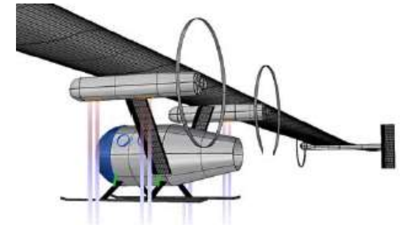
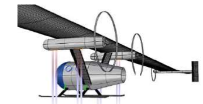
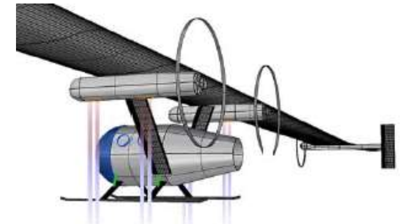
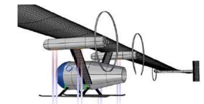




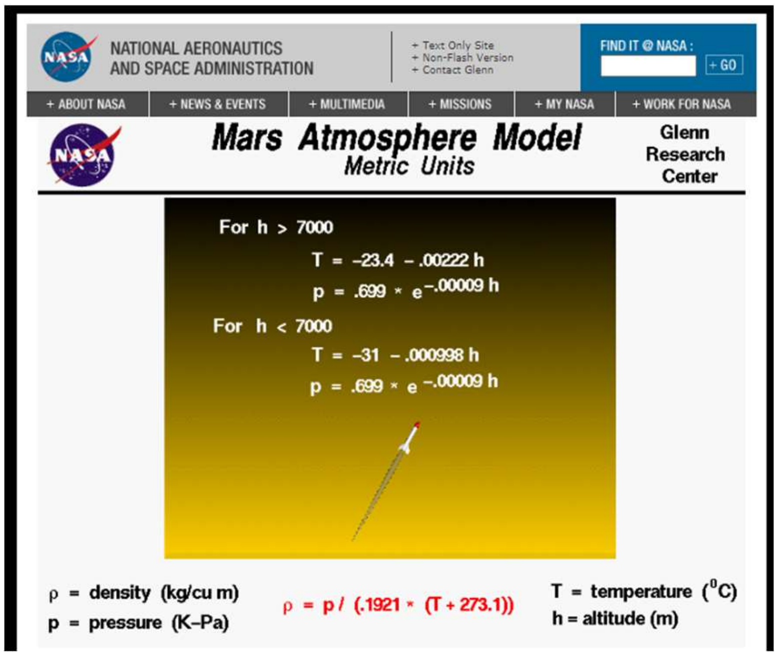
Raymer Manned Mars Plane

Name: Joabe Marcos de Souza
Task: Performance and Propulsion

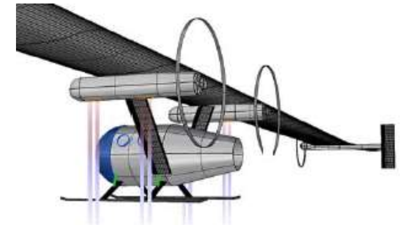


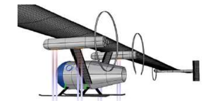


RMMP- Mars Atmosphere

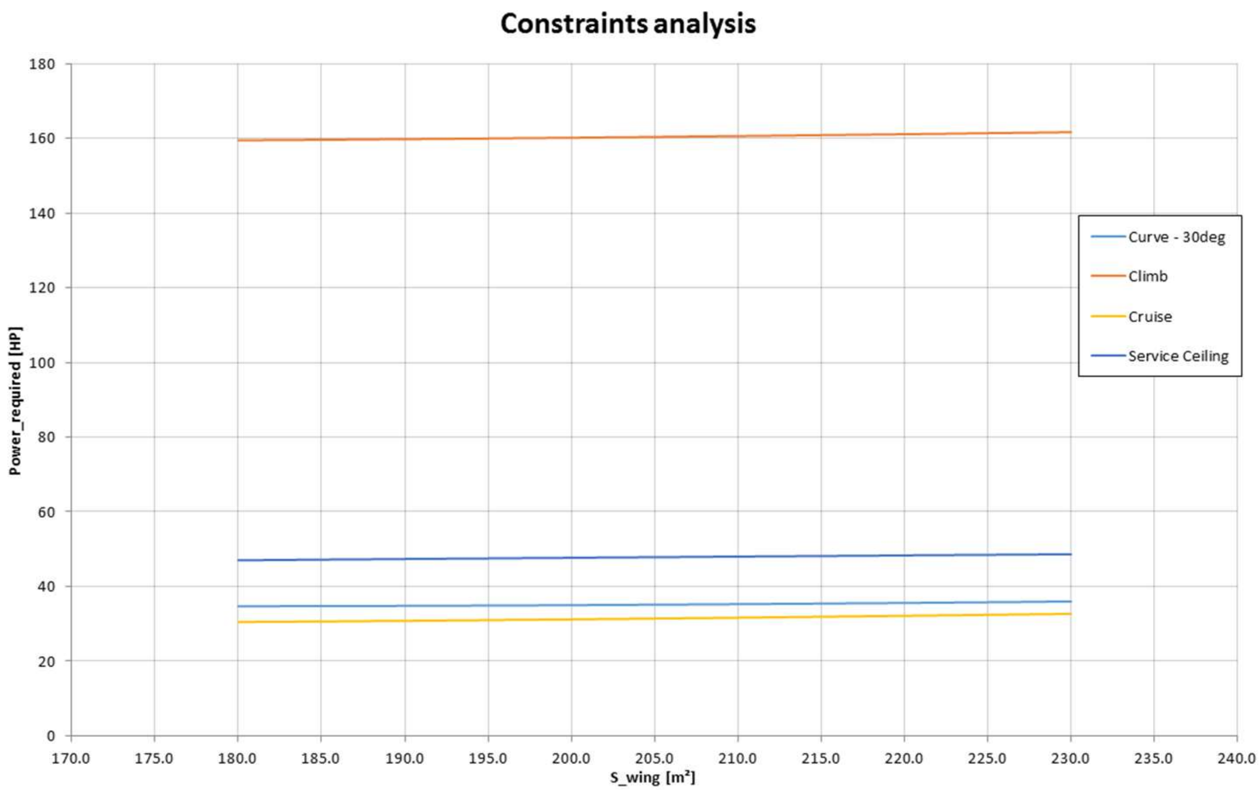


T [h=0]	-31	[ºC]
P [h=0]	0.699	[kPa]
ρ [h=0]	0.01503	[kg/m³]





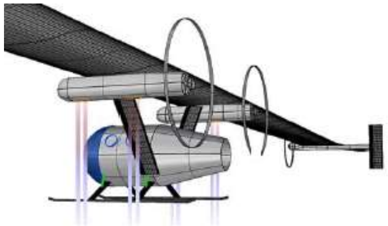
RMMP- Constraints analysis



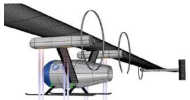
- Propeller efficiency = 0.8
- Climb at a maximum value of ROC = 1500 fpm
- Cruise at 150 KCAS
- Service Ceiling with ROC = 100 fpm

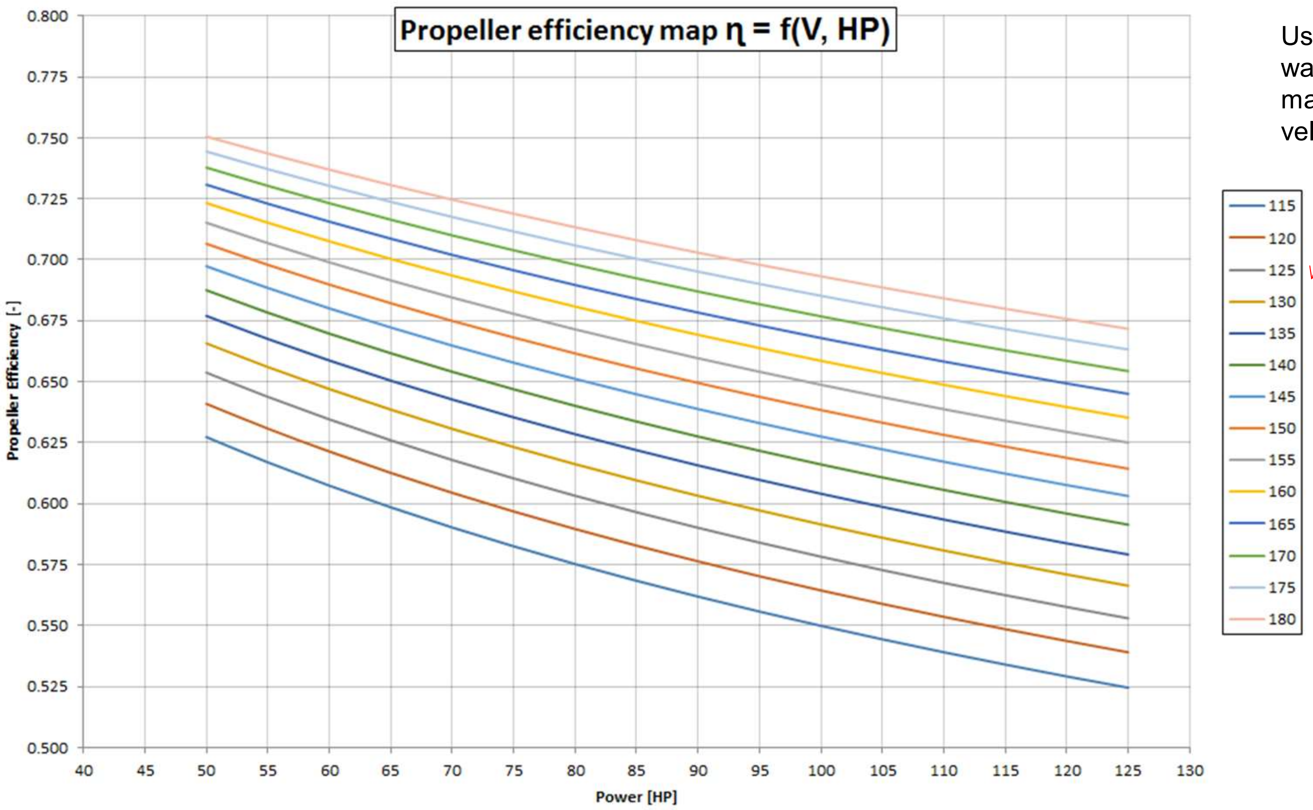
- It seems that we are over estimating the power designed (500HP) for the mission.

- Solar Impulse has ~ 70 hp (https://aroundtheworld.solarimpulse.com/adventure)

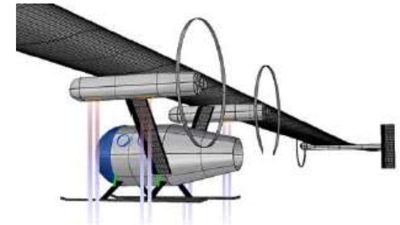


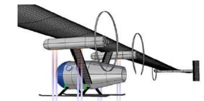
RMMP- Detailed analysis





Using the Momentum Theory it was build a propeller efficiency map in function of power and velocity in knots.

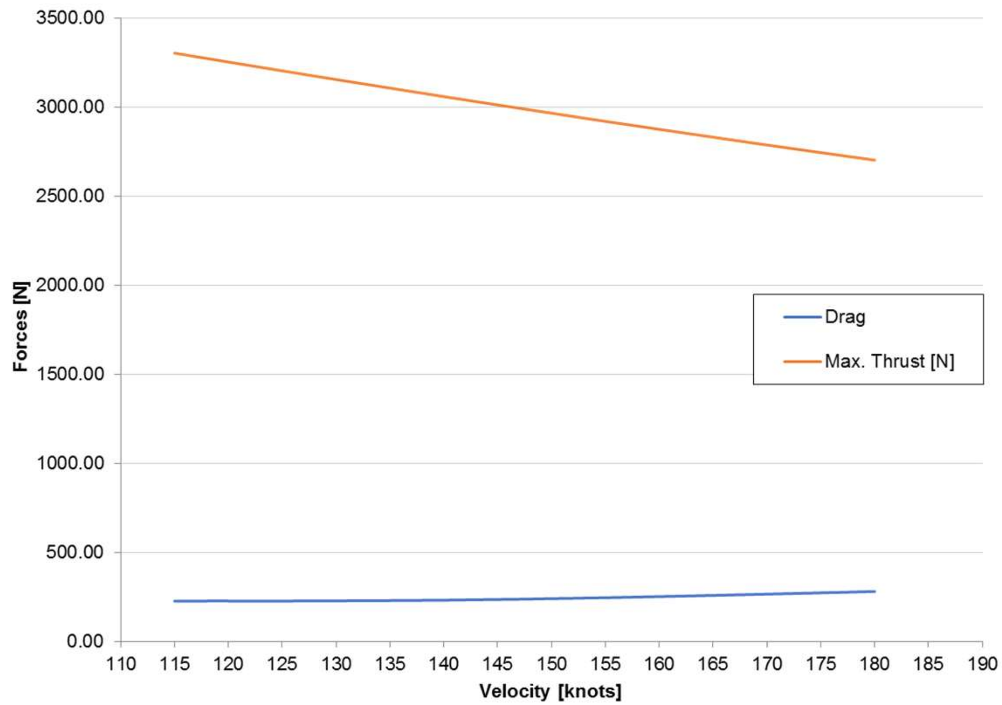


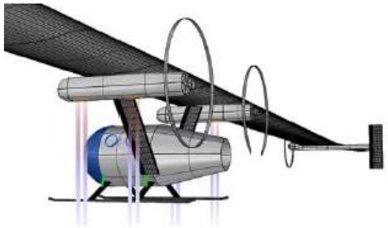


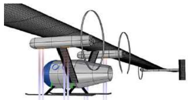
RMMP- Detailed analysis – Cruise flight

- Propeller efficiency in function of speed
- Specific energy = 500 Wh/kg
- Efficiency from battery to motor shaft = 0.9
- Efficiency due installation losses = 0.97

Again, it seems that we are over estimating the power designed (500 HP)



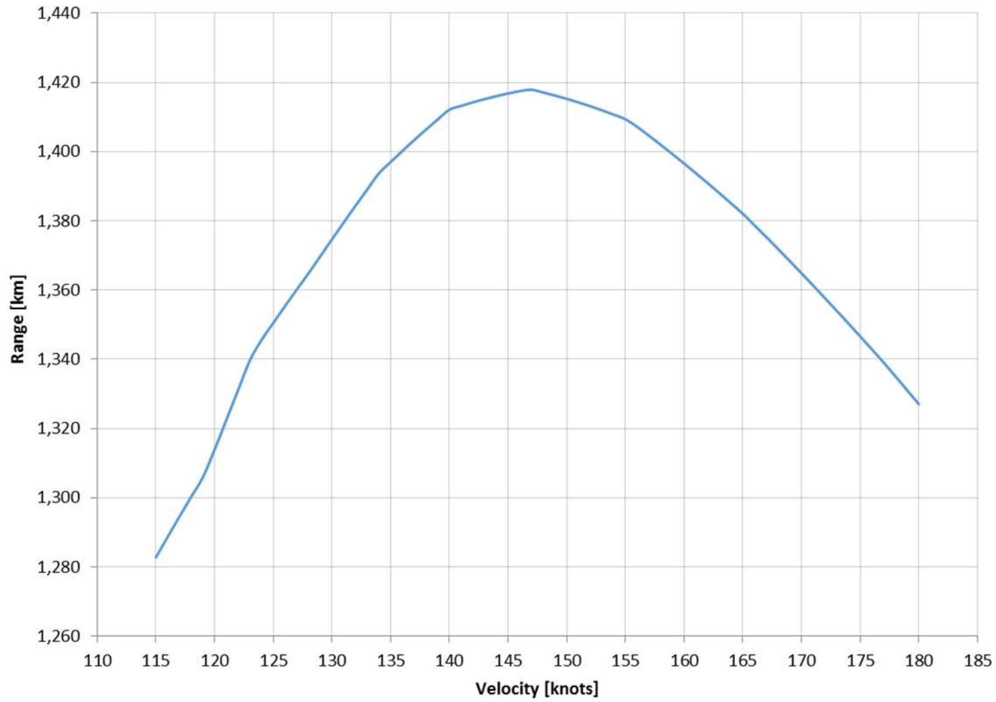


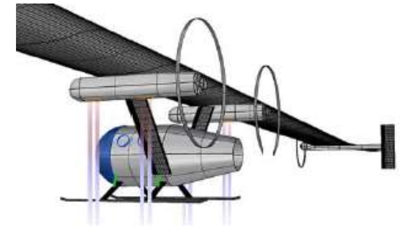


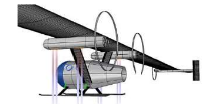
RMMP- Detailed analysis – Cruise flight

Considering:

- mbat/TOW = 0.13
- Propeller efficiency in function of speed
- Specific energy = 500 Wh/kg
- Efficiency from battery to motor shaft = 0.9
- Efficiency due installation losses = 0.97



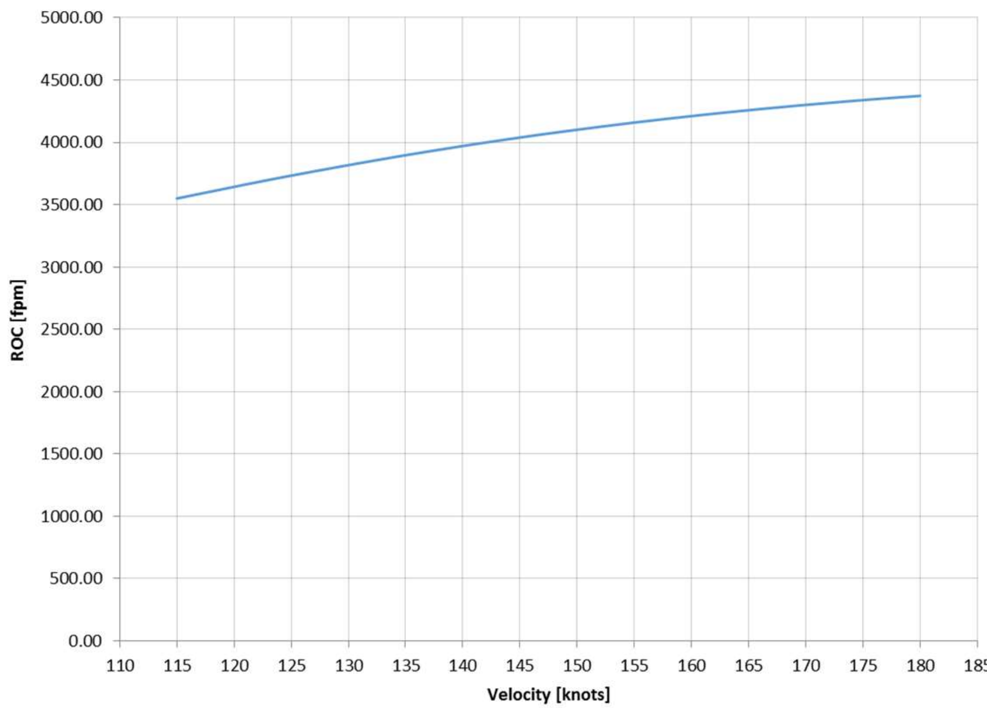


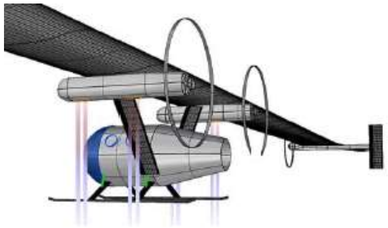


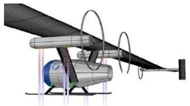
RMMP- Detailed analysis - Climb

Considering:

- Propeller efficiency in function of speed
- Efficiency from battery to motor shaft = 0.9
- Efficiency due installation losses = 0.97







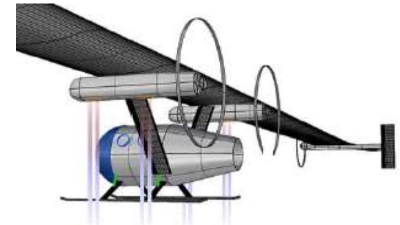
RMMP- Proposal

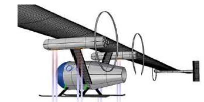
The following modifications are being proposed:

- Resize the engine from 500 hp to 200 hp (4 engines of 50 hp each)
- Use Lithium-Sulfur batteries with Specific energy = 700 Wh/kg
- Reduce wing-span until the L/D reaches the value of 30.

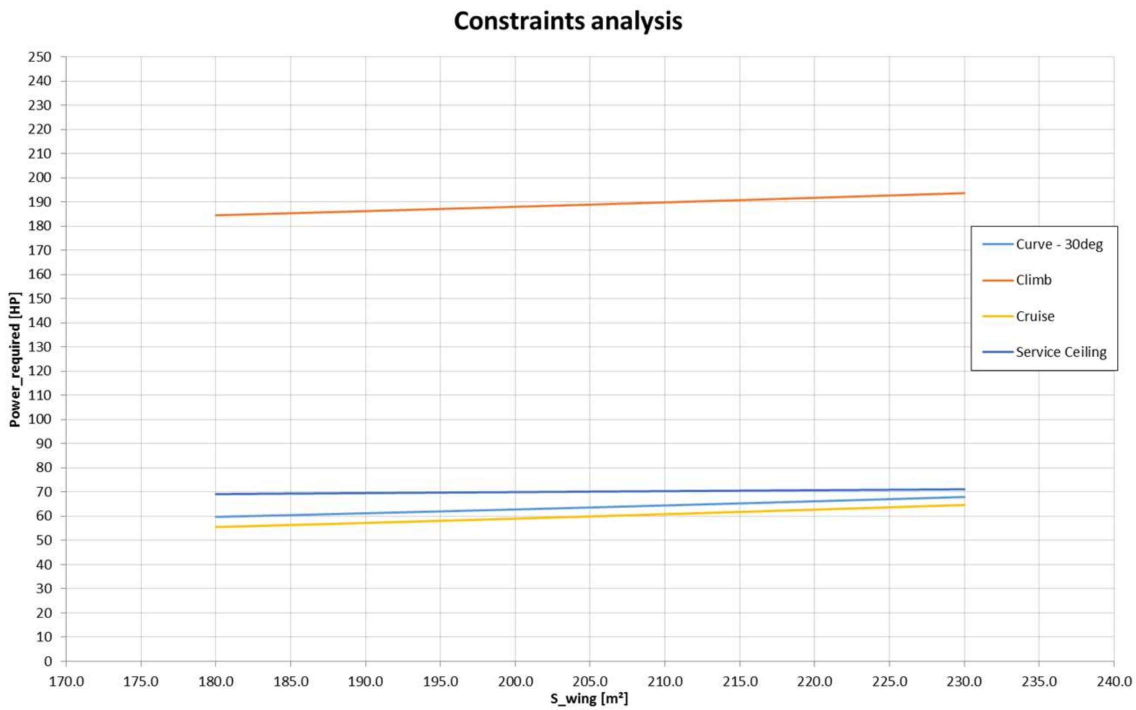
Table 2.1: Projected performance ranges of lithium-based batteries at cell level for the year 2035

	Unit	Li-Ion	Li-S	Li-$O_{2,open}$	Li-$O_{2,closed}$
Specific Energy	Wh/kg	250-350	600-700	**800-1500**	600-1200
Specific Power	W/kg	**500-600**	350-500	300-400	300-400
Energy Density	Wh/l	600-800	300-350	**1000-1700**	1000-1600
Charge/Discharge efficiency	%	**90-95**	70-90	60-85	60-85
Cycle life	# cycles	**1000-3000**	1000-2500	500-1000	500-1000
Degree of Discharge	%	70-90	**90-100**	70-90	70-90
Lifetime	yrs.	7-15	7-14	5-10	5-10
Cost ($ 2010)	$/kWh	**250-350**	250-500	400-800	300-700
Uncertainty	-	**low**	medium	high	high



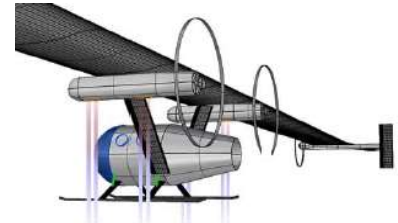


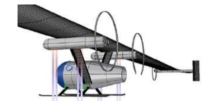
RMMP- Results with the proposed data



- Propeller efficiency = 0.8
- Climb at a maximum value of ROC = 1500 fpm
- Cruise at 150 KCAS
- Service Ceiling with ROC = 100 fpm

- New drag polar considering the maximum L/D = 30

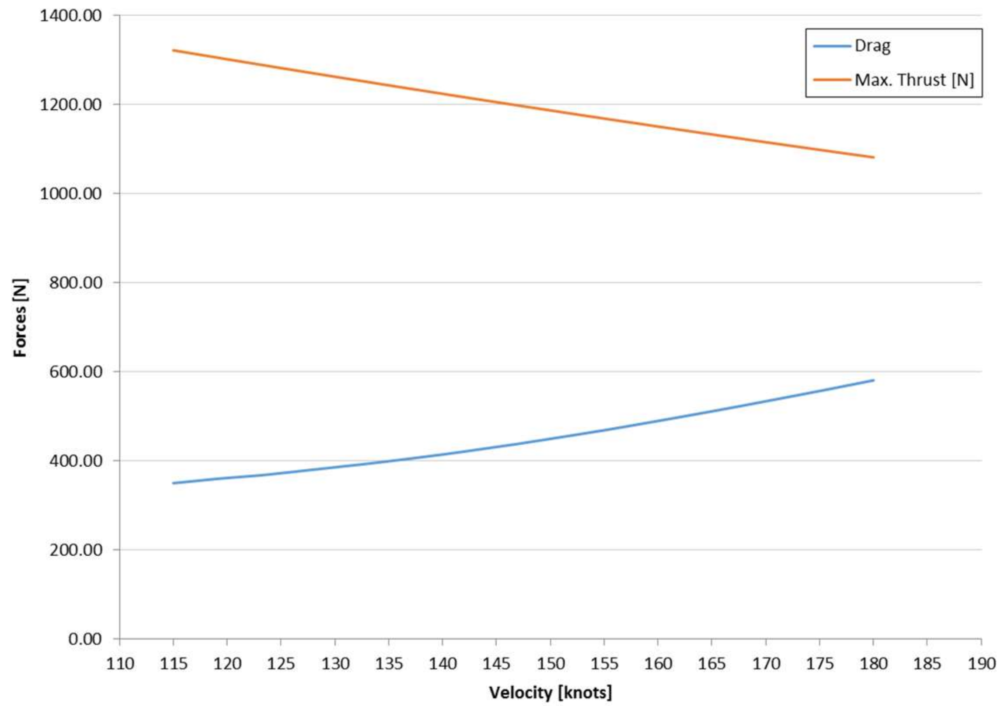


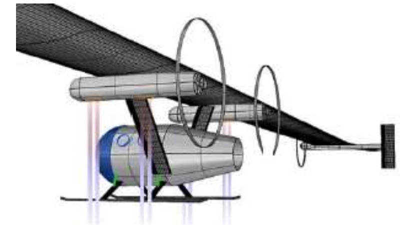


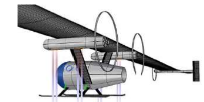
RMMP- Results with the proposed data - Cruise

Considering:

- Propeller efficiency in function of speed
- Efficiency from battery to motor shaft = 0.9
- Efficiency due installation losses = 0.97

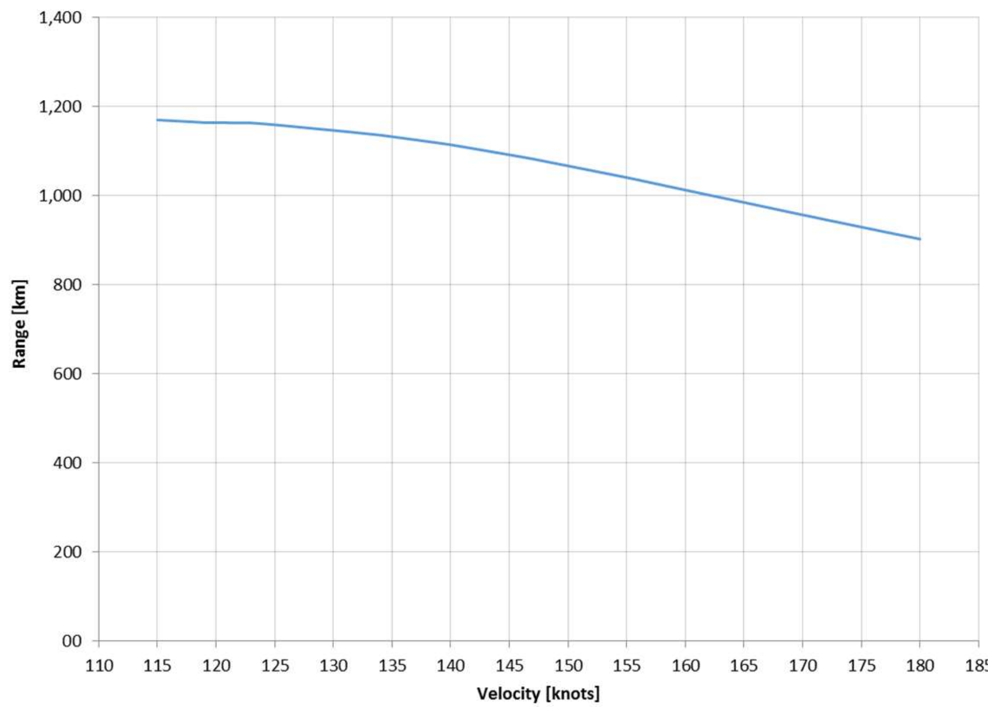


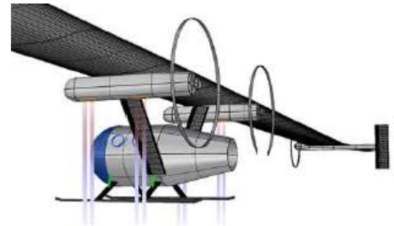


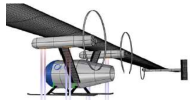


RMMP- Results with the proposed data - Range

Considering:
- mbat/TOW = 0.13
- Propeller efficiency in function of speed
- Specific energy = 700 Wh/kg
- Efficiency from battery to motor shaft = 0.9
- Efficiency due installation losses = 0.97







RMMP- Results with the proposed data - Climb

Considering:

- Propeller efficiency in function of speed
- Efficiency from battery to motor shaft = 0.9
- Efficiency due installation losses = 0.97