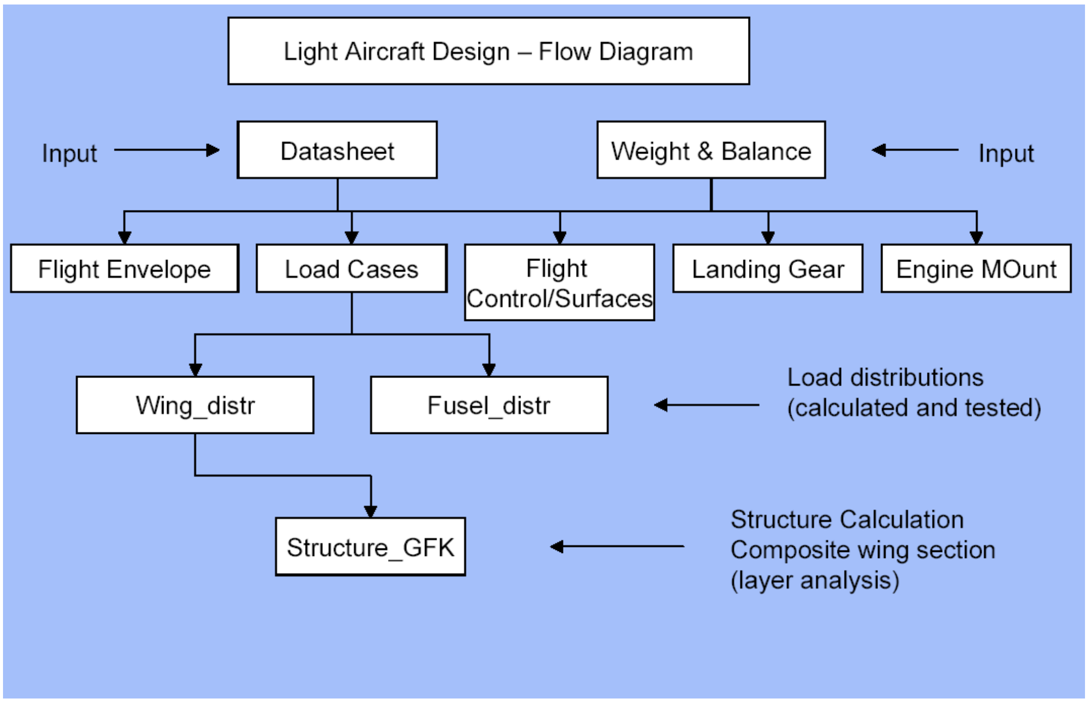
New: Sport Pilot (LSA)

The Light Aircraft Design Computer Program Package - based on MS-Excel-application – was now extented with the new Sport Pilots (LSA) loads module, which includes compliance for the "Standard Specifiation for Design and Performance of a Light Sport Airplane – ASTM F 2245-04" loads section.

Light Aircraft Design

- Loads and Static Tests
- Structure Calculations
- Aerodynamic



The Loads may be calculated according to the following regulations:

- UL Germany (LTF-UL)
- FAR 23 / VLA
- **NEW***Sport Pilots (LSA)***NEW**

- All programs are MS-EXCEL modules some of them using MS Visual Basic calculation modules in background.

- Summary descriptions of the methods are included in the spreadsheets.

- Most of the results are presented in graphic form.

The UL Germany (LTF-UL), Sport Pilots (LSA) and FAR23/VLA includes the following modules:

- Data Sheet
- Weight and Balance
- Flight Envelope
- Design Cases
- Landing Gear Loads
- Engine Mount Loads
- Control Surfaces and Flight Control Loads
- Fuselage Load Distributions (calculated and tested)
- Wing Load Distributions (calculated and tested)

Prices: *

LTF-UL : 500€

LSA – Sport Pilots : 800€

FAR 23/VLA: 900€

Special Offer: LTF-UL + LSA-Sport Pilots + FAR 23/VLA: 1400€

*add supplementary 19% taxes (MWSt.)

Supplementary the following modules may be ordered: *

Flight Controls Kinematics (49€)

Propeller Layout / Design (49€)

Manoeuvre and Gust Flight Simulation (99€)

Structure Calculation: Wing Sections (metal and composite) (49€)

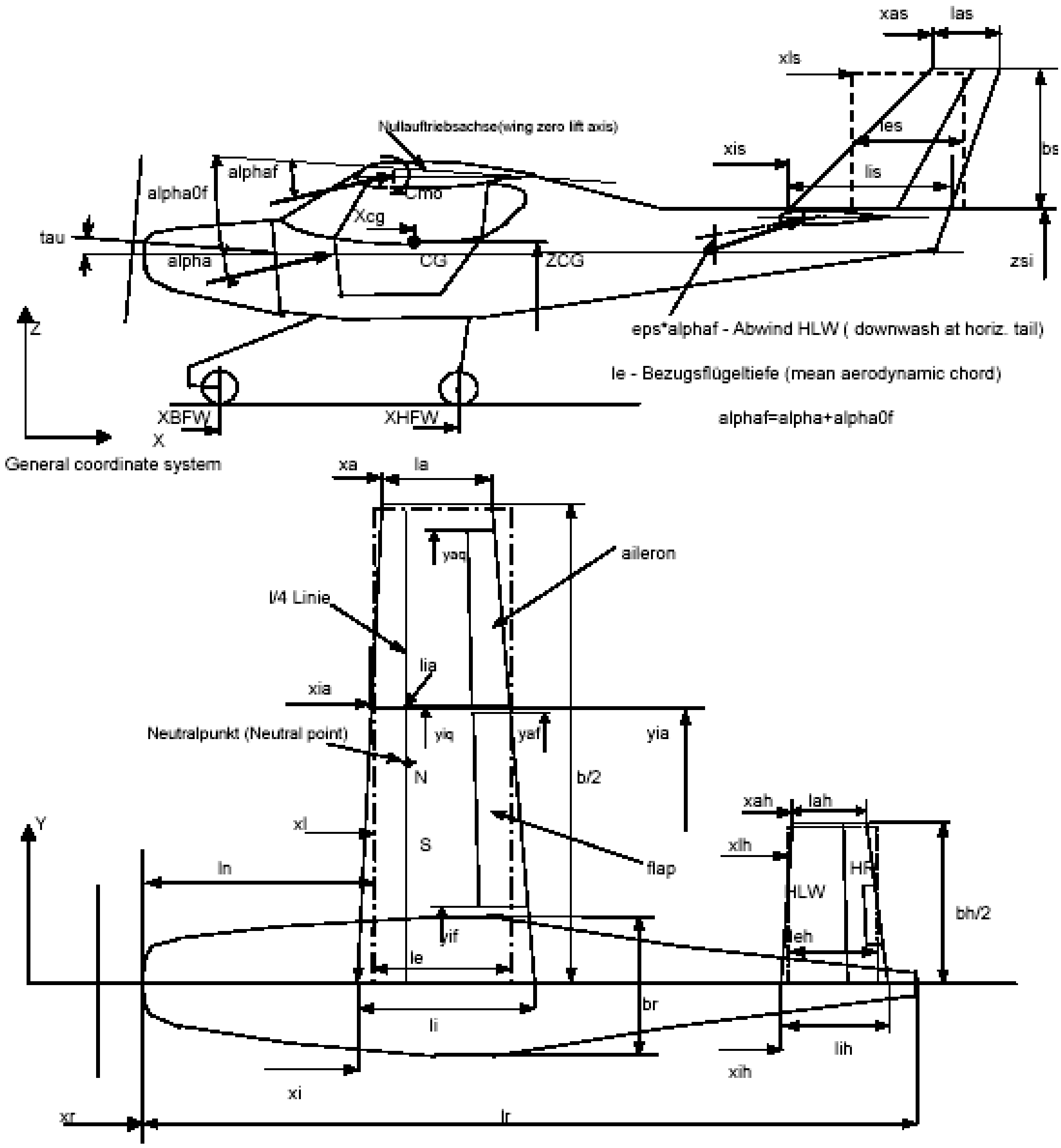
Landing Gear Strut. Calculation (99€)

Fuselage Design (99€)

*add supplementary 19% taxes (MWSt.)

- Data Sheet

All geometric and aerodynamic data of the aircraft are defined or calculated: mean aerodynamic chords, aspect ratios, tail volumes, lift curve slopes, hinge lift and moment coefficients for control surfaces and tabs, neutral point wing, tails and fuselage influence, propeller slipstream effect.



- Weight and Balance

Calculates the mass distribution of the aircraft, CG position and inertial moments.

- Flight Envelope

Calculates the design speeds and the corresponding load factors for manoeuvre and gusts.

(graphic)

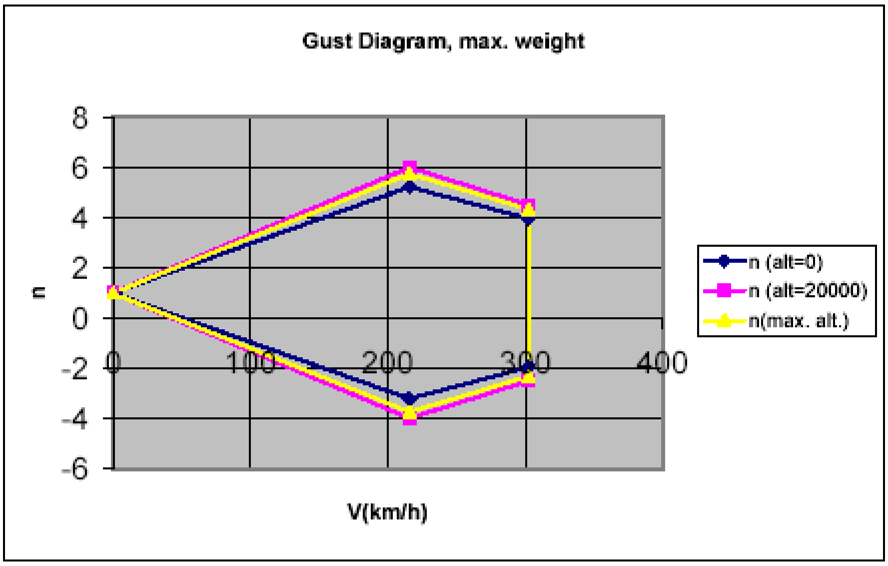
Eingabedaten (input data)

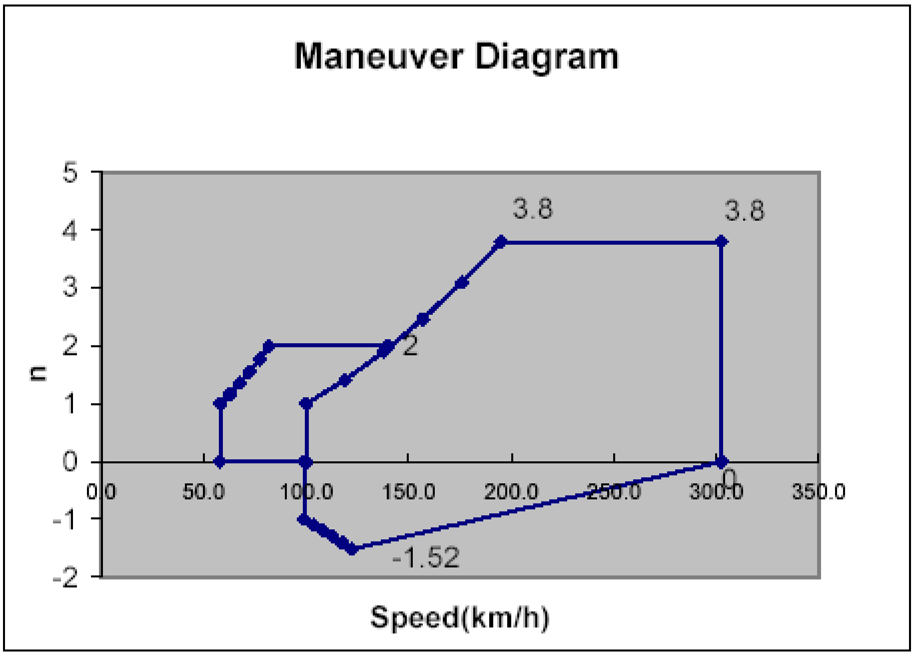
max. Flugzeugmasse - m(kg)	450	(max. aircraft mass)
min. Fliegbare Masse (kg)	357	(min. flying weight)
Spannweite (m)	9.62	(Span)
Flügelfläche (m^2)	11.8750521	(wing surface)
Mittlere Flügeltiefe (m)	1.2344129	(mean aerodynamic chord)
nA (+ VA)	3.8	
nD (+ VD)	3.8	
nE (-VD)	0	
nF (-VA)	-1.52	
n flaps(+VF)	2	
VS(km/h)	100	min.V mit 0° Klappen (min. speed without flaps)
VSF(km/h)	58	min. V mit max. Klappen (min. speed with flaps)
VH(km/h)	240	max. Geschwindigkeit im Horizontalflug

Geschwindigkeiten - JAR 23.335 (Speeds)

n*m*g=ro/2*S^2*V^2*Ca

VA=	194.935887	km/h	VC	216	km/h
VD=VE	302.4	km/h			
VF=	140	km/h	VFE=	140	km/h
VG	122.250109	km/h	VNE=	272.16	km/h





- Design Cases

The critical design cases according to the LSA (Sport Pilots), LTF-UL (Ultralight Germany) or FAR 23 are defined and the corresponding forces on the wing, tail are calculated.

- Landing Gear Loads

The design cases and corresponding forces on the main and nose gear are calculated.

- Engine Mount Loads

Forces and moments in the engine mount CG (including gyroscopic effects are calculated).

- Control Surfaces/Flight Control Loads

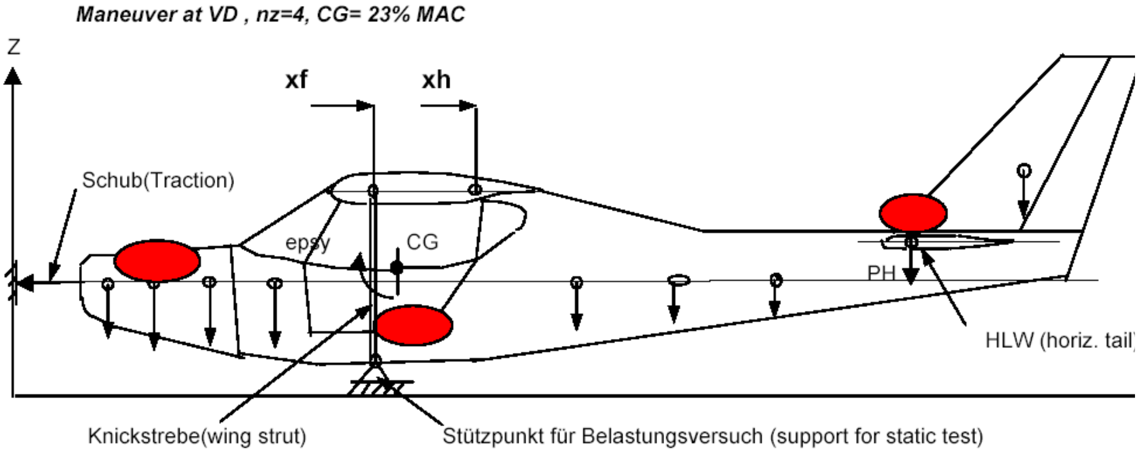
The total critical loads and hinge moments (aileron, elevator, rudder, flaps) on the control surface of the aircraft are calculated.

- Fuselage Load Distributions (calculated and tested)

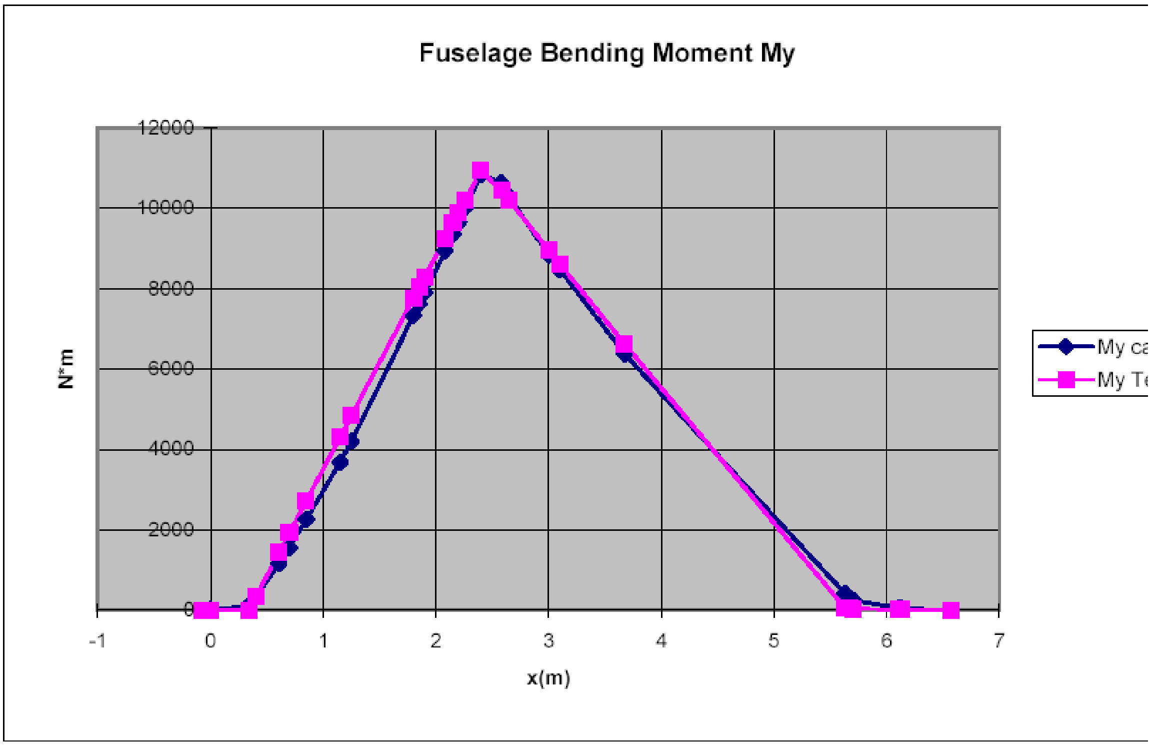
The fuselage bending and shear force diagrams for the critical fuselage loading are calculated.

Position for the points where the fuselage will be loaded during the static test are defined. The corresponding test load diagrams are computed and compared with the calculated ones.

(graphic)



Maneuver at VD , nz=4, CG= 23% MAC
Z
xf
xh
Schub(Traction)
epsy
CG
PH
HLW (horiz. tail)
Knickstrebe(wing strut)
Stützpunkt für Belastungsversuch (support for static test)



Fuselage Bending Moment My
N*m
12000
10000
8000
6000
4000
2000
0
-1
0
1
2
3
4
5
6
7
x(m)

- Wing Load Distributions (calculated and tested)

The wing aerodynamic load distribution for critical design cases is calcualted with the well known Multhop lifting line method.

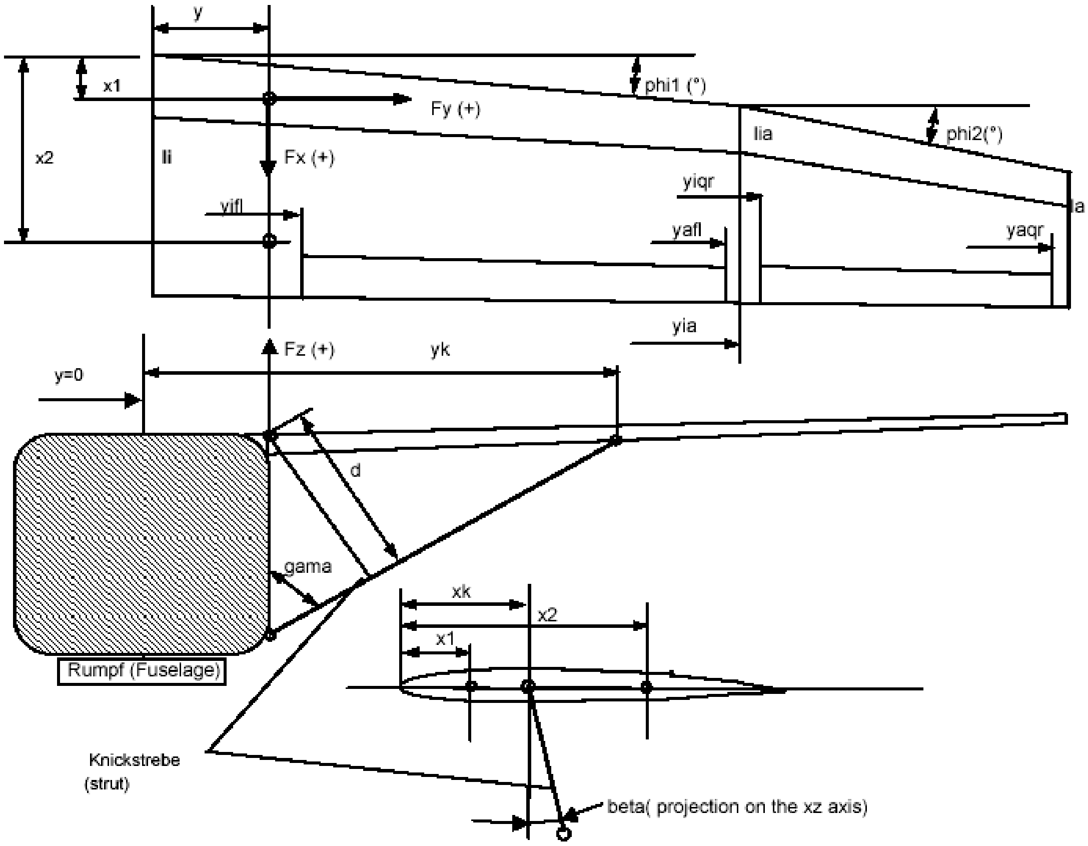
The effect of flap/aileron is considered.

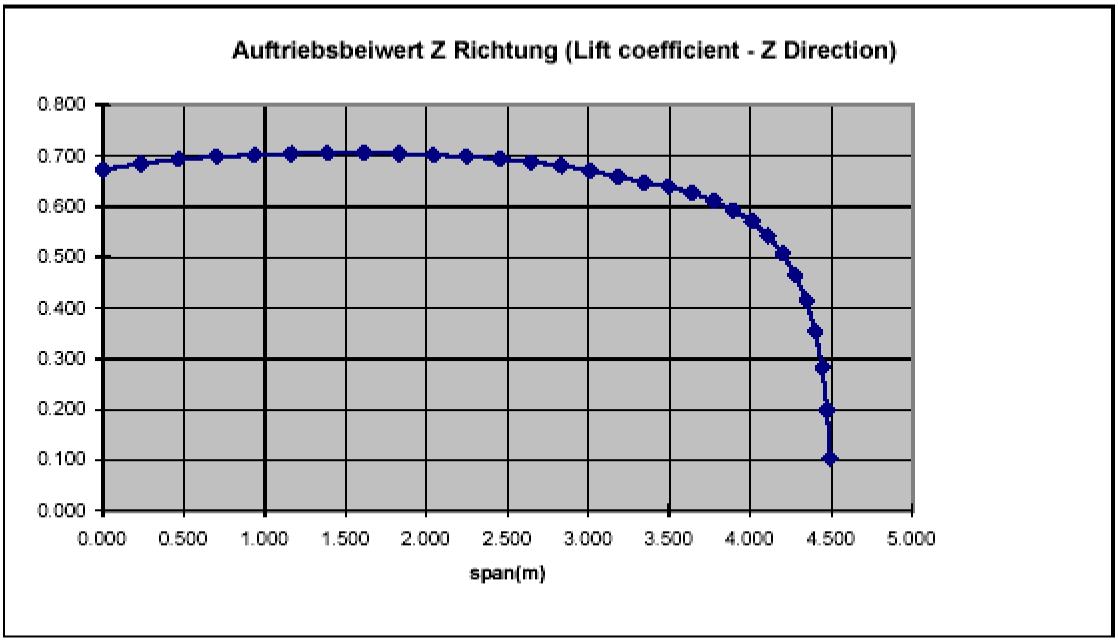
The mass load distribution (structure, fuel, lumped masses like landing gear) due to vertical and roll acceleration is considered.

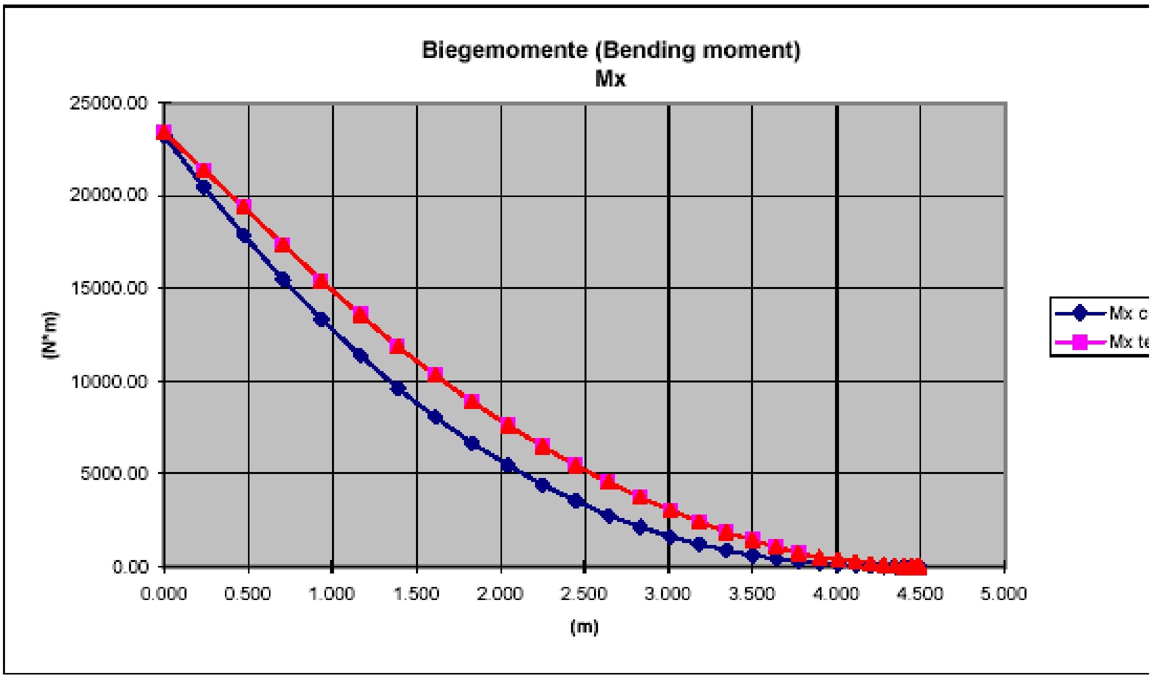
The total shear (Tx,Ty,Tz) and moment diagrams (bending-Mx, torsion - My and in plane bending –Mz) moments are calculated.

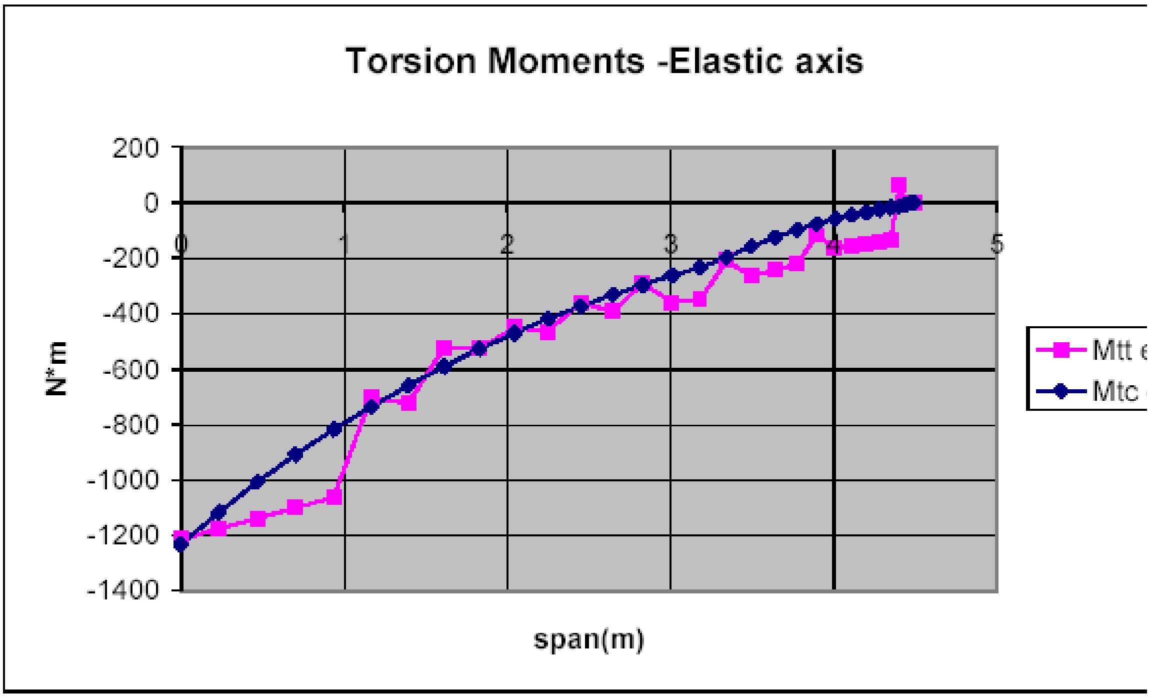
The static test loading may be also defined and compared with the calcualted one.

(graphic)




Auftriebsbeiwert Z Richtung (Lift coefficient - Z Direction)
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000 4.500 5.000
span(m)


Biegemomente (Bending moment)
Mx
25000.00
20000.00
15000.00
10000.00
5000.00
0.00
(N*m)
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000 4.500 5.000
(m)



- Flight Controls Kinematics (49 EUR)

This program calculates the forces in a 3D push-pull control system for different control system deflections.

Cross sections of the rods are defined.

The safety factors for buckling are calculated.

(graphic)

Control System Kynematics and Force Calculation

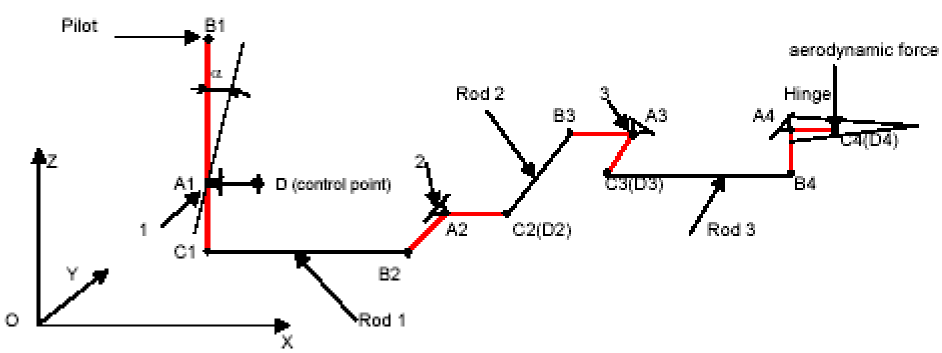
Error (should be zero)	
1.89E-12	

Pilot force(N)=	1000
(+ push)	

Hinge Moment = 375756 N*mm

Point No.	1	2	3	4	5	6	7	8
Used Index	1	1	1	1	0	0	0	0
alpha(°)	20	-20.0222	20.1425	15.96203	0	0	0	0
Mb plane(N*mm)	300000	-298642	291417.7	375755.6	0	0	0	0
Mb perp.(N*mm)	0	1920.889	0	4767.347	0	0	0	0
Rod Force (N)	1000	-3185.63	-3928.77	3897.947	0	0	0	0
Rod length(mm)	300	1000	300	400	1673.918	0	0	0
Rod Diam. ext(mm)	20	21	20	20	0	0	0	0
Rod Diam. int(mm)	18	17	18	18	0	0	0	0
E rod(N/mm^2)	73000	73000	73000	73000	0	0	0	0
E*I (N)	1.97E+08	3.98E+08	1.97E+08	1.97E+08	0	0	0	0
Buckling Force(N)	21610.08	3922.05	21610.08	12155.67	0	0	0	0
Rod no.		1	2	3	4	5	6	7
Safety Factor (j)		1.23117	5.500465	0	0	0	0	0
xa	0	1000	1160	1560				
ya	0	100	400	320				
za	100	0	0	100				
xb	0	1000	1080	1560				
yb	0	0	400	320				
zb	400	0	0	0				
xc	0	1080	1160	1640				
yc	0	100	320	320				
zc	0	0	0	100				
xd	100	1080	1160	1640				
yd	0	100	320	320				
zd	100	0	0	100				

How to use this spreadsheet



1. Introduce the X,Y and Z coordinates of points A, B, C, D
Note: Point D is needed if points A,B,C are on the same line and cann't define a plane. Otherwise point D=C.

Note: The program is configurated for 8 points(A1,A2,....) including the pilot input (control stick or rudder pedal) and the hinge
For the last not used points (if there are less then 8 points) the "used index" should be set to "0".

2. Introduce the rod diameters (external and internal) and E module

3. Introduce the pilot force and the rotation angle in this point (alpha for point no. 1)

4. Use the EXCEL Solver (Menu Tools) to minimize the error in the blue cell G8.
How to initializate the SOLVER:
- Set Target Cell: "G8"
- Equal to: "Min"
- By changing cells: c15;$...$15 (green marked)

SOLVER is an EXCEL very powerful optimisation algorithm. In our case SOLVER looks for the right values of the rotation angles in points "2", "3",...... which are compatible with the rotation of point "1" (pilot). Compatibility means that the rod length is the same after rotation(deflection).

Notations:

- Rod force "+" - tensile; "-" compression

- Mb plane - Bending moment in point "A" in the plane "ABCD"

- Mb perp. - Bending moment in point"A" perpendicular to the plane"ABCD" (when the rod is not in the plane "ABCD"

Mb plane and Mb perp. may be used for the stress calculation of the control lever arms.

- the safety factor for buckling is "0" for tensile (convention). For compression this factor must be higher than 1.

- the input cells are jellow marked

- the last lever is the hinge and Mb plane=M hinge.

- Propeller Layout/Design (49 EUR)

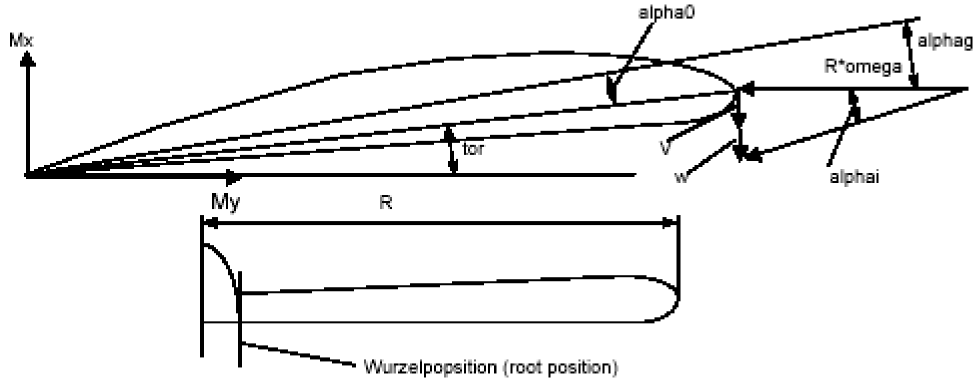
This module calculates the propeller curves using a very efficient energy method.

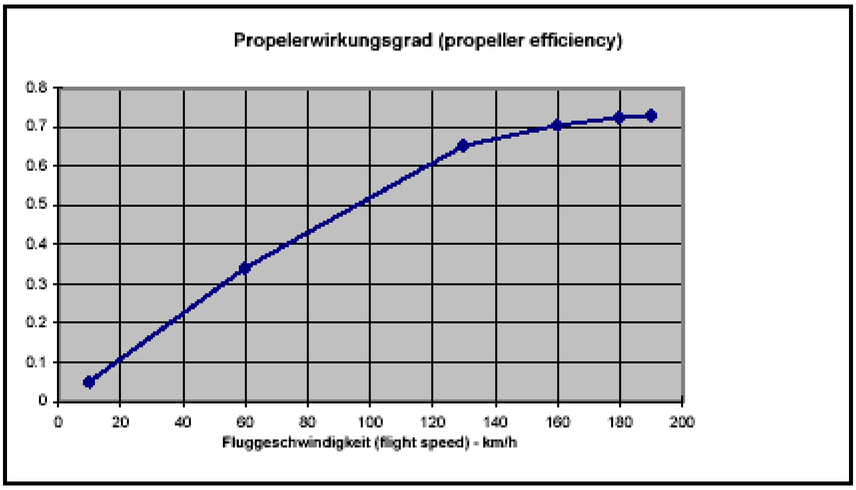
The propeller planform and torsion is defined as input.

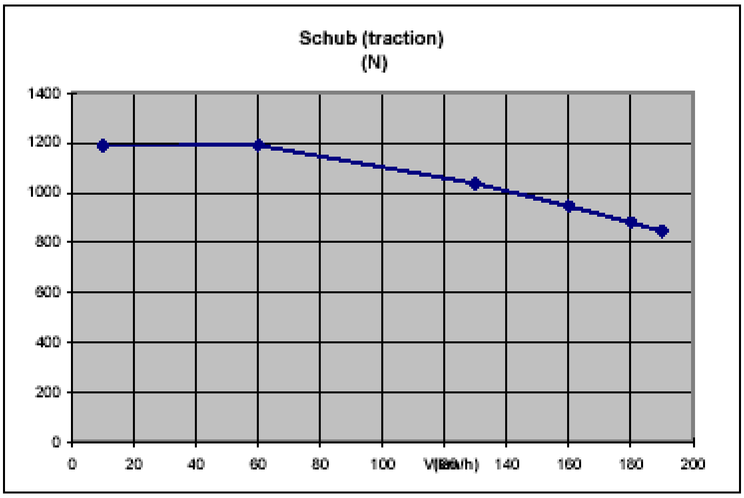
Using the “SOLVER” optimization algorithm from MS-EXCEL some parameters may be optimized (form, torsion) in order to get the best efficiency in a given working point.

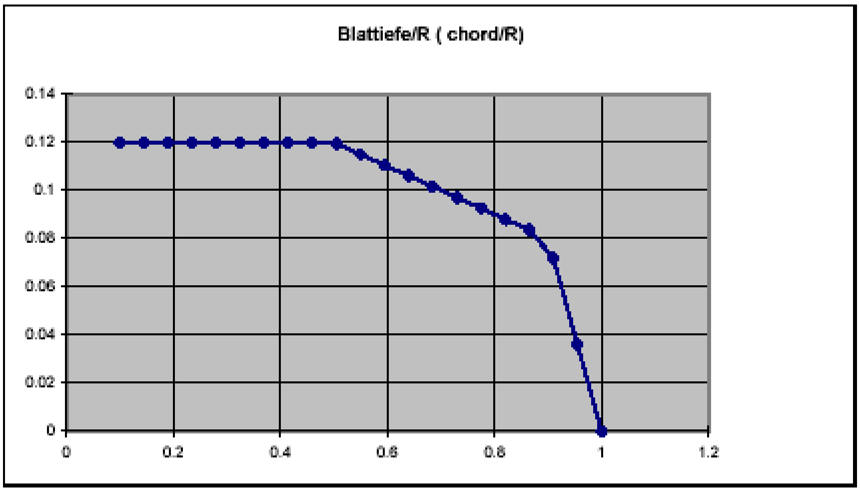
Bending and torsion moments in propeller cross sections are calculated.

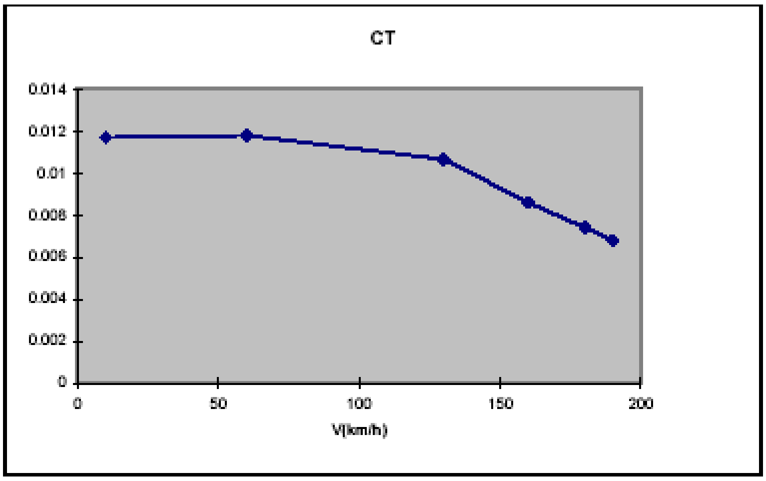
(graphic)

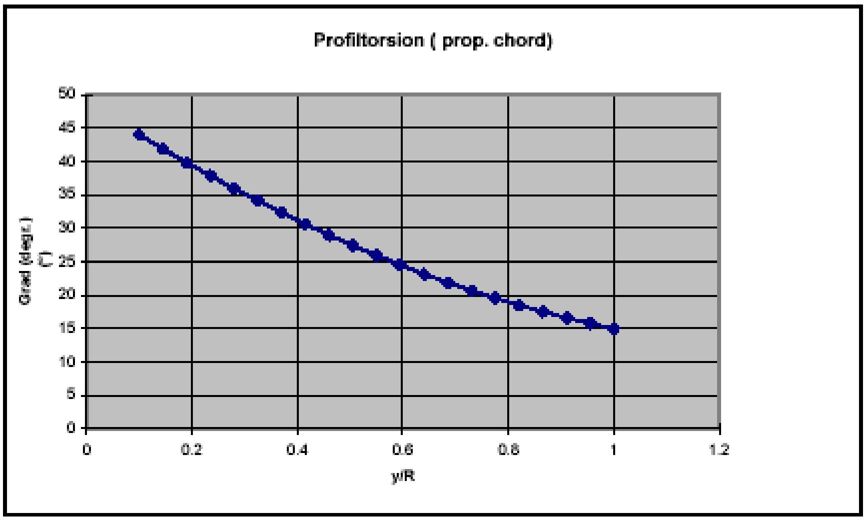

alpha0
Mx
alphag
R*omega
tor
V
w
alphai
My
R
Wurzelpopsition (root position)

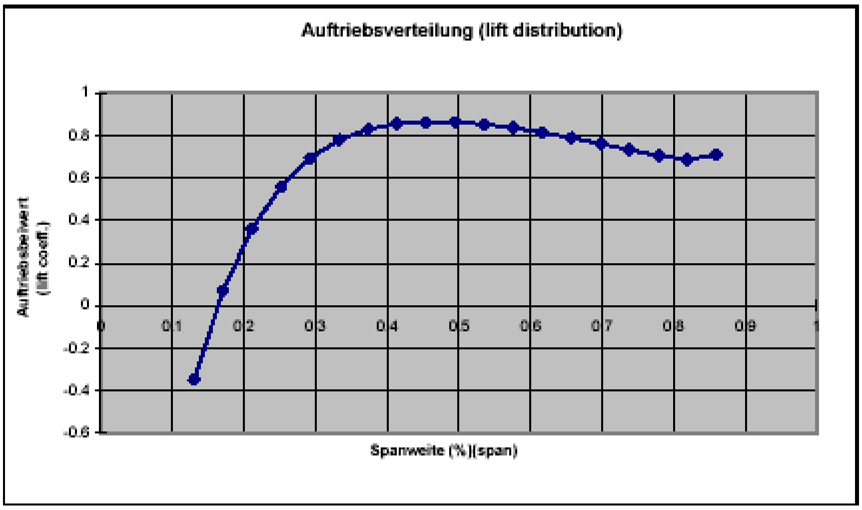

Propelerwirkungsgrad (propeller efficiency)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
120
140
160
180
200
Fluggeschwindigkeit (flight speed) - km/h

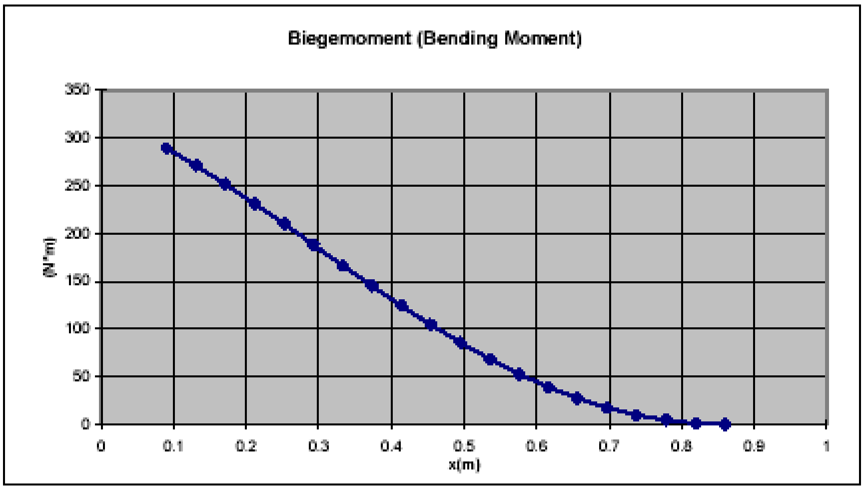

Schub (traction)
(N)
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
140
160
180
200


Blattiefe/R (chord/R)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.2
0.4
0.6
0.8
1
1.2


CT
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
V(km/h)


Profiltorsion (prop. chord)
Grad (degr.) (°)
50
45
40
35
30
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1
1.2
y/R





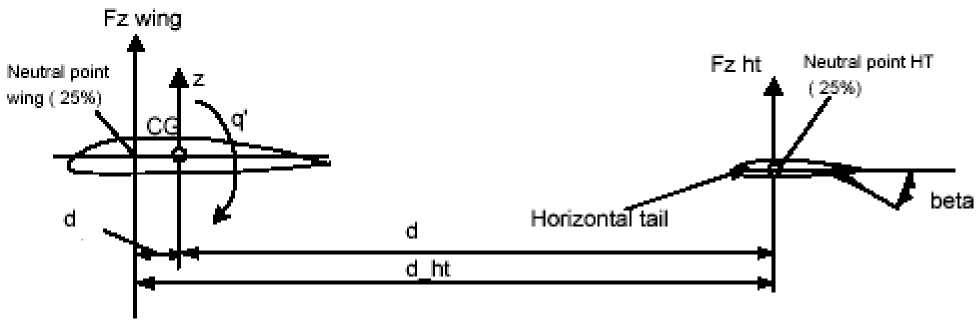
- Manoeuvre and Gust Flight Simulation (99 EUR)

Regulations (FAR/JAR/CS,VLA, LTF-UL) provide simplified formulas for gust. The resulted forces and load factors are normally conservative.

A more detailed calculation may be performed by means of a flight simulation of the gust/manoeuvre in which the vertical translation and pitch rotation of the aircraft are considered. A differential equation system defines the A/C motion.

By means of this method a time history of all A/C parameters (angle of incidence, pitch rate, pitch acceleration, A/C load factor, wing load, HT load) is calculated.

(graphic)



Theoretical Description:

The pitching moment and lift equation of motion were integrated.
In order to avoid errors due to integration a very low integration step was used (0.02 sec.)
The inertial massic forces due to the HT local load factor will be also considered
The standard JAR 23 "cos" vertical gust was introduced:
U=Ude/2*(1-cos(2*3.141/25/C))
The gust penetration delay between wing and horizontal tail was considered.

Two second order differential equations of motion will be integrated:

q''=Mtot/Jyy (diff. Equation for the rotation)
z''=Fz/V/m (diff. Equation for vertical translation)

alpha_g_w(t)= Ude/2*(1-cos(2*3.141*V*t/25/C))/V
alpha_g_ht(t)= Ude/2*(1-cos(2*3.141*V*(t-tau)/25/C))/V if t-tau>0 (else alpha_g_ht=0)
tau=d/V (time delay between wing and HT)
No. of iterations for tau: int(tau/dt)
alpha_w(t)=alpha_g_w(t)-z'(t)/V+q
alpha_ht(t)=-alpha_w(t-tau)*deps/dalpha+q'*(d_ht-MAC*(CG(%)-25)/100)/V+q

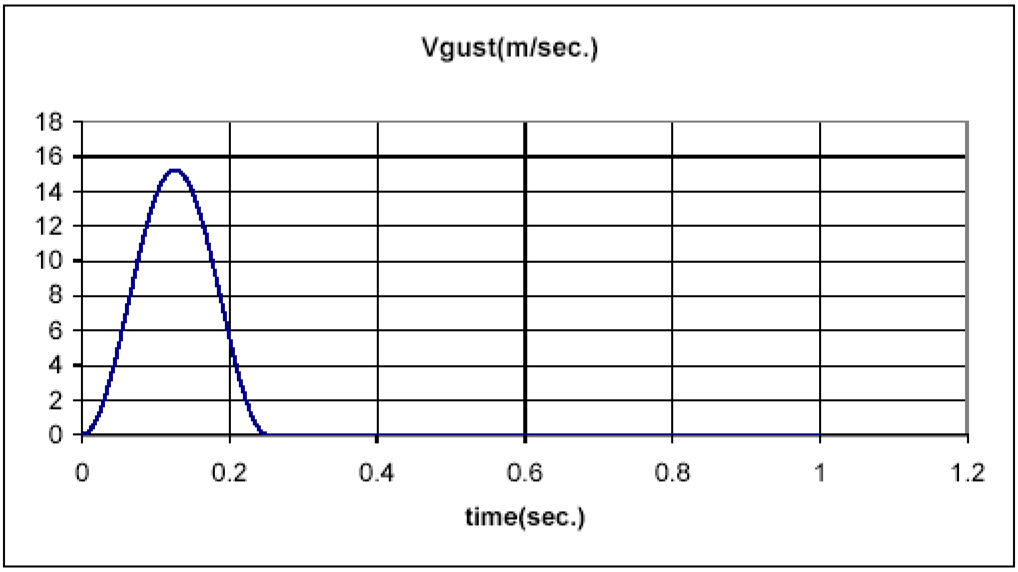
Fz=Fzwing + Fz_ht (vertical force)
Fz wing= Fz wing(alpha_w)=pdyn*S_wing*d(Cl_wing)/d(alpha)* alpha_w

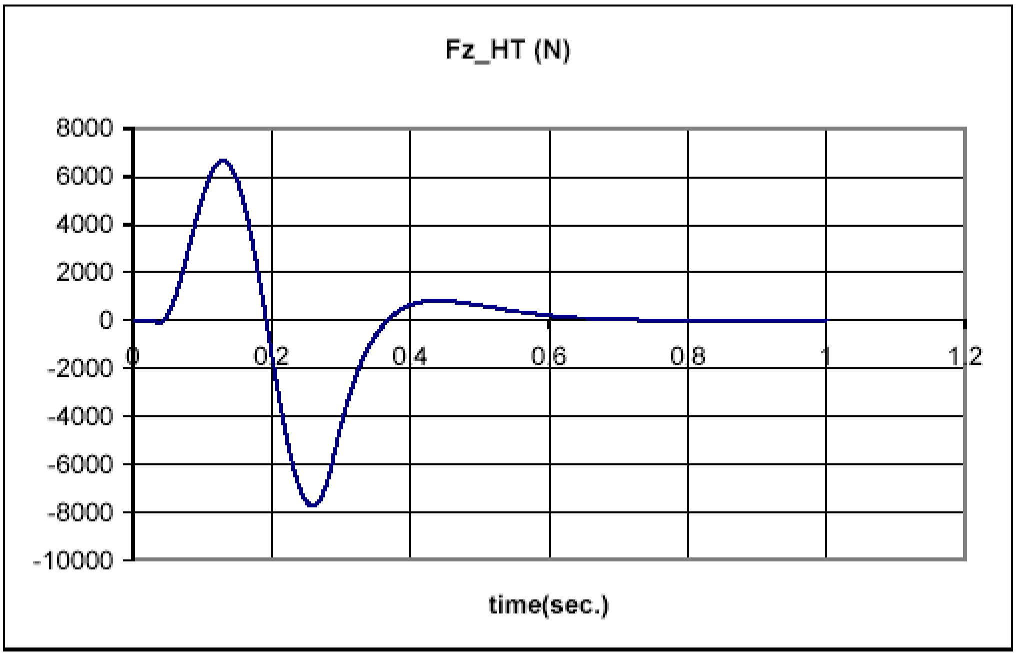
Fz_ht=Palpha_ht +Pq'_ht +Pbeta_ht
Pbeta_ht=pdyn*Sht*d(alpha)/d(beta)*d(Cl_ht)/d(alpha)*beta
Palpha_ht=pdyn*S_ht*d(Cl_ht)/d(alpha)*alpha_ht
Pq'_ht=pdyn*S_ht*d(Cl_ht)/d(alpha)*q'*(d_ht-MAC*(CG(%)-25)/100)/V

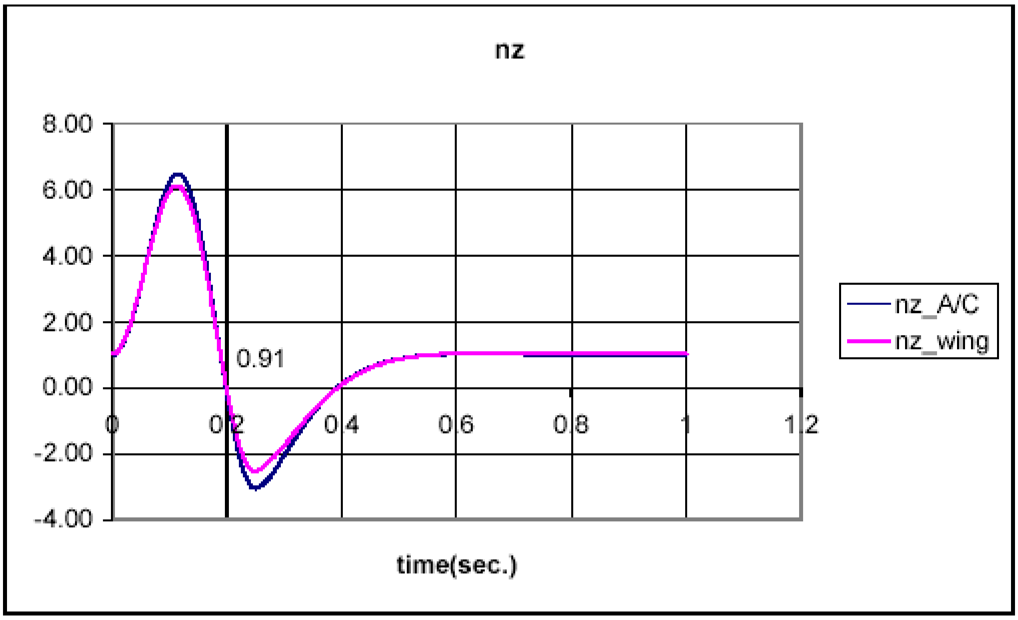
Mtot=M(q') +M(alpha) + M(beta)

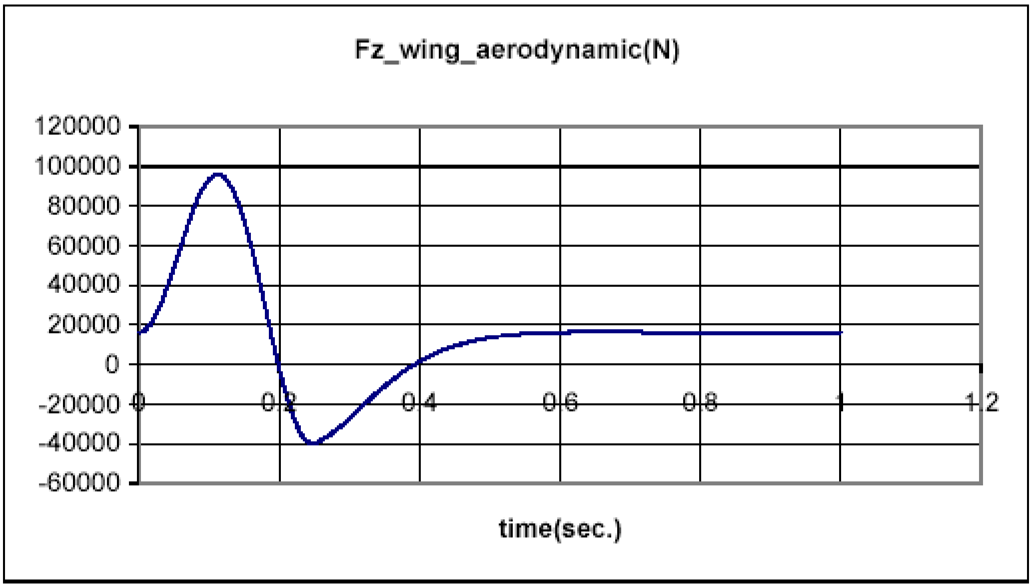
M(alpha)= Fz wing*MAC*(CG(%)-25)/100-Fz_ht*(d_ht-MAC*(CG(%)-25)/100)
M(q')=-(d_ht-MAC*(CG(%)-25)/100)*Pq'
M(beta)=-(d_ht-MAC*(CG(%)-25)/100)*Pbeta

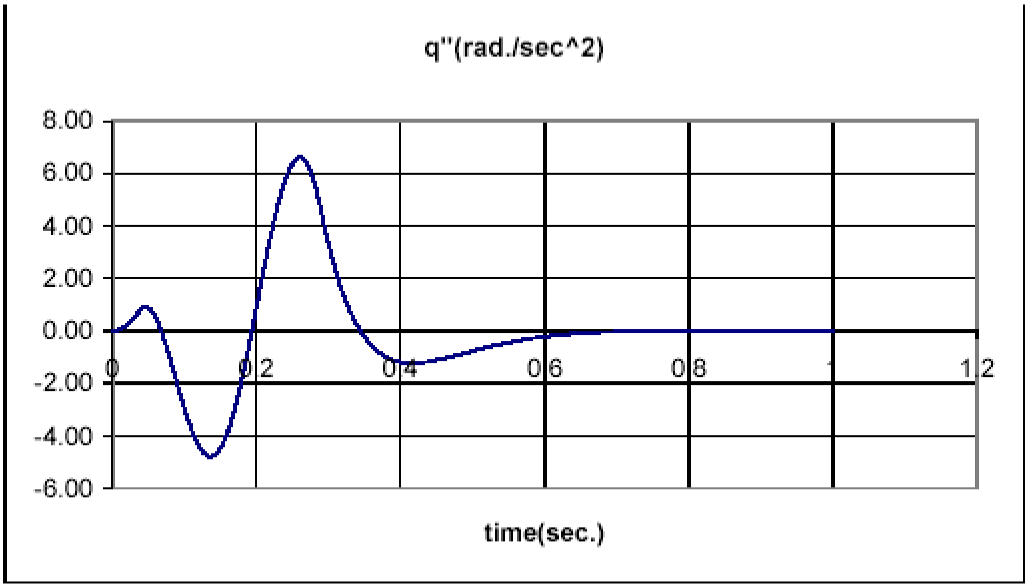
Load factor: nz=1+Fz/m_tot/9.81
HT local load factor nz_ht=1+nz +q'' *d/9.81
Fz_ht_tot= Peq+Fz_ht-nz_ht *m_ht


Vgust(m/sec.)
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
time(sec.)


Fz_HT (N)
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
0
0.2
0.4
0.6
0.8
1
1.2
time(sec.)


nz
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
0
0.2
0.4
0.6
0.8
1
1.2
0.91
nz_A/C
nz_wing
time(sec.)


Fz_wing_aerodynamic(N)
120000
100000
80000
60000
40000
20000
0
-20000
-40000
-60000
0
0.2
0.4
0.6
0.8
1
1.2
time(sec.)



- Wing Sections (metal and composite) (49 EUR)

A library of composite material layers is defined including all material properties.

This library is used to define the layout of a wing cross section (type and no. of layers, layer direction).

The section bending and torsion moment are defined.

The bending and shear stresses are calculated.

Finaly the safety factors for each layer is defines (Tsai criteria).

(graphic)

Lay-out definition (Schichtendefinition) Table 1

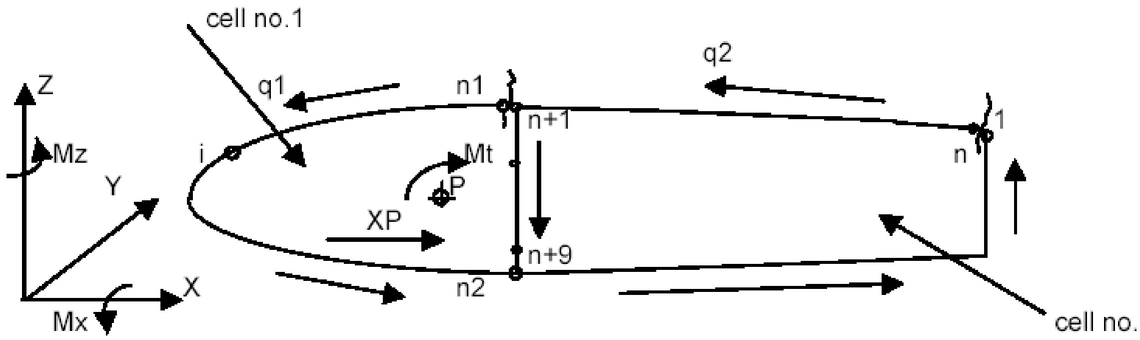
Layer no.	Mat. Name	Thick.(mm)	Densit(g/cm^3)	E(0)(N/mm^2)	E(90)(N/mm^2)	G(N/mm^2)	ν(contr. coe	sigxt	sigxc	sigyt	sigyc	tauxy
1	Gewebe 92125	0.26	1.75	22900	22900	1320	0	176	-176	176	-176	37
2	UD Gelege KDU 1009	0.47	1.37	73700	1	1	0.5	360	-360	1	-1	1
3	Gewebe 92125	0.26	1.75	22900	22900	1320	0	176	-176	176	-176	37
4												
5												

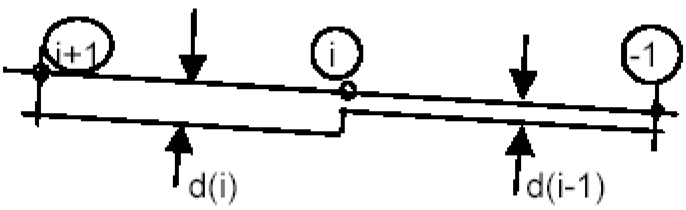
Results for layers (Ergebnisse für die Schichtanalyse): Table 3

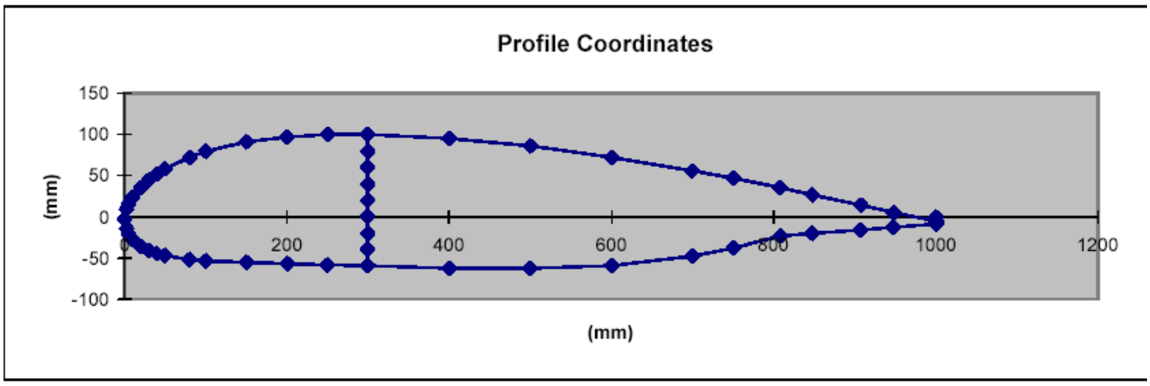
Allgemein - Koordinatensystem / Schicht - Koordinatensystem

Layer No.	General coord. system			Layer coordinate system			
	sigmax(N/mm^2)	sigmay(N/mm^2)	tau(N/mm^2)	sigx(N/mm^2)	sigy(N/mm^2)	tau(N/mm^2)	RF
1	24.50	0	9.52	2.73	21.77	12.25	
2	141.40	0	0.00	141.40	0.00	0.00	
3	24.50	0	9.52	2.73	21.77	12.25	
4	0.00	0	0.00	0.00	0.00	0.00	
5	0.00	0	0.00	0.00	0.00	0.00	

Struture Calculation: Bending and Torsion
(Strukturberechnung: Biegung und Torsion)







n=	51	
n1=	11	
n2=	37	
k=	1.2	(scale factor for profile length)
Mx=	4000	(N*m)
Mz=	0	(N*m)
Mt=	1000	(N*m)

- Landing Gear Strut. Calculation (99 EUR)

This program simulates the landing of an elastic landing gear leaf (strut) by means of an iterative method. Large geometrical deformations are considered. The force-deformation diagram and the deflected form of the leaf are plotted.

The form of the landing gear strut is defined: rectangular or round section. The safety factors for each cross sections are calculated (bending, torsion and total loading). Half struts or cross one piece) struts may be calculated.

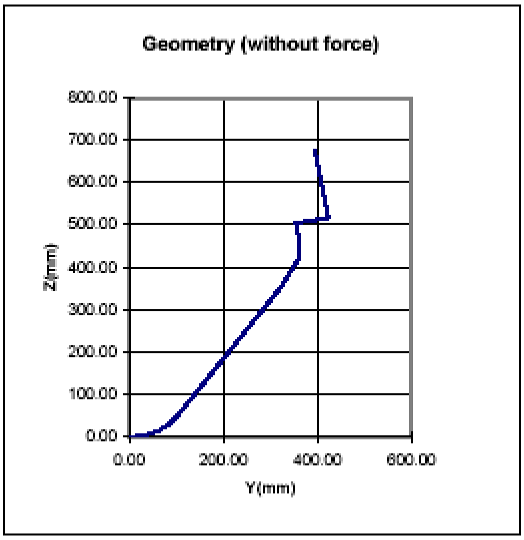
The tire elastic characteristic is considered.

(graphic)

Results:

Max. inertial load factor:	**3.26**
Max. vertical force (N):	**6000**
Max. drag force(N):	1980
Max. lateral force (N):	0
Tire deflection(mm):	42.86
Tire+Strut deflection(mm):	242.27
Strut torsion angle (°):	0.00
Tyre lateral defl. (mm)	-244.70
Wheel angle(°)	-22.95

No.	y (mm)	z (mm)	Deflected geometry yd(mm)	zd(mm)	Normal stress Ft(N/mm^2)	Tangential stress Fs(N/mm^2)	Equivalent stress Fe(N/mm^2)	Safety factor J
1	-225.00	0.00	-225.00	0.00	0.00	0.00	0.00	1000.00
2	-192.86	0.00	-192.86	0.00	374.80	0.00	374.80	4.00
3	-160.71	0.00	-160.71	0.00	608.75	0.00	608.75	2.46
4	-128.57	0.00	-128.57	0.00	804.10	0.00	804.10	1.87
5	-96.43	0.00	-96.43	0.00	978.08	0.00	978.08	1.53
6	-64.29	0.00	-64.29	0.00	1137.77	0.00	1137.77	1.32
7	-32.14	0.00	-32.14	0.00	1286.95	0.00	1286.95	1.17
8	0.00	0.00	0.00	0.00	1427.94	0.00	1427.94	1.05
9	8.00	0.00	7.95	-0.90	1405.76	0.00	1405.76	1.07
10	34.61	3.15	34.81	-1.01	1331.34	0.00	1331.34	1.13
11	59.76	12.43	61.13	4.39	1259.81	0.00	1259.81	1.19
12	82.04	27.32	85.77	15.11	1194.73	0.00	1194.73	1.26
13	100.23	47.00	107.64	30.72	1139.37	0.00	1139.37	1.32
14	109.68	60.00	142.05	60.46	1094.78	0.00	1094.78	1.37
15	136.38	96.78	177.60	88.81	1046.98	0.00	1046.98	1.43
16	163.08	133.56	214.20	115.81	997.28	0.00	997.28	1.50
17	189.76	170.35	251.73	141.48	945.93	0.00	945.93	1.59
18	216.45	207.14	290.11	165.86	893.40	0.00	893.40	1.68
19	243.12	243.93	329.25	189.01	840.74	0.00	840.74	1.78
20	269.79	280.74	369.06	210.97	790.62	0.00	790.62	1.90
21	296.46	317.54	409.46	231.83	751.06	0.00	751.06	2.00
22	323.11	354.35	450.38	251.64	760.19	0.00	760.19	1.97
23	359.10	419.44	489.36	275.46	569.74	0.00	569.74	2.63
24	360.27	464.78	513.90	313.98	497.19	0.00	497.19	3.02
25	356.80	484.48	521.44	332.51	434.53	0.00	434.53	3.45
26	353.33	504.17	529.12	350.98	384.12	0.00	384.12	3.91
27	422.27	516.32	593.59	323.72	149.99	10.36	151.06	9.93
28	394.5044174	673.8939835	639.208	431.6191	147.6540777	18.6632507	151.151174	9.92384



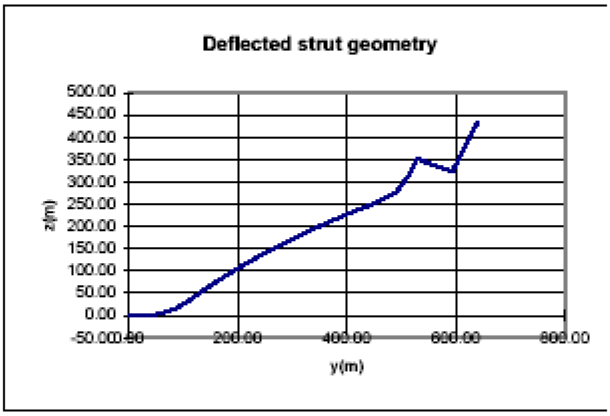


Fig. 1

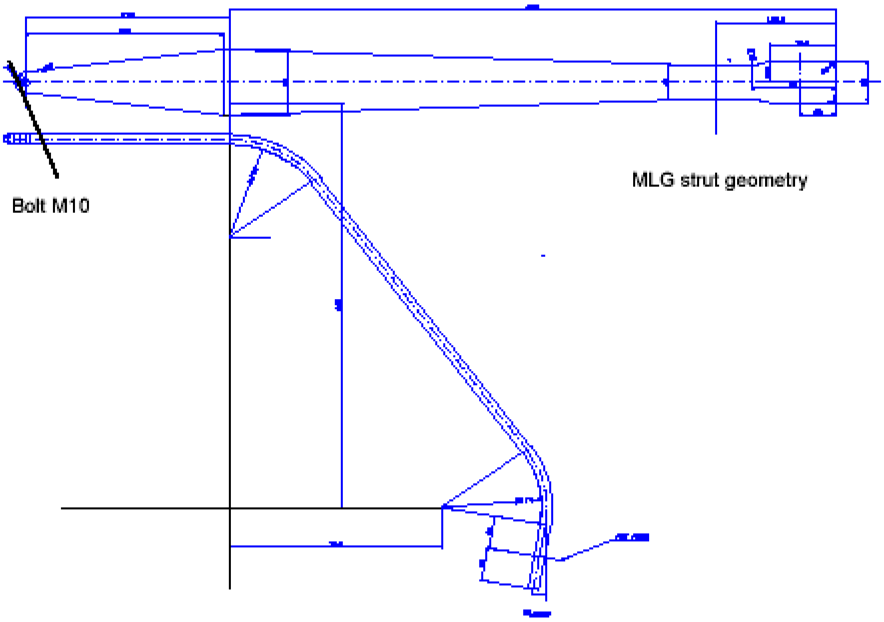
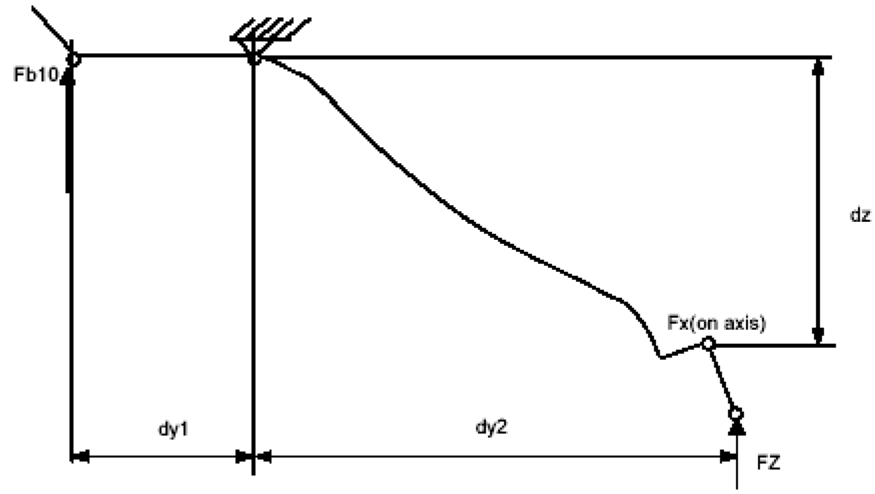


Fig. 3 MLG deflected geometry



- Fuselage Design (99 EUR)

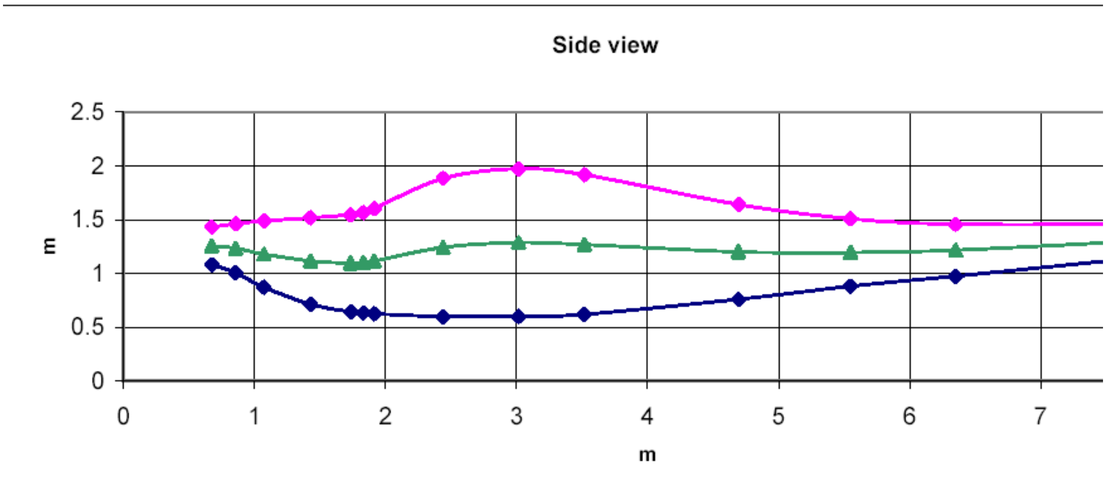
The main fuselage contour lines are defined: upper and lower from the side view, line of max. width, position of the max. width line.

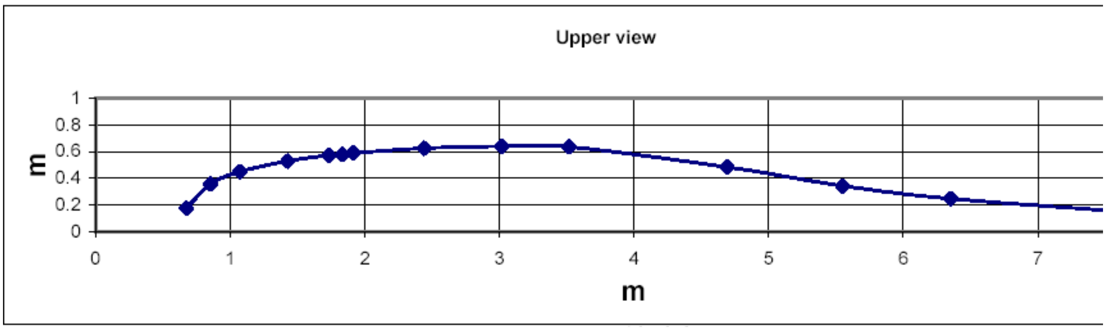
The cross sections of the fuselage are defined by means of conical curves (one curve for the upper side and one for the lower side). A conical coefficient defines the form of the cross section.

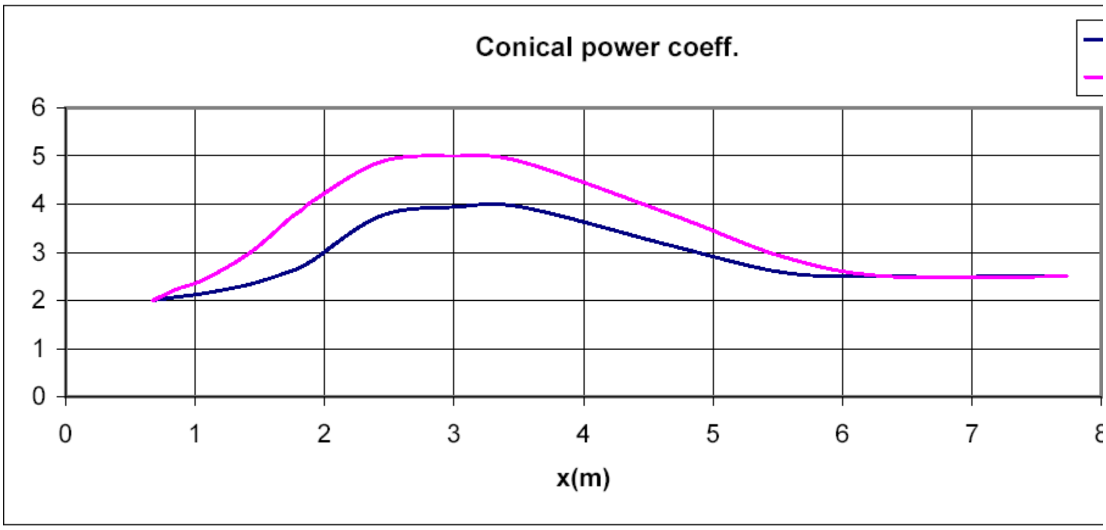
A ".DXF" file may be exported and read directly in CAD programs in order to define a very smooth surface form of the fuselage.

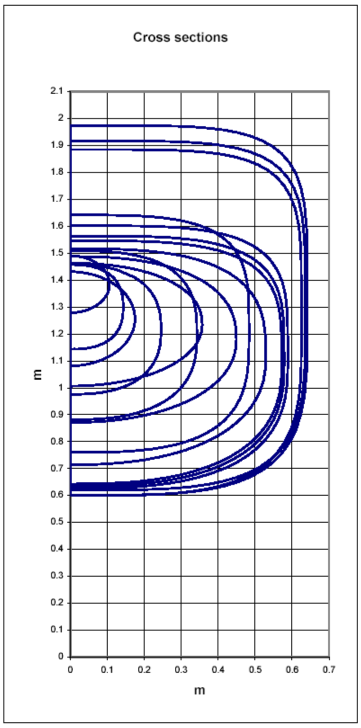
The whole procedure may be done in less then one hour.

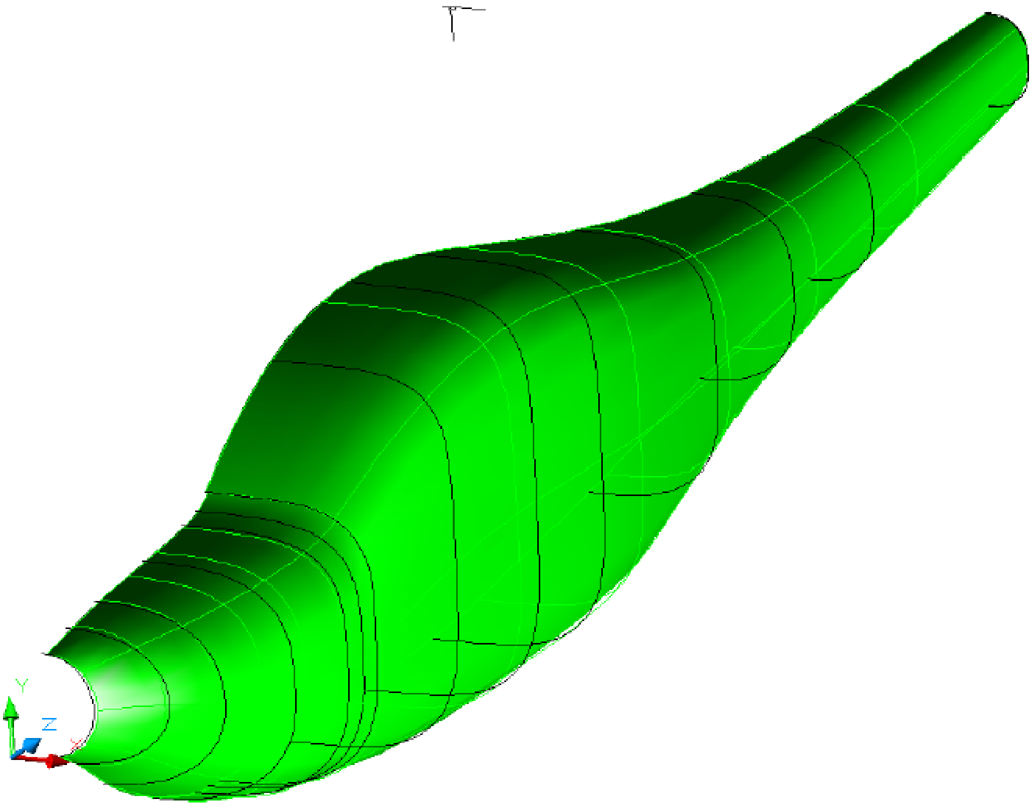
(graphic)






Conical power coeff.
x(m)


Cross sections
m
m



Coming Soon: Lifting Surface Aerodynamic Load Distribution (MS-EXCEL application)
Calculates the lift and induced drag distribution for complex aircraft 3D configurations like canard, winglets. Control surface deflections are included.
The lifting surface theory is used to define the pressure distributions.

Coming Soon: Spreadsheets:
Weight & Balance
Vertical Climbing Speed
Propeller Performance and Noise Measurements
Standard Atmosphera

consequences, which can result from the use of the program, adhesion.

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