



**POLITECNICO
DI TORINO**

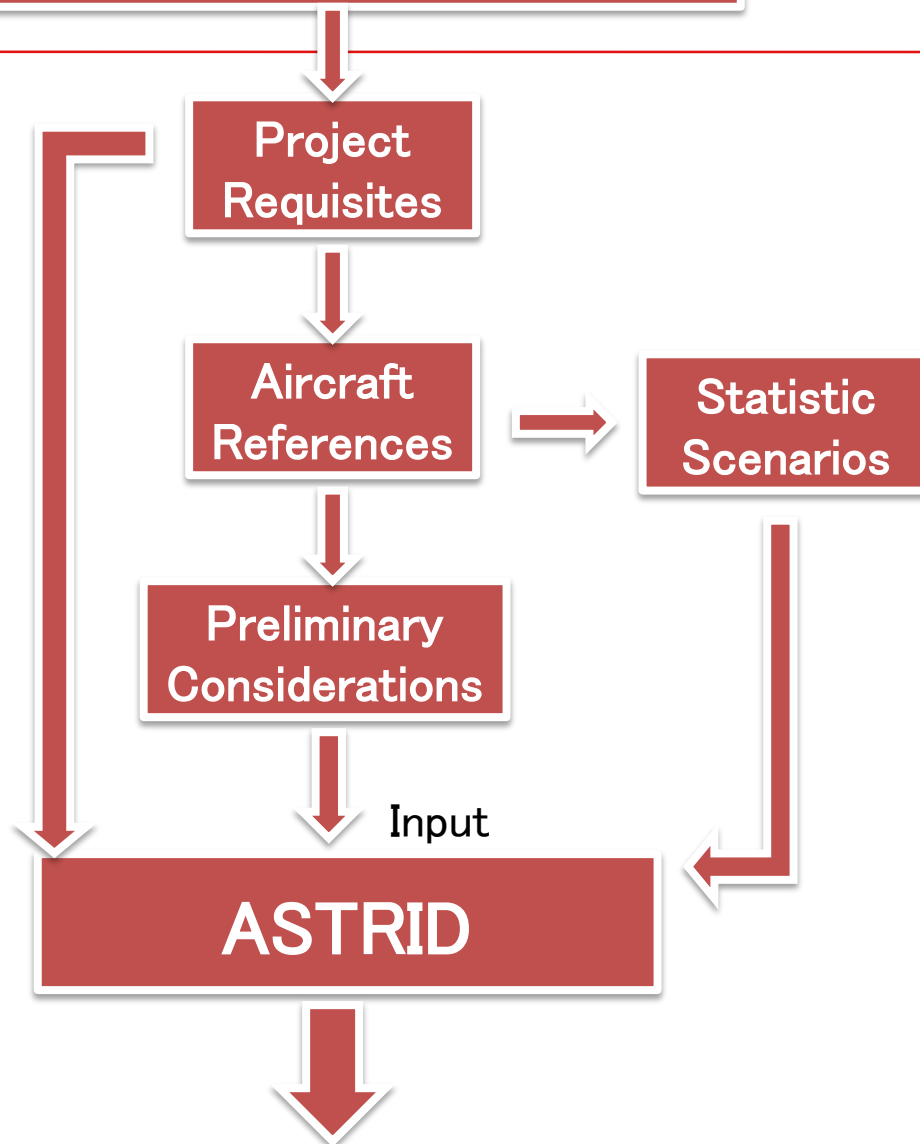
Group:

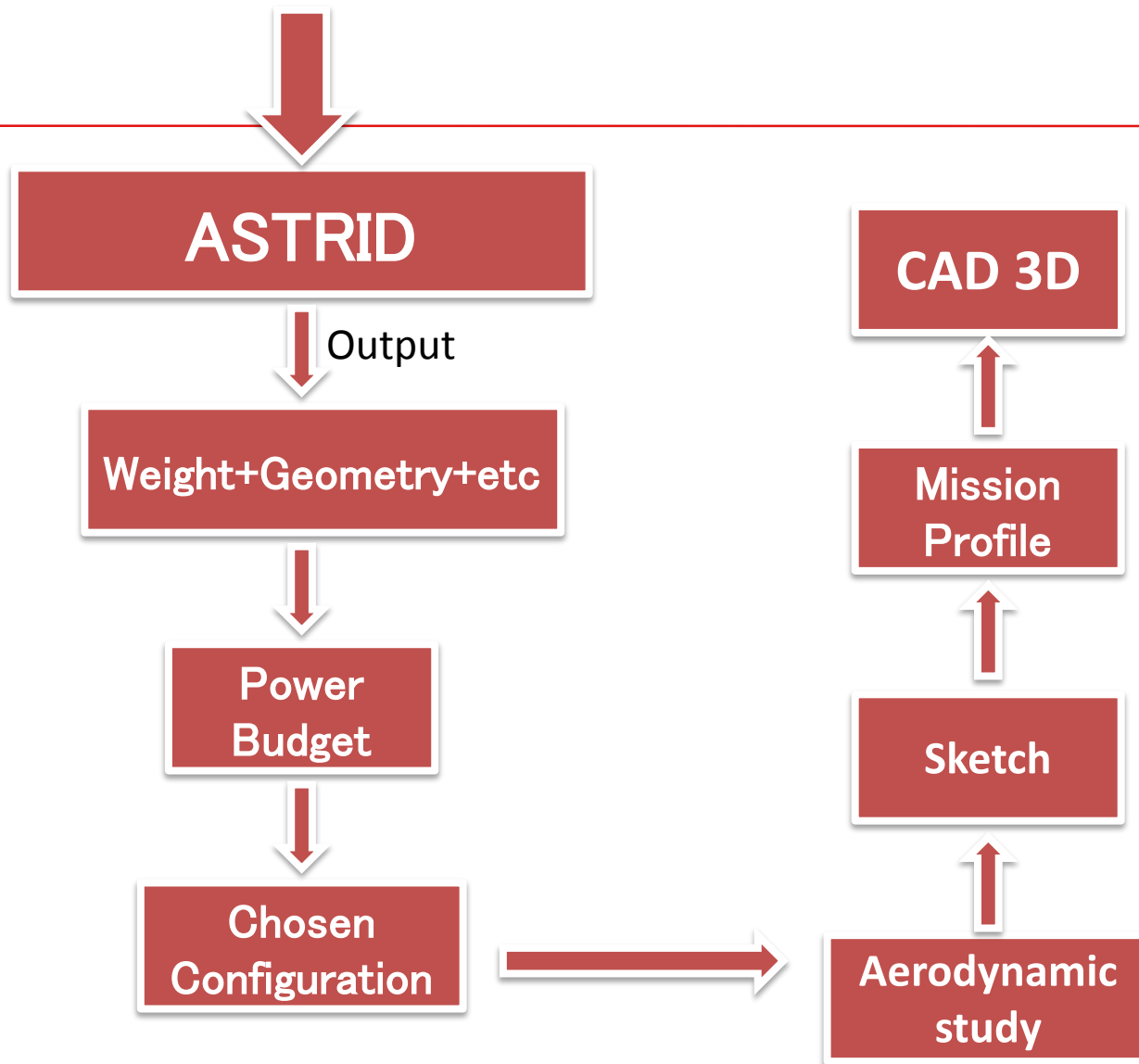
Alessio Cataudella, Beatriz Catarino
Francesco Imerti, Ruben Vallenari, Stefano Di Noia

MINI-BEE



PRELIMINARY DESIGN





Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------

PROJECT REQUISITES

- Number of passengers + pilot: 4;
- Maximum range: 1000 + 100 km to alternative airport;
- Cruise speed of 300 km/h;
- Vertical Take-Off and Landing;
- Configuration required: twin-engine, tilt-rotor, extensive use of composite material and a creation of a system architecture more-electric.

AIRCRAFT REFERENCES

Cessna Skylane



- Height: 2,84 m
- Wingspan: 10,97 m
- Length: 8,84 m
- Max Take-Off Weight: 1406 Kg
- Power: 230 hp
- Engine: lycoming IO-540-AB-1A5
- Maximum speed: 269 Km/h
- Range: 1695 Km
- Price: 277 300 \$

Piper Archer



- Height: 2,2 m
- Wingspan: 10,8 m
- Length: 7,3 m
- Max Take-Off Weight: 1157 Kg
- Power: 180 hp
- Engine: Lycoming O-360-A4M
- Maximum speed: 237 Km/h
- Range: 967 Km
- Price: 357 700 \$

Cessna TTX



- Height: 2,74 m
- Wingspan: 10,97 m
- Length: 7,68 m
- Max Take-Off Weight: 1633 Kg
- Power: 310 hp
- Engine: turbo TSIO-550-c
- Maximum Speed: 435 Km/h
- Range: 2315 Km
- Price: 733 950 \$

Aeromobil 3.0



- Height: 1,50 m
- Wingspan: 8,32 m
- Length: 6 m
- Power: 81 hp
- Engine: rotax 912
- Maximum speed: 200 Km/h
- Range: 700 Km

Robinson R44



- Height: 3,3 m
- Rotor diameter: 10,1 m
- Length: 11,7 m
- Max Take-Off Weight: 1089 Kg
- Power: 248 hp
- Engine: lycoming IO-540-AE1A5
- Maximum speed: 240 Km/h
- Range: 560 Km
- Price: 456 000 \$

Agusta Westland AW609



- Height: 5,1–6,6 m
- Wingspan: 11,7 m
- Length: 13,3 m
- Max Take-Off Weight: 7200 Kg
- Power: 1900 hp
- Engine: Pratt & Whitney Canada PT6C-67A
- Maximum speed: 616 Km/h
- Range: 1390 Km
- Price: 10 000 000 \$

PRELIMINARY CONSIDERATIONS

- Possibility of horizontal take-off and landing in case of failure of the electric power train
- Rechargeable battery during flight and on the ground
- Cockpit inspired by car ergonomic design
- Intuitive commands
- Robust structure
- Integration of the practicability of a car with the speed of an aircraft.
- More simple, fast and economic than a traditional helicopter

Aircraft configurations to be chosen:

- Power distribution between electric and Heat
- Heat engine type: Turbin, Piston and Wankel
- Number of Heat engines: 1 or 2
- Number of electric engines: from 2 to 4
- Electric engines layout: inside the fuselage or protruding
- Electric system supply: alternator (Heat engine) or battery

OVERVIEW

Number of persons on board:		4
Weight for person (including hand luggage) [kg]:		100
Dropped payload [kg]:		0
<u>Carried Payload [kg]:</u>		210
Maximum Mach:		0,243
Take off field distance [m]:	?	680
Landing field distance [m]:	?	580
Cl_max:	?	1,5 ▼
Cl_max_TO:		1,8 ▼
Cl_max_LND:		1,9 ▼
Cl during cruise (mean):		0,73
Airfield altitude [m]:		1000
Aspect ratio (A):	?	8,5
<u>Fuselage length [m]:</u>	?	8
Cruise altitude [m]:		4200
Percentage of throttle during cruise [%]		75

Wing geometry

Wing area [m²]:

18,78

Aspect ratio (A):

8,50

Wing span (b) [m]:

12,64

Taper ratio:

?

0,95

Mean chord [m]:

1,49

Root chord [m]:

1,52

Tip chord [m]:

1,45

Sweep angle [°]:

?

0

Distance fuselage top - C0 leading edge [m]:

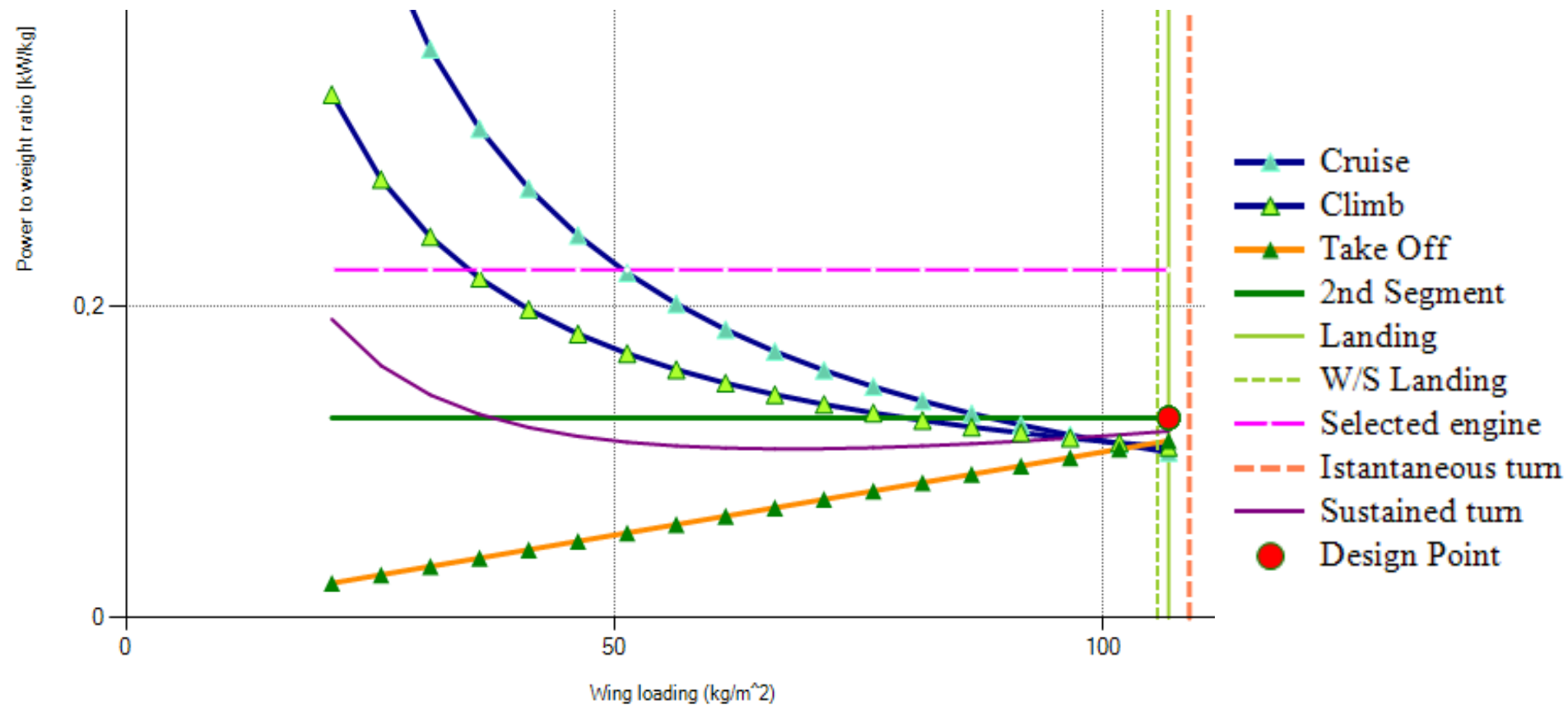
3,06

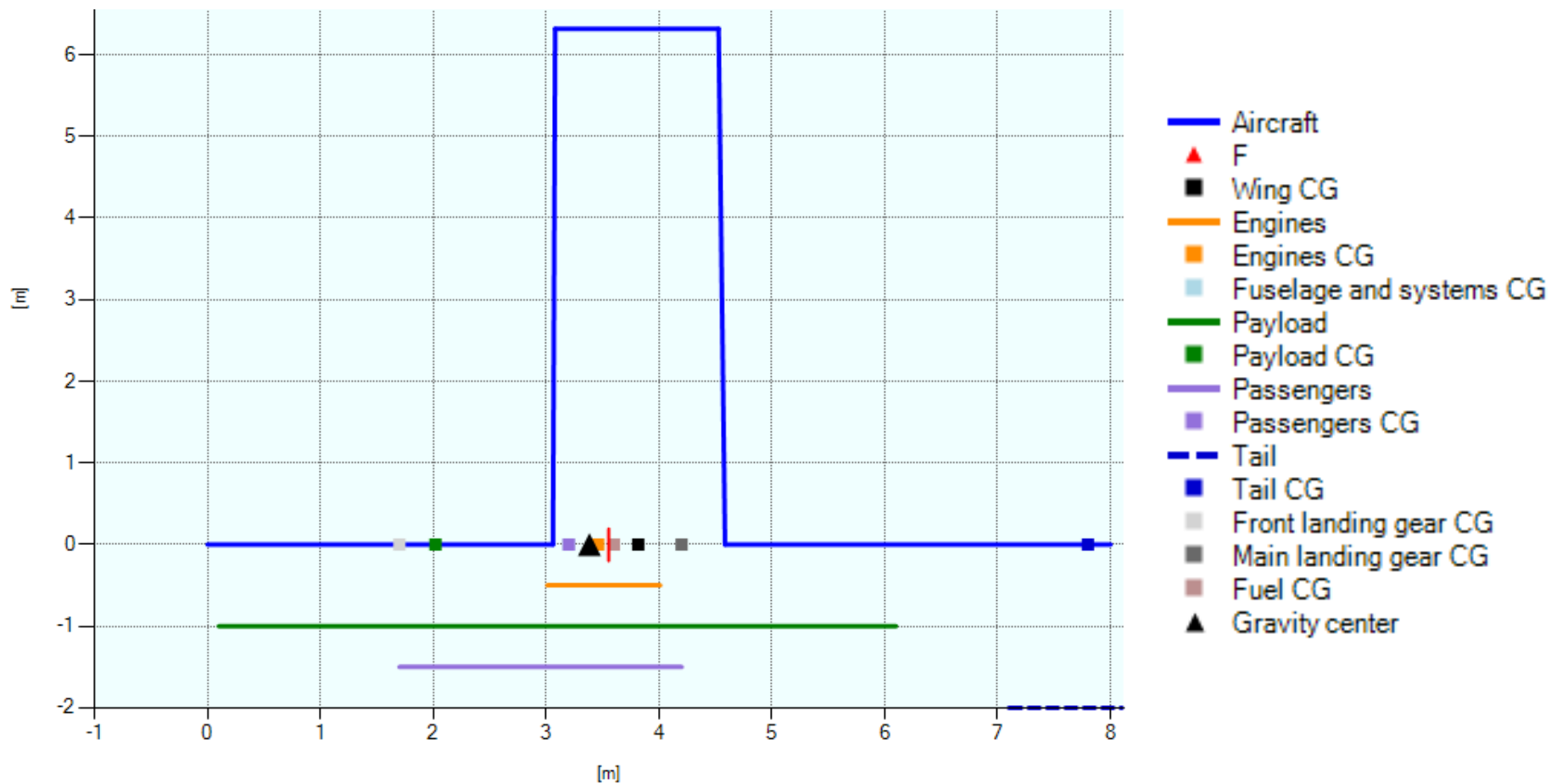
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------

Weights:

- Fuselage: 182,25Kg
- Engines: 450 Kg
- Systems: 349,81 Kg
- Payload: 610Kg
- Empty: 1287,68 Kg
- **MTOW: 2005,54 Kg**

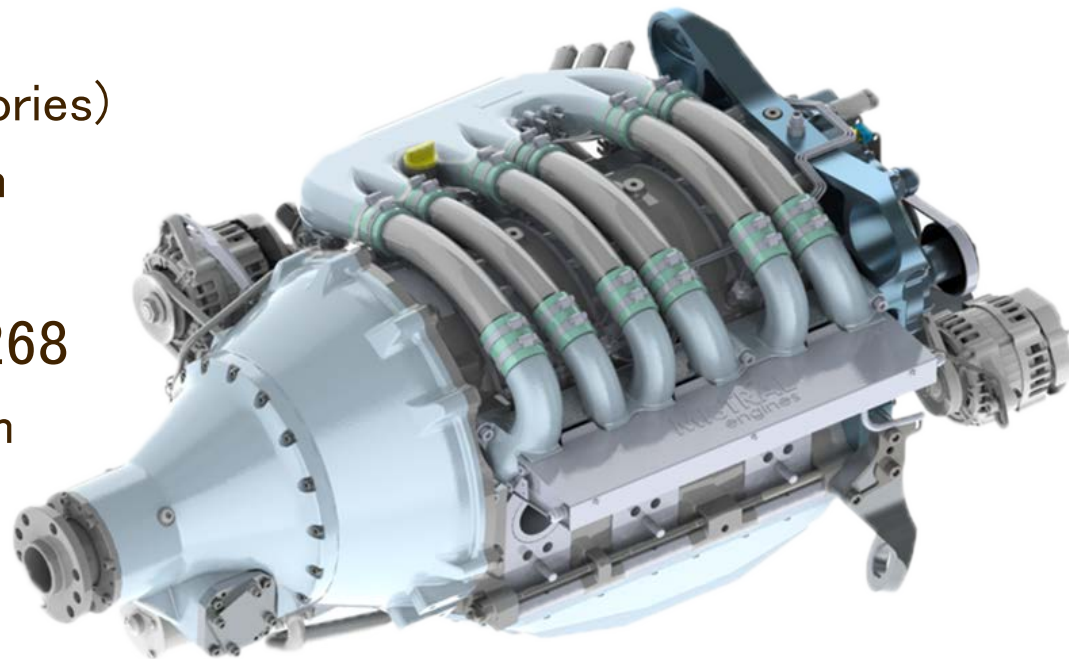
Matching Chart





Chosen engines:

- Heat engine: G-300 Mistral
 - 300 hp
 - 177 kg (including accessories)
 - LxWxH: 672x549x520 mm
- Electric engine: Emrax 268
 - 54 hp (80 kW) a 4000 rpm
 - 20,3 kg
 - ØxH: 268x91 mm



AB9

✕

✓

fx

=(2*1,225*3,14*(AB\$2^2)*(\$B9^2)/4)^(1/3)

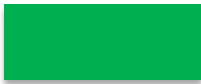
	A	B	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	TERMICO [N]		diametro elica [m]															
2			1,5	1,6	1,7	1,8	1,9	2	2,1	2,2	2,3	2,4	2,5	2,6	2,7	2,8	2,9	3
3	potenza [w]	100000	3511	3665	3816	3965	4110	4253	4394	4532	4668	4803	4935	5066	5195	5323	5449	5573
4		120000	3965	4139	4310	4477	4641	4803	4961	5118	5272	5423	5573	5721	5866	6010	6153	6293
5		140000	4394	4587	4776	4961	5144	5323	5498	5672	5842	6010	6176	6340	6501	6661	6819	6974
6		160000	4803	5014	5221	5423	5622	5818	6010	6200	6386	6570	6751	6930	7107	7281	7453	7624
7		180000	5195	5423	5647	5866	6082	6293	6501	6706	6908	7107	7303	7496	7687	7876	8062	8247
8		200000	5573	5818	6058	6293	6524	6751	6974	7194	7411	7624	7834	8042	8247	8449	8649	8847
9		220000	5939	6200	6455	6706	6952	7194	7432	7666	7897	8124	8348	8569	8788	9003	9216	9427
10		240000	6293	6570	6841	7107	7368	7624	7876	8124	8368	8609	8847	9081	9312	9541	9767	9990



4 electric engines



2 electric engines with maximum diameter



2 electric engines with minimum diameter

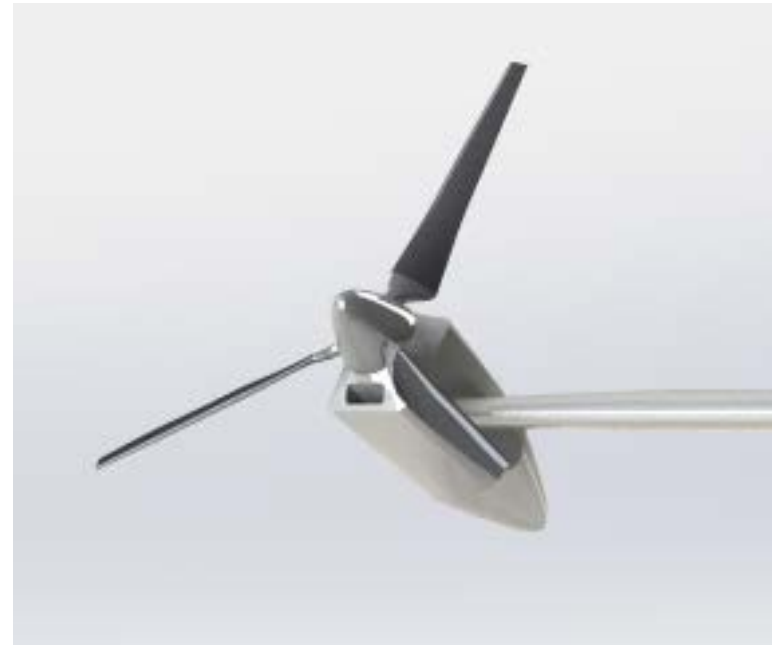
CU93 : f_x $= (4 * 1,225 * 3,14 * (CU\$2^2) * (\$AW93^2) / 4) ^ {1/3}$

	AV	AW	AX	AY	AZ	BA	CU
1	ELETTRICO [N]		diametro elica [m]				
2			0,5	0,52	0,54	0,56	1,48
3		75000	1755,4	1801,9	1847,82	1893,16	3618,85
4		75500	1763,19	1809,9	1856,02	1901,57	3634,92
5	potenza [w]	76000	1770,97	1817,89	1864,2	1909,95	3650,95
6		76500	1778,73	1825,85	1872,37	1918,32	3666,94
7		77000	1786,47	1833,8	1880,52	1926,67	3682,9
8		77500	1794,2	1841,73	1888,65	1935	3698,83
9		78000	1801,9	1849,64	1896,77	1943,32	3714,72
10		78500	1809,6	1857,54	1904,86	1951,61	3730,58
11		79000	1817,27	1865,42	1912,94	1959,89	3746,4
12		79500	1824,93	1873,28	1921,01	1968,15	3762,19
13		80000	1832,58	1881,12	1929,05	1976,4	3777,95
14		80500	1840,2	1888,95	1937,08	1984,62	3793,68
91		119000	2387,99	2451,26	2513,71	2575,4	4922,98
92		119500	2394,68	2458,12	2520,75	2582,61	4936,76
93		120000	2401,35	2464,97	2527,78	2589,81	4950,52

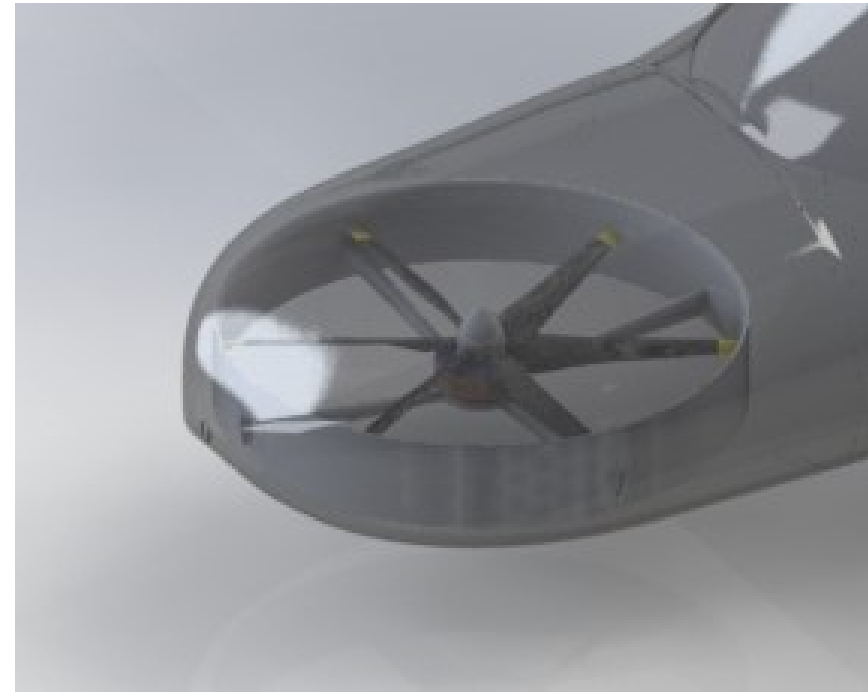
4 elettrici		SPINTA INSTALLATA	[N]	SPINTA RICHIESTA		spinta/ peso
		31944		20417		1,56
2 elet. Con diam.Max		SPINTA INSTALLATA	[N]	SPINTA RICHIESTA		spinta/ peso
		28834		20248		1,42
2 elet. Con diam.Min		SPINTA INSTALLATA	[N]	SPINTA RICHIESTA		spinta/ peso
		28755		20248		1,42

Chosen configuration:

- Power distribution between electrical and thermal: 40%–60%
- Number of heat engines: 2
- Number of electric engines: 2



- Electric engines layout: inside the fuselage
- Electric system supply: batteries as the main supplier and charges with an alternator during cruise (Heat engine)

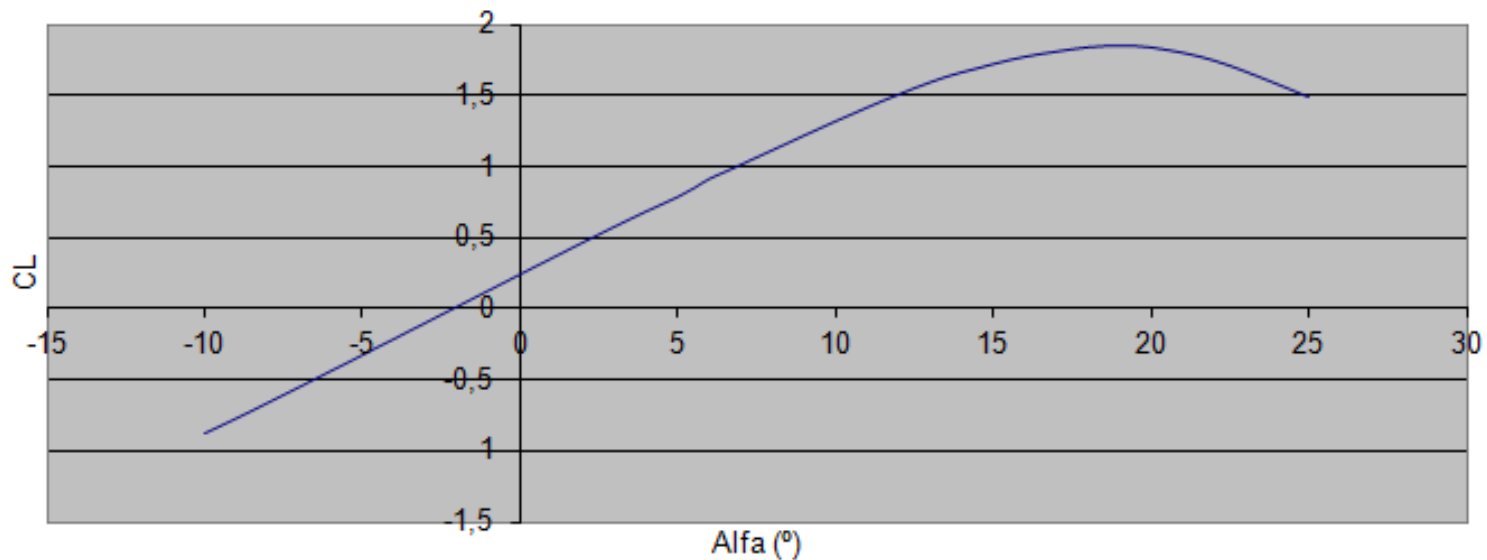


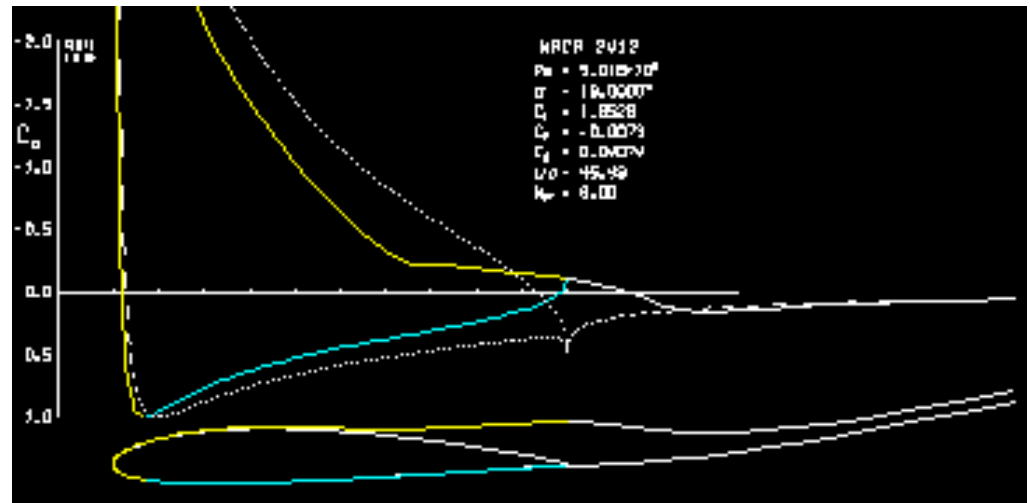
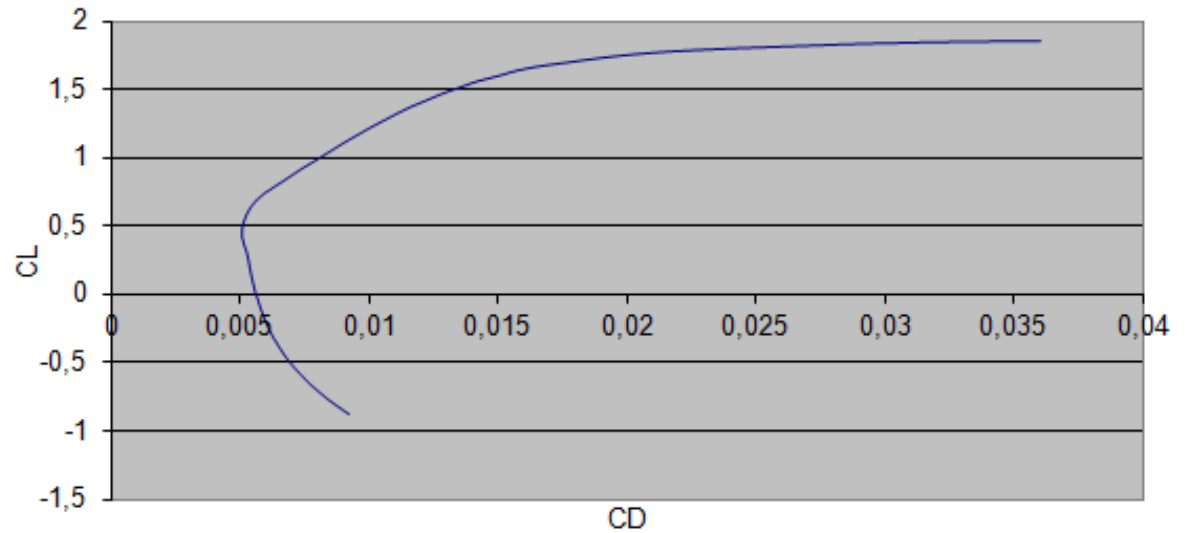
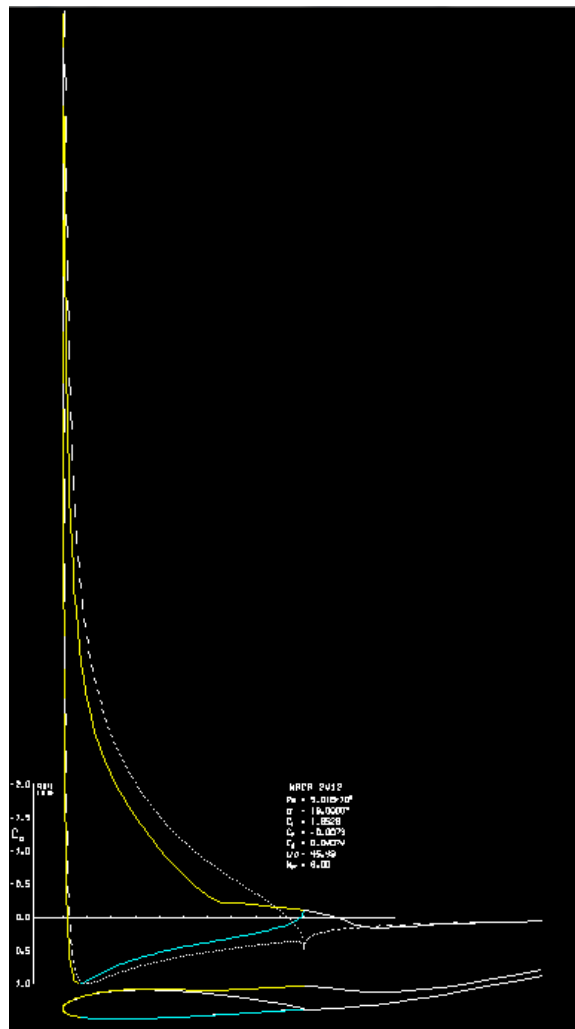
Dimensionamento batteria agli ioni di litio						
Dati input						
Potenza richiesta dal carico [W]		489795,9	244897,96	244897,96		
Durata totale batteria [minuti]		10	10	10		
Carica residua [%]		6	6	6		
Efficienza trasmissione		0,85	0,85	0,85		
Energia/peso [Wh/kg]	160					
Energia/volume [Wh/L]	270					
Potenza/peso [W/kg]	1800					
Dati output						
Durata totale batteria in ore		0,166667	0,1666667	0,1666667		
Depth Of Discharge [%]		94	94	94		
Capacità batteria [Wh]		45604,83	22802,417	22802,417		
Numero celle Li-Ion necessarie		7016,128	3508,0642	3508,0642		
Peso [kg]		285,0302	142,51511	142,51511		
Volume [m ³]		0,168907	0,0844534	0,0844534		



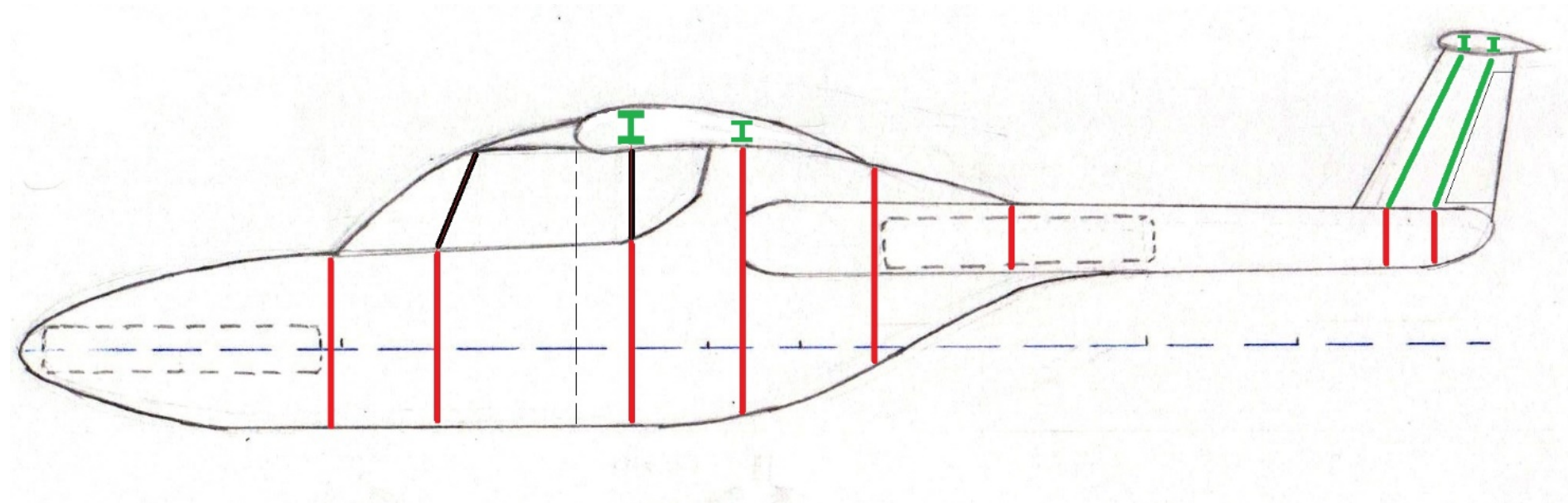
AERODYNAMIC STUDY

- NACA 2412
- Reynolds=5,0176 x 10⁶
- Cl crit=1,8529
- Critical Cl for alfa= 19°

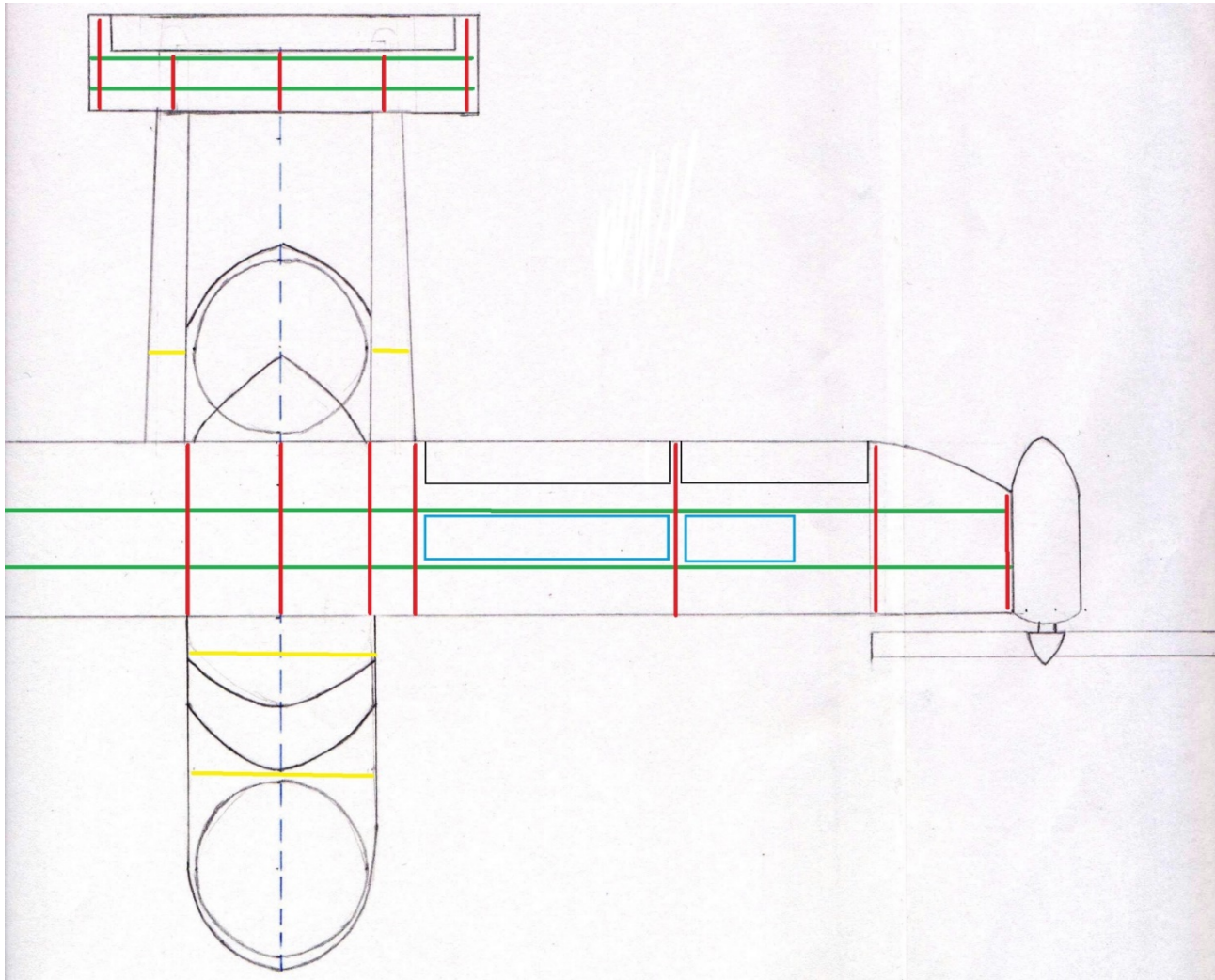




SKETCH

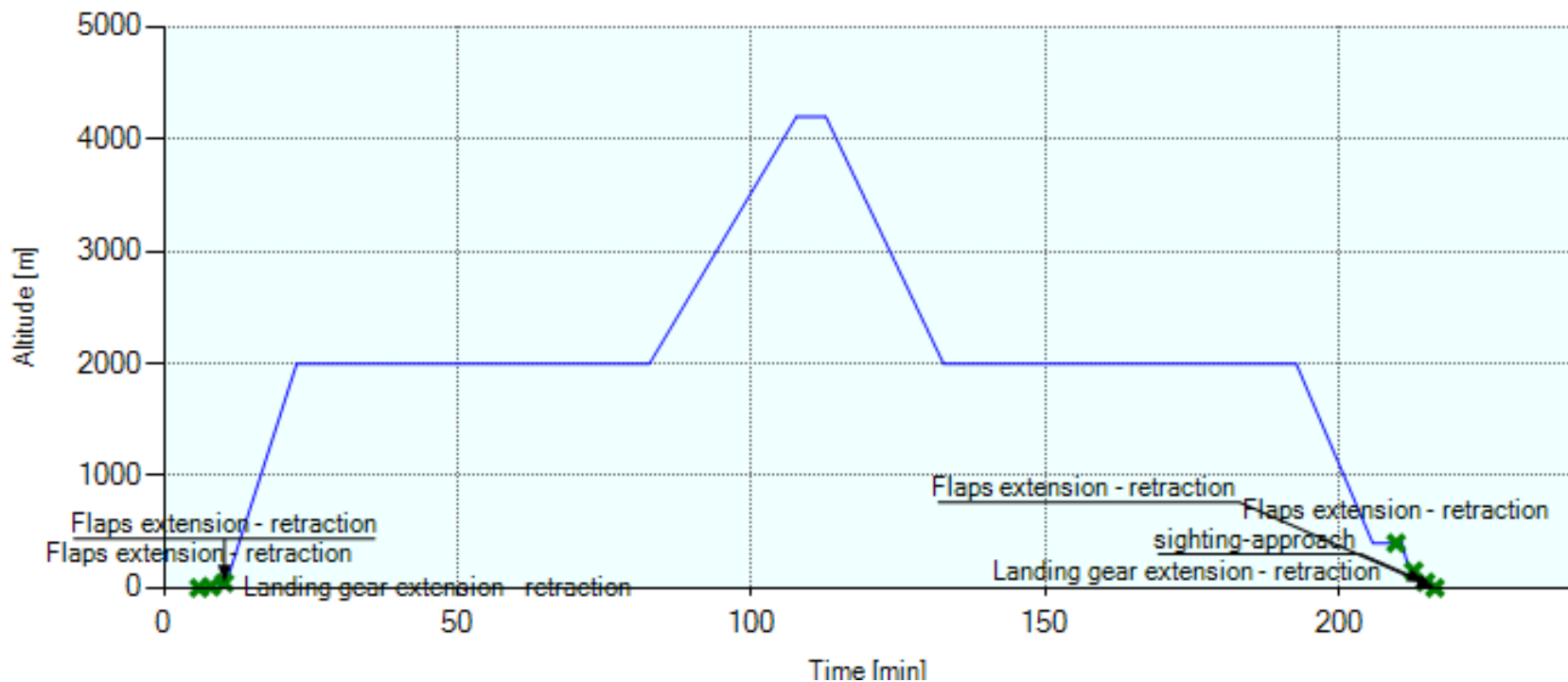


Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



MISSION PROFILE

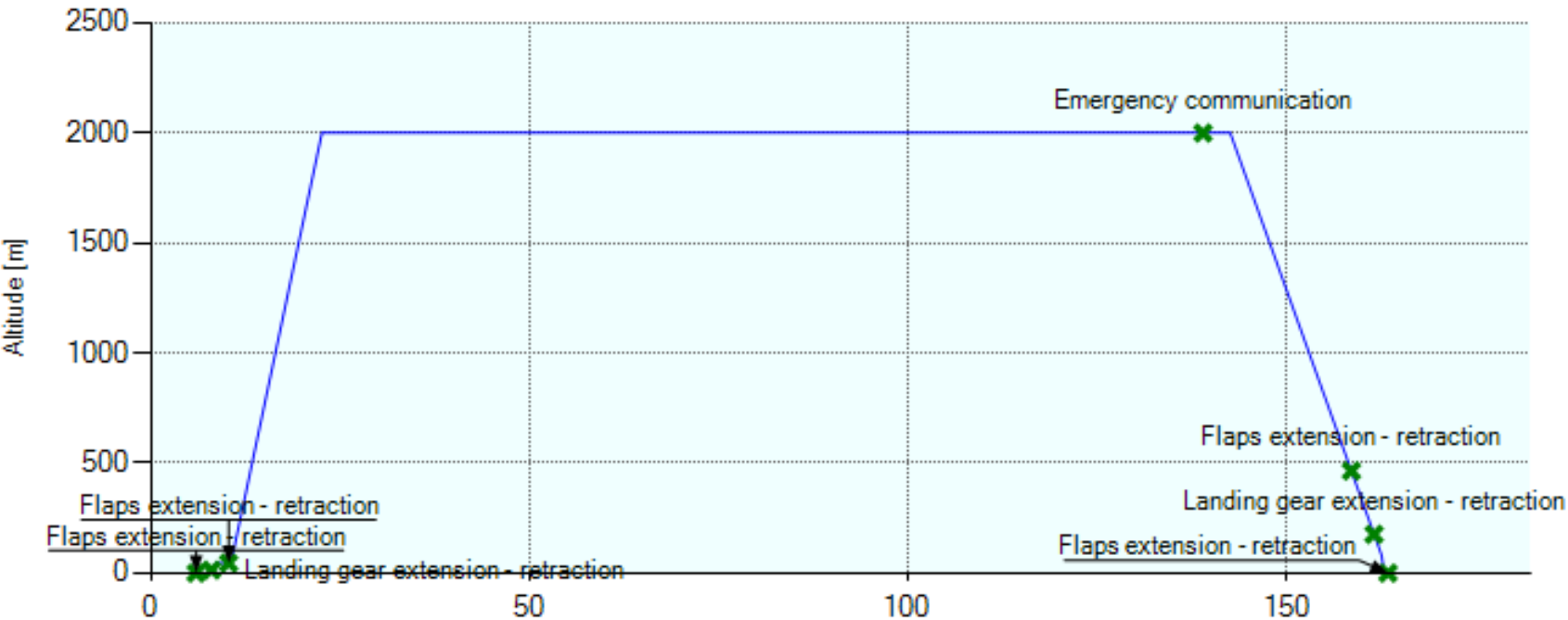
Vertical Takeoff and Landing



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------

Phase	Duration		Altitude (start)	Altitude (end)	Speed	Climb rate	Specific Consumption
	hour	Min	m	m	km/h	m/s	lb/Hp/h
Engine start-up	0	0,3	0	0	0	0	0
Taxi out	0	4,5	0	0	60,0001	0	0,44
Flaps extension - retraction	Start time	60	-	-	-	-	-
Vertical Take off	0	0,8	0	45	0	0,9375	0,46
Landing gear extension - retraction	Start time	25	-	-	-	-	-
Rotors orientation	0	2	45	45	100,0001	0	0,45
Flaps extension - retraction	Start time	85	-	-	-	-	-
Climb	0	12	45	2000	200,0002	2,7153	0,45
1° cruise	1	0	2000	2000	299,9999	0	0,4299
obstacle deviation (climb)	0	25	2000	4200	249,9998	1,4667	0,45
Mini-cruise	0	5	4200	4200	249,9998	0	0,44
obstacle deviation (scent)	0	20	4200	2000	270	-1,8333	0,435
2° cruise	1	0	2000	2000	300	0	0,4299
Descent	0	13	2000	400	240	-2,0513	0,435
Holding	0	5	400	400	200	0	0,4331
Flaps extension - retraction	Start time	80	-	-	-	-	-
2° rotors orientation	0	1	400	200	100	-3,3333	0,45
Vertical Landing	0	4	200	0	20	-0,8333	0,447
Landing gear extension - retraction	Start time	25	-	-	-	-	-
sighting-approach	Start time	75	-	-	-	-	-
Taxi in	0	2	0	0	60	0	0,44
Flaps extension - retraction	Start time	30	-	-	-	-	-
Engine shutdown	0	0,2	0	0	0	0	0

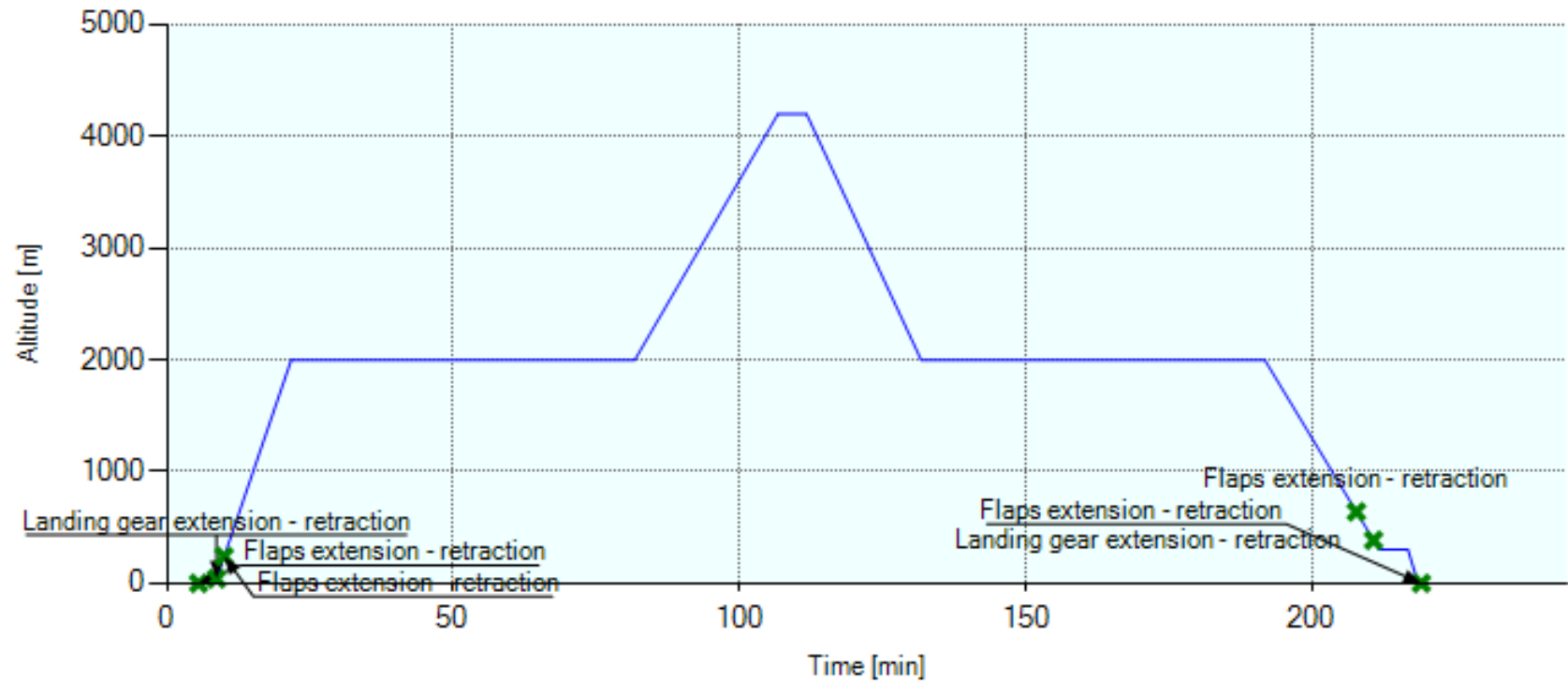
Vertical Takeoff and horizontal Landing – in case of emergency



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------

Phase	Duration		Altitude (start)	Altitude (end)	Speed	Climb rate	Specific Consumption
	hour	Min	m	m	km/h	m/s	lb/Hp/h
Pre - flight checks	0	3	0	0	0	0	0
Engine start-up	0	0,3	0	0	0	0	0
Taxi out	0	4,5	0	0	60,0001	0	0,44
Flaps extension - retraction	Start time	60	-	-	-	-	-
vertical Take off	0	0,8	0	45	0	0,9375	0,46
Landing gear extension - retraction	Start time	30	-	-	-	-	-
Rotors orientation	0	2	45	45	100	0	0,45
Flaps extension - retraction	Start time	85	-	-	-	-	-
Climb	0	12	45	2000	200,0001	2,7153	0,45
cruise	2	0	2000	2000	300	0	0,4299
Emergency communication	Start time	97	-	-	-	-	-
Descent	0	20	2000	80	200	-1,6	0,44
Landing gear extension - retraction	Start time	95	-	-	-	-	-
Flaps extension - retraction	Start time	80	-	-	-	-	-
Landing (manoeuvre)	0	0,3	80	0	150,0001	-4,4444	0,44
Landing (run)	0	0,6	0	0	100	0	0,44
Flaps extension - retraction	Start time	90	-	-	-	-	-
Taxi in	0	2	0	0	60	0	0,4299
Engine shutdown	0	0,2	0	0	0	0	0

Horizontal Takeoff and Landing



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------

Phase	Duration		Altitude (start)	Altitude (end)	Speed	Climb rate	Specific Consumption
	hour	Min	m	m	km/h	m/s	lb/Hp/h
Pre - flight checks	0	3	0	0	0	0	0
Engine start-up	0	0,3	0	0	0	0	0
Taxi out	0	4,5	0	0	60,0001	0	0,4
Flaps extension - retraction	Start time	50	-	-	-	-	-
Take off (run)	0	0,6	0	0	80	0	0,44
Take off (manoeuvre)	0	0,3	0	45	140	2,5	0,46
Landing gear extension - retraction	Start time	90	-	-	-	-	-
Climb	0	13	45	2000	220	2,5064	0,45
Flaps extension - retraction	Start time	10	-	-	-	-	-
1° cruise	1	0	2000	2000	300	0	0,4299
obstacle deviation (climb)	0	25	2000	4200	250	1,4667	0,45
mini-cruise	0	5	4200	4200	280	0	0,4451
obstacle deviation(descent)	0	20	4200	2000	270	-1,8333	0,44
2°cruise	1	0	2000	2000	300	0	0,4299
descent	0	20	2000	300	220	-1,4167	0,44
Landing gear extension - retraction	Start time	95	-	-	-	-	-
Flaps extension - retraction	Start time	80	-	-	-	-	-
Holding	0	5	300	300	170	0	0,44
approach	0	1,5	300	45	150	-2,8333	0,44
Landing (manoeuvre)	0	0,3	45	0	140	-2,5	0,44
Landing (run)	0	0,6	0	0	100	0	0,44
Flaps extension - retraction	Start time	90	-	-	-	-	-
Taxi in	0	3	0	0	60	0	0,44
Engine shutdown	0	0,2	0	0	0	0	0

Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------

CAD



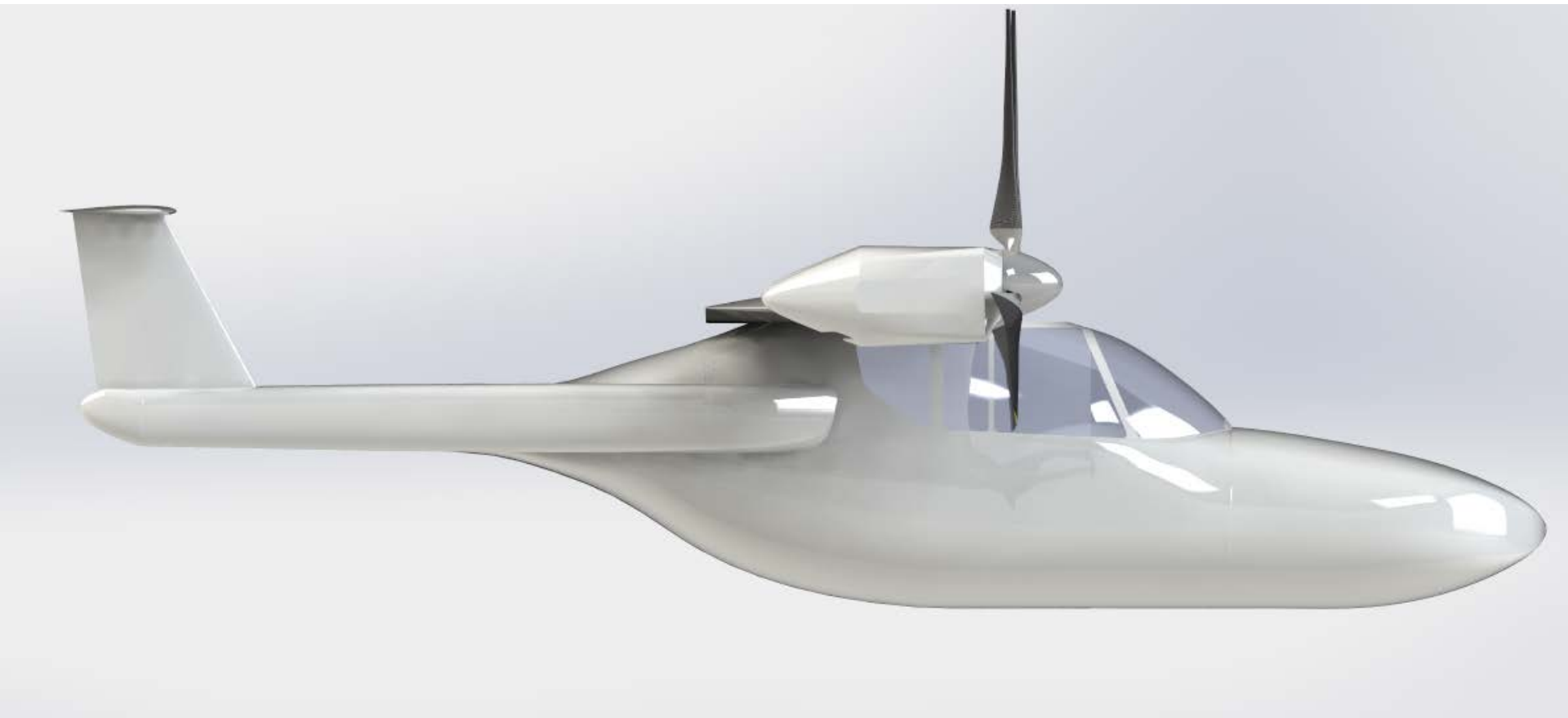
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



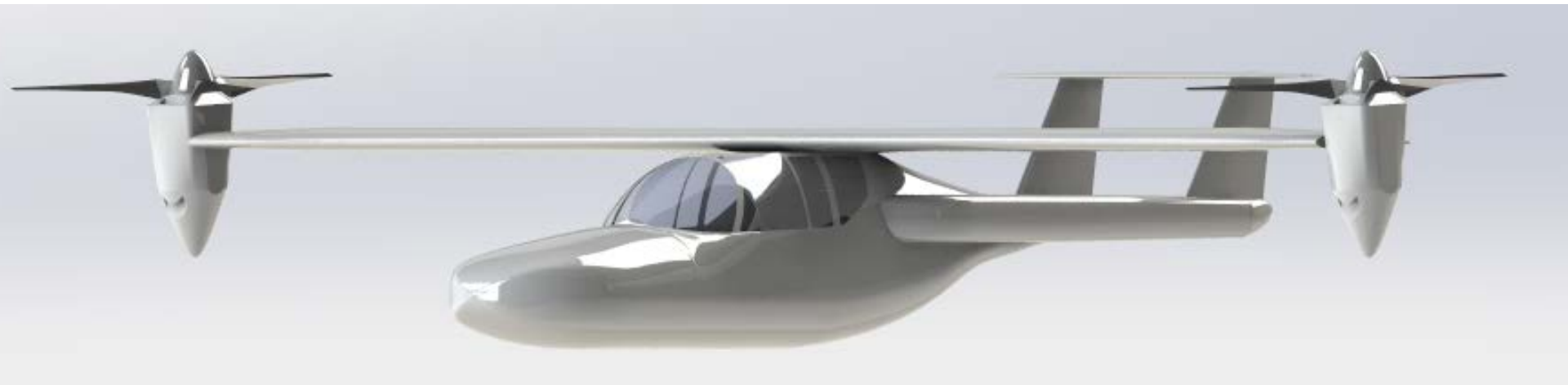
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



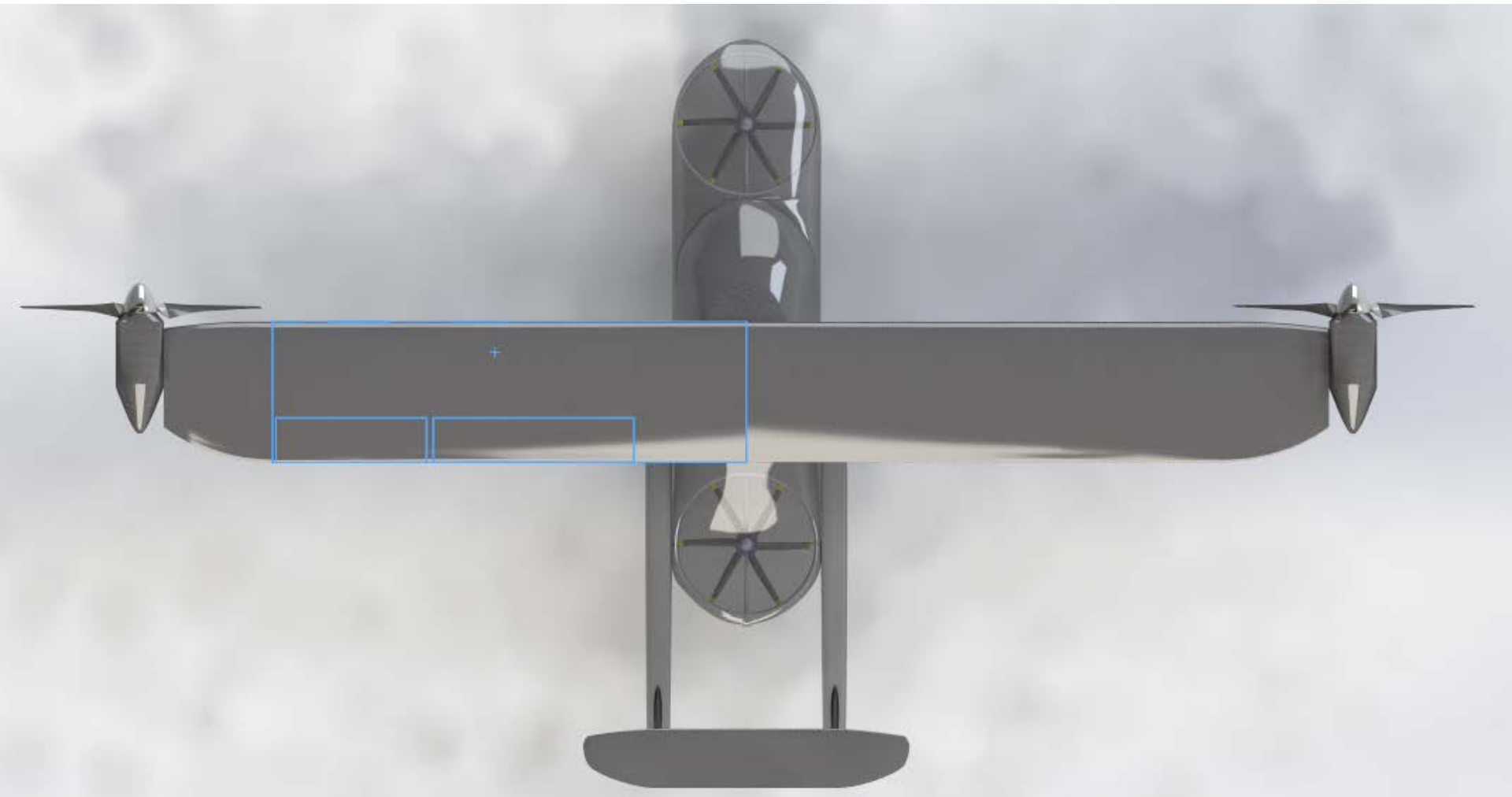
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



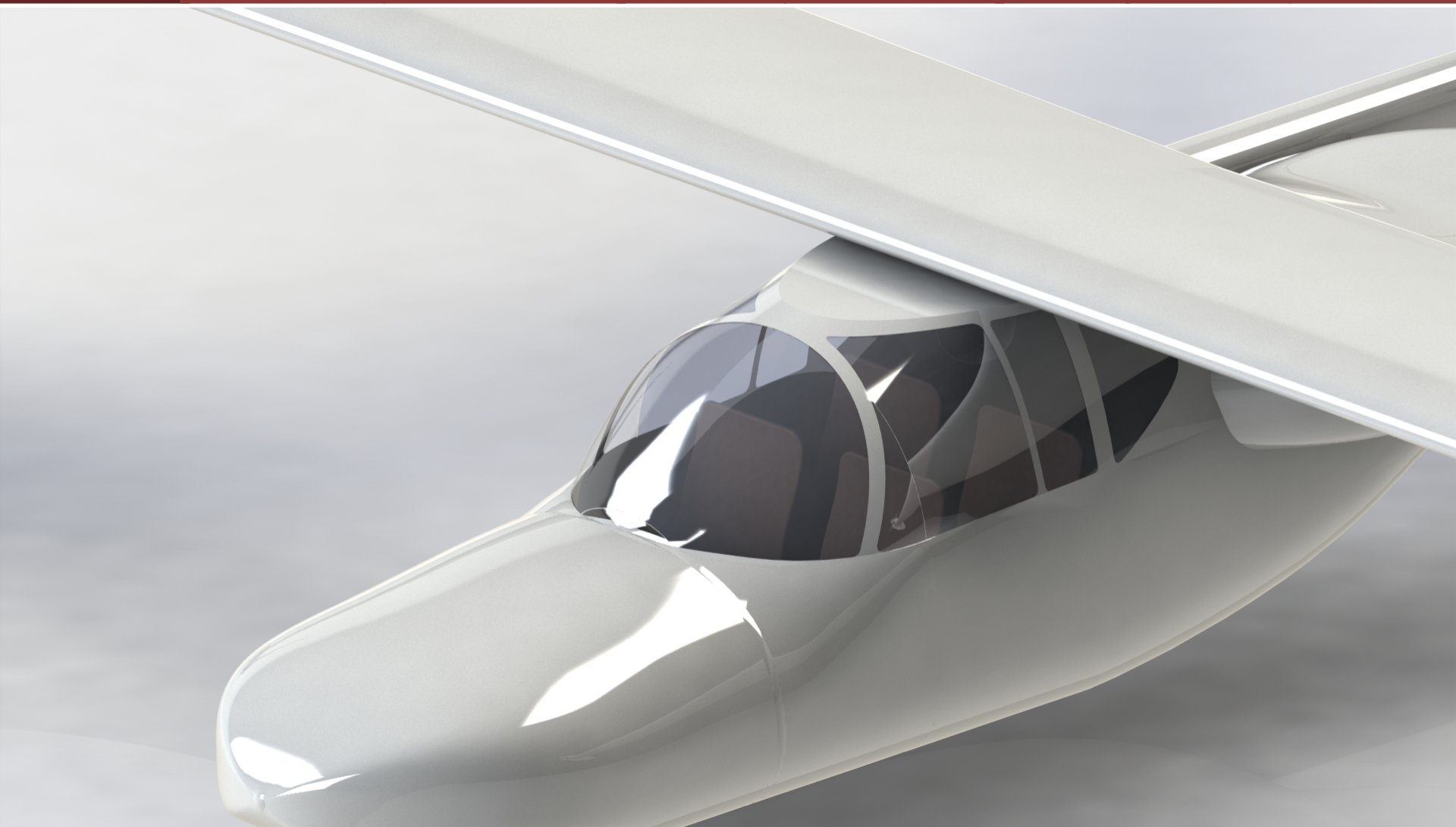
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



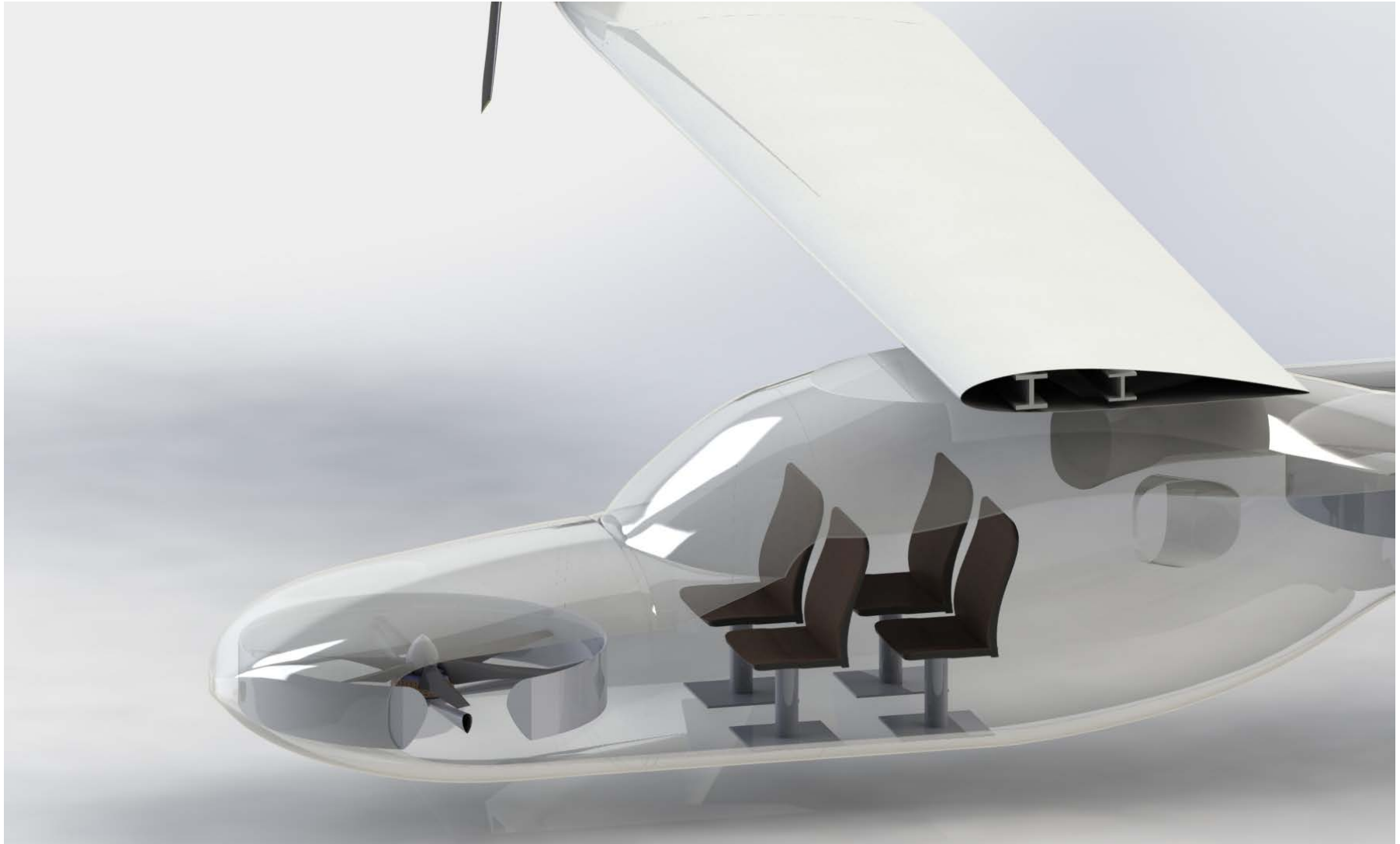
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



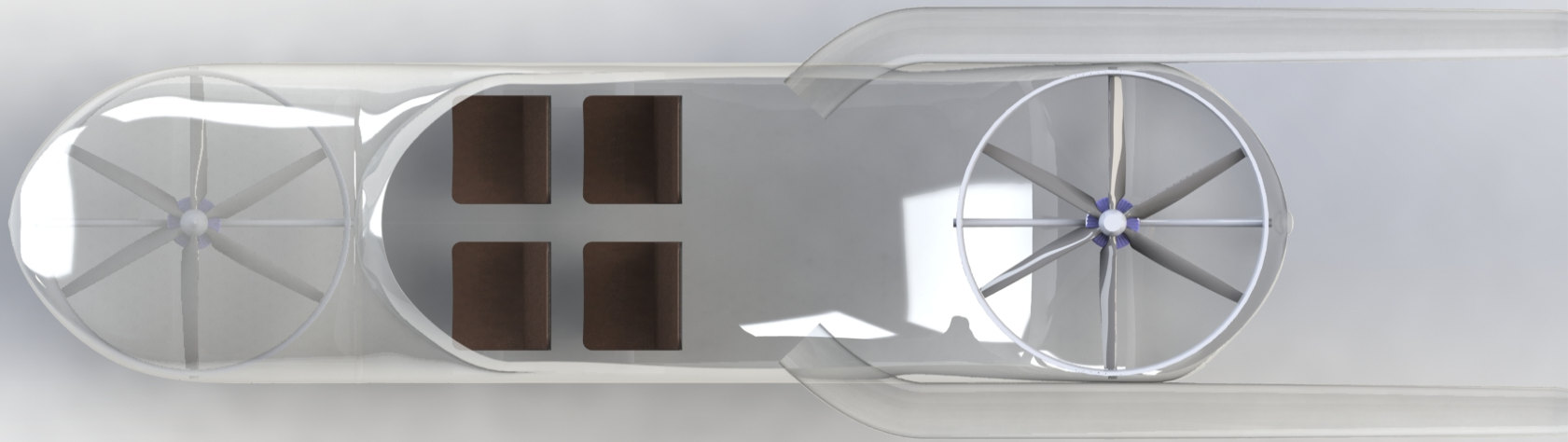
Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------



Project Requisites	Aircraft References	Preliminary considerations	Overview	Aerodynamic study	Sketch	Mission profile	CAD 3D
--------------------	---------------------	----------------------------	----------	-------------------	--------	-----------------	--------





Any Questions?

