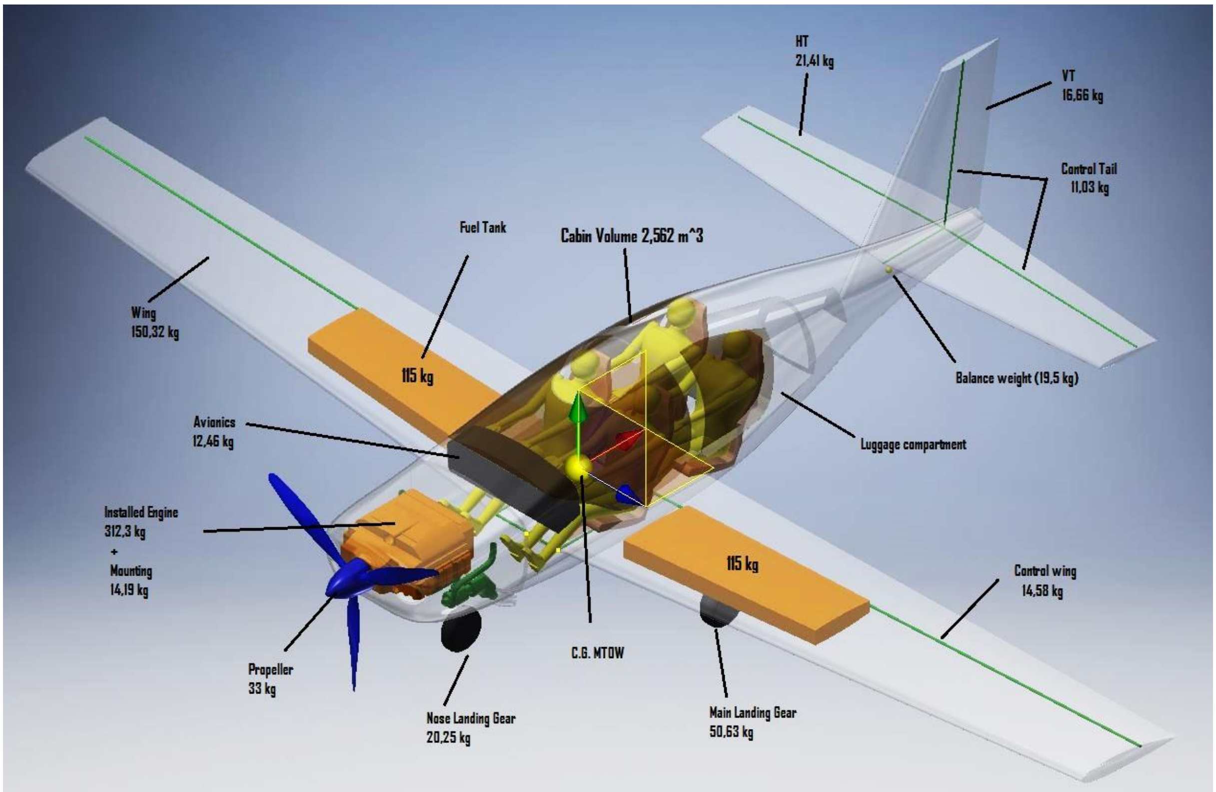
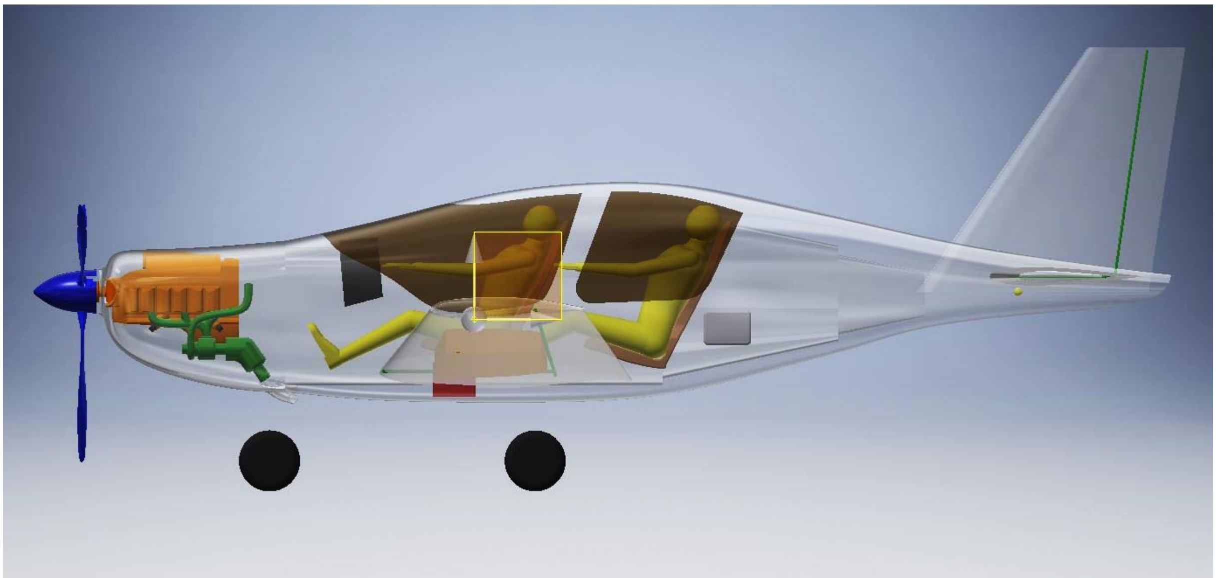
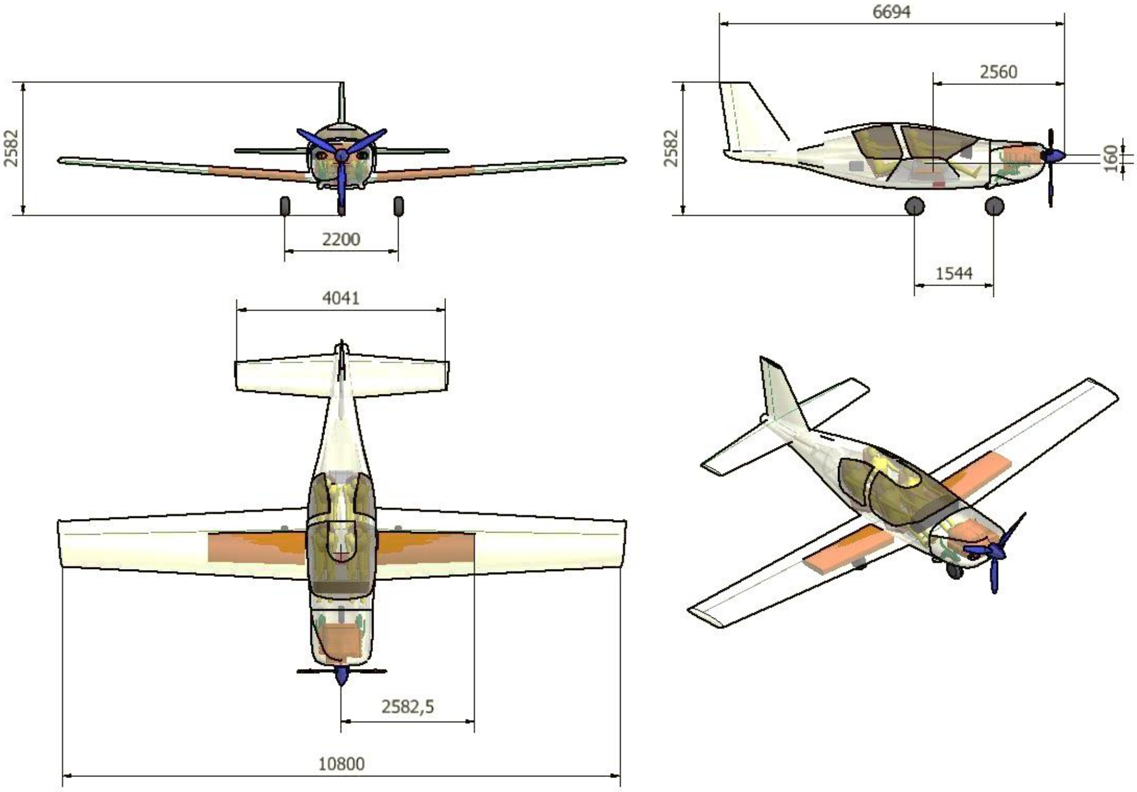
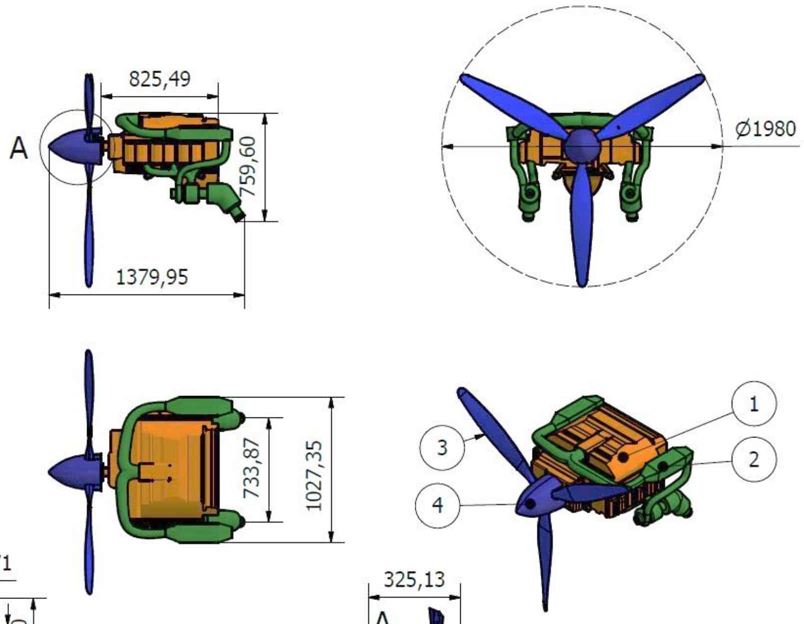
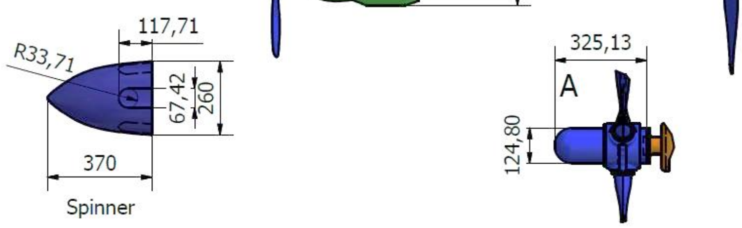
Attachments







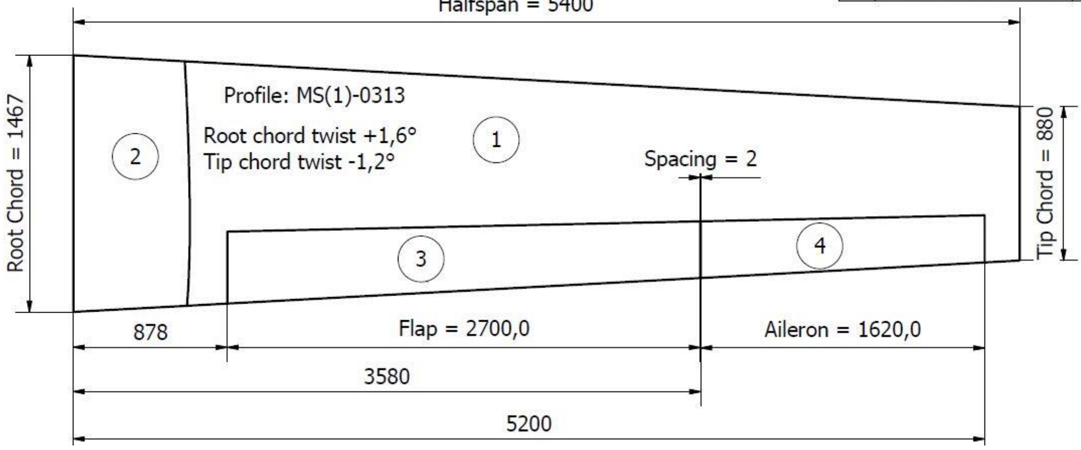




Components		
Number	Part Name	Mass
1	Engine Dry	194,591 kg
2	Engine Installations	-
3	Propeller	33 kg

Wing Parameters

#	Name	Value [m²]
-	Aspect ratio	9,2 [-]
-	Taper Ratio	0,6 [-]
1	Wing area	12,678
2	Reduced Wing area by Fuselage	1,878
3	Area of Flaps	1,984
4	Area of Ailerons	0,962



Matlab code used in constraint analysis

```
%% Constraint Analysis
%%
%%
clear global
close all
clc

%% Requirements
%%
M=1565;                     %[kg]
MtoS=20:200;                %[kg/m^2]       Weight to wing area ratio range
239.4015:2777.0574
AR=9.2;                     %[-]            Aspect Ratio
n=1/cos(45*(pi/180));       %[-]            Load factor = 1/cos(phi)
h=2500;                     %[m]            Flight Level(Cruise)
hceiling=6000;              %[m]            Service Ceiling
etap=0.85;                   %[-]            Propeller efficiency

%%
%Lift and Drag coefficients from Table 3-1 (Typical Aerodynamic Characteristics of
selected Aircraft)
CDmin=0.025;                %[-]            Minimum drag coefficient
CDTO=0.035;                 %[-]            Drag coefficient during T-O run
CLTO=0.7;                   %[-]            Lift coefficient during T-O run

%%
%Aircraft speed and ground run performance Charakteristics
vc=320/3.6;                 %[m/s]          Cruise Speed
vclimb=170/3.6;             %[m/s]          Climb Speed
vv=7;                       %[m/s]          Rate of climb(ROC)
vs=107/3.6;                 %[m/s]          Stall Speed
vlof=118/3.6;               %[m/s]          Lift-off Speed (vs+10%)
Sg=400;                     %[m]            Ground run

%%
%Constant values
```

```
rho0=1.225;                  %[kg/m^3]       Air density
g=9.80665;                   %[m/s^2]        Gravity
mu=0.04;                     %[-]            Ground friction coefficient
vvceiling=0.508;             %[m/s]          Minimum acceptable Rate of climb(ROC)

%% Step 1:    Estimation of Oswald's Span efficiency(straight wings) "e"
e=1.78*(1-0.045*AR^0.68)-0.64; %[-]  %Oswald's Span efficiency

%% Step 2:    Lift-induced drag constant "k"
k=1/(pi*AR*e); %[-]  %Lift-induced drag constant

%% Step 3:    T/W for Level Constant-velocity Turn
rho1=rho0*(1-(0.0065/288.15)*h)^4.256; %[kg/m^3]
q1=0.5*rho1*vc^2; %[N/m^2]
TtoW=q1*((CDmin./(MtoS*g))+k*((n/q1)^2).*(MtoS*g)); %[-]

%% Step 4:    T/W for a Desired Rate of Climb
q2=0.5*rho0*vclimb^2; %[N/m^2]
TtoW2=(vv/vclimb)+(q2./(MtoS*g))*CDmin+(k/q2).*(MtoS*g); %[-]

%% Step 5:    T/W for a Desired T-O Distance
q3=0.5*rho0*(vlof/sqrt(2))^2; %[N/m^2]
TtoW3=(vlof^2/(2*g*Sg))+((q3*CDTO)./(MtoS*g))+(mu*(1-((q3*CLTO)./(MtoS*g)))); %[-]

%% Step 6:    T/W for a Desired Cruise Airspeed
TtoW4=q1*CDmin*(1./(MtoS*g))+k*(1/q1).*(MtoS*g); %[-]

%% Step 7:    T/W for a Service Ceiling(ROC=100fpm)
rho2=rho0*(1-(0.0065/288.15)*hceiling)^4.256; %[kg/m^3]
TtoW5=(1./sqrt(MtoS*g))*(vvceiling/(sqrt(((2/rho2))*(sqrt(k/(3*CDmin))))))+4*sqrt((
k*CDmin)/3); %[-]

%% Step 8:    Plotting W/S vs. T/W
figure('Name','Wing Loading vs. Thrust
Loading','units','normalized','position',[.25 .52 .4 .4]);
plot(MtoS,TtoW,'k'); hold on;
plot(MtoS,TtoW2,'r');
plot(MtoS,TtoW3,'-.b');
plot(MtoS,TtoW4,'m');
plot(MtoS,TtoW5,'b');
axis([0 200 0 0.35])
grid
grid minor
title('Constraint Diagram')
xlabel('Wing Loading, M/S [kg/m^2]')
ylabel('Thrust Loading, T/W [-]')
legend('Turn Requirement','Climb Requirement','T-O Requirement',...
    'Airspeed Requirement','Service Ceiling','Location','north')

%% Step 9.1: Required Engine Power(kW)
T=TtoW*M*g;    %[N]
T2=TtoW2*M*g; %[N]
T3=TtoW3*M*g; %[N]
T4=TtoW4*M*g; %[N]
T5=TtoW5*M*g; %[N]

P=((T*vc)/(etap))/1000;                                                   %[kW]
P2=((T2*vclimb)/(etap))/1000;                                             %[kW]
P3=((T3*vclimb)/(etap))/1000;                                             %[kW]
P4=((T4*vc)/(etap))/1000;                                                 %[kW]
P5=((T5.*(sqrt((2/rho2).*(MtoS*g)*(sqrt(k/(3*CDmin))))))/(etap))/1000; %[kW]

figure('Name','Wing Loading vs. Power
Requirements','units','normalized','position',[.46 .04 .4 .4]);
plot(MtoS,P,'k'); hold on;
plot(MtoS,P2,'r');
plot(MtoS,P3,'-.b');
plot(MtoS,P4,'m');
```

```matlab
plot(MtoS,P5,'b');
axis([0 200 0 300])
grid
grid minor
title('Power Requirements')
xlabel('Wing Loading, M/S [kg/m^2]')
ylabel('Engine Power Required, [kW]')
legend('Turn Requirement','Climb Requirement','T-O Requirement',...
    'Airspeed Requirement','Service Ceiling','Location','northeast')

%%  Step 9.2: Required Engine Power(BHP)-Normalized to SL conditions
sigma=rho1/rho0;
sigma2=rho0/rho0;
sigma3=rho0/rho0;
sigma4=rho1/rho0;
sigma5=rho2/rho0;
P_SL=P/(1.132*sigma-0.132);      %[kW]
P_SL2=P2/(1.132*sigma2-0.132);   %[kW]
P_SL3=P3/(1.132*sigma3-0.132);   %[kW]
P_SL4=P4/(1.132*sigma4-0.132);   %[kW]
P_SL5=P5/(1.132*sigma5-0.132);   %[kW]

% figure('Name','Wing Loading vs. Power at Sea Level');
% plot(MtoS,P_SL,'k'); hold on;
% plot(MtoS,P_SL2,'r');
% plot(MtoS,P_SL3,'-.b')
% plot(MtoS,P_SL4,'m');
% plot(MtoS,P_SL5,'b');
% axis([0 200 0 300])
% grid
% grid minor
% title('Power Requirements Normalized to Sea Level')
% xlabel('Wing Loading, M/S [kg/m^2]')
% ylabel('Engine Power Required, [kW]')
% legend('Turn Requirement','Climb Requirement','T-O Requirement',...
%     'Airspeed Requirement','Service Ceiling','Location','south')
% hold off

%%  Step 10: Adding Stall Speed Limits
qstall=(0.5*rho0*(vs^2));
CLmax=(1./qstall).*((MtoS)*g);

%%
figure('Name','Wing Loading vs. Power at Sea
Level','units','normalized','position',[.052 .04 .4 .4]);
hold on
plot(MtoS,P_SL,'k',MtoS,P_SL2,'r',MtoS,P_SL3,'-.b',MtoS,P_SL4,'m', ...
    MtoS,P_SL5,'b');
axis([0 200 0 300])
ax = plotyy(MtoS, P_SL, MtoS, CLmax);
ylim([0 300])
set(gca,'yTick',0:50:300)
set(ax(2),'YLim', [0 3]);
set(ax(2),'yTick', 0:0.5:3);
grid on
grid minor
title('Power Requirements Normalized to Sea Level')
xlabel('Wing Loading, M/S [kg/m^2]')
ylabel('Engine Power Required, P-SL [kW]')
legend('Turn Requirement','Climb Requirement','T-O Requirement',...
    'Airspeed Requirement','Service Ceiling','Location','south')

vc_km=vc*3.6;
vclimb_km=vclimb*3.6;
vlof_km=vlof*3.6;

annotation('textbox',...
    [0.76 0.3 0.3 0.12],...
```

```
'FitBoxToText','on',...
'String',{['MTOW = ' num2str(M) ' kg']...
['AR = ' num2str(AR)]...
['h = ' num2str(h) ' m']...
['hceiling = ' num2str(hceiling) ' m']...
['vc = ' num2str(vc_km) ' km/h']...
['vclimb = ' num2str(vclimb_km) ' km/h']...
['vv = ' num2str(vv) ' m/s']...
['vlof = ' num2str(vlof_km) ' km/h']...
['n = ' num2str(n)]...
['etap = ' num2str(etap)]...
['Sg = ' num2str(Sg) ' m']},...
'FontSize',11,...
'BackgroundColor',[.95  .95 .95],...
'Color',[0 0 0]);
```