Design Input Parameters

Requirement Goals

Payload Weight	**15 Kg**
Flight Endurance	**2 Hours**
Handling Qualities	**Compact, Portable**
Mission	**Payload Delivery, Reconnaissance**

Design Goals

Cruise Velocity (Cr V)	**100-120 Km/hr**
Max Velocity (Max V)	**130 Km/hr**
Rate of Climb (ROC)	**5 m/s**
Maximum Range (Max R)	**200 Km**
Service Ceiling (H)	**2000 m**
Atmosphere Model	**Indian Standard Atmosphere**

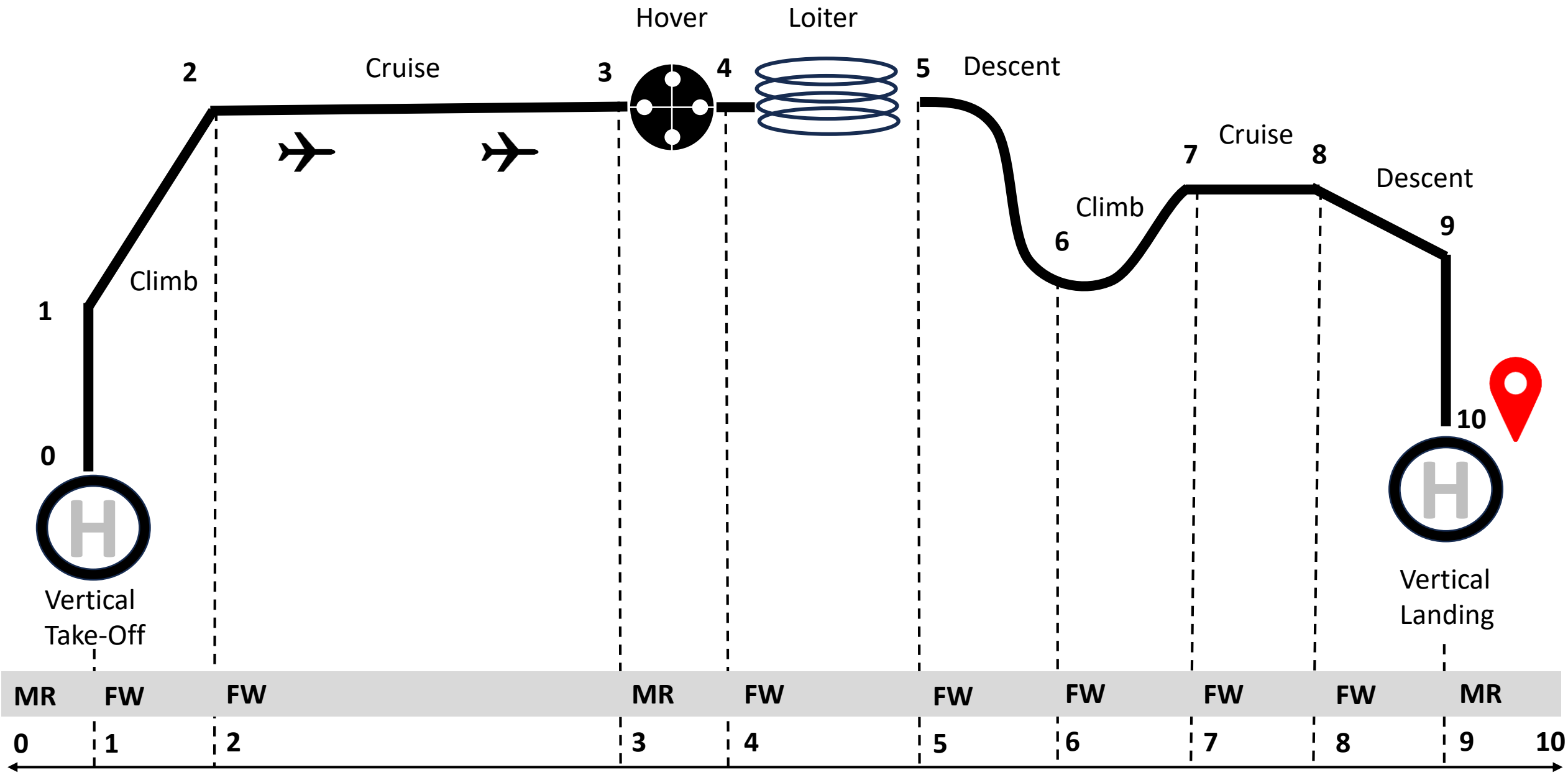
Features

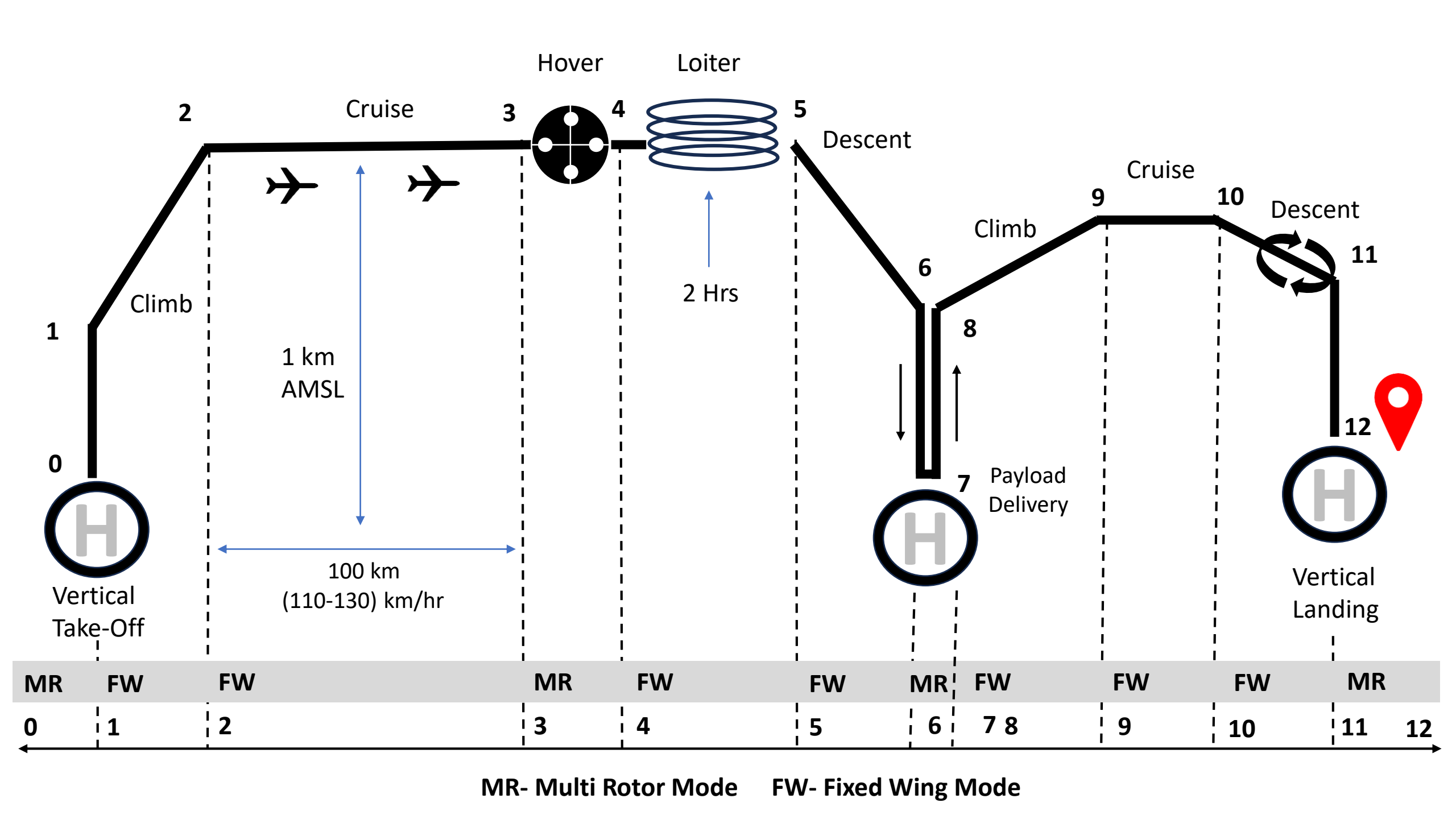
Low Gross Take-off Weight

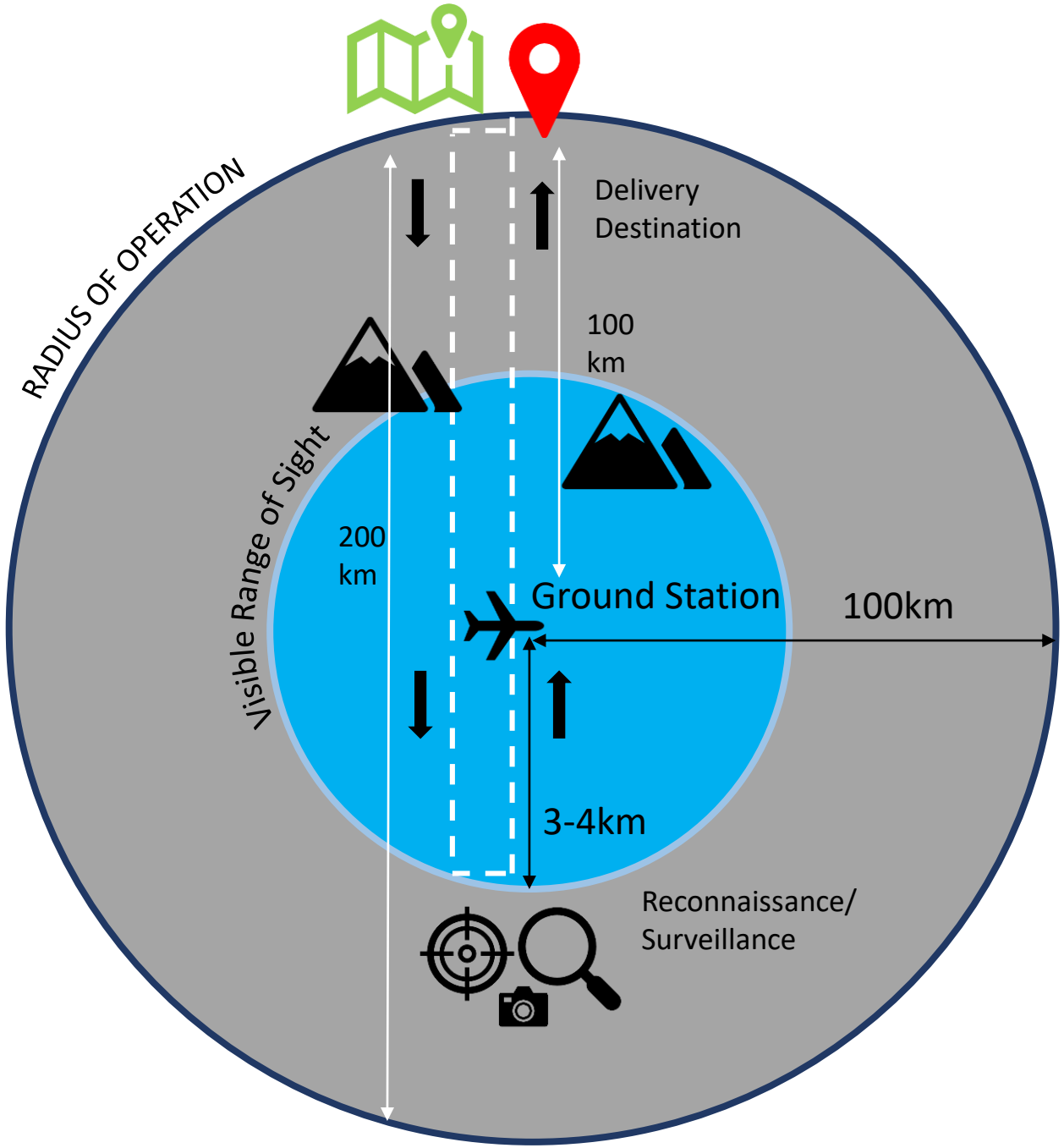
Autonomous

Easy Assembly (DIY)

Low Acoustics (Toroidal Propeller)


Hover
Loiter
2
Cruise
3
4
5
Descent
Cruise
7
8
Descent
Climb
6
9
Climb
1
10
0
Vertical
Take-Off
Vertical
Landing
MR
FW
FW
MR
FW
FW
FW
FW
FW
MR
0
1
2
3
4
5
6
7
8
9
10


Hover
Loiter
Cruise
Descent
Cruise
Climb
Descent
Climb
2 Hrs
1 km
AMSL
100 km
(110-130) km/hr
Payload
Delivery
Vertical
Take-Off
Vertical
Landing
0
1
2
3
4
5
6
7
8
9
10
11
12
MR
FW
FW
MR
FW
FW
MR
FW
FW
FW
MR
0
1
2
3
4
5
6
7 8
9
10
11
12
MR- Multi Rotor Mode
FW- Fixed Wing Mode



MISSION Analysis- **VTOL Defense**:

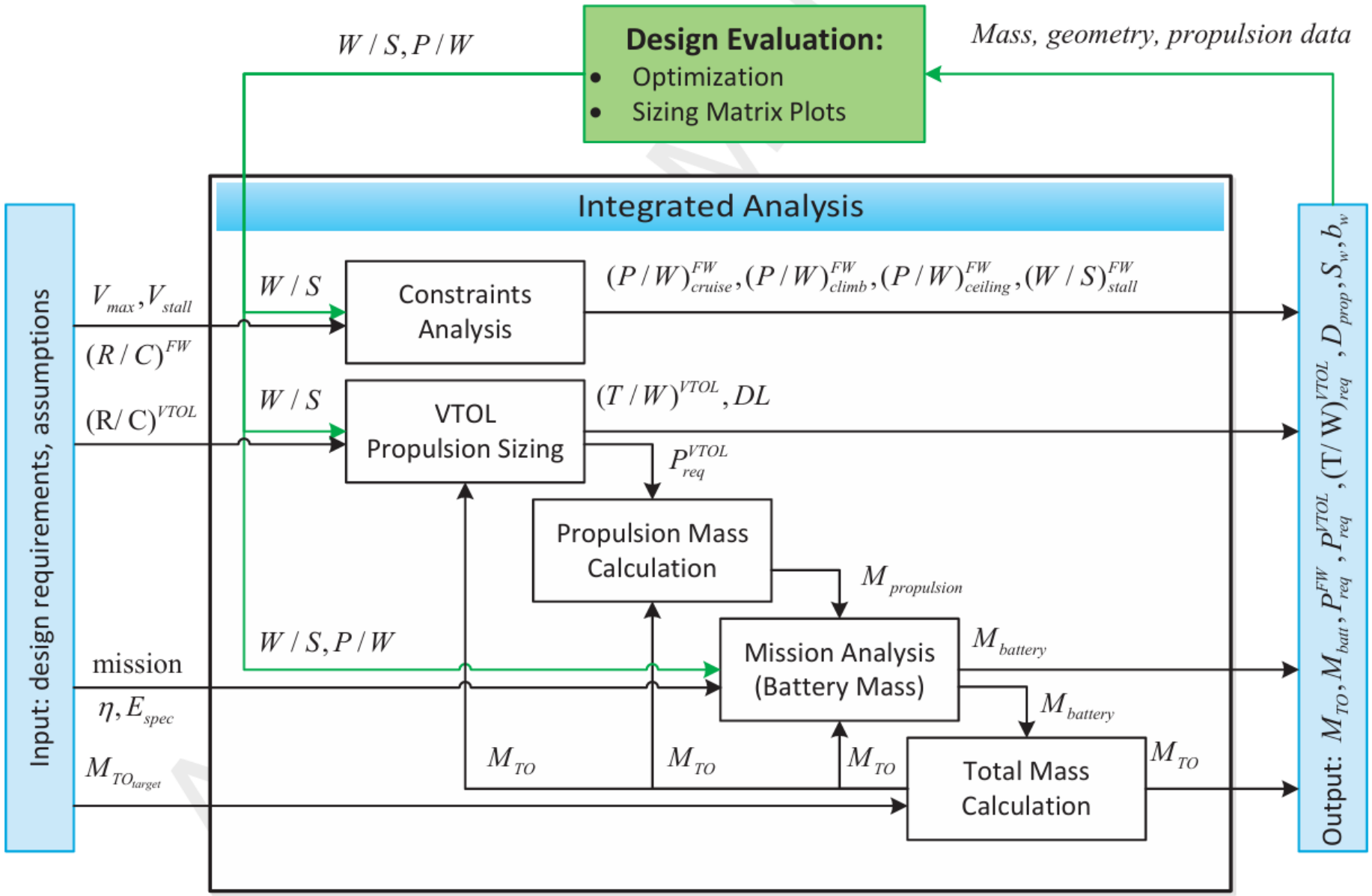
Total maximum operating range: **200 km**

Loiter Endurance : **2 Hrs**

Payload: **15 Kg**

Task**: Military Reconnaissance, Surveillance, Payload Delivery.**

Mode:
VTOL-Multirotor Mode: Take-off, Landing, Hover.
Fixed Wing Mode: Cruise, Climb, Loiter, Descent.


Design Evaluation:
Optimization
Sizing Matrix Plots
$W/S, P/W$
Mass, geometry, propulsion data
Integrated Analysis
Input: design requirements, assumptions
V_{max}, V_{stall}
$(R/C)^{FW}$
$(R/C)^{VTOL}$
mission
η, E_{spec}
$M_{TO_{target}}$
W/S
Constraints Analysis
$(P/W)^{FW}_{cruise}, (P/W)^{FW}_{climb}, (P/W)^{FW}_{ceiling}, (W/S)^{FW}_{stall}$
VTOL Propulsion Sizing
$(T/W)^{VTOL}, DL$
P^{VTOL}_{req}
Propulsion Mass Calculation
$M_{propulsion}$
Mission Analysis (Battery Mass)
$M_{battery}$
Total Mass Calculation
M_{TO}
Output: $M_{TO}, M_{batt}, P^{FW}_{req}, P^{VTOL}_{req}, (T/W)^{VTOL}_{req}, D_{prop}, S_w, b_w$

$$Wo = Wcrew + Wpayload + Wfuel + Wempty$$

$$Wgross = \frac{Wcrew + Wpayload}{1 - \left(\frac{Wfuel}{Wgross}\right) - \left(\frac{Wempty}{Wgross}\right)}$$

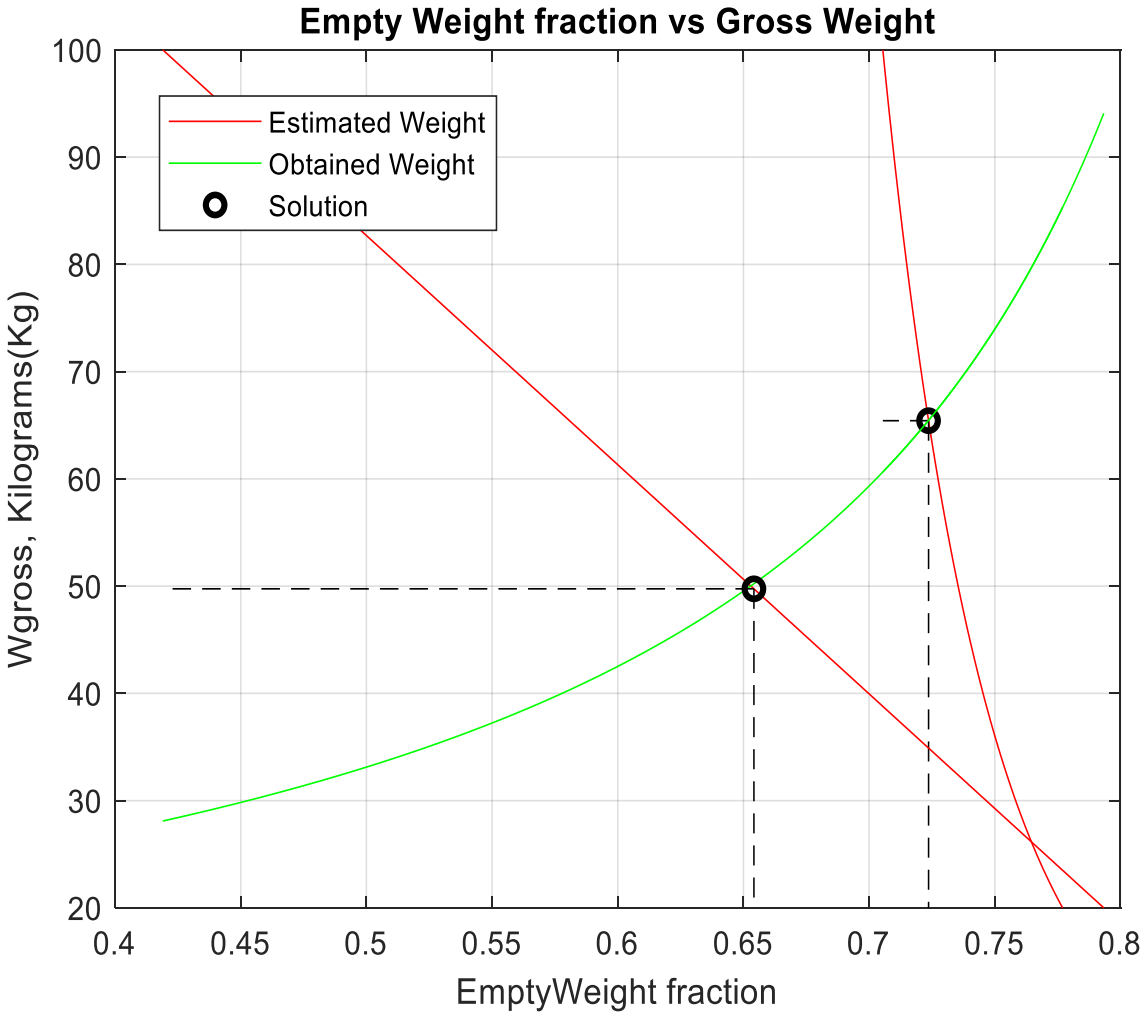
$$\frac{Wempty}{Wgross} = 1.05 * \left((estimatedWgross)^{-0.05}\right) * 1$$

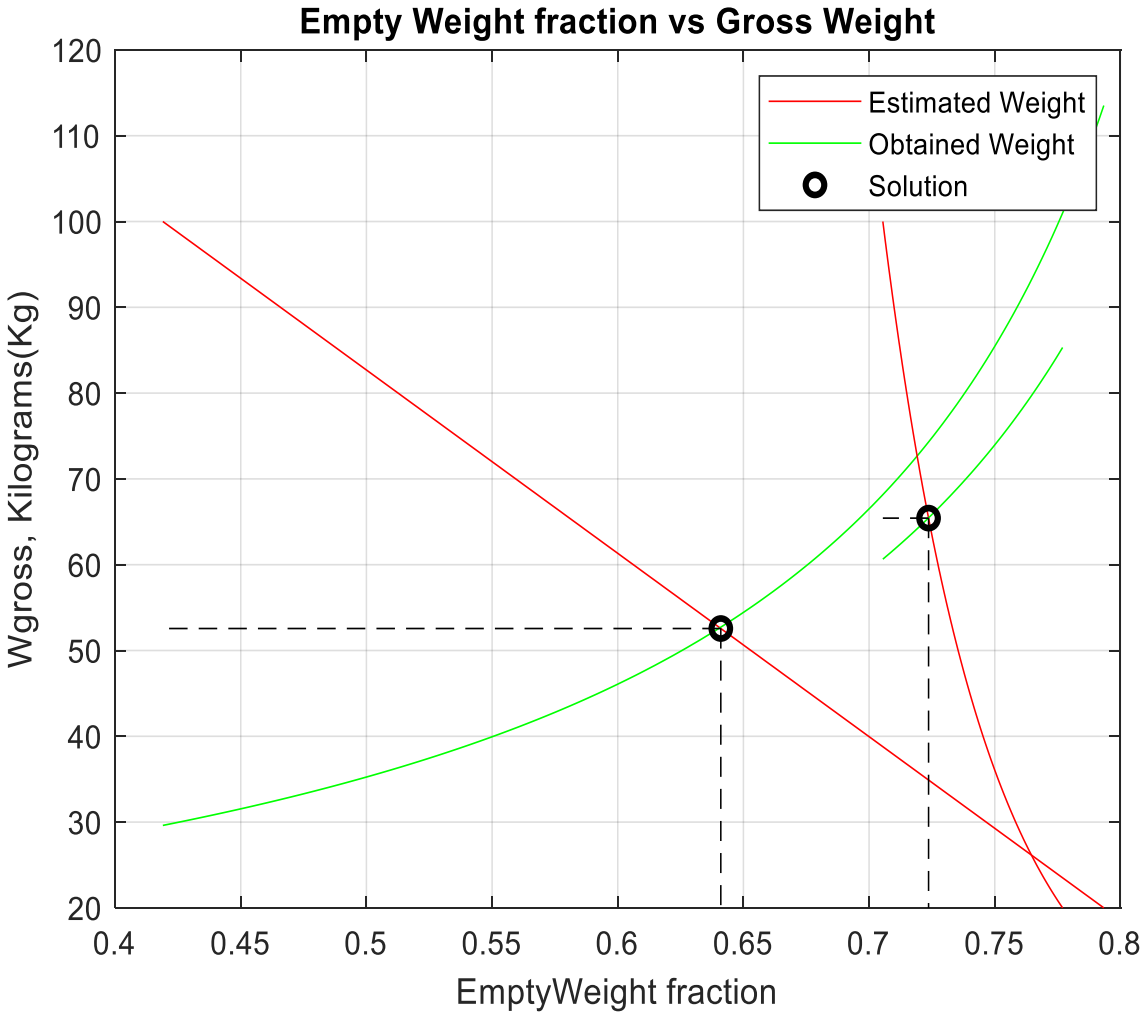
$$\frac{W20}{Wgross} = \left(\frac{W1}{W0}\right) * \left(\frac{W2}{W1}\right) * \left(\frac{W3}{W2}\right) * \left(\frac{W4}{W3}\right) * \left(\frac{W5}{W4}\right) \ldots . * \left(\frac{W20}{W19}\right)$$

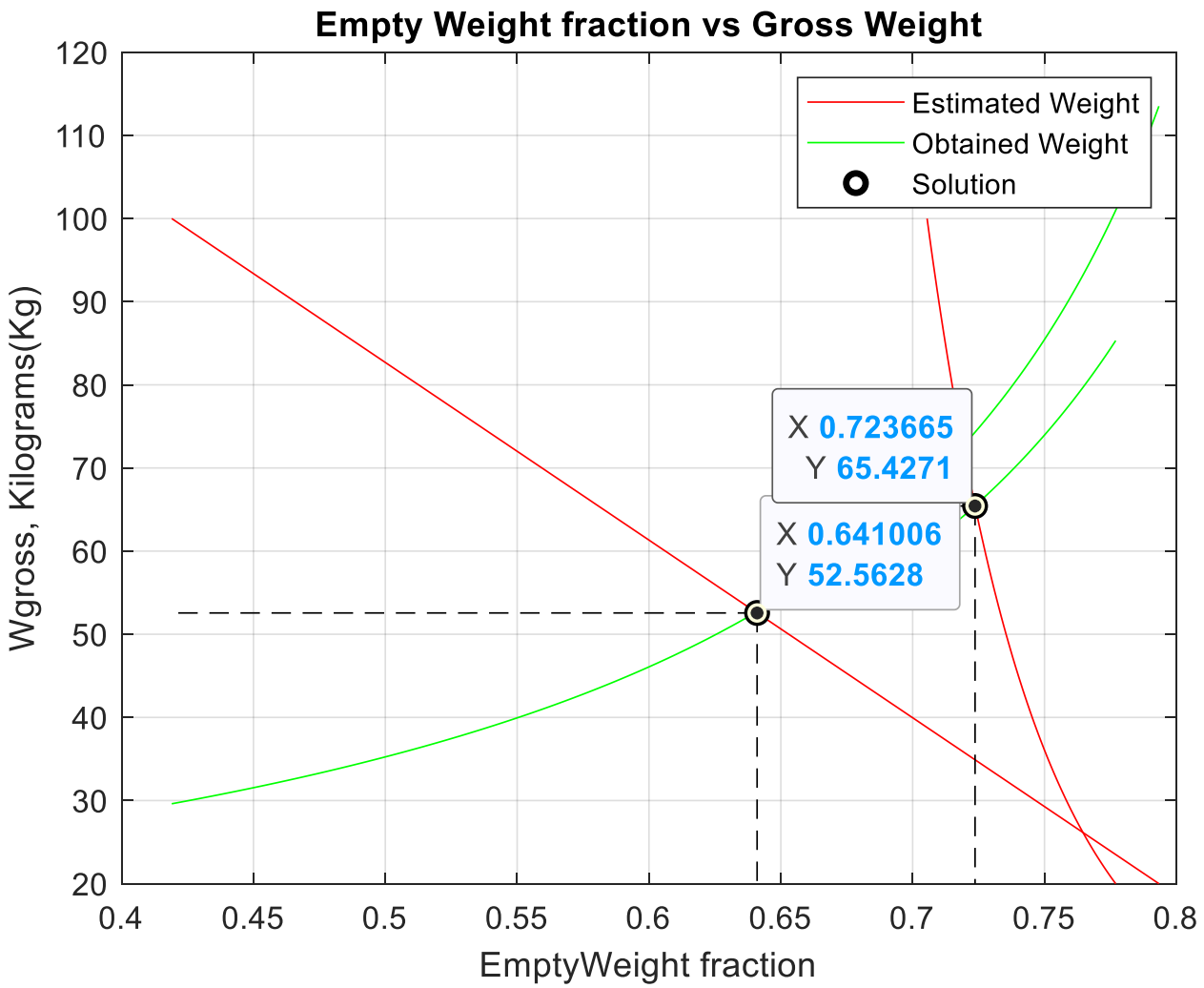
$$\frac{Wfuel}{Wgross} = 1.06 * \left(1 - \frac{W20}{Wgross}\right)$$

$$\frac{Wi}{Wi - 1} = \exp\left(-\left(R * \frac{Ct}{V * \left(\frac{L}{D}\right) cruise}\right)\right)$$

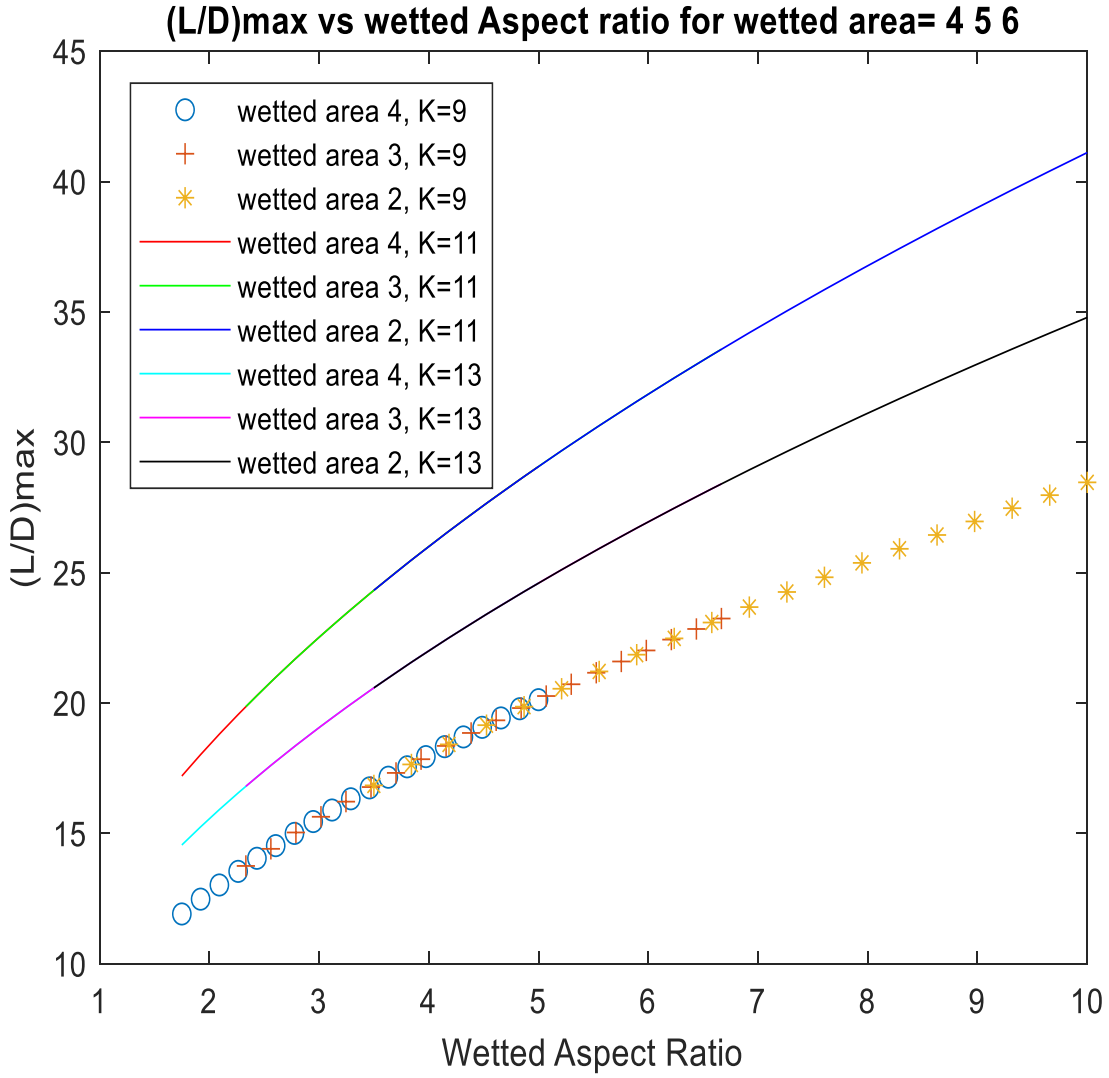
$$\frac{Wi}{Wi - 1} = \exp\left(-\left(E * \frac{Ct}{\left(\frac{L}{D}\right) loiter}\right)\right)$$

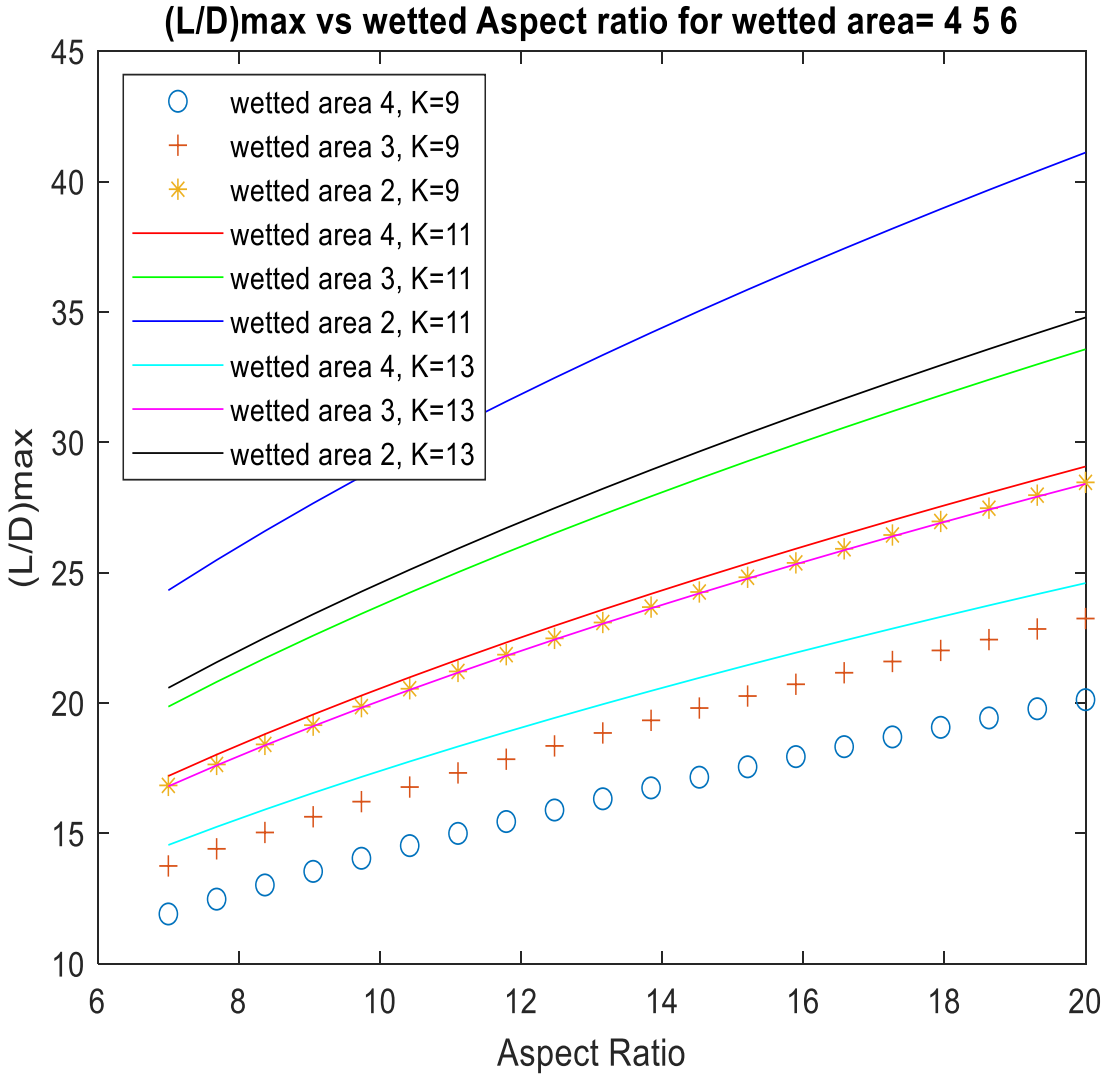

Empty Weight fraction vs Gross Weight
Estimated Weight
Obtained Weight
Solution
Wgross, Kilograms(Kg)
EmptyWeight fraction
100
90
80
70
60
50
40
30
20
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8

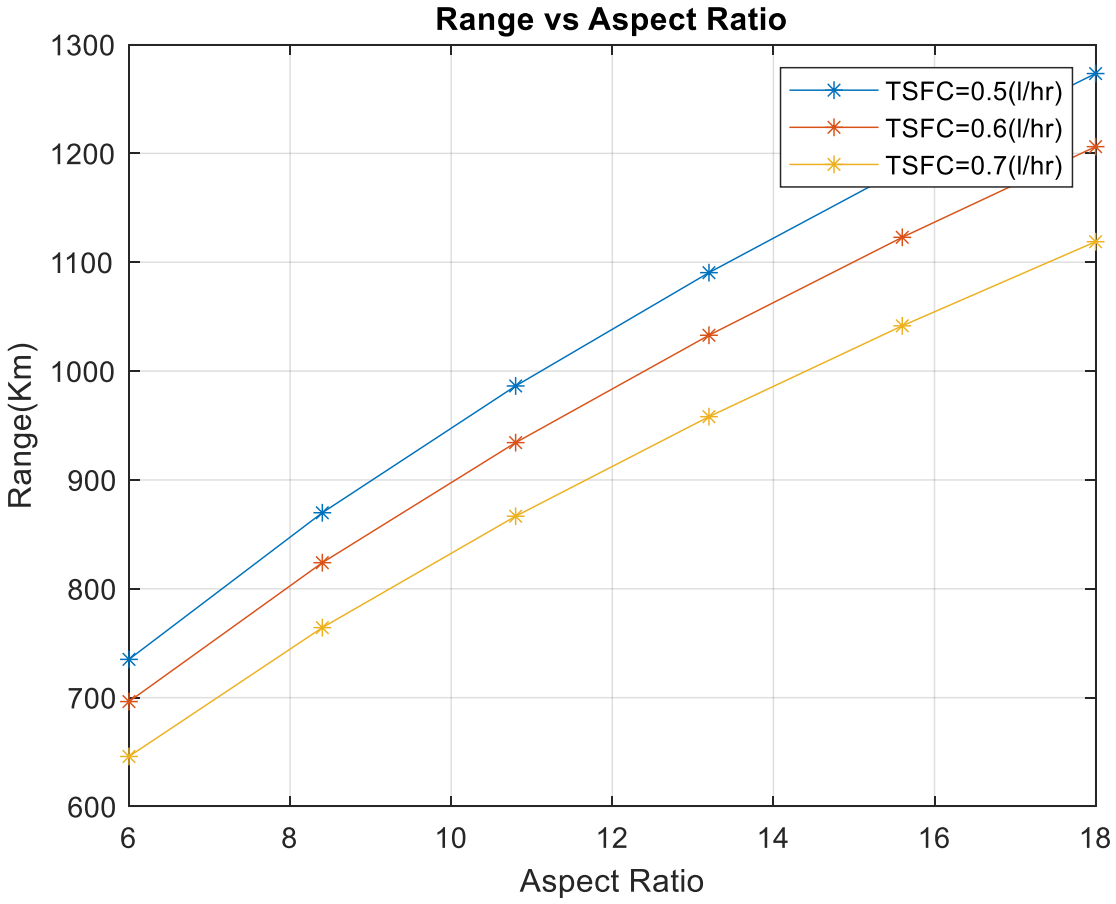

Empty Weight fraction vs Gross Weight
Estimated Weight
Obtained Weight
Solution
Wgross, Kilograms(Kg)
EmptyWeight fraction
120
110
100
90
80
70
60
50
40
30
20
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8

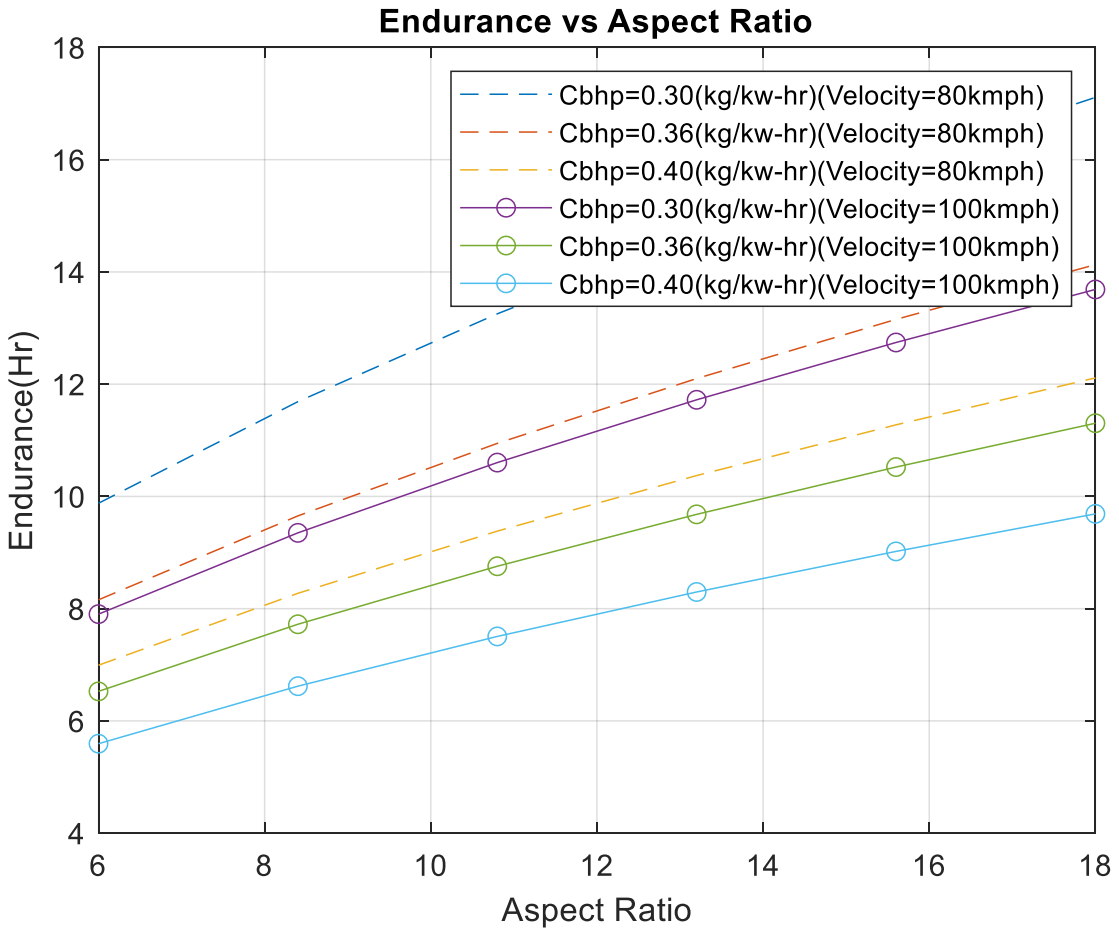


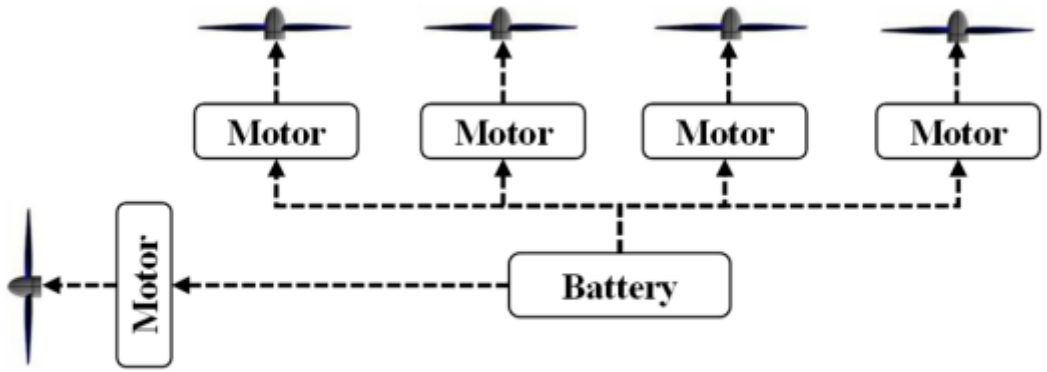
Wgross =	52.6067 kg
CalculatedWempty =	33.6931 kg
CalculatedWfuel =	3.9137 kg
Wpayload =	15 kg
Wcrew =	0 kg
Weightwithnopayload =	37.6067 kg


(L/D)max vs wetted Aspect ratio for wetted area= 4 5 6
wetted area 4, K=9
wetted area 3, K=9
wetted area 2, K=9
wetted area 4, K=11
wetted area 3, K=11
wetted area 2, K=11
wetted area 4, K=13
wetted area 3, K=13
wetted area 2, K=13
(L/D)max
Wetted Aspect Ratio
45
40
35
30
25
20
15
10
1
2
3
4
5
6
7
8
9
10

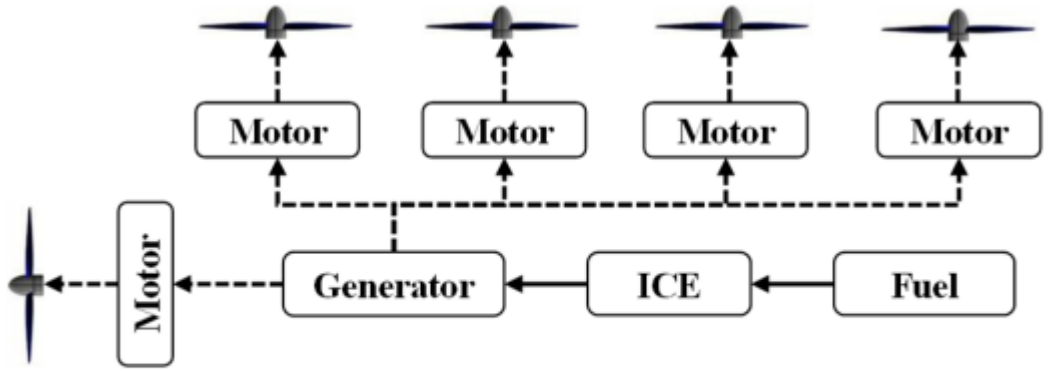

(L/D)max vs wetted Aspect ratio for wetted area= 4 5 6
wetted area 4, K=9
wetted area 3, K=9
wetted area 2, K=9
wetted area 4, K=11
wetted area 3, K=11
wetted area 2, K=11
wetted area 4, K=13
wetted area 3, K=13
wetted area 2, K=13
(L/D)max
Aspect Ratio
45
40
35
30
25
20
15
10
6
8
10
12
14
16
18
20


Range vs Aspect Ratio
TSFC=0.5(l/hr)
TSFC=0.6(l/hr)
TSFC=0.7(l/hr)
Range(Km)
Aspect Ratio
1300
1200
1100
1000
900
800
700
600
6
8
10
12
14
16
18

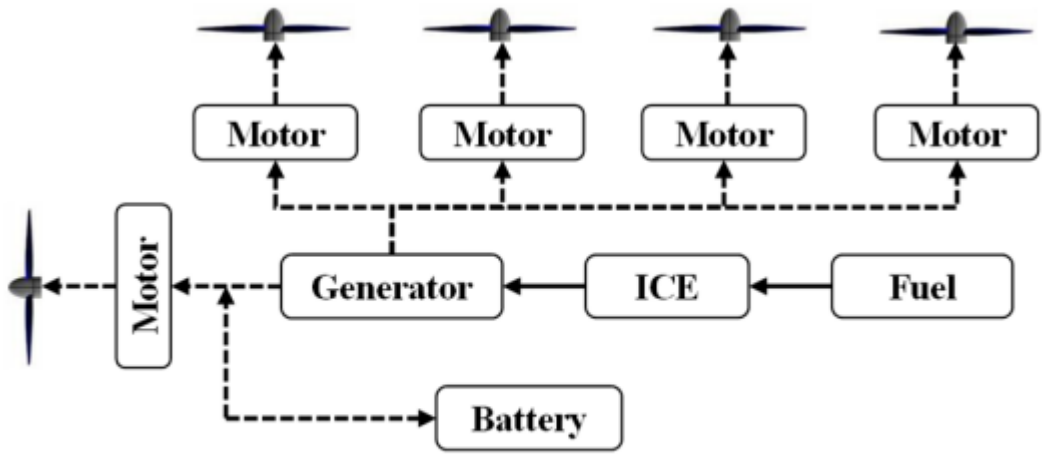

Endurance vs Aspect Ratio
Cbhp=0.30(kg/kw-hr)(Velocity=80kmph)
Cbhp=0.36(kg/kw-hr)(Velocity=80kmph)
Cbhp=0.40(kg/kw-hr)(Velocity=80kmph)
Cbhp=0.30(kg/kw-hr)(Velocity=100kmph)
Cbhp=0.36(kg/kw-hr)(Velocity=100kmph)
Cbhp=0.40(kg/kw-hr)(Velocity=100kmph)
Endurance(Hr)
Aspect Ratio
18
16
14
12
10
8
6
4
6
8
10
12
14
16
18



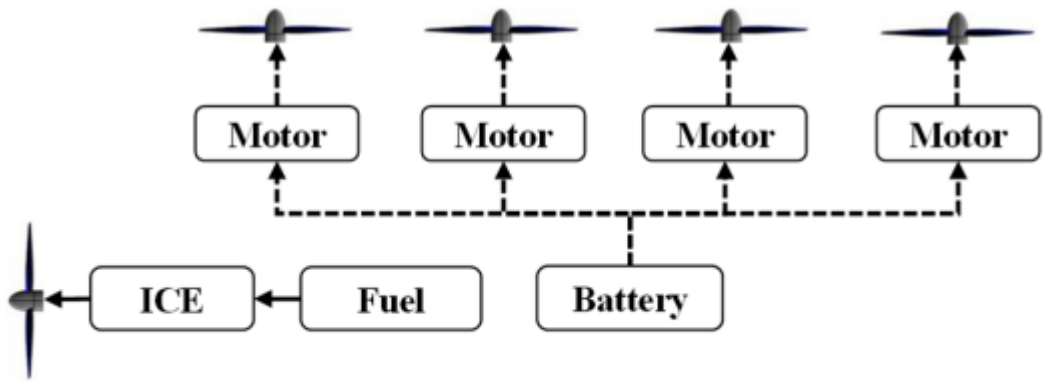
All electric propulsion system



Turboelectric propulsion system



Series hybrid-electric propulsion system



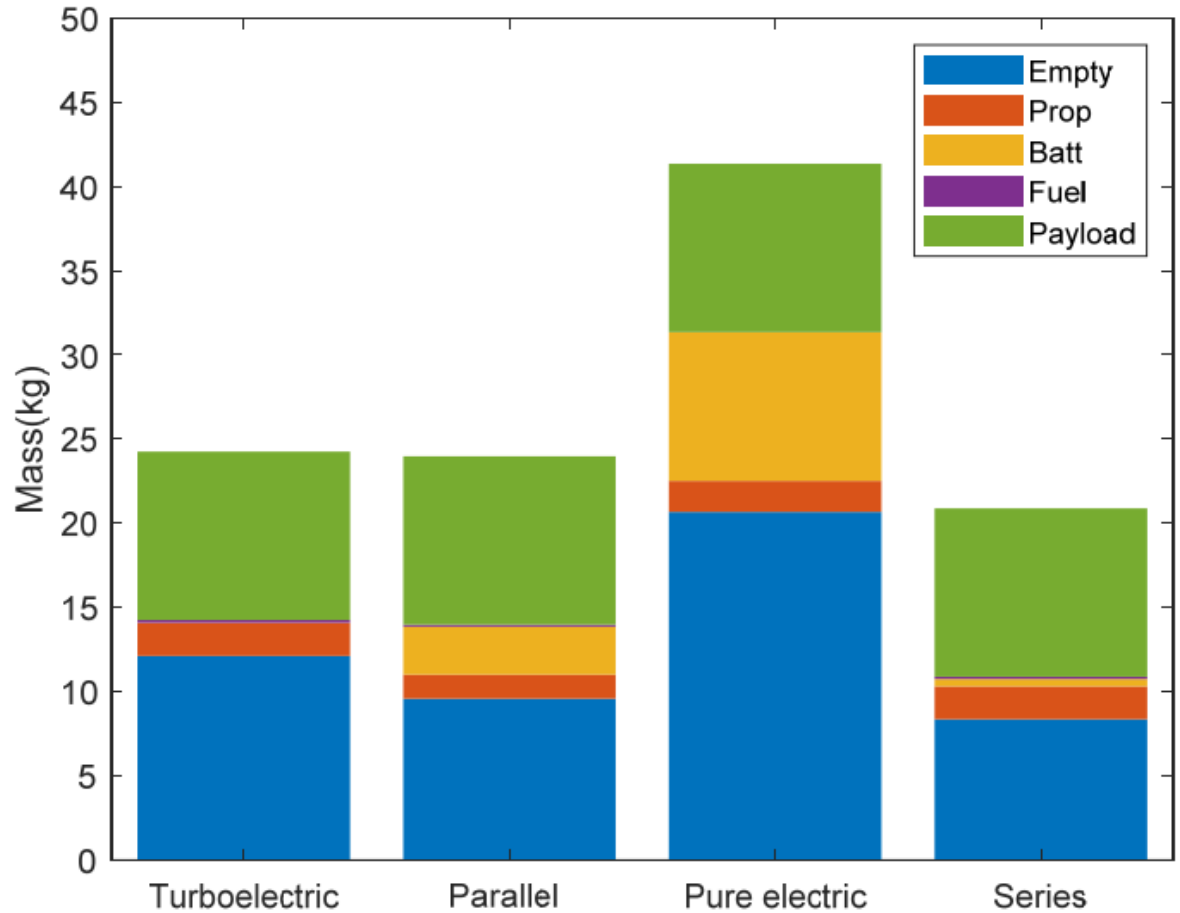
Parallel hybrid-electric propulsion system

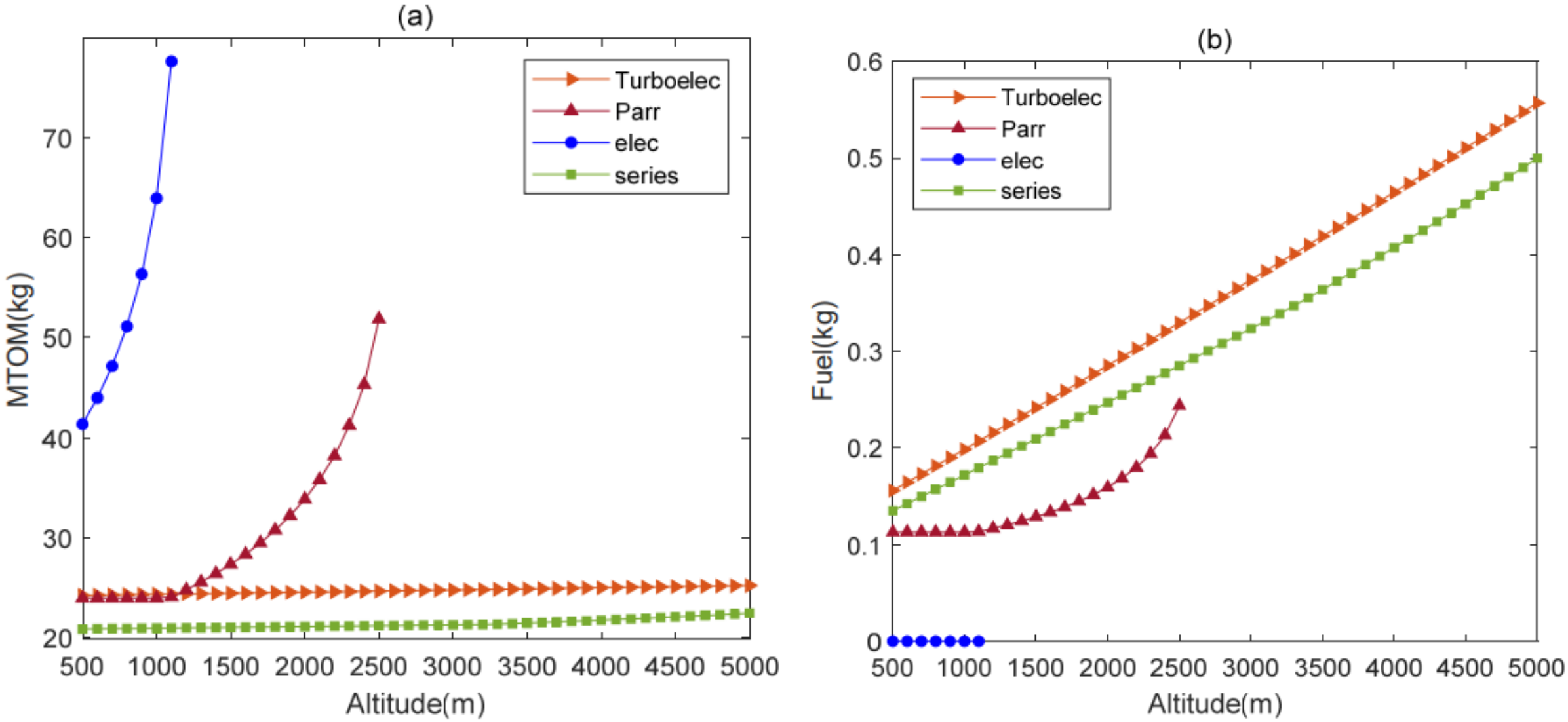
Table 3. Performance requirements.

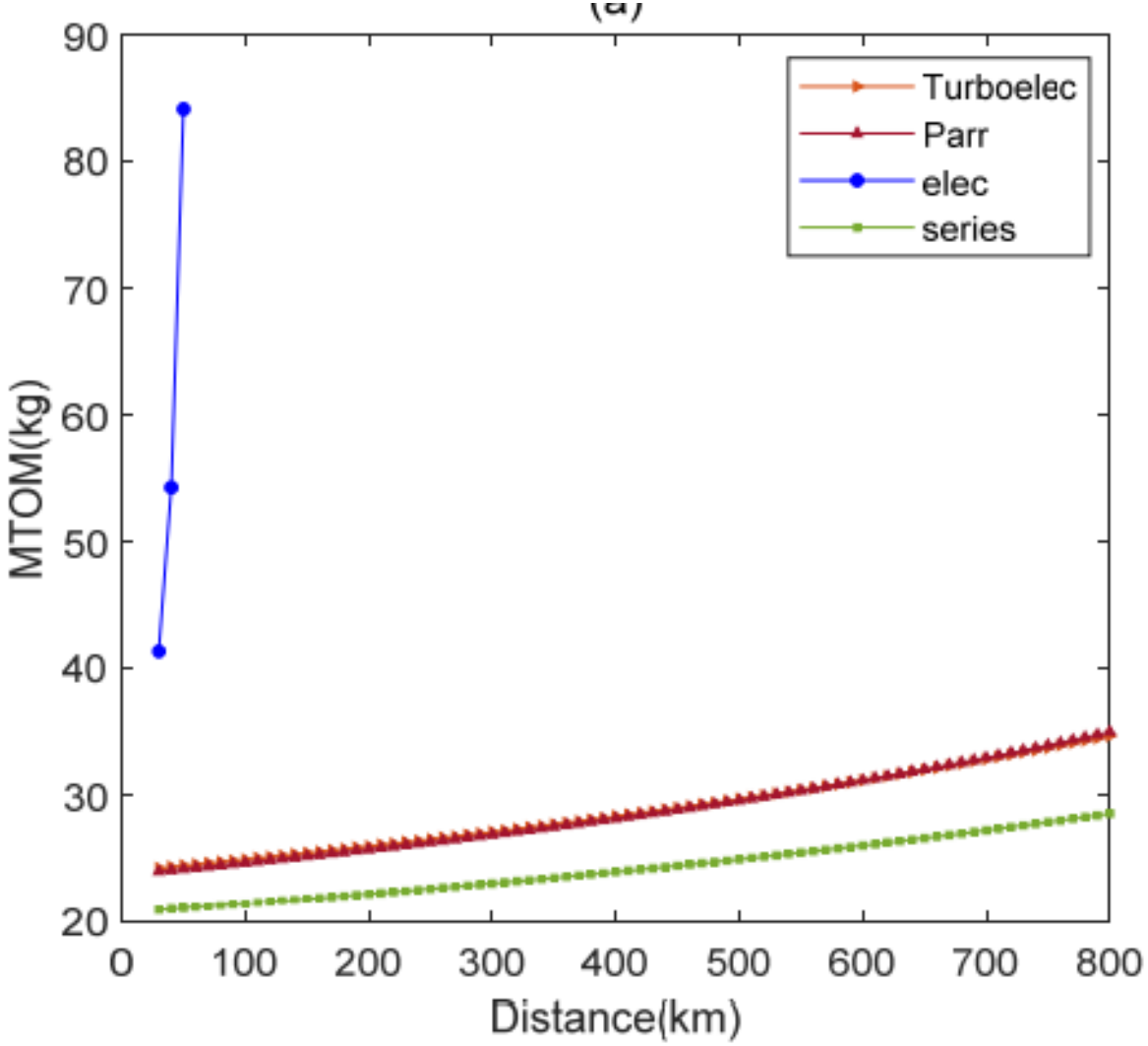
Performance	Value
Cruise speed	30 m/s
ROC	3 m/s
Service ceiling	1000 m
Stall speed	12.5 m/s
Payload	10 kg

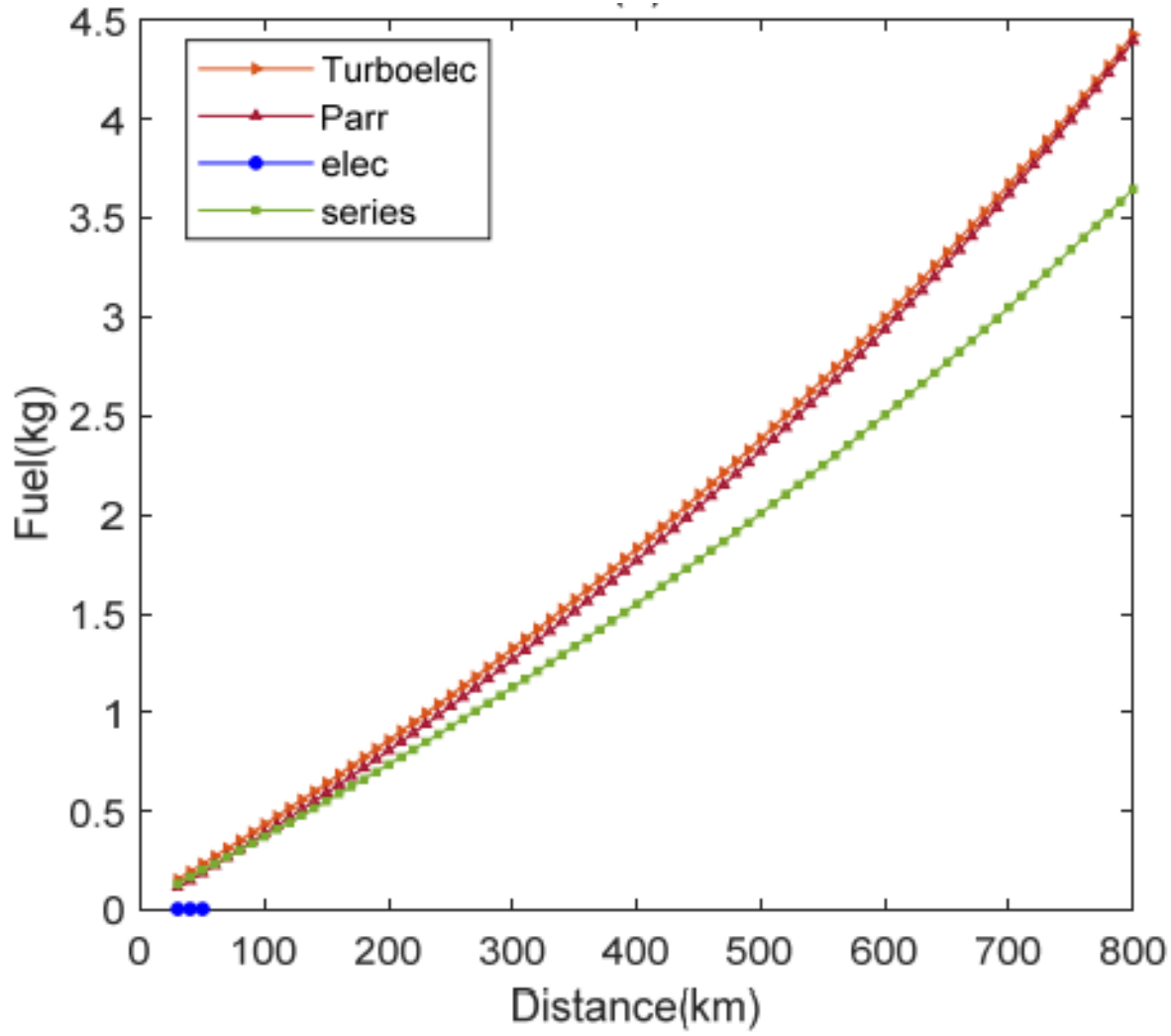
Table 4. Mission profile paraments.

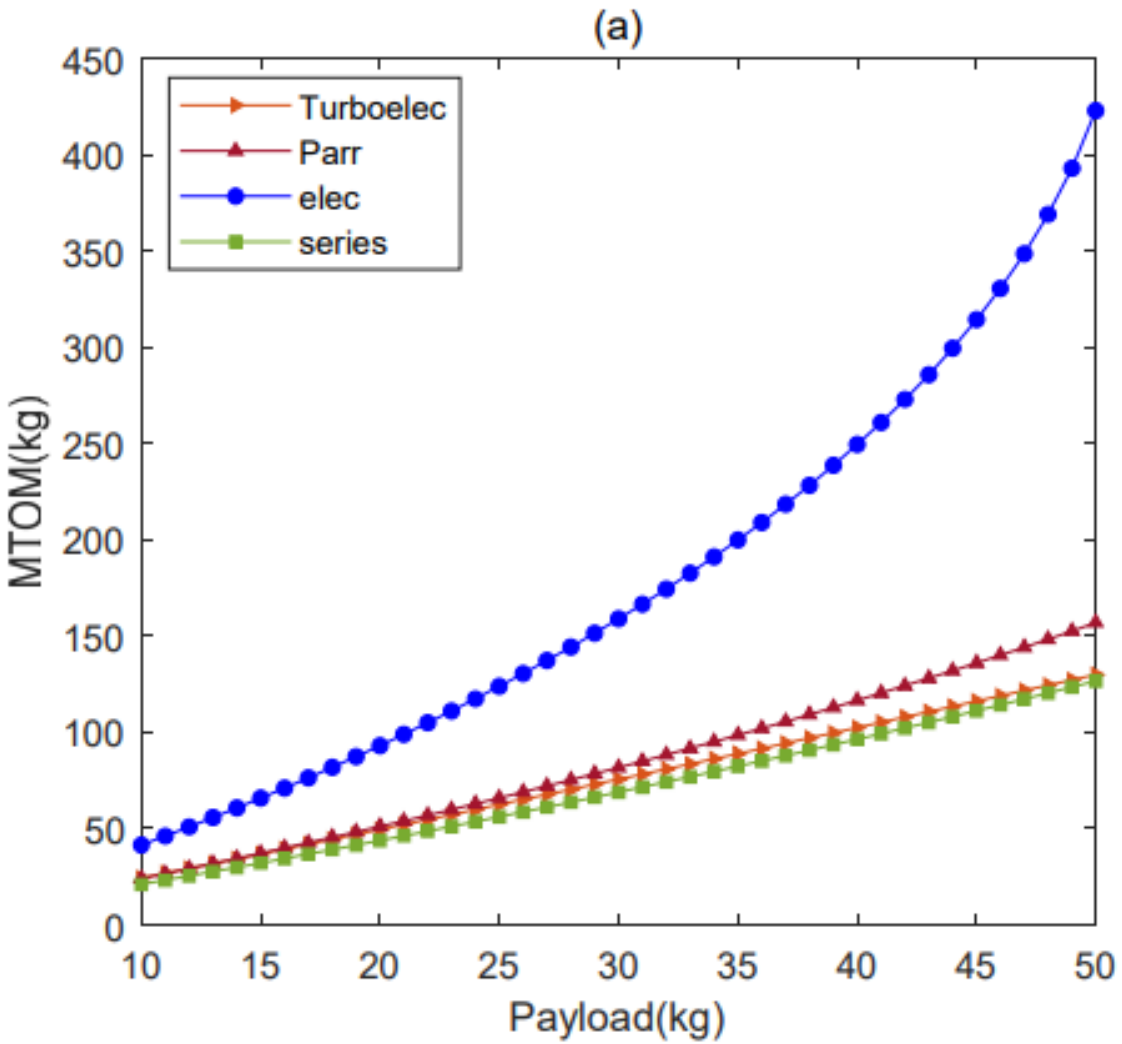
Cases	Takeoff Altitude (m)	Cruise Distance (km)
Case 1	500	30
Case 2	1500	100
Case 3	3000	500

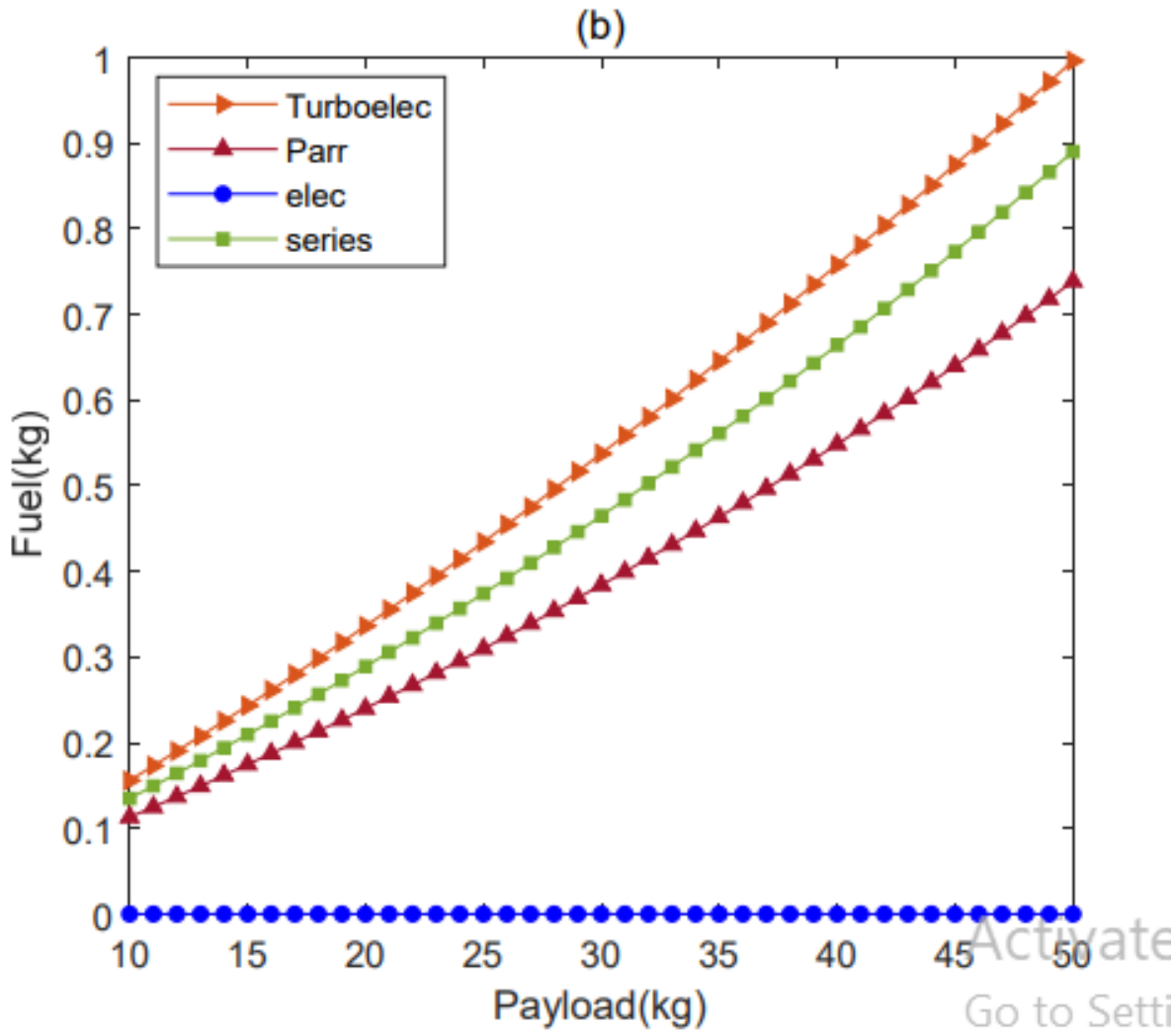


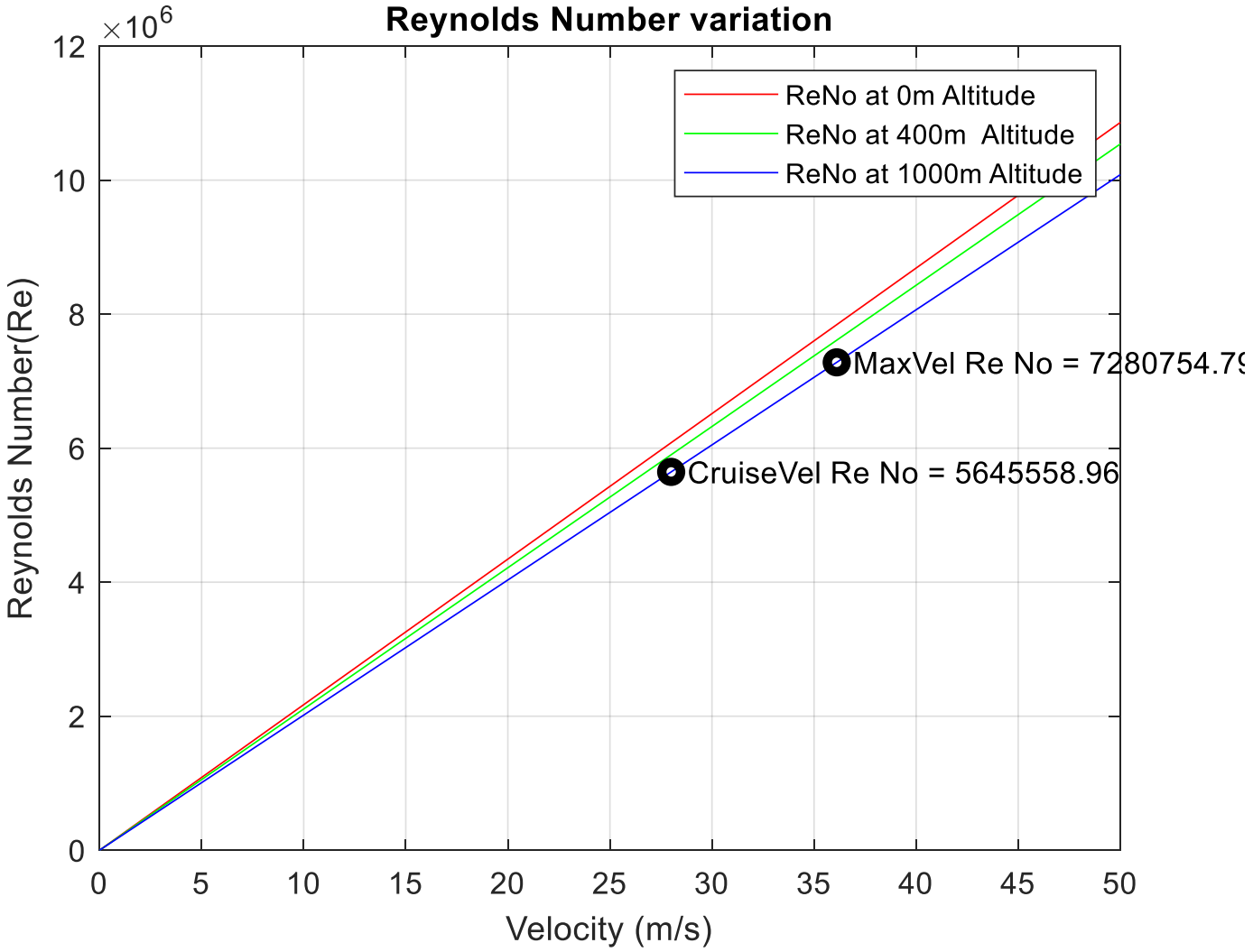

(a)
Turboelec
Parr
elec
series
MTOM(kg)
70
60
50
40
30
20
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Altitude(m)
(b)
Turboelec
Parr
elec
series
Fuel(kg)
0.6
0.5
0.4
0.3
0.2
0.1
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Altitude(m)


(a)
MTOM(kg)
Distance(km)
Turboelec
Parr
elec
series
90
80
70
60
50
40
30
20
0
100
200
300
400
500
600
700
800

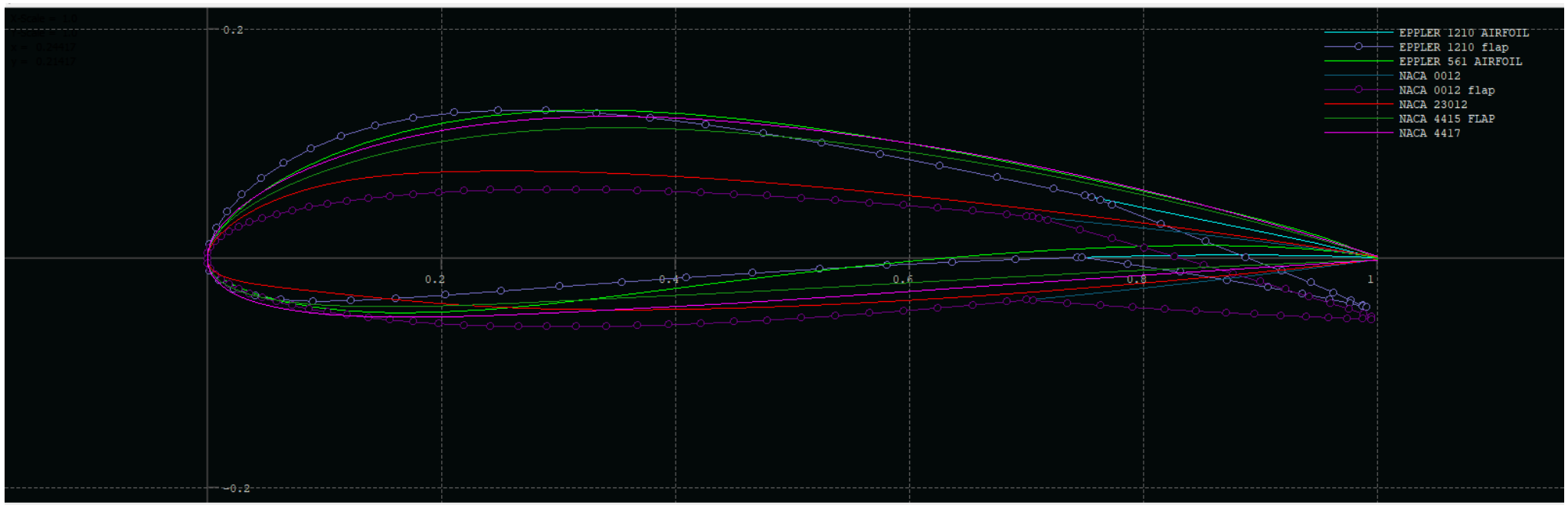

Fuel(kg)
Distance(km)
Turboelec
Parr
elec
series
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
800





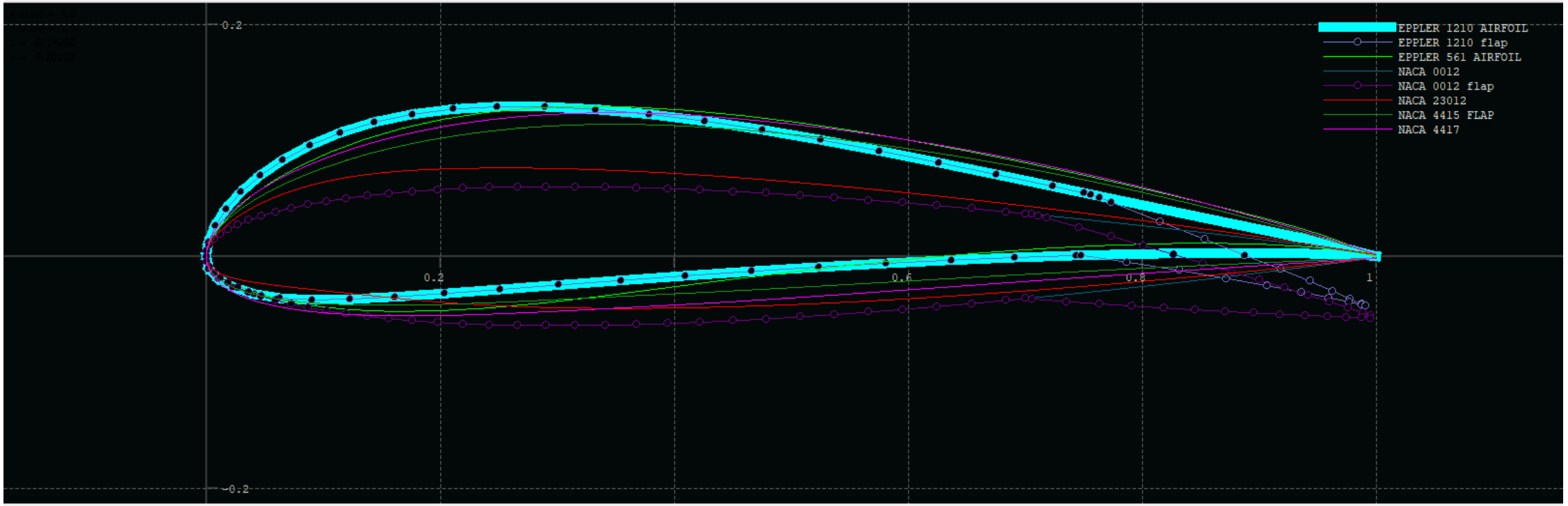

Reynolds Number variation
×10^6
12
10
8
6
4
2
0
Reynolds Number(Re)
0
5
10
15
20
25
30
35
40
45
50
Velocity (m/s)
ReNo at 0m Altitude
ReNo at 400m Altitude
ReNo at 1000m Altitude
MaxVel Re No = 7280754.79
CruiseVel Re No = 5645558.96

EPPLER 556 AIRFOIL				NACA 4415 AIRFOIL		
	Mach no-0.096	Mach no-0.081			Mach no-0.096	Mach no-0.081
Cl max	1.2574	1.83		Cl max	1.98	1.9521
AOA at Cl max	5	19		AOA at Cl max	15	18
Stall AOA		20		Stall AOA	16.5	19
Cl at 0 AOA	0.6224	0.5653		Cl at 0 AOA	0.5614	0.5048
AOA at 0 cl	-4.5	-4.5		AOA at 0 Cl	-4	-4
EPPLER 1210 AIRFOIL				NACA 4417 AIRFOIL		
	Mach no-0.096	Mach no-0.081			Mach no-0.096	Mach no-0.081
Cl max	2.3612	2.1103		cl max	1.905	1.9118
AOA at Cl max	14	14.1		AOA at Cl max	15.5	18.5
Stall AOA	15	14.4		Stall AOA	16.5	19.5
Cl at 0 AOA		0.5839		Cl at 0 AOA	0.562	0.5057
AOA at 0 Cl	-4.5	-4.8		AOA at 0 cl	-4	-4
EPPLER 561 AIRFOIL				NACA 23012 AIRFOIL		
	Mach no-0.096	Mach no-0.081			Mach no-0.096	Mach no-0.081
Cl max	1.581	1.889		Cl max	1.8608	1.3818
AOA at Cl max	7	15.5		AOA at Cl max	13	37.5
Stall AOA		16.5		Stall AOA		40
Cl at 0 AOA	0.8438	0.7591		Cl at 0 AOA	0.1567	0.1396
AOA at 0 Cl	-6	-6		AOA at 0 cl	-1	-1



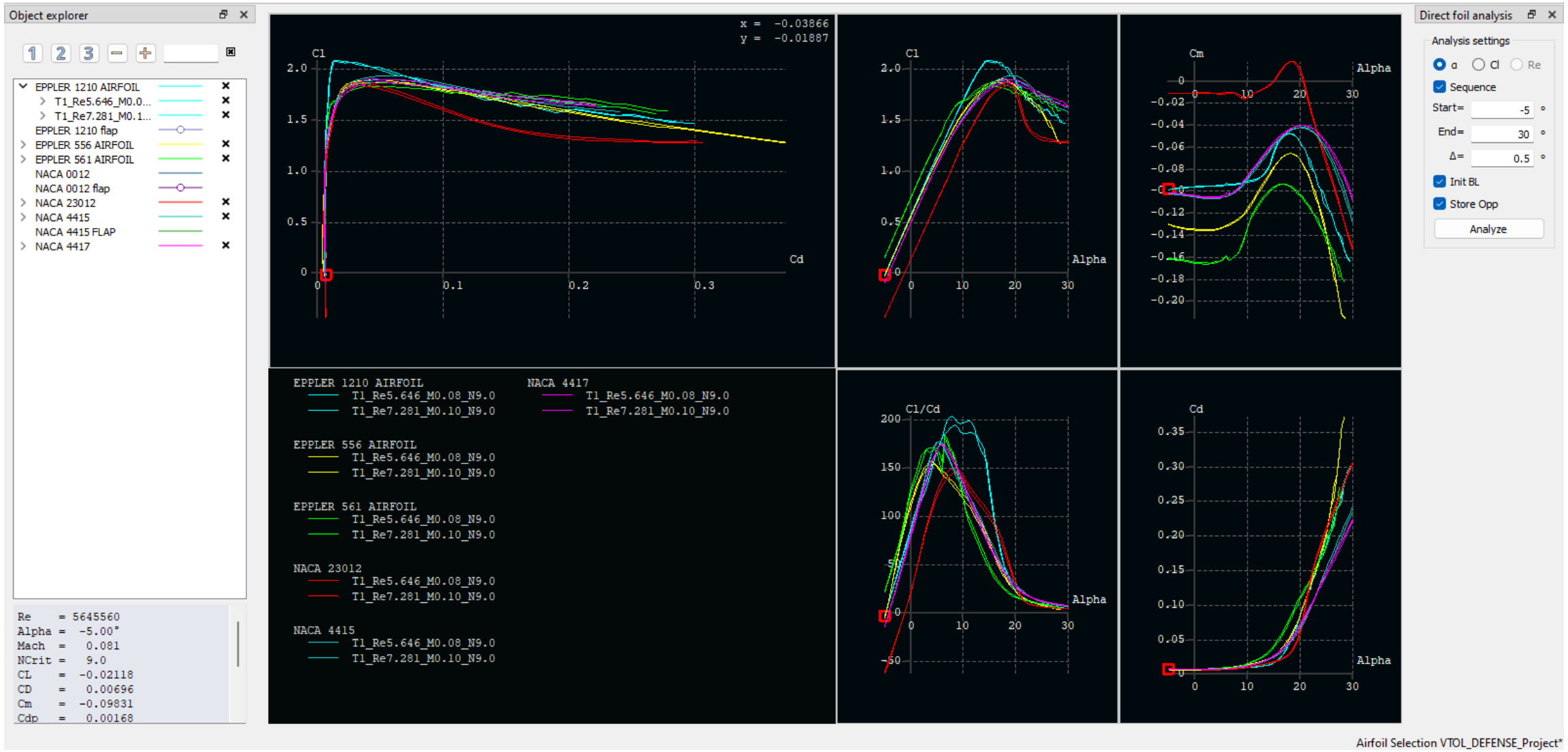
Foil direct design

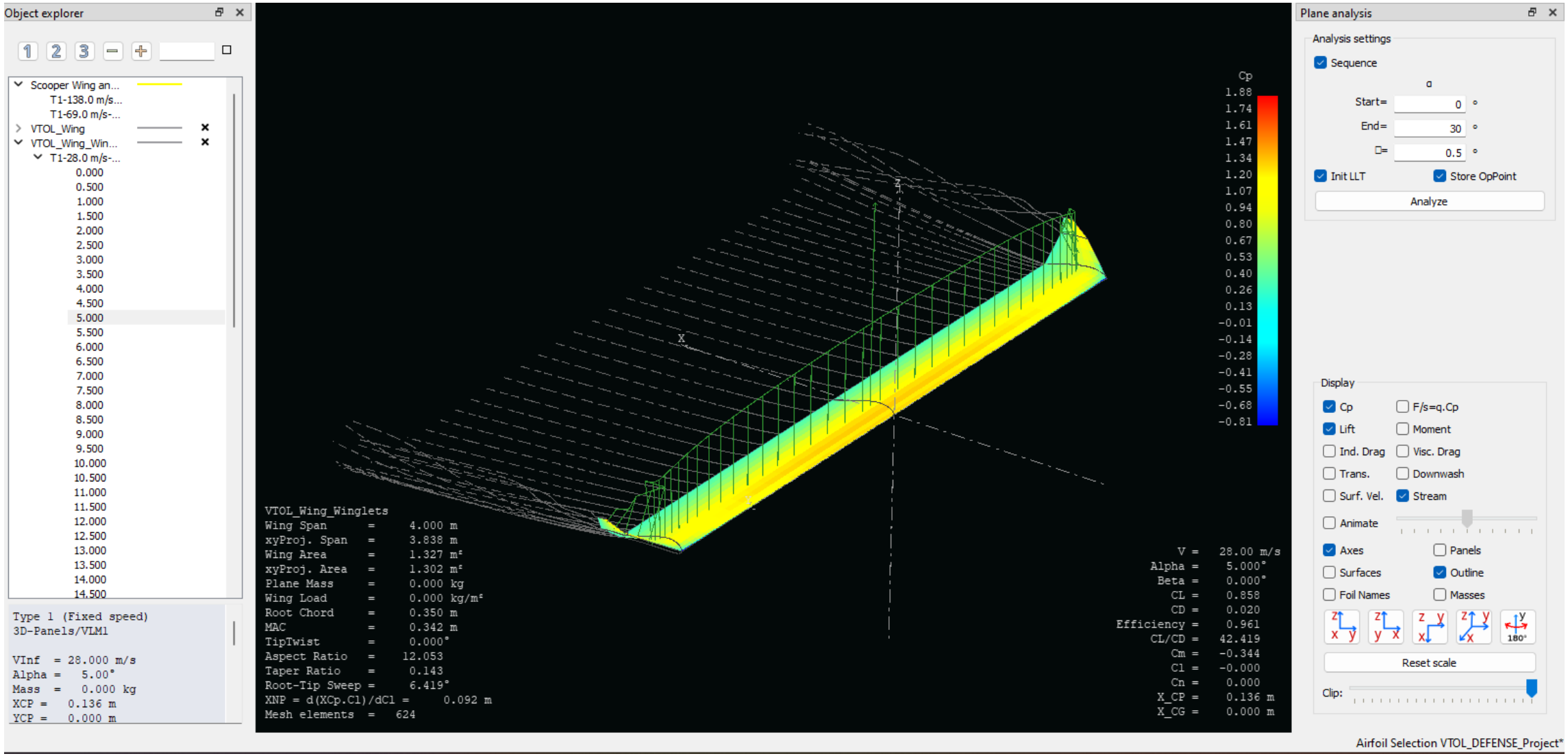
	Name	Thickness (%)	at (%)	Camber (%)	at (%)	Points	TE Flap (°)	TE XHinge	TE YHinge	Show	Centerline	Style
1	Spline Foil	9.04	29.40	0.00	0.00	158	0.00	0.00	0.00			
2	EPPLER 1210 AIRFOIL	15.85	21.12	5.20	33.33	61	0.00	0.00	0.00	✕		
3	EPPLER 1210 flap	15.85	21.12	5.20	33.33	65	10.00	75.00	50.00	✕		
4	EPPLER 556 AIRFOIL	16.01	31.13	3.12	61.46	72	0.00	0.00	0.00			
5	EPPLER 561 AIRFOIL	16.90	27.83	5.11	45.85	61	0.00	0.00	0.00	✕		
6	NACA 0012	12.00	29.03	0.00	0.00	99	0.00	0.00	0.00	✕		

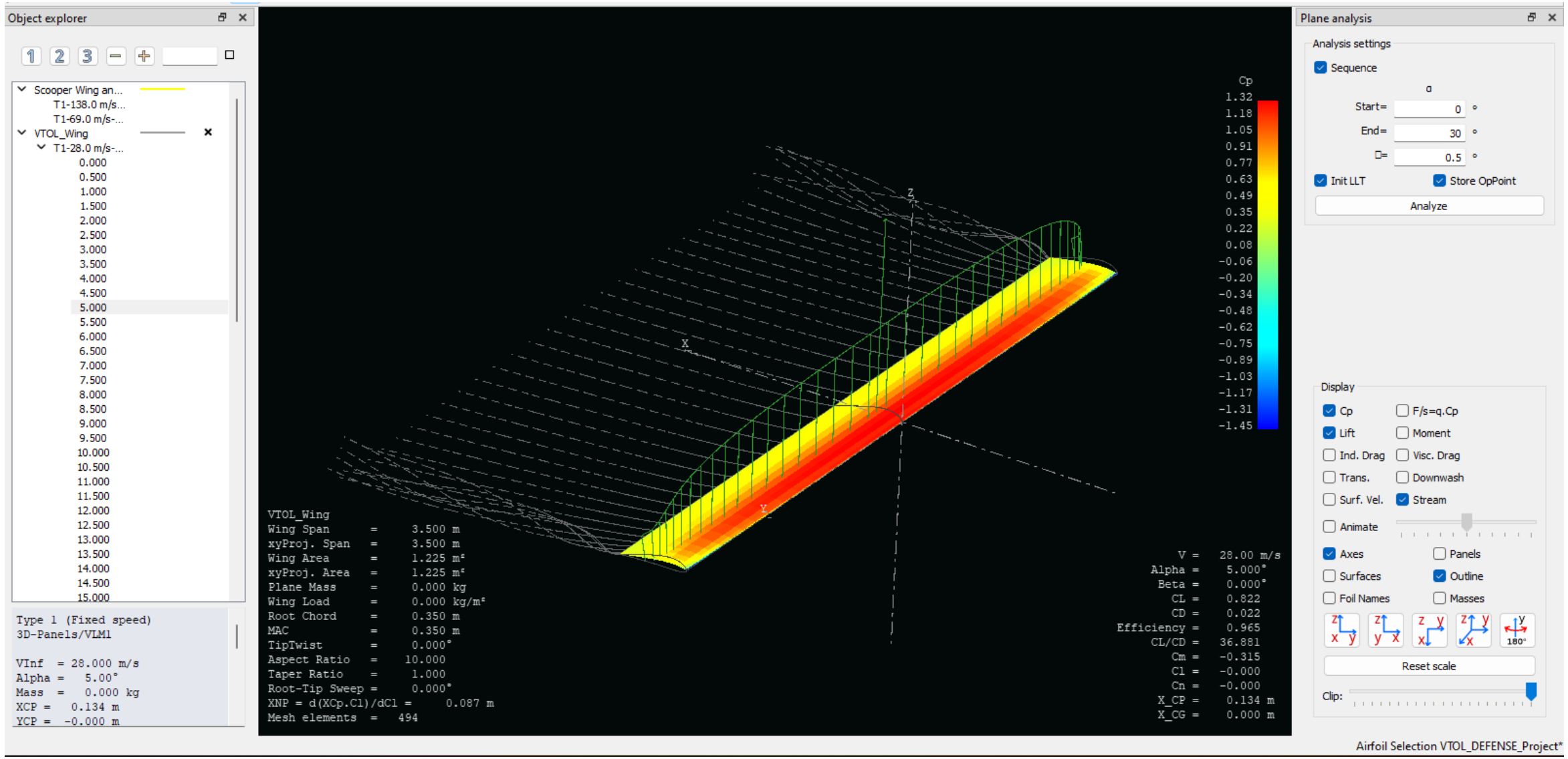


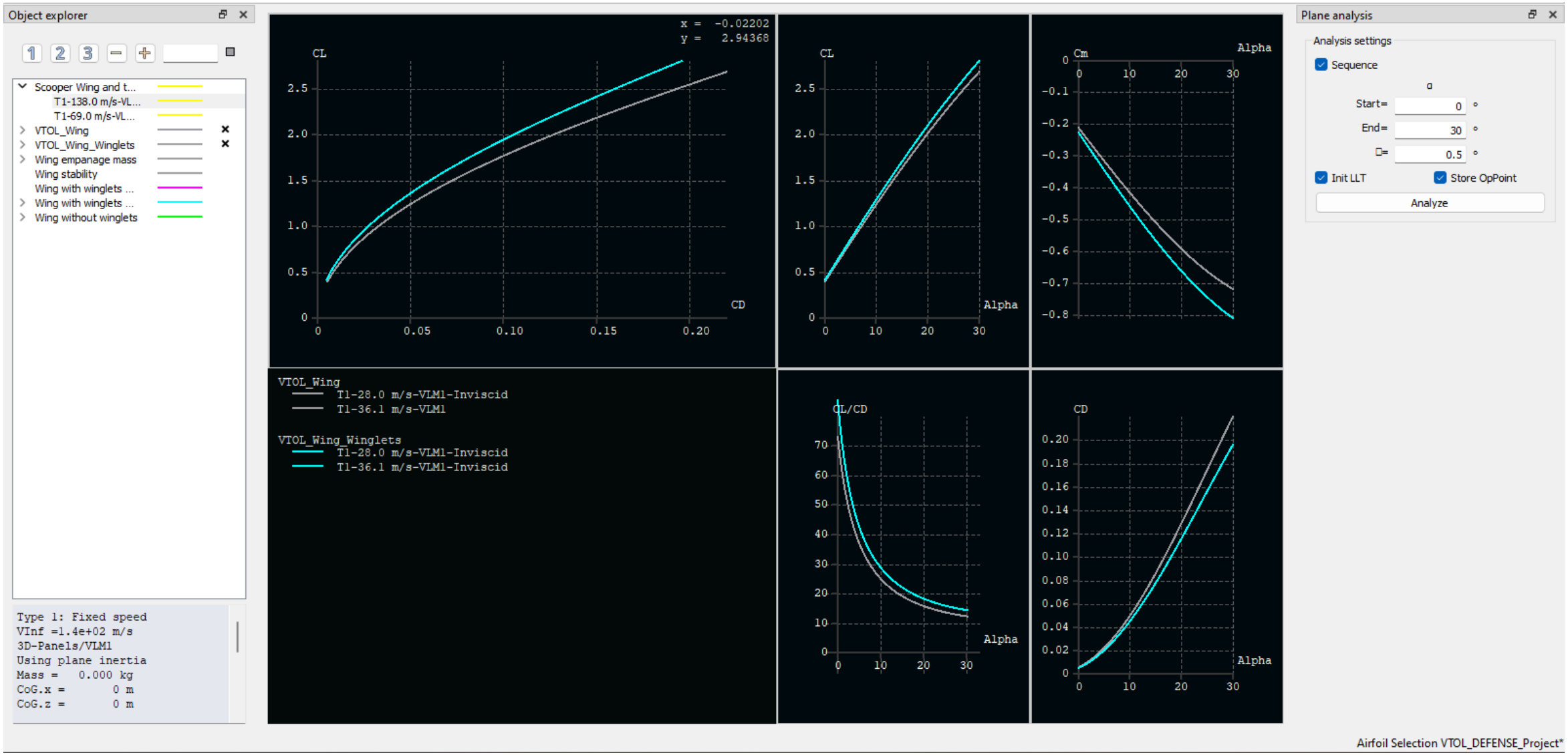
Foil direct design

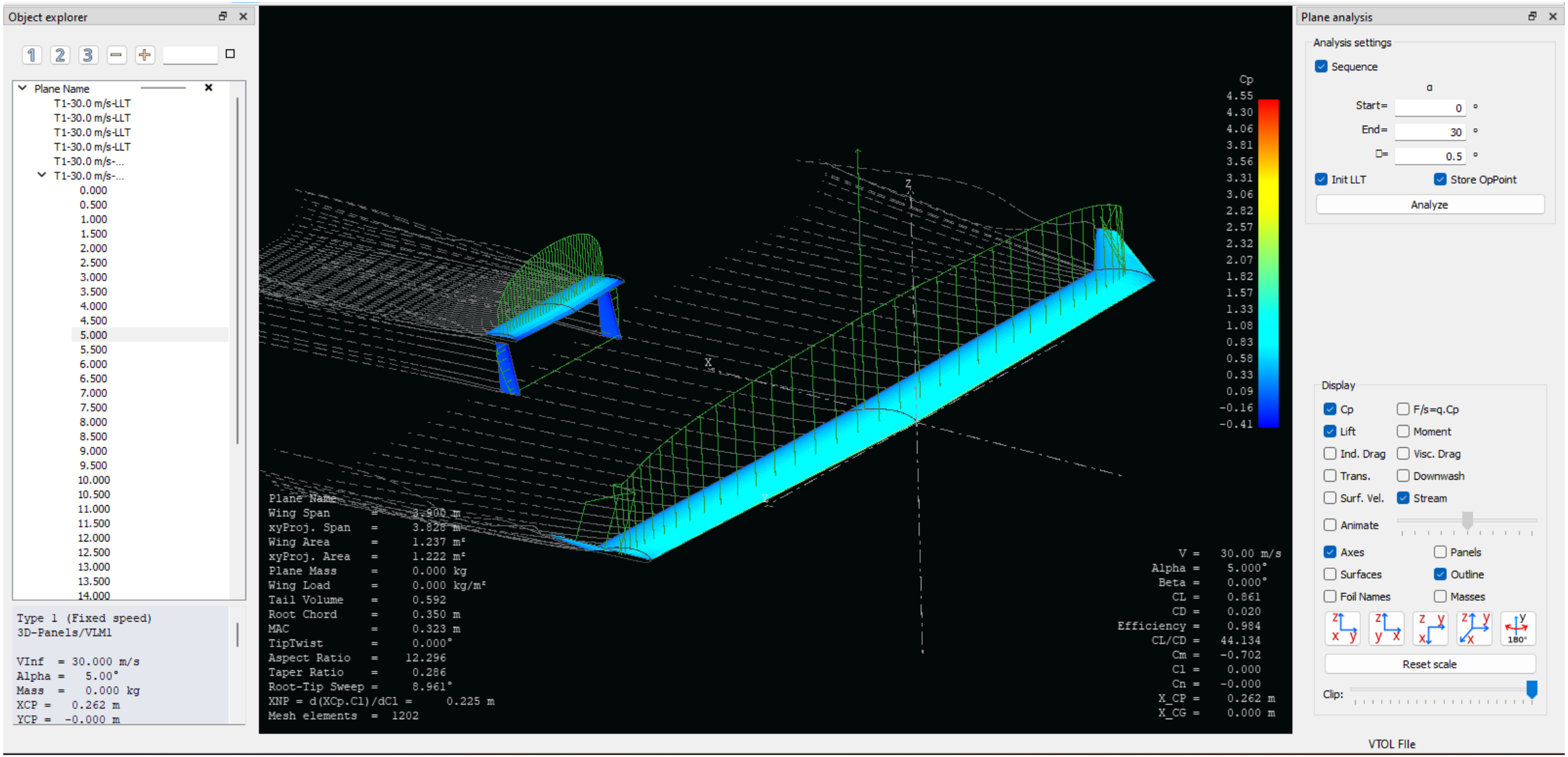
	Name	Thickness (%)	at (%)	Camber (%)	at (%)	Points	TE Flap (°)	TE XHinge	TE YHinge	Show	Centerline	Style
1	Spline Foil	9.04	29.40	0.00	0.00	158	0.00	0.00	0.00			
2	EPPLER 1210 AIRFOIL	15.85	21.12	5.20	33.33	61	0.00	0.00	0.00	✕		
3	EPPLER 1210 flap	15.85	21.12	5.20	33.33	65	10.00	75.00	50.00	✕		
4	EPPLER 556 AIRFOIL	16.01	31.13	3.12	61.46	72	0.00	0.00	0.00			
5	EPPLER 561 AIRFOIL	16.90	27.83	5.11	45.85	61	0.00	0.00	0.00	✕		
6	NACA 0012	12.00	29.03	0.00	0.00	99	0.00	0.00	0.00	✕		


Object explorer
EPPLER 1210 AIRFOIL
T1_Re5.646_M0.0...
T1_Re7.281_M0.1...
EPPLER 1210 flap
EPPLER 556 AIRFOIL
EPPLER 561 AIRFOIL
NACA 0012
NACA 0012 flap
NACA 23012
NACA 4415
NACA 4415 FLAP
NACA 4417
Re = 5645560
Alpha = -5.00°
Mach = 0.081
NCrit = 9.0
CL = -0.02118
CD = 0.00696
Cm = -0.09831
Cdp = 0.00168
x = -0.03866
y = -0.01887
Cl
Cd
Cm
Alpha
Cl/Cd
EPPLER 1210 AIRFOIL
T1_Re5.646_M0.08_N9.0
T1_Re7.281_M0.10_N9.0
EPPLER 556 AIRFOIL
T1_Re5.646_M0.08_N9.0
T1_Re7.281_M0.10_N9.0
EPPLER 561 AIRFOIL
T1_Re5.646_M0.08_N9.0
T1_Re7.281_M0.10_N9.0
NACA 23012
T1_Re5.646_M0.08_N9.0
T1_Re7.281_M0.10_N9.0
NACA 4415
T1_Re5.646_M0.08_N9.0
T1_Re7.281_M0.10_N9.0
NACA 4417
T1_Re5.646_M0.08_N9.0
T1_Re7.281_M0.10_N9.0
Direct foil analysis
Analysis settings
α
Cl
Re
Sequence
Start= -5 °
End= 30 °
Δ= 0.5 °
Init BL
Store Opp
Analyze
Airfoil Selection VTOL_DEFENSE_Project*


Object explorer
Scooper Wing an...
T1-138.0 m/s...
T1-69.0 m/s-...
VTOL_Wing
VTOL_Wing_Win...
T1-28.0 m/s-...
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000
6.500
7.000
7.500
8.000
8.500
9.000
9.500
10.000
10.500
11.000
11.500
12.000
12.500
13.000
13.500
14.000
14.500
Type 1 (Fixed speed)
3D-Panels/VLM1
VInf = 28.000 m/s
Alpha = 5.00°
Mass = 0.000 kg
XCP = 0.136 m
YCP = 0.000 m
Cp
1.88
1.74
1.61
1.47
1.34
1.20
1.07
0.94
0.80
0.67
0.53
0.40
0.26
0.13
-0.01
-0.14
-0.28
-0.41
-0.55
-0.68
-0.81
VTOL_Wing_Winglets
Wing Span = 4.000 m
xyProj. Span = 3.838 m
Wing Area = 1.327 m²
xyProj. Area = 1.302 m²
Plane Mass = 0.000 kg
Wing Load = 0.000 kg/m²
Root Chord = 0.350 m
MAC = 0.342 m
TipTwist = 0.000°
Aspect Ratio = 12.053
Taper Ratio = 0.143
Root-Tip Sweep = 6.419°
XNP = d(XCp.Cl)/dCl = 0.092 m
Mesh elements = 624
V = 28.00 m/s
Alpha = 5.000°
Beta = 0.000°
CL = 0.858
CD = 0.020
Efficiency = 0.961
CL/CD = 42.419
Cm = -0.344
Cl = -0.000
Cn = 0.000
X_CP = 0.136 m
X_CG = 0.000 m
Plane analysis
Analysis settings
Sequence
α
Start= 0 °
End= 30 °
□= 0.5 °
Init LLT
Store OpPoint
Analyze
Display
Cp
F/s=q.Cp
Lift
Moment
Ind. Drag
Visc. Drag
Trans.
Downwash
Surf. Vel.
Stream
Animate
Axes
Panels
Surfaces
Outline
Foil Names
Masses
180°
Reset scale
Clip:
Airfoil Selection VTOL_DEFENSE_Project*


Object explorer
Scooper Wing an...
T1-138.0 m/s...
T1-69.0 m/s-...
VTOL_Wing
T1-28.0 m/s-...
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000
6.500
7.000
7.500
8.000
8.500
9.000
9.500
10.000
10.500
11.000
11.500
12.000
12.500
13.000
13.500
14.000
14.500
15.000
Type 1 (Fixed speed)
3D-Panels/VLM1
VInf = 28.000 m/s
Alpha = 5.00°
Mass = 0.000 kg
XCP = 0.134 m
YCP = -0.000 m
Cp
1.32
1.18
1.05
0.91
0.77
0.63
0.49
0.35
0.22
0.08
-0.06
-0.20
-0.34
-0.48
-0.62
-0.75
-0.89
-1.03
-1.17
-1.31
-1.45
VTOL_Wing
Wing Span = 3.500 m
xyProj. Span = 3.500 m
Wing Area = 1.225 m²
xyProj. Area = 1.225 m²
Plane Mass = 0.000 kg
Wing Load = 0.000 kg/m²
Root Chord = 0.350 m
MAC = 0.350 m
TipTwist = 0.000°
Aspect Ratio = 10.000
Taper Ratio = 1.000
Root-Tip Sweep = 0.000°
XNP = d(XCp.Cl)/dCl = 0.087 m
Mesh elements = 494
V = 28.00 m/s
Alpha = 5.000°
Beta = 0.000°
CL = 0.822
CD = 0.022
Efficiency = 0.965
CL/CD = 36.881
Cm = -0.315
Cl = -0.000
Cn = -0.000
X_CP = 0.134 m
X_CG = 0.000 m
Plane analysis
Analysis settings
Sequence
α
Start= 0 °
End= 30 °
□= 0.5 °
Init LLT
Store OpPoint
Analyze
Display
Cp
F/s=q.Cp
Lift
Moment
Ind. Drag
Visc. Drag
Trans.
Downwash
Surf. Vel.
Stream
Animate
Axes
Panels
Surfaces
Outline
Foil Names
Masses
180°
Reset scale
Clip:
Airfoil Selection VTOL_DEFENSE_Project*


Object explorer
Scooper Wing and t...
T1-138.0 m/s-VL...
T1-69.0 m/s-VL...
VTOL_Wing
VTOL_Wing_Winglets
Wing empanage mass
Wing stability
Wing with winglets ...
Wing with winglets ...
Wing without winglets
Type 1: Fixed speed
VInf =1.4e+02 m/s
3D-Panels/VLM1
Using plane inertia
Mass = 0.000 kg
CoG.x = 0 m
CoG.z = 0 m
x = -0.02202
y = 2.94368
CL
CD
CL
Alpha
Cm
Alpha
VTOL_Wing
T1-28.0 m/s-VLM1-Inviscid
T1-36.1 m/s-VLM1
VTOL_Wing_Winglets
T1-28.0 m/s-VLM1-Inviscid
T1-36.1 m/s-VLM1-Inviscid
CL/CD
Alpha
CD
Alpha
Plane analysis
Analysis settings
Sequence
α
Start= 0 °
End= 30 °
□= 0.5 °
Init LLT
Store OpPoint
Analyze
Airfoil Selection VTOL_DEFENSE_Project*

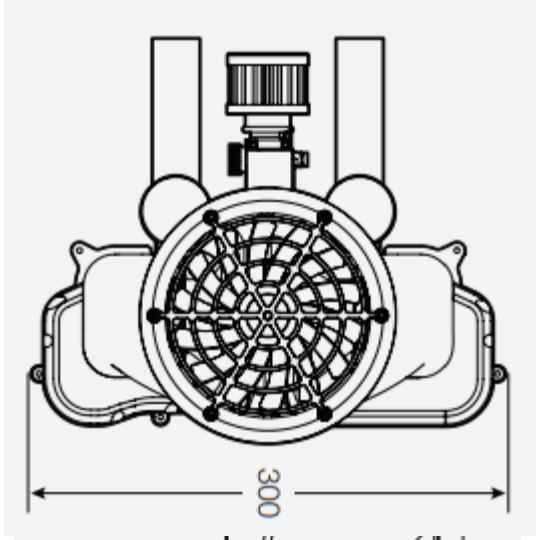

Object explorer
Plane Name
T1-30.0 m/s-LLT
T1-30.0 m/s-LLT
T1-30.0 m/s-LLT
T1-30.0 m/s-LLT
T1-30.0 m/s-...
T1-30.0 m/s-...
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000
6.500
7.000
7.500
8.000
8.500
9.000
9.500
10.000
10.500
11.000
11.500
12.000
12.500
13.000
13.500
14.000
Type 1 (Fixed speed)
3D-Panels/VLM1
VInf = 30.000 m/s
Alpha = 5.00°
Mass = 0.000 kg
XCP = 0.262 m
YCP = -0.000 m
Cp
4.55
4.30
4.06
3.81
3.56
3.31
3.06
2.82
2.57
2.32
2.07
1.82
1.57
1.33
1.08
0.83
0.58
0.33
0.09
-0.16
-0.41
Plane Name
Wing Span = 3.900 m
xyProj. Span = 3.826 m
Wing Area = 1.237 m²
xyProj. Area = 1.222 m²
Plane Mass = 0.000 kg
Wing Load = 0.000 kg/m²
Tail Volume = 0.592
Root Chord = 0.350 m
MAC = 0.323 m
TipTwist = 0.000°
Aspect Ratio = 12.296
Taper Ratio = 0.286
Root-Tip Sweep = 8.961°
XNP = d(XCp.Cl)/dCl = 0.225 m
Mesh elements = 1202
V = 30.00 m/s
Alpha = 5.000°
Beta = 0.000°
CL = 0.861
CD = 0.020
Efficiency = 0.984
CL/CD = 44.134
Cm = -0.702
Cl = 0.000
Cn = -0.000
X_CP = 0.262 m
X_CG = 0.000 m
Plane analysis
Analysis settings
Sequence
α
Start= 0 °
End= 30 °
□= 0.5 °
Init LLT
Store OpPoint
Analyze
Display
Cp
F/s=q.Cp
Lift
Moment
Ind. Drag
Visc. Drag
Trans.
Downwash
Surf. Vel.
Stream
Animate
Axes
Panels
Surfaces
Outline
Foil Names
Masses
180°
Reset scale
Clip:
VTOL FIle

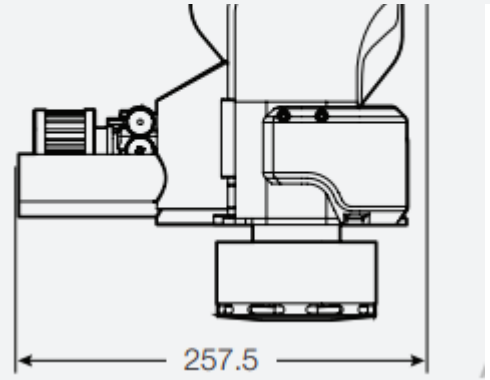
OPERATIONAL SPECIFICATIONS

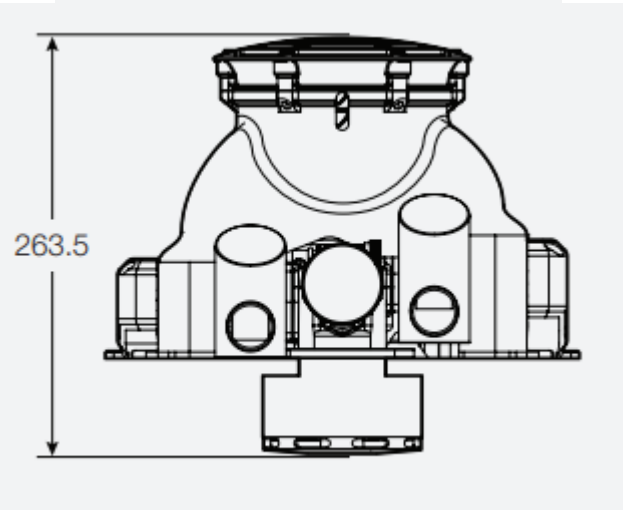
Input Voltage	50v (12S)
Output Voltage	50v (12S)
Output Power	70amps - 3500 Watts
System Weight	4.1kg
Engine Displacement	70cc
Engine Control	INF Electronic Fuel Injection
Ignition	Electronic Capacitive Discharge
Power Control	Intelligent Power on Demand
Telemetry	TTL 9600 Baud rate
Operating Temperature	-15°c to 40°c (Ambient)
Max Engine Temp	205°c (CHT)
Operational Altitude	0 - 12000ft
Lubrication	Two Cylinder 2-Stroke
Fuel Type	Gasoline 91 Octane
Cooling	Air Cooled
Starting	Self-Starting via Alternator
Service Cycle	150h

iHE7 Features

- Proven Reliability
- Single power supply for the entire engine system
- Light weight
- MIL DTL 83513 wiring harness and connectors
- Automatic altitude tuning based on barometric sensors
- Fuel Injection overheat protection
- Automatic Throttle control
- On-board Data logging SD card
- TTL Engine Telemetry to Flight Control System
- Standard Exhaust or silencer options available







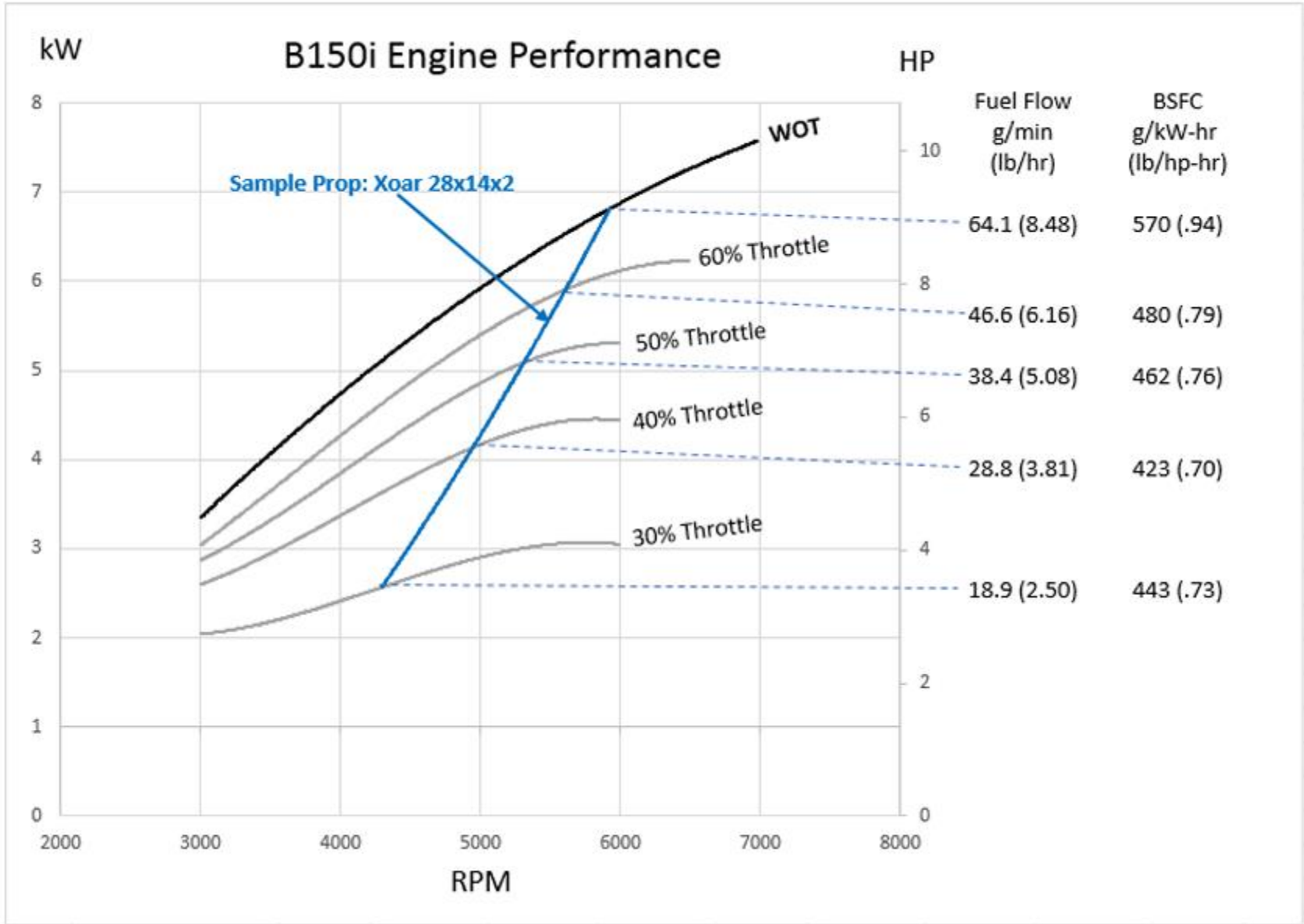
Contact: Power4Flight
202 Wasco Loop, Suite 104
Hood River, OR 97031
(541) 308-0650

B150i Engine

Performance:

Engine Type:	Forced air-cooled 2-stroke twin
Displacement:	150 cc (9.15 ci)
Weight:	4.3 kg (9.48 lb) as shown
Power:	7.5 kW (10 hp) @ 7000 RPM
BSFC @ cruise:	460 g/kW-hr (.76 lb/hp-hr)
Fuel Type:	Gasoline, 50:1 Premix

- Low Vibration: Opposed twin layout for greatly reduced primary vibration
- Reliability: Four-bearing crankshaft and high rod/stroke ratio reduces stress
- Flexibility: Dedicated PTO, dual spark option, dual crank sense provides tractor or pusher capability.
- Compatibility: Readily integrates with flight control systems; available with Currawong ECU or Power4Flight IntelliJect EFI.

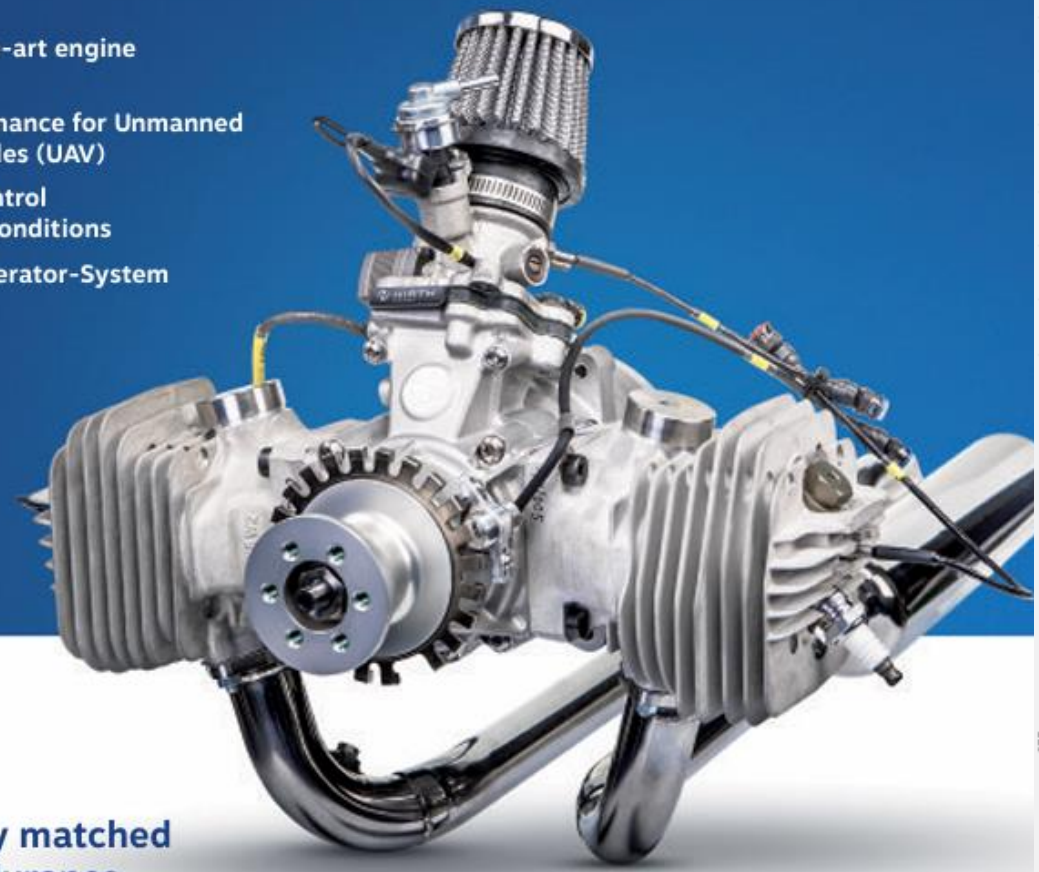

kW
B150i Engine Performance
HP
Fuel Flow
g/min
(lb/hr)
BSFC
g/kW-hr
(lb/hp-hr)
WOT
Sample Prop: Xoar 28x14x2
60% Throttle
50% Throttle
40% Throttle
30% Throttle
64.1 (8.48)
570 (.94)
46.6 (6.16)
480 (.79)
38.4 (5.08)
462 (.76)
28.8 (3.81)
423 (.70)
18.9 (2.50)
443 (.73)
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
2000
3000
4000
5000
6000
7000
8000
RPM

HIRTH ENGINES

4201

42 Series

- 2-Stroke
- Air Cooled
- State-of-the-art engine technology
- Best performance for Unmanned Aerial Vehicles (UAV)
- Ultimate control in extreme conditions
- Starter-Generator-System



DESCRIPTION

Perfectly matched with endurance.

The 42 Series air cooled two-stroke engines utilise advanced closed-loop control, optimising performance for extreme environmental conditions.

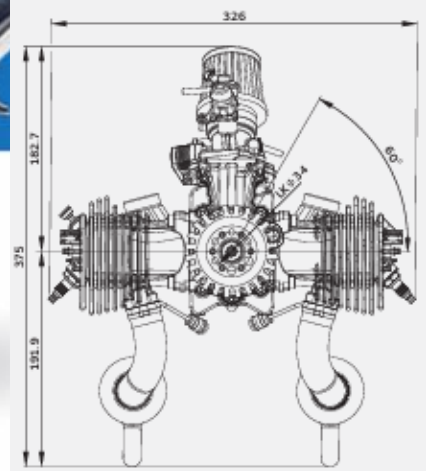
4201

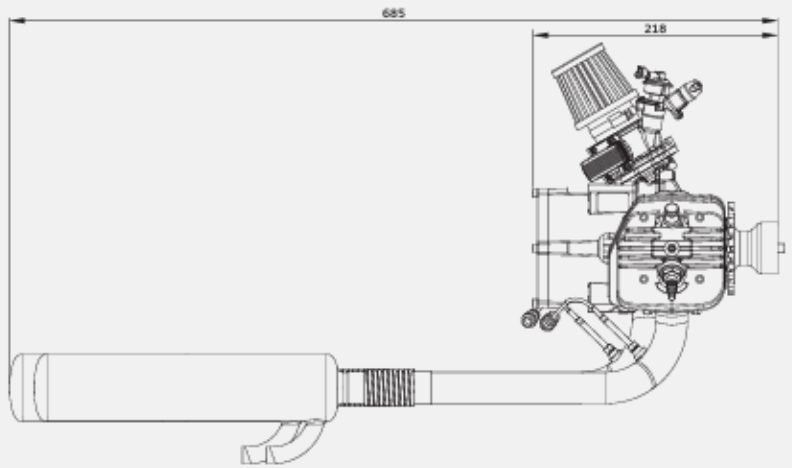
42 Series

TECHNICAL SPECIFICATION:

TYPE:	**Two cylinder** two stroke (opposed)
DISPLACEMENT:	**183 cm³** (11.5 in³)
STROKE:	**40 mm** (1.57 in)
BORE:	**54 mm** (2.13 in)
MAX. PERFORMANCE:	**11 kW (15 HP)** at 6500 rpm according DIN 70020
SPEED RANGE:	**1800-6500** RPM
MIXTURE FORMATION:	**Fuel injecton**
IGNITION SYSTEM:	**CDI** controlled by the ECU
FUEL MIXTURE :	**Mixture 1:80** 2-stroke-oil API TC or BLUEMAX, MOGAS o. AVGAS fuel min. 95 octane (RON)

WEIGHT:	**5700 g** (12.5 lb) with exhaust system, sensors and wirring harness **600 g** (1.33 lb) subcomponents (ECU, ignition system, fuel supply)
WEIGHT GENERATOR OPTION:	**800 g** (1.76 lb) 1kW generator **600 g** (1.33 lb) 0,5kW/28V starter/regulator box **550 g** (0.88 lb) 0,5kW/28V regulator box
LENGTH:	**213 mm** (8.38 in)
WIDTH:	**330 mm** (12.99 in)
HEIGHT:	**160 mm** (6.29 in)
RUNNING DIRECTION:	**Clockwise,** view to output shaft
COOLING:	**Air cooled**
CONTROL:	**Integrated throttle servo** (Fa. Volz)





HIRTH ENGINES

4103

41 Series

- 2-Stroke
- Air Cooled
- Exceptional reliability
- Latest Unmanned Aerial Vehicle (UAV) technology
- Maximum performance in extreme conditions
- Starter-Generator-System

DESCRIPTION

Reliable in a wide operating range.

The 41 Series air cooled two-stroke engines utilise advanced closed-loop control, optimising performance for extreme environmental conditions.

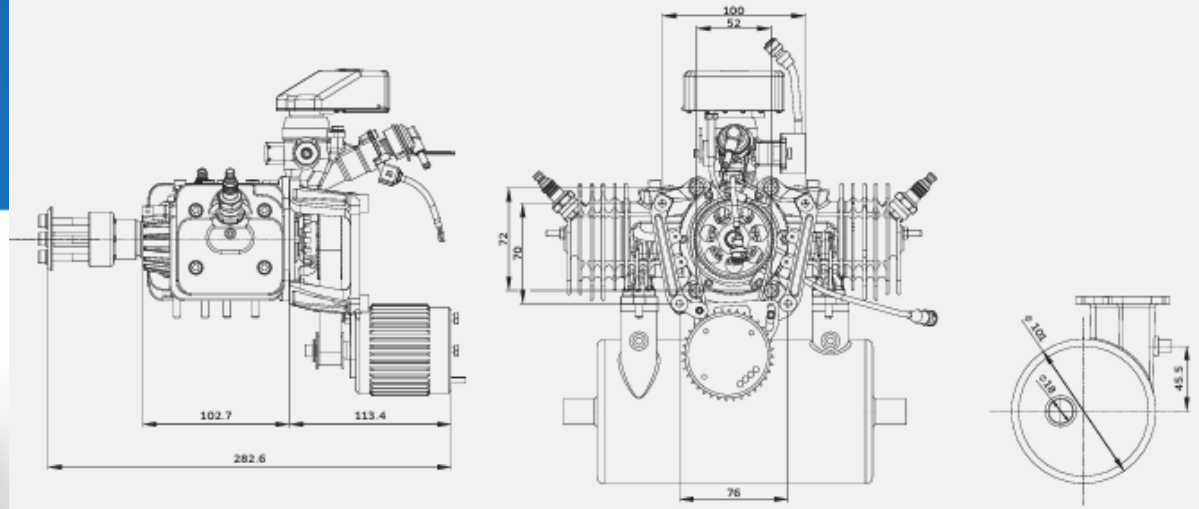
4103

41 Series

TECHNICAL SPECIFICATION:

TYPE:	**Two cylinder** two stroke (opposed)
DISPLACEMENT:	**100 cm³** (6.3 in³)
STROKE:	**34 mm** (1.34 in)
BORE:	**44 mm** (1.73 in)
MAX. PERFORMANCE:	**5,96 kW (8 HP)** at 6700 rpm according DIN 70020
SPEED RANGE:	**1800-6500** RPM
MIXTURE FORMATION:	**Fuel injecton**
IGNITION SYSTEM:	**CDI** controlled by the ECU
FUEL MIXTURE:	**Mixture 1:80** 2-stroke-oil API TC or BLUEMAX, MOGAS o. AVGAS fuel min. 95 octane (RON)

WEIGHT:	**3400 g (7.5 lb)** with exhaust system, sensors and wirring harness **600 g (1.33 lb)** subcomponents (ECU, ignition system, fuel supply)
LENGTH:	**259 mm** (10.20 in)
WIDTH:	**286 mm** (12.99 in)
HEIGHT:	**308 mm** (6.29 in)
RUNNING DIRECTION:	**Clockwise,** view to output shaft
COOLING:	**Air cooled**
CONTROL:	**Integrated throttle servo** (Fa. Volz)



DA120 EFI Data Sheet

120cc Boxer Twin, Electronic Fuel Injected Two Stroke Engine

Featuring:

- 7.7 kW at 8500 RPM
- 10.1 Nm torque from 5500 RPM to 6500 RPM
- 590 g/kWh average BSFC
- 2.5 kg full system weight
- 1-amp peak current draw
- RS-232 and CAN Telemetry

HFE INTERNATIONAL

8060 E. Research Ct.
Tucson, AZ 85710
520-578-0818

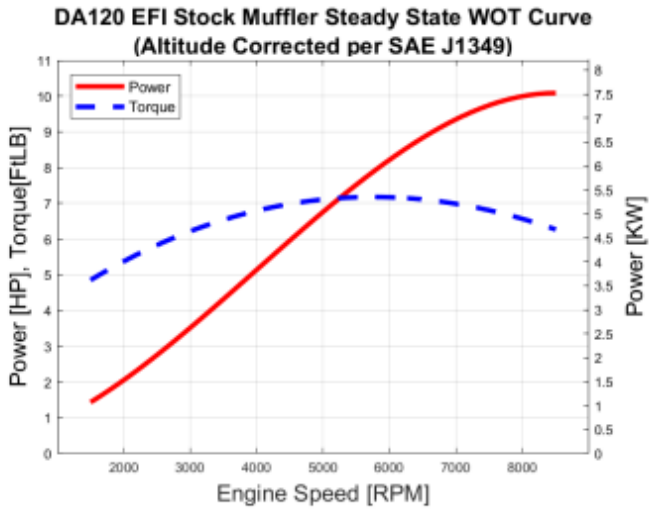


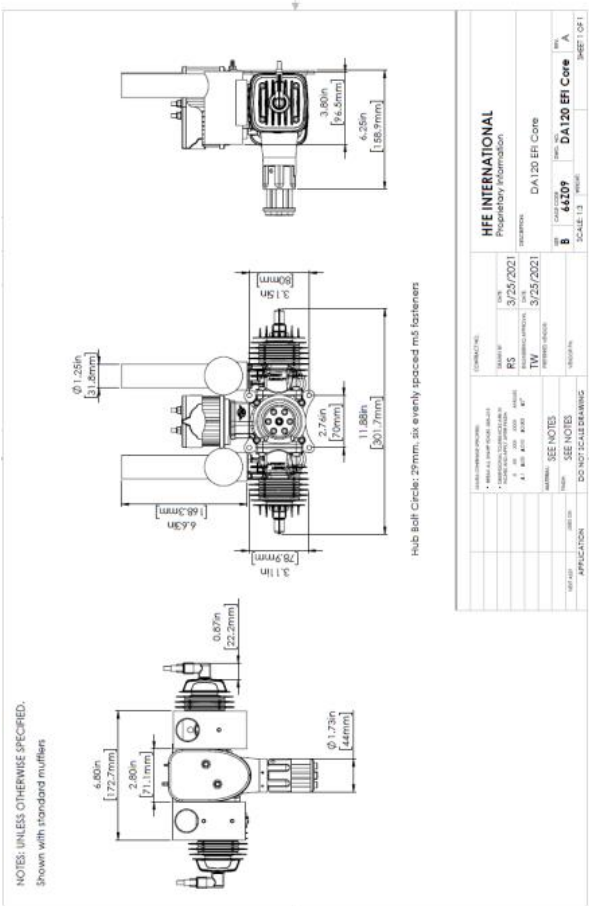
Figure 1: Power curve generated from steady state wide open throttle conditions from 1500 RPM to 8500 RPM in 500 RPM increments. Measured torque was averaged over 30 seconds at each RPM, accounting for all high/low torque spikes that are present in normal operating conditions.

	METRIC	IMPERIAL
DISPLACEMENT	120 cc	7.4 ci
MAX POWER (8500 RPM)*	7.7 kW	10.3 HP
MAX TORQUE (5500 RPM)*	10.1 Nm	7.4 lbft
CONTINUOUS POWER (7000 RPM)*	7.0 kW	9.3 hp
CONTINUOUS TORQUE (7000 RPM)*	9.5 Nm	7.0 lbft
OPERATING RPM RANGE	2000 RPM to 8000 RPM	
AVERAGE BSFC	590 g/kWh	0.98 lb/HPh
WEIGHT (ENGINE WITH THROTTLE BODY)	2.25 kg	4.95 lb
WEIGHT (ECM)	85 g	2.9 oz
WEIGHT (FUEL PUMP)	88 g	3.1 oz
WEIGHT (IGNITION)	150 g	5.3 oz
WEIGHT (WIRE HARNESS/ FUEL LINES)	170 g	6.0 oz
FUEL**	Any Grade Pump Gasoline	
TWO STROKE OIL	Red Line, 40:1 Mixture	
REQUIRED OPERATING VOLTAGE	10V to 15V	
CURRENT DRAW	1A Peak	
RECOMMENDED BATTERY	3s or greater LiPo, 1 hour / 1000 mAh	
AMBIENT TEMPERATURE RANGE	-12° to 49° C	10° to 120° F

*Stock Muffler **No heavy fuel option at this time

Propeller Recommendations					
2-Blade	**Max RPM +/- 50**	**Estimated Max Thrust (lbs) ±5%**	**3-Blade**	**Max RPM +/- 50**	**Estimated Max Thrust (lbs) ±5%**
28 x 10	6600*	53	26 x 12	5000**	39
28 x 12	5750*	42	27 x 10	5600**	52
29 x 10	6200**	51			

*Recorded from static test stand **Estimated via simulation



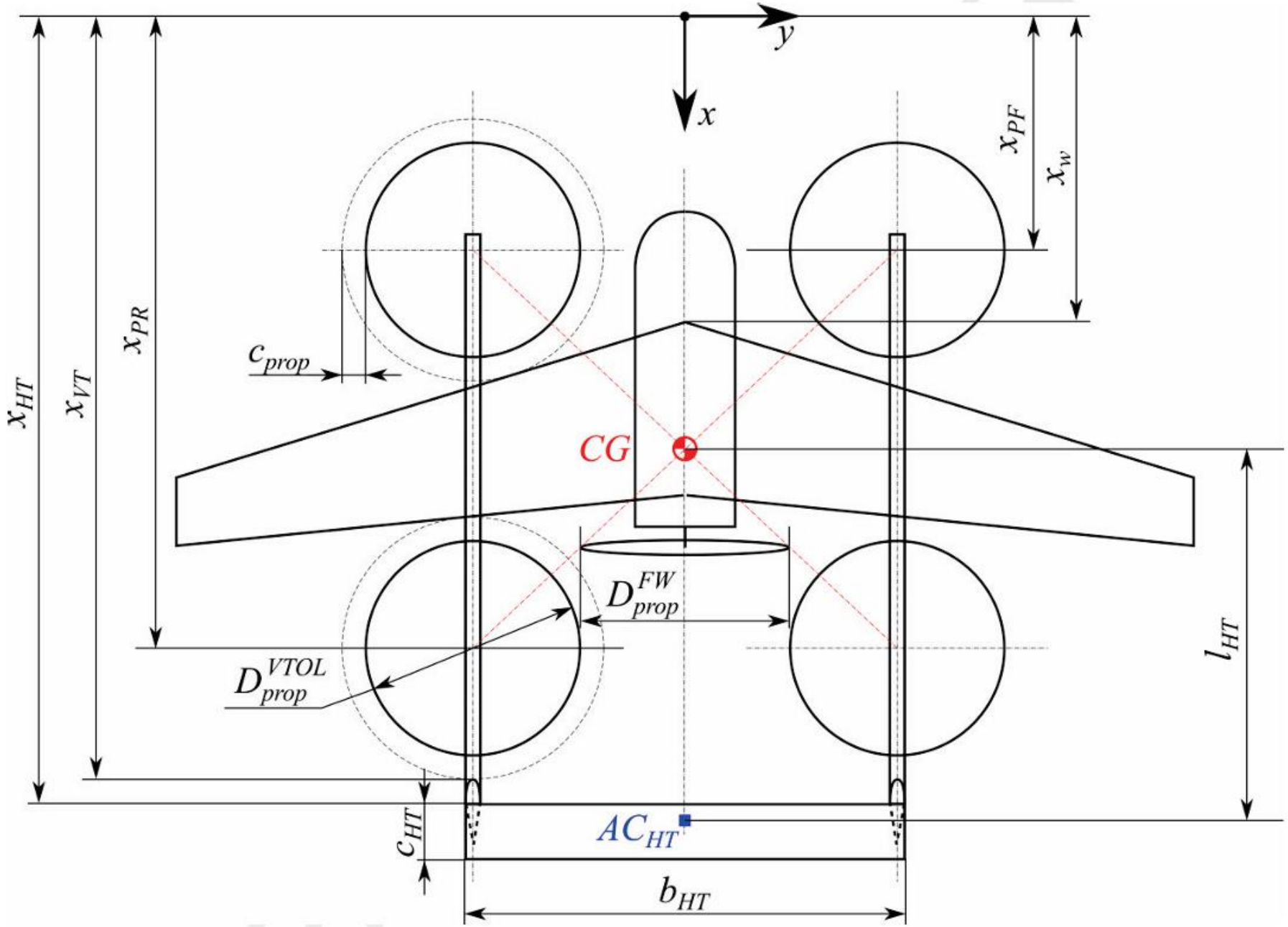
Material Selection

Parameter	Value
Wingspan	2.6 m
Fuselage length	1 m
Aspect ratio	8
Maximum take-off weight (MTOW)	12 kg
Payload type	Electro-optical (EO) and gas sensor
Payload weight	2–3 kg
Maximum endurance	> 50 min
Range	> 20 km
Propulsion type	Brushless direct current (BLDC) electric motor
Battery type	Li-Po (6S),10-amp hours

Table 2 Experimental data vs. material combination (flexural test, tensile)

Composite name	Sheet weight	Young's mod (GPa)	Yield stress (MPa)	Peak stress (Mpa)	Wing weight
AC68-AR-AC68-R0	9 g	3.81	0.005	3.108	1097.49 g
AC68-AR-AC68-R45		0.775	0.004	2.794	
CF64-AR-AC64-R0	16 g	7.767	0.007	4.438	1639.99 g
CF64-AR-AC64-R45		1.636	0.005	3.648	
CF64-AR-AC205-R40	16 g	5.54	0.006	3.925	1639.99 g
CF64-AR-AC205-R45		0.722	0.005	3.347	
CF68-AR-CF68-R0	12 g	2.353	0.007	4.663	1329.99 g
CF68-AR-CF68-R45		0.473	0.005	2.913	
CF93-AR-AC68-R0	11 g	5.275	0.007	4.818	1252.49 g
CF93-AR-AC68-R45		0.945	0.005	3.139	
CF93-AR-AF75-R0	13 g	2.353	0.01	6.717	1407.49 g
CF93-AR-AF75-R45		0.473	0.005	3.112	
CF93-AR-CF93-R0	10 g	5.806	0.008	5.023	1174.99 g
GF93-AR-CF93-R45		1.364	0.004	2.233	
CF93-CF2-CF93-R0	**9 g**	**7.429**	**0.004**	**12.384**	**1097.49 g**
CF93-CF2-CF93-R45		**3.235**	**0.003**	**10.923**	

The number with composite material represents the gsm value of the cloth


y
x
x_{PF}
x_w
x_{PR}
x_{VT}
x_{HT}
c_{prop}
CG
D_{prop}^{FW}
D_{prop}^{VTOL}
l_{HT}
AC_{HT}
c_{HT}
b_{HT}