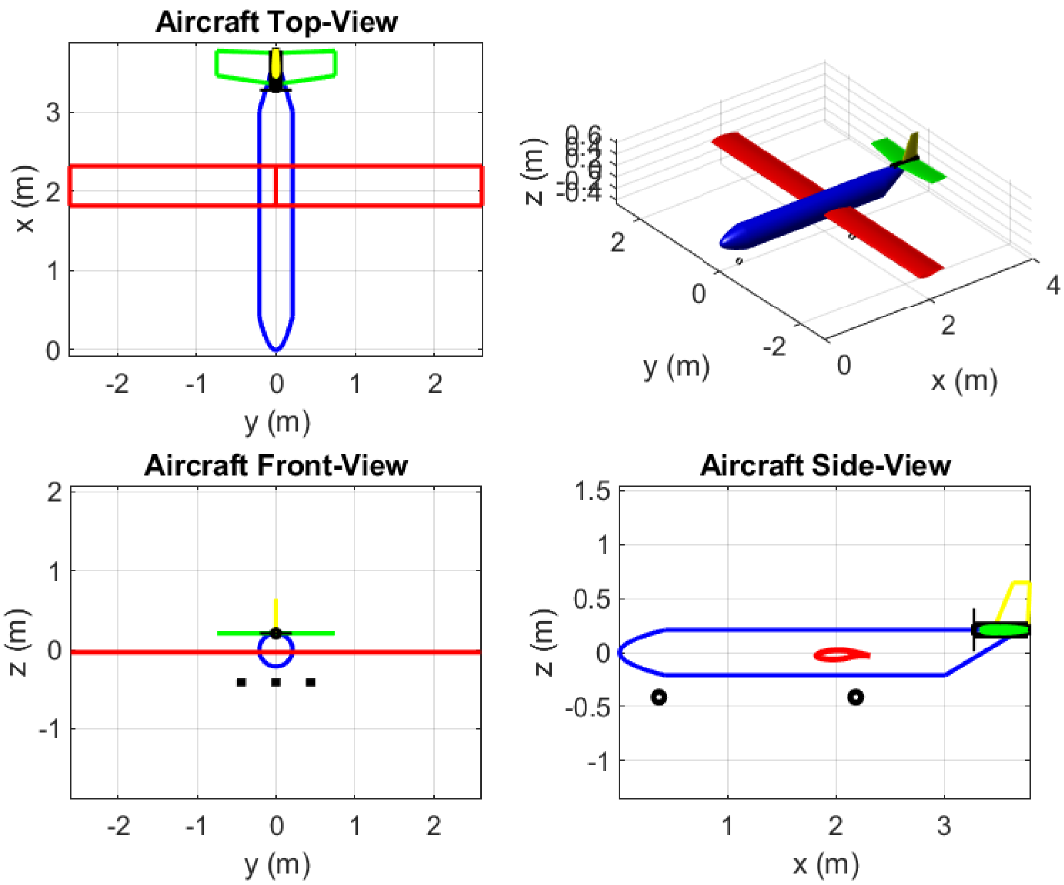
Flight Loads: DroneVLA aircraft



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Chapter 1. Introduction

This document defines the SUBPART C - Structure - Flight Loads of the:DroneVLA.The boundaries of the flight envelope will be defined within this document. All speeds are calibrated airspeeds (CAS) (requirement 4.4 [1])and given in knots if not stated otherwise.All other units used are metric (SI units).The weights are given in mass units (kg) but the formulas require force units as input,therefore these are calculated in place wherever they are used.Note: The speeds defined within this document should be used for the placards,speed markings, aeroplane flight manual (limitations), load calculations and need to be verified by flight test.

Chapter 2. References

1. ASTM F2245-12d," ASTM."ASTM F2245-12d, ASTM.
2. ABCD-FL-57-00 Wing Load Calculation, EASA.
3. ISO 2533:1975, International Standardization Organization, 1975.
4. CS-LSA Certification Specifications and Acceptable Means of Compliance, Amnd.1 29.Jul.2013, EASA, 2013.
5. "ABCD-FTR-01-00 Flight Test Report," EASA.
6. L. Smith, "NACA technical note 1945, 'Aerodynamic characteristics of 15 NACA airfoil sections at seven Reynolds numbers from 0.7x10E6 to 9x10E6," 1949.
7. ABCD-WB-08-00 Weight and Balance Report, EASA.

HERE BELOW AN EXAMPLE OF REFERENCES TO BE EDITED

Chapter 3. List of Abbreviations

- CL = lift coefficient
- CD....
- ...
- ...
- ...
- ...
- ...

ADD HERE list of abbreviations as a formatted table....to be created

Chapter 4. Aircraft data

The aircraft geometrical, masses, inertial and aerodynamic data, useful for flight loads estimation are summarized in this chapter.

4.1. Geometry

The aircraft reference geometrical characteristics are summarized in the following tables.Wing parameters

Table 4.1. Wing parameters

Wing parameters	Value	Measure unit
b	5.2	m
S	2.589	m^2
AR	10.446	-
taper	1	Non dimensional
sweep	0	deg
sweep_location	0	percentage
secondary_sweep_location	0	percentage
croot	0.498	m
ctip	0.498	m
xle	1.638	m
yle	0	m
zle	0.165	m
xtip_le	NaN	% fuselage length
dihedral	0	deg
mac	0.498	m
xmac	NaN	% fuselage length
ymac	NaN	% semispan
ypos	NaN	% semispan
zpos	NaN	% fuselage diameter
camberloc	0.15	Percentage
thickchord	0.18	Percentage
twist_angle	3	deg
mgc	0.49788	m

Table 4.2. Horizontal Tail parameters

Horizontal parameters	Value	Measure unit
S	0.529	m^2

Horizontal parameters	Value	Measure unit
l	1.492	m
camber	0	percentage
camberloc	NaN	percentage
thickchord	0.12	percentage
twist	0	deg
twistloc	0.25	percentage
xloc0	1.49	m
xloc	3.128	m
yloc	0	m
zloc	0.15	m
xrot	0	m
yrot	0	m
zrot	0	m
b	1.496	m
ctip	0.3136	m
croot	0.3929	m
sweep	15	deg
sweeploc	0	percentage
secsweeploc	1	percentage
dihedral	0	deg
location_of_camber	0.2	percentage
secondary_sweep_location	1	percentage
ce_c_root	0.34	Non dimensional
ce_c_tip	0.36	Non dimensional

Table 4.3. Vertical Tail parameters

Vertical parameters	Value	Measure unit
xle	0.95	% of fuselage length
croot	0.3136	m
ctip	0.15347	m
xtip_le	1	% of fuselage length
b	0.4375	m
zpos	1	% of df
S	0.1022	m^2
chord	0.3136	m
MAC	0.23354	m
l_vt	1.65	m

Table 4.4. Fuselage parameters

Fuselage parameters	Value	Measure unit
length	3.64	Non dimensional
diameter	0.42	Non dimensional
Non_dim_radius_of_gyration	0.34	Non dimensional
Radius_of_gyration	NaN	m

Table 4.5. Elevator parameters

Elevator parameters	Value	Measure unit
S	0.14749	m^2
chord	0.12324	m
chord_ratio_ce_c	0.35	Non dimensional
overhang	0.12	Non dimensional
span_ratio	0.8	Non dimensional
S_hinge	0.126	m^2
eta_inner	0.1	percentage
eta_outer	0.9	percentage
cf_c_inner	0.3	percentage
cf_c_outer	0.3	percentage
y_inner	0.0748	m
y_outer	0.6732	m
cf	0.10845	m
moment_arm	0.016021	m

Table 4.6. Rudder parameters

Rudder parameters	Value	Measure unit
S	0.019062	m^2
chord	0.10893	m
chord_ratio_cf_c	0.35	Non dimensional
overhang	0.12	Non dimensional
span_ratio	0.8	Non dimensional
cr_c_root	0.45	Non dimensional
cr_c_tip	0.5	Non dimensional
eta_inner	0.1	Non dimensional
eta_outer	0.9	Non dimensional
croot	0.14112	m
ctip	0.076735	m

Rudder parameters	Value	Measure unit
y_inner	0.021875	m
y_outer	0.19688	m
moment_arm	0.014161	m

Table 4.7. Aileron parameters

Aileron parameters	Value	Measure unit
S	0.14018	m^2
b	0.908	m
ca	0.15438	m
cb	0.019	m
y_inner	1.63	m
y_outer	2.538	m
eta_inner	0.627	Non dimensional
eta_outer	0.976	Non dimensional
ca_c_inner	0.31	Non dimensional
ca_c_outer	0.31	Non dimensional
croot	0.15438	m
ctip	0.15438	m
cf	0.13538	m
moment_arm	0.016928	m

4.2. Masses and inertia

The aircraft reference masses and inertia are summarized in this subsection

The Aircraft masses and inertia are summarized in Table: Weight parameters

Table 4.8. Weight parameters

Weight	Value	Measure unit
W_maxTakeOff	100	kg
W_OperativeEmpty	NaN	kg
W_Payload	NaN	kg
W_Fuel	NaN	kg
W_Crew	NaN	kg
IY	100	kg * m^2

4.3. Aerodynamic

The aircraft reference aerodynamic is in figure: Wing-Body reference Aerodynamics

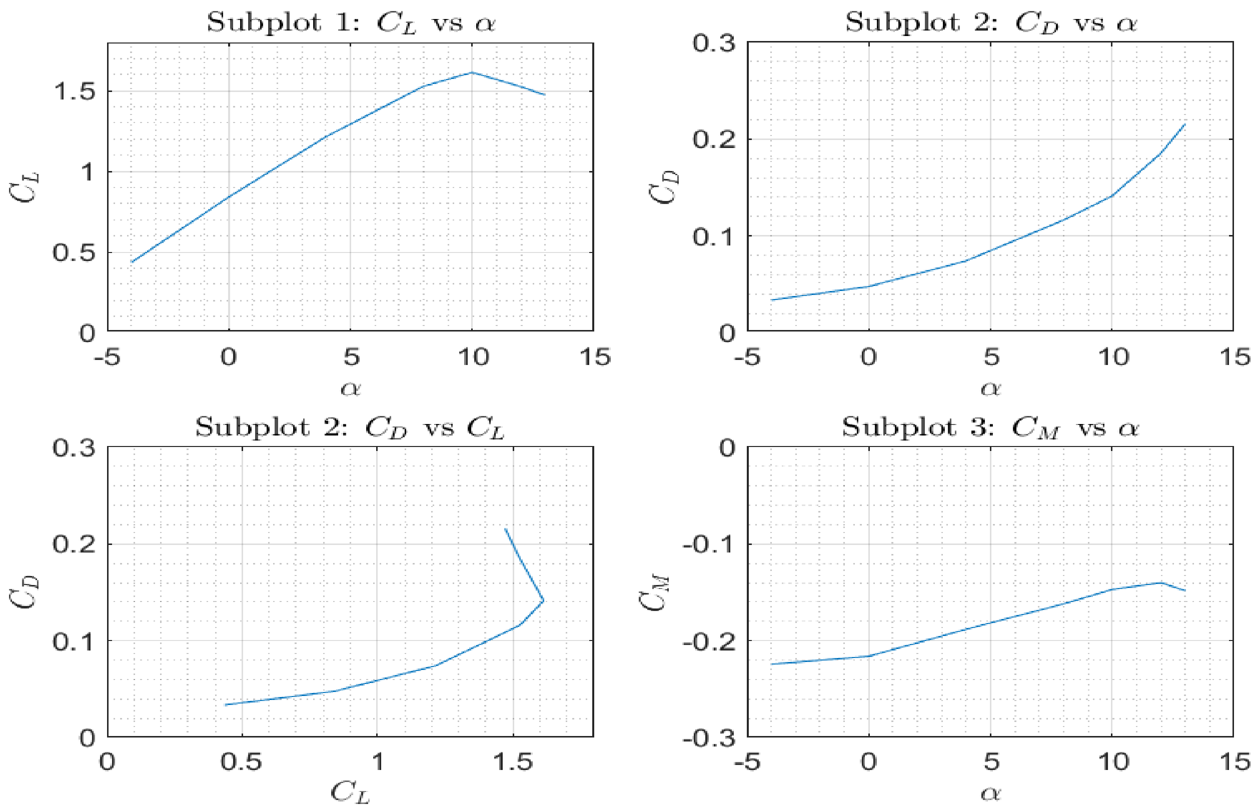

Figure 4.1. Wing-Body reference Aerodynamics

Chapter 5. Design Airspeeds

This chapter defines the operating and design airspeeds as required for certification-CSVLA

5.1. Maximum speed in level flight VH

Data not yet available...to be added Available and Required Power.

5.2. Stall speeds VS, VS0, VS1

These speeds will be verified by flight test according to certification requirements.In order to calculate the stall speed, the maximum lift coefficient of the aeroplane as a whole is determined first. The maximum lift coefficient of the aeroplane has been calculated from high fidelity CFD. In landing configuration computed with full flap, CLMAX landing =2.1 in take-off configuration leading to CLMAX takeoff =1.9, and in clean configuration, leading to CLMAX clean =1.58 , also considering the horizontal tail balancing force.

Flaps retracted(clean configuration):

$$V_S \;=\; \sqrt{\frac{2\;W_{MTOM}}{\rho_0 C_{L_{MAX_{Clean}}} S}} \;=\; \sqrt{\frac{2*981}{1.225*1.58*2.589}} \;=19.7839 m/s$$

Flaps extended(Landing configuration):

$$V_{S_0} \;=\; \sqrt{\frac{2\;W_{MTOM}}{\rho_0 C_{L_{MAX_{Landing}}} S}} \;=\; \sqrt{\frac{2*981}{1.225*2.1*2.589}} \;=17.1606 m/s$$

Flaps extended(Take-off configuration):

$$V_{S_1} \;=\; \sqrt{\frac{2\;W_{MTOM}}{\rho_0 C_{L_{MAX_{Takeoff}}} S}} \;=\; \sqrt{\frac{2*981}{1.225*1.9*2.589}} \;=19.2208 m/s$$

Add here comments if necessary

Note: These speeds are estimates. The methods for the estimation can be various.It is important that these estimations are as precise as possible. Flight tests will be used to validatethe stall speeds. In case the flight tests show different values, this might have an impact on the speedsused for design and ultimately might impair the compliance to the-CSVLA

5.3. Design manoeuvring speed VA

According to requirement-CSVLA-335,

the maneuvering speed VA cannot be less then:

$$V_A \geq V_S\sqrt{n_{max}} = 19.7839 * \sqrt{3.8} = 38.566m/s$$

Add here comments if necessary

5.4. Flaps maximum operating speed VF

According to requirement-CSVLA -345,

such speed shall be not less than the greater of 1.4VS and 1.8VS0

The speed has been selected as the greater between 1.4VS =27.6975m/s and 1.8 VSF =24.0248m/s, where VSF is the computed stalling speed with flaps fully extended at the design weight.

The flaps operating speeds is:

$$V_F = 27.6975m/s$$

5.5. Flaps maximum extension speed VFE

On this aeroplane the maximum flap extension speed is identical to the flap operating speed VF. This speed is the maximum speed for flaps in take-off and landing configuration.

$$V_{FE} = 27.6975m/s$$

5.6. Design cruising speed VC

According to requirement-CSVLA-335.

- VC (in m/s) may not be less than -

$$2.4\sqrt{\frac{Mg}{S}}\left(V_C(kt) = 4.7\sqrt{\frac{Mg}{S}}\right) \rightarrow 2.4 * \sqrt{\frac{100 * 9.8066}{2.589}} = 46.7095m/s$$

where M/S is the wing loading in kg/m2 and g is the acceleration due to gravity in m/s2.

- VC need not be more than 0·9 VH at sea level.

VH must be available. Otherwise previous value is considered!!!

$$V_C = 46.7095m/s$$

5.7. Design dive speed VD

According to requirement-CSVLA-335.

(1) VD may not be less than 1·25 VC; and (2) with VCmin, the required minimum design cruising speed, VD may not be less than 1·40 VCmin.

(1) 1.25VC =58.3869m/s

(2) 1.4VCmin =40m/s

$V_C = 1.25 * 46.7095 = 58.3869 m/s$

5.8. Demonstrated dive speed VDF

VDF is not a design airspeeds for this category.

5.9. Never exceed speed VNE

VNE is not a design airspeeds. It must be checked into sec. CS-VLA 1505 Airspeed limitations.

5.10. Design Airspeeds summary

Design airspeeds summary is resumed in Table:Design airspeeds

Table 5.1. Design airspeeds

Design airspeeds	Value	Measure unit
VS	19.78	m/s
VS0	17.16	m/s
VS1	19.22	m/s
VA	38.57	m/s
VC	46.71	m/s
VD	58.39	m/s
VE	58.39	m/s
VG	30.46	m/s
VS_inv	24.87	m/s
VF	30.89	m/s

Chapter 6. Altitude

The maximum permissible operational altitude for the aircrat is 1300m. Despite the-CSVLA requirements do not require to accounts for the effects of altitude,such effects have been considered up to 1300m. In fact the gust load factor have been calculated at such altitude. This is considered acceptable since it covers the operational range within which the aeroplane will fly most of the time.

(Note: the-CSVLA requirement does not require to account for the effects of altitude.Calculating the loads at sea level would be acceptable. In this case, the choice to consider such effect up to 1300m is a decision of a designer, which would be accepted by the team.)

Chapter 7. Manoeuvring and Gust load factors n

According to-CSVLA-337(a) The positive limit manoeuvring load factor n may not be less than 3·8. (b) The negative limit manoeuvring load factor may not be less than -1·5.)

The following value will be considered:

1. nmax =3.8
2. nmin =-1.5

7.1. Gust envelope

Gust load factors need to be considered because they can exceed the prescribed maximum load factors at different weights and altitudes. Since gust loads depend on air density and aircraft mass they will be calculated for Compliance with the flight load requirements of this subpart to show:

(1) At each critical altitude within the range in which the aeroplane may be expected to operate, from sea level up to maximum operative altitude equal to:1300m.

(2) At each practicable combination of weight and disposable load within the operating limitations specified in the Flight Manual according to requirement-CSVLA-321 and fully extended (requirement-CSVLA-345 at V_F.

The calculation is based on-CSVLA-341. To calculate the gust loads at altitudes other than at sea level the following equation is altered to include the density at any altitude.

$$n = 1 + \frac{1/2\ \rho_0\ V\ a\ K_g\ U_{de}}{Mg/S}$$

where:

- $K_g = \dfrac{0.88\mu_g}{5.3+\mu_g}$
- $\mu_g = \dfrac{2(M/S)}{\rho\bar{C}a}$
- U_{de} = derived gust velocities referred to in CSVLA 333(c) (m/s)
- ρ_0 = density of air at sea level (kg/m3)
- ρ = density of air (kg/m3)
- M/S = wing loading (kg/m2)
- $\bar{c}$ = mean geometric chord (m); g = acceleration due to gravity (m/s2);
- a = slope of the aeroplane normal force coefficient curve CNA per radian

Since the gust loads on the wing and tail have been chosen to be treated together, a is the slope of the lift-curve of the aeroplane is equal to a =5.2341/rad and0.09131/deg.

The gust speed at VC is equal to: 15.24m/s

The gust speed at VD is equal to: 7.62m/s

TABLE TO BE CHECKED!!!

Table 7.1. Gust load factor, different Speeds and Altitude

ID	V(m/s)	M(kg)	M/S(kg/m^2)	Altitude(m)	rho(kg/m^3)	mug	Kg	Ude(m/s)	n
1	46.71	100	38.62	1300	1.079	27.47	0.7377	15.24	4.915

(Note: the applicant should provide the method for the calculation of the slope of the lift-curve of the aeroplane)

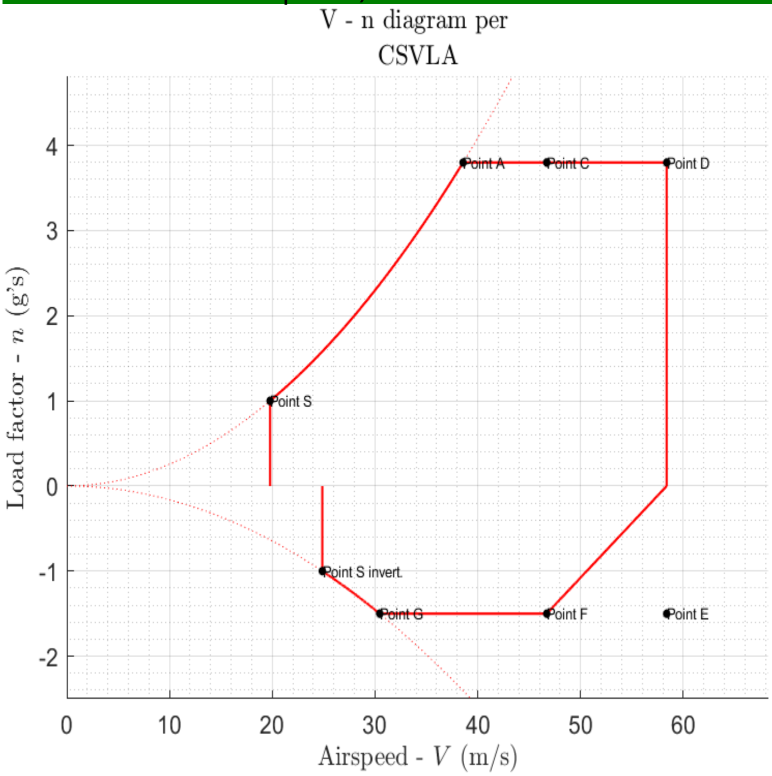

Figure 7.1. V-n diagram

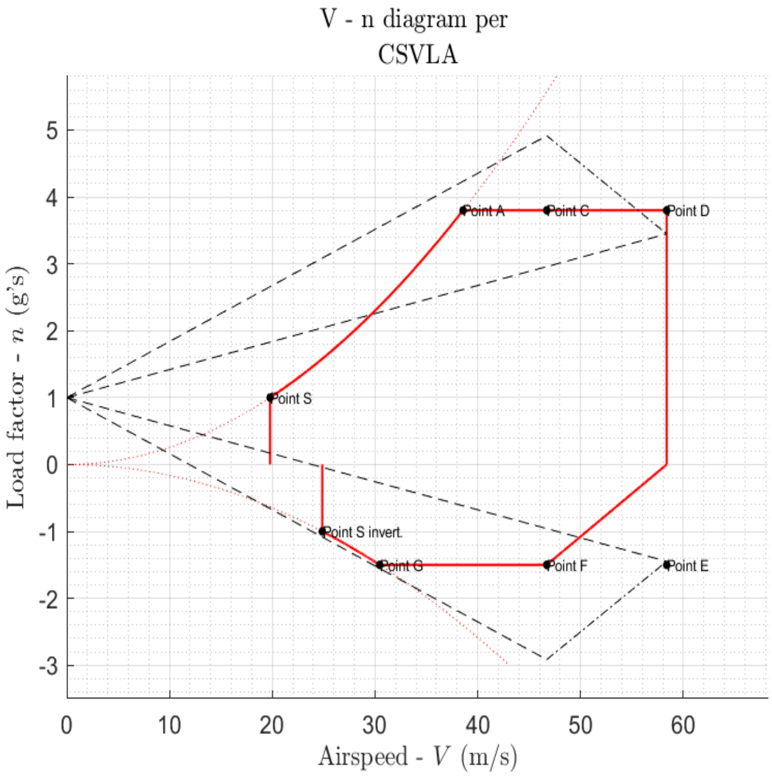

Figure 7.2. Gust diagram

Chapter 8. V-n Envelope

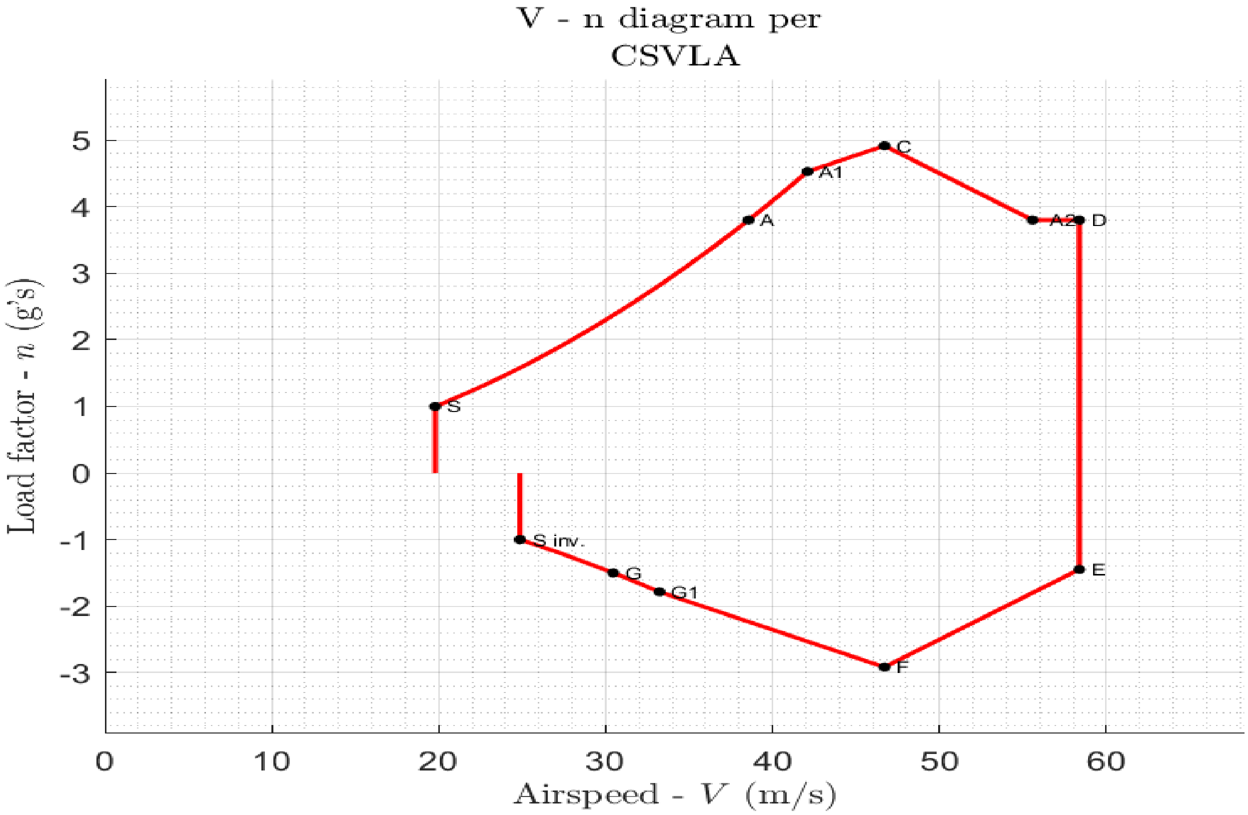

Figure 8.1. Maneuver and Gust load factors and diagram

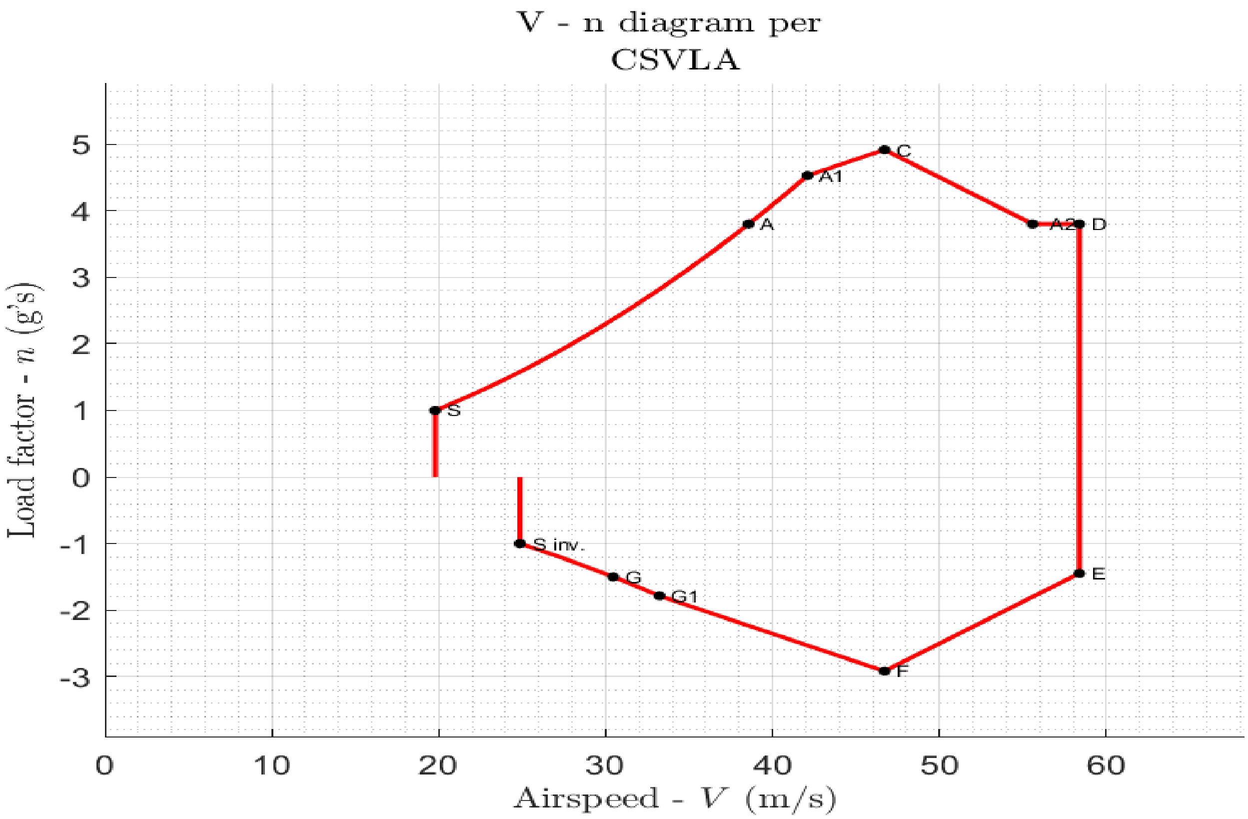

Figure 8.2. Maneuver and Gust load factors and diagram

ADD HERE V-n Envelope

Chapter 9. Loads on the aeroplane

ADD HERE details for balancing Equation

ADD HERE details for balancing Equation

9.1. Reference axes and sign convention

9.1.1. aaaaa

ADD HERE details for balancing Equation

9.2. Symmetrical flight conditions

ADD HERE details for balancing Equation

9.3. Aerodynamic centre

ADD HERE details for balancing Equation

9.4. Pitching moment of the wing

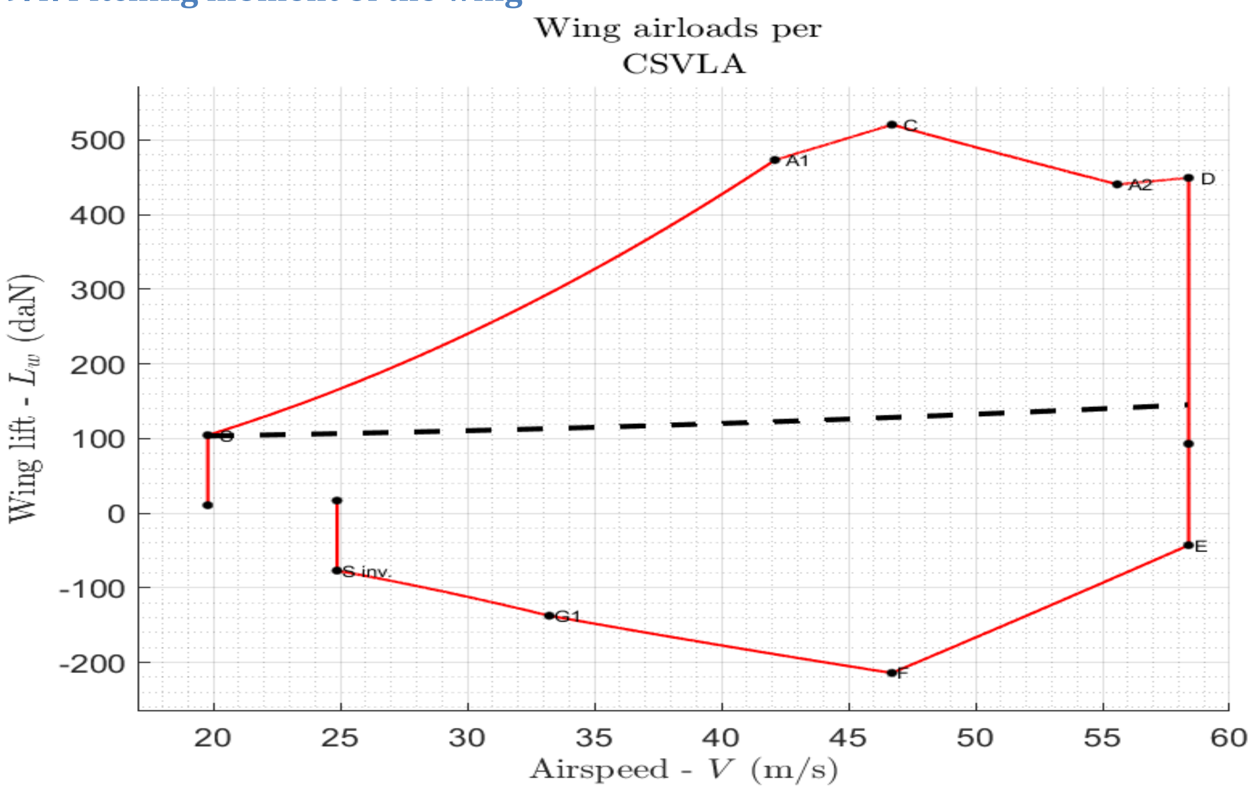

Figure 9.1. Wing airloads

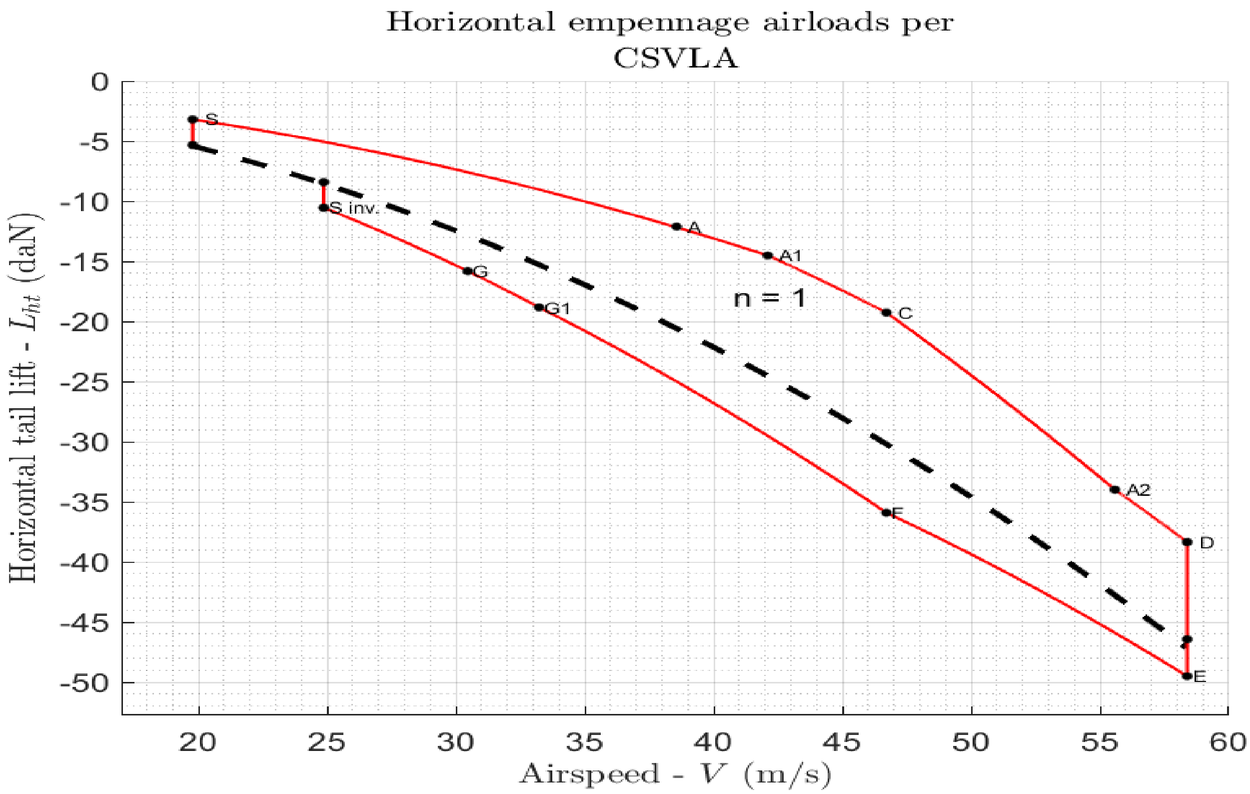

Figure 9.2. Balancing loads

Chapter 10. Loads on the wing

ADD HERE details for balancing Equation

ADD HERE details for fuselage effect how are they accounted?

10.1. Influence of the fuselage

ADD HERE details for balancing Equation

10.2. Forces and moments acting on the wings

10.2.1. SpanWise Airloads Distribution

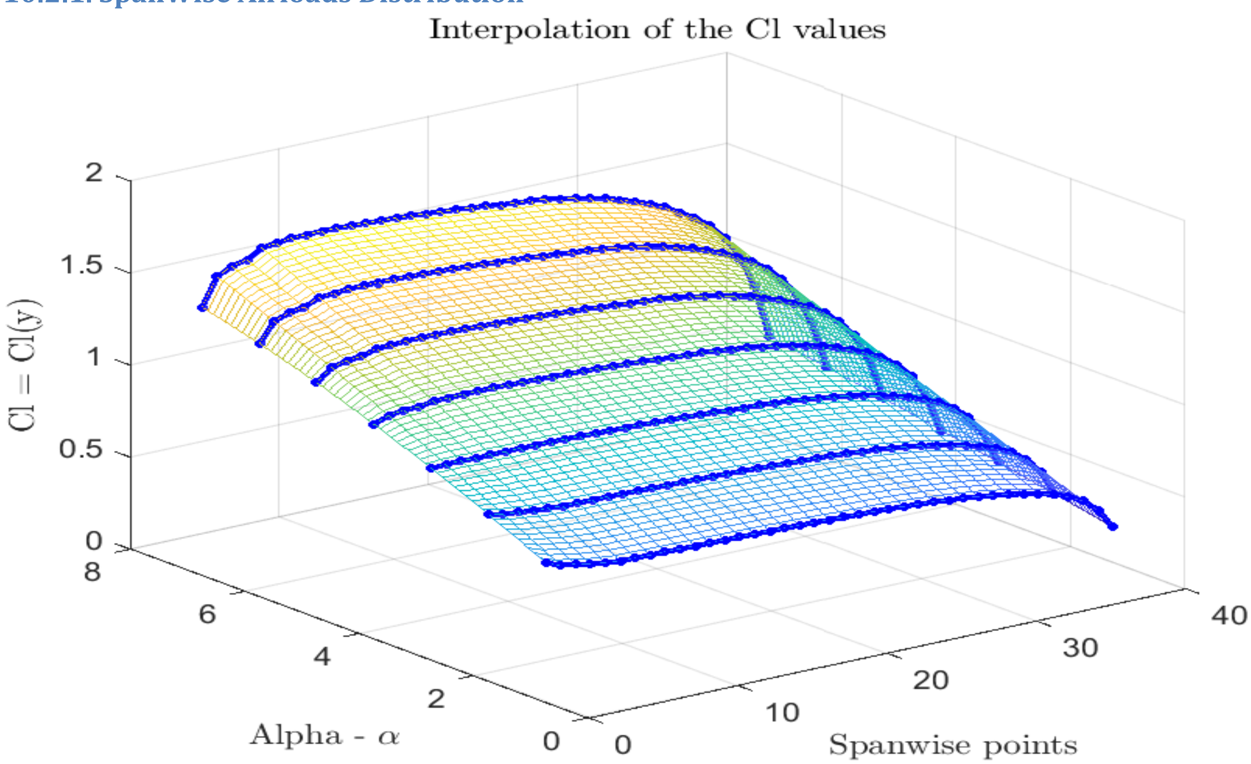

Figure 10.1. Wing lift coefficient spanwise distribution

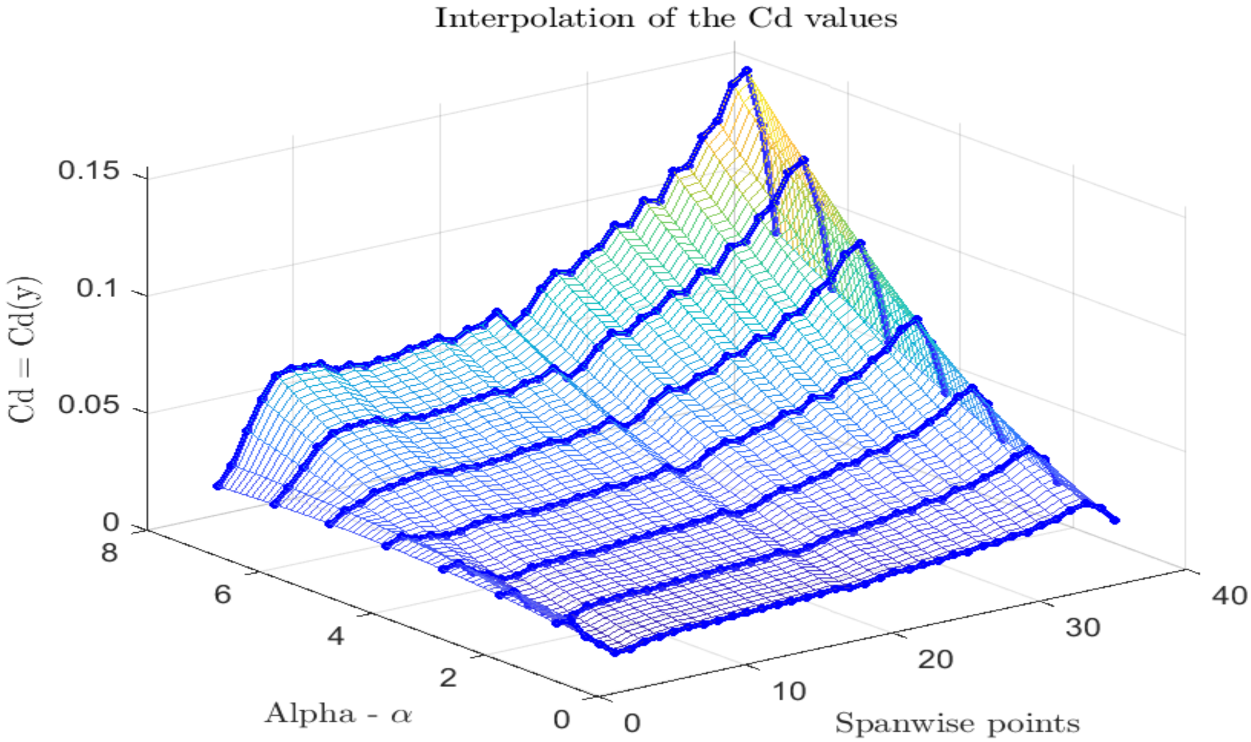

Figure 10.2. Wing drag coefficient spanwise distribution

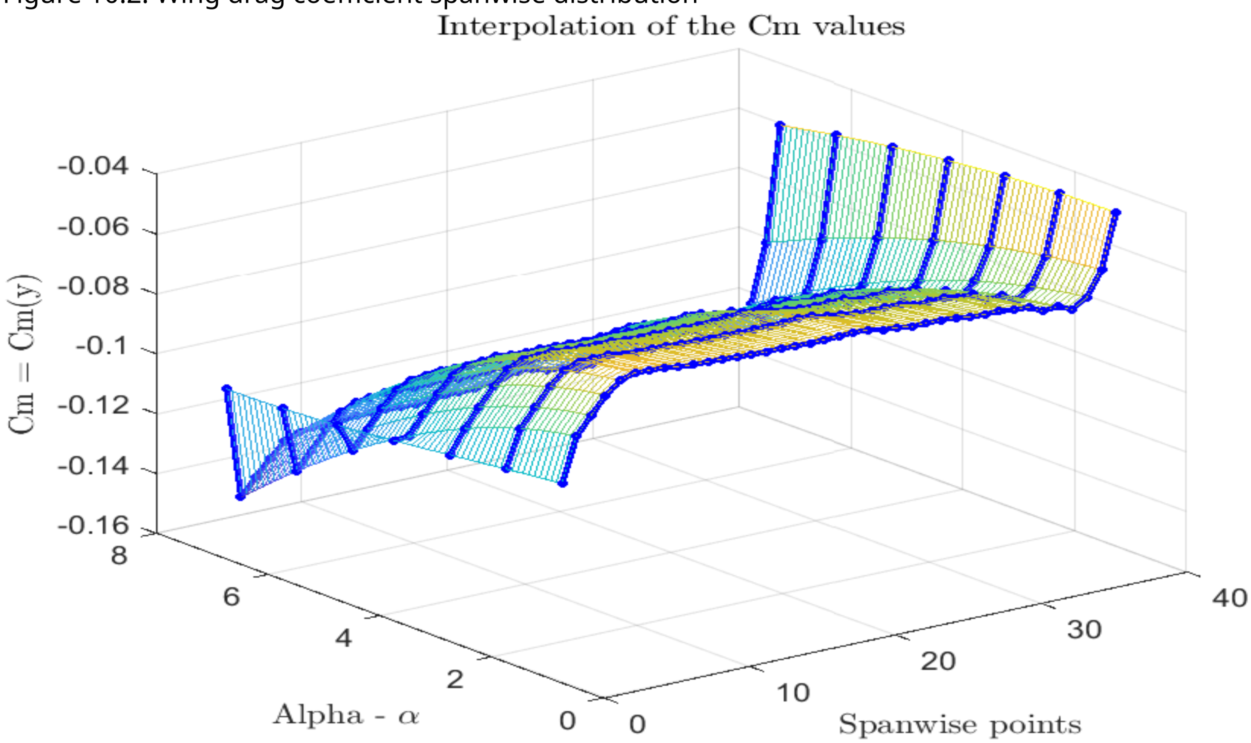

Figure 10.3. Wing pitching moment coefficient (0.25mac) spanwise distribution

10.2.2. Normal and parallel component

10.2.3. Shear, Bending and Torsion

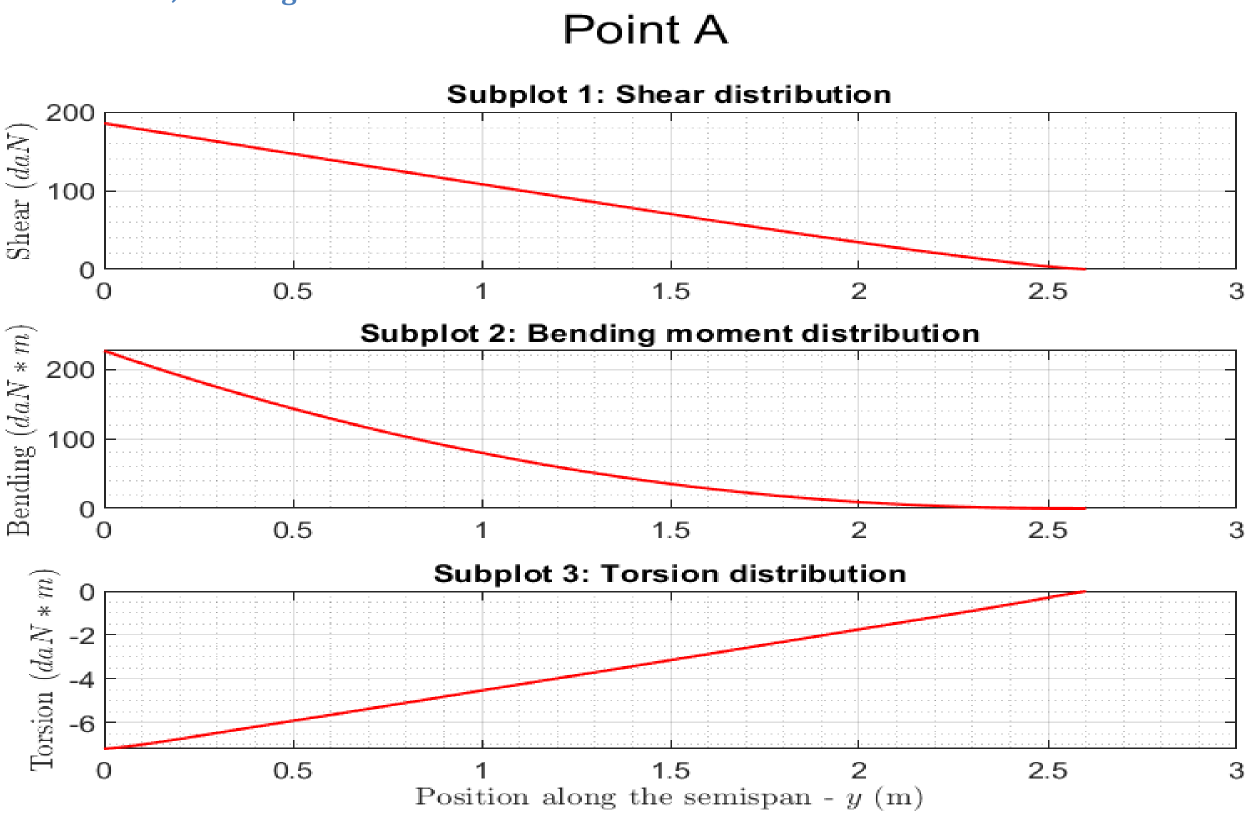

Figure 10.4. Shear, Bending and Torsion due to airloads - POINT A

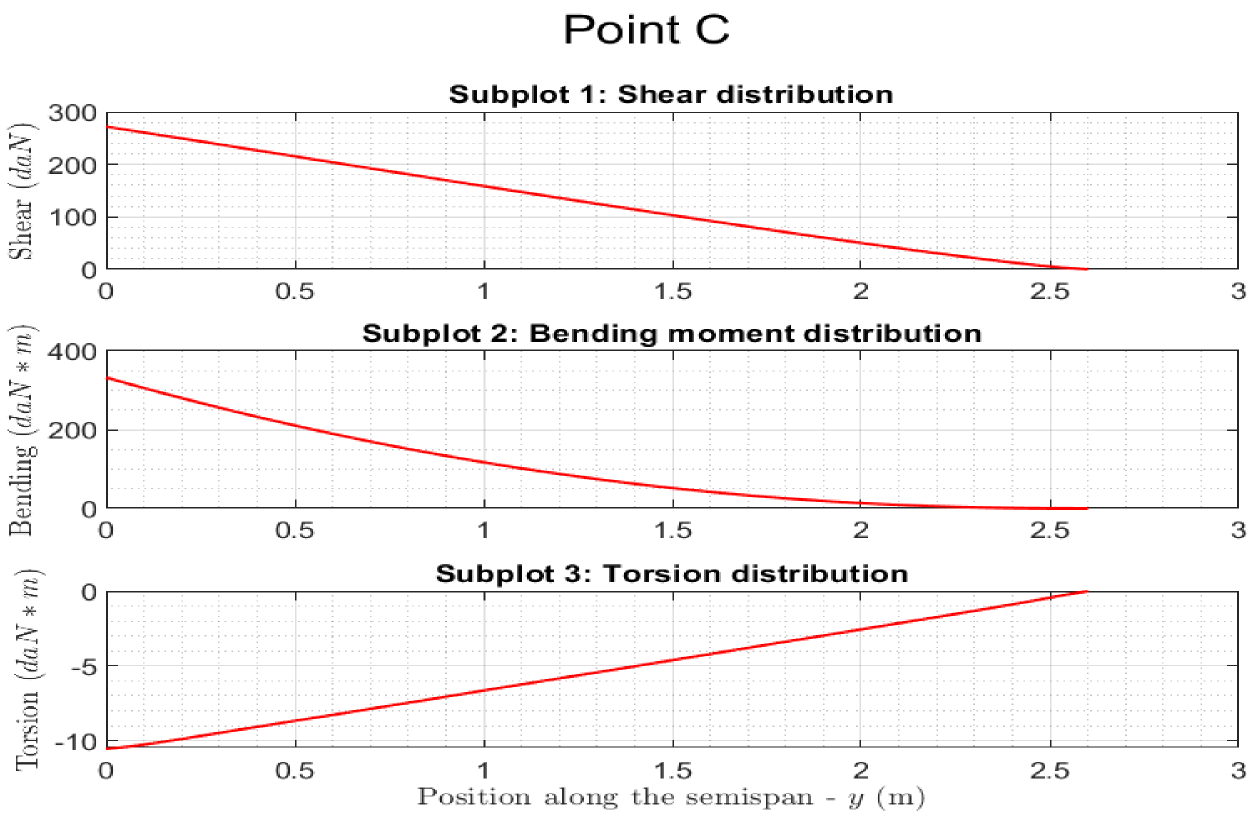

Figure 10.5. Shear, Bending and Torsion due to airloads - POINT C

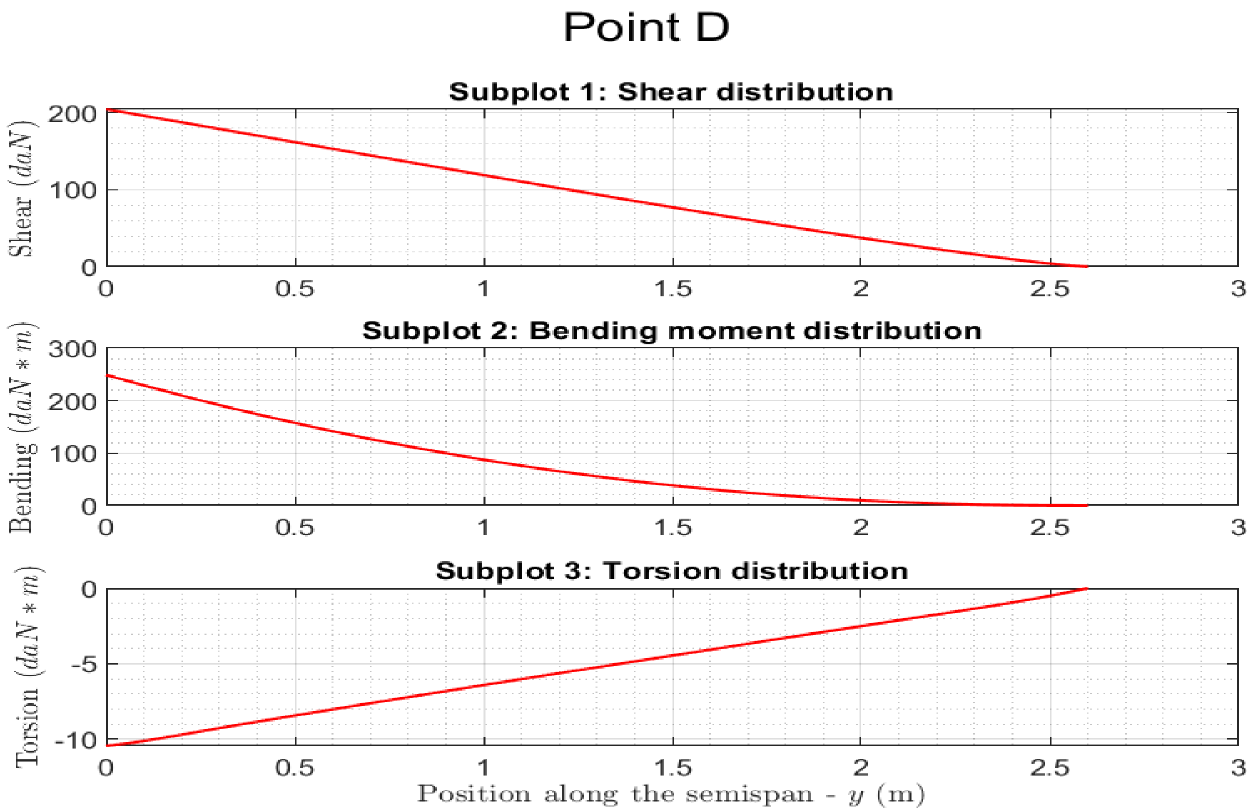

Figure 10.6. Shear, Bending and Torsion due to airloads - POINT D

10.2.4. Critical load condition

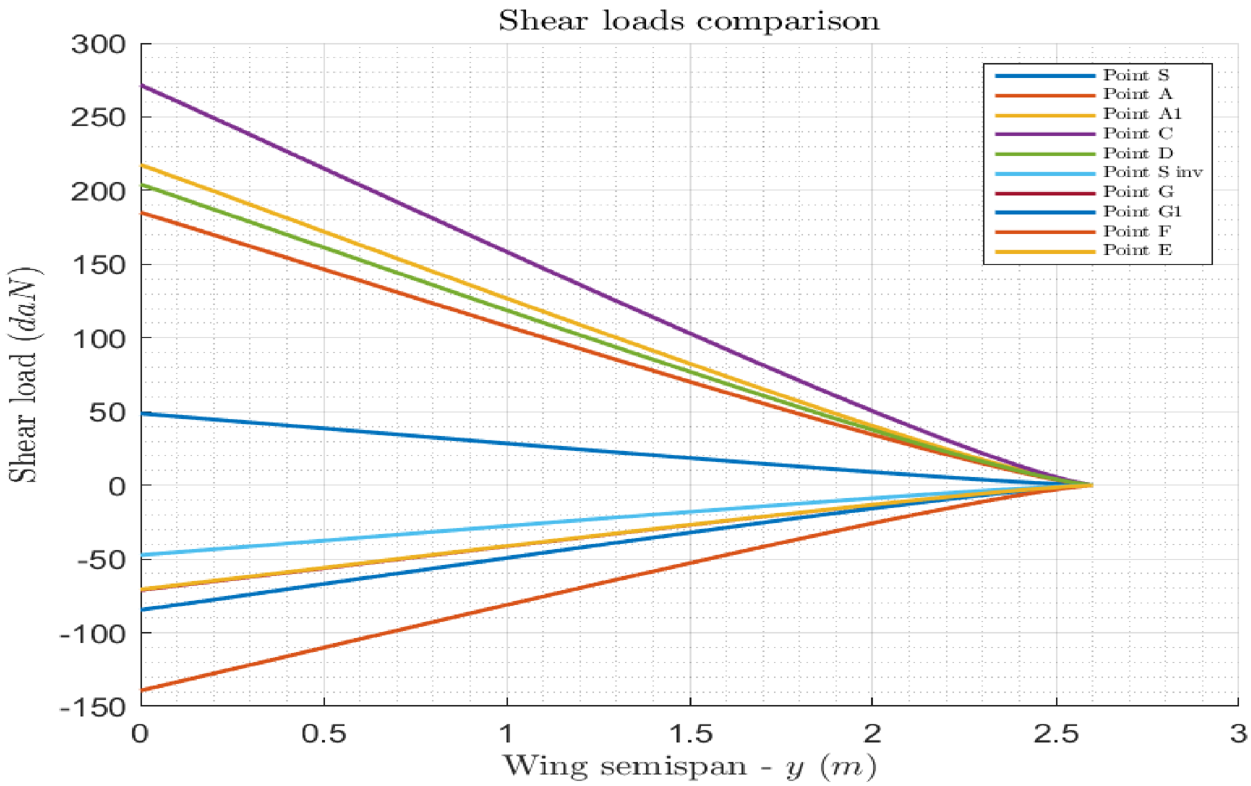

Figure 10.7. Shear comparison

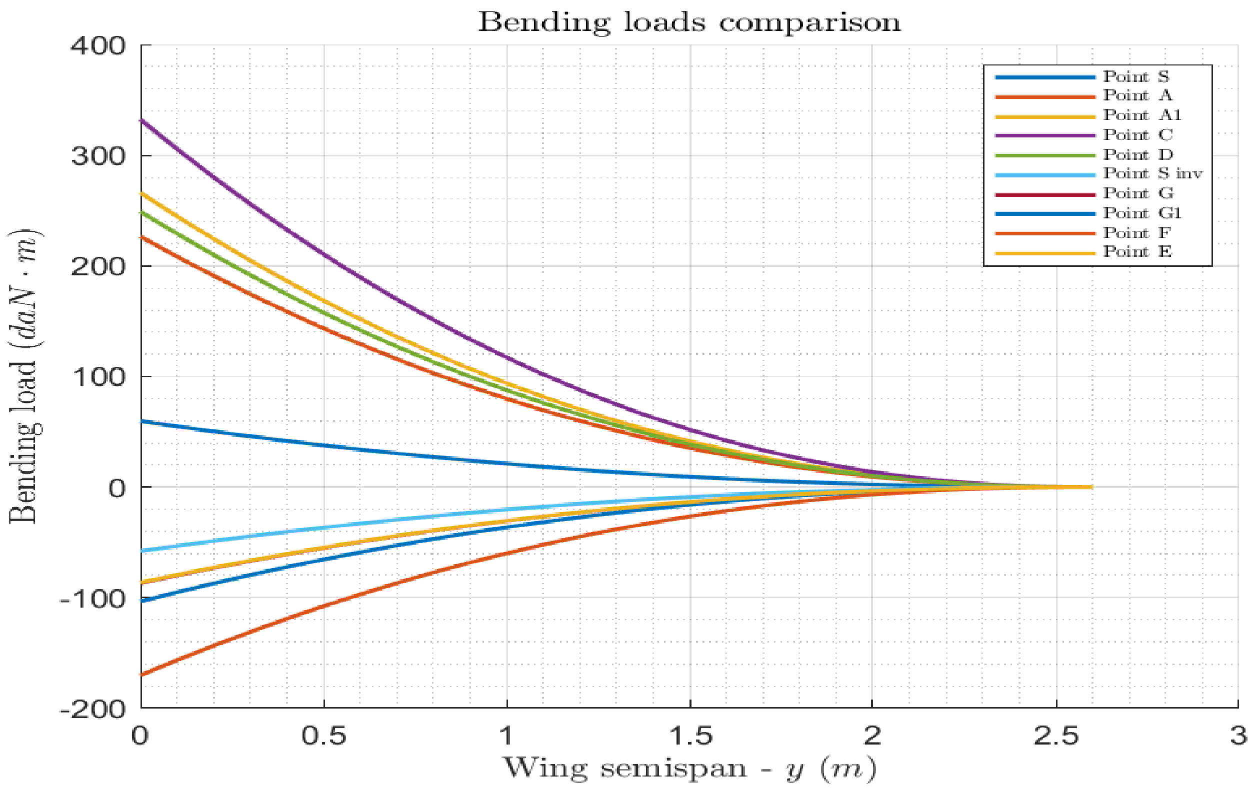

Figure 10.8. Bending comparison

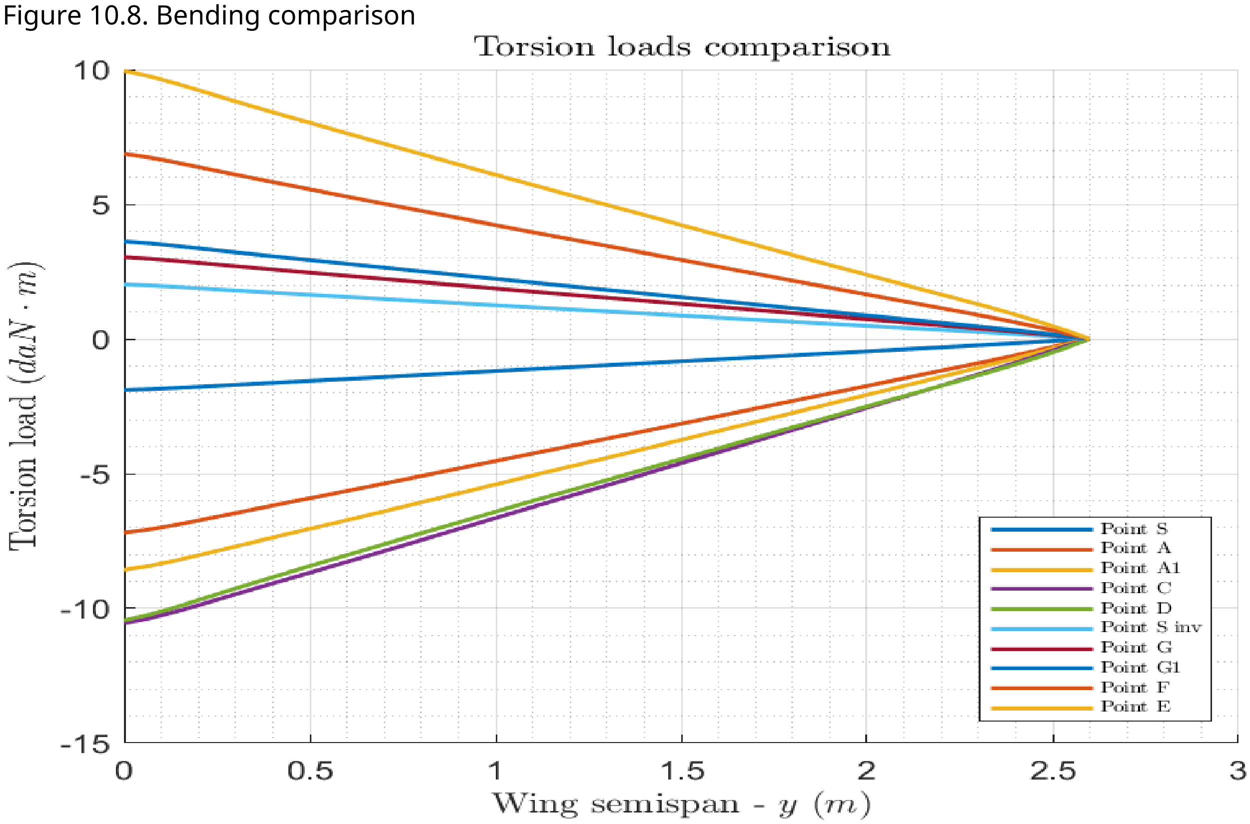

Figure 10.9. Torsion comparison

ADD HERE details for uns loads

10.3. Unsymmetrical loads

10.3.1. Rolling condition

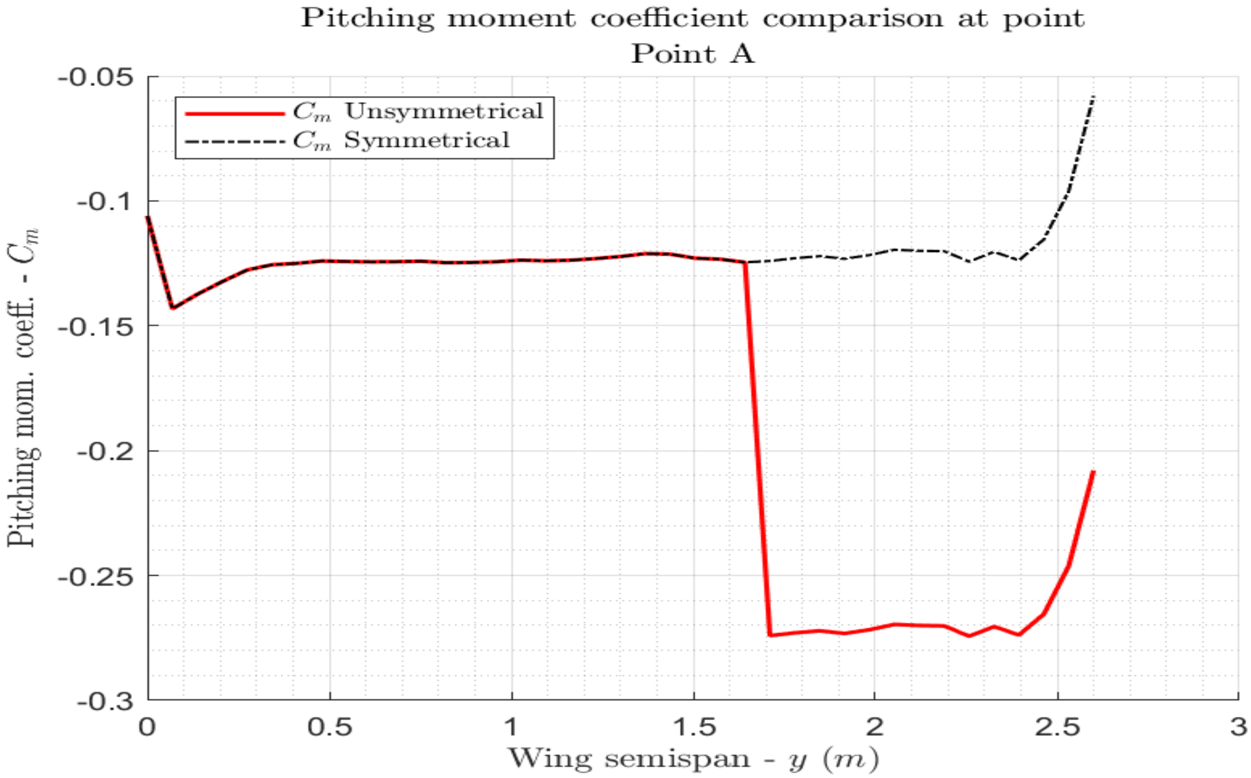

Figure 10.10. Pithcing moment coefficient - POINT A

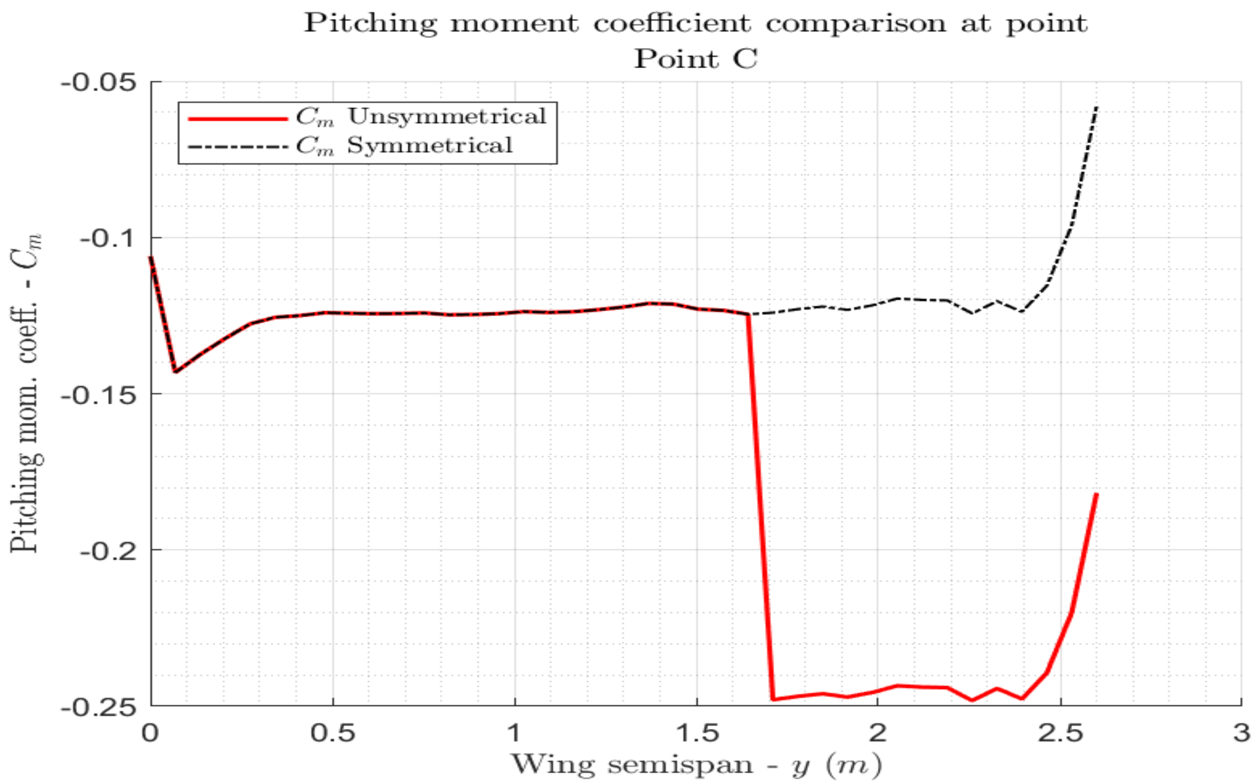

Figure 10.11. Pithcing moment coefficient - POINT C

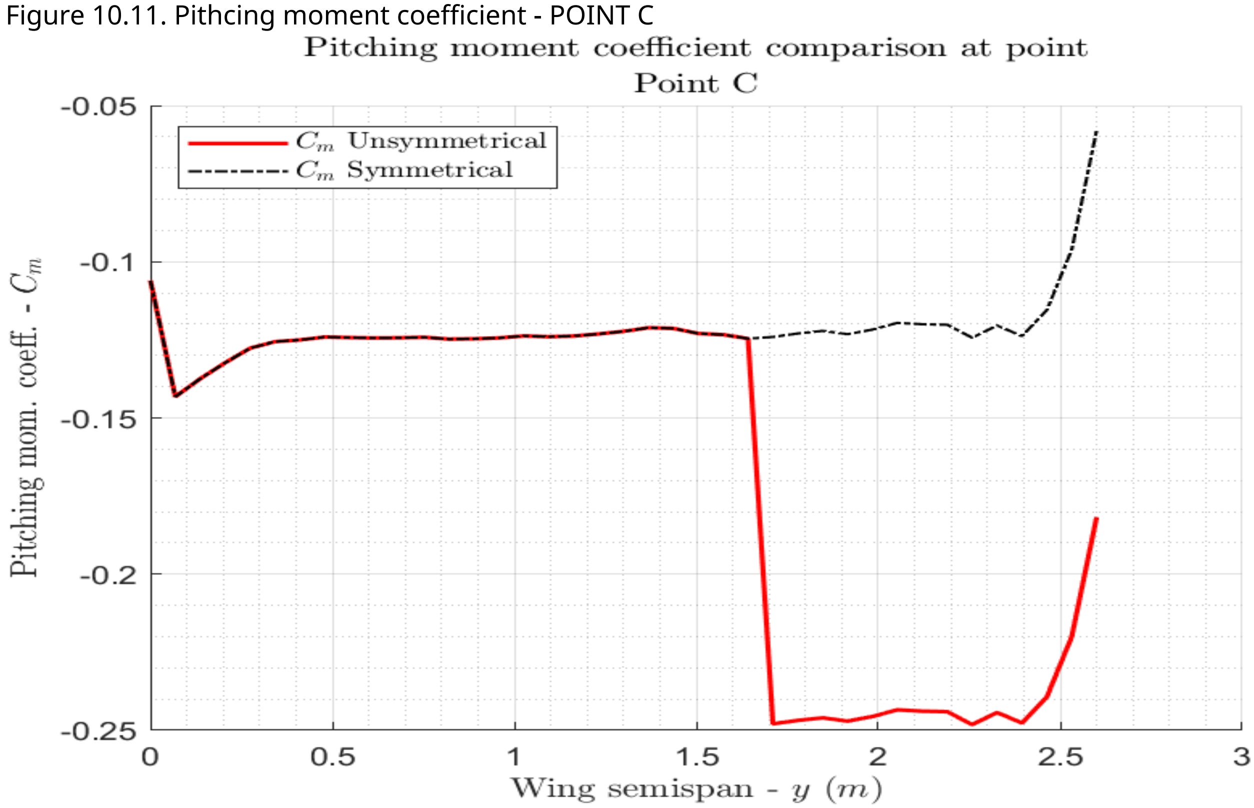

Figure 10.12. Pithcing moment coefficient - POINT D

10.3.2. Effect of aileron displacement on the wing torsion

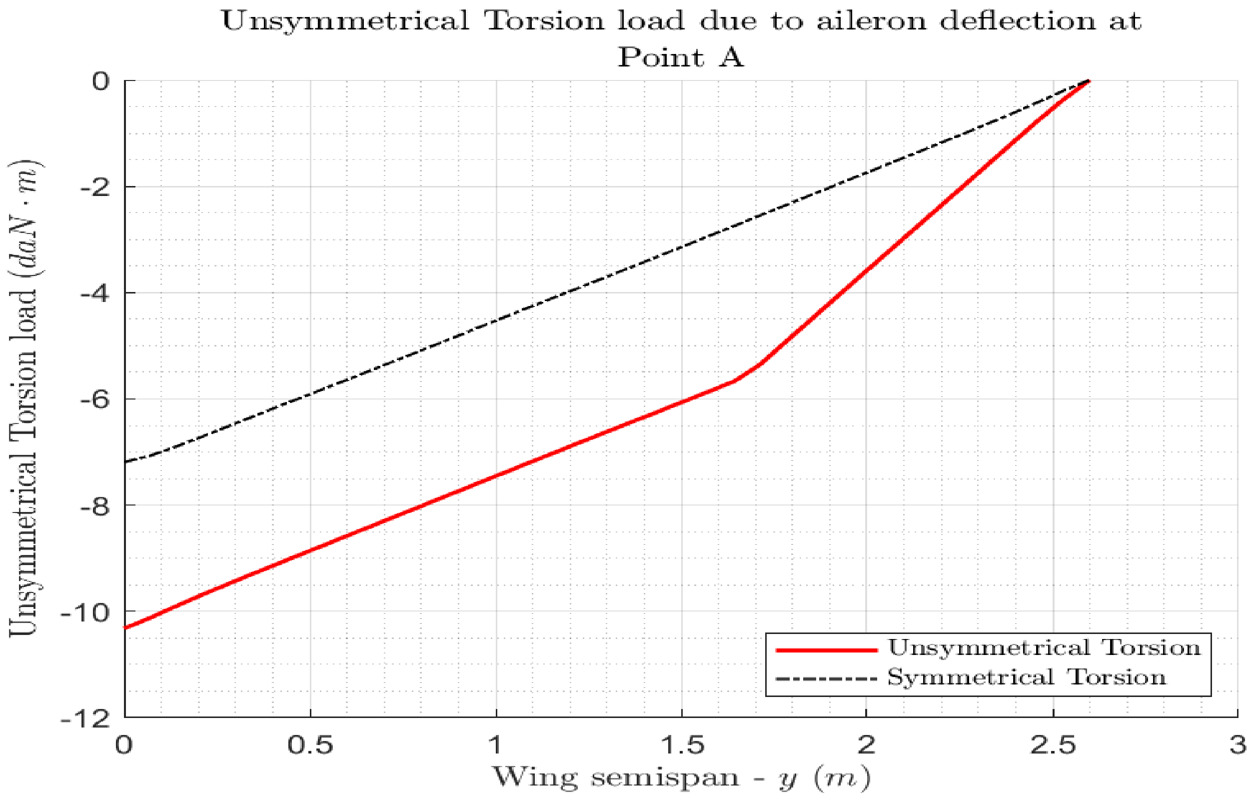

Figure 10.13. Torsion distribution full loads - POINT A

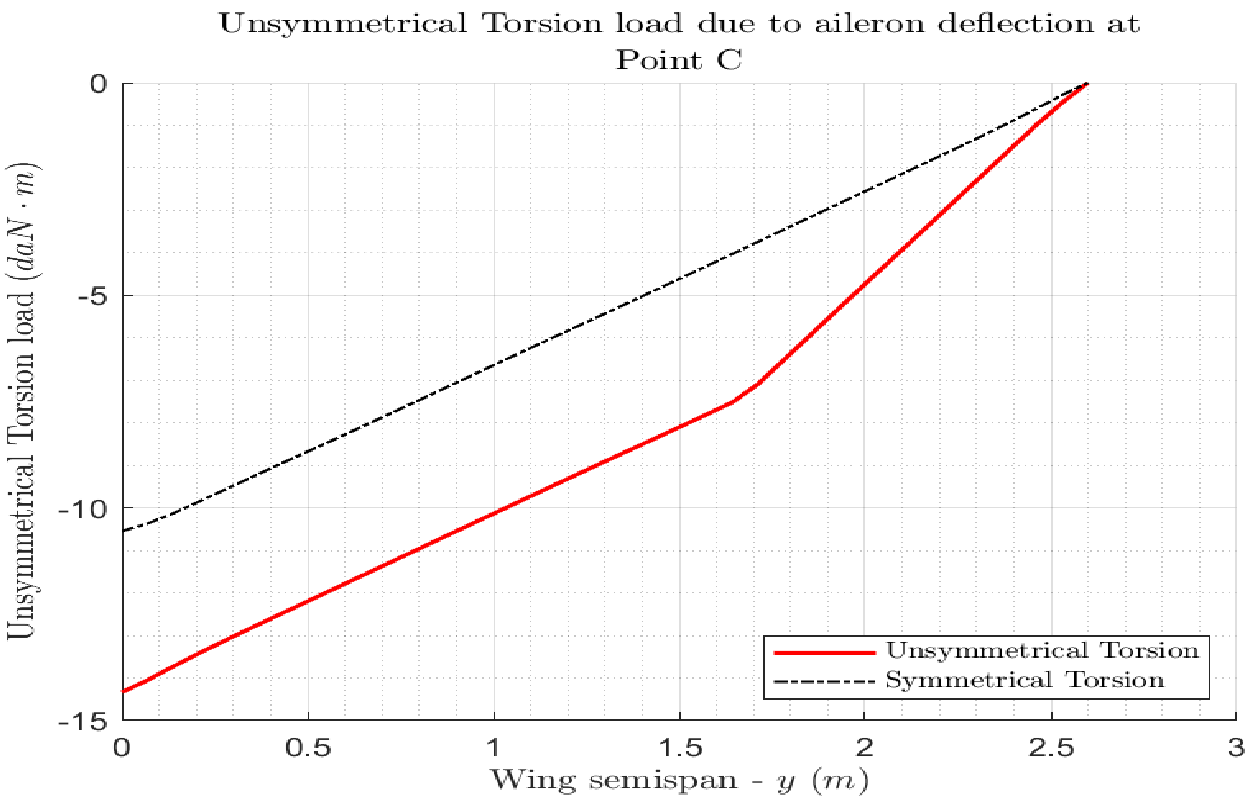

Figure 10.14. Torsion distribution full loads - POINT C

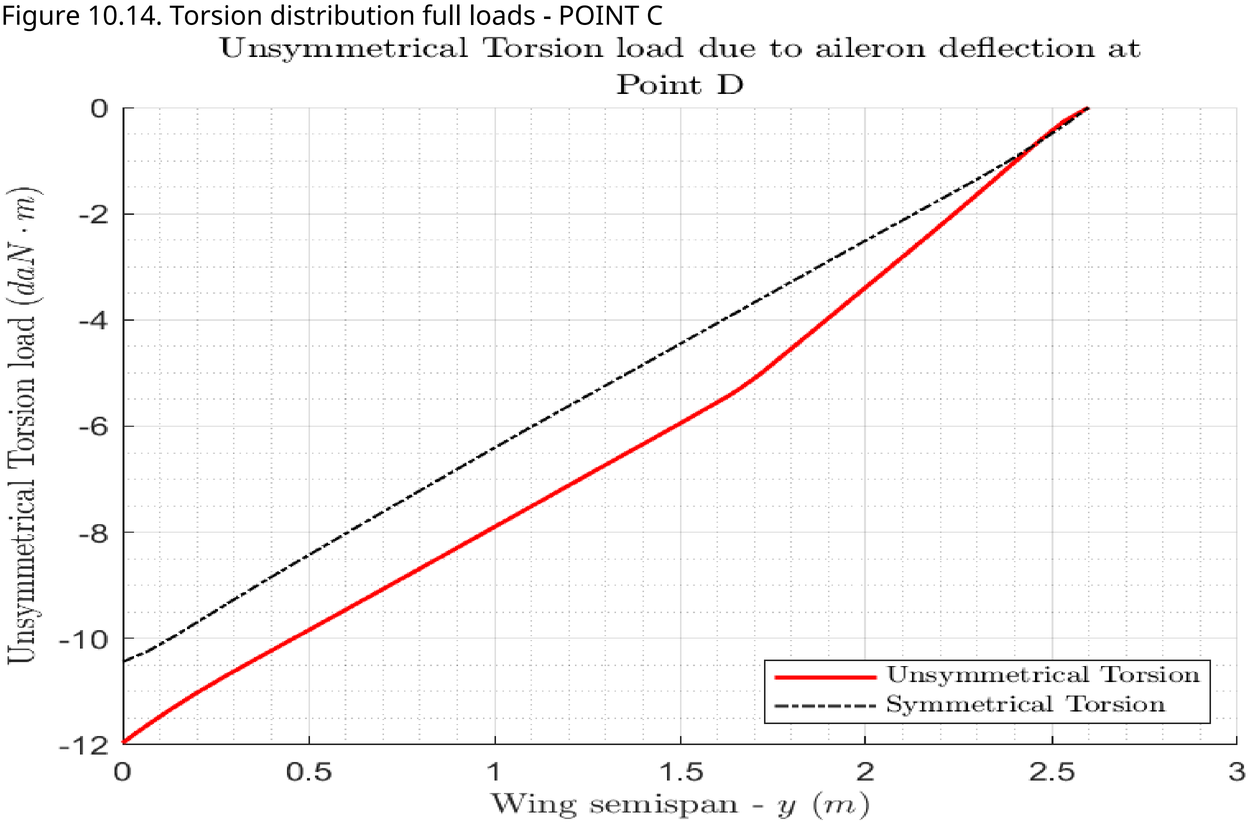

Figure 10.15. Torsion distribution full loads - POINT D

Chapter 11. Loads on the horizontal tail

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11.1. Balancing loads

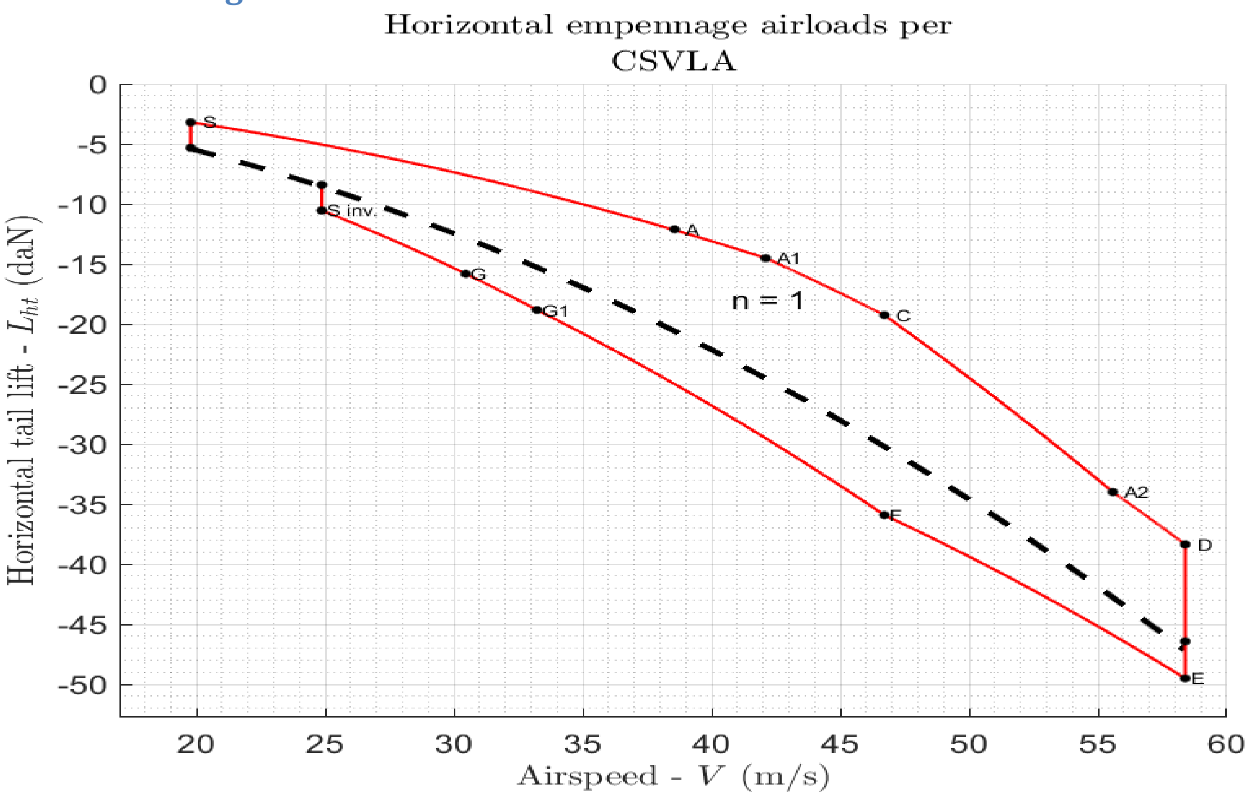

Figure 11.1. Balancing loads

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11.2. Manouevring loads

11.2.1. Unchecked manoeuvre

11.2.2. Checked manoeuvre

11.2.3. Gust loads

ADD HERE details

11.3. Horizontal tail loads summary

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11.4. Unsysmmetrical loads

Chapter 12. Loads on the vertical tail

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12.1. Manouevring loads

12.1.1. a(1)

12.1.2. a(2)

12.1.3. a(3)

12.1.4. Gust loads

ADD HERE details

12.2. Vertical tail loads summary

ADD HERE details on h-v combined loads

12.3. Combined loads

Chapter 13. Loads on the wing flaps

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Chapter 14. Loads on the control surfaces

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14.1. Ailerons

ADD HERE details

14.2. Elevator

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14.3. Rudder

Chapter 15. Power plant

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15.1. Engine torque

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15.2. Side load on engine mount

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15.4. Gyroscopic loads