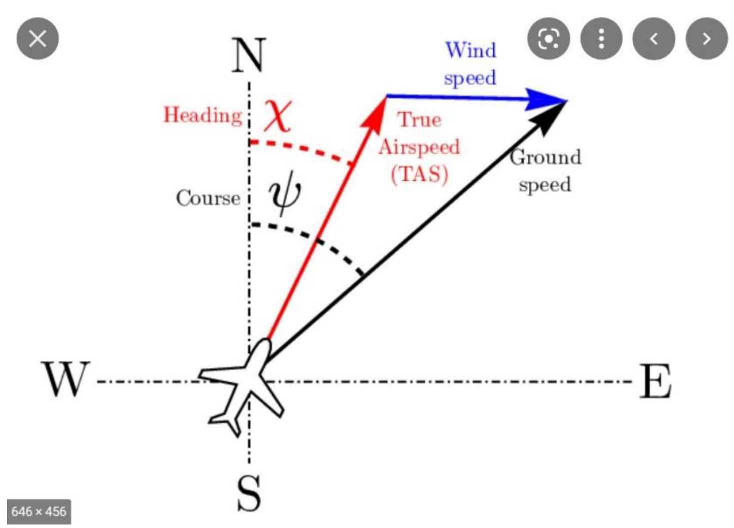
First, we deal with the effect of wind on the endurance;

$$\sum_{t=1}^{T}\sqrt{\left(x(t)-x(t+1)\right)^2-\left(y(t)-y(t+1)\right)^2}+\cdots$$

$$\sum_{t=1}^{T}\max\left(\frac{\sqrt{\overbrace{\left(True\ Speed.Sin(\chi_t)-Ground\ Speed\ (t).Sin(\psi_t)\right)^2}^{\text{Wind speed component (x)}}+\overbrace{\left(True\ Speed.Cos(\chi_t)-Ground\ Speed(t).Cos(\psi_t)\right)^2}^{\text{Wind speed component (y)}}}\ .\ Energy\ consumption\ per\ speed}{\underbrace{\sqrt{\left(True\ Speed.Sin(\chi_t)-Ground\ Speed\ (t).Sin(\psi_t)\right)^2+\left(True\ Speed.Cos(\chi_t)-Ground\ Speed(t).Cos(\psi_t)\right)^2}}_{Remaining\ Endurance\ (t\setminus\{t_{Take\_off}\})}\pm \underbrace{r_t}_{\text{Resistance Proportional coefficient}}A}-1,0\right)$$

A

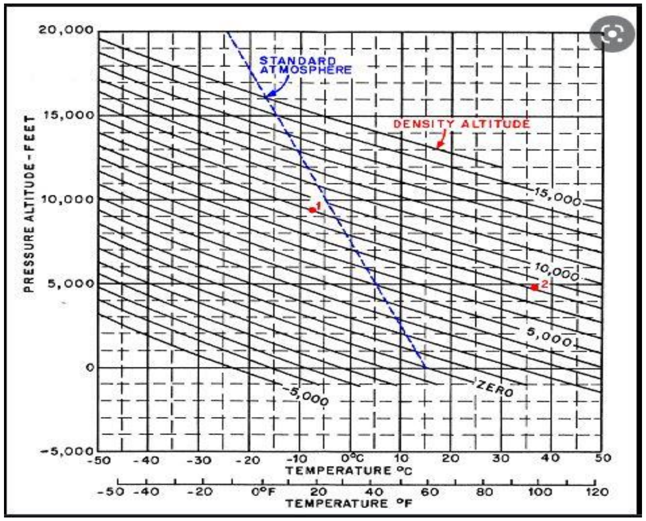


Second, we deal with the effect of specific temperature of density altitude on the endurance in pre-flight condition:

$$\sum_{t_{take\_off}=1}^{T_{take\_off}} \max\left(\frac{\left(\frac{\sqrt{\left(x(t_{take-off}+1)-x(t_{take-off})\right)^2+\left(y(t_{take-off}+1)-y(t_{take-off})\right)^2}}{Normal\ take\_off\ distance\ in\ the\ \ airport\ temp}.100\right).endurance\ consumption\ per\ feet(distance)}{required\ Endurance(t_{Take\_off})}-1{,}0\right)$$

Third, we deal with the effect of specific temperature of density altitude on the endurance in in-flight condition:

$$\sum_{t=1}^{T} \max\left(\frac{\frac{Density\ altitude(t)}{Density\ altitude\ (t-1)}\cdot\frac{Pressure\ altitude(t-1)}{Pressure\ altitude\ (t)}.energy\ consumption\ per\ unit\ of\ density\ altitude\ in\ specific\ temperature}{in\_flight\ remaining\ Endurance(t)}-1{,}0\right)$$



Wind speed component (X):

Wind speed is obtained through subtraction of True speed and Ground speed. True speed and Ground speed are decomposed in X axes $(True\ Speed.Sin(\chi_t) - Ground\ Speed\ (t).Sin(\psi_t))$ based on heading and course angles. As illustrated the subtraction of True and Ground speed on X axes is the Wind speed on the X axes. This decomposition on X axes is according to the heading and course angles as shown above.

Wind speed component (Y):

Wind speed is obtained through subtraction of True speed and Ground speed. True speed and Ground speed are decomposed in Y axes $(True\ Speed.Cos(\chi_t) - Ground\ Speed(t).Cos(\psi_t))$ based on heading and course angles. As illustrated the subtraction of True and Ground speed on X axes is the Wind speed on the X axes. This decomposition on X axes is according to the heading and course angles as shown above.

Energy consumption definition in the three different parts of the Cost function;

1. The first part of the cost function carries an energy consumption part that shows consumption per speed. This speed is cruise speed of the utilizing UAV in either X or Y direction.
2. The second part of the cost function carries an energy consumption part that illustrates energy consumption per distance in the pre-take-off condition for the utilizing UAV.
3. The third part of the cost function carries an energy consumption part that illustrates energy consumption per either increase or decrease in pressure-density altitude. This ratio will reveal the proportion of density altitude to pressure altitude is either increased or decreased and based on this change, this energy consumption is calculated per unit of altitude per feet.

Fuel consumption model in different part of Cost Function;

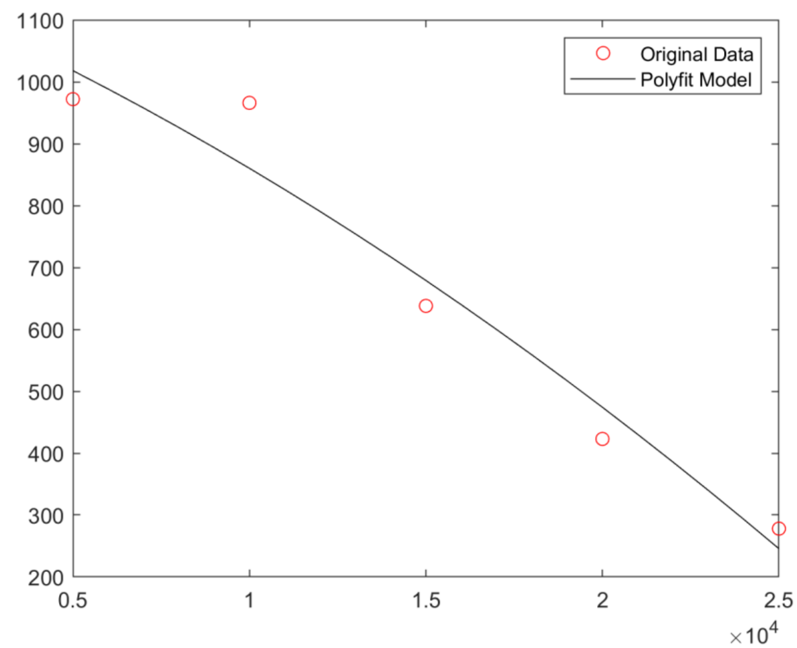
modeling fuel consumption takes three approaches;

1- Classical approaches such as polynomial fitting curve (data-driven approach).
2- Modern approaches such as fuzzy logic approaches, neural networks
3- Cutting edge approaches such as Dynamic System Identification (DSI).

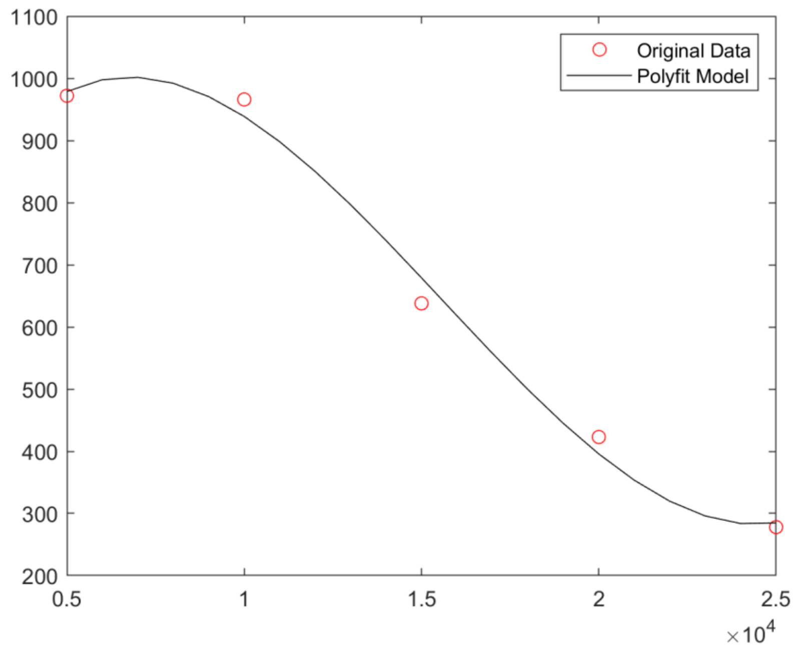
For the fuel consumption model, I have taken the classic approach and finally could approximate fuel consumption equation based on its considered coefficients in different part of the cost function.

In MATLAB, I illustrate an example for clarification on this approach. Three different example are illustrated below in three different degrees.

Fitted polynomial with degree (2):



Fitted polynomial with degree (3):



Fitted polynomial with degree (4):