POLITECNICO DI MILANO

NeoCASS 1.3:
Overview and GUIs Tutorial (Rel.1)

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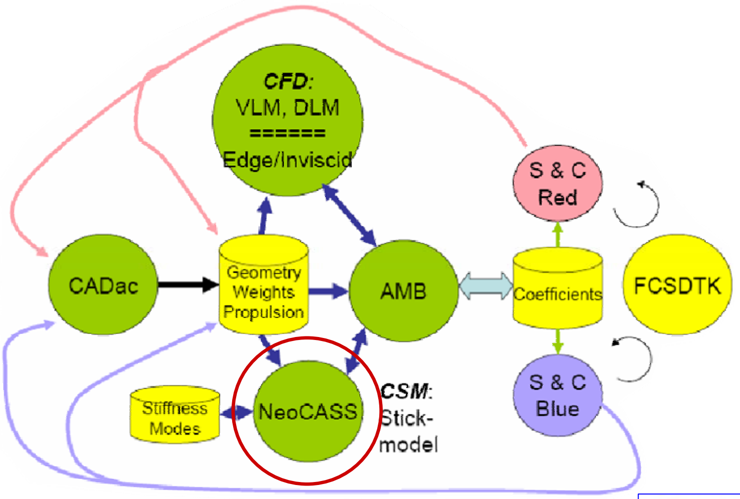
PART I
NeoCASS overview

SimSAC Galaxy architecture



SimSAC

NeoCASS overview

- Collection of analysis modules for:
  - **Initial Structural Sizing** (Guess)
  - **Modal analysis**
  - **Aeroelastic Analysis** (Static Aeroelasticity, Flutter)
- connected with tools for:
  - **CSM/CFD coupling**
  - **Aerodynamic Analysis** (VLM, DLM, Edge, other…)
  - **MDO**
- interfaced to:
  - **external codes** (Edge, others)
  - **other Stars**

SimSAC

NeoCASS in details

- Step by Step NeoCASS sequence of operations:
  1. Input of **Aircraft Geometric description** from CADac module through XML file;
  2. Input of **Aircraft Requirements**;
  3. Input of **tecnological** solutions;
  4. Initial structural sizing;

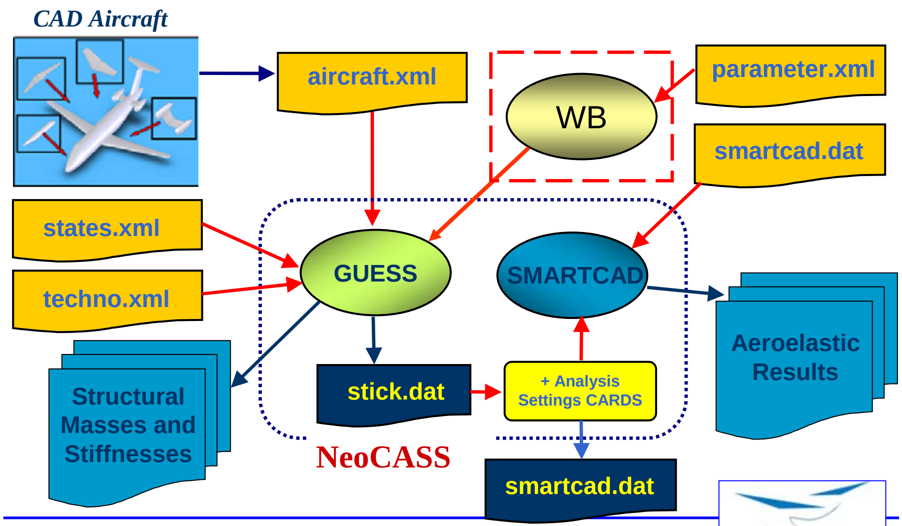
  Guess

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

  SmartCAD

SimSAC

NeoCASS architecture



SimSAC

Weight and Balance module characteristics (1)

- Based on A. Isikveren's PhD Thesis *(Quasi-analytical modelling and optimization techniques for transport aircraft design, KTH 2002);*
- Relies on statistical and/or empirical formulas like Raymer's or Torenbeek's approaches;
- Minimize user's intervention:
  - External geometry and some information on internal layout (mainly recovered from geometry module) ;
  - Passengers number, crew number and an estimate of maximum fuel in tanks;
  - If available, concentrated masses and their CoGs, which represent, for instance, APU or auxiliary tanks.

Weight and Balance module characteristics (2)

The weights of can be classified in three principal groups:

- those directly related to Maximum Take Off Weight (MTOW), i.e. fuselage or wing;
- those related to "fixed" equipment, which depend only on passengers number, and held constant;
- those related to payload and fuel.

These three concur to total weight by means of an iterative method: a fixed amount of fuel (MFW_decrement_to_MTOW) serves as control variable and, once the method has converged, the minimum MTOW, which that fulfills airframe strength requirements at fixed payload, is found.

Weight and Balance module characteristics (3)

The module returns each component mass (kilogram) and its CoG coordinates (meters) with respect to a coordinate system, which has the origin on aircraft nose (x axis positive from nose to tail), the inertia matrix and two CoG (global) position referred to two different weight scenarios: MEW (Maximum Empty Weight) and MTOW.

W&B: Input file structure

The main parameters to be inserted are related to passengers, baggage, cabin's dimensions and fuel quantity in each tank.

Aside from passengers number and fuel, the other parameters can all be set to zero, thus forcing the code to make an estimate for them.

Fuel data are mandatory parameters because they directly influence the optimization procedure.

In the subsequent slides the XML syntax is shown, highlighting some fields related to W&B module, which can be modified using either a common XML editor (like XML Notepad) or the AcBuilder, that, having a graphical interface, is more user friendly.

W&B: Input file structure (2)

- **Baggage**

XML:

<Baggage idx="1" type="struct" size="1 1">
<installation_type idx="1" type="double" size="1 1"> **0.(*)** </installation_type>
<gross_volume idx="1" type="double" size="1 1"> **-1(*)** </gross_volume>
<Baggage_combined_length idx="1" type="double" size="1 1"> **0.(*)** </Baggage_combined_length>
<Baggage_apex_per_fuselgt idx="1" type="double" size="1 1"> **0.(*)** </Baggage_apex_per_fuselgt>
</Baggage>

Remark: the values here shown (*) are suggested as default when most of the information about baggage is missing; in particular -1 forces gross volume calculation.

W&B: Input file structure (3)

- **Cabin**

XML:

<cabin idx="1" type="struct" size="1 1">
<Cabin_length_to_aft_cab idx="1" type="double" size="1 1"> … </Cabin_length_to_aft_cab>
<Cabin_max_internal_height idx="1" type="double" size="1 1"> **0. (*)** </Cabin_max_internal_height>
<Cabin_max_internal_width idx="1" type="double" size="1 1"> **0. (*)** </Cabin_max_internal_width>
<Cabin_floor_width idx="1" type="double" size="1 1"> **0. (*)** </Cabin_floor_width>
<Cabin_volume idx="1" type="double" size="1 1"> **0.(*)** </Cabin_volume>
<Cabin_attendant_number idx="1" type="double" size="1 1">…</Cabin_attendant_number>
<Flight_crew_number idx="1" type="double" size="1 1">…</Flight_crew_number>
<Passenger_accomodation idx="1" type="double" size="1 1">…</Passenger_accomodation>
<Seats_abreast_in_fuselage idx="1" type="double" size="1 1">…</Seats_abreast_in_fuselage>
<Seat_pitch idx="1" type="double" size="1 1">…</Seat_pitch>
<Maximum_cabin_altitude idx="1" type="double" size="1 1">…</Maximum_cabin_altitude>
<Max_pressure_differential idx="1" type="double" size="1 1"> …</Max_pressure_differential>
</cabin>

Remark: the values here showed (*) are suggested as default when most of the information about cabin is missing. For what concerns cabin internal layout only its length is mandatory, the other information are estimated (if set to 0, however, the code compute it subtracting nose and tail cone length from total length).

W&B: Input file structure (4)

- **Fuel**

```
<weight_balance idx="1" type="struct" size="1 1">
  <Fuel idx="1" type="struct" size="1 1">
    <Maximum_fuel_in_wings idx="1" type="double" size="1 "> ... </Maximum_fuel_in_wings>
     <Maximum_fuel_in_auxiliary idx="1" type="double" size="1 1"> … </Maximum_fuel_in_auxiliary>
     <Maximum_fuel_in_central_wingbox idx="1" type="double" size="1 1"> … 
</Maximum_fuel_in_central_wingbox>

    …
  <\Fuel>
<\weight_balance>

<fuel idx="1" type="struct" size="1 1">
   <box_ea_loc_root idx="1" type="double" size="1 1">     ...  </box_ea_loc_root>
   <box_ea_loc_kink1 idx="1" type="double" size="1 1">    ...  </box_ea_loc_kink1>
   <box_ea_loc_kink2 idx="1" type="double" size="1 1">    ...  </box_ea_loc_kink2>
  <box_ea_loc_tip idx="1" type="double" size="1 1">        ...  </box_ea_loc_tip>
  <box_semispan_root idx="1" type="double" size="1 1">    ...  </box_semispan_root>
  <box_semispan_kink1 idx="1" type="double" size="1 1"> ...  </box_semispan_kink1>
  <box_semispan_kink2 idx="1" type="double" size="1 1"> ...  </box_semispan_kink2>
  <box_semispan_tip idx="1" type="double" size="1 1">     ...  </box_semispan_tip>
 </fuel>
```


W&B: TCR02 Example

Part [Kg]	WB	SAAB
Wing	24.693	21.534
HT	1.031	1.929
VT	2.927	3.678
Land. Gear	7.383	8.102
Fuselage	21.017	21.353
Power Plant	36.316	31.127

XCG_{MEW} [m]	XCG_{MTOW} [m]	I_{xx} [kg/m^2]	I_{yy} [kg/m^2]	I_{zz} [kg/m^2]
37.42	37.34	$1.096\cdot10^7$	$2.325\cdot10^7$	$3.201\cdot10^7$

MTOW [Kg]	WB	SAAB
	220.035	226.764

W&B: B747-100 Example

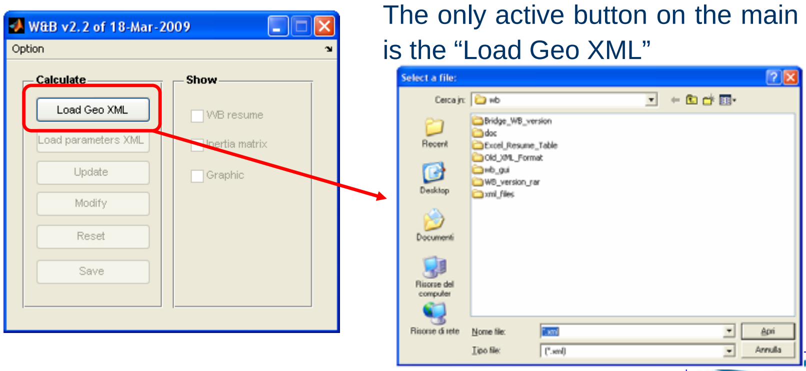
# COMPONENT	LABEL	X [m]	Y [m]	Z [m]	MASS [Kg]
1	WING1	26,2983	0	-1,77813	46261,8
2	WING2	0	0	0	0
3	HT	59,48747	0	1,712045	4129,396
4	VT	58,19936	0	7,581888	2071,613
5	FUSELAGE	30,82869	0	-0,711	23386,72
6	LANDING GEAR	0	0	0	11970,53
7	POWERPLANT1	26,41478	0	-0,34223	13405,55
8	POWERPLANT2	23,80198	0	-0,22342	20108,33
17	FURNITURE	30,82869	0	-0,711	44795,82
18	WING TANKS	29,76799	0	-1,30944	100000
19	CENTRE FUEL TANKS	25,76417	0	0	40000
20	AUXILIARY TANKS	0	0	0	0
21	INTERIOR	35,96076	0	-0,70438	30035,55
22	PILOTS	7,36076	0	-2,13098	255
23	CREW	0	0	0	750
24	PASSENGERS	35,96076	0	-2,13098	40002
25	BAGGAGE	20,23978	0	0,5301	5102,628
27	CG@MTOW	29,50813	0	-0,95702	0
29	CG@MEW	27,85651	0	-0,70257	0

PART II
Weight & Balance and
NeoCASS GUIs overview

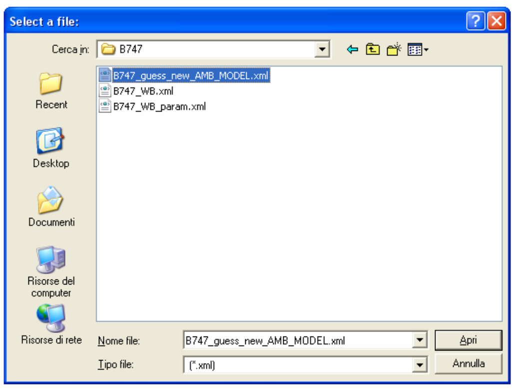
W&B: Load Geo File

Once the Matlab path for NeoCASS is set (using *set_neocass_path* command), the W&B GUI can be issued typing *wb_gui* at prompt.

The only active button on the main panel is the “Load Geo XML”

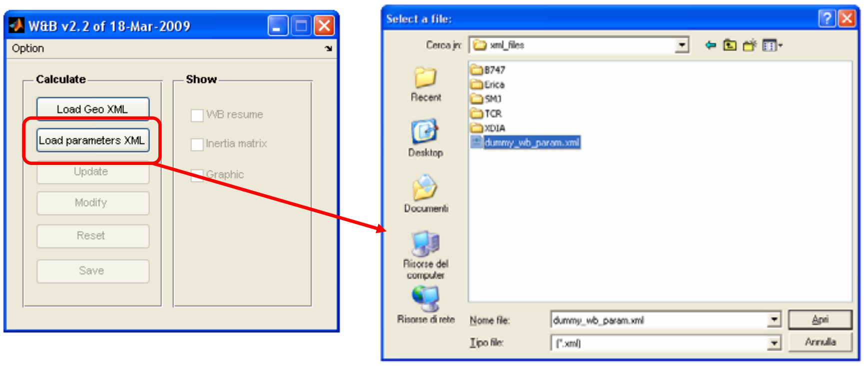


W&B: Load Geo File (2)



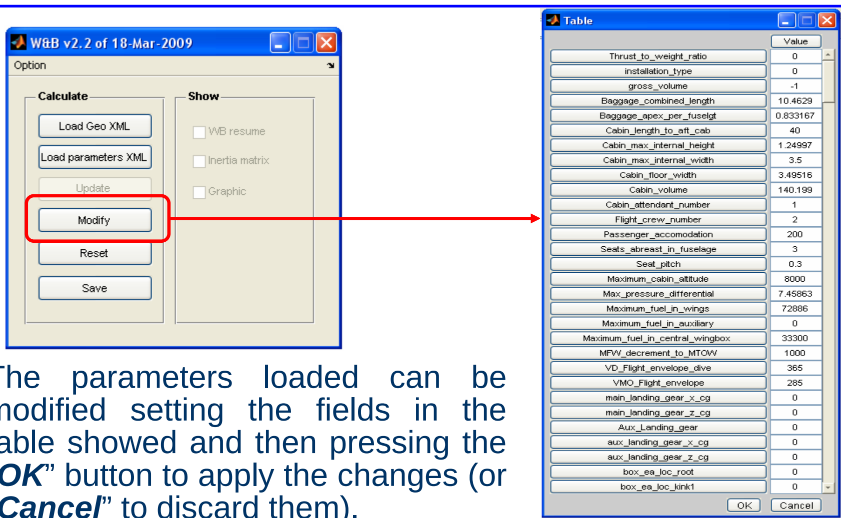
The first file to load (some example can be found in \wb\xml_files\) is the one produced by CEASIOM Geo Module.

W&B: Load Parameter File



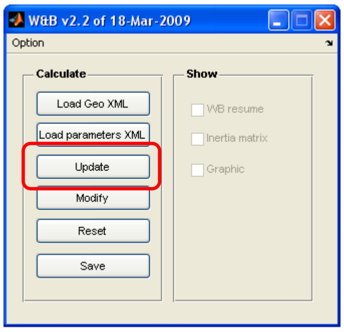
To get started a default file labeled as *dummy_wb_param.xml* is saved in \wb\xml_files\; it has all the required fields and can be modified using the GUI or by an XML editor.

W&B: Modify parameters



The parameters loaded can be modified setting the fields in the table showed and then pressing the "***OK***" button to apply the changes (or "***Cancel***" to discard them).

W&B: Compute Weights and Inertias



The "Update" button run the W&B code, "merging" data from Geo and parameter file.

W&B: Typical output

Checking fuel input...
- Fuel weight for Wing tank within the limit of 165972.5 [Kg]
- Fuel weight for Central tank within the limit of 52644.5 [Kg]

done.

Warning: Cabin length inserted 40.00 [m] doesn't correspond to computed value of 40.02 [m]

> In weight_xml at 288
In wb_gui>pushbutton2_Callback at 470
In gui_mainfcn at 95
In wb_gui at 69

Iteration # 1
Structural weights:

Wing weight [Kg]:	23962.67
HT weight [Kg]:	1365.68
VT weight [Kg]:	1591.42
Fuselage weight [Kg]:	18805.29
Engine1 group weight [kg]:	666.51
Engine2 group weight [kg]:	0.00
Landing gear weight [kg]:	6437.58

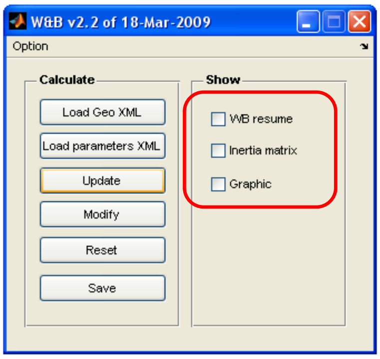
W&B: Typical output (2)

Total "dry" weight [Kg]: 71040.59
Max zero fuel weight [Kg]: 90998.39
Max Take-off weight [Kg]: 196138.39

Inertia estimation [Kgm^2]

Coarse approximation (w.r.t. CoG):
Ixx = 9623546.7
Iyy = 20406238
Izz = 28090862
Ixy = 0
Iyz = 0
Ixz = 0
done.

W&B: Visualize results

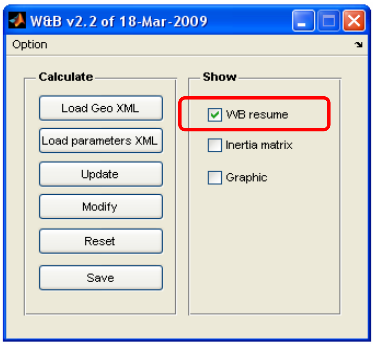


After the code has run, three visualization options become available:

- WB resume: issues a table where each row characterize an aircraft's component, showing its mass and coordinate w.r.t. nose origin;
- Inertia Matrix [3x3];
- Graphical representation of component's CoG.

Flagging/Unflagging each box open/close the related window.

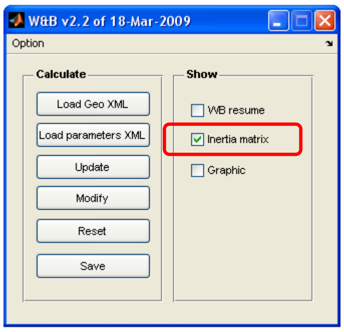
W&B: Resume

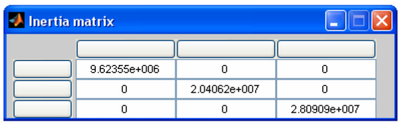


	X [m]	Y [m]	Z [m]	M [Kg]
WING1	39.0062	0	-0.990272	23962.7
WING2	0	0	0	0
HT	12.4816	0	0	1365.68
VT	52.0703	0	5.30509	1591.42
FUSELAGE	36	0	-0.37	18805.3
LANDING GEAR	0	0	0	6437.58
POWERPLANT1	46.62	7.01305	0	666.500
POWERPLANT2	0	0	0	0
AUX LANDING GEAR	0	0	0	0
############	0	0	0	0
############	0	0	0	0
############	0	0	0	0
############	0	0	0	0
############	0	0	0	0
############	0	0	0	0
############	0	0	0	0
FURNITURE	36	0	-0.37	11172.8
WING TANKS	39.3401	0	-0.997523	72886
CENTRE FUEL TANKS	31.4296	0	0	33300
AUXILIARY TANKS	55.8	0	0	0
INTERIOR	29.99	0	0.408018	6793.69
PILOTS	9.39	0	0.45803	170
CREW	0	0	0	75
PASSENGERS	29.99	0	0.45803	18143.8
BAGGAGE	55.2214	0	1.04002	1814
############	0	0	0	0
CG_at_MTOW_wrt_nose	35.1649	0	-0.438324	0
############	0	0	0	0
CG_at_MEW_wrt_nose	32.6454	0	-0.326581	0
############	0	0	0	0

The highlighted rows store aircraft CoG position at MTOW (Maximum Take Off Weight) and MEW (Manufacturer's Empty Weight): these two weight scenarios characterize CoG extents.

W&B: Inertia matrix

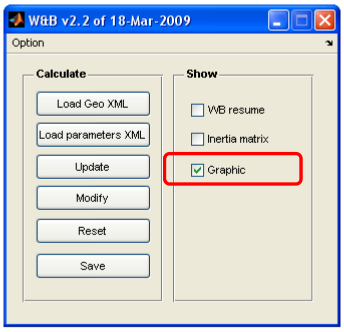


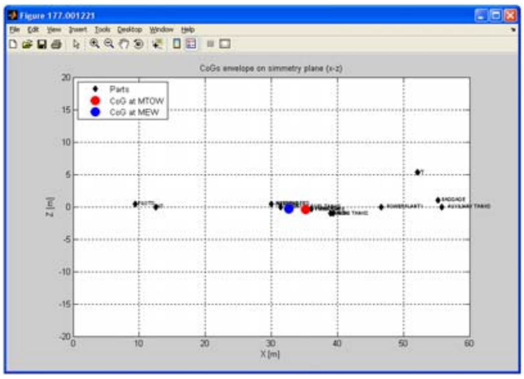


	9.62355e+006	0	0
	0	2.04062e+007	0
	0	0	2.80909e+007

The inertia matrix is computed with a "coarse" approximation, treating the aircraft as a solid with constant density and applying correction factor (like Raymer's approach) and it's referred to aircraft centre of gravity.

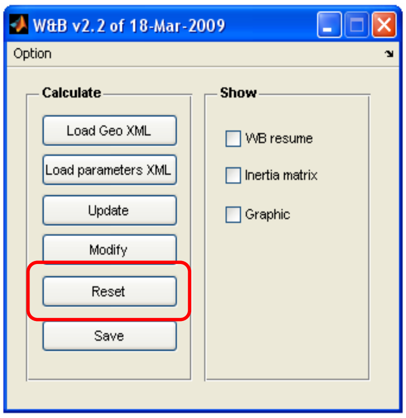
W&B: Graphical representation





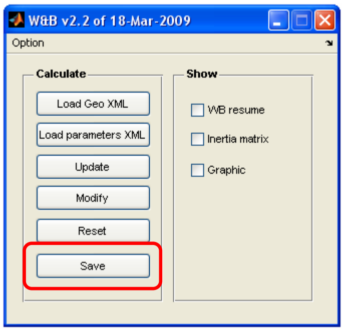
This graphical output allows the user to check mass positions and aircraft centre of gravity limits.

W&B: Reset parameters to default values



The "Reset" button allows returning to default parameters values, those loaded with "Load parameters XML"; however, to effectively apply the changes, the "Update" button must be pressed (running again the computation).

W&B: Save results

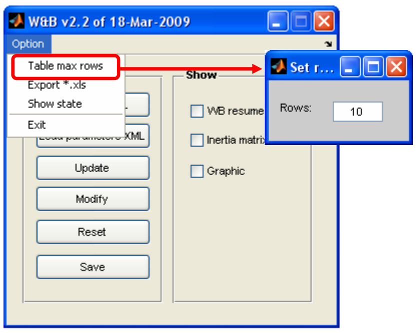


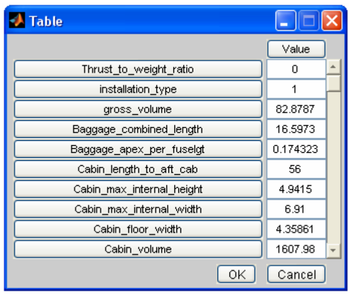
Two files are saved in the directory where W&B GUI was issued:

- Geo_filename_WB.xml: complete Geo&WB XML, ready to be processed in NeoCASS;
- Geo_filename_WB_param.xml: parameter file storing all changes applied, useful to quickly reload results.

The extension _WB and _WB_param are automatically appended to input file name coming from Geo Module.

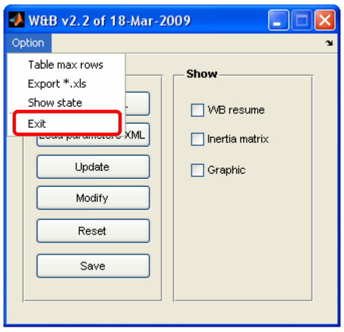
W&B: Option menu





This option allow to resize the modify parameter table and is useful on laptop PC where often the screen can’t contain all the table.

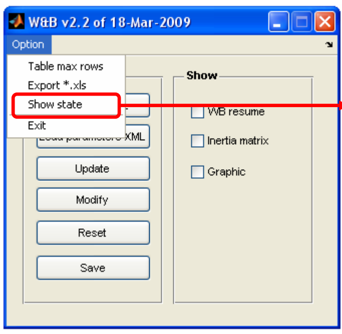
W&B: Option menu (2)



This option is available only under Windows OS with Excel and allows to export resume table and inertia matrix in a *.xls file (into a sheet labeled with “WB results”).

The file will be saved in the work directory where W&B GUI was issued and its name is composed appending _excel to the original input Geo file name.

W&B: Option menu (3)

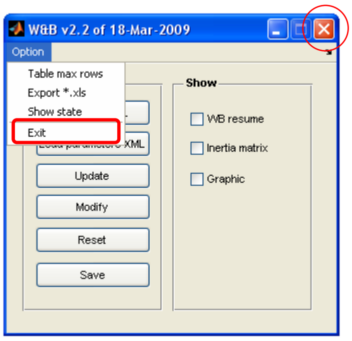



```
- WB GUI state:
   input_filename: 'B747_guess_new_AMB_MODEL.xml'
     param_struct: [1x1 struct]
          input: [1x1 struct]
         output: [1x1 struct]
          param: [1x1 struct]
     num_vis_rows: 10
        version: 'W&B v2.2 of 18-Mar-2009'
           flag: 0
     show_handles: [7.0029 7.0032 177.0012]

 - Accessing W&B workspace (to exit press F5 or digit "return").
K>>
```

Give direct access to GUI workspace and is intended only for debugging purposes (pressing F5 or writing “return” at the prompt exit).

W&B: Exit



Both these buttons close the GUI **without** saving results.

W&B: Remarks

Some parameters highlighted in the modify table, read from parameter XML, are already present in Geo XML file and are "extracted" and carried to user's attention because their values influence heavily computation (i.e. cabin length, thrust to weight ratio).

If the user has set them correctly from the start, by default the code operates in "preserve mode" and, even loading *dummy_wb_param.xml,* the common values are preserved.

However it is also possible to overwrite these values resetting all parameters to default (if *dummy_wb_param.xml* is loaded).

For "Overwrite mode", the GUI must be called this way:

wb_gui('Overwrite', 'yes');

W&B: Batch mode

It is also possible to launch W&B module in batch mode providing the two files needed and an optional flag (logical, true/false).

aircraft = wb_batch(aircraft_xml, param_xml, flag)

INPUT: NAME TYPE DESCRIPTION

NAME	TYPE	DESCRIPTION
aircraft_xml:	string	stores aircraft file name from Geo module (*.xml);
param_xml:	string	stores parameters needed by W&B (*.xml);
flag:	logical	[optional] if 'false' disable parameter overwriting and leave default values; could be omitted, i.e. flag = true.

OUTPUT: NAME TYPE DESCRIPTION

NAME	TYPE	DESCRIPTION
aircraft	struct	stores all aircraft data with updated W&B fields

NeoCASS GUI interface

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

and two sub-panels, i.e.:

  - REFERENCE Settings;
  - ANALYSIS Settings.

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

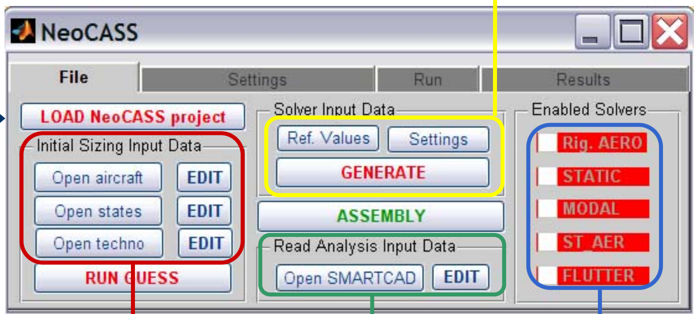
NeoCASS GUI – FILE Panel

- The GUI Panel File 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 GUESS 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);
  -
  - Open an already available SMARTCAD input ¯le (ascii .dat ¯le);
  - .

NeoCASS GUI interface – FILE Panel

Button for opening an already existent NeoCASS project

Definition of setting parameters for different type of analyses

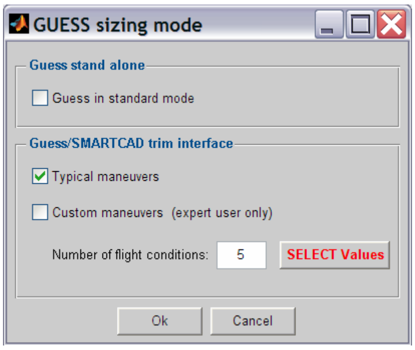


GUESS Subpanel: Files input, Edit and RUN Guess

Open and Edit SmartCAD files

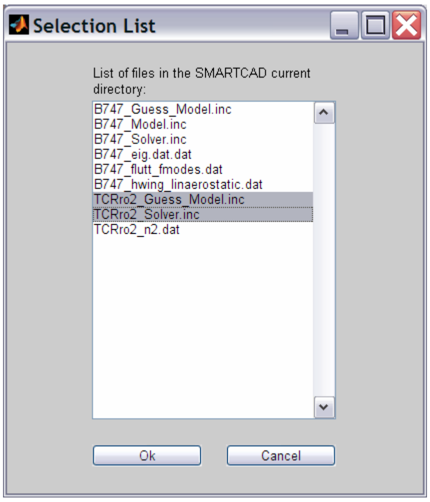
List of enabled solvers

Assembly a Smartcad analysis file



After pressing the ***Open states file button*** a new window appears, enabling the user to run Guess in standard mode (using predefined maneuver for structural sizing) or in advanced mode, alloeing the possibility to input different maneuvers to be used during first structural sizing.

Assembly a Smartcad analysis file

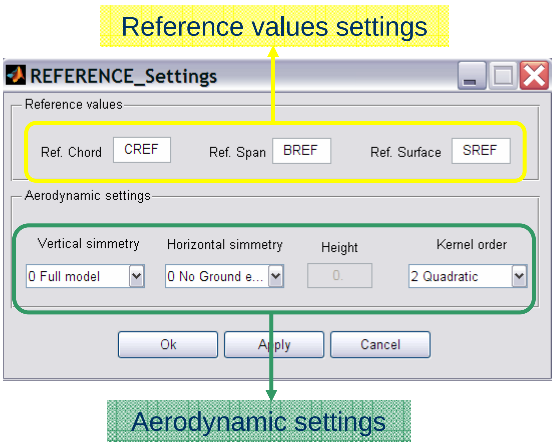


When the ***ASSEMBLY Button*** is pressed, a listbox window pops up showing all the .inc and .dat files available in the current directory. In this way it is possible to assemble a final Smartcad analysis file, simply merging a stick model file with specific .inc files including the requested analysis 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.

Reference Settings Subpanel

- The GUI 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);
  -
  -
  - Height (active if Ground Effect is selected);
  -

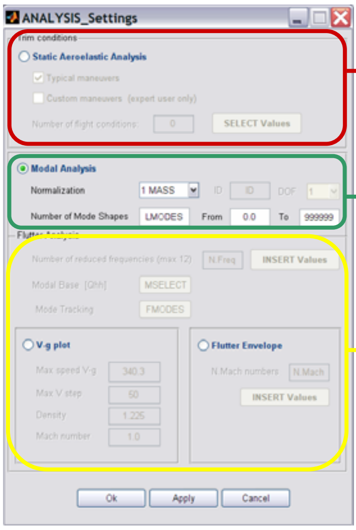
Reference and Aerodynamic Settings Subpanel



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 analysis

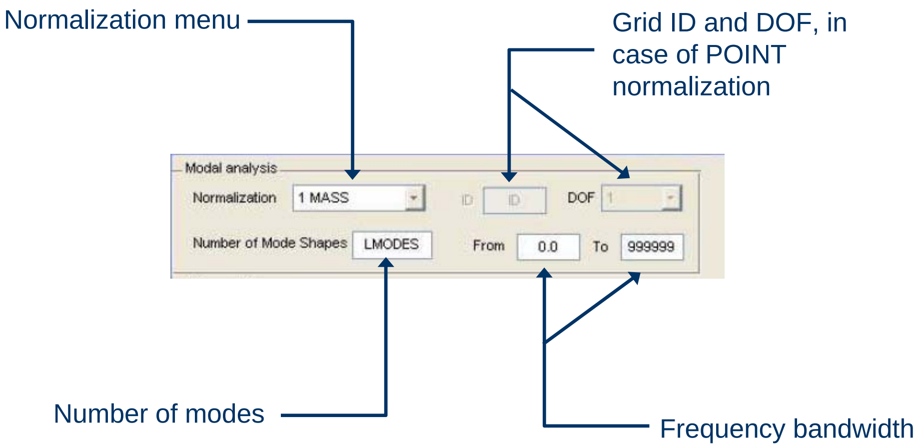
Input data for flutter analysis

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 flutter 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

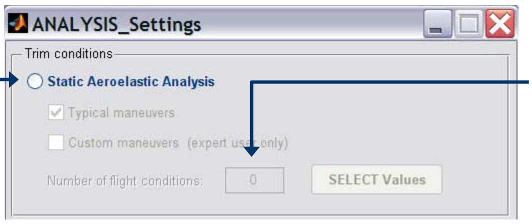
When static Aeroelastic Analysis is selected, three are the requested input parameters:

- Choice 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.

SimSAC

Analysis Settings Subpanel: Static Aeroelasticity

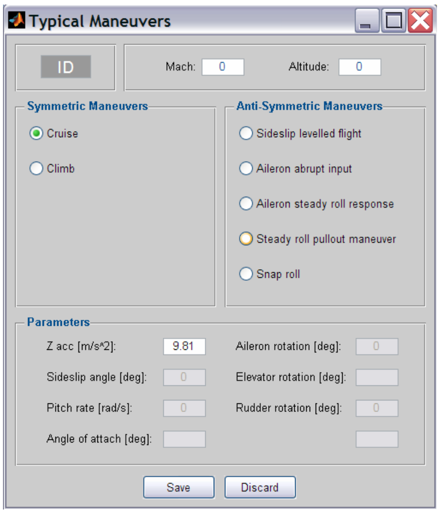
Radio button to select Static AeroelasticAnalysis



Number of flight conditions

SimSAC

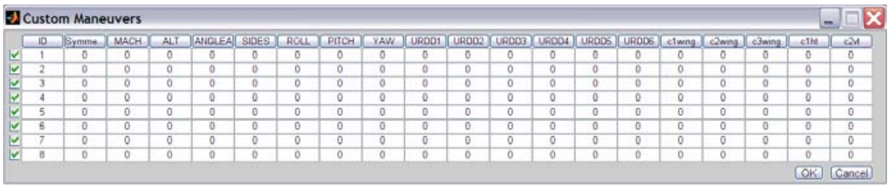
Analysis Settings Subpanel: Static Aeroelasticity



In case of typical maneuvers have been chosen, 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.

Analysis Settings Subpanel: Static Aeroelasticity

When custom maneuvers option is selected, the complete table of all flight parameters 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 flighting aircraft.



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

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 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:

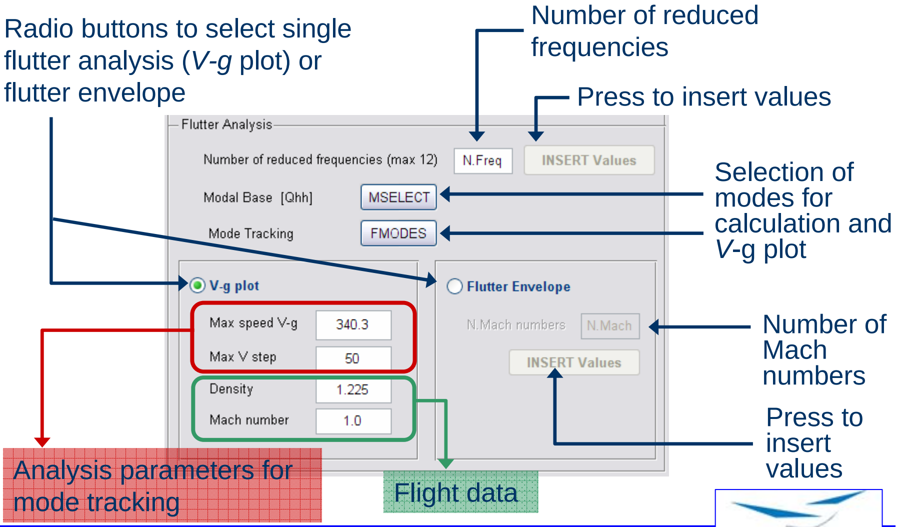
- Max Speed for flutter calculation;
- Max V step (number of steps used during iterative mode tracking);
- Air Density;
- Mach Number.

Analysis Settings Subpanel: Flutter Analysis

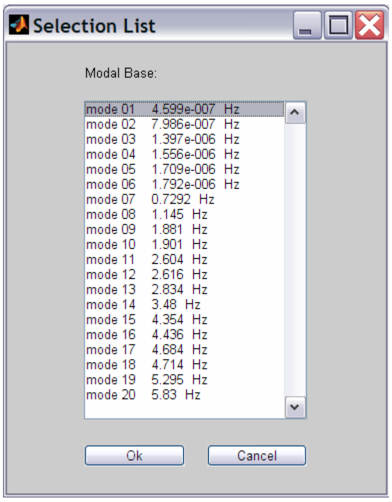
When Flutter Envelope is selected, the requested input parameters are:

- 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

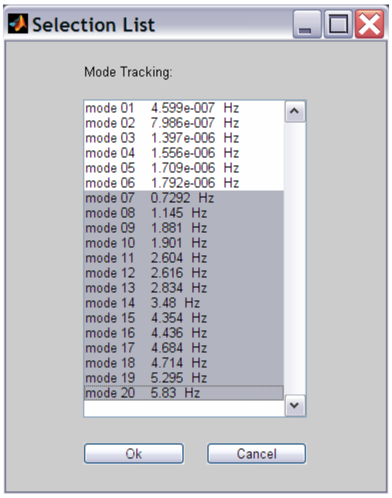


Analysis Settings Subpanel: Flutter Analysis



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 button.

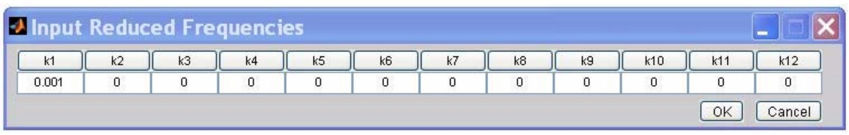
Analysis Settings Subpanel: Flutter Analysis

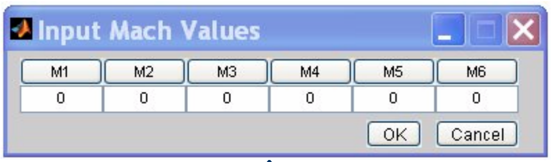


When the ***FMODES Button*** is pressed, a listbox window pops up showing the list of eigenvalues available (as set by LMODES card). The user can select the list of modes he want to track during the V-g plot calculation. For example, rigid modes can be retained into the modal bases during calculation 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

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 GUI 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 1.1 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…

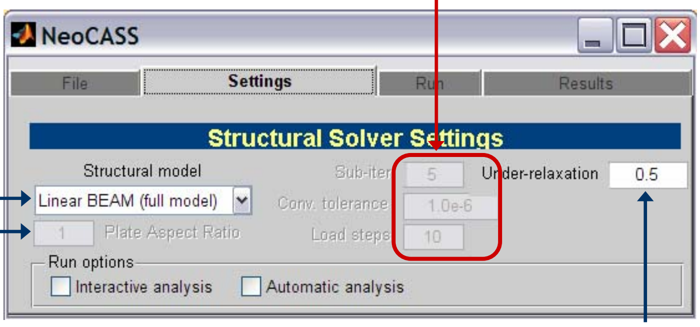
General Settings Panel

- 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 od 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

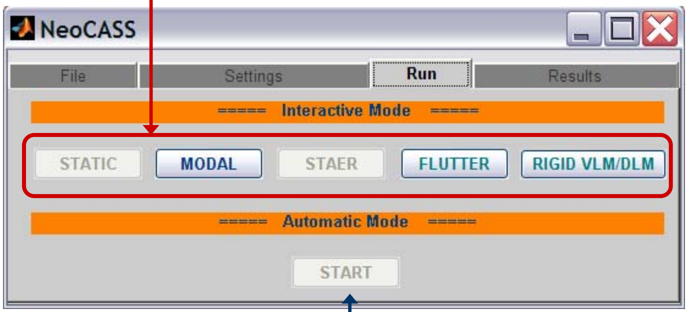
RUN Panel

The GUI Panel Run 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 1.3). The following analyses can be started by the panel:

- **STATIC**: Static analysis under aerodynamic and inertial relief loads;
- **MODAL**: Eigenvalues analysis;
- **STAER**: Static aeroelasticity analysis: trim and aeroelastic stability derivatives;
- **FLUTTER**: Flutter analysis;
- **STEADY VLM**: 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

GUI Panel Results 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);

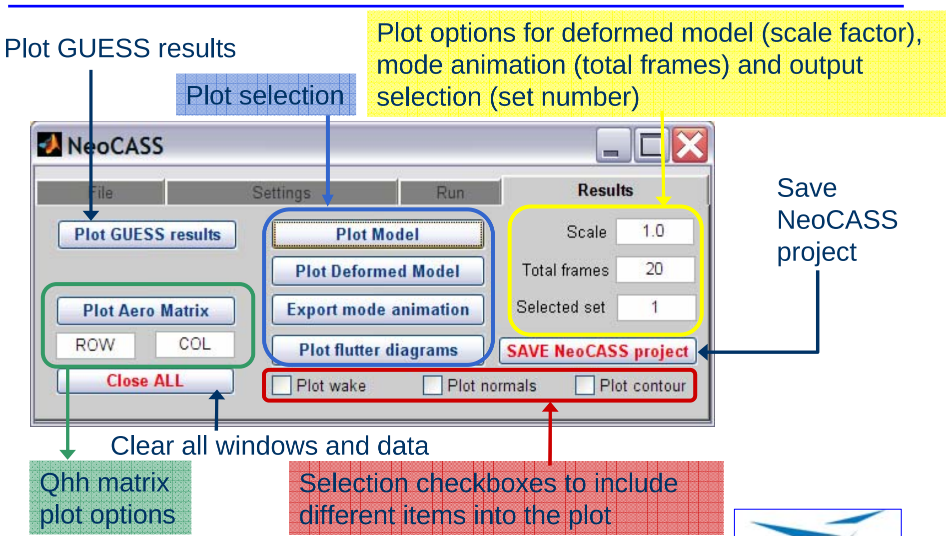
RESULTS Panel

- **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



PART III
NeoCASS Application Examples

Getting Started

In the following pages, it will assumed that NeoCASS V1.1 has been installed into the NeoCASS home directory. The user must go into this directory and run the MATLAB script:

```
set_neocass_path.m
```

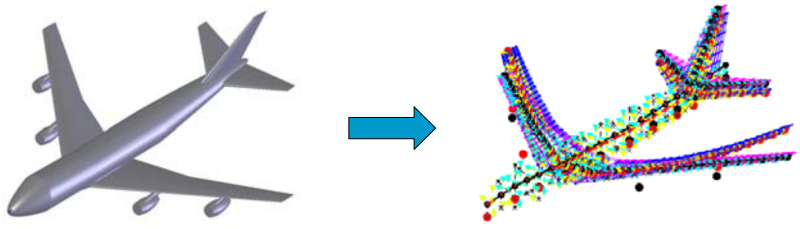
that can be found in the same directory. This script automatically scans all the subdirectories building up the correct path variable. After that, it is possible to run all NeoCASS Modules. First of all, the user must run the GUI Interface Panel, from which it is possible to access all NeoCASS modules, simply by pressing:

```
NeoCASS
```

after a splash image, the Gui Panel File of NeoCASS GUI interface will appear.

Getting Started

CASE 1: Only the geometrical and weight description data of aircraft are available, summarized into .xml file. The stick model has to be generated by GUESS and setting parameters requested by different solvers have to be setup to generate the SmartCAD input file



Aircraft geometry, as described into Caesiom aircraft.xml file

Stick model, as represented into SmartCAD .dat file

Example 1: Boeing B747-100

The example 1 concerns the structural sizing and aeroelastic analysis of Boeing B747-100 aircraft. In the following slides we will see how to accomplish the following goals:

- To perform a conceptual structural sizing using GUESS code in Standard Mode (pre-defined sizing maneuvers);
- To generate the aircraft stick model;
- To generate the SmartCAD input file starting from the stick model generated by GUESS;
- To run different analysis available into SmartCAD library;
- To analyze the obtained results;
- To import and export NeoCASS results.

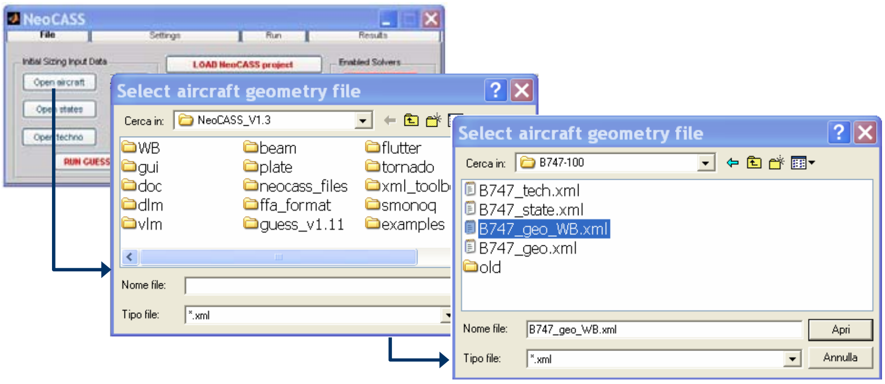
Example 1: Boeing B747-100

STEP 1: Running GUESS and generation of stick model aircraft
It is assumed that the following files are already available:

- **aircraft.xml**: it contains the complete description of aircraft geometry and weights and balance data in xml format. It can be created by means of Cadac module or editing by hands an already available aircraft.xml, by updating all relevant items;
- **states.xml**: it contains the flight conditions to be analyzed
- **technological.xml**: it contains structural data and coefficients related to different structural concept, used by GUESS. At the moment the easiest way to generate this file is by using an old one as a template.

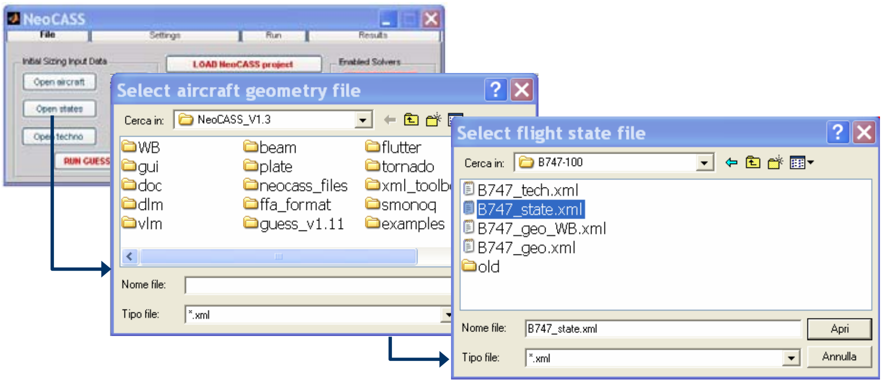
Example 1: Boeing B747-100

On the GUI FILE Panel press the *Open aircraft* button, a pop-up file selection window will appear. Navigate through the directory ***examples/guess/B747-100*** and open the file named ***B747_geo_WB.xml***

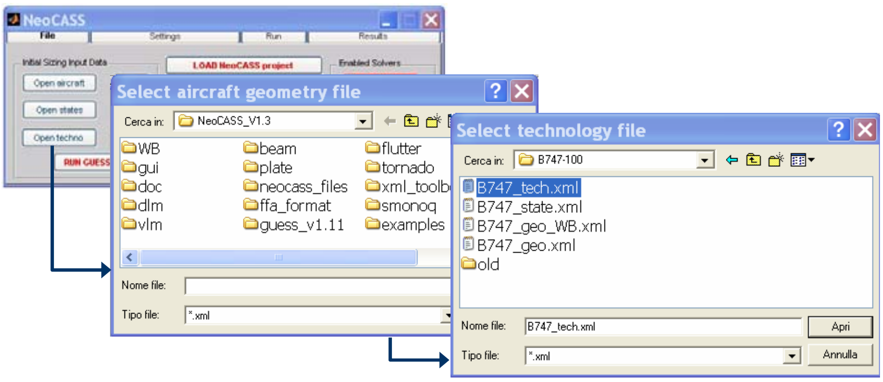


Example 1: Boeing B747-100

Now repeat the same operation pressing *Open states* and *Open techno* buttons and load, from the same directories, the following files ***B747_state.xml*** and ***B747_tech.xml***:

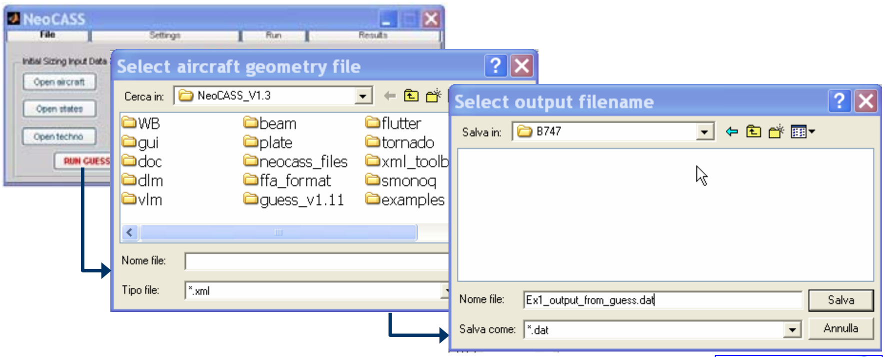


Example 1: Boeing B747-100



Example 1: Boeing B747-100

If no errors have been found during the reading file operations, now we can run GUESS by pressing *RUN GUESS* button. The system requires the input of the file name where the stick model, generated by GUESS, has to be saved: insert the following name ***Ex1_output_from_guess.dat***.



Example 1: Boeing B747-100

The messages summarized in the Matlab Command Windows must be the following (only the main statements are reported):

```
Running GUESS solver...
 - Loading input files...
 completed.
 - Estimating structural weight...
 completed.
 - Estimating structural weight...
 completed.
 - Creating geometric stick model...
 completed.
 - Determining sections mechanical properties...
 completed.
 - Determining non-structural masses...
 completed.
 - Exporting stick model output file...
 completed.
 - Refinement loop history:
     Iter:    1. Estimated total structural weight: 93801.965 Kg..
completed.
>>
```

Example 1: Boeing B747-100

Looking at the directory containing the input files, it is possible to see that a new file has been created, named ***Ex1_output_from_guess.dat***. It is a plain text file, that can be open using any preferred Editor, containing the complete stick model written in a Nastran-like syntax, describing the following aircraft properties (for more details please check the NeoCASS Manual):

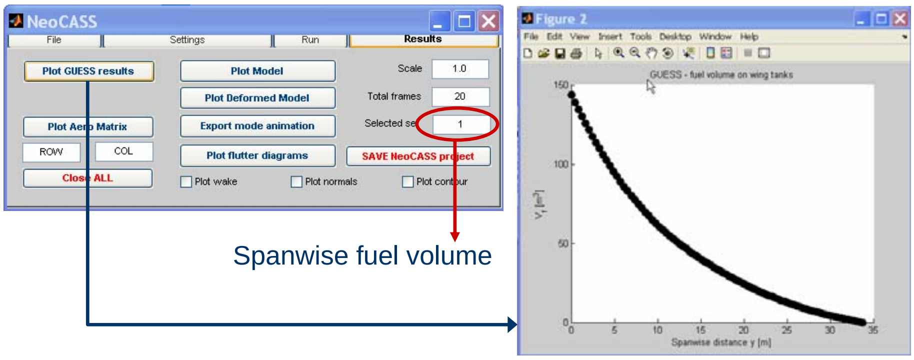
- Material definition (MAT1 cards)
- Node definition (GRID cards)
- Aeronode definition ((GRID cards)
- Beam properties (PBAR cards)
- Beam definition (CBAR cards)
- Lifting surface definition (CAERO1 cards)
- Structural interpolations set (SET1 cards)
- Interpolation definition (SPLINE2 card)
- Lumped masses (CONMN2 cards)

Example 1: Boeing B747-100

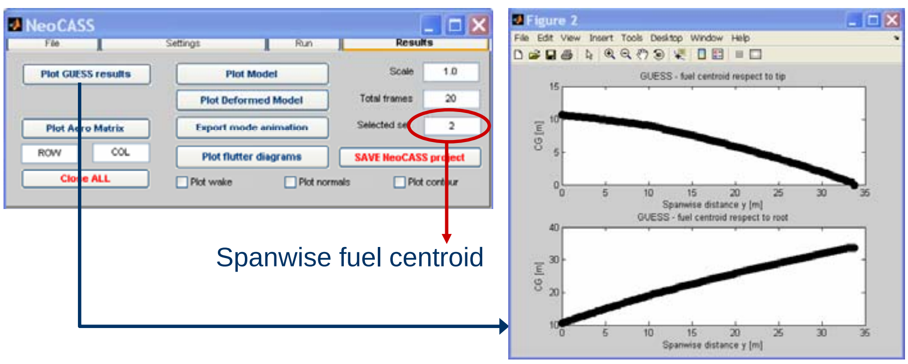
It is possible now to look at some GUESS results, using the GUI RESULTS Panel. In particular the following items, accessible by selecting the appropriate SET field, are available:

- Output set 1: Fuel volume
- Output set 2: Fuel centroid
- Output set 3: Lift load area
- Output set 4: Center of pressure
- Output set 5: Shear force
- Output set 6: Bending moment
- Output set 7: Thickness estimation
- Output set 8: Weight estimation (bending-shear-total)
- Output set 9: Weight estimation (Guess-structural weight-primary weight total)
- Output set 10: Guess vs. stick model properties

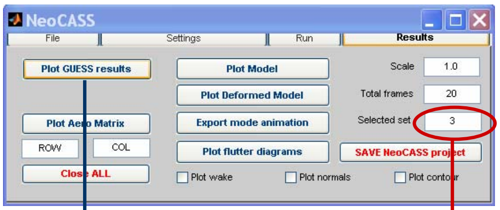
Example 1: Boeing B747-100

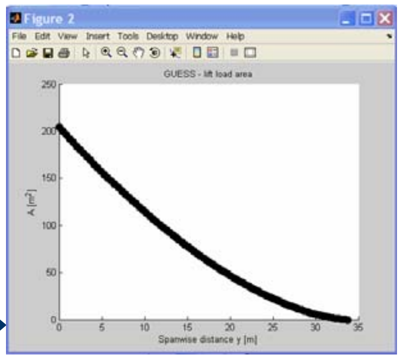


Example 1: Boeing B747-100



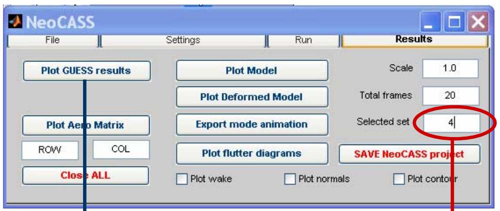
Example 1: Boeing B747-100

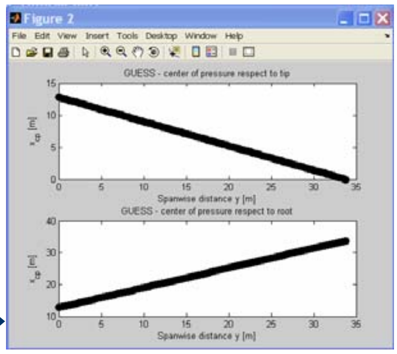




Spanwise lift load area

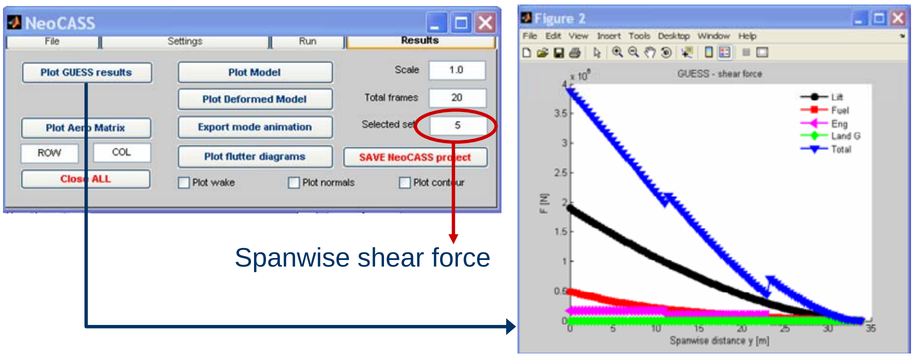
Example 1: Boeing B747-100



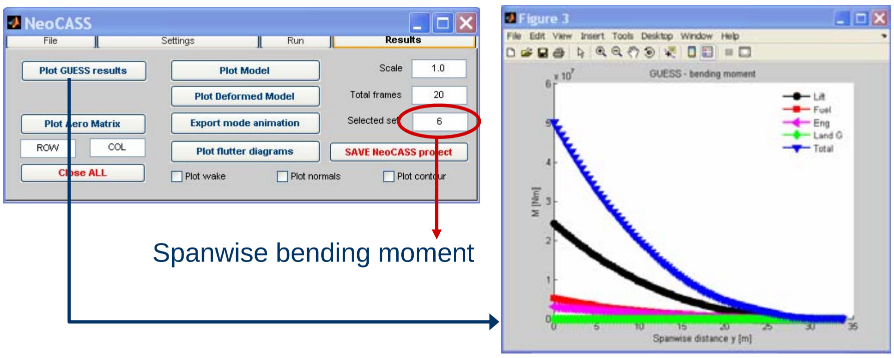


Center of pressure with respect to tip

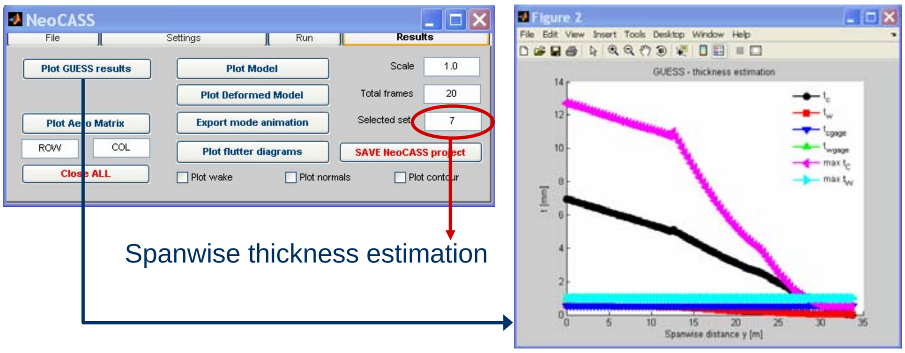
Example 1: Boeing B747-100



Example 1: Boeing B747-100

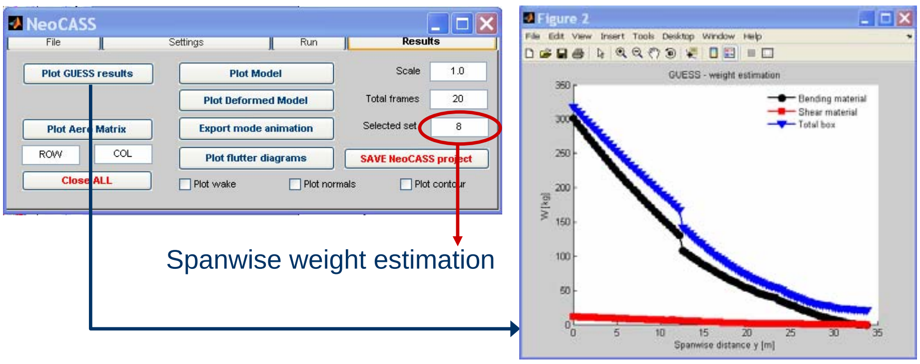


Example 1: Boeing B747-100



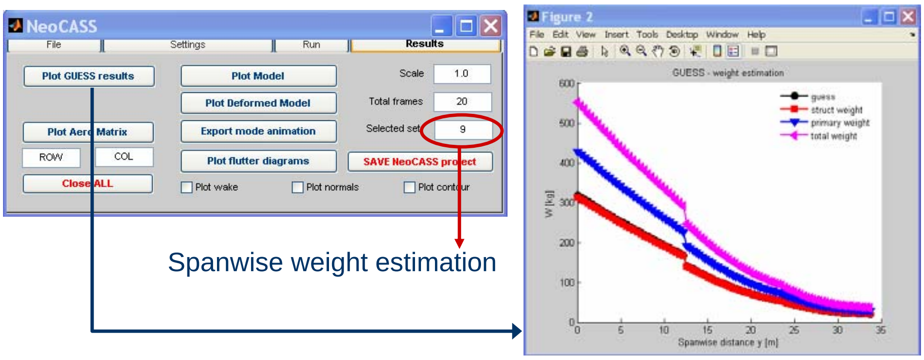
SimSAC

Example 1: Boeing B747-100

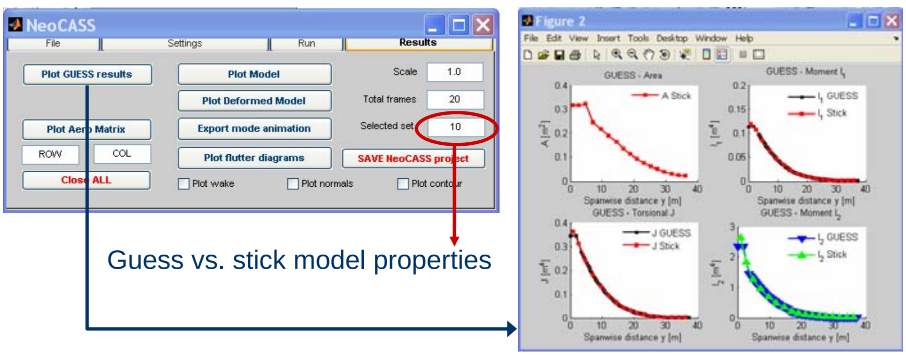


SimSAC

Example 1: Boeing B747-100



Example 1: Boeing B747-100



Example 1: Boeing B747-100

STEP 2: Preparation of SmartCAD input file

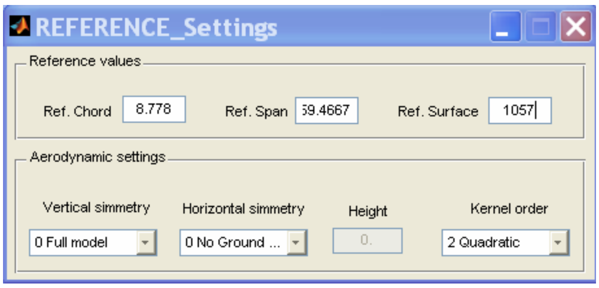
The text file generated from GUESS (***Ex1_output_from_guess.dat***) at the moment contains only the description of stick model in terms of geometrical, structural, aerodynamic schematization and structure-aerodynamic interface properties. At the moment it does not contain any specific info about what kind of analysis is requested and the related input data. In few words, it is not a SmartCAD input file. To have it, two are the possible ways:

- Manually editing the file, adding the necessary cards;
- Using the General Settings and Analysis Settings GUI SubPanels.

Example 1: Boeing B747-100

Pressing the button *Ref. Values* it is possible to access the General Settings GUI subpanel. Input the following values:

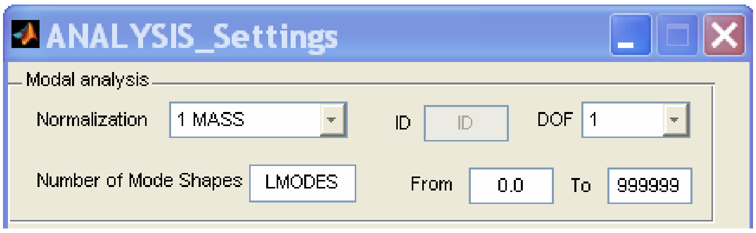
- CREF=8.778, BREF=59.4667, SREF=1057, and leave all other fields the default values, as reported in the following figure and close the REFERENCE Settings windows pressing the X button, as usual.



Example 1: Boeing B747-100

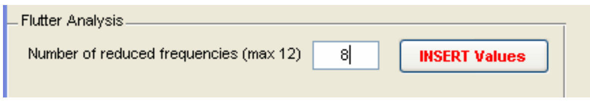
Pressing now the button *Settings* it is possible to access the ANALYSIS Settings GUI subpanel. In the top section, related to the modal analysis input data, input the following values:

- LMODES=20 (number of modes computed and retained for further analyses) and leave to all other fields the default values.

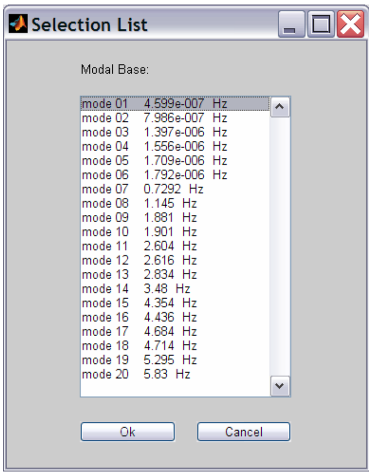


Example 1: Boeing B747-100

ANALYSIS TYPE: FLUTTER (V-g Plot)
First of all, input the number of reduced frequencies to compute the generalized aerodynamic forces matrices equal to 8, and press the button ***INSERT Values*** to specify their values. A pop-up table will appear where to add the following values: 0.001, 0.01, 0.1, 0.5, 1, 1.5, 2, 5. Press the ***OK*** button to accept the values and close the table window.

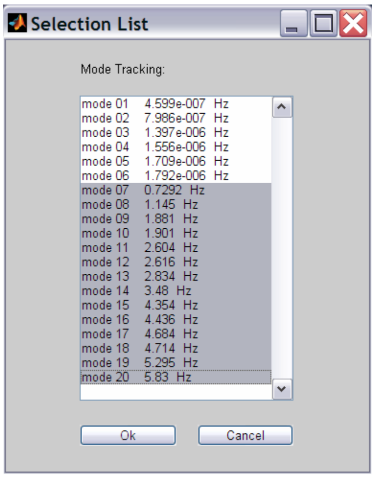


Example 1: Boeing B747-100



ANALYSIS TYPE: FLUTTER (V-g Plot)
Now, pressing the ***MSELECT*** and ***FMODES*** buttons it is possible to select how many modes and which must be used for calculation of Generalized Aerodynamic Forces, and how many and which modes must be tracked during the V-g plot calculation. We can for example select all the 20 modes for calculation using the mouse or down arrow plus SHIFT buttons.

Example 1: Boeing B747-100

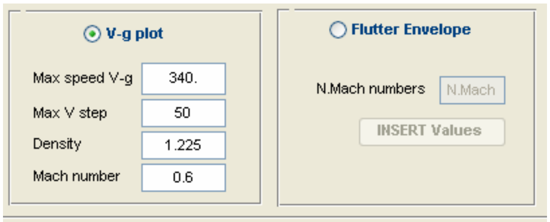


ANALYSIS TYPE: FLUTTER (V-g Plot)
In the same way, it is possible to choose the modes have to be tracked. For example, we have to skip first 6 rigid modes to avoid any convergence problem during V-g plot calculation. Even in this case, multiple selection can be done combining mouse or arrow button with SHIFT or CTRL button.

Example 1: Boeing B747-100

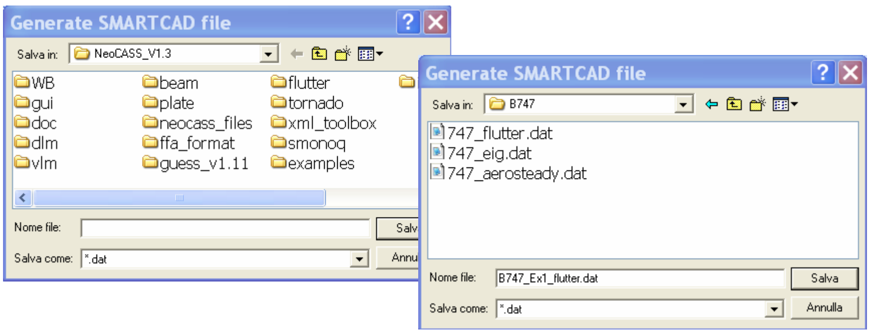
In the bottom section of the GUI select the radio button ***V-g Plot*** (automatically the ***Flutter Envelope*** subpanel becomes grey and unclickable) and input the following values, then close the ANALYSIS_Settings windows as usual:

- Max Speed=340 (m/s)
- Max Vstep=50 (m/s)
- Density=1.225 (Kg/m3)
- Mach number=0.6



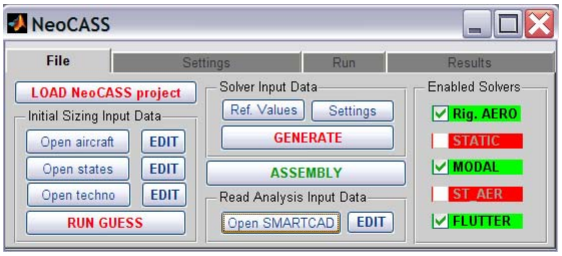
Example 1: Boeing B747-100

Pressing finally the button ***GENERATE***, the system will ask about the name of the SmartCAD input file and will save it. Just as an example, go to the directory ***examples/smartcad/B747*** and insert the following file name: ***B747_Ex1_flutter.dat***.



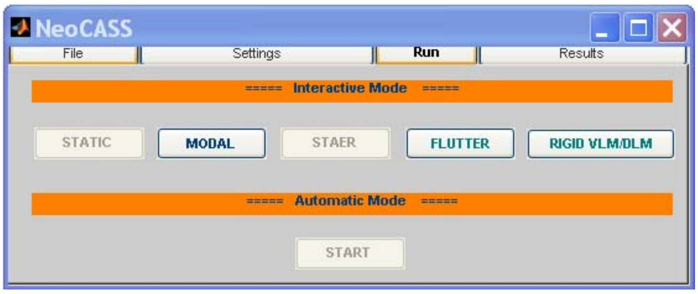
Example 1: Boeing B747-100

At this point, we have created a SmartCAD file containing the instructions for flutter analysis. Still again in the GUI FILE Panel, we can open it pressing the button Open SMARTCAD and navigating into the directories to find the previously saved file named ***examples/smartcad/B747/B747_Ex1_flutter.dat***. Once read the file, the GUI FILE Panel will appear as follows:



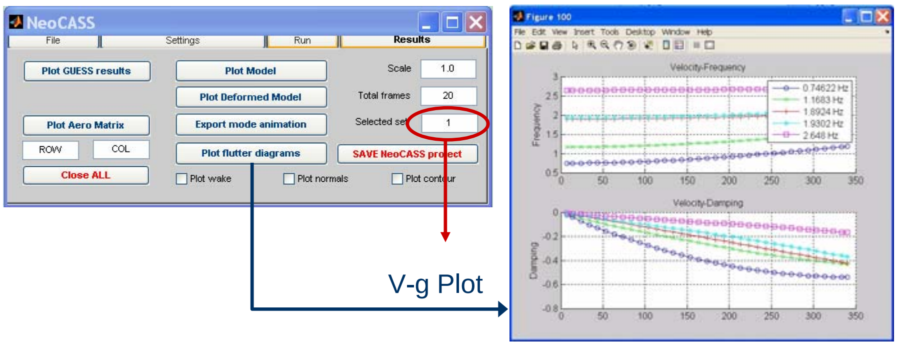
Example 1: Boeing B747-100

In the right side the checkboxes named Rig.Aero, MODAL and FLUTTER are green, while the others are still again grey. It means that the cards included into the SmartCAD file just read allow to execute these three kind of analysis. In fact, going to the GUI RUN Panel the related buttons are active: we can press ***FLUTTER*** button to run the flutter analysis.



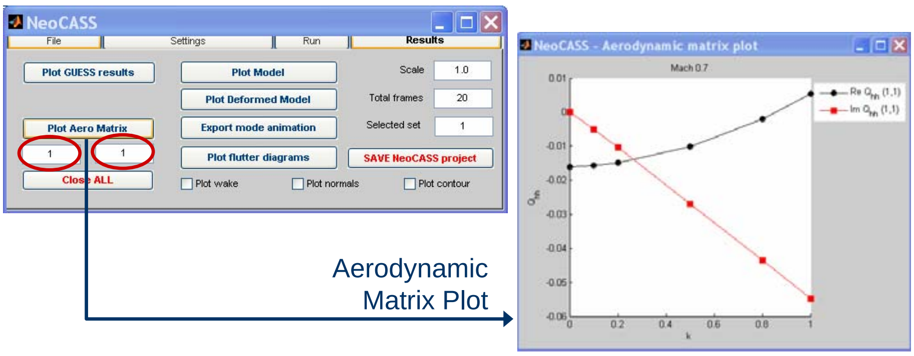
Example 1: Boeing B747-100

After completion of the flutter analysis, if no error have been found (check for that the Matlab window), the window containing the V-g plot will appear as follows: the same diagram can be selected pressing the ***Plot flutter diagrams*** from GUI RESULTS Panel.



Example 1: Boeing B747-100

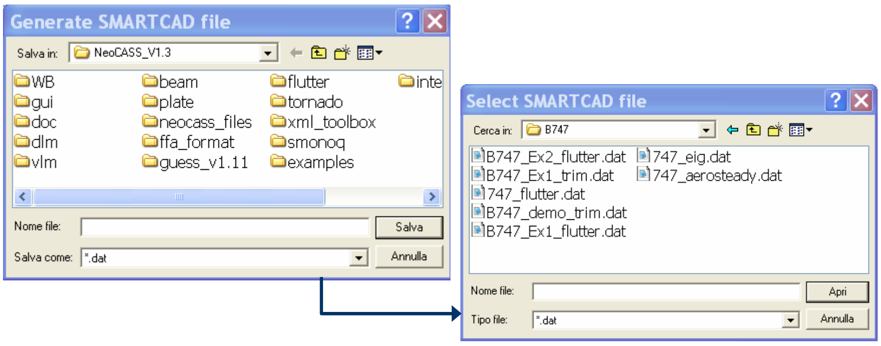
From the same GUI RESULTS Panel it is also possible to plot each term of Generalized Aerodynamic forces matrix. For example, selecting ROW 1 and COL 1 then pressing the Plot Aerodynamic Matrix the following diagram will appear on the screen.



Example 1: Boeing B747-100

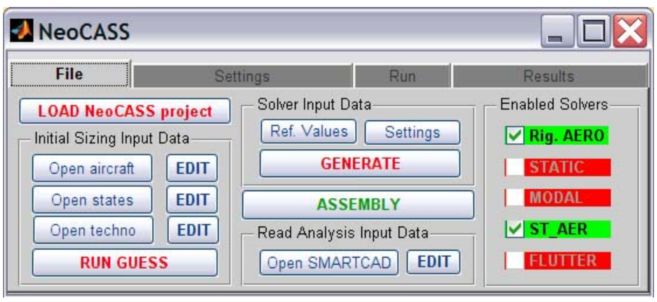
ANALYSIS TYPE: RIGID AERODYNAMIC ANALYSIS

As usual, starting from GUI FILE Panel, press button Open Smartcad File and select in the directory ***examples/smartcad/B747/*** the filename ***B747_Ex1_trim.dat***



Example 1: Boeing B747-100

In the right side the checkboxes named Rig.AER and ST_AER are green, while the others are still again grey. It means that the cards included into the SmartCAD file just read allow to execute these two kind of analysis.

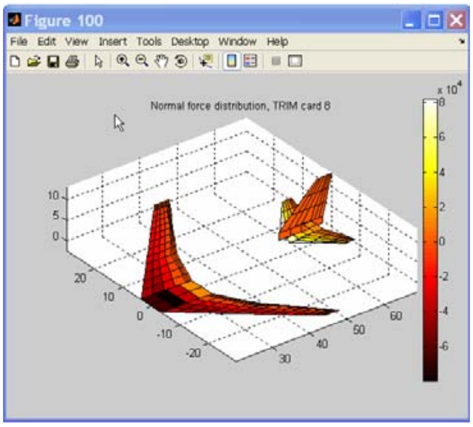


Example 1: Boeing B747-100

Indeed, looking at GUI Run Panel only two buttons are active, ones related to STAER and RIGID VLM/DLM. Let's try to compute the aerodynamic distribution over the rigid aircraft by VLM aerodynamic tool, pressing the ***RIGID VLM/DLM button***.

Example 1: Boeing B747-100

At the end of aerodynamic calculation a result window appear reporting the pressure distribution over the VLM schematization.



Example 1: Boeing B747-100

ANALYSIS TYPE: TRIM AEROELASTIC ANALYSIS

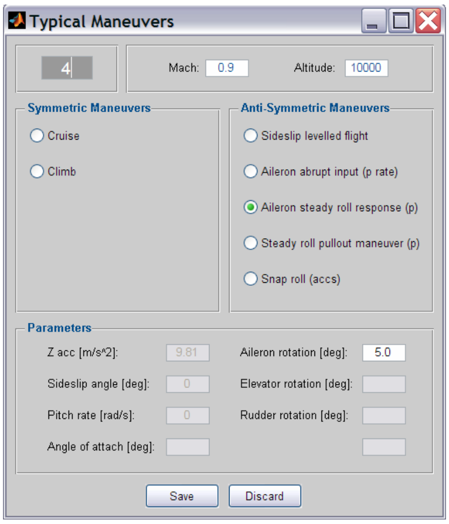
The same data file used for RIGID AERODYNAMIC ANALYSIS can be used to perform the trim aeroelastic analysis of the free flying aircraft. First of all the trimmed condition is found for the rigid aircraft, then the deformability is introduced and the trimmed condition for flexible aircraft is determined. In this way is possible to calculate the steady deformation assumed by the aircraft and the stability derivatives corrected due to the structural flexibility.

Example 1: Boeing B747-100

STEP 1: DEFINITION OF FLIGHT CONDITIONS

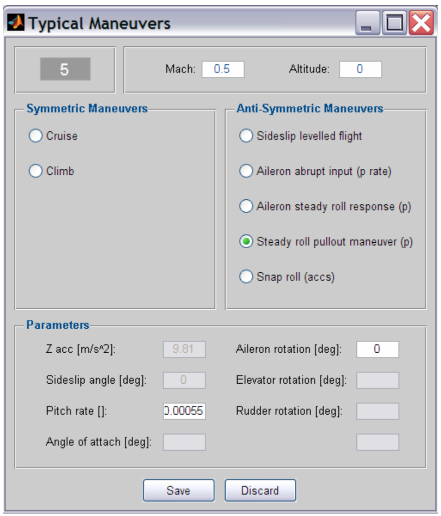
Starting from the ***ANALYSIS Settings*** Subpanel and selecting the radio button ***Static Aeroelastic Analysis***, it is possible to choose between typical and custom maneuvers. Clicking on the ***Typical maneuvers*** checkbox a new window appears where it is possible to select among predefined maneuvers.

Example 1: Boeing B747-100



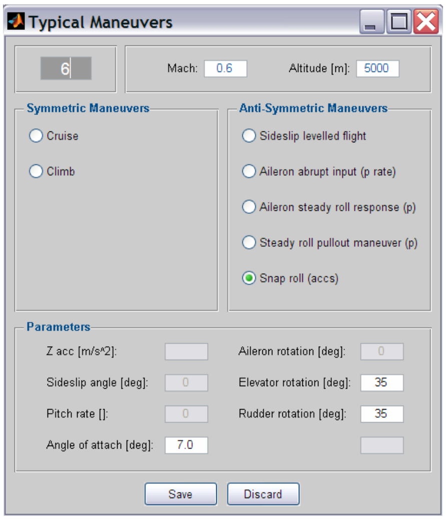
On the left it is possible to see how the windows appears when a Aileron steady roll response maneuver is requested.
In the top part of the window the flight conditions, in terms of Mach and Altitude, are requested. In the bottom part of the same window, the only input parameter requested to solve the trim problem is the Aileron rotation, in this case set equal to 5 degs.

Example 1: Boeing B747-100



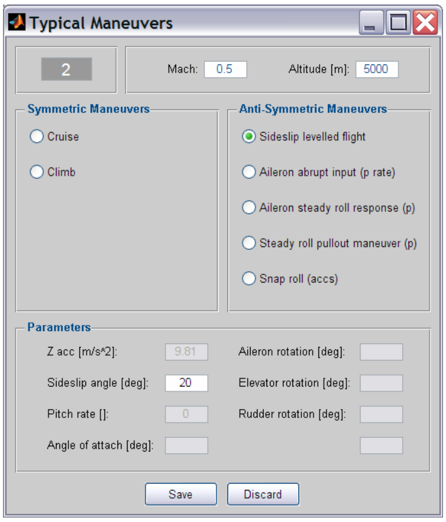
On the left it is possible to see the definition of a Steady roll pullout maneuver.

Example 1: Boeing B747-100



On the left it is possible to see the definition of a Snap roll maneuver.

Example 1: Boeing B747-100

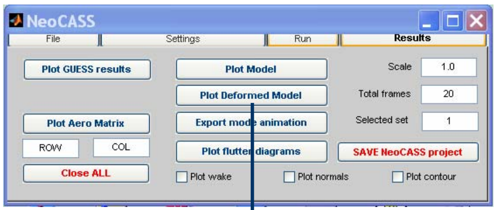


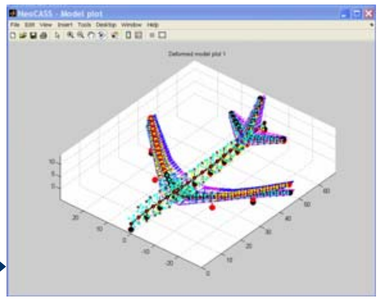
On the left it is possible to see the definition of a Sideslip levelled flight maneuver.

Once defined all the requested maneuvers it is possible so save the related TRIM cards into a .inc file that will be assembled to a stick model file to prepare a smartcad analysis file.

Example 1: Boeing B747-100

It is possible to see the deformed configuration of trimmed aircraft as usual by pressing the ***Plot deformed model*** button into GUI RESULTS Panel. Is must be underlined that only the last executed trim condition will be available for visualization using the NeoCASS GUI.

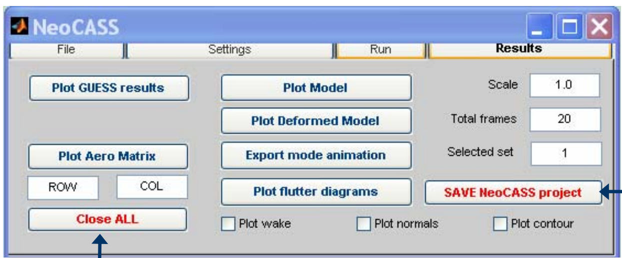




Deformed aircraft

Example 1: Boeing B747-100

Two possibilities are available to exit from Neocass, by pressing the ***SAVE NeoCASS project*** button, or simply by pressing the ***Close ALL*** button. In the first case, a complete data base is saved including all the results that can be reimported later during a new NeoCASS analysis session pressing the related button.



Clear all windows and data

Save NeoCASS project