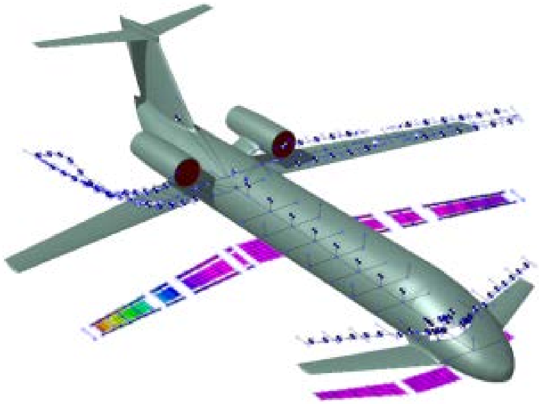
Masses in NeoCASS Acbuilder & GUESS



January 2019

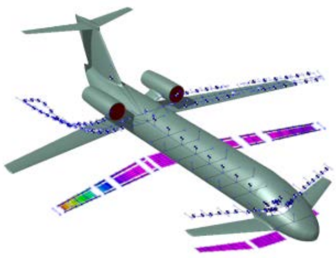
NeoCASS 2.2.856

Acbuilder

All mass information coming from Acbuilder Weight&Balance module is stored inside the .xml file and is directly accessible and editable with any xml Editor.

Even if a lot of fields inside the xml are related to mass estimation, the only part that GUESS module has access to is the COG matrix, containing mass and center of gravity coordinates for a limited number of items.

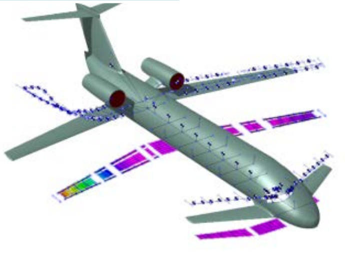
It can be find in the path aircraft/weight_balance/COG. Its dimensions are 30X4X15.
30 is the total number of items, 4 are CG coordinates (x,y,z) plus the mass of the item, 15 is the maximum number of different mass configurations, but just the first one is accessible by GUESS.



XML COG

N°	ITEM
1	WING1
2	WING2
3	HORIZONTAL TAIL
4	VERTICAL TAIL
5	FUSELAGE
6	LANDING GEAR
7	POWERPLANT1
8	POWERPLANT2
9	AUXILIARY LANDING GEAR
10	VERTICAL TAIL 2
11	CANARD
12	TAILBOOMS
13	-
14	-
15	-

N°	ITEM
16	-
17	TOTAL SYSTEMS
18	FUEL-WING
19	FUEL-CENTRE
20	FUEL-AUXILIARY
21	INTERIOR
22	PILOTS
23	CREW
24	PASSENGERS
25	BAGGAGE & CARGO
26	-
27	X
28	-
29	X
30	-

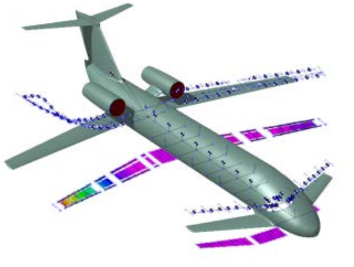


XML COG

Entries 27 and 29 are reserved.

Entries 13, 14, 15, 16, 26, 28 and 30 can be edited by the user as they are, by default, zero.

Any modification to the COG matrix must be done after exporting the xml from Acbuilder. Every time the Weight & Balance module is executed the COG is reset, so any further modification is lost.



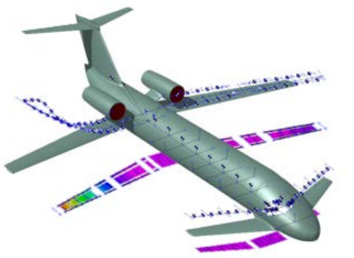
XML editing

The XML file can be edited directly in Matlab using NeoCASS functions. In the example below we are interested in setting the WING1 mass to 35 t.

```
xmlFileName = 'F:\NeoCASS\Examples\B747-100\B747-100.xml';

aircraft = neocass_xmlwrapper (xmlFileName);

aircraft.weight_balance.COG(1,4,1) = 35000;

neocass_xmlunwrapper(xmlFileName, aircraft);
```

We insert the full path of the xml file we want to edit and we open it with the function “neocass_xmlwrapper”.

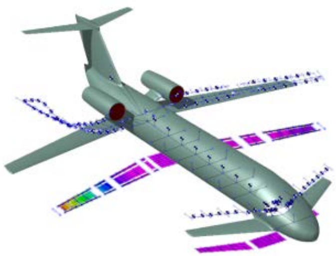
Then we access the matrix containing all mass information (COG) that can be found in the Matlab data structure aircraft.weight_balance.COG.



XML editing

The WING1 item is the number 1 (as we can see from the table in the previous slides), the mass is stored in index 4, the last index is always 1.
So we access COG(1,4,1) to change WING1 mass as we prefer.

Then we overwrite the xml using the function "neocass_xmlunwrapper". If we wanted to create a new file instead of overwriting the original one, we would have had to insert the full path of the new file.



XML editing

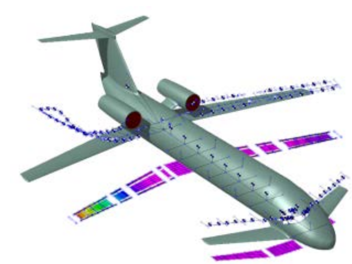
W&B COG Viewer

File

Total mass [kg]: 390823.77

	X [m]	Y [m]	Z [m]	Mass [kg]
(1) WING1	26.8617	0	-1.7081	4.6520e+04
(2) WING2	0	0	0	0
(3) HT	64.5431	0	1.3483	3.5314e+03
(4) VT	64.1297	0	6.9715	1.8060e+03
(5) FUSELAGE	34.9195	0	-0.7110	2.7832e+04
(6) LANDING GEAR	26.8617	0	-1.7081	1.4920e+04
(7) POWERPLANT1	26.5992	12.1666	-3.3234	1.3010e+04
(8) POWERPLANT2	34.7404	21.4704	-1.9414	1.3010e+04
(9) AUX LANDING GEAR	0	0	0	0
(10) VT2	0	0	0	0
(11) CANARD	0	0	0	0
(12) TAILBOOMS	0	0	0	0
(13) DUMMY MASS #1	0	0	0	0
(14) DUMMY MASS #2	0	0	0	0
(15) DUMMY MASS #3	0	0	0	0
(16) DUMMY MASS #4	0	0	0	0
(17) SYSTEMS	34.9195	0	-0.7109	4.1611e+04
(18) WING TANKS	31.9297	0	-1.1513	115000
(19) CENTRE FUEL TANKS	27.8549	0	0	46000
(20) AUXILIARY TANKS	0	0	0	0
(21) INTERIOR	39.3390	0	-1.1392	22000
(22) PILOTS	3.4000	0	-1.8855	255
(23) CREW	36.5000	0	-1.8855	225
(24) PASSENGERS	36.5000	0	-1.8855	4.1005e+04
(25) BAGGAGE	49.1760	0	1.9710	4.0996e+03
(26) DUMMY MASS #5	0	0	0	0
(27) CG_at_MTOW_wrt_nose	32.6057	0	-1.1081	0
(28) DUMMY MASS #6	0	0	0	0
(29) CG_at_MEW_wrt_nose	32.4582	0	-1.4088	0
(30) DUMMY MASS #7	0	0	0	0

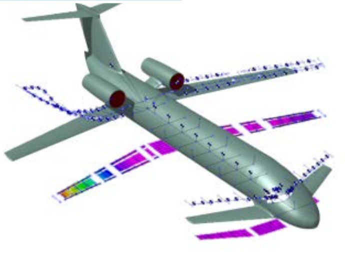
Another way to edit the COG is using the function “WB_Table_Viewer”.
After calling it in Matlab, a window opens.
Clicking on File it is possible to load an existing .xml file.
The COG with all labels is displayed and every field can be edited.
When finished, a new .xml file can be exported.



GUESS – automatic mass management

N°	ITEM	FEM
1	WING1	Structural
2	WING2	Structural
3	HORIZONTAL TAIL	Structural
4	VERTICAL TAIL	Structural
5	FUSELAGE	Structural
6	LANDING GEAR	Concentrated
7	POWERPLANT1	Concentrated
8	POWERPLANT2	Concentrated
9	AUXILIARY LANDING GEAR	Concentrated
10	VERTICAL TAIL 2	Structural
11	CANARD	Structural
12	TAILBOOMS	Structural
13	-	Concentrated
14	-	Concentrated
15	-	Concentrated

N°	ITEM	FEM
16	-	Concentrated
17	TOTAL SYSTEMS	Distributed
18	FUEL-WING	Concentrated
19	FUEL-CENTRE	Concentrated
20	FUEL-AUXILIARY	Concentrated
21	INTERIOR	Distributed
22	PILOTS	Distributed
23	CREW	Distributed
24	PASSENGERS	Concentrated
25	BAGGAGE & CARGO	Concentrated
26	-	Concentrated
27	X	
28	-	Concentrated
29	X	
30	-	Concentrated



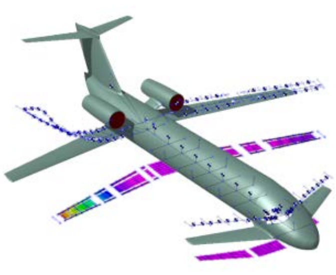
GUESS – mass types

In the previous table each item is labelled as structural, concentrated or distributed, depending on how GUESS automatically manages that specific mass.

Structural: the mass is the material density times the volume of the structure and is changed in each iteration during GUESS sizing.

Concentrated: the mass is considered concentrated and is attributed to the nearest node in the FEM model.

Distributed: the mass is distributed along the fuselage trying to keep the center of gravity specified by the user. It is stored in the non structural mass linear density field of each bar of the FEM model.

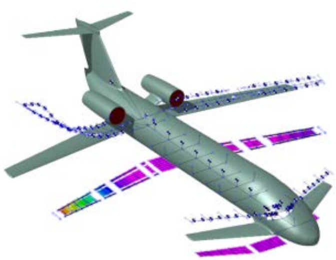


GUESS – regression mass

Once the structural mass has been determined, regression formulas are used to estimate non structural mass of fuselage, wing and other lifting surfaces.

Fuselage: non structural mass includes joints fasteners, keel beam, fail-safe straps, flooring, flooring structural supplies, pressure web, the lavatory structure, galley support, partitions, shear ties, tie rods, structural firewall, torque boxes, and attachment fittings.

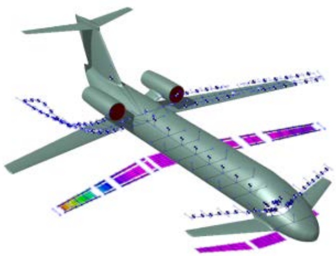
Lifting surfaces: non structural mass includes joints and fasteners, landing gear support beam, leading and trailing edges, tips, structural firewall, bulkheads, jacket fittings, terminal fittings, and attachments, high-lift devices, control surfaces, and access items.



GUESS – regression mass

Regression mass is subdivided in concentrated masses based on the volume of each element. In the FEM model concentrated masses are positioned on leading and trailing edges of lifting surfaces and along the fuselage.

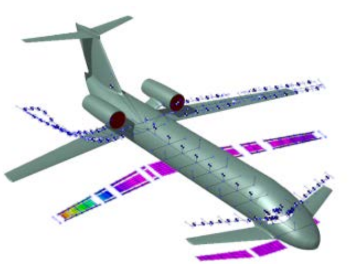
Paint mass is estimated using formulas based on wetted surface and is treated as a distributed mass.



GUESS – output interpretation

```
-------------------------------------------- SUMMARY --------------------
------------- Fuselage [Kg] -------------------------

Ideal structural mass  14327.43
Total structure mass   27038.73

------------- Semi-wingbox [Kg] ---------------------

Bending material mass  2353.31
Shear material mass    524.22
Predicted wingbox mass 2877.53
Actual wingbox mass    8622.77

------------- Wing Carrythrough [Kg] ----------------

Bending material mass   2244.02
Shear material mass     168.56
Torsion material mass   1389.39
CarryThrough mass       3801.98
Final CarryThrough mass 5110.62

------------- Wing [Kg] -----------------------------

Ideal structural mass          17245.54
Structural mass                16974.79
Primary structure mass         23181.46
Total structure mass           29958.96
Total structure including CT   35069.57

------------- Vertical tail [Kg] --------------------

Ideal structural mass              6141.86
Structural mass                    6045.43
Primary structure mass             8255.88
```

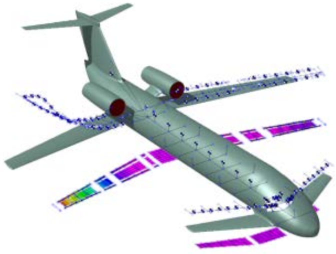
GUESS output can, at first, appear confusing. Here is how to interpret it.



GUESS – output interpretation

Fuselage: “ideal structural mass” is the mass before the regression, which gives the “total structural mass” (which includes the nonstructural mass).

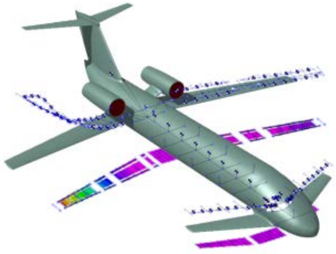
Semi-wingbox: there are two methods to estimate the structural mass: one gives directly shear and bending material mass, the other one gives thicknesses and calculates the mass. For the “Actual wingbox mass”, the maximum is taken. “Predicted wingbox mass” is the sum of “Bending material mass” and “Shear material mass” so, when the first method gives the maximum weight, Predicted and Actual mass are the same. This value is the mass of a semi-wingbox without the carrythrough and before applying any regression formula. If KCON9 is selected, “Torsional material mass” appears, but it shouldn’t be added to other masses.



GUESS – output interpretation

Wing Carrythrough: "Carrythrough mass" is given by the sum of Bending, Shear and Torsion material mass. In the case of KCON9, the Torsional material mass shouldn't be added. "Final Carrythrough mass" is the mass after regression formula has been applied. This is the mass of the whole carrythrough, not just half.

Wing: "Ideal structural mass" is the mass coming from the sizing process, it is twice the "Actual wingbox mass". "Structural mass", "Primary Structural mass" and "Total structural mass" are different masses coming from different regression formulas. Just the "Total structural mass" is the one corresponding to the FEM model and include non structural mass, too. "Total structure including CT" is the sum of "Total structural mass" and "Final Carrythrough mass". This is the total mass of the wing after regression analysis and including the carrythrough.

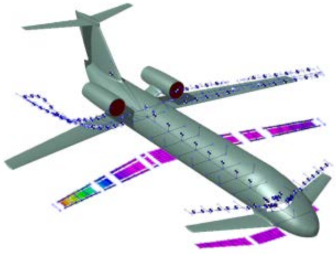


GUESS – output interpretation

Horizontal tail, vertical tail, Canard: the interpretation is the same as for the wing, but not everything is actually written.

Tailbooms: Total structure mass is the final mass after regression analysis that includes non structural mass, too.

For a detailed description of what is included at each level of regression, check NASA Technical Memorandum 110392 “Analytical Fuselage and Wing Weight Estimation of Transport Aircraft”, Mark D. Ardema, Mark C. Chambers, Anthony P. Patron, Andrew S. Hahn, Hirokazu Miura, and Mark D. Moore, 1996.



GUESS – output interpretation

Keep in mind that structural mass is present in the FEM model as a result of the volume of each elements times the material density, so the discretization can introduce an error, which is almost always very small. This can be seen summing all different mass contributions and comparing this number to the Maximum takeoff weight.

This error can be reduced increasing the number of elements used to discretize the structure (Acbuilder-> technology -> Geometry (beam_model)) or decreasing the number of elements used by GUESS internally during the sizing process (Acbuilder-> technology-> Experienced).