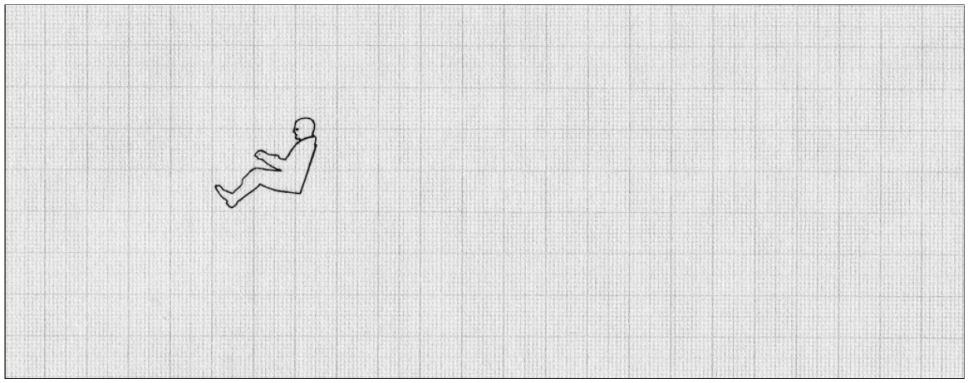
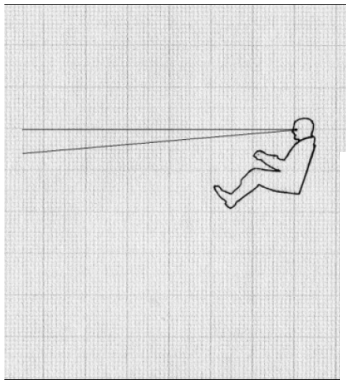
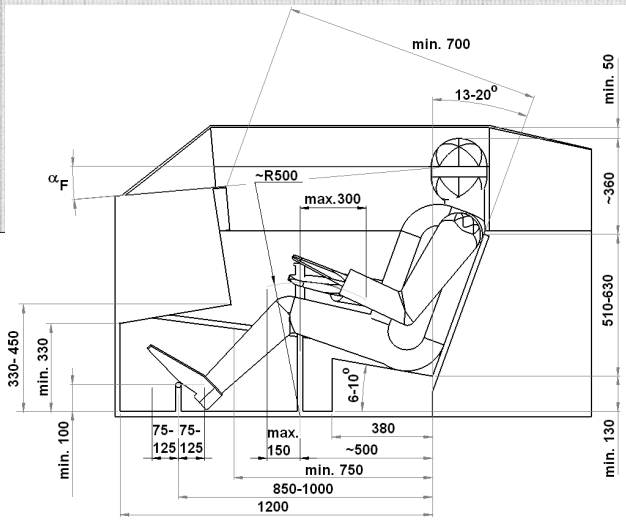
Training aeroplane

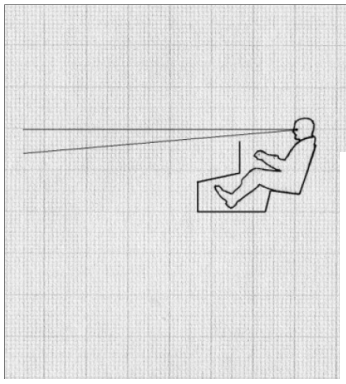


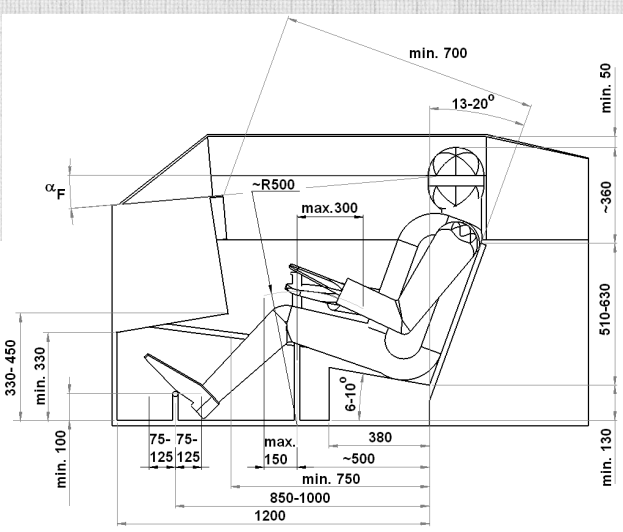
TLiA 6/1973
Stinton „The Design of the aeroplane”

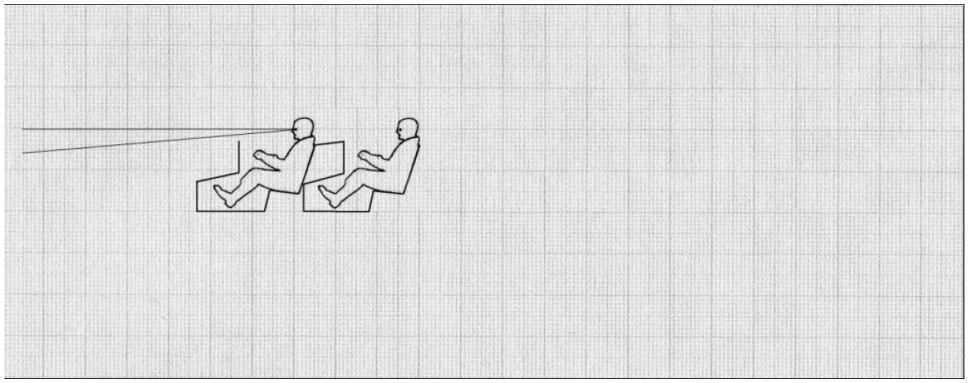


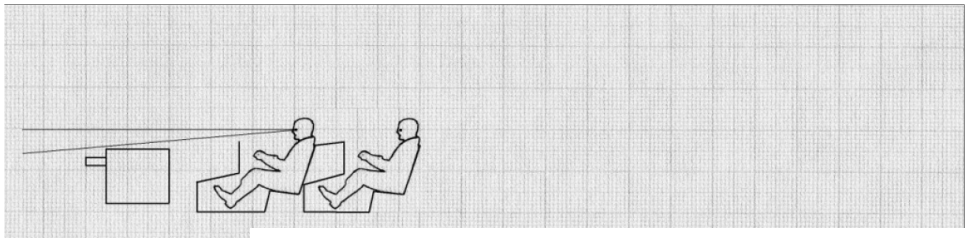
Aircraft type	α_F [°]
general	5-10
commercial	11-20
fighter	11-15
transport	17-20

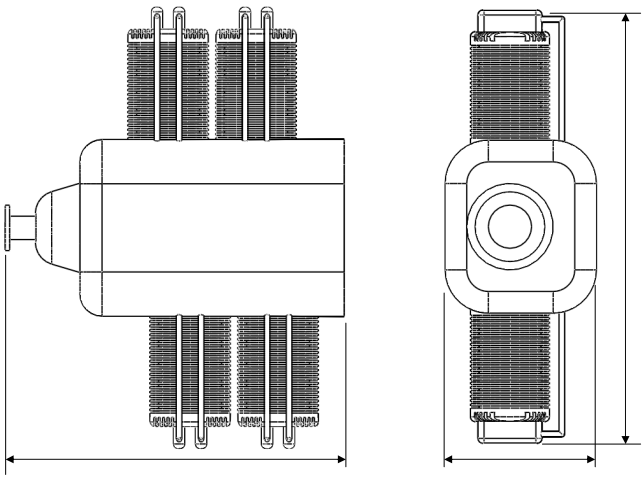


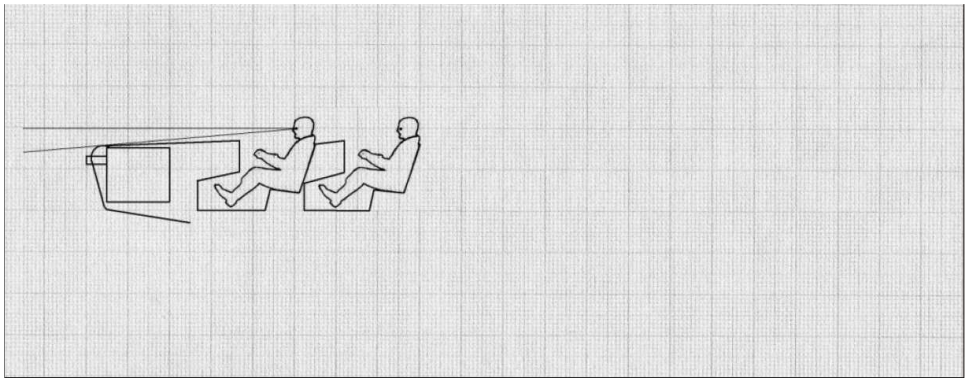


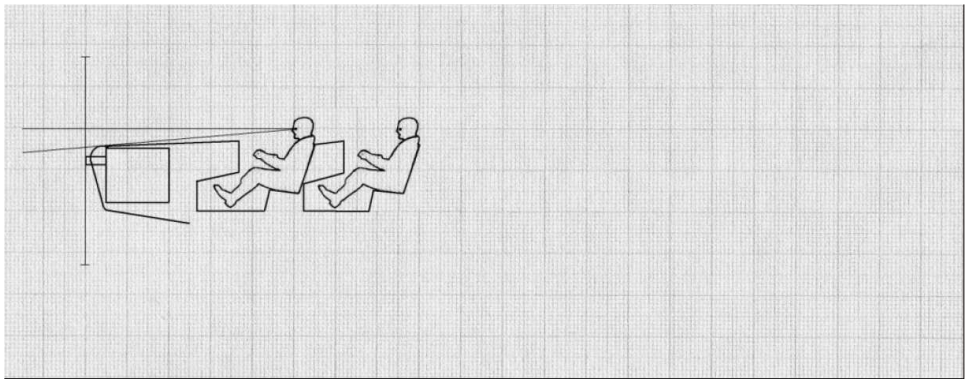




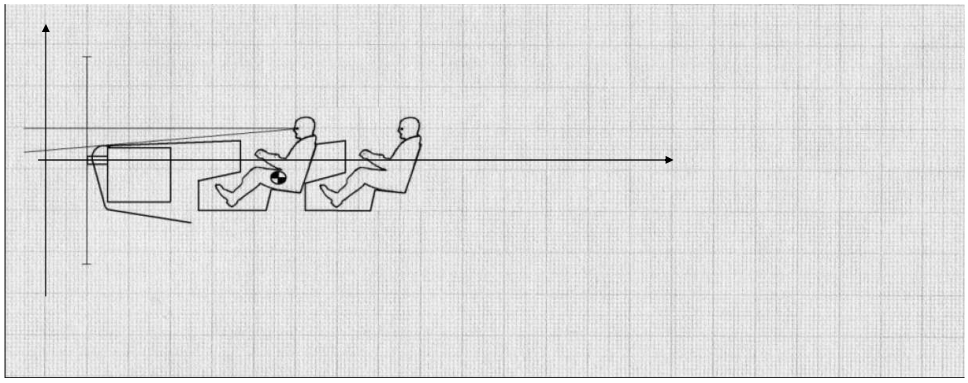




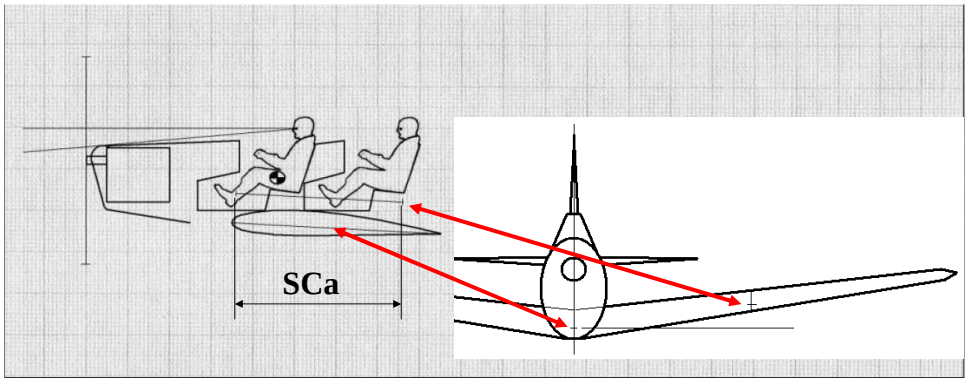




$$\sqrt{V_{max}^2 + (\omega \cdot r)^2} < 0{,}85 \cdot a$$

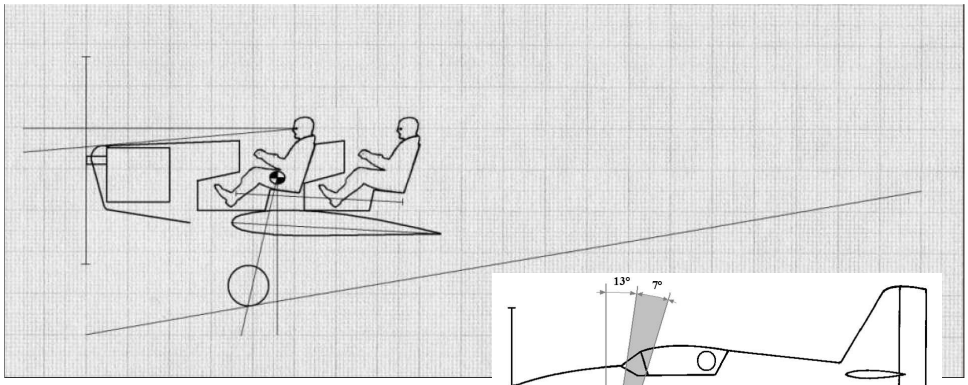


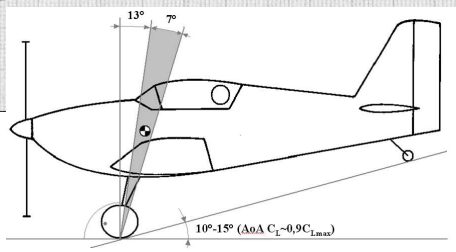
$$m \cdot x = m_1 \cdot x_1 + m_2 \cdot x_2 + m_3 x_3$$

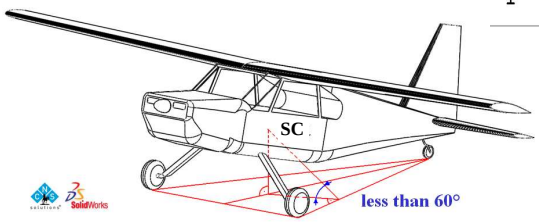


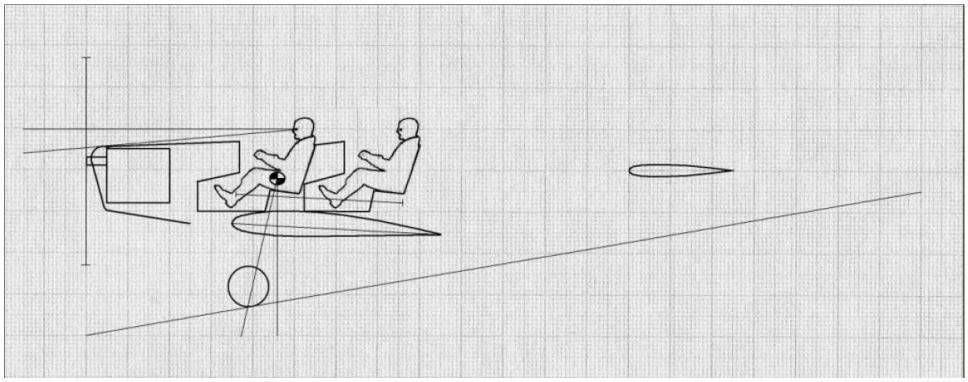
Center of gravity of the whole aeroplane should be located between 25-35% mac, so

1. **center of gravity of basic masses (engine, pilot, payload) should be located between 0-25% mac if most of other masses are to be located behind CG;**
2. **center of gravity of basic masses (engine, pilot, payload) should be located between 30-45% mac if most of other masses are to be located in front of CG.**

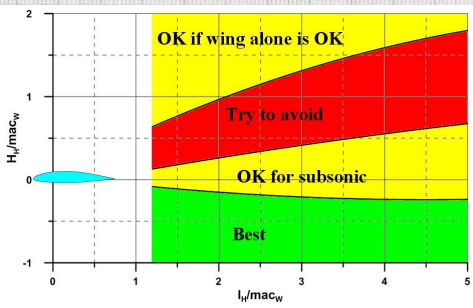


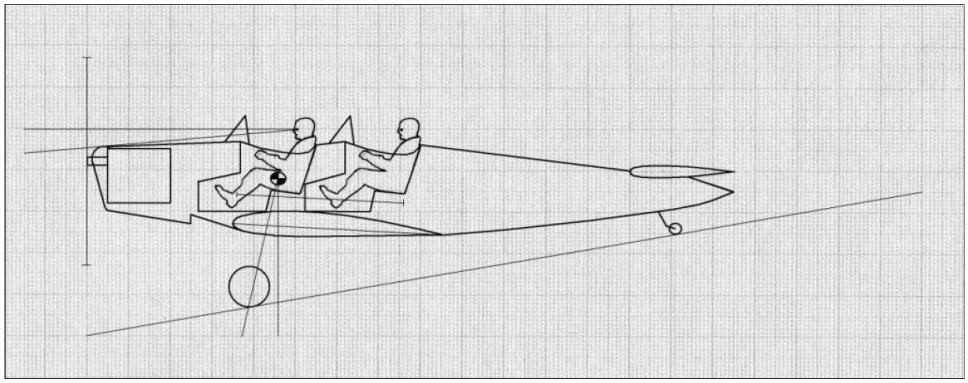


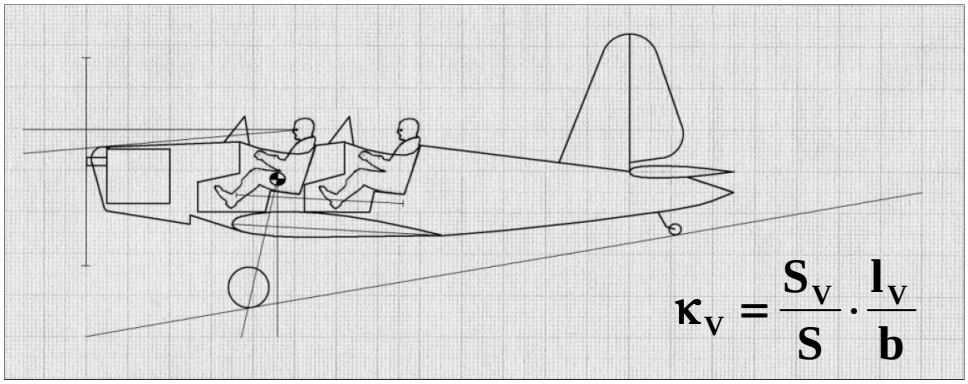




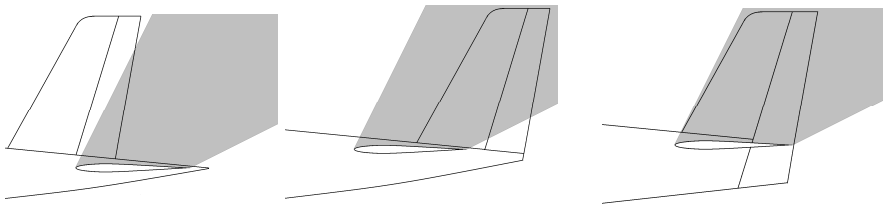
$$\kappa_H = \frac{S_H}{S} \cdot \frac{l_H}{SCa}$$





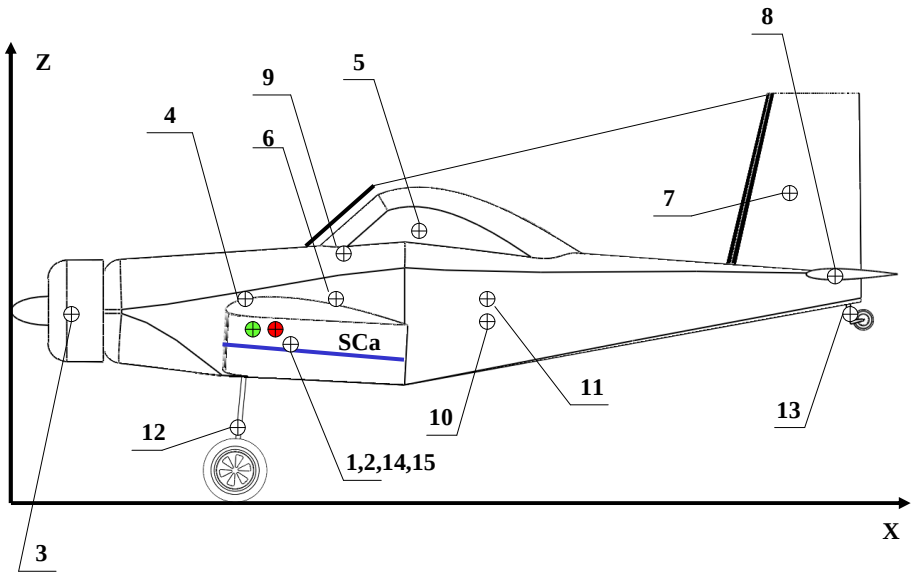


$$\kappa_V = \frac{S_V}{S} \cdot \frac{l_V}{b}$$

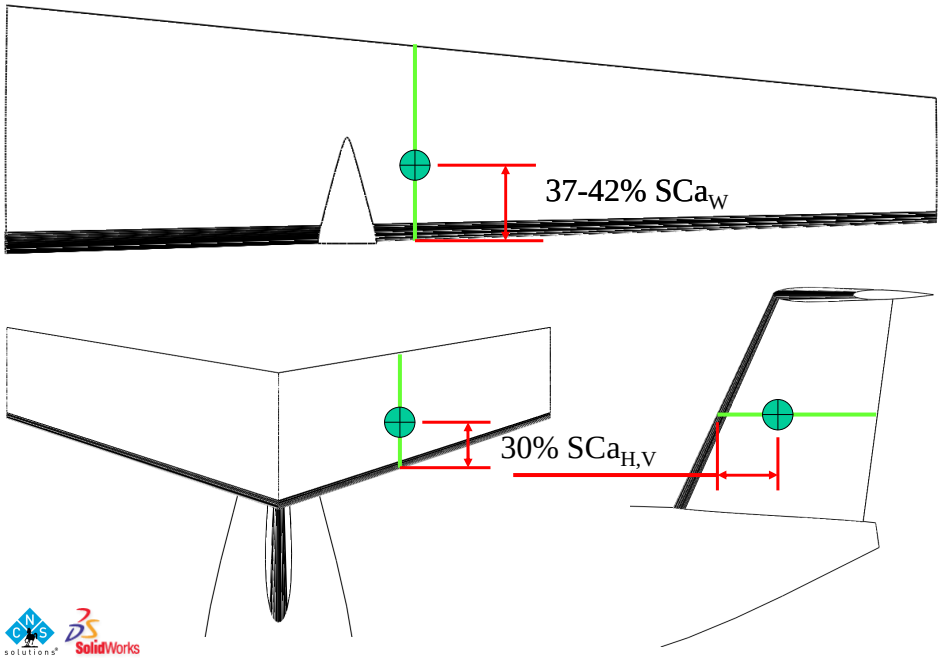


Detailed mass analysis

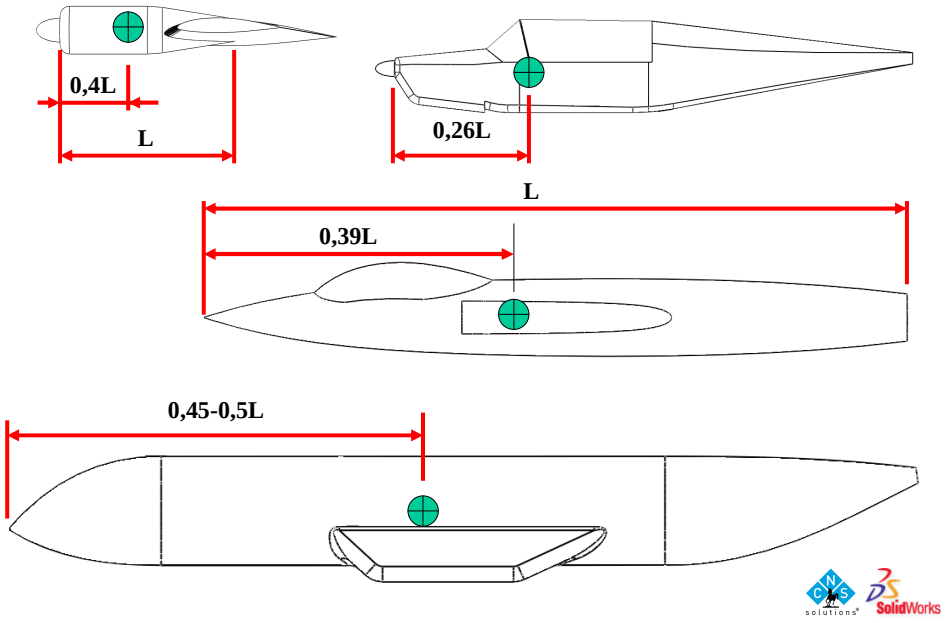
Masses should be calculated according to:
Raymer „Aircraft Design, a Conceptual Approach”
Corke „Design of Aircraft”
Danilecki „Projektowanie samolotów”



Positions of component's Centers of Gravity



Positions of component's Centers of Gravity



		Weight (kg)	X (m)	Y (m)	Z (m)
1	Left wing	125	4.4	-5	0.15
2	Right wing	125	4.4	5	0.15
3	Vertical stabilizer	35	6.6	0	0.7
4	Nose leg of landing gear	35	0.7	0	-0.9
5	Left leg of main landing gear	70	4.5	-1.3	-0.75
6	Right leg of landing gear	70	4.5	1.3	-0.75
7	Fuselage	170	3.1	0	0
8	Left engine	270	4.4	-1.05	0
9	Right engine	270	4.4	1.05	0
10	Control system	65	4.6	0	0
11	Electrical installation	150	4.3	0	0
12	Avionics	50	6.7	0	0.1
13	Other equipment	65	4	0	0
I	Empty weight	1500	4.285	0	-0.05
14	Payload (bay A)	250	2.1	0	0
15	Payload (bay B)	250	4.6	0	-0.5
16	Payload (bay C)	200	6.4	0	-0.2
II	Full aeroplane less fuel	2200	4.265	0	-0.11
17	Fuel in left wing	1440	4.6	-5.6	0.17
18	Fuel in right wing	1440	4.6	5.6	0.17
19	Fuel in fuselage	1220	3.4	0	0
III	Maximum takeoff weight (m_{TO})	6300	4.251	0	0.04
IV	m_{TO} less payload	5600	4.254	0	0.08

$$X_{CG} = \frac{\sum_{i=1}^{n} m_i x_i}{\sum_{i=1}^{n} m_i} \quad , \quad Y_{CG} = \frac{\sum_{i=1}^{n} m_i y_i}{\sum_{i=1}^{n} m_i} \quad , \quad Z_{CG} = \frac{\sum_{i=1}^{n} m_i z_i}{\sum_{i=1}^{n} m_i}$$

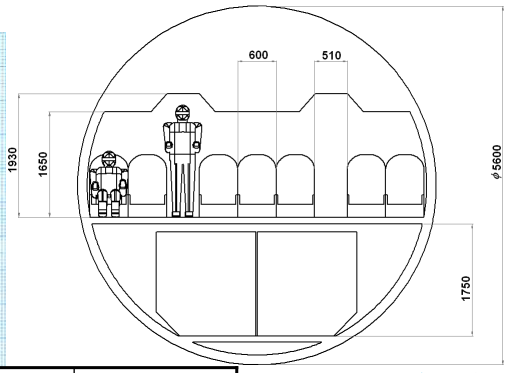
$$x_{CG}[\%] = 100\left(X_{CG} - (X_A - 0.25Ca)\right)/Ca$$

Where: A - point, where ¼ mac is located

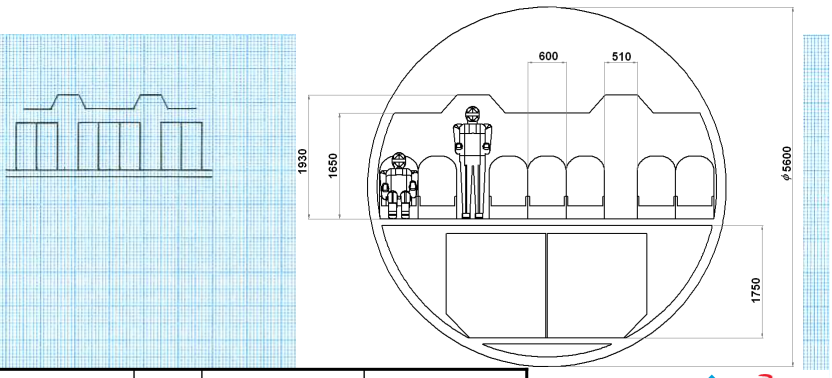
$$J_X = \sum_{i=1}^{n} m_i(y_i^2 + z_i^2) \quad , \quad J_Y = \sum_{i=1}^{n} m_i(x_i^2 + z_i^2) \quad , \quad J_Z = \sum_{i=1}^{n} m_i(x_i^2 + y_i^2)$$

$$J_{XY} = \sum_{i=1}^{n} m_i(x_i y_i) \quad , \quad J_{XZ} = \sum_{i=1}^{n} m_i(x_i z_i) \quad , \quad J_{YZ} = \sum_{i=1}^{n} m_i(y_i z_i)$$

Long range commercial aeroplane for 200 passengers



		Long range		Short range	
Seat width	m	0.43	0.71	0.41	0.46
Seat pitch	m	0.86	1.02	0.76	0.81
Headroom	m	1.65	1.65		
Aisle width	m	0.51	0.71	0.38	
Aisle height	m	1.93	1.93	1.52	
Passenger/cabin		10	36		50
Passenger/lavatories		10	20	40	50
Galley volume/passenger	m^3	0.03	0.23	0.0	0.03
Baggage/passenger	kg	18.14	27.22	18.14	



		Long range		Short range	
Seat width	m	0.43	0.71	0.41	0.46
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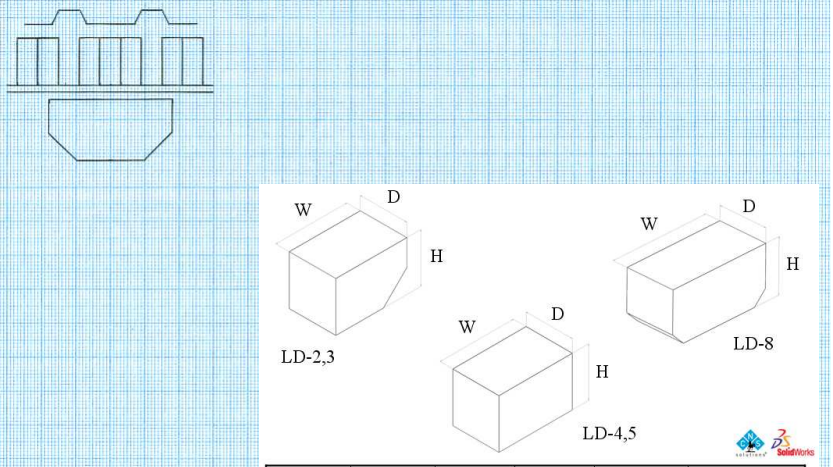
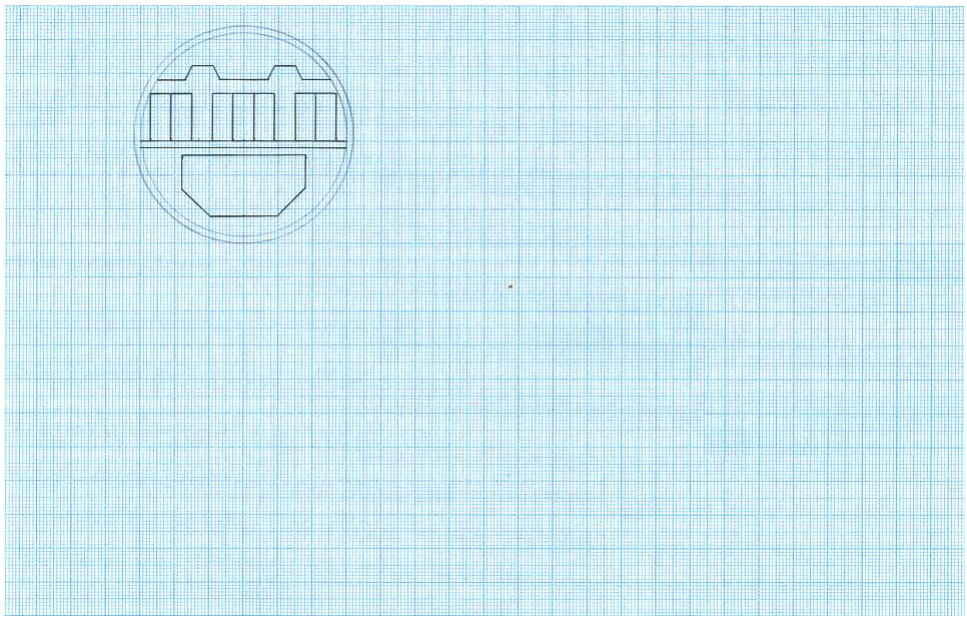
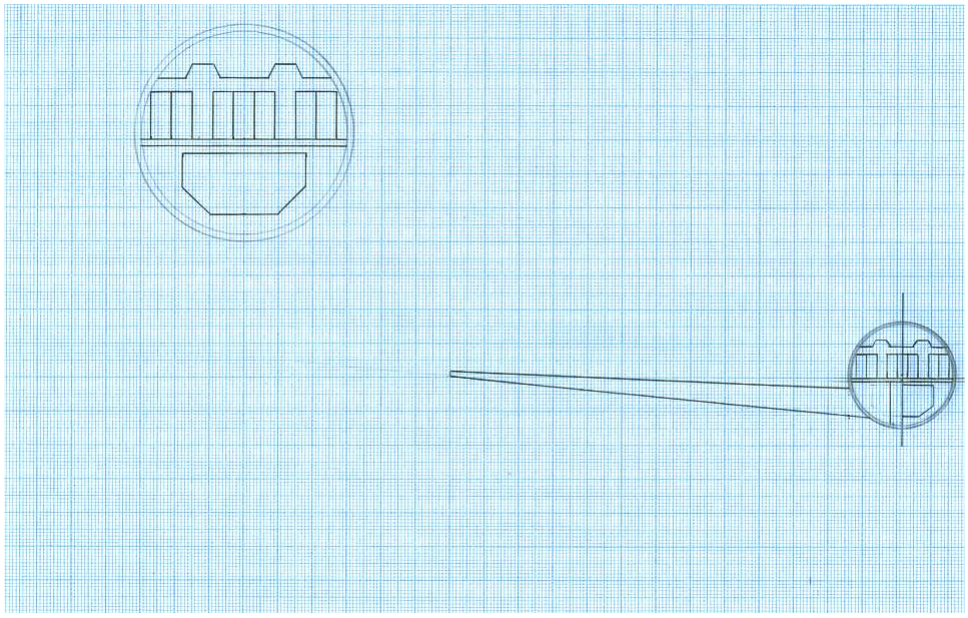
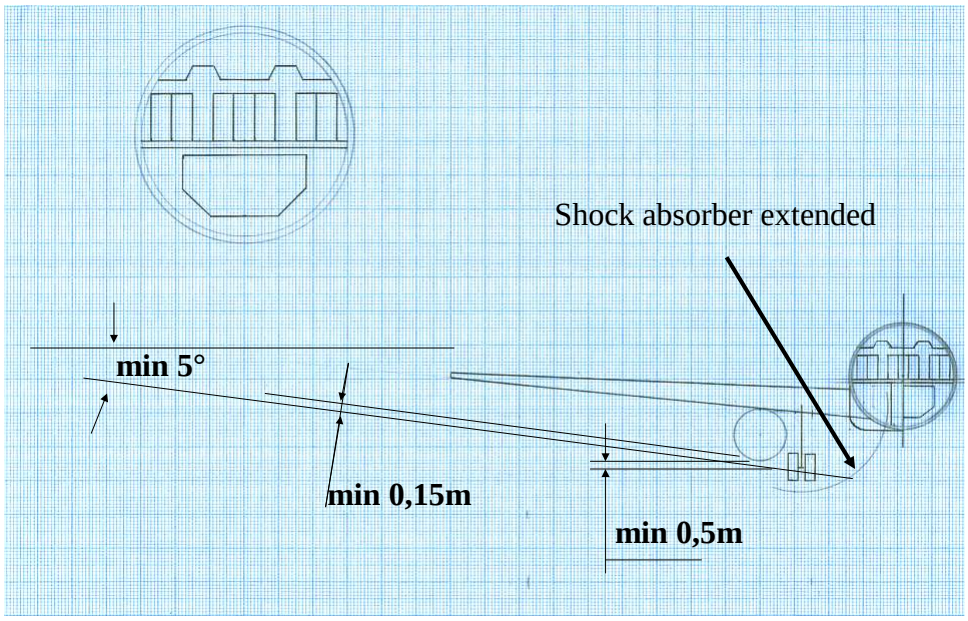
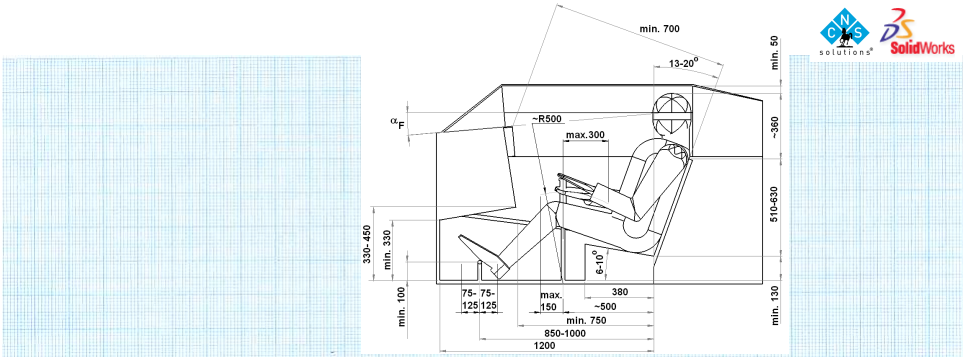


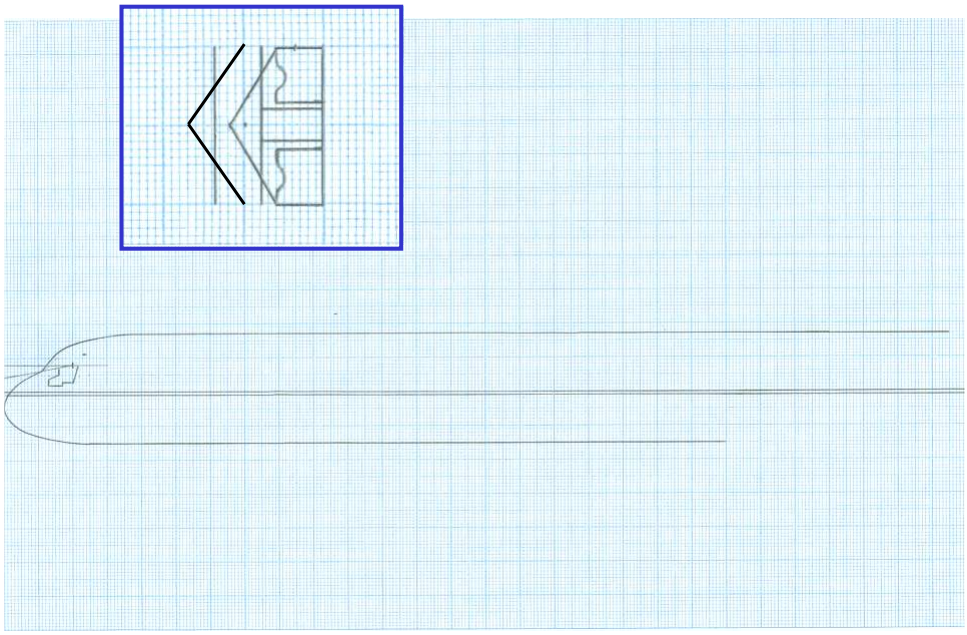
type	Height [m]	Width [m]	Depth [m]	Volume [m^3]	mass max. [kg]
LD-2	1.626	1.562	1.534	3.398	1224.7
LD-3	1.626	2.007	1.534	4.417	1587.6
LD-4	1.626	2.438	1.534	5.522	2449.4
LD-5	1.626	3.175	1.534	7.9	2449.4
LD-8	1.626	3.175	1.534	6.938	2449.4






Shock absorber extended
min 5°
min 0,15m
min 0,5m


min. 700
13-20°
min. 50
~R500
max.300
~360
510-630
330-450
min. 330
6-10°
min. 100
75- 75-
125 125
max.
150
380
~500
min. 750
850-1000
1200
min. 130



		Long range		Short range	
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Seat pitch	m	0.86	1.02	0.76	0.81
Headroom	m	1.65	1.65		
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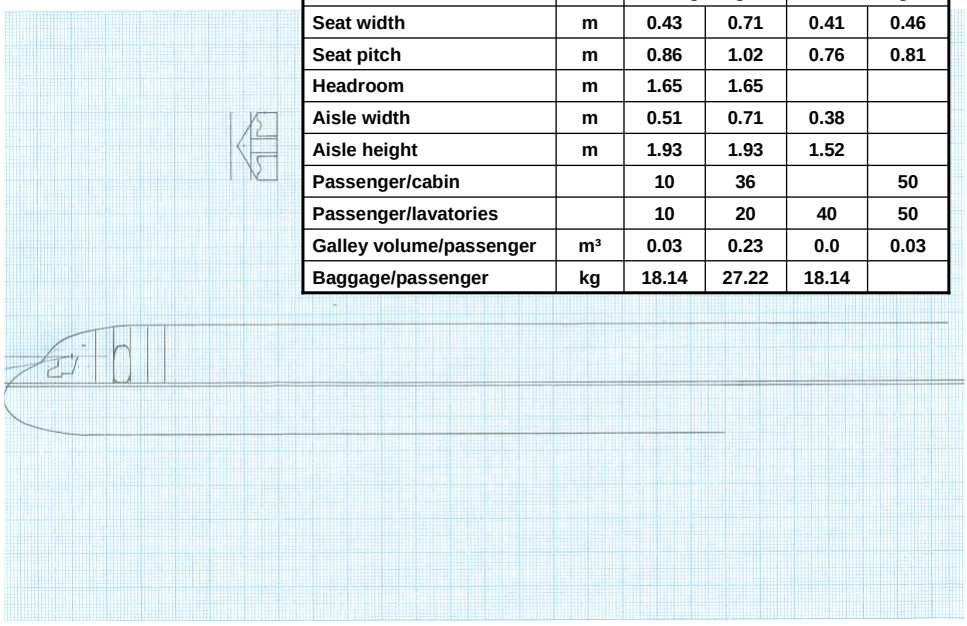
Aisle height	m	1.93	1.93	1.52	
Passenger/cabin		10	36		50
Passenger/lavatories		10	20	40	50
Galley volume/passenger	m^3	0.03	0.23	0.0	0.03
Baggage/passenger	kg	18.14	27.22	18.14	



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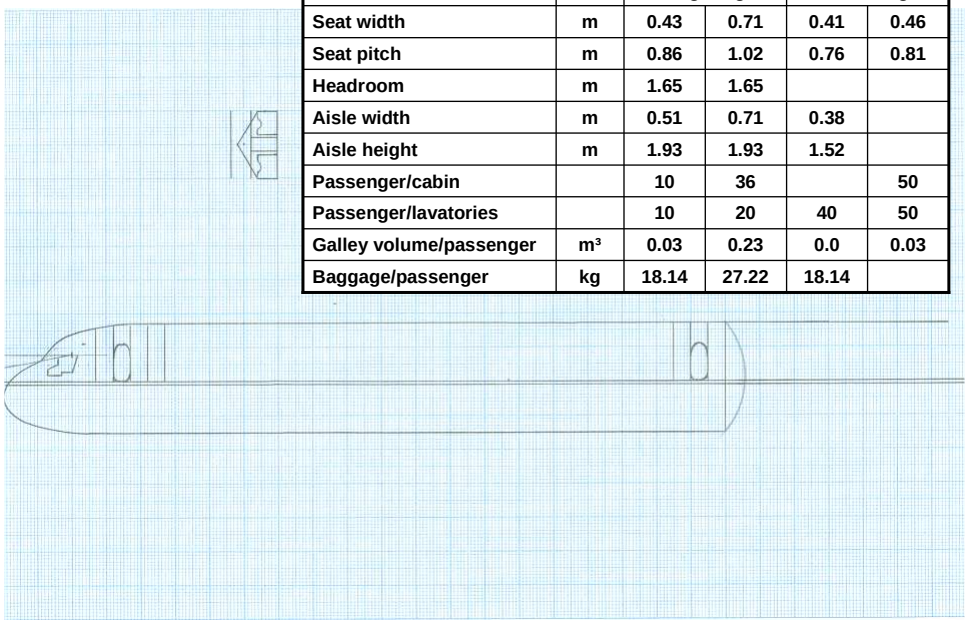
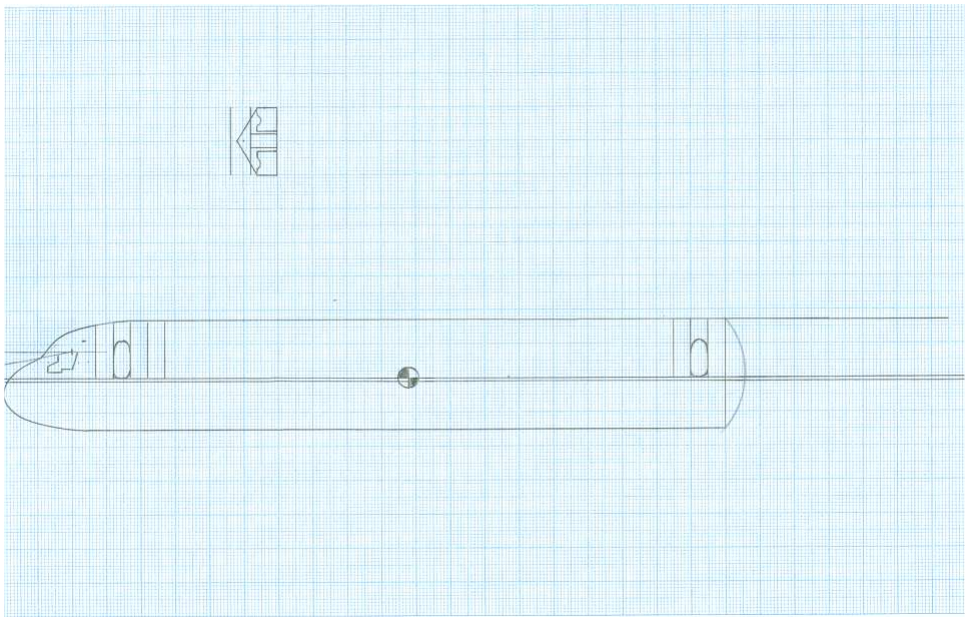
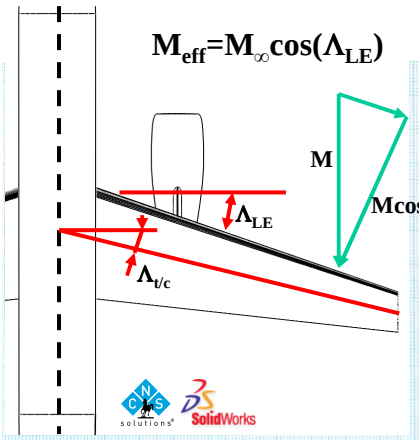
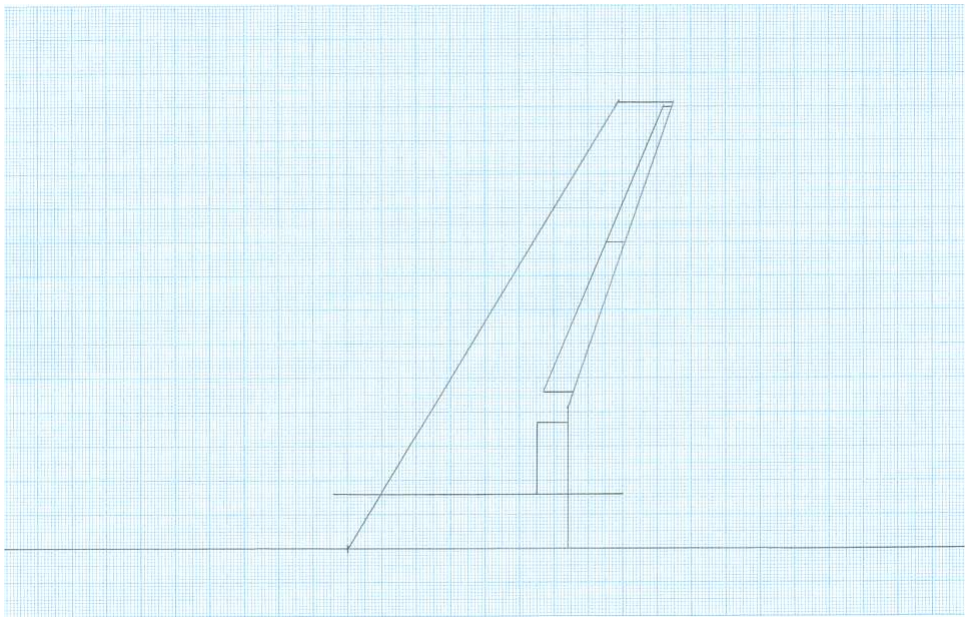
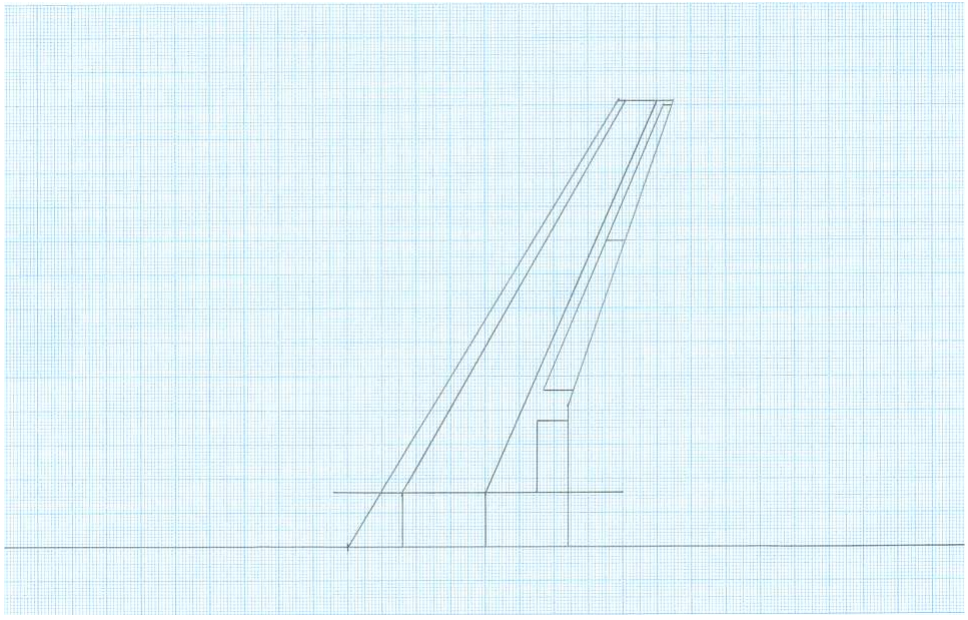
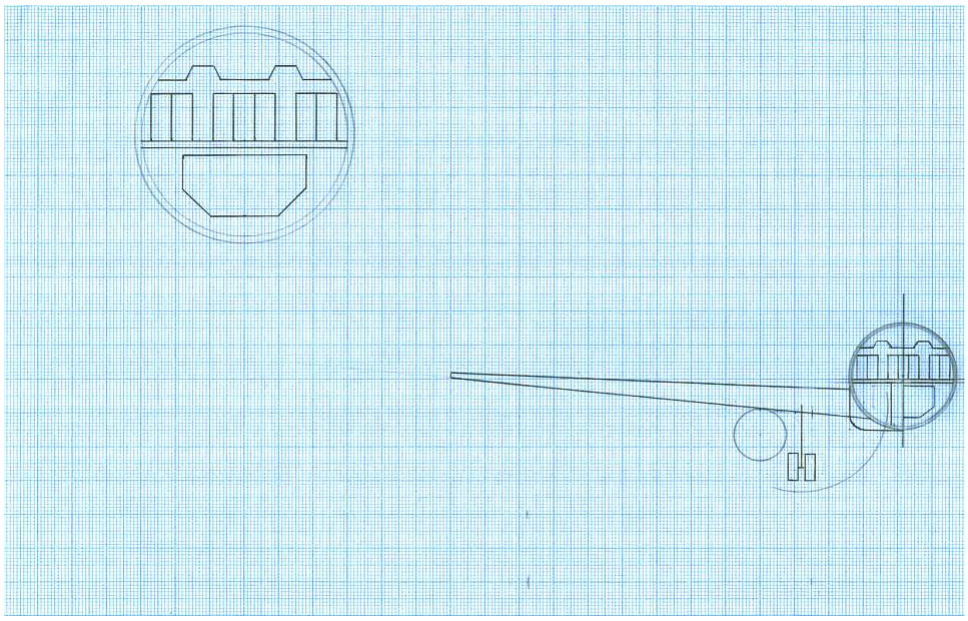


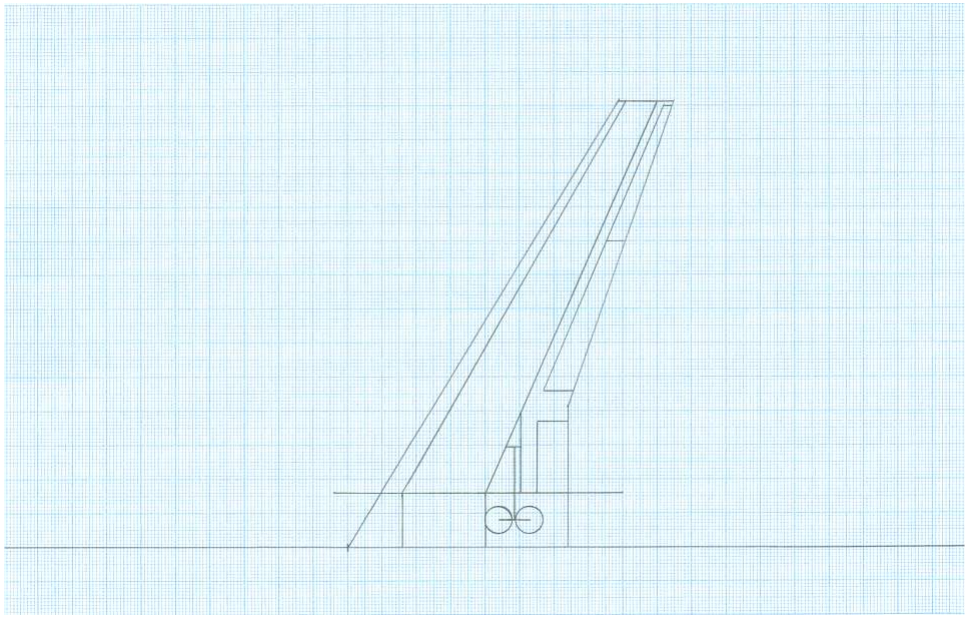


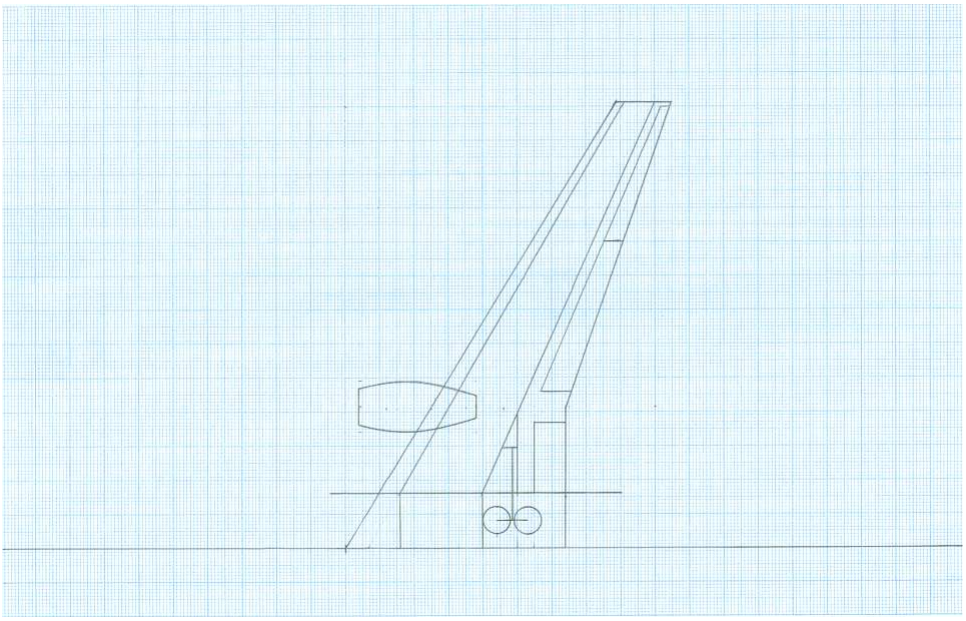

$M_{eff}=M_{\infty}\cos(\Lambda_{LE})$
M
$M\cos\Lambda_{LE}$
Λ_{LE}
$\Lambda_{t/c}$



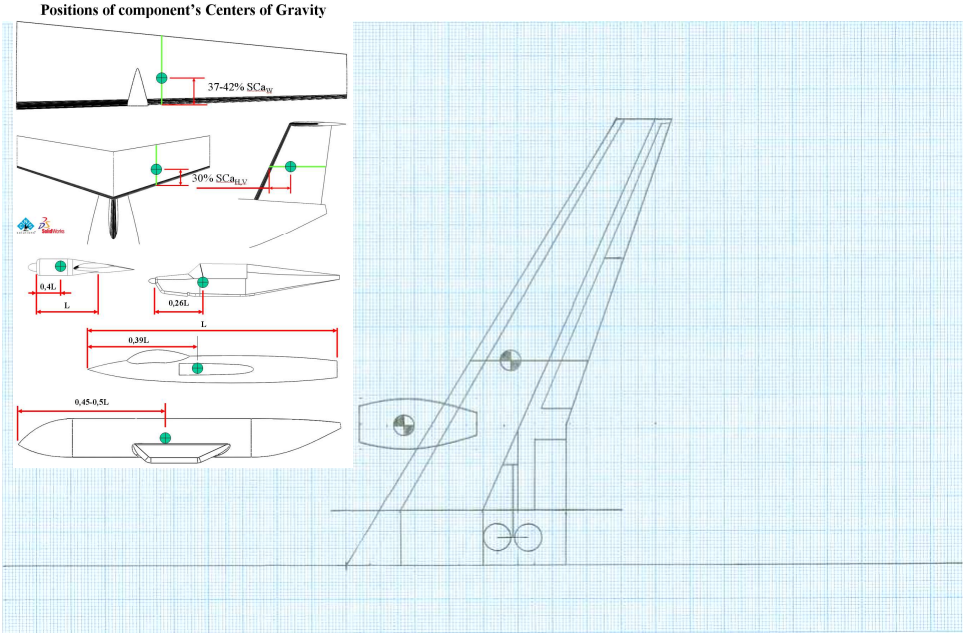


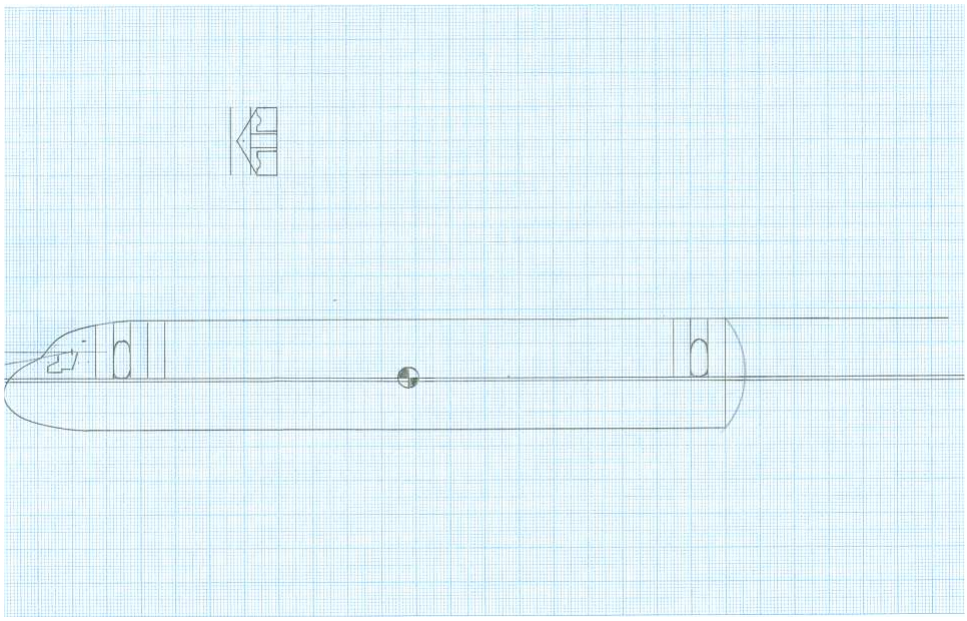


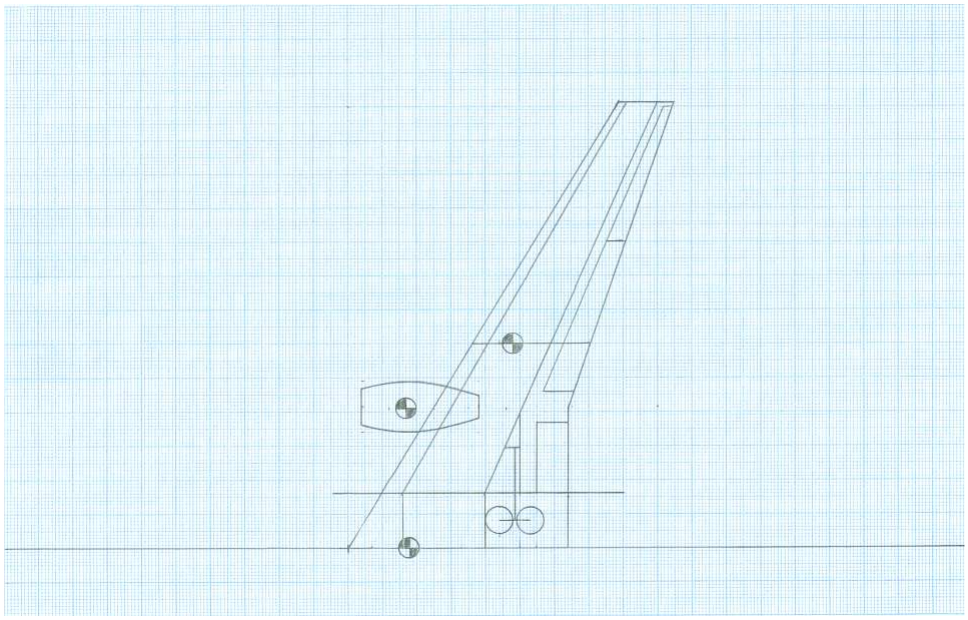




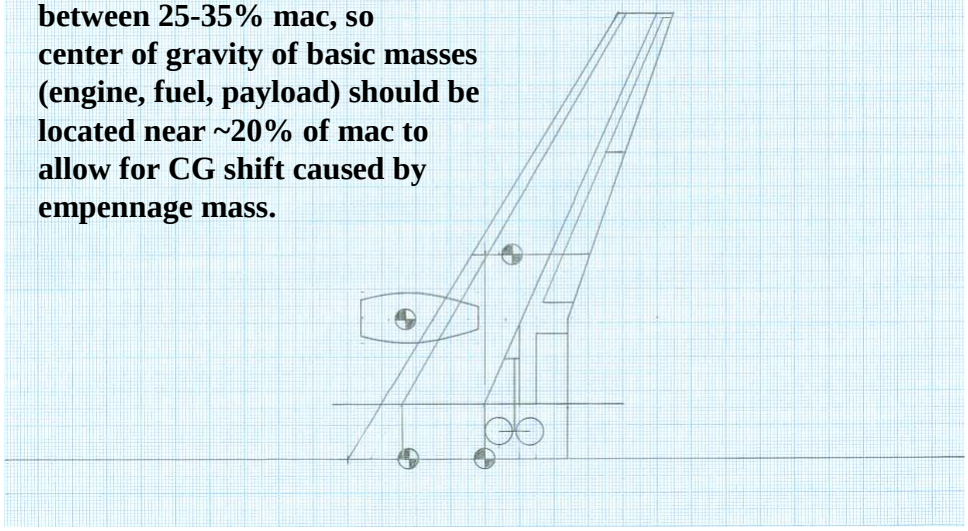
Positions of component's Centers of Gravity

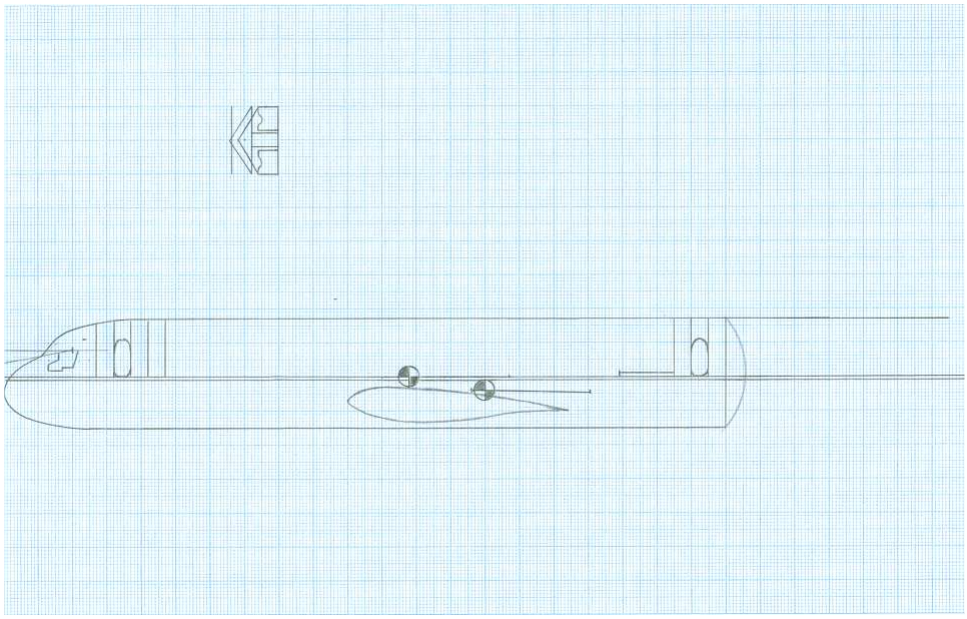


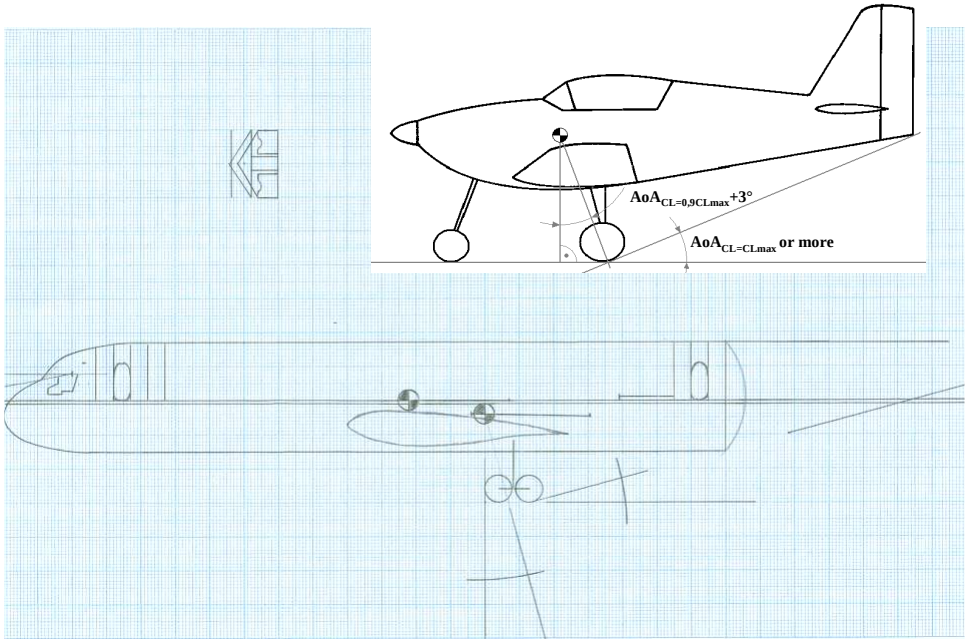


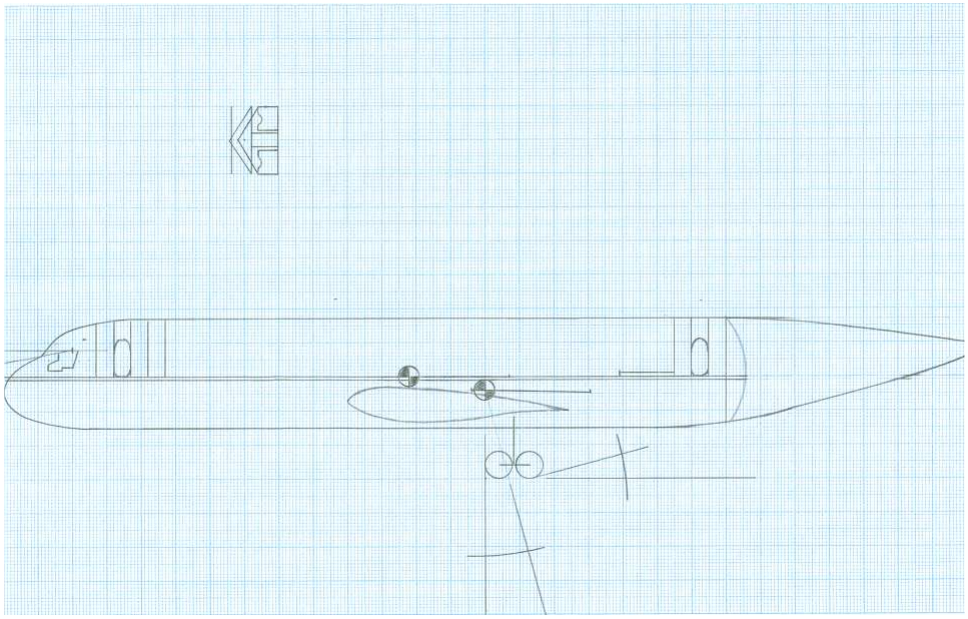


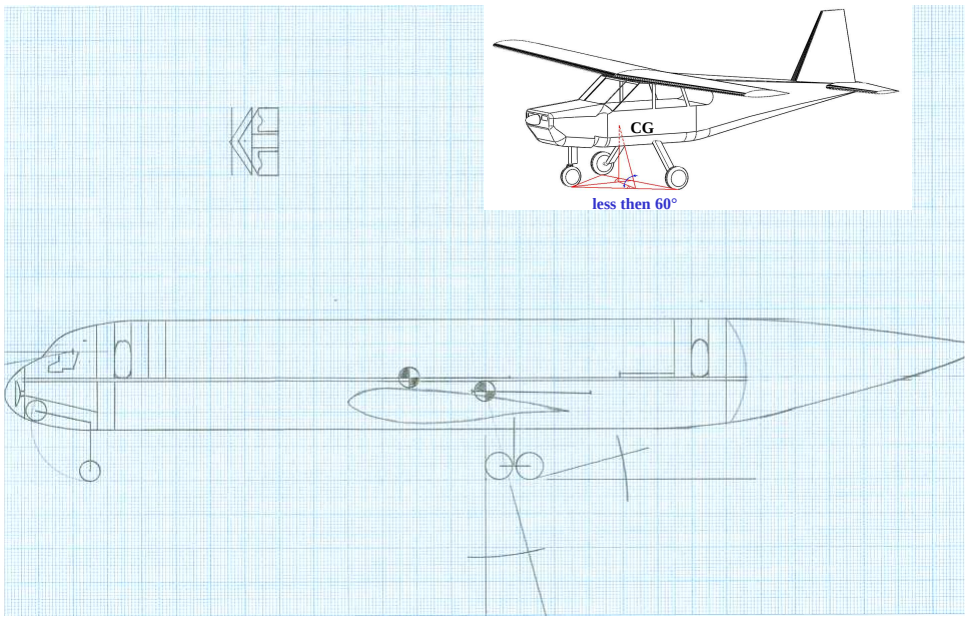
Center of gravity of the whole aeroplane should be located between 25-35% mac, so center of gravity of basic masses (engine, fuel, payload) should be located near ~20% of mac to allow for CG shift caused by empennage mass.

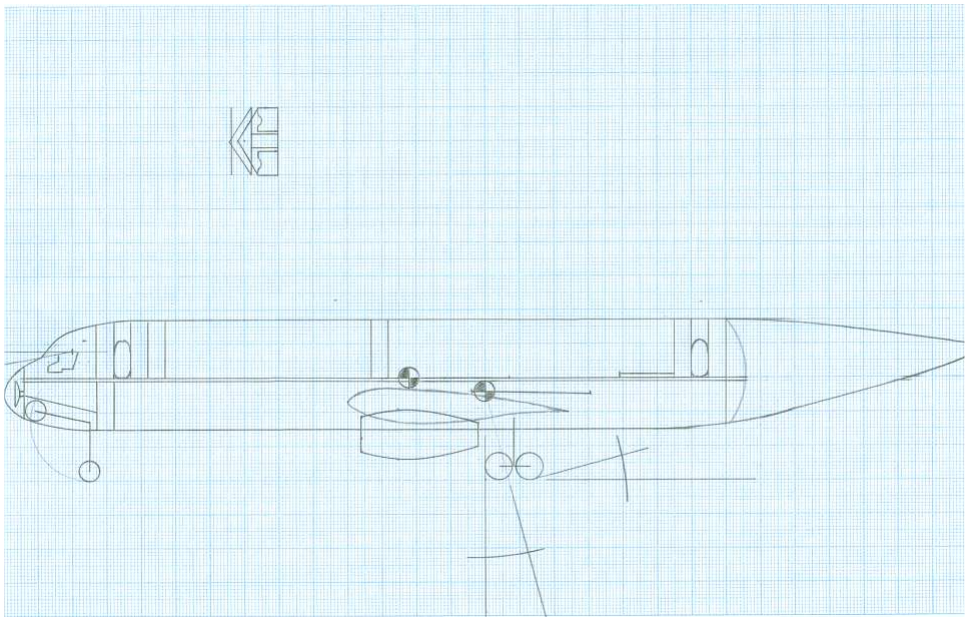




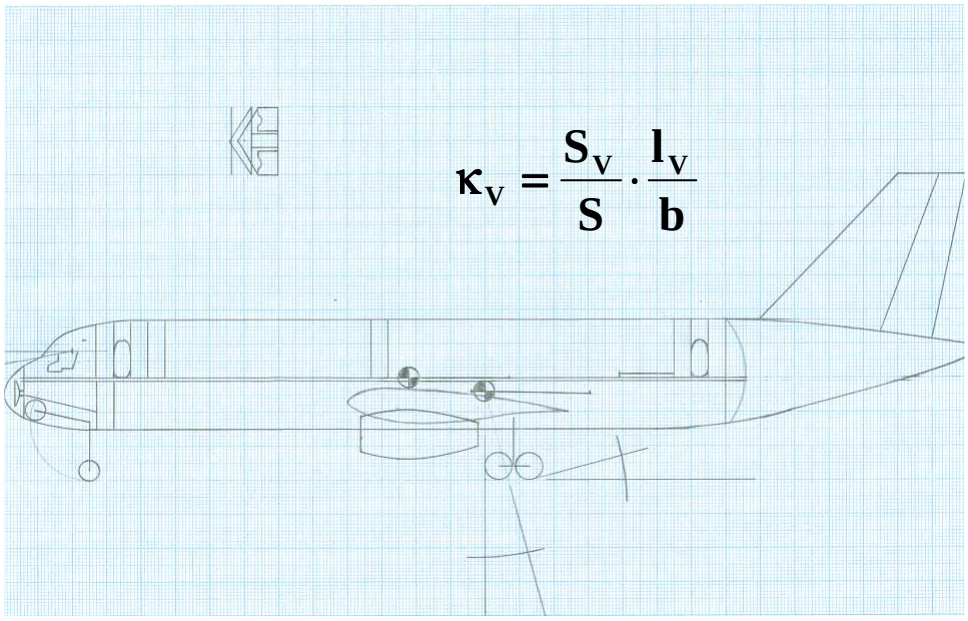

AoA$_{CL=0,9CLmax}$+3°
AoA$_{CL=CLmax}$ or more

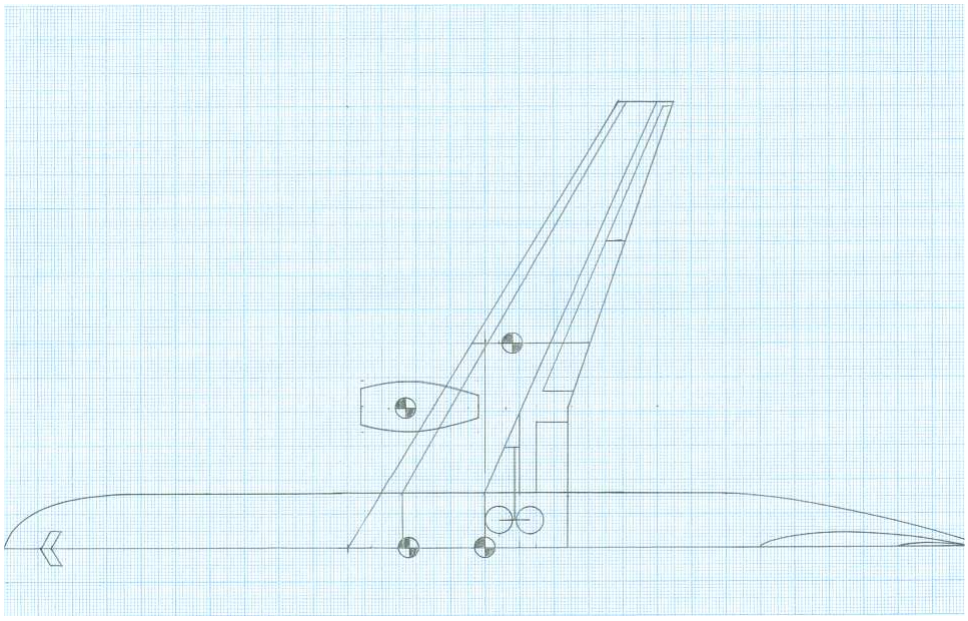



CG
less then 60°



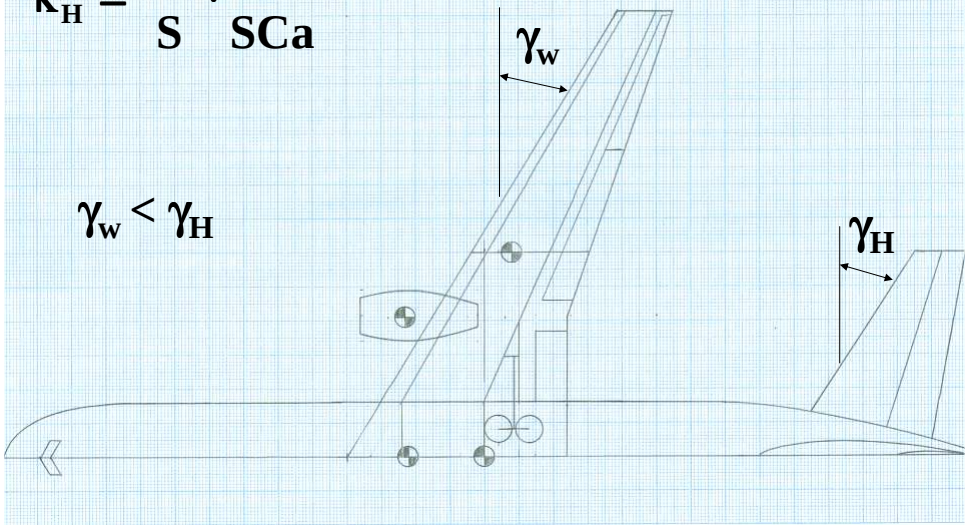
$$\kappa_V = \frac{S_V}{S} \cdot \frac{l_V}{b}$$

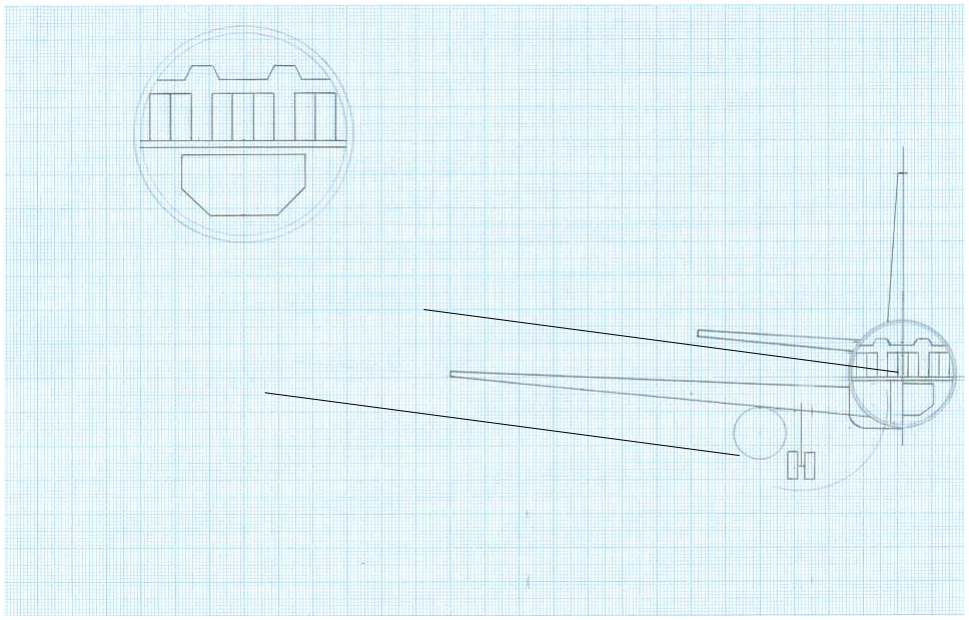


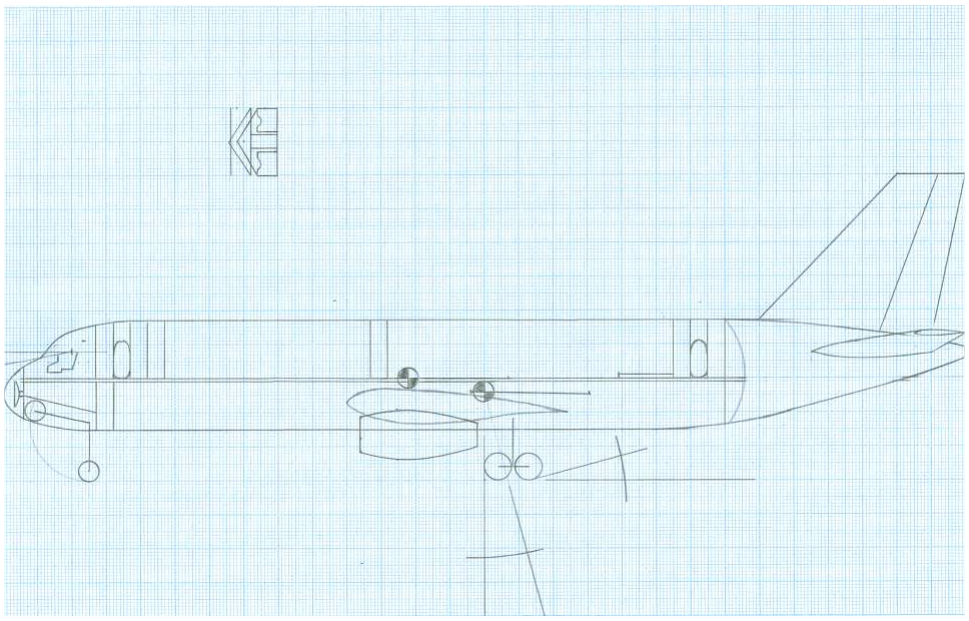


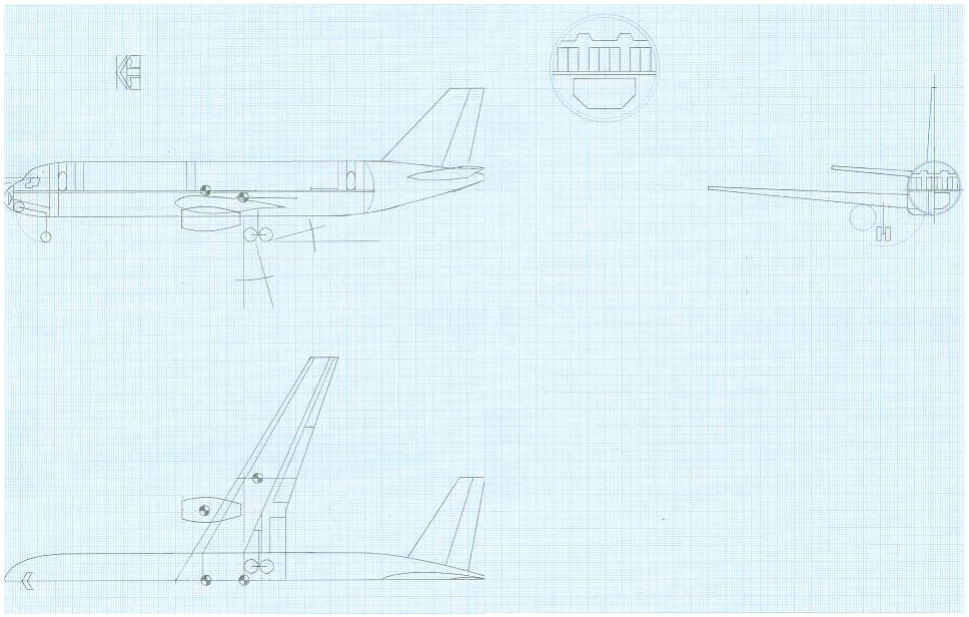
$$\kappa_H = \frac{S_H}{S} \cdot \frac{l_H}{SCa}$$

$\gamma_w < \gamma_H$









Detailed mass analysis

Masses should be calculated according to:
Raymer „Aircraft Design, a Conceptual Approach”
Corke „Design of Aircraft”
Danilecki „Projektowanie samolotów”