baseline, 10.79 Hz.



First bending anti-symmetric

AcBuilder Overview



AcBuilder: overview

What is AcBuilder?

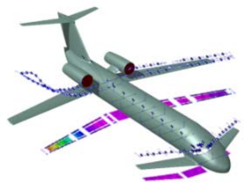
- AcBuilder is a graphic editor of XML file including some CAD capabilities.
- It is a tool running under Matlab used to support the user in the preparation of aircraft XML file to be processed by CEASIOM or its single modules like NeoCASS.
- It is the standard pre-processor for NeoCASS module.

What are the requested inputs to run AcBuilder?

- The geometric data describing the aircraft.

What are the typical outputs produced by AcBuilder?

- A single .XML file that describes completely the aircraft.
- Snapshots of different windows.

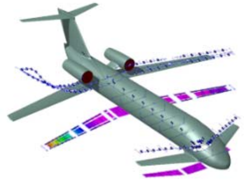


AcBuilder: Menus structure

AcBuilder is driven by a top level **Main Menu**, some contextual **Side Menus** and a table-like **Panel** to insert the numeric data.

The top level Main Menu is composed by the following items:

- **Project**
  - *Set default/Import XML/Export XML/Take screenshot/Save data and close/ Close window*
- **View**
  - *Reset/Side/Front/Top/Background color*
- **Geometry**
  - *Component/Fuel/Geometry output/Export SDSA geometry*
- **Weight & balance**
  - *Weight & Balance/Center of gravity*
- **Technology**
  - *Technology/Import XML*



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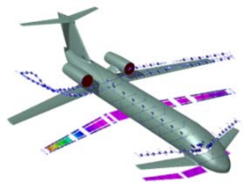
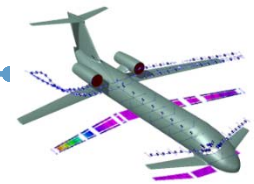


AcBuilder: tips & tricks

- When Acbuilder is invoked from the Matlab command window by entering AcBuilder, a ***template*** aircraft is automatically loaded. In this way, a set of reference data is already defined. The user has simply to modify the data, checking on the screen the results of his changes.
- The default values for Template aircraft are defined in the Matlab routine named *acb_initac.m*
- The airfoil data are included in a subdirectory named airfoil. The full path of this directory must be defined into the matlab routine *acbuilder.m* (variable *afpath*)
- Press Left (or right) mouse button to rotate the aircraft.
- Press CTRL Left (or CTRL right) mouse button to move the aircraft.



AcBuilder: menus and windows

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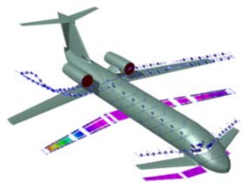
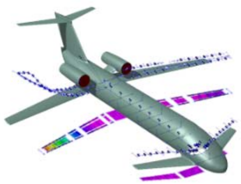
- *Geometry*
  - *Component/Fuel/Geometry output/Export SDSA geometry*
- *Weight & balance*
  - *Weight & Balance/Center of gravity*
- *Technology*
  - *Technology/Import XML*

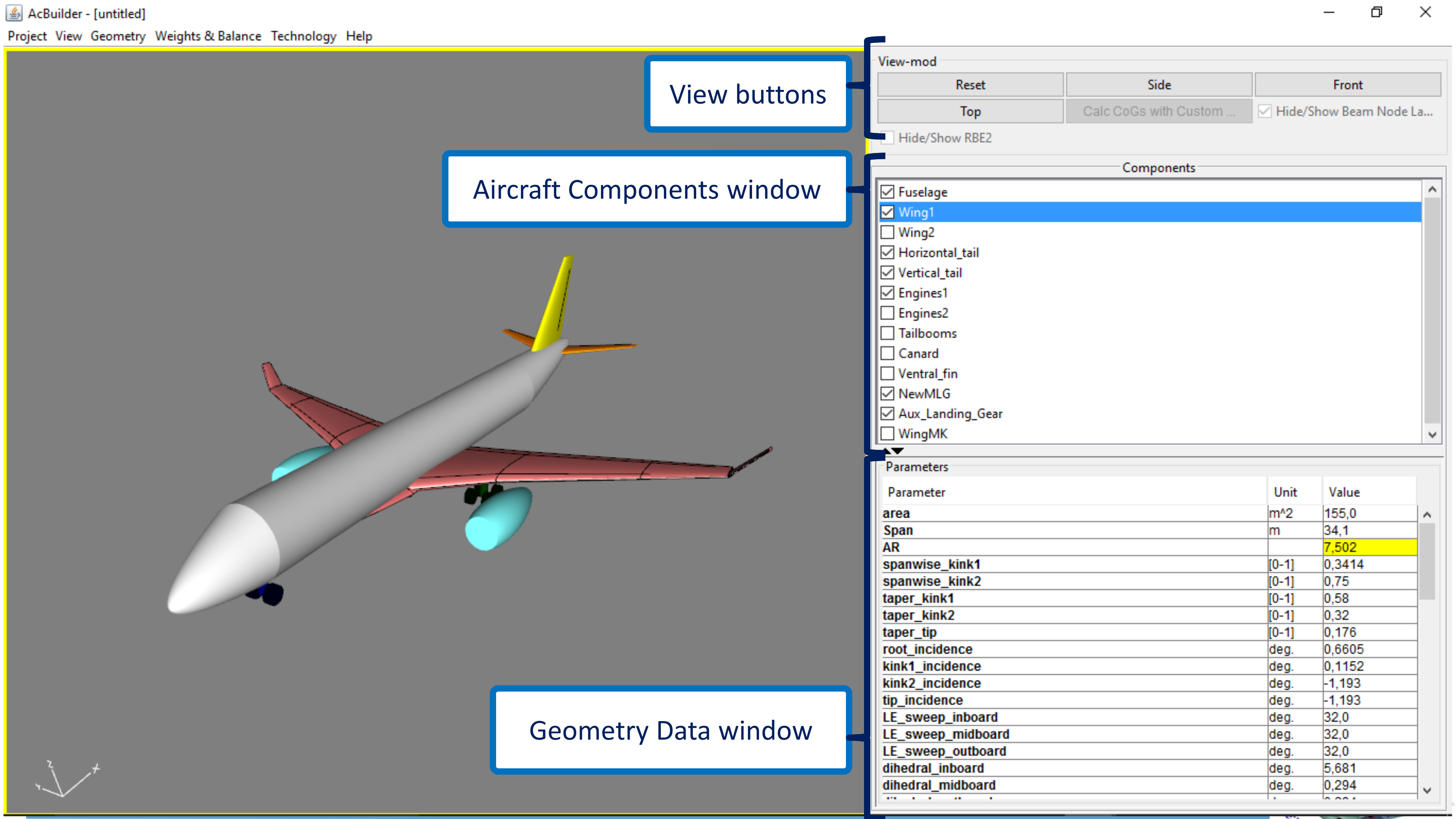


Main menus goals

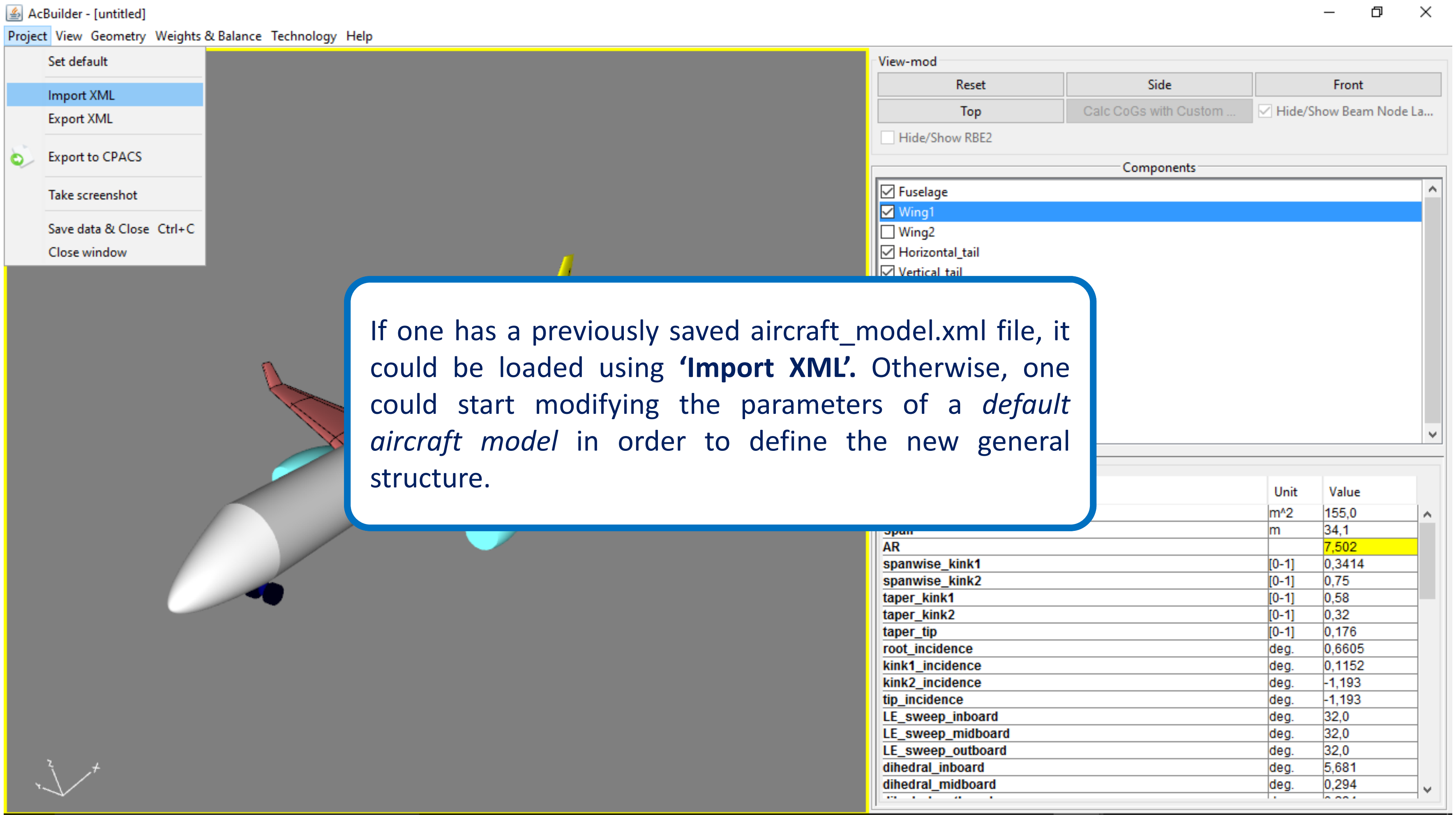
- Project
  - To open, import, export and save the aircraft XML file and to take some screenshots
- View
  - To select the view style and to change the Background color
- Geometry
  - To define the geometry of each aircraft’s component; to define the size of fuel tanks and wingbox; to compute all the relevant geometry properties
- Weight & balance
  - To define the cabin properties; to define the known masses; to compute the weight & balance properties
- Technology (used only for NeoCASS)
  - To define the structural and aerodynamic meshes; to define the material properties; to define some sizing conditions.



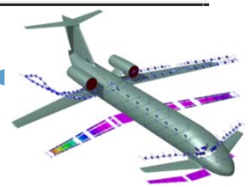
Main menu windows



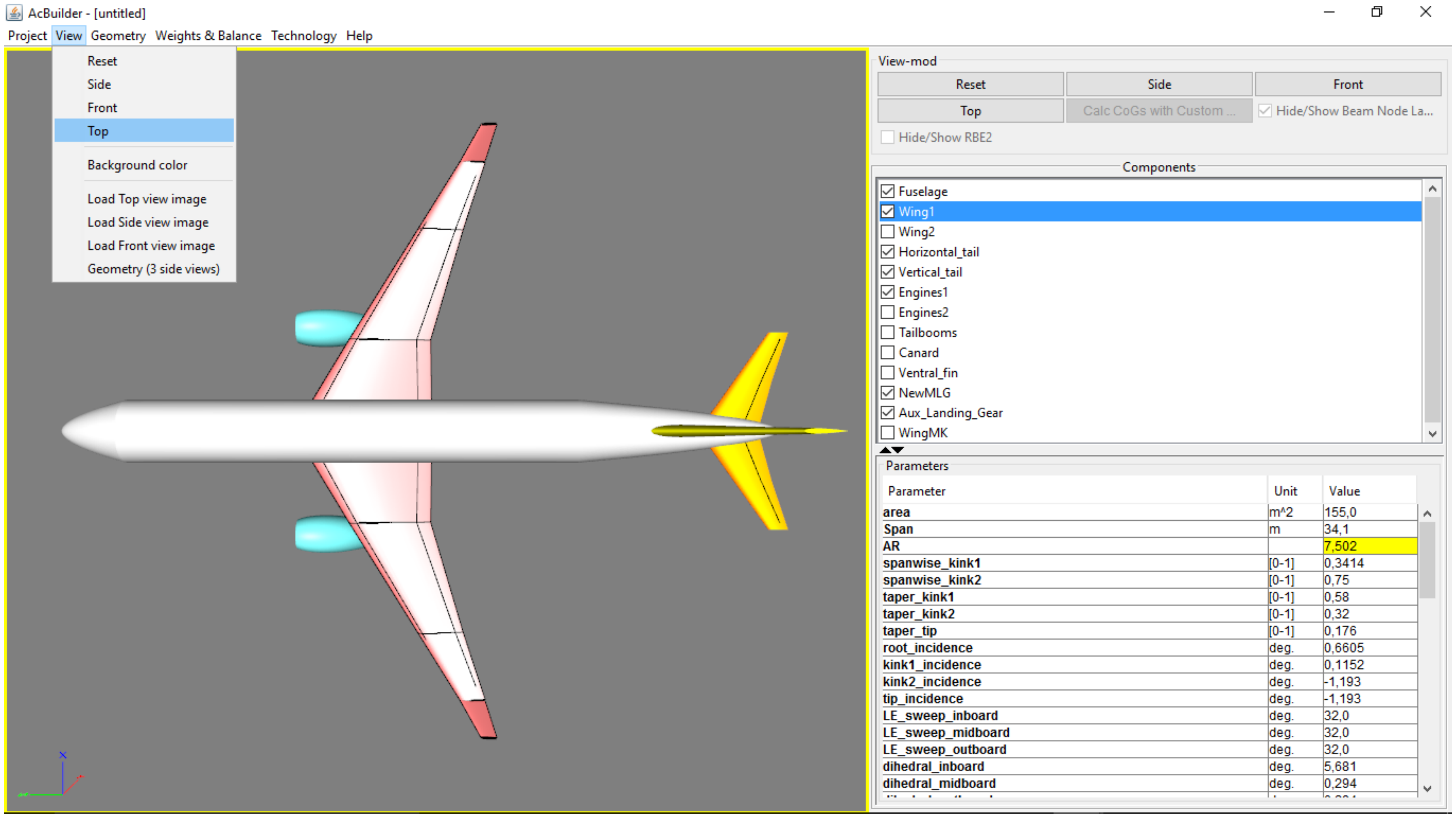
Main menu Project



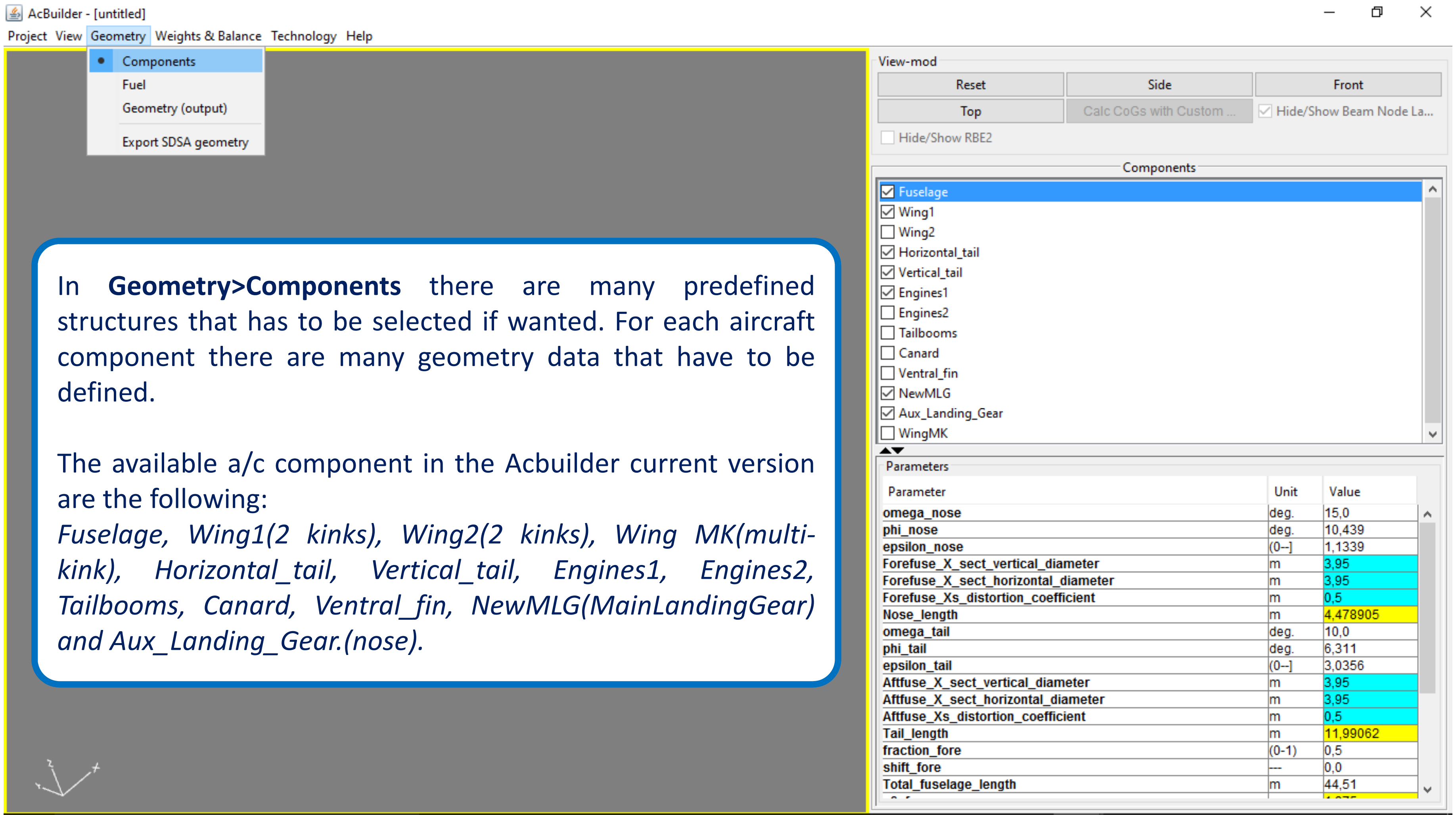
If one has a previously saved aircraft_model.xml file, it could be loaded using **'Import XML'.** Otherwise, one could start modifying the parameters of a *default aircraft model* in order to define the new general structure.



Main menu view

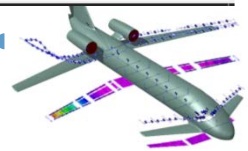


Main menu: Geometry components

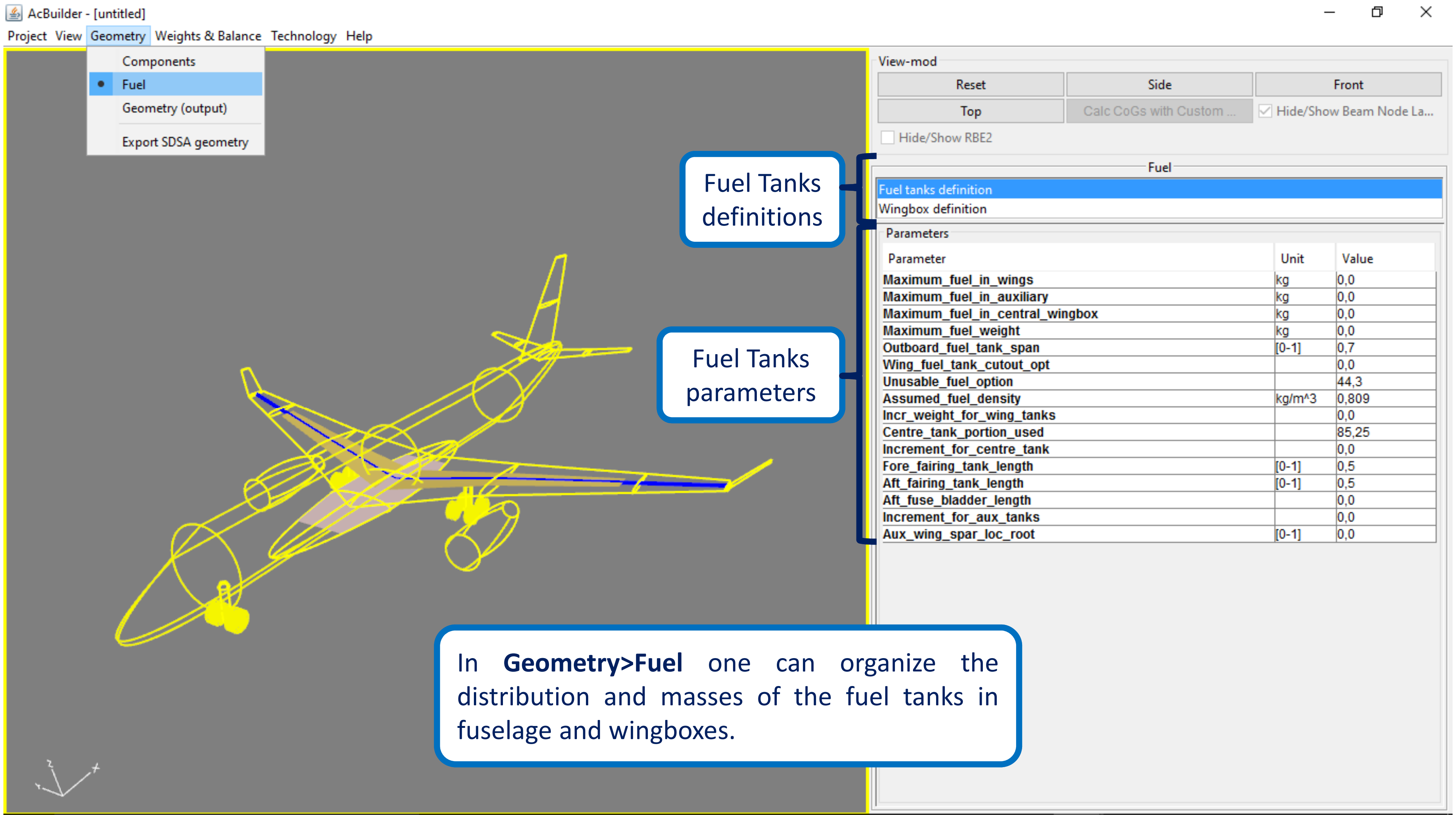


In **Geometry>Components** there are many predefined structures that has to be selected if wanted. For each aircraft component there are many geometry data that have to be defined.

The available a/c component in the Acbuilder current version are the following:
Fuselage, Wing1(2 kinks), Wing2(2 kinks), Wing MK(multi-kink), Horizontal_tail, Vertical_tail, Engines1, Engines2, Tailbooms, Canard, Ventral_fin, NewMLG(MainLandingGear) and Aux_Landing_Gear.(nose).

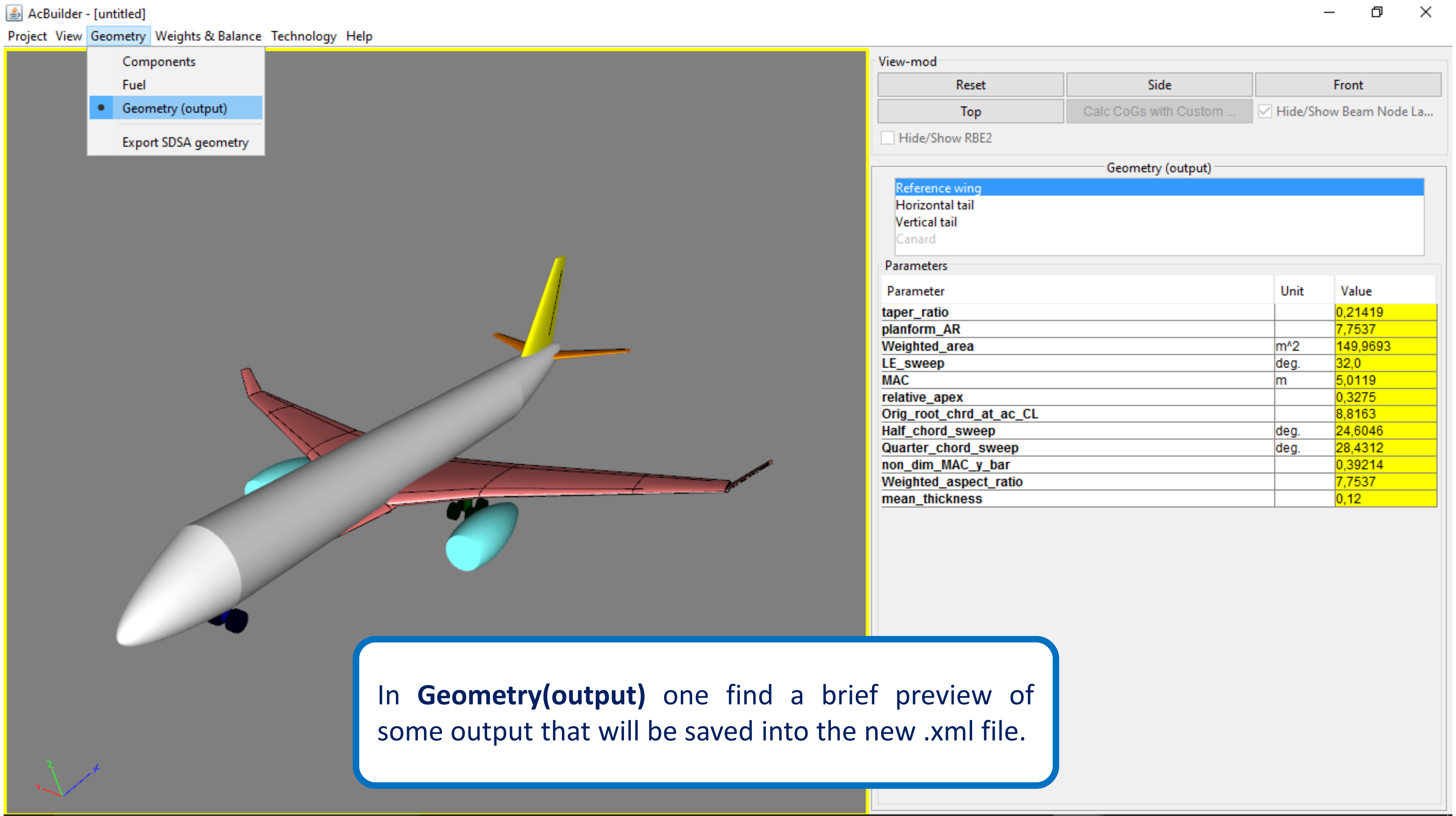


Main menu: Geometry, Fuel



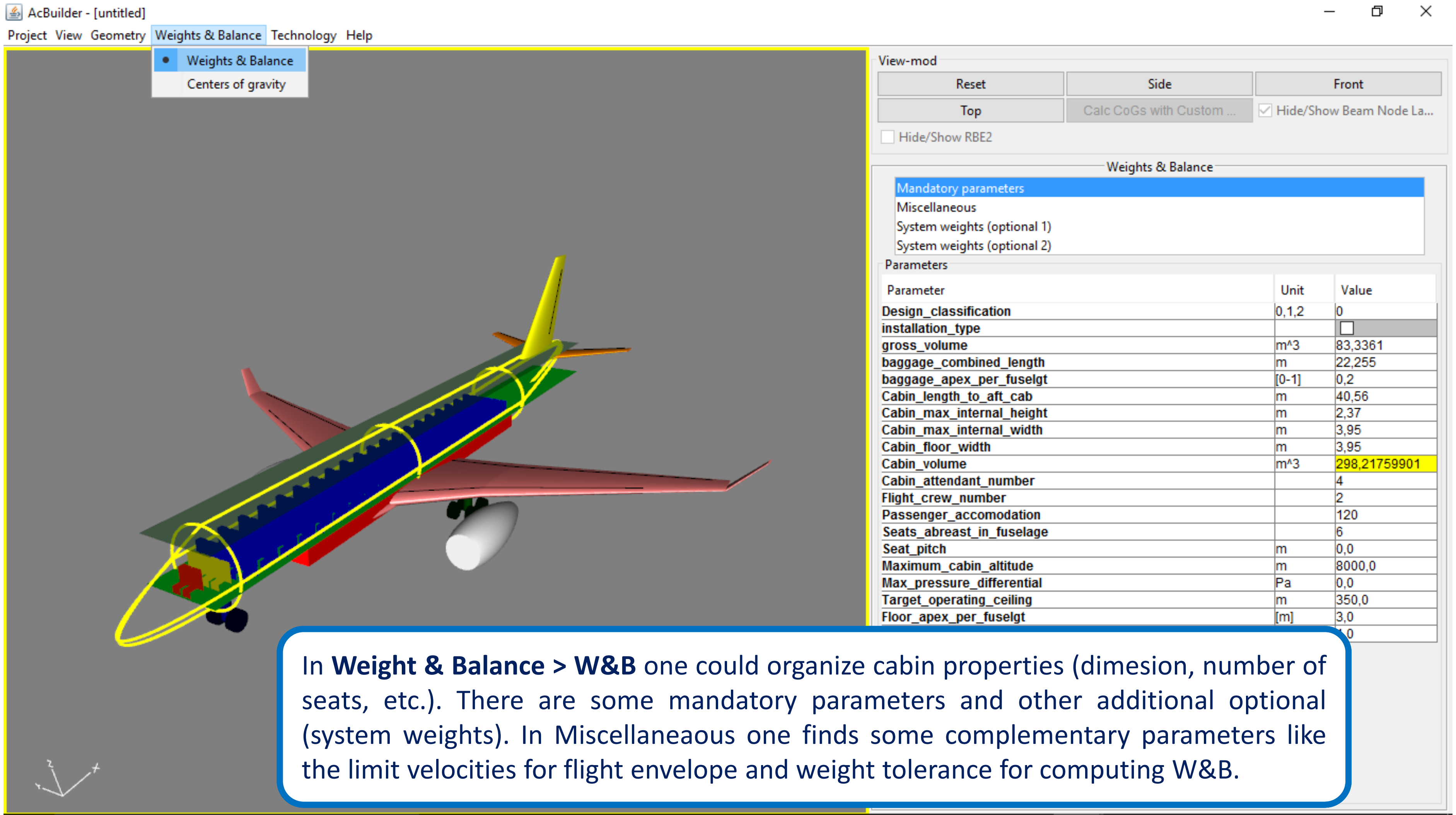
In **Geometry>Fuel** one can organize the distribution and masses of the fuel tanks in fuselage and wingboxes.

Main menu: Geometry output

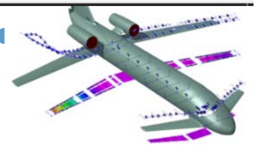


In **Geometry(output)** one find a brief preview of some output that will be saved into the new .xml file.

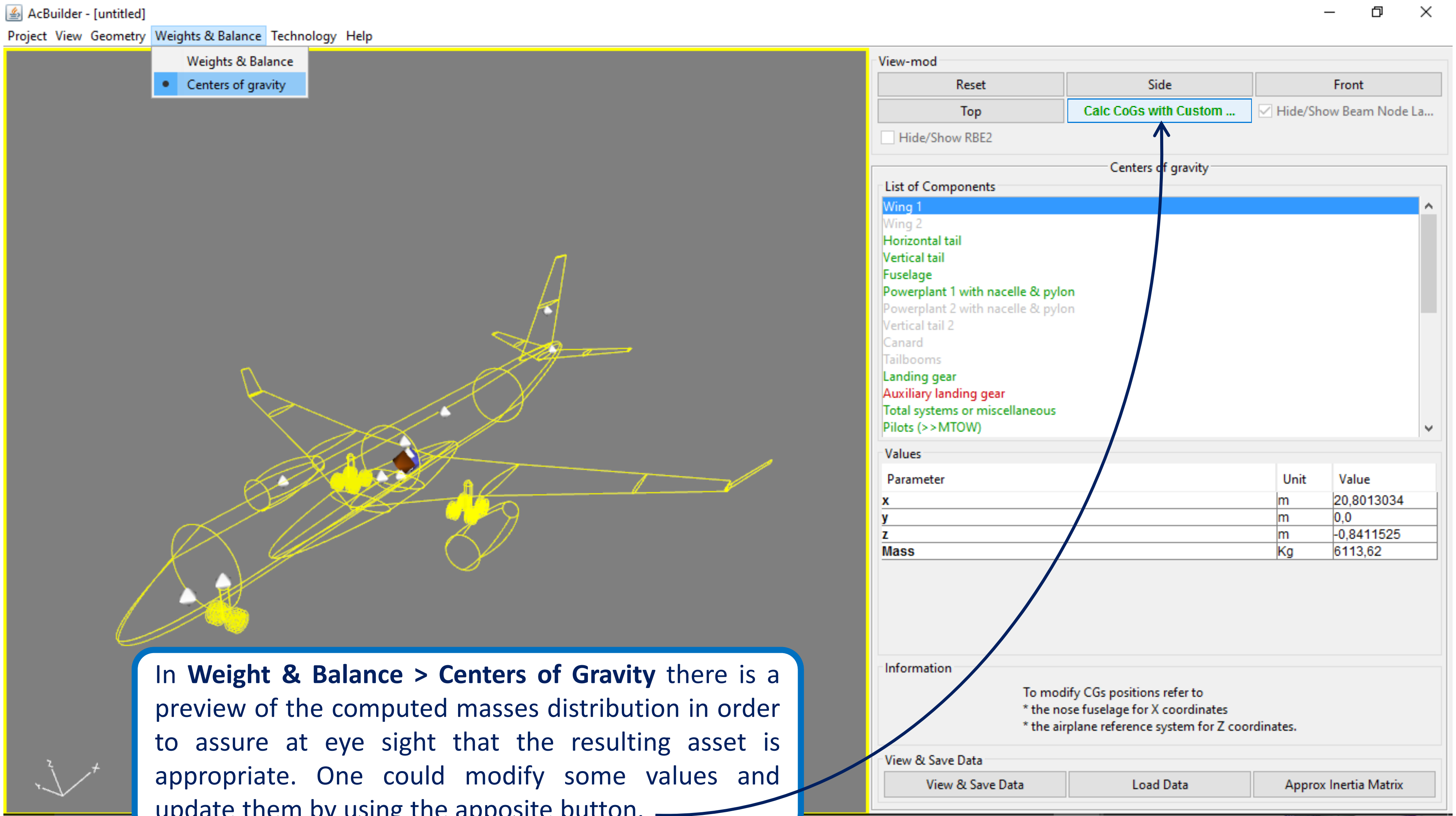
Main menu: Weight and Balance



In **Weight & Balance > W&B** one could organize cabin properties (dimesion, number of seats, etc.). There are some mandatory parameters and other additional optional (system weights). In Miscellaneaous one finds some complementary parameters like the limit velocities for flight envelope and weight tolerance for computing W&B.



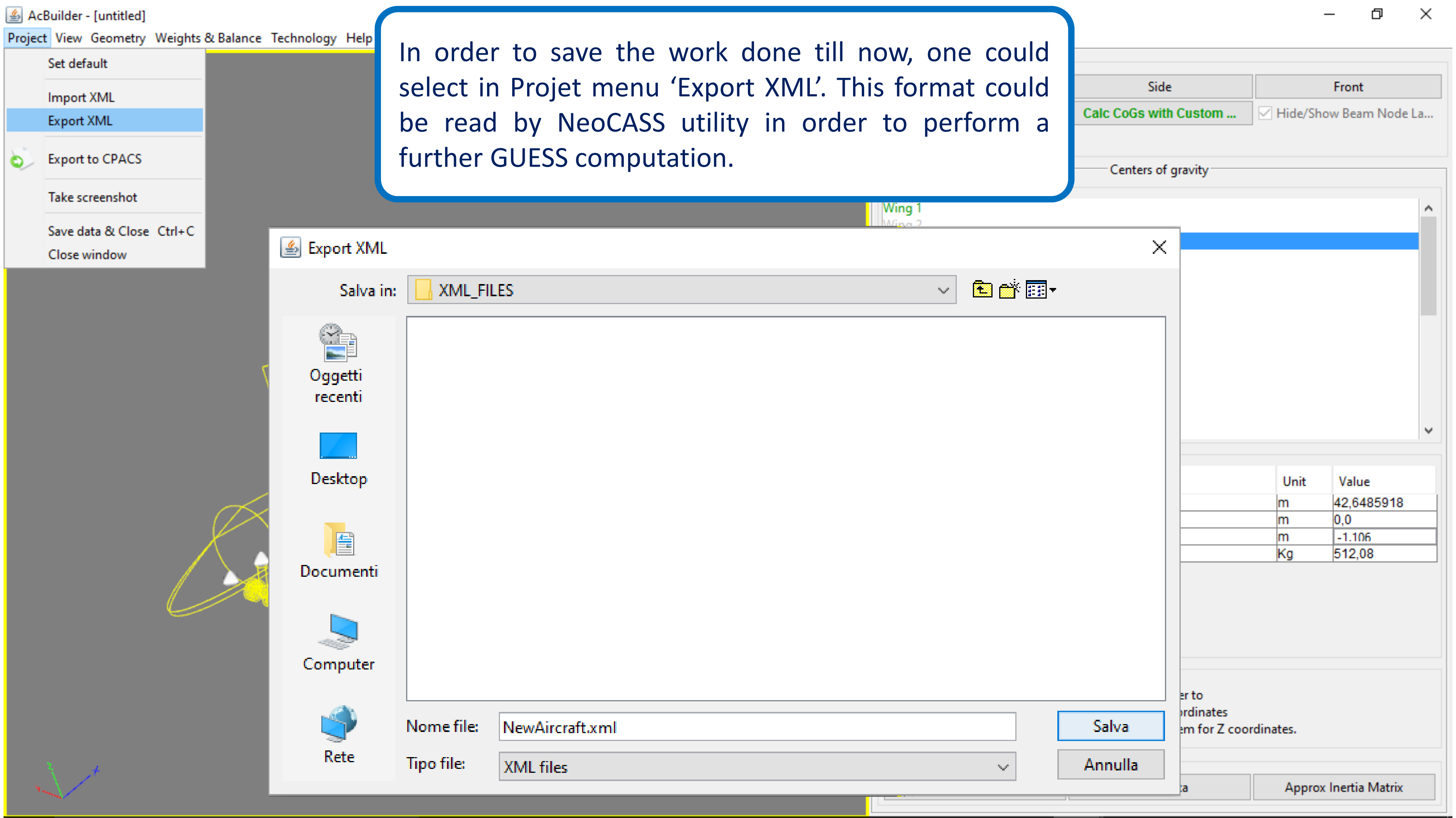
Main menu: Centers of Gravity



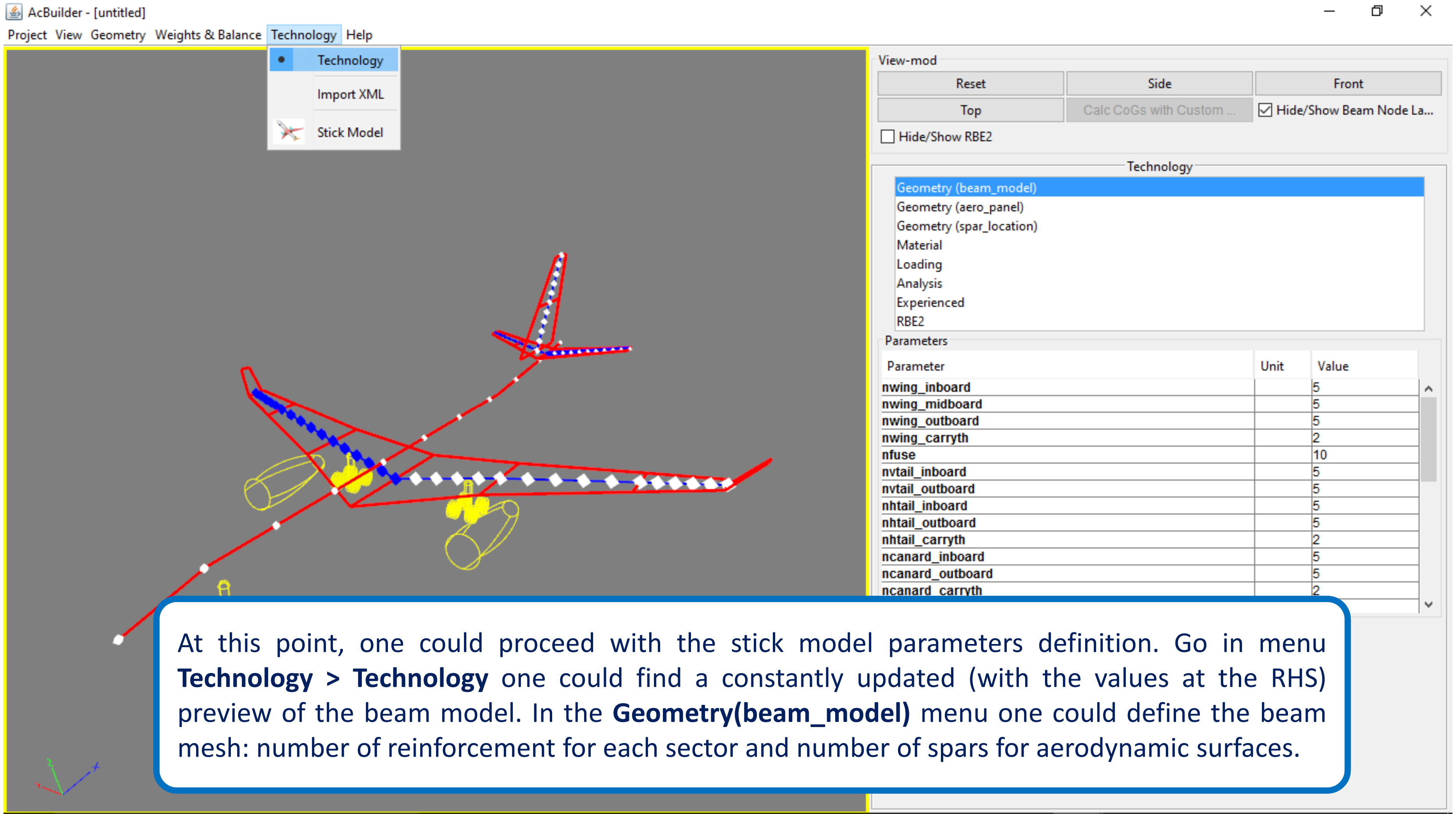
In **Weight & Balance > Centers of Gravity** there is a preview of the computed masses distribution in order to assure at eye sight that the resulting asset is appropriate. One could modify some values and update them by using the apposite button.

Main menu: Centers of Gravity

In order to save the work done till now, one could select in Projet menu 'Export XML'. This format could be read by NeoCASS utility in order to perform a further GUESS computation.

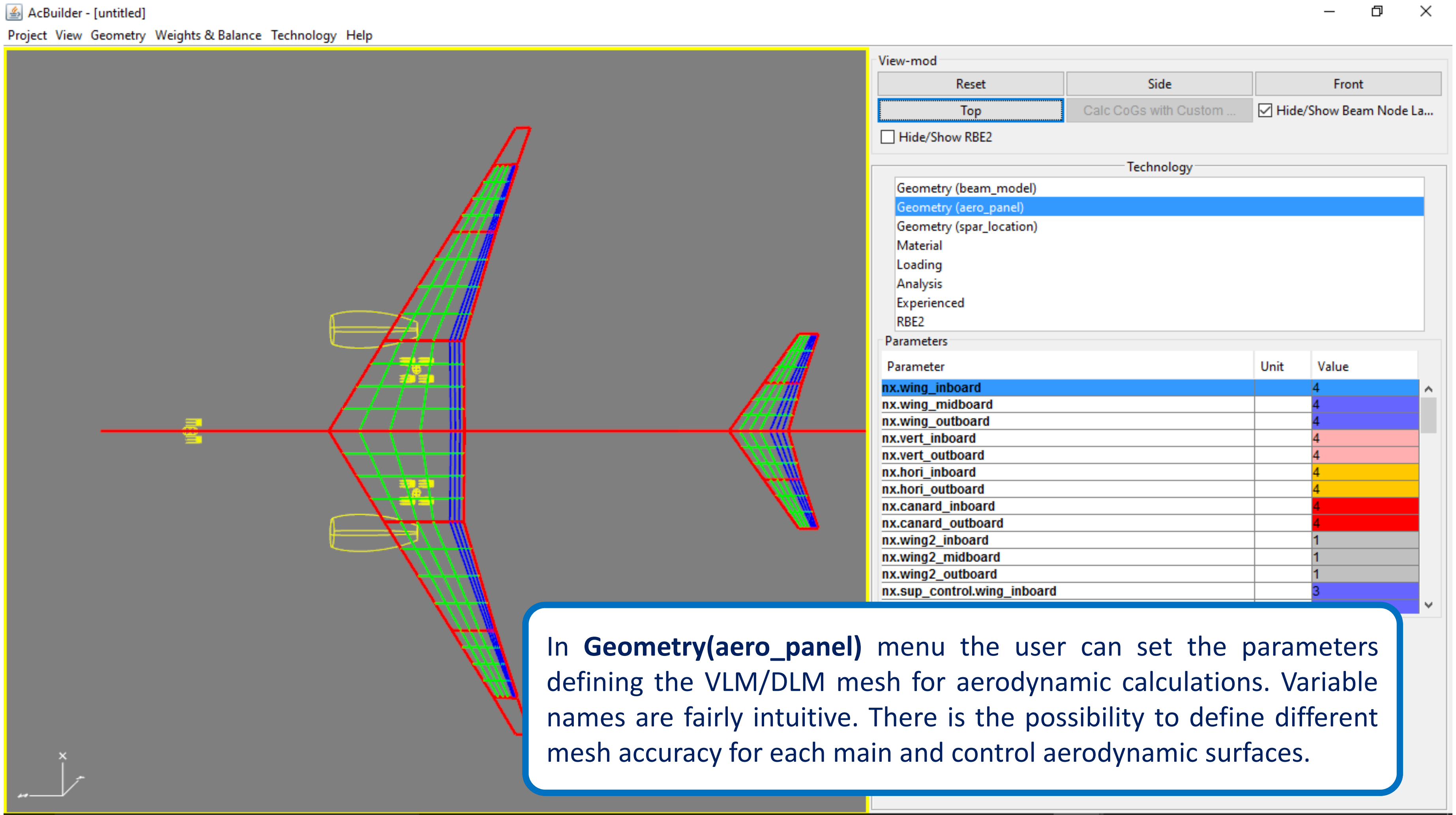


Main menu: Technology, Beam model

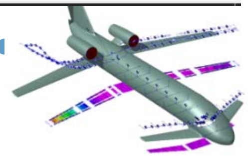


At this point, one could proceed with the stick model parameters definition. Go in menu **Technology > Technology** one could find a constantly updated (with the values at the RHS) preview of the beam model. In the **Geometry(beam_model)** menu one could define the beam mesh: number of reinforcement for each sector and number of spars for aerodynamic surfaces.

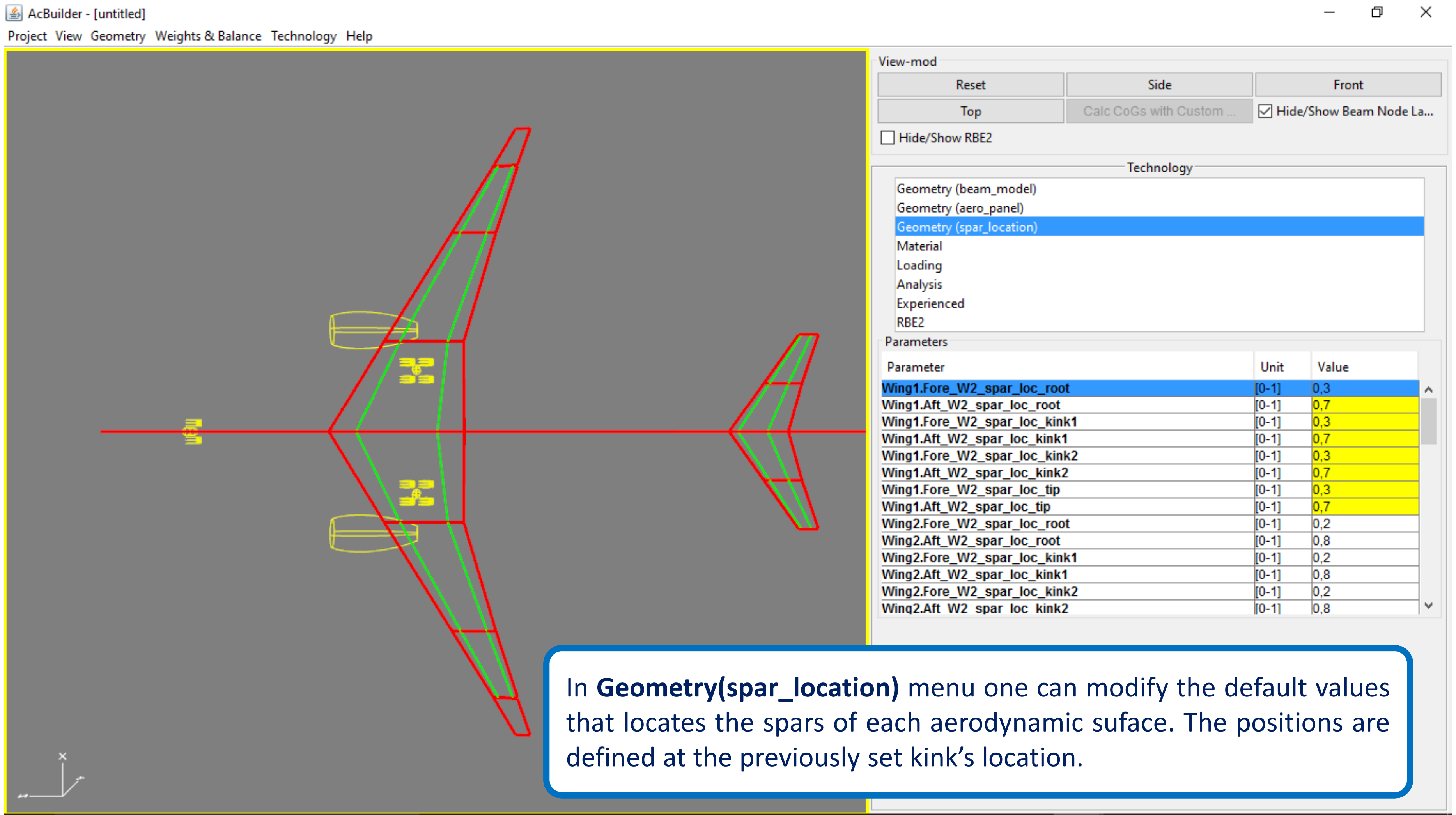
Main menu: Technology, Aero panel



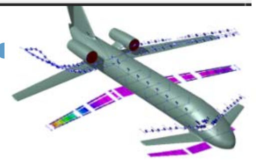
In **Geometry(aero_panel)** menu the user can set the parameters defining the VLM/DLM mesh for aerodynamic calculations. Variable names are fairly intuitive. There is the possibility to define different mesh accuracy for each main and control aerodynamic surfaces.



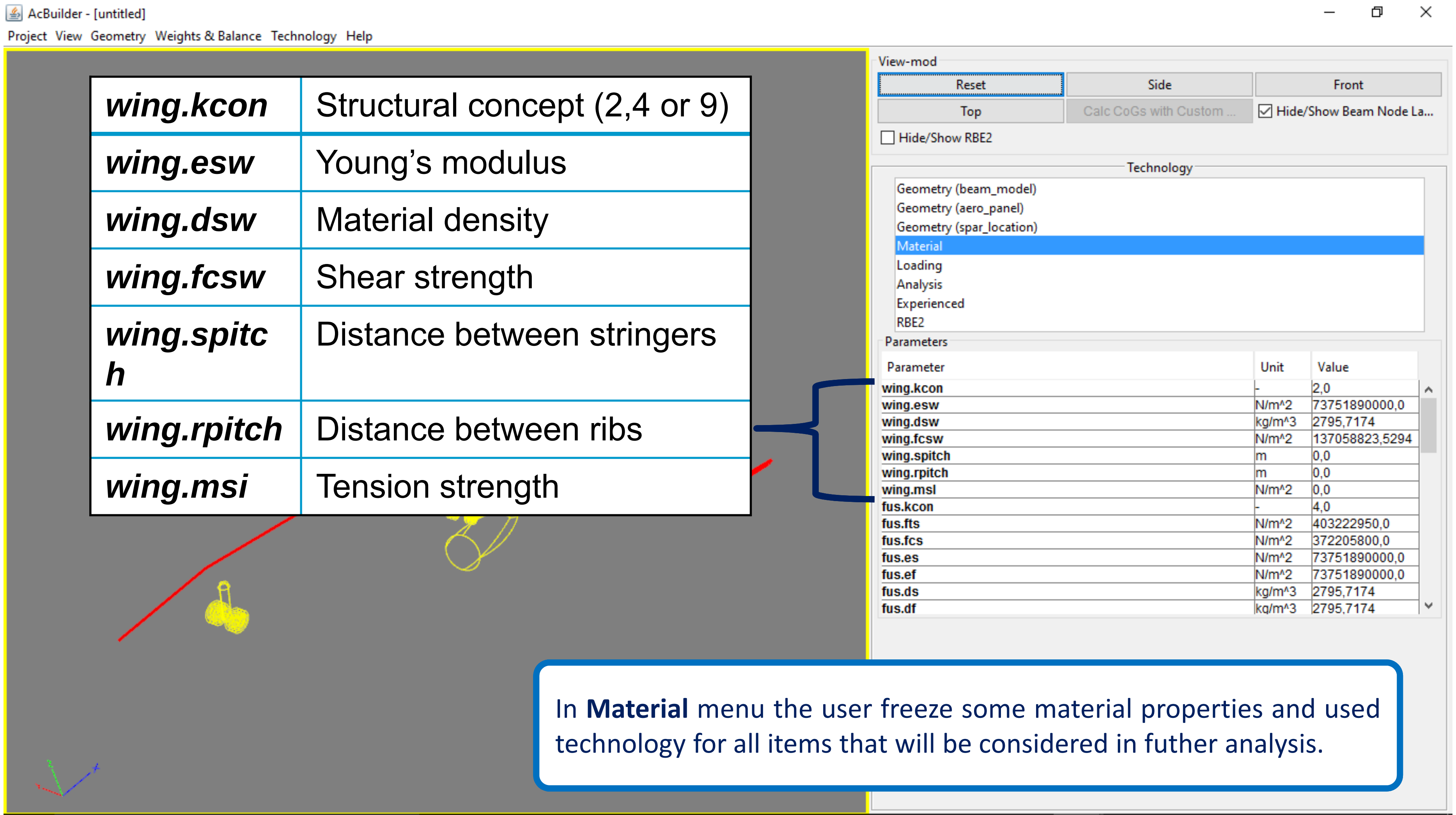
Main menu: Technology, Spar location



In **Geometry(spar_location)** menu one can modify the default values that locates the spars of each aerodynamic suface. The positions are defined at the previously set kink's location.



Main menu: Technology, Material properties

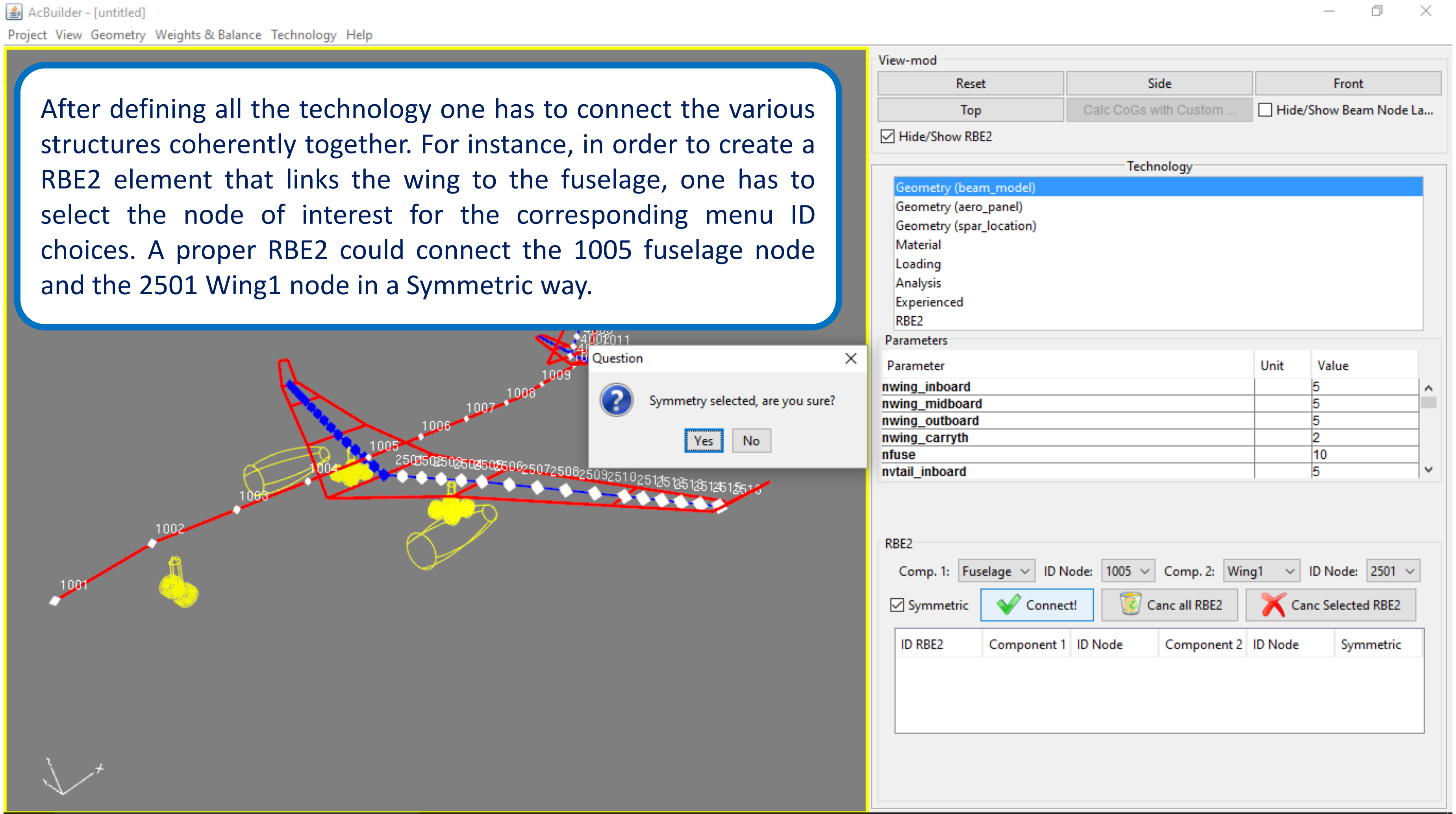


wing.kcon	Structural concept (2,4 or 9)
wing.esw	Young's modulus
wing.dsw	Material density
wing.fcsw	Shear strength
wing.spitch	Distance between stringers
wing.rpitch	Distance between ribs
wing.msi	Tension strength

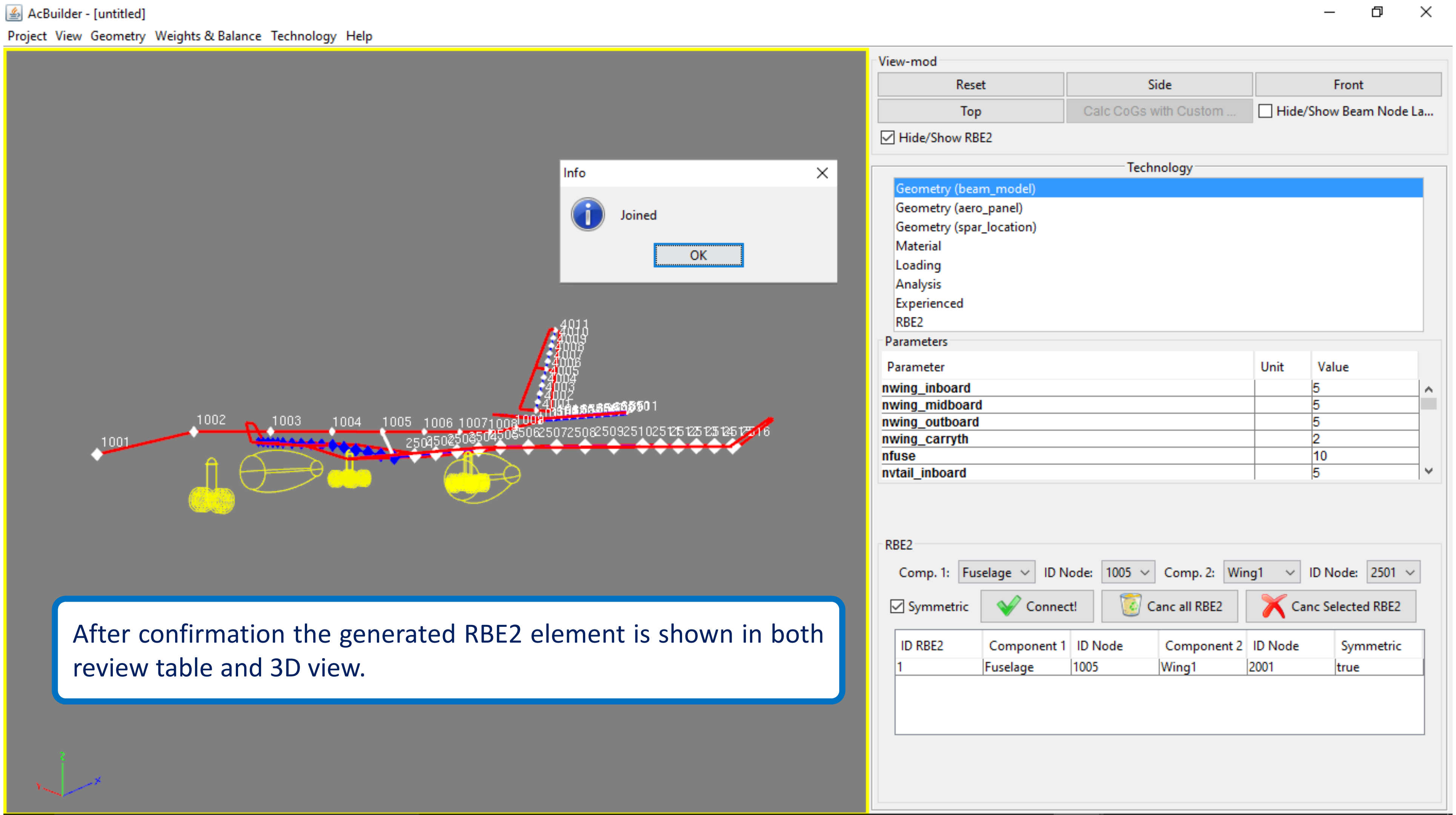
In **Material** menu the user freeze some material properties and used technology for all items that will be considered in futher analysis.

Main Menu: Technology: create RBE2

After defining all the technology one has to connect the various structures coherently together. For instance, in order to create a RBE2 element that links the wing to the fuselage, one has to select the node of interest for the corresponding menu ID choices. A proper RBE2 could connect the 1005 fuselage node and the 2501 Wing1 node in a Symmetric way.

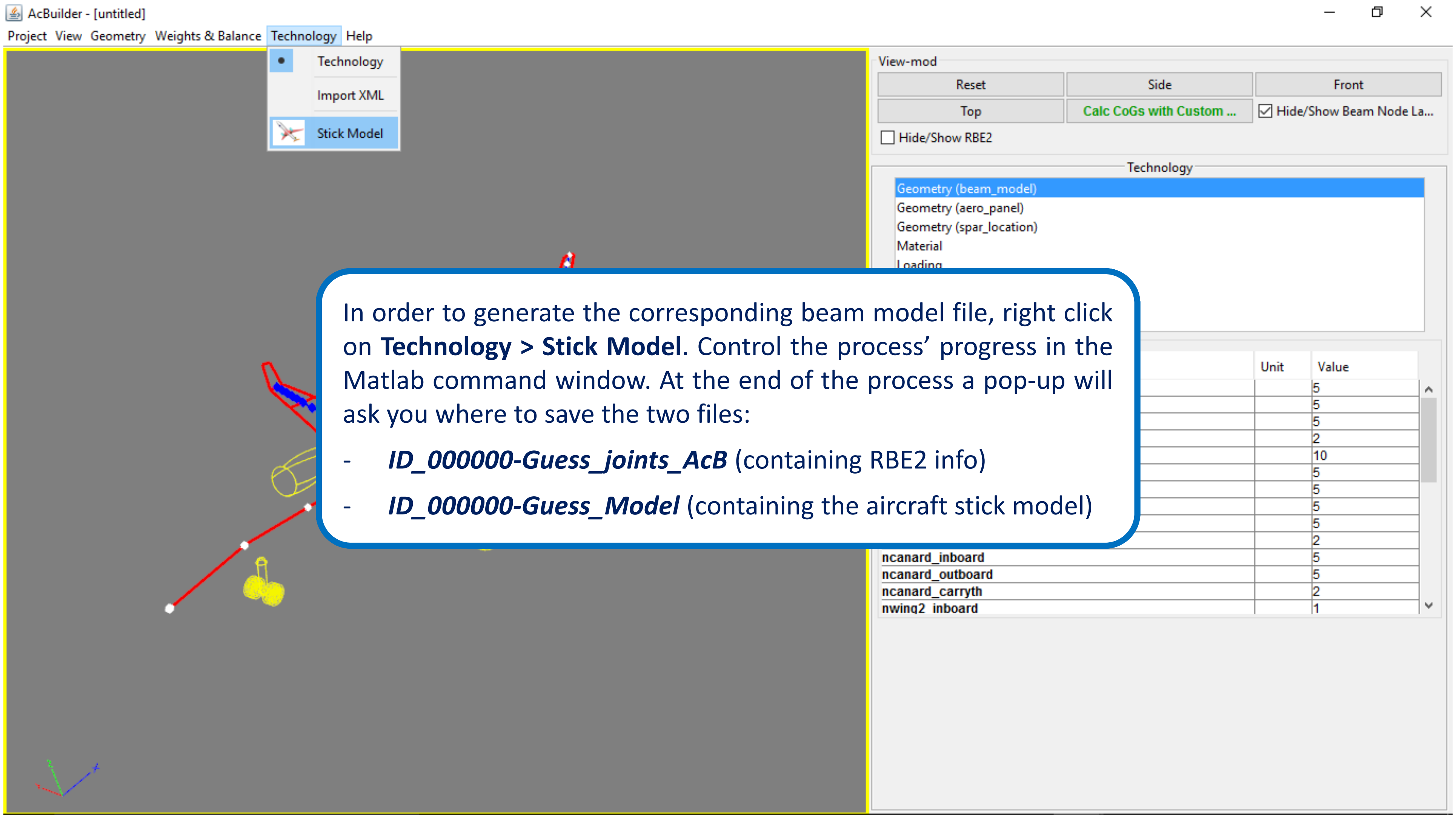


Main Menu: Technology: create RBE2



After confirmation the generated RBE2 element is shown in both review table and 3D view.

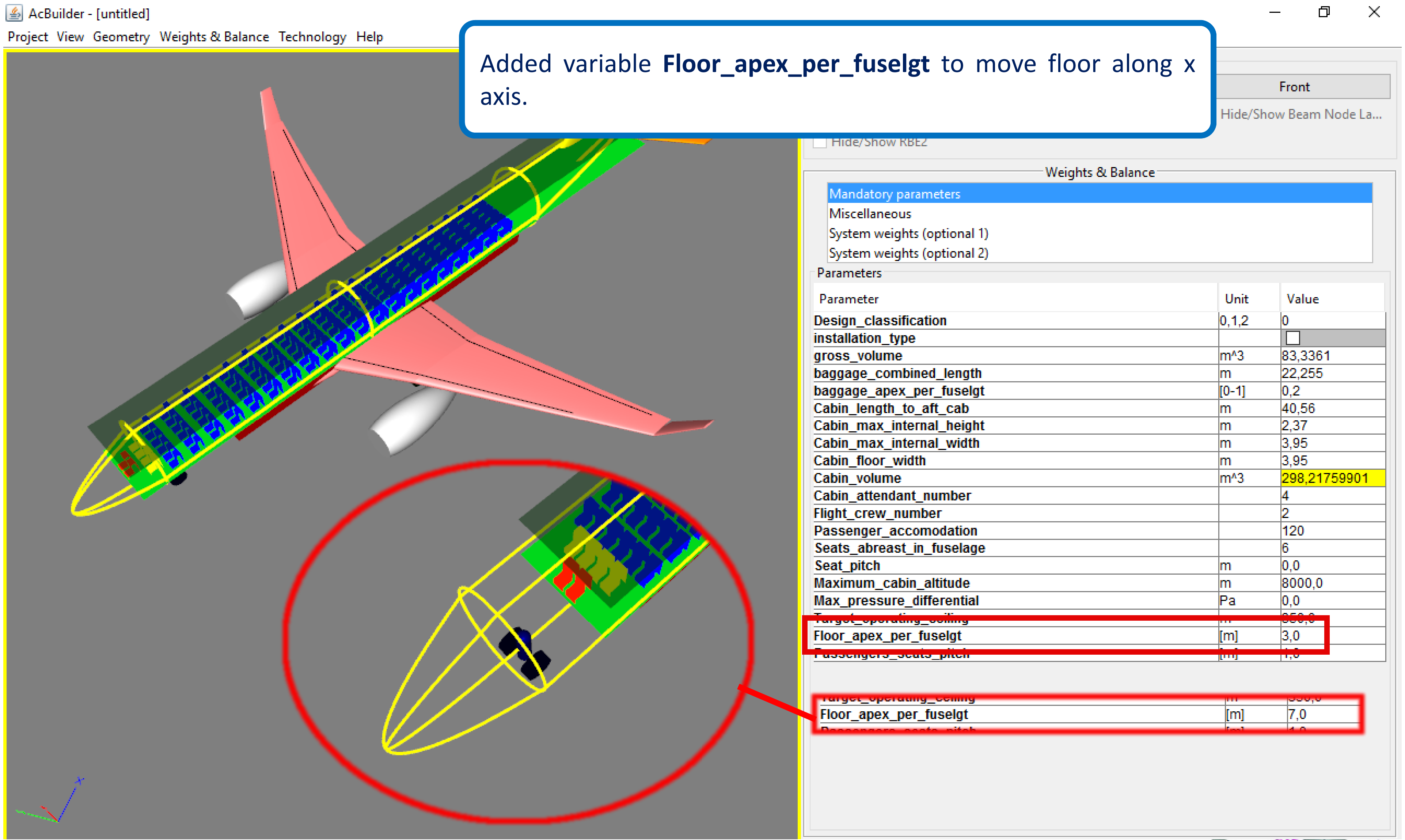
Main menu: Technology, Export stick model



In order to generate the corresponding beam model file, right click on **Technology > Stick Model**. Control the process' progress in the Matlab command window. At the end of the process a pop-up will ask you where to save the two files:

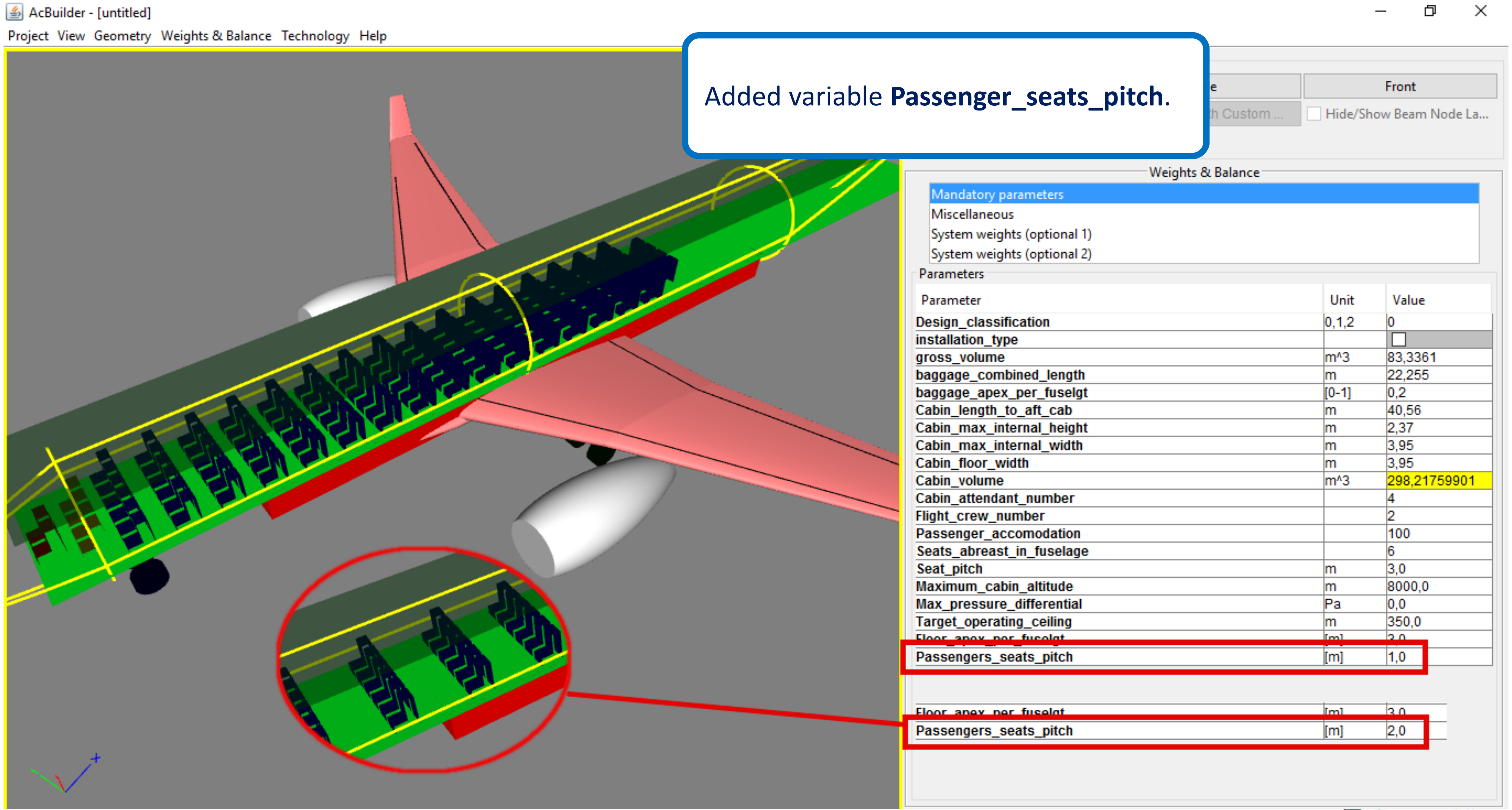
- ***ID_000000-Guess_joints_AcB*** (containing RBE2 info)
- ***ID_000000-Guess_Model*** (containing the aircraft stick model)

New features in Last Updates – Move floor



Added variable **Floor_apex_per_fuselgt** to move floor along x axis.

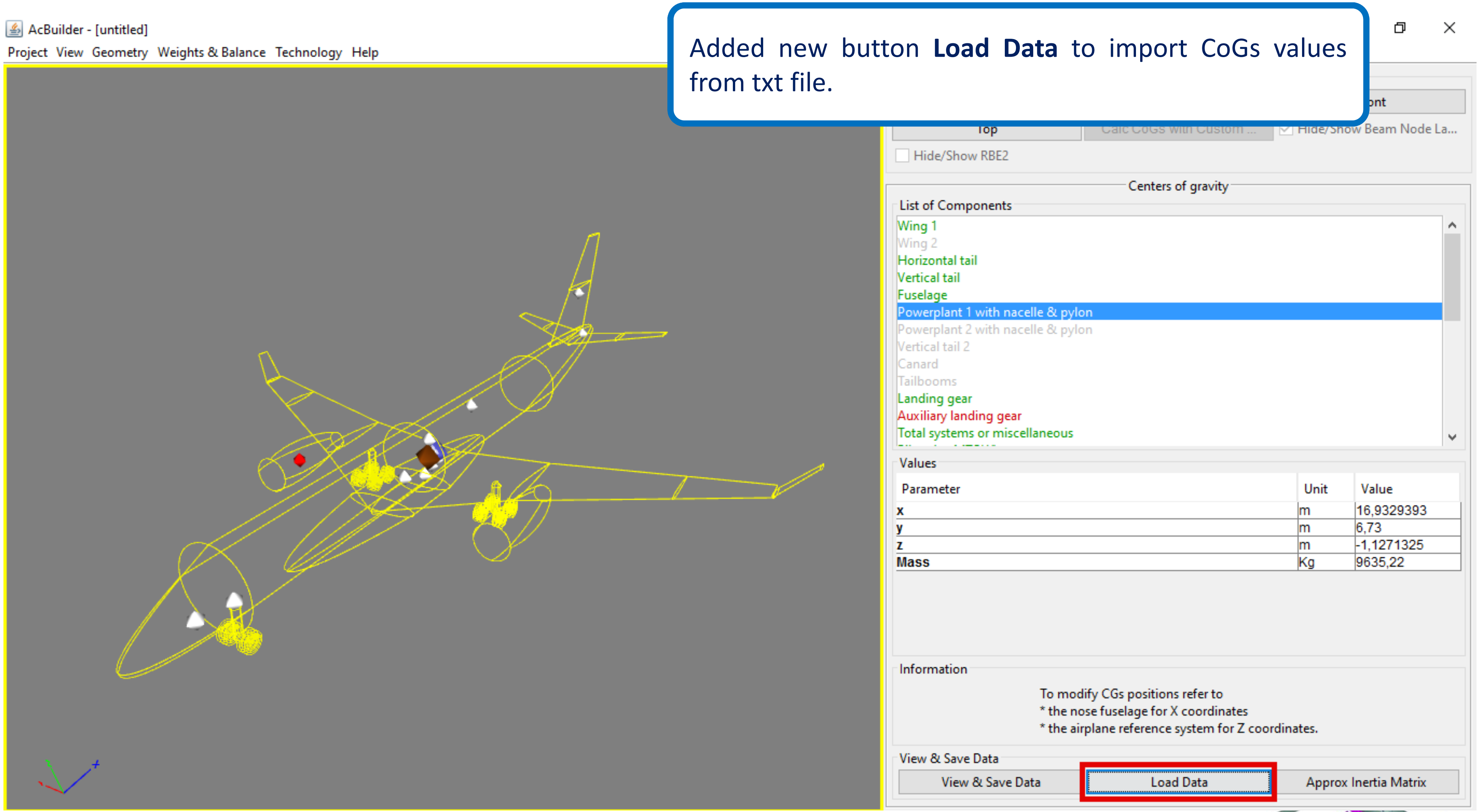
New features in Last Updates – New passengers seats pitch



Added variable **Passenger_seats_pitch**.

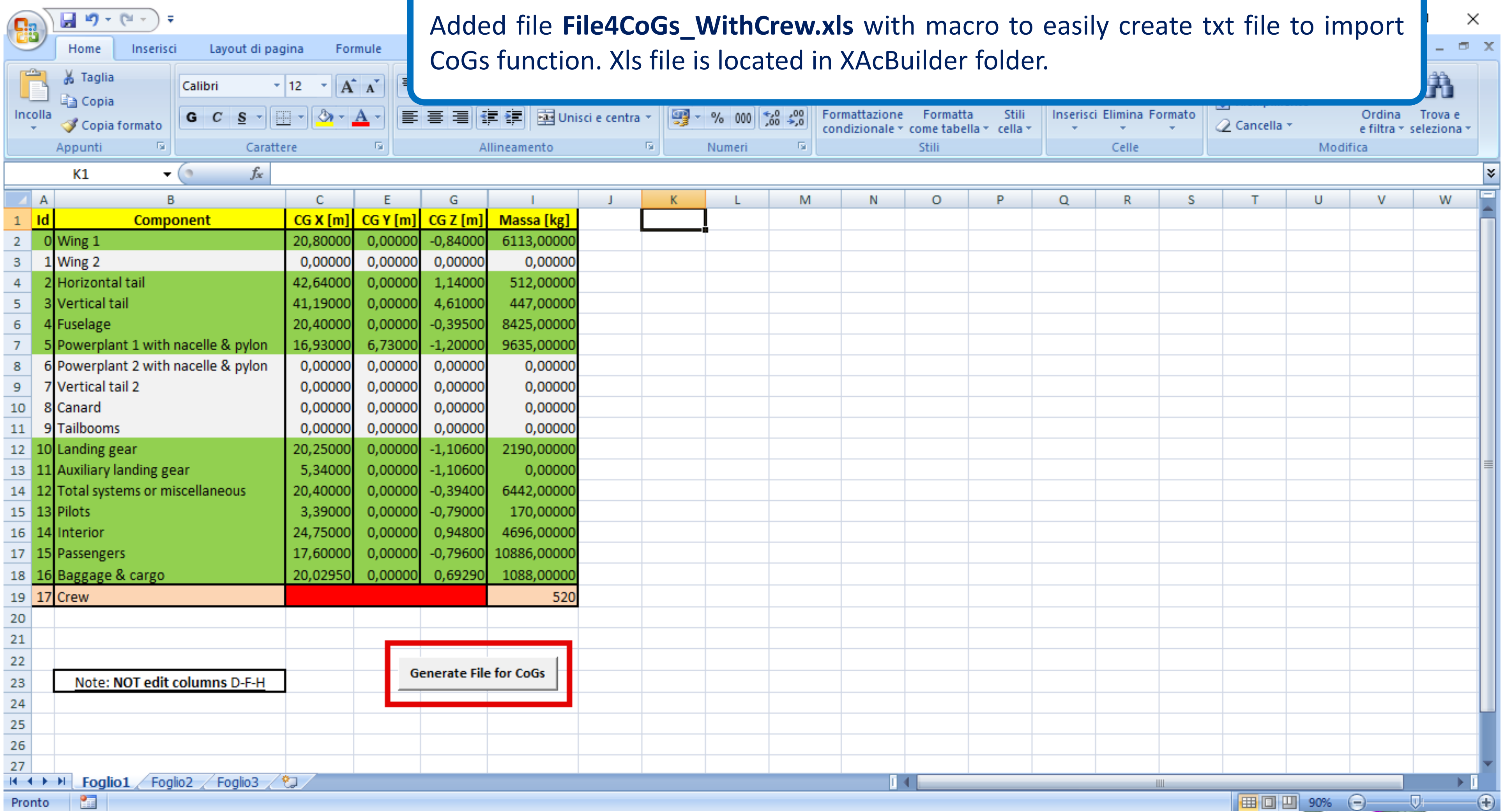
New features in Last Updates – Import CoGs data from file

Added new button **Load Data** to import CoGs values from txt file.



New features in Last Updates – Use Xls Model to generate txt file with CoGs data and import it in CoGs AcBuilder module

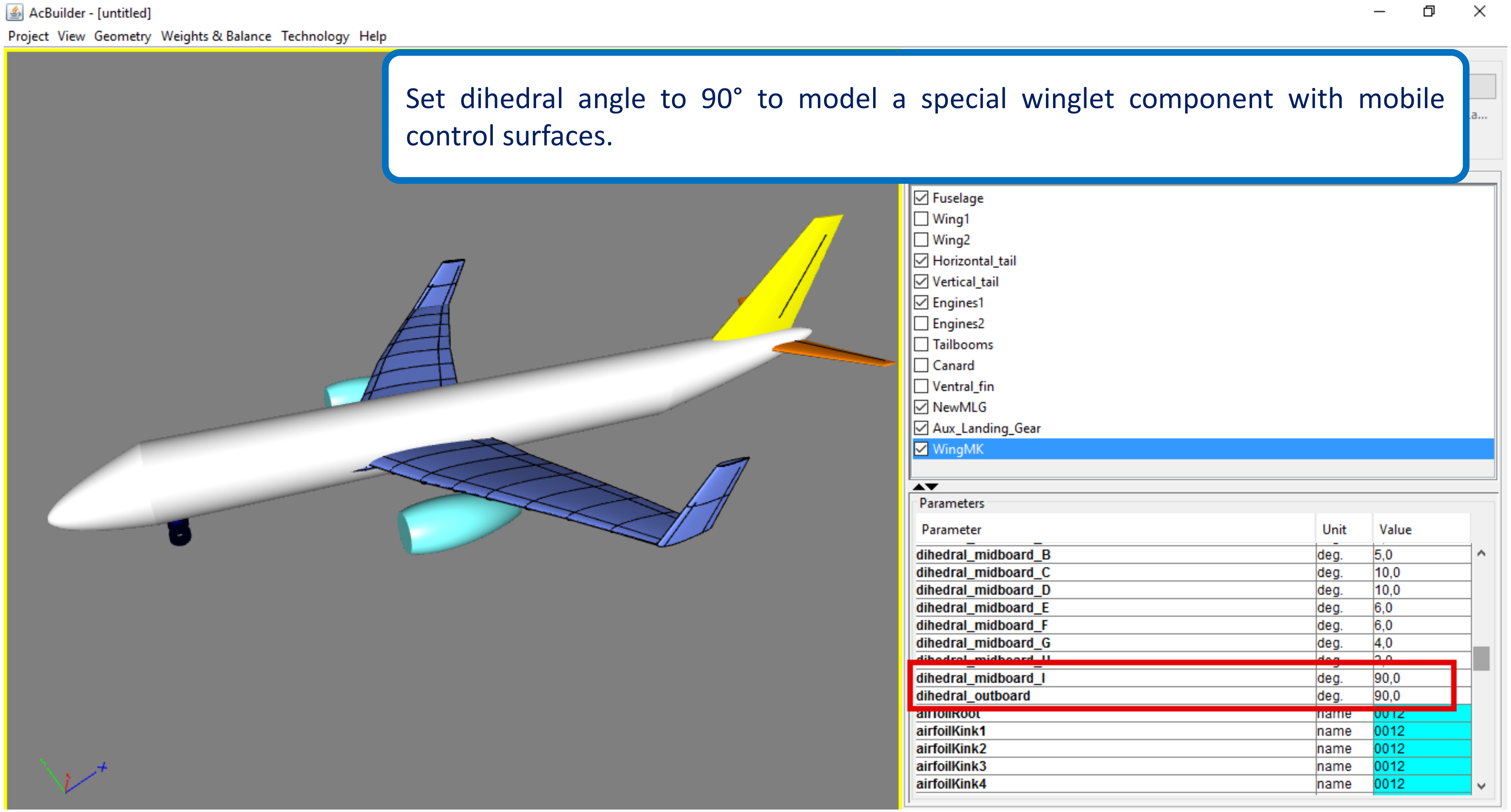
Added file **File4CoGs_WithCrew.xls** with macro to easily create txt file to import CoGs function. Xls file is located in XAcBuilder folder.



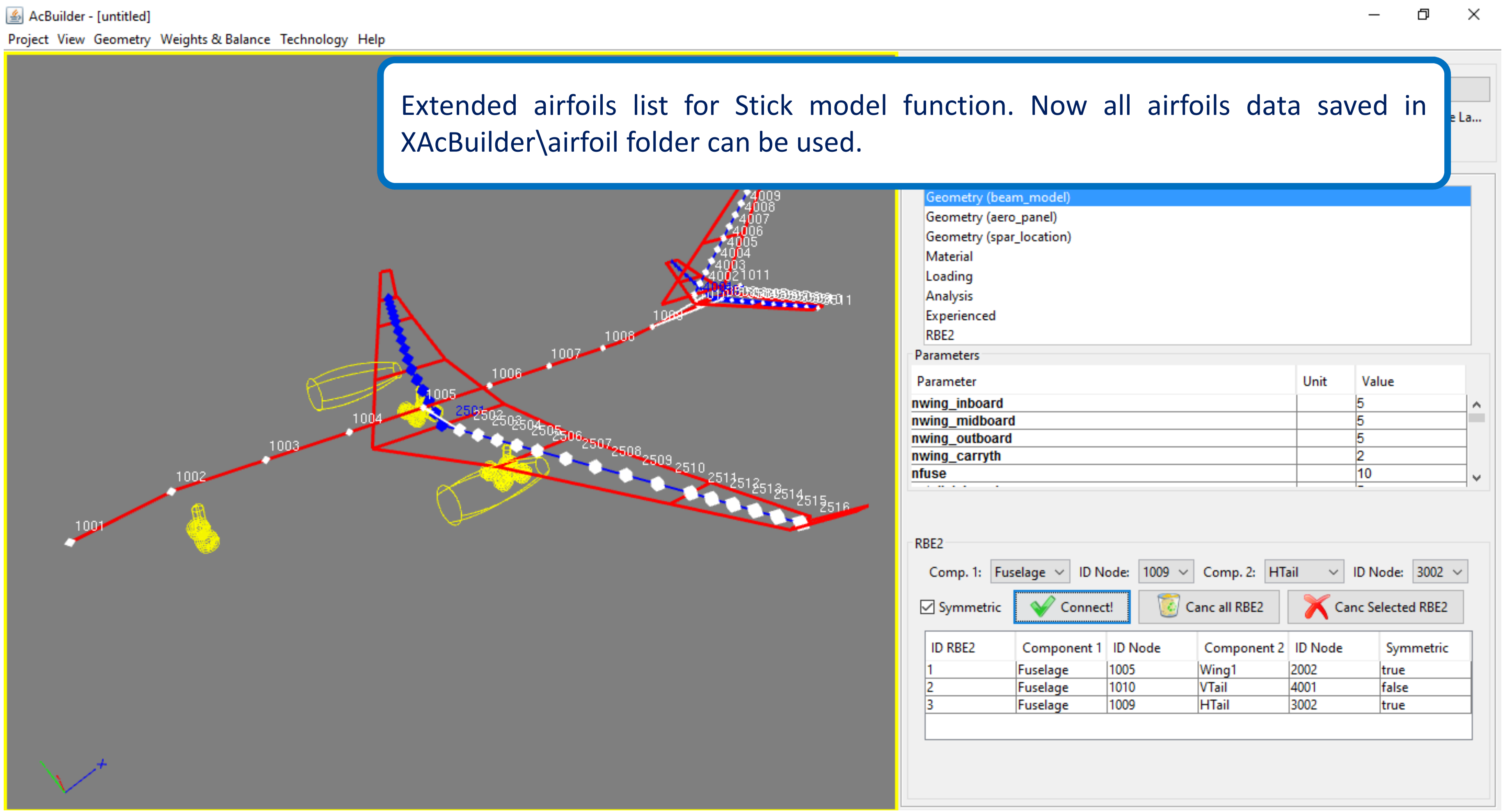
Id	Component	CG X [m]	CG Y [m]	CG Z [m]	Massa [kg]
0	Wing 1	20,80000	0,00000	-0,84000	6113,00000
1	Wing 2	0,00000	0,00000	0,00000	0,00000
2	Horizontal tail	42,64000	0,00000	1,14000	512,00000
3	Vertical tail	41,19000	0,00000	4,61000	447,00000
4	Fuselage	20,40000	0,00000	-0,39500	8425,00000
5	Powerplant 1 with nacelle & pylon	16,93000	6,73000	-1,20000	9635,00000
6	Powerplant 2 with nacelle & pylon	0,00000	0,00000	0,00000	0,00000
7	Vertical tail 2	0,00000	0,00000	0,00000	0,00000
8	Canard	0,00000	0,00000	0,00000	0,00000
9	Tailbooms	0,00000	0,00000	0,00000	0,00000
10	Landing gear	20,25000	0,00000	-1,10600	2190,00000
11	Auxiliary landing gear	5,34000	0,00000	-1,10600	0,00000
12	Total systems or miscellaneous	20,40000	0,00000	-0,39400	6442,00000
13	Pilots	3,39000	0,00000	-0,79000	170,00000
14	Interior	24,75000	0,00000	0,94800	4696,00000
15	Passengers	17,60000	0,00000	-0,79600	10886,00000
16	Baggage & cargo	20,02950	0,00000	0,69290	1088,00000
17	Crew				520

New features in Last Updates – Dihedral angle of last two sectors can be set to 90° in WingMK component

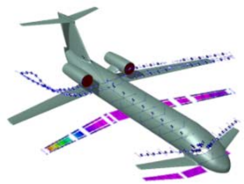
Set dihedral angle to 90° to model a special winglet component with mobile control surfaces.



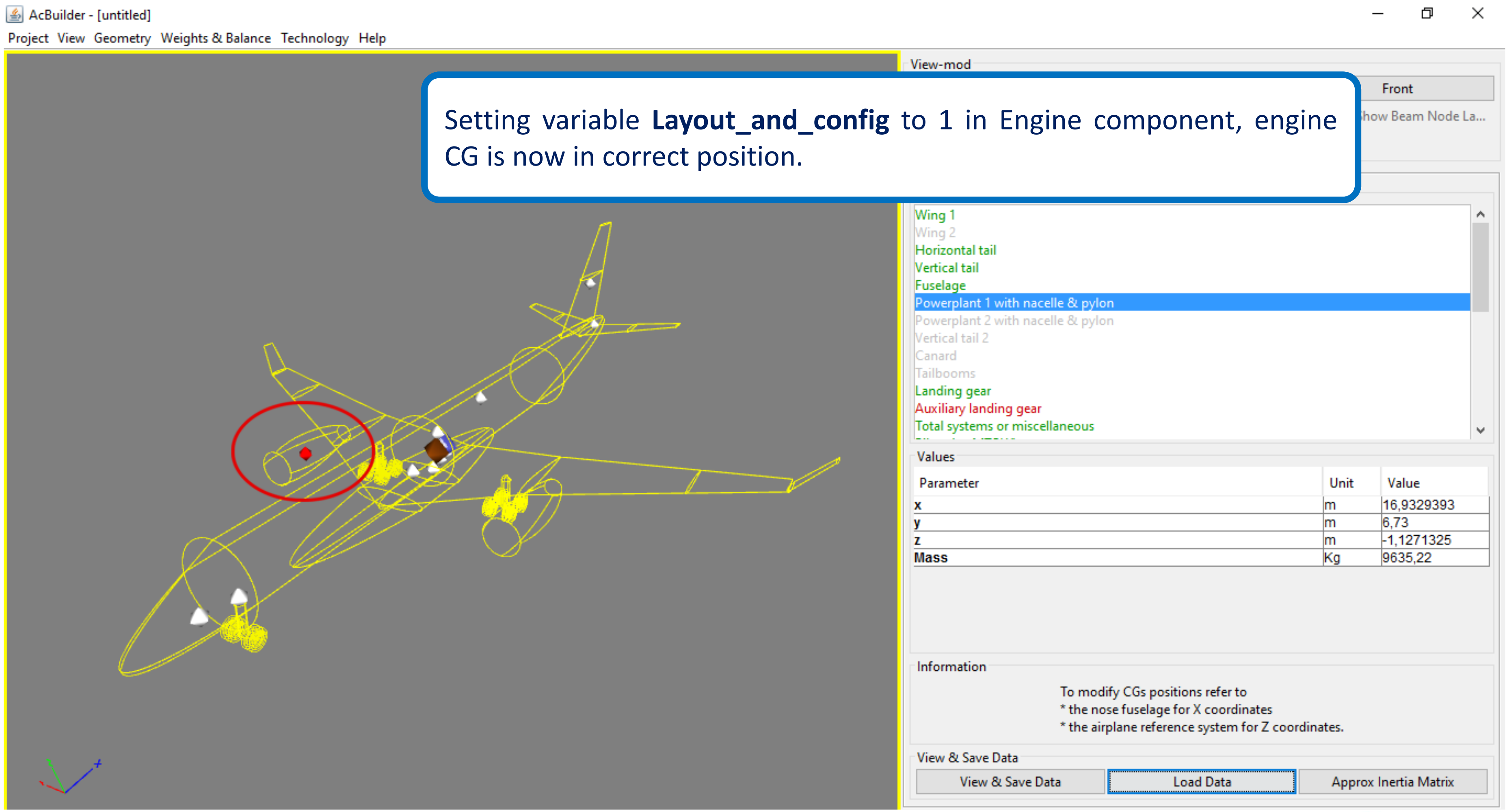
New features in Last Updates – Stick model function can use many airfoils



Extended airfoils list for Stick model function. Now all airfoils data saved in XAcBuilder\airfoil folder can be used.



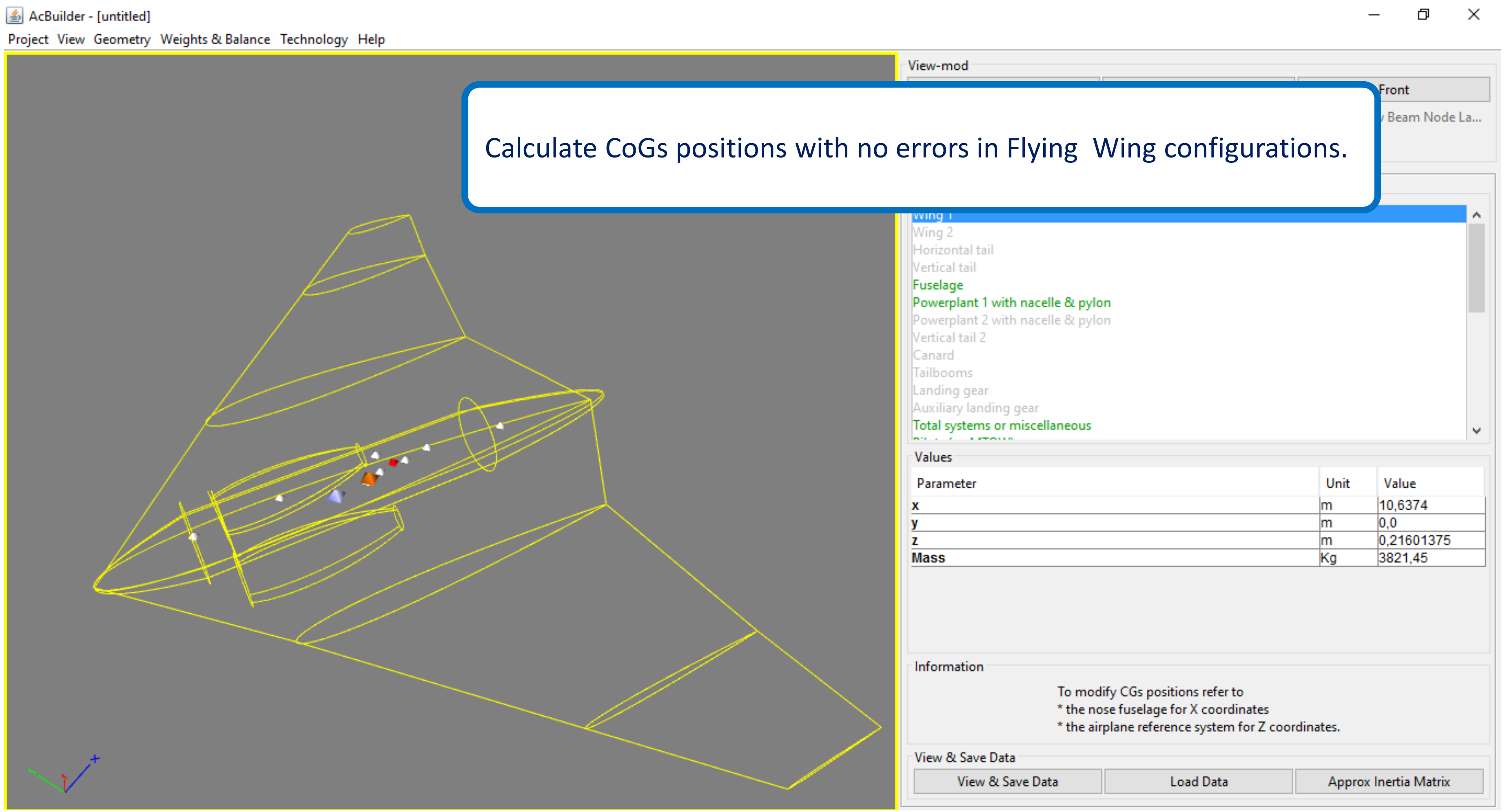
Bugs fixes in Last Updates – CoGs position in InWings Engines configuration

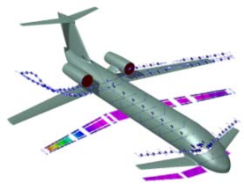


Setting variable **Layout_and_config** to 1 in Engine component, engine CG is now in correct position.

Bugs fixes in Last Updates – Flying Wing configurations

Calculate CoGs positions with no errors in Flying Wing configurations.

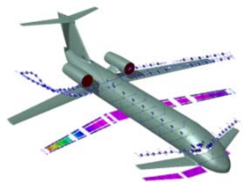




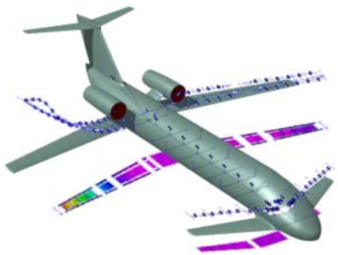
Bugs fixes in Last Updates – Crew and Total Systems or miscellaneous mass values

```
------------ Item Weights [Kg] ---

Fuselage
Wing
Horizontal tail
Vertical tail
Interior                           3278.00
Systems                            3199.00
Nose landing gear                   120.00
Main landing gear                   971.00
Engines1                           3728.00
Engines2                              0.00
Pilots                              190.00
Crew                                150.00

Passengers                         8264.00
Baggage                            2983.00
Central tank                          0.00
Wing tank                          1967.00
Fuel wing span fraction from 11.6342 to 80 %
Aux. tank                             0.00

------------ Item CG [m] from nose ----------------

Fuselage                             14.00
Wing                                 14.08
Horizontal tail                      29.23
Vertical tail                        27.57
Interior                             13.43
Systems                              13.38
Nose landing gear                     2.36
Main landing gear                    14.16
Engines1                             11.35
Engines2                              0.00
Pilots                                2.85
Crew                                 14.37
```

Guess function of NeoCASS suite can read the correct mass values of Crew and Total Systems or miscellaneous variables set in CoGs AcBuilder module.



NeoCASS GUI Overview



NeoCASS 2.2.809
July 2018

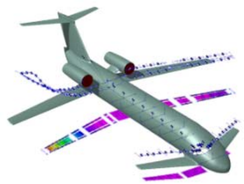
NeoCASS GUI interface

- GUI interface to **NeoCASS** Suite is based on four main Panels, i.e.:
  - File;
  - Settings;
  - Run;
  - Results;

and different sub-panels and windows to help the user in the correct definition of input data. Using these user-friendly menu, the user could introduce all parameters requested by different analysis modules, while the order of the GUI panels well reproduces the typical analysis sequence.

NeoCASS GUI – FILE Panel

- The FILE Panel is the first one that appears when **NeoCASS** code is invoked. By means of this panel it is possible to perform the following actions:
  - Read input files requested by **GUESS** , run **GUES**S code and generate the aircraft stick model.
  - Add Reference Values for geometrical and aerodynamic parameters.
  - Select type of analysis to be run and related input/output data.
  - Open a previously saved **NeoCASS** data base (Matlab format).
  - Save all input data into a new **SMARTCAD** input file (ascii .dat file).
  - Open an already available **SMARTCAD** input file (ascii .dat file).
  - Select among enabled solvers which one must be actually executed.

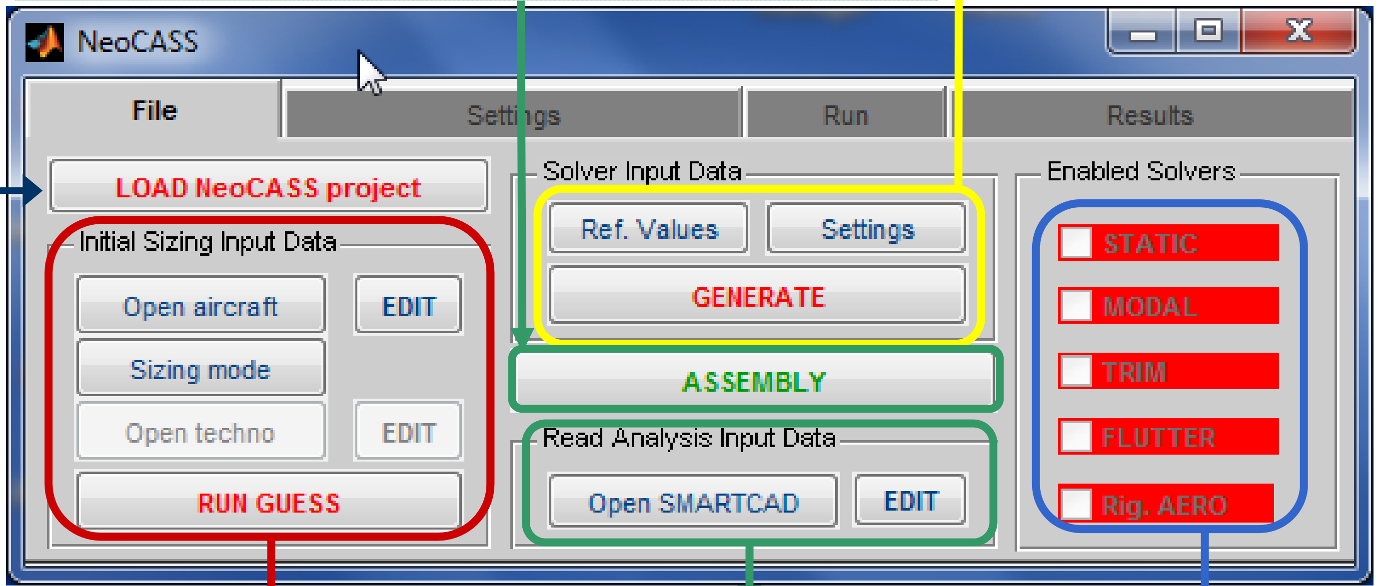


NeoCASS GUI – FILE Panel

Button for opening an already existent **NeoCASS** project

Definition of setting parameters for different type of analyses

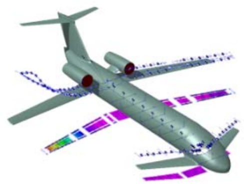
Assembly a SMARTCAD analysis file



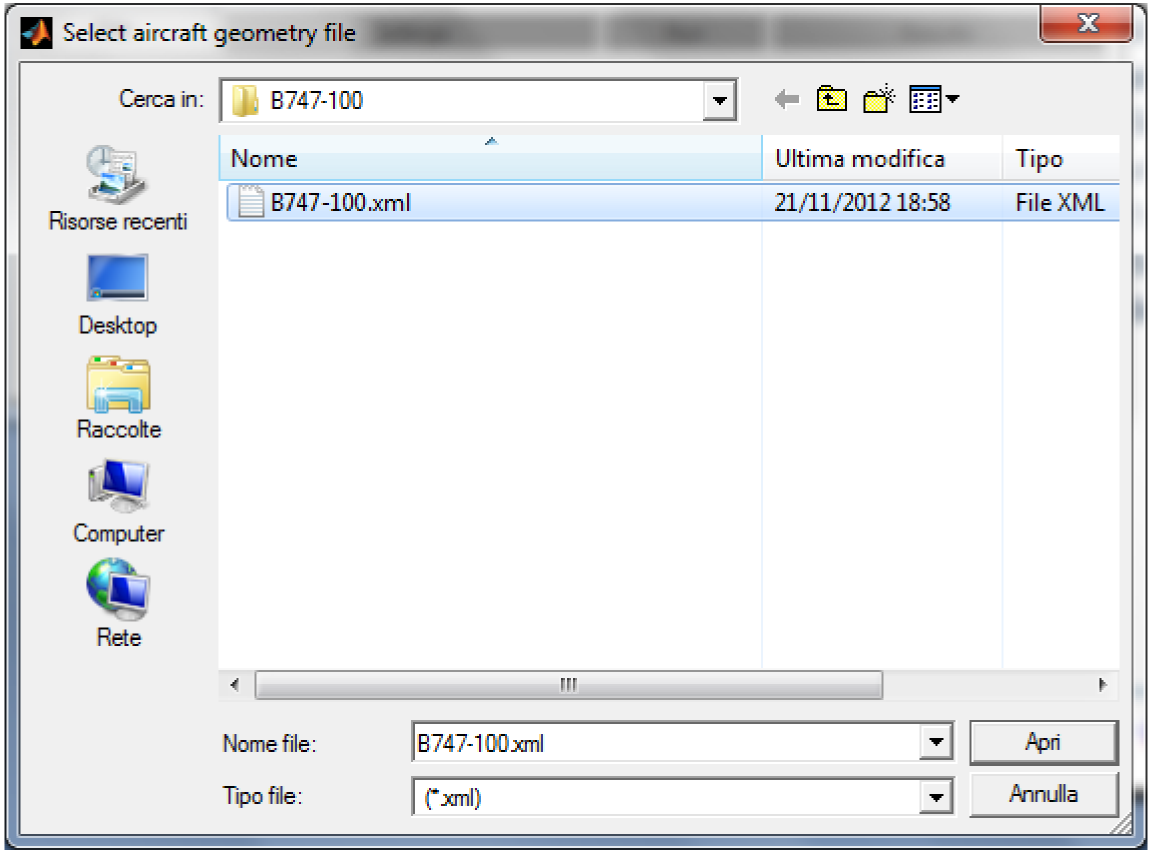
GUESS Subpanel: Files input, Edit and RUN **GUESS**

Open and Edit **SMARTCAD** files

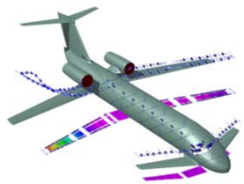
List of enabled solvers



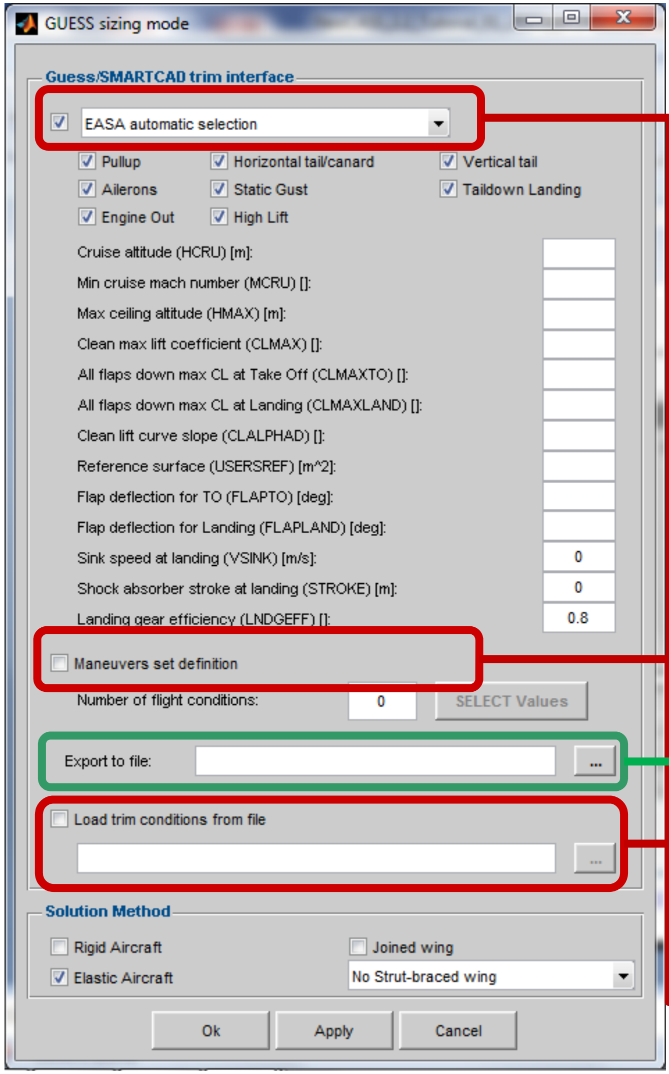
Open aircraft window



After pressing the ***Open aircraft button*** a select file window appears where the user can select the .XML file describing the aircraft to be designed



Sizing mode window

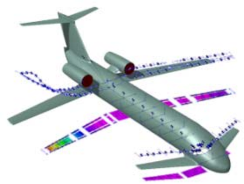


After pressing the ***Sizing mode button*** a new window appears, enabling the user to select among three options: sizing using certification-based maneuver; user-defined maneuvers; pre-defined maneuvers already available in a file.

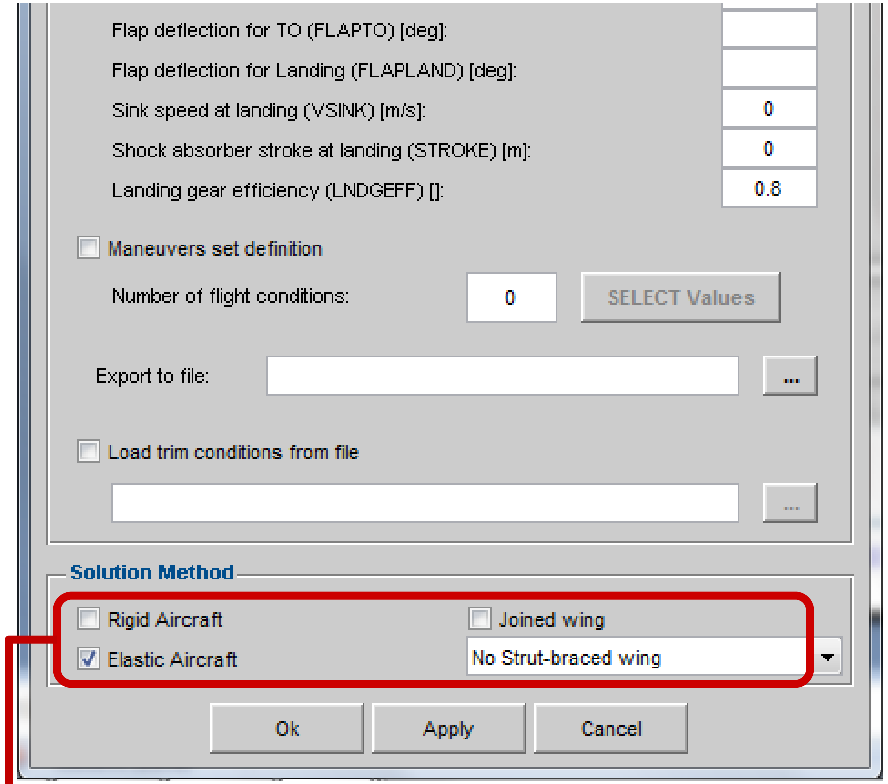
When using user-defined option, the maneuvers are then save into a file.

File where the maneuvers are saved

Sizing mode options

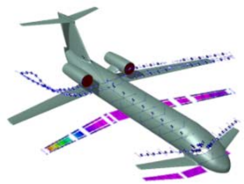


Sizing mode window

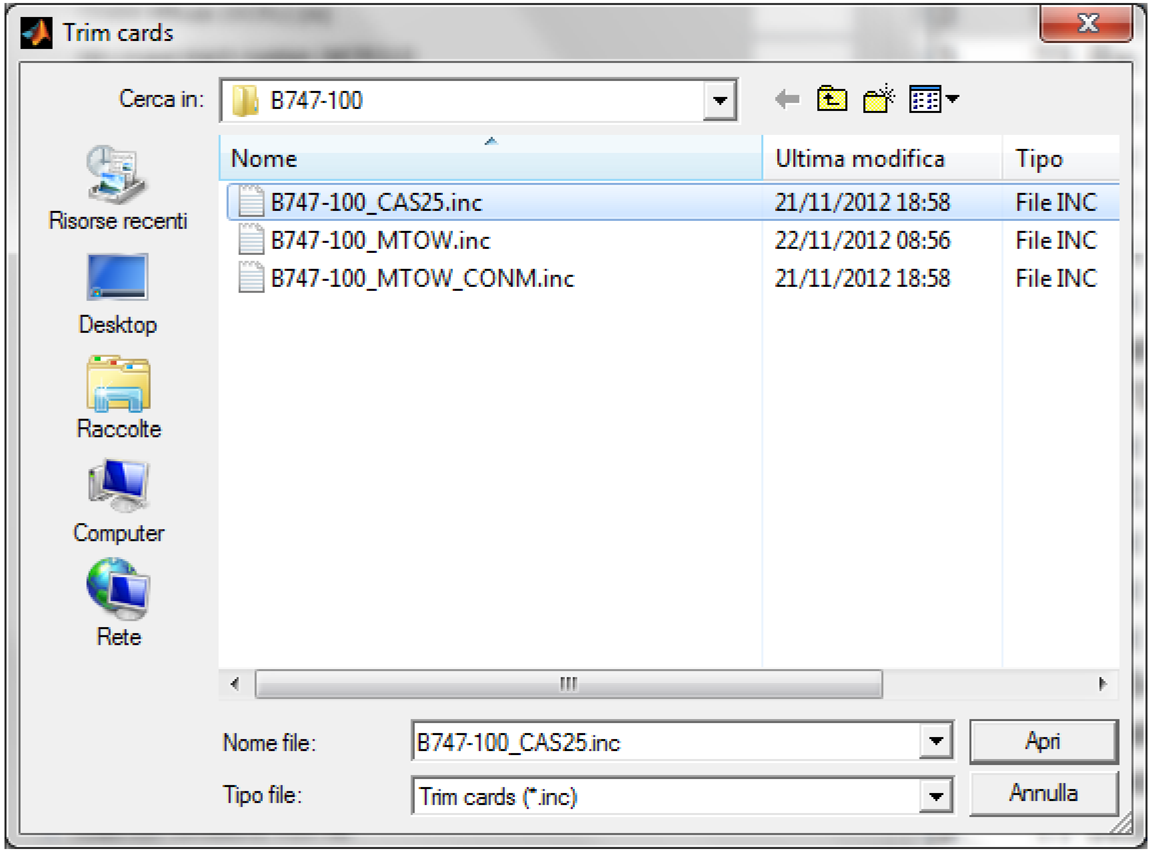


Sizing mode options

Two other options are available in the bottom part of sizing panel: Rigid aircraft, meaning force method, applicable to conventional configurations only Elastic, meaning displacement method, requested for unconventional (undetermined) configurations. In that case, using the options on the right, it is possible to specify different configurations: Joined, strut braced with and without aerodynamics on strut.



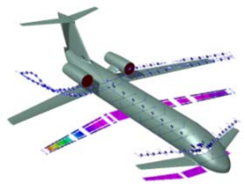
RUN GUESS window



Let try to select the option ***Load trim conditions from file***, and select the file

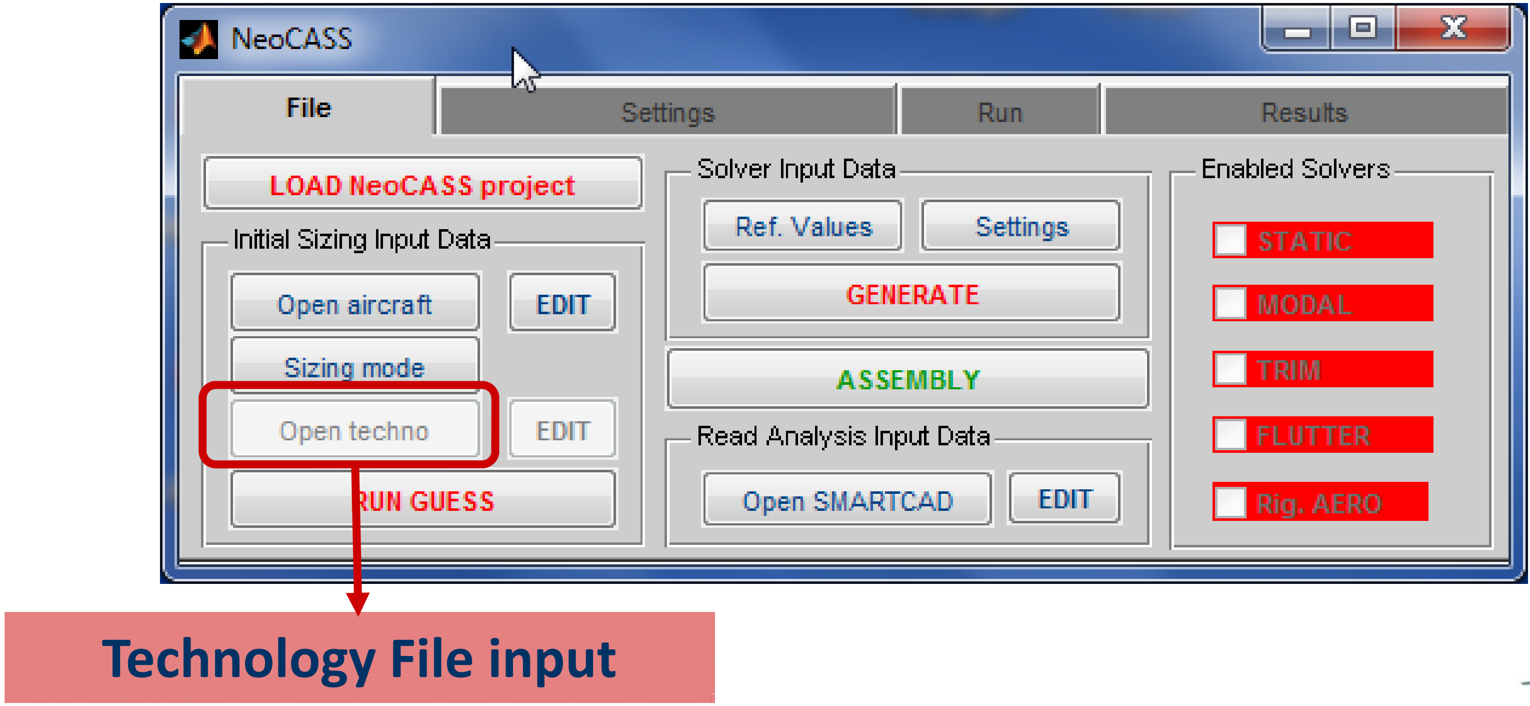
`B747-100_CAS25.inc`

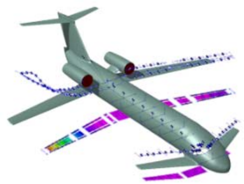
available into the B747-100 directory. The, select the ***Rigid option*** and press **OK** button.



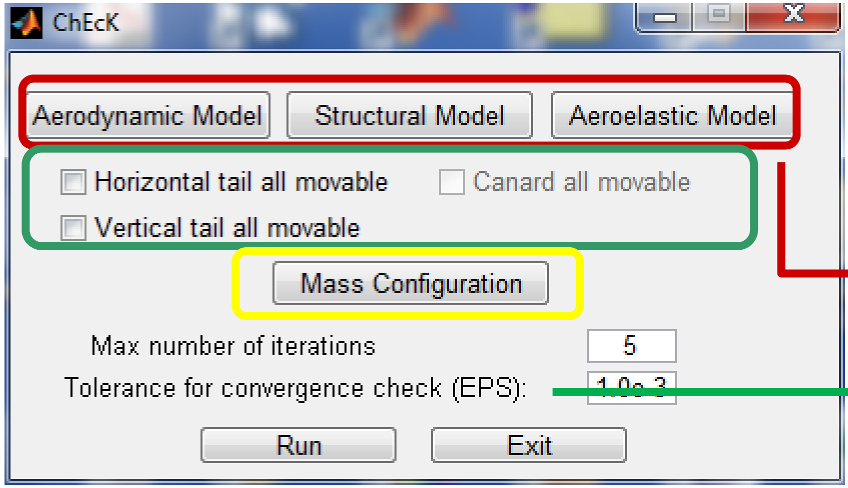
Technology File Button

The ***Open Techno*** button is inactive if the XML file already contains the Technology parameters requested by **NeoCASS**, generated by AcBuilder. NeoCASS check if these data are present, in case they are missing, the button becomes Active and the user has to provide a Technology file.





ChEcK window

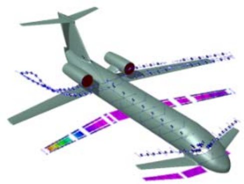


Before running **GUESS**, the system shows a new window, named ChEcK, with different options for the user.

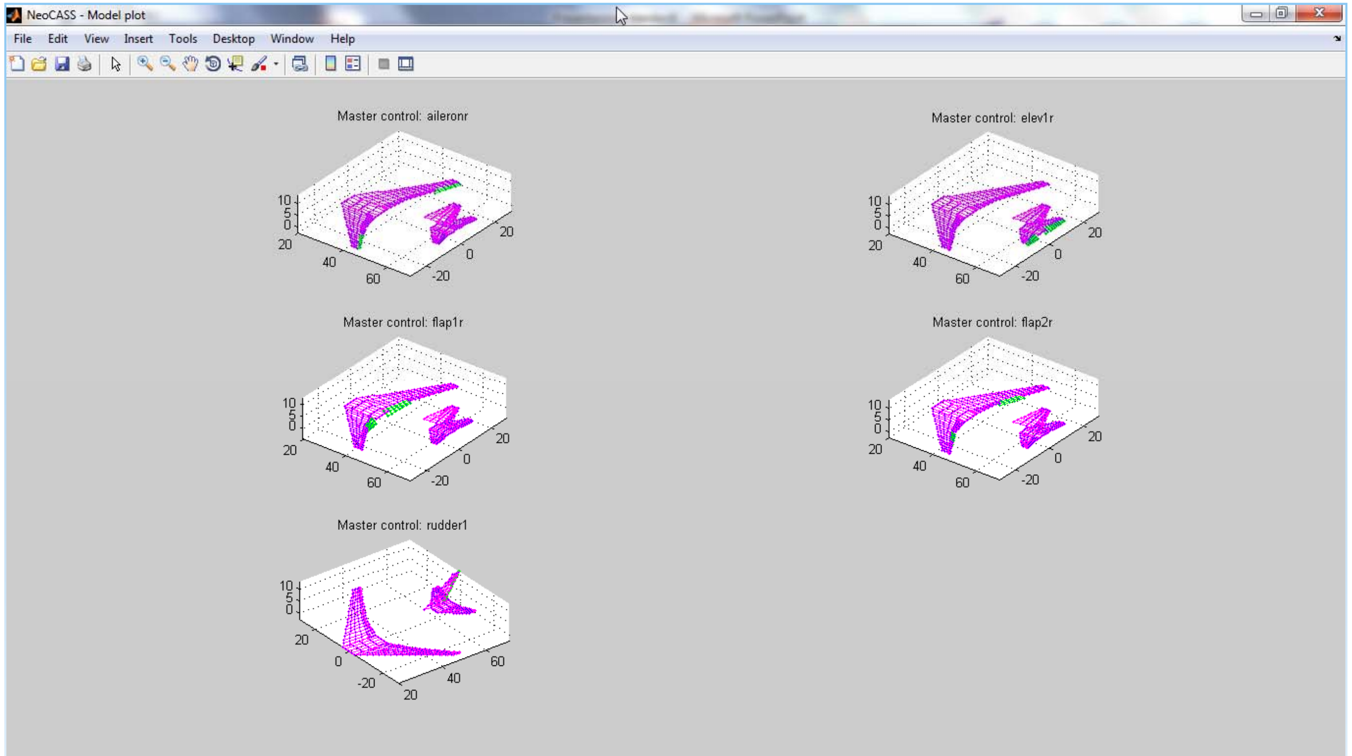
Models visualization options

Definition of all movable control surfaces

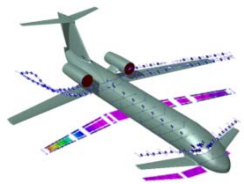
Definition of different mass configurations



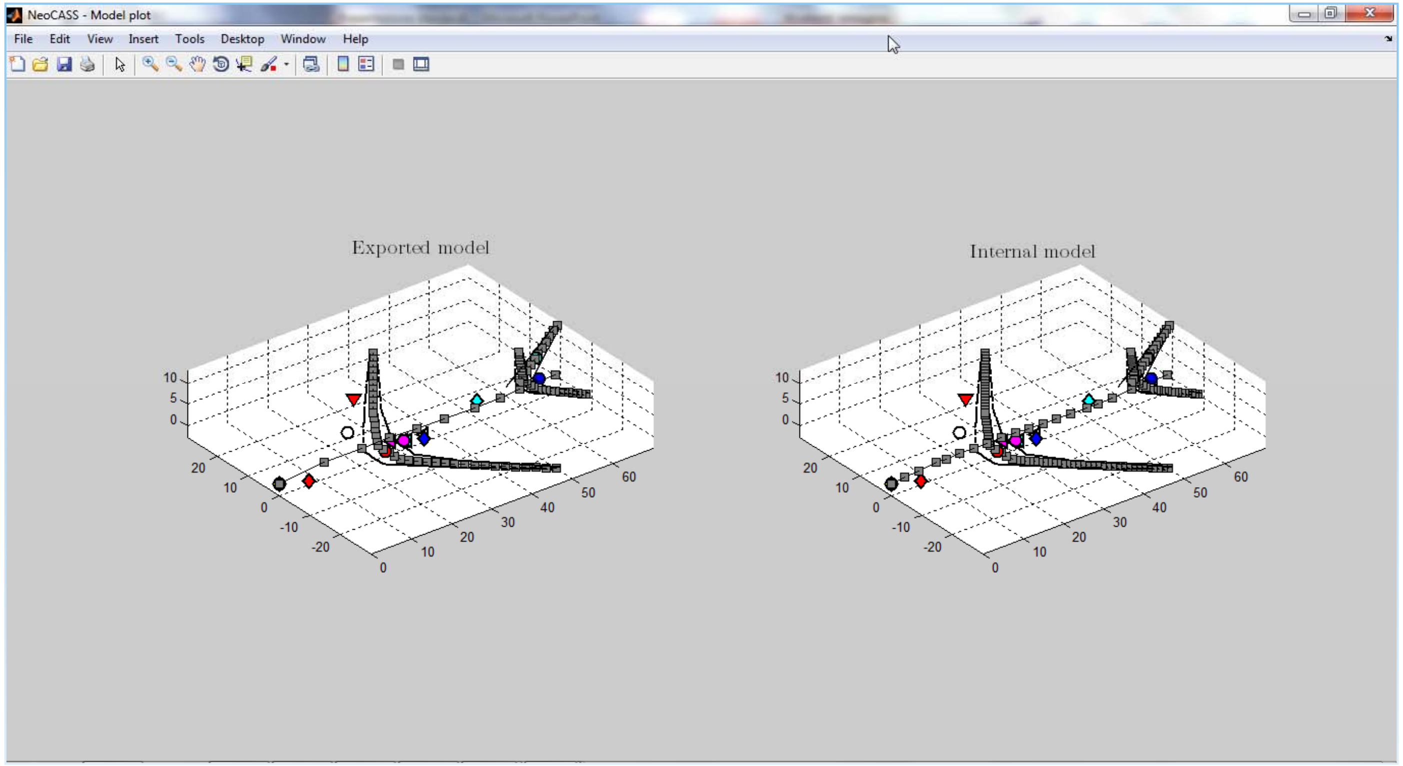
Aerodynamic model window



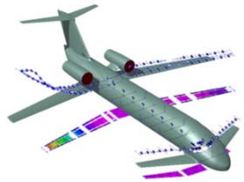
By pressing the ***Aerodynamic model button*** it is possible to visualize the aerodynamic mesh including the control surfaces.



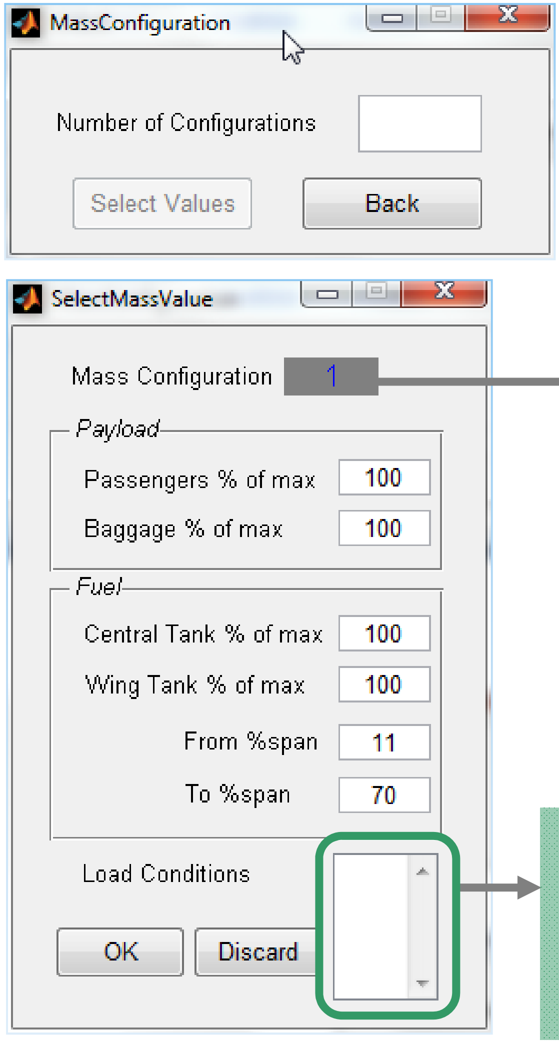
Structural model window



By pressing the ***Structural model button*** it is possible to visualize the internal (analytical) and exported (stick model) structural models.

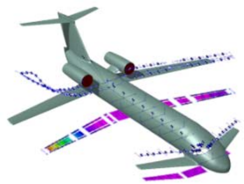


Mass configuration window



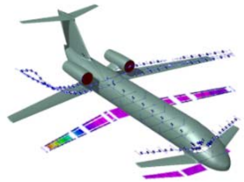
Using the ***Mass configuration button*** it is possible to define different mass configurations, in terms of Fuel and Passengers. Only in the case of **GUESS** with **Elastic option** mode it is possible to link each mass configuration to a specific sizing maneuver.

Linking between Mass configuration and Load condition (Sizing maneuvers).

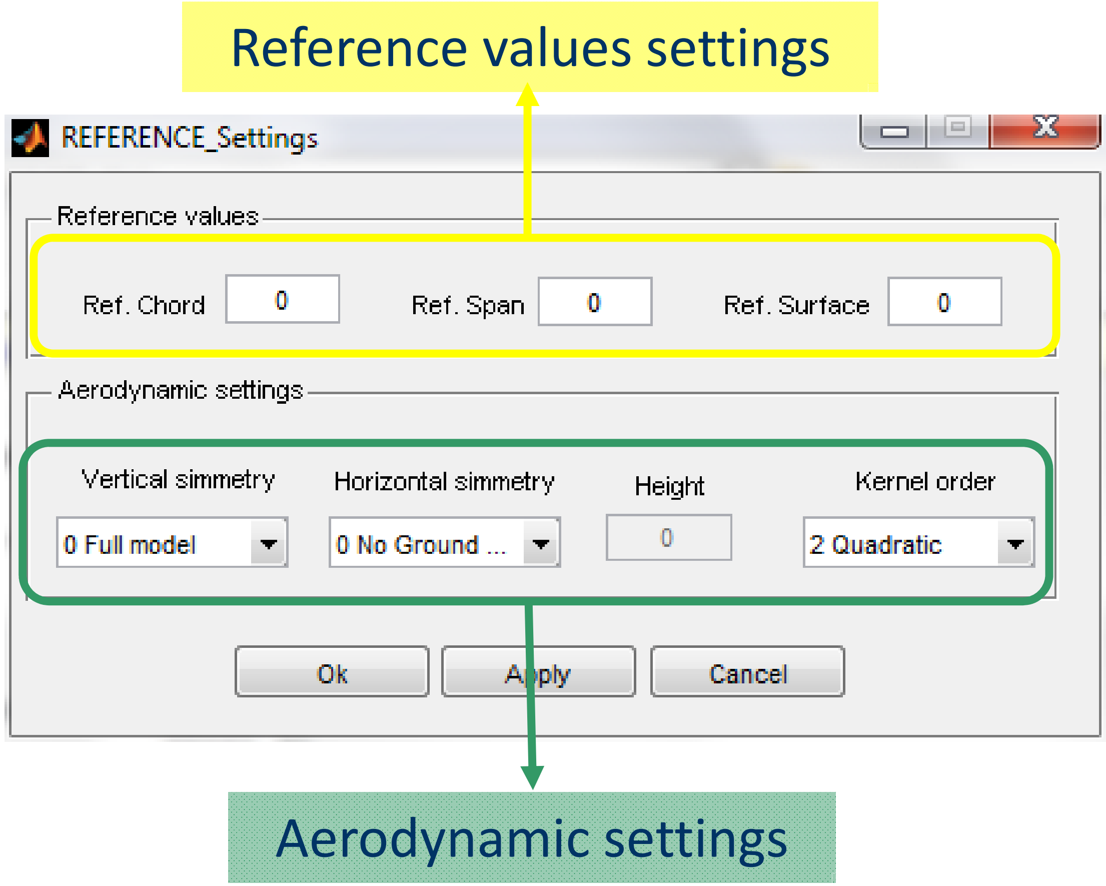


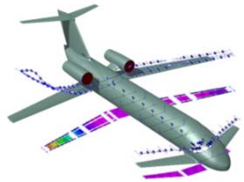
Reference Settings Subpanel

- The Subpanel REFERENCE Settings must be used to input reference parameters used for the aerodynamic calculations, i.e.:
  - Reference **Chord** (CREF);
  - Reference **Span** (BREF);
  - Reference **Surface** (SREF);
  - Vertical Simmetry (0 Full model, 1 half model);
  - Horizontal Simmetry (0 No Ground, 1 Ground effect);
  - Height (active if Ground Effect is selected);
  - Kernel order for DLM solver (1 Linear, 2 Quadratic).



Reference and Aerodynamic Settings Subpanel

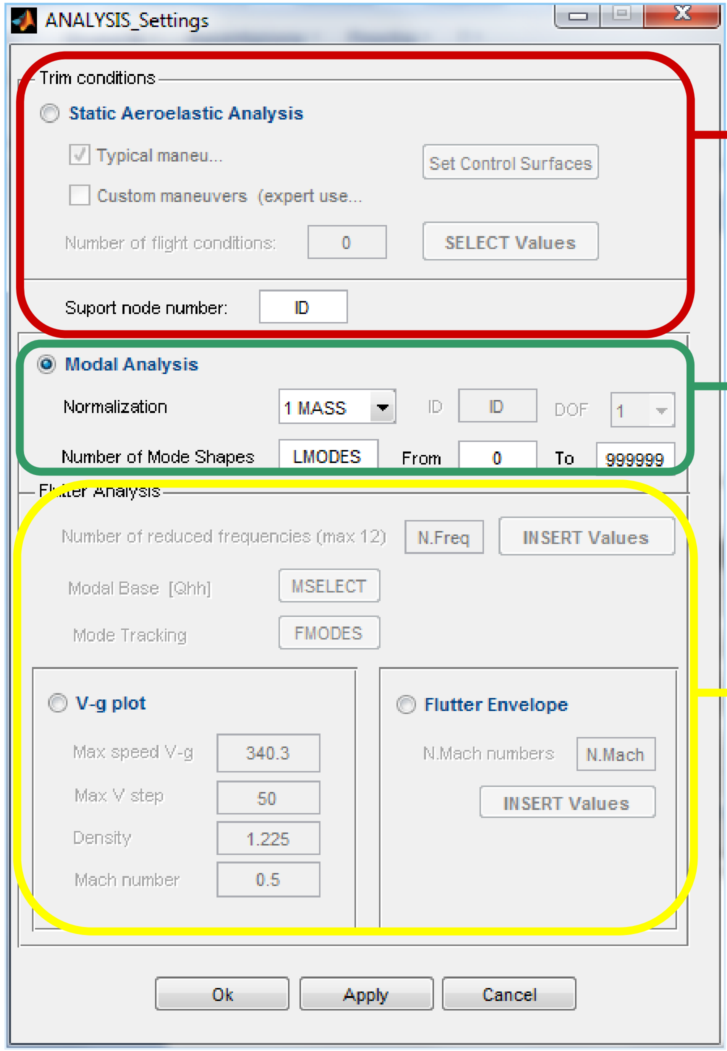




Analysis Settings Subpanel

- The GUI Subpanel ANALYSIS Settings must be used to select which kind of analysis must be run and to input the requested parameters. The GUI Subpanel could be divided into three small panels, related to the the following type of analysis:
  - Static aeroelastic analysis;
  - Modal analysis;
  - Flutter analysis;

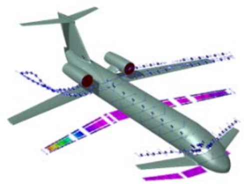
Analysis Settings Subpanel



Input data for static aeroelastic analysis

Input data for modal analysis

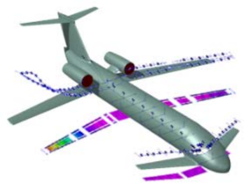
Input data for flutter analysis



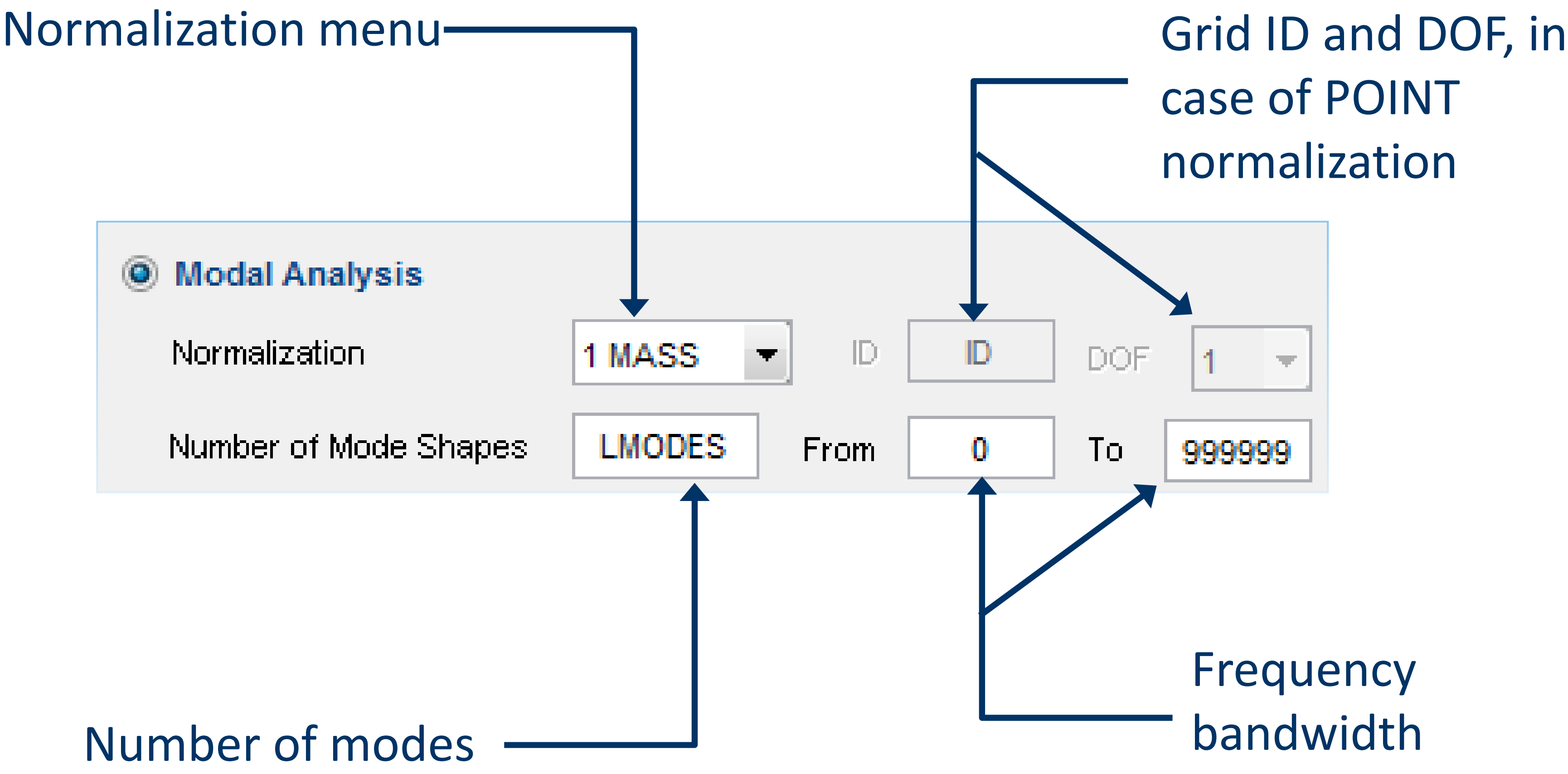
Analysis Settings Subpanel: Modal Analysis

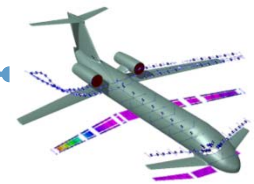
The parameters that must be provided to run a Modal Analysis are the following:

- Normalization (1 MASS, 2 MAX, 3 POINT): in case a POINT normalization is chosen the user must provide the Grid Point ID and DOF with respect to the normalization is done;
- ID: Grid Identification Number;
- DOF (1,2,3,4,5,6);
- LMODES: Number of modes retained during modal calculations;
- From - To: an alternative way to define the bandwidth of interest (lower and upper frequencies).



Analysis Settings Subpanel: Modal Analysis

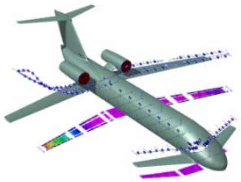




Analysis Settings Subpanel: Static Aeroelasticity

When static Aeroelastic Analysis is selected, three are the requested input parameters:

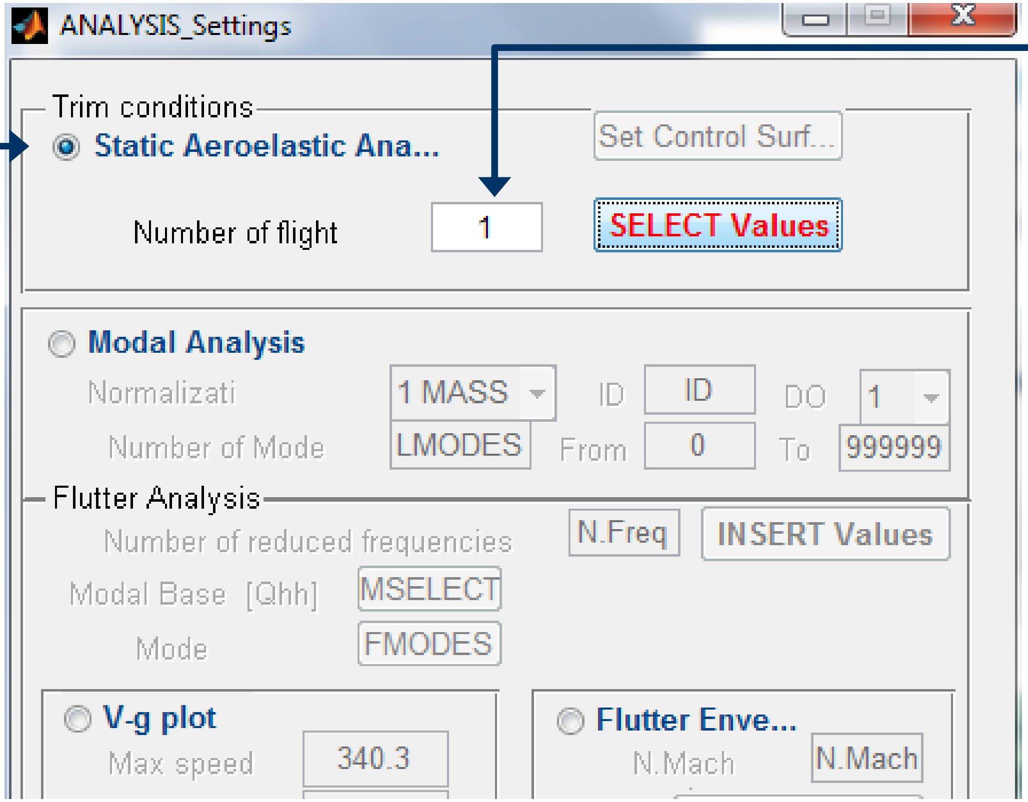
- Selection between typical (symmetric or asymmetric) or custom maneuvers, by pressing the related checkboxes. Using the first option only the minimum set of parameters necessary to solve the trim problem is requested as input. Using the second option, all the fields included into the TRIM card are requested;
- Number of Flight Conditions;
- Values for the TRIM card parameters for each flight condition.

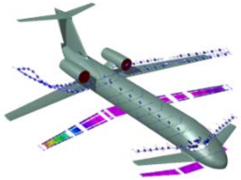


Analysis Settings Subpanel: Static Aeroelasticity

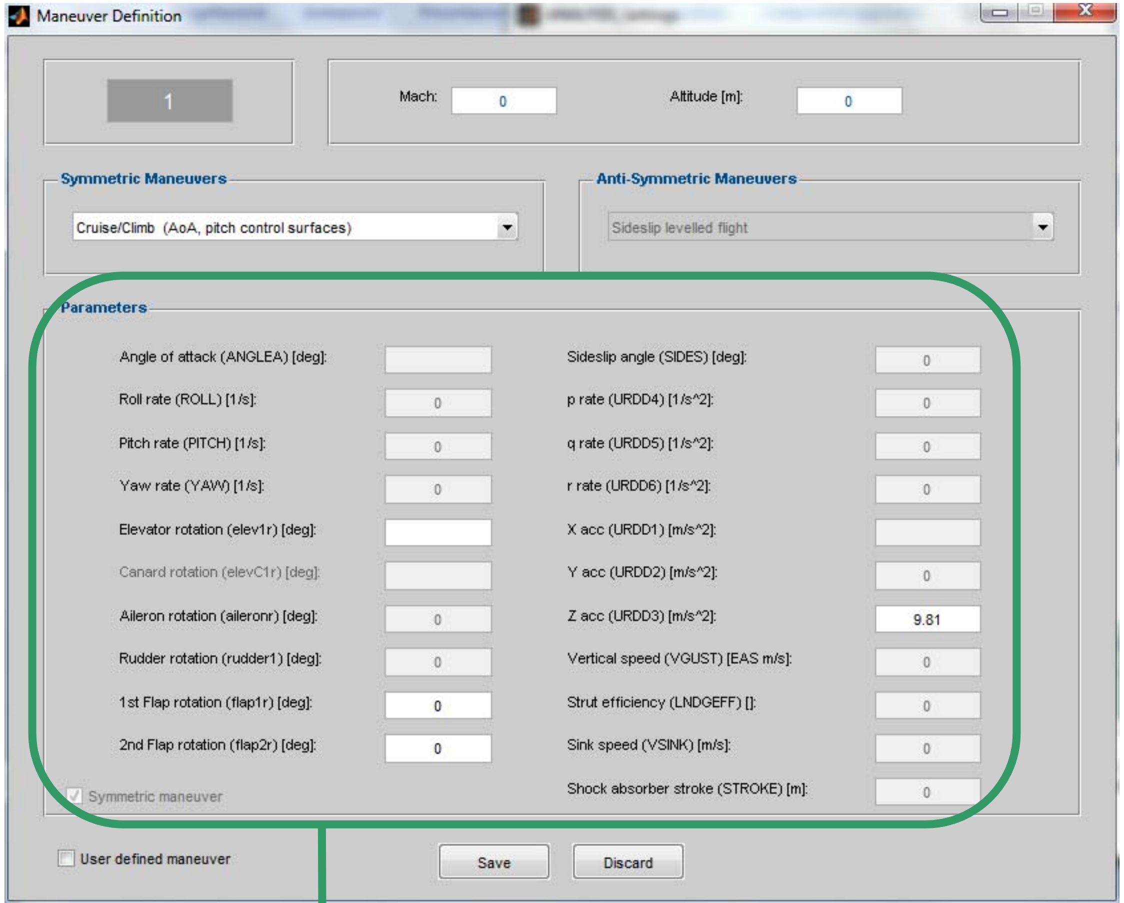
Radio button to select Static Aeroelastic Analysis

Number of flight conditions



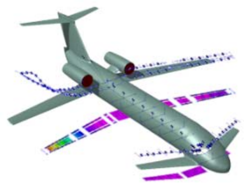


Analysis Settings Subpanel: Static Aeroelasticity



Once Select Values button has been selected, the following window is issued as many time as the number of flight conditions input by the users. For each kind of maneuver only the parameters necessary to solve the trim problem are requested.

Flight and control states necessary to define the prescribed maneuver.



Analysis Settings Subpanel: Static Aeroelasticity

When custom maneuvers option is selected, the complete table of all flight states must be filled by the user in a consistent way, so to be able to solve the trim problem that in general is stated as a system of 6 equilibrium equations for a free flying aircraft.

Custom Maneuvers

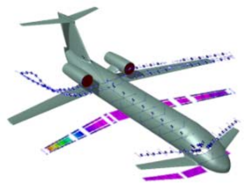
ID	Symme...	MACH	ALT	ANGLEA	SIDES	ROLL	PITCH	YAW	URDD1	URDD2	URDD3	URDD4	URDD5	URDD6	c1wing	c2wing	c3wing	c1ht	c2vt
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

OK Cancel

Analysis Settings Subpanel: Flutter Analysis

When Flutter Analysis is selected, the user first of all must specify the number of reduced frequencies (max. 12) and insert their values in the Table that appears after pressing the button ***INSERT Values***. The minimum reduced frequency is automatically set to 0.001 but it can be modified by the user. Then, user must specify the number and list of modes to be retained for the calculation of Generalized Aerodynamic Forces matrix (Qhh) and the number and list of modes to be tracked during the V-g plot calculation. Finally, users must choose between two possibilities: **Flutter analysis** for a single assigned flight condition or **Flutter Envelope** for an assigned number of Mach values. In the first case (generation of *V-g* plot) the requested input parameters are:

- Max Speed for flutter calculation;
- Max V step (number of steps used during iterative mode tracking);
- Air Density;
- Mach Number.



Analysis Settings Subpanel: Flutter Analysis

When Flutter Envelope is selected, the requested input parameters are:

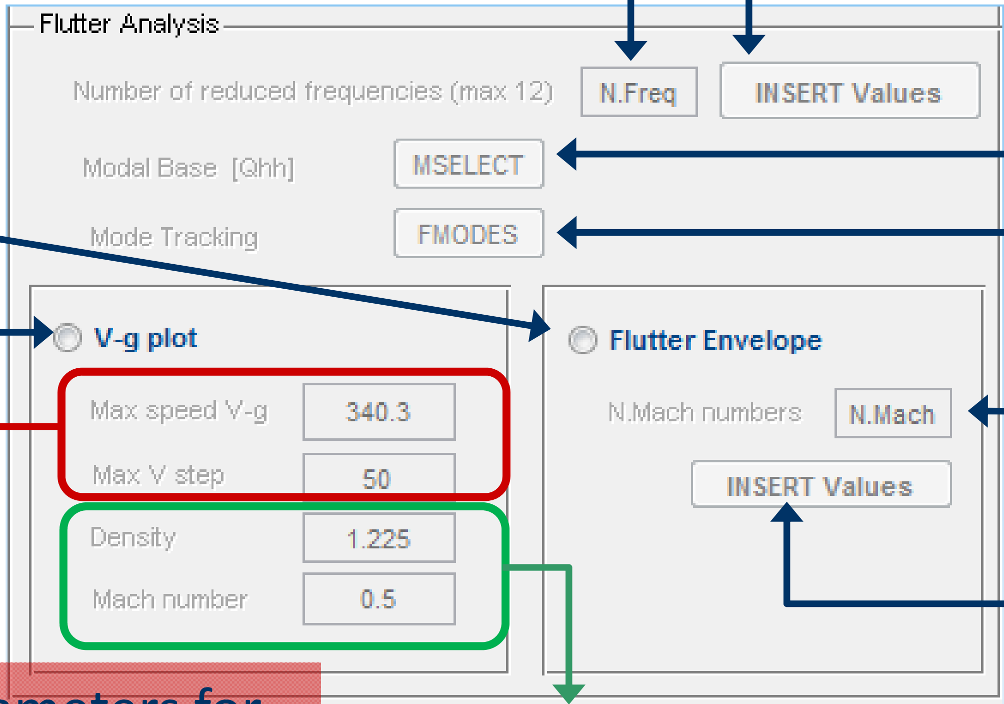
- Number of Mach values for which flutter envelope is computed;
- Values of Mach numbers: when the Insert Values button is pressed a table appears where the user must insert Mach number values.

Analysis Settings Subpanel: Flutter Analysis

Radio buttons to select single flutter analysis (*V*-g plot) or flutter envelope

Number of reduced frequencies

Press to insert values



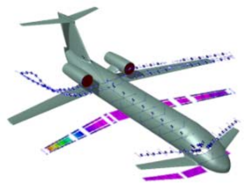
Selection of modes for calculation and *V*-g plot

Number of Mach numbers

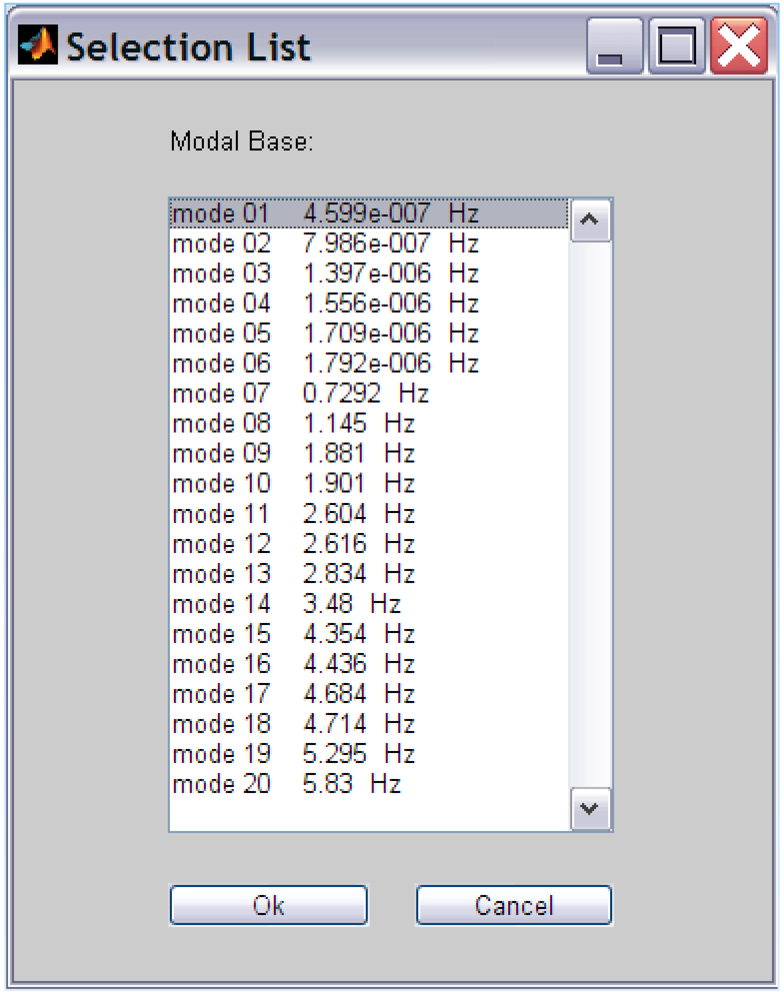
Press to insert values

Analysis parameters for mode tracking

Flight data

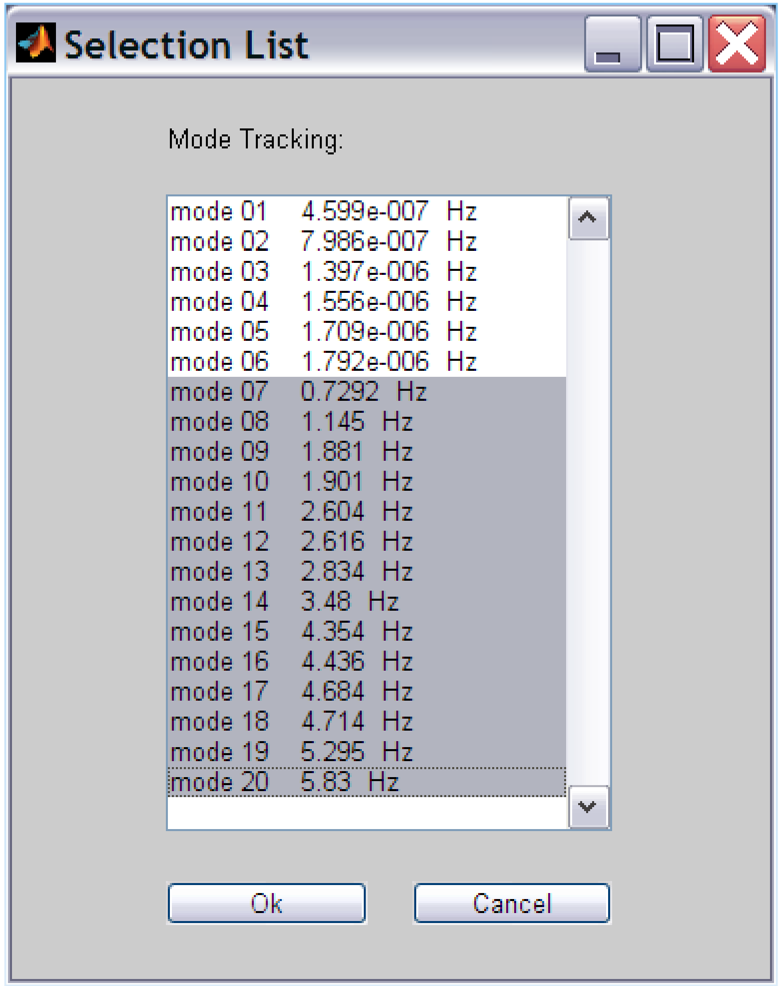


Analysis Settings Subpanel: Flutter Analysis

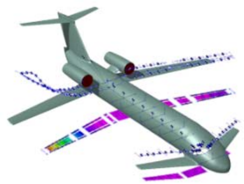


When the ***MSELECT Button*** is pressed, a listbox window pops up showing the list of eigenvalues available (as set by LMODES card). The user can select the list of retained modes simply selecting different rows by pressing at the same time SHIFT or CTRL buttons.

Analysis Settings Subpanel: Flutter Analysis

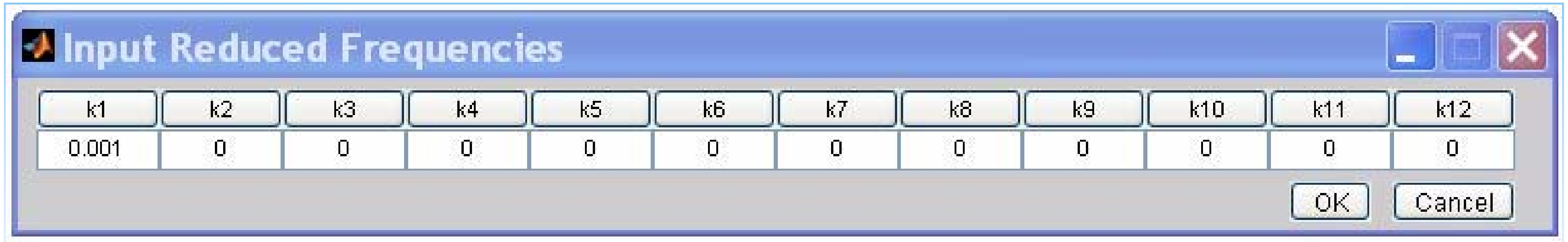


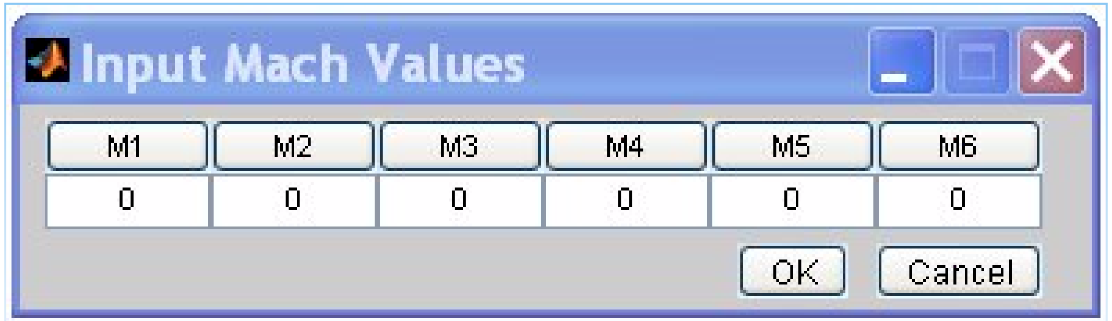
When the ***FMODES Button*** is pressed, a listbox window pops up showing the list of eigenvalues available (as set by LMODES card). The user can select the list of modes he want to track during the *V-g* plot calculation. For example, rigid modes can be retained into the modal basis during calculation of generalized forces but they cannot be tracked during the *V-g* plot calculation.



Analysis Settings Subpanel: Flutter Analysis

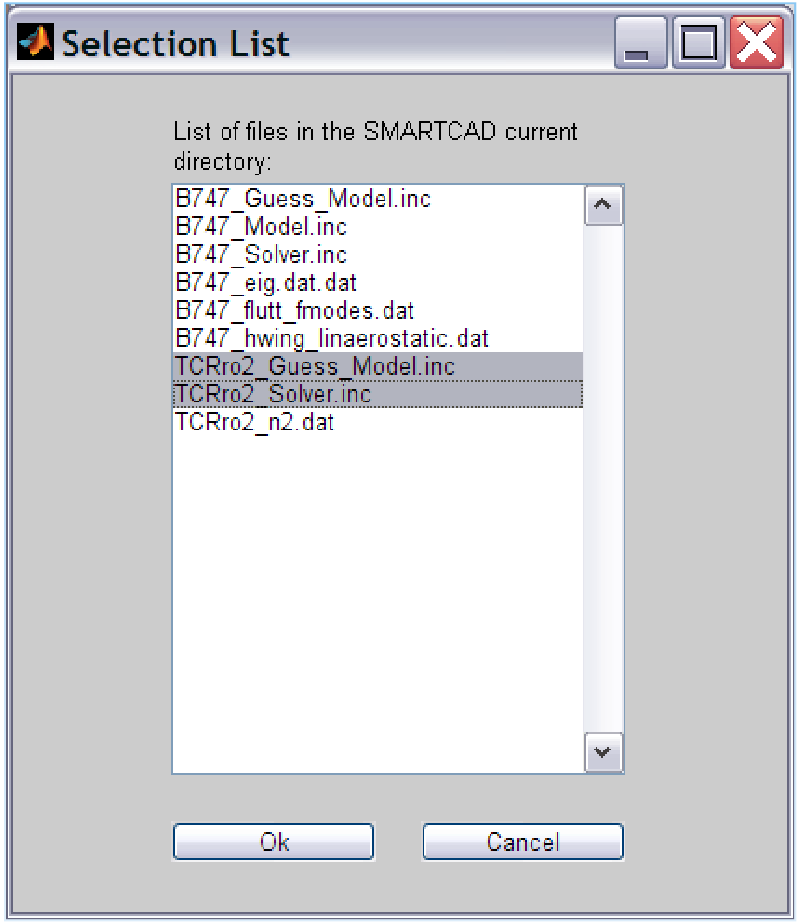
Input reduced frequencies



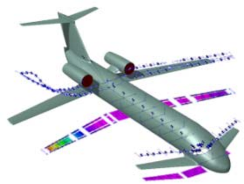


Input Mach values

Assembly a SMARTCAD analysis file

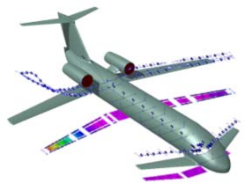


When the ***ASSEMBLY Button*** is pressed, a listbox window pops up showing all the .inc and .dat files available in the current directory. In this way it is possible to assemble a final SMARTCAD analysis file, simply by merging a stick model file with specific .inc files including the requested analysis cards. The assembly is done by means of the INCLUDE card that is automatically written on the final .dat file. Multi selection is possible using SHIFT and CTRL buttons.



Saving the .inc analysis files

After the input of all parameters for each kind of analysis, the user will be asked to save them into a .inc file. In this way it is possible to save different .inc files including different kind of analysis that later can be merged with a stick model file in a final .dat smartcad using the INCLUDE card.



General Settings Panel

The Panel Settings is used to input parameters for analysis solvers. In particular, the following parameters must be selected by the user:

- Structural Model (1 Linear Beam, 2 Equivalent Plate, 3 Non-Linear Beam). In the version 2.0 of **NeoCASS** the Equivalent Plate structural model is not active even if already included;
- Aspect Ratio: when Equivalent Plate is selected the user can control the size (and number) of Plate elements automatically generated by means of this parameter, which control the aspect ratio of Plate. It is set by default equal to 1;
- Sub-Iter: when Non-Linear beam is selected, Sub-Iter defines the number steps needed to reach convergence with an assigned load;
- contd…

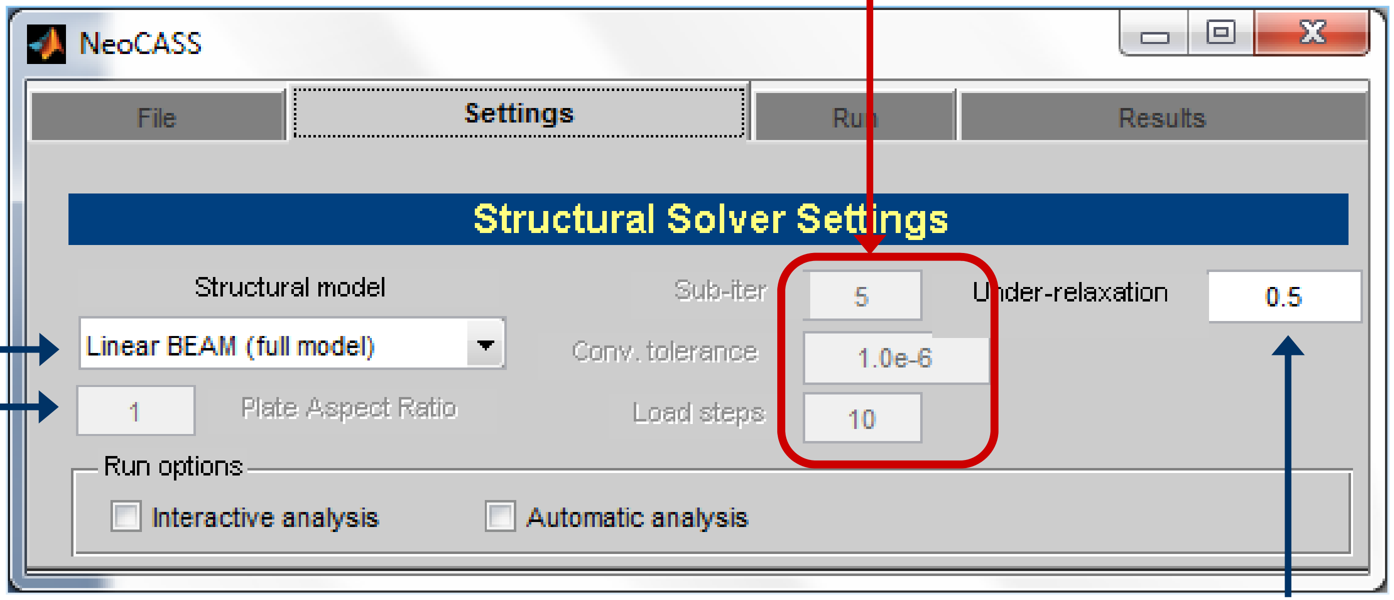
General Settings Panel

- Conv. Tolerance (convergence error on the residue during non-linear analysis);
- Load Steps: number of load steps during static non-linear analysis or maximum number of coupled iterations during Static Aeroelastic Analysis;
- Under-relaxation (relaxation factor adopted transferring loads from aerodynamic to structural mesh): 0.5 is the default value.

General Settings Panel

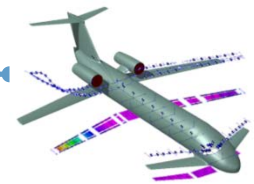
Structural model selection

Non-linear analysis control parameters



Control of equivalent plate Aspect Ratio

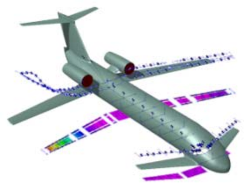
Structural-aerodynamic coupling control parameter



RUN Panel

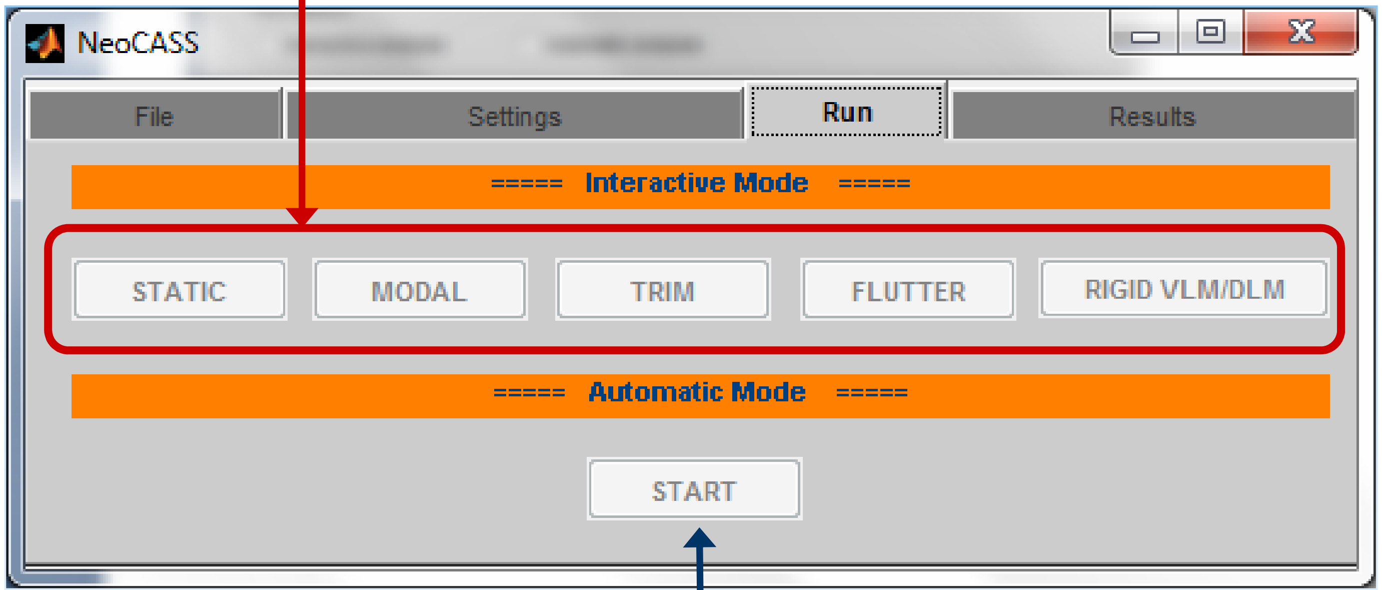
The RUN Panel simply collects all buttons related to each solvers. Only buttons related to solvers for which all the requested data have been correctly input are active (clickable). In the same panel is located the button named Start used to start all solvers in the automatic analysis mode, when selected (option inactive for Version 2.0). The following analyses can be started by the panel:

- **STATIC**: Static analysis under aerodynamic and inertial relief loads;
- **MODAL**: Eigenvalues analysis;
- **TRIM**: Static aeroelasticity analysis: trim and aeroelastic stability derivatives;
- **FLUTTER**: Flutter analysis;
- **STEADY VLM/DLM**: Aerodynamic loads over rigid aircraft.

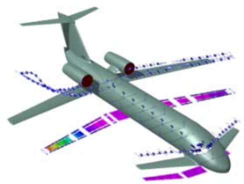


RUN Panel

Buttons to start available analyses



Button to start a sequence of analyses in automatic mode (inactive for the current version)



RESULTS Panel

RESULTS Panel is a collection of buttons and checkbox options allowing the user to analyze and post-processing the results of a **NeoCASS** run. Many of the buttons and selection fields available on this GUI Panel have a different meaning, depending on which kind of analysis has been performed. The post-processing options are the following:

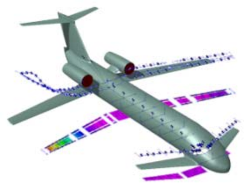
- **GUESS**: By pressing the button **GUESS** it is possible to plot the results of a **GUESS** analysis. The selection of which kind of diagram has to be plotted is done by filling the Selected Set field, ranging in this case from 1 to 10;
- **Aerodynamic Matrix**: In case of Flutter analysis, by pressing the button Plot Aero Matrix it is possible to plot the component of Aerodynamic Generalized Forces (Qhh): in this case the user must supply the ROW and COL indices. The Selected Set field in this case allows the user chose among the different Mach numbers for which Qhh has been computed (Flutter Envelope option);

RESULTS Panel

- **Plot Model**: When a simple structural analysis has been performed (Modal Analysis), by pressing the button Plot Model a new figure showing the structural model is created. Otherwise, in case of a Steady Rigid Aerodynamic Analysis (VLM) the same button allows to see both structural and aerodynamic panels;
- **Plot Deformed Model**: In case of a simple structural analysis (Modal Analysis), pressing the button Plot Deformed Model it is possible to visualize the mode shapes. The number of mode to be plotted is as usual controlled by the Selected Set field, while the Scale factor field determines the amplitude of the deformed shape. It is possible to generate an animation for each mode shape, choosing the number of mode and the number of frames. Pressing button Export Mode Animation an .AVI file is created containing the vibration mode animation.

RESULTS Panel

- **Plot Flutter Diagrams**: In case of Flutter Analysis pressing the button Plot Flutter diagrams the figures reporting V-g plot and Flutter envelope are created (if related output has been requested);
- **Selection Checkboxes**: Three selection checkboxes are available, all related to the plot of aerodynamic panels. They allow to include or exclude into the plot the wake elements, the panels normals and the contour visualization.
- **SAVE NeoCASS Project**: Pressing this button all intermediate results and data, organized into separated MATLAB c structures, are saved into an unique MATLAB c binary file (.MAT). In this way, it is possible in any moment to read it by pressing the related button into the GUI Panel File so recovering all the available data.
- **Close ALL**: To Exit from **NeoCASS** and delete all temporary files.

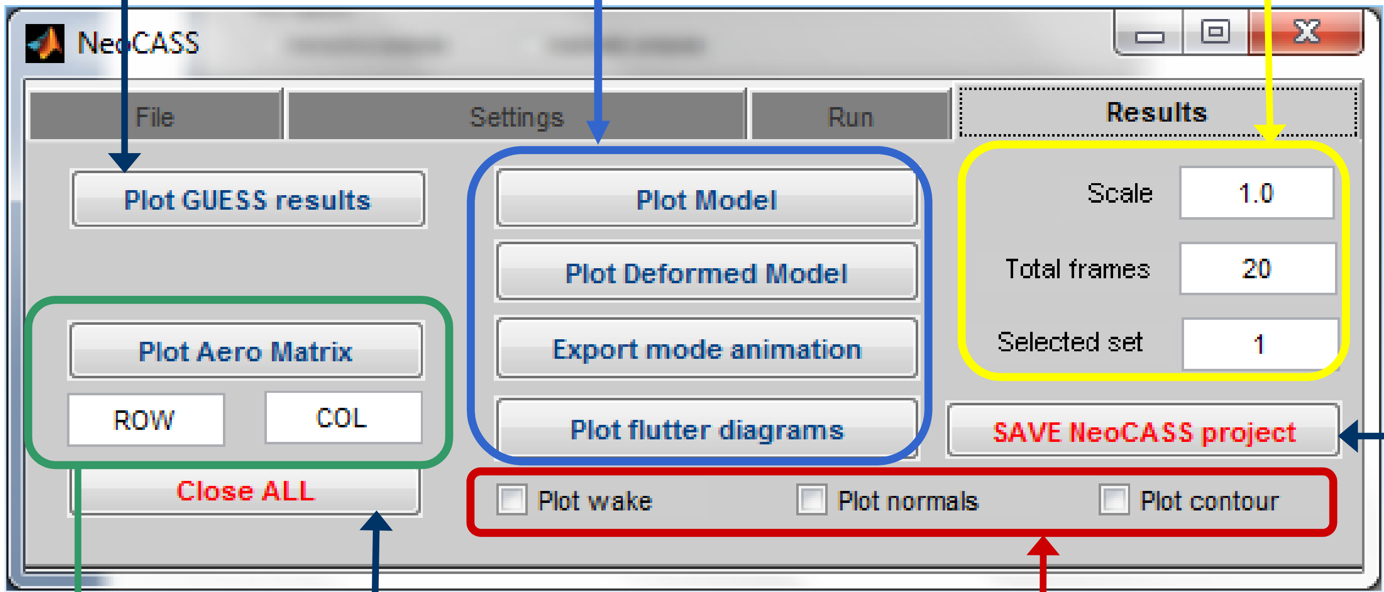


RESULTS Panel

Plot **GUESS** results

Plot selection

Plot options for deformed model (scale factor), mode animation (total frames) and output selection (set number)



Save **NeoCASS** project

Clear all windows and data

Qhh matrix plot options

Selection checkboxes to include different items into the plot