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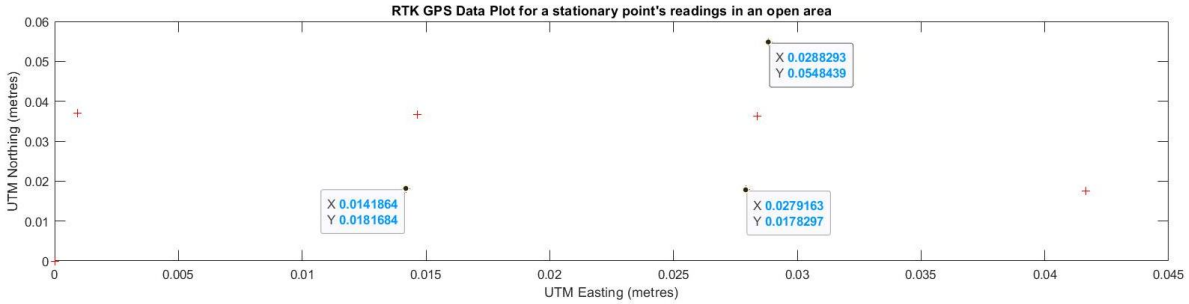
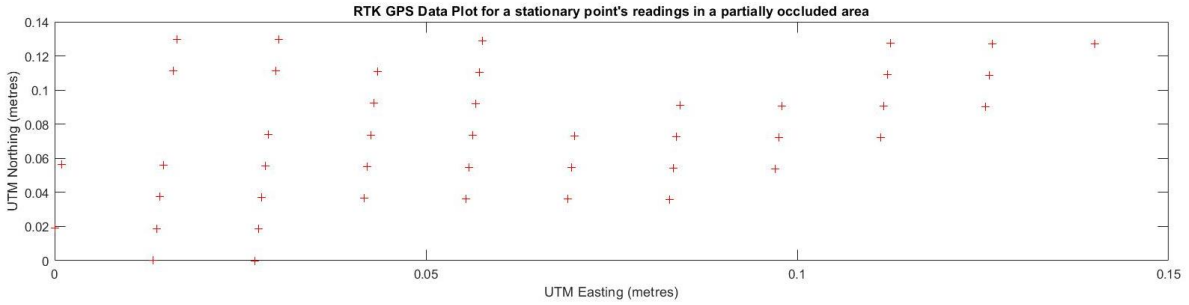
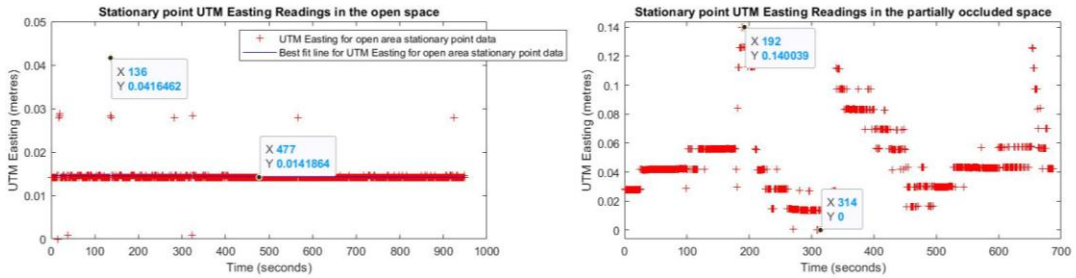
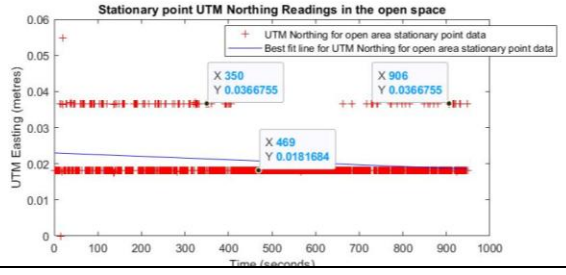
LAB-2 REPORT

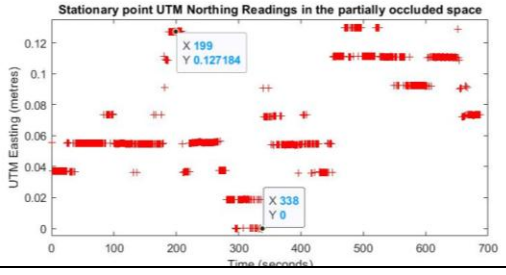


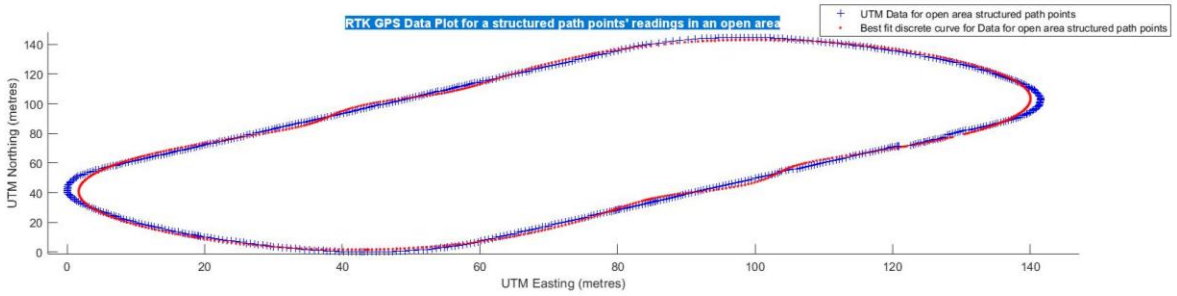


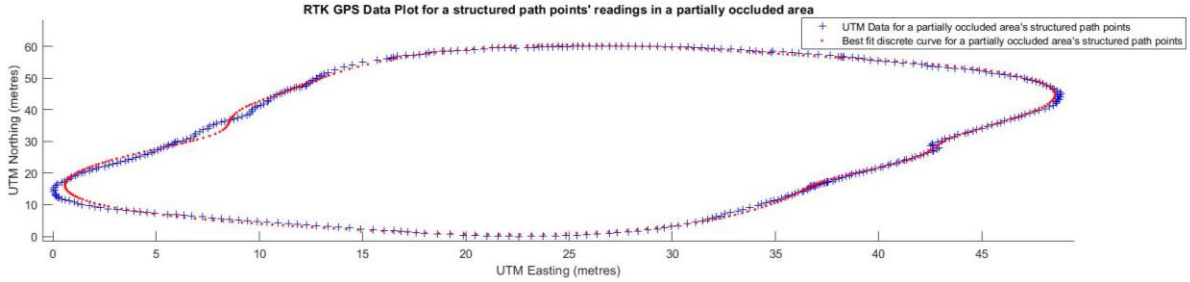
The RTK GPS Data plot gives the UTM Northing vs UTM Easting value as shown in the above plot. The data plot for stationary point readings in the open area shows readings that are fewer in number of points than that in the occluded area. This is because there are several effects which disperse and make the data erratic in occluded areas, that are avoided when data is collected in an open area. The several effects include multipath error(same signal bouncing off multiple obstructions), other obstacles, atmospheric conditions etc. In addition, the Kaalman filter in the GPS sensor presents better tracking while in motion than uncorrelated readings in the stationary data. This effect can be seen in the next plot for moving data. Further, when the stationary data is collected and the satellite configurations from which information is retrieved changes, the data first collected and the next data in the sequence might be a treated as a completely different point. All of this contributes to the data plot as shown above, even though the base and rover are completely stationary. But overall, the UTM Easting and Northing values fix around a constant mean point of 327228.5037 m and 4689744.9369m respectively as shown in below plots:



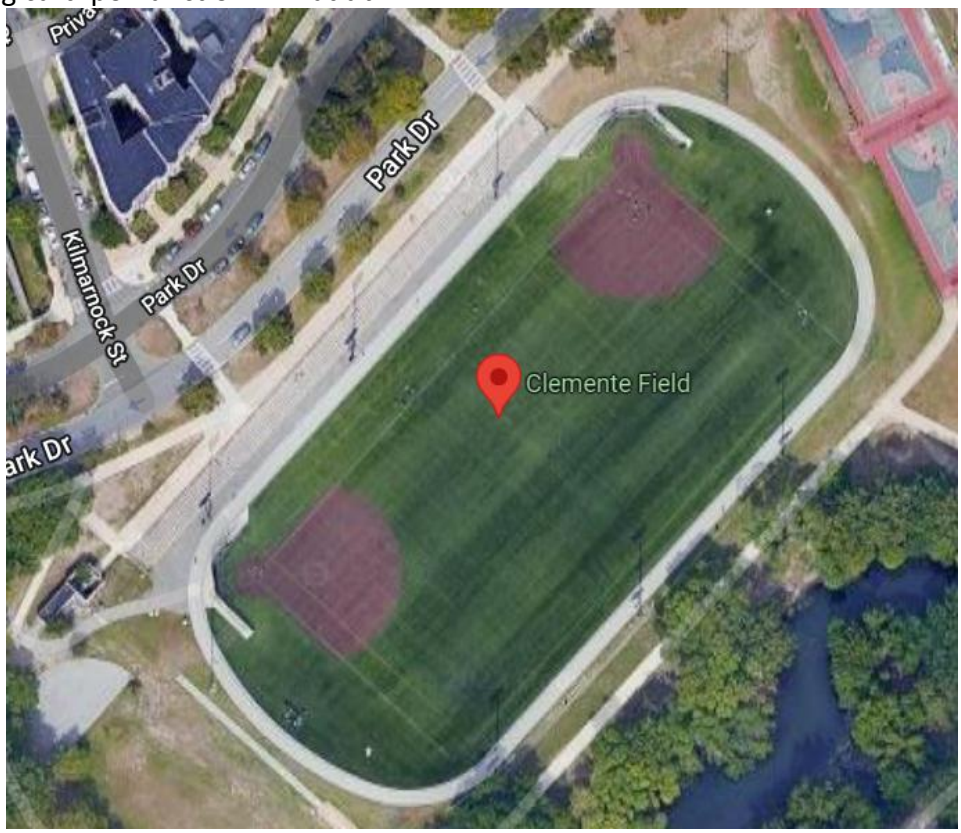


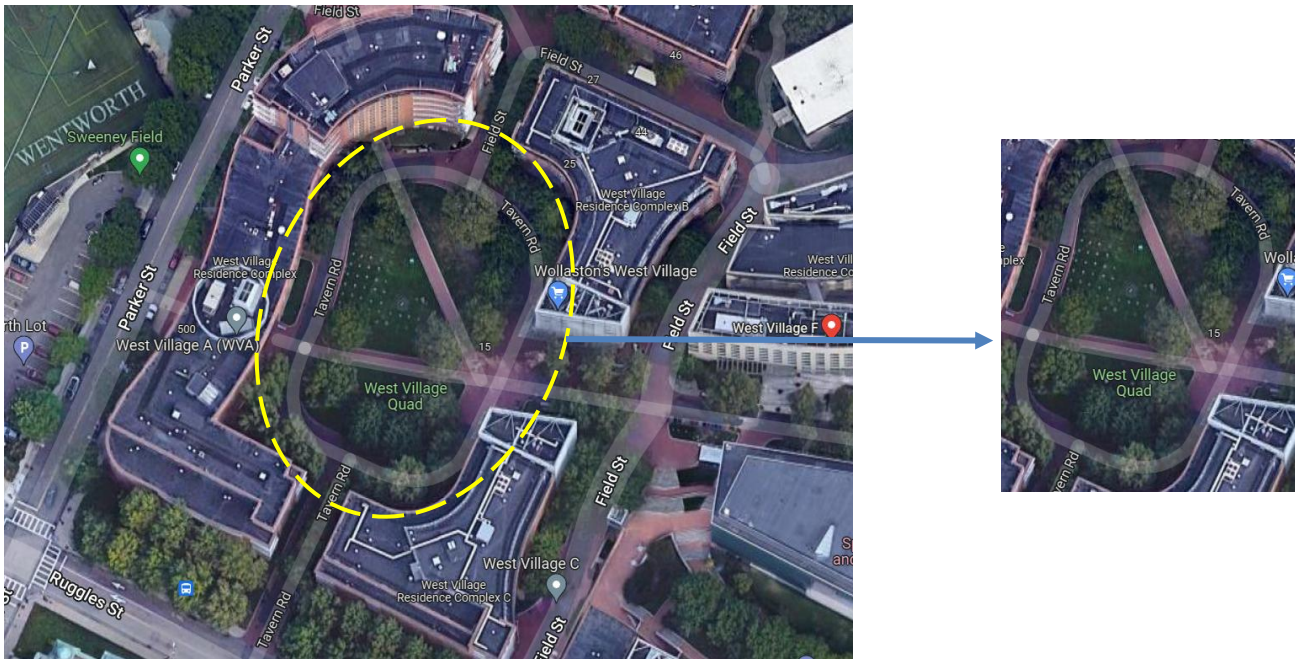




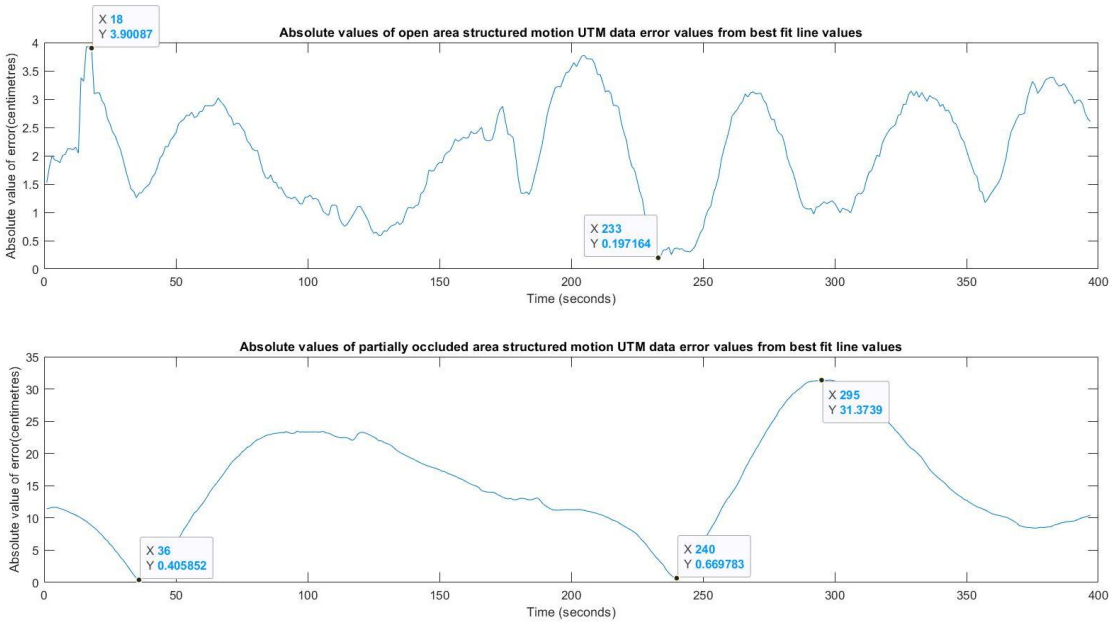


The above plots shows the GPS data for structured motion along an open area track and a partially occluded pathway track. The actual locations are Clement Field and West Village Quad as shown in the below terrain map images. The above plots are also fitted with best fit discrete curves using cart2pol function in matlab.





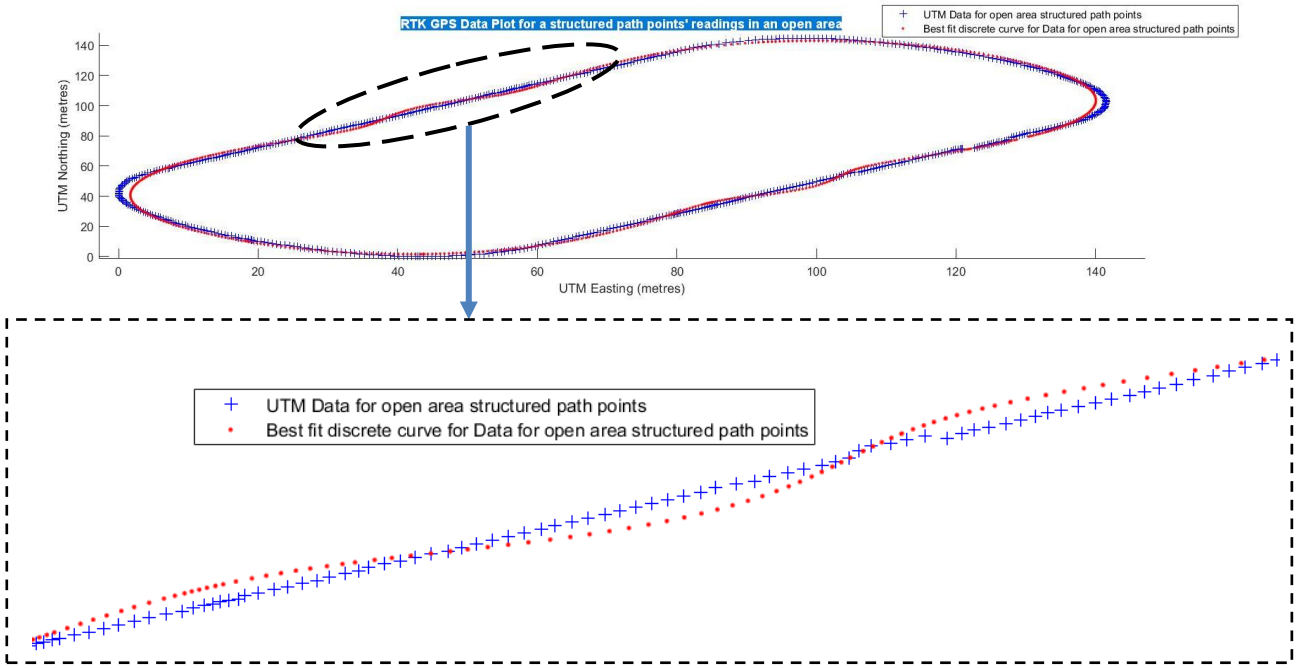
The effect of the Kalman filter as described in the first description of the dispersed plot points in the stationary point data values can be seen in the above plot describing the structured motion data. We see that the Kalman filter helps track the data to give an approximate shape of the field. In the open space structure motion data, the points are quite accurate and precise in terms of tracing the field path. The West Village Quad track is occluded by buildings, trees and other obstacles on all sides and hence the data does not provide much accuracy. But here too, the Kalman filter provided a good sense of the shape of the path traced. The errors were calculated as the euclidean distance between the best fit curve point and corresponding actual data point. The error plot is as shown:



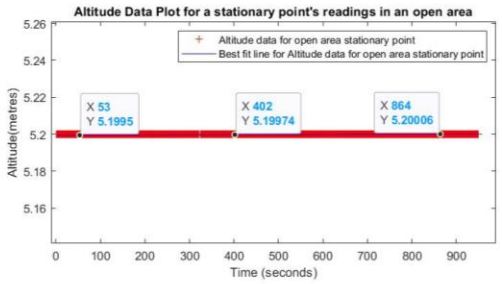
The statistical analysis of the data is as shown in the below table:

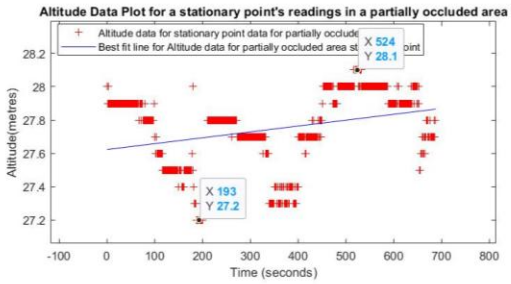
Parameter	UTM Easting(metres)	UTM Northing(metres)
Mean(Stationary Point open area)	327228.5037	4689744.937
Standard deviation(Stationary point open area)	0.0018	0.0065
Mean(Stationary Point partially occluded area)	327608.5069	4689345.148
Standard deviation(Stationary point partially occluded)	0.264	0.0333
Mean(Error values of structured motion open area)	1.2022	0.4206
Standard deviation(Error values of structured motion op	0.7512	0.2795
Mean(Error of structured motion partially occluded area	15.1515	1.5078
Standard deviation(Error of structured motion partially c	7.8828	0.8351
Minimum value(Error values of structured motion open a	0.00022105	0.000095427
Maximum value(Error values of structured motion open	0.032072	0.036245
Minimum value(Error of structured motion partially occl	0.00017905	0.00017169
Maximum value(Error of structured motion partially occl	0.31367	0.014559
Range(Error values of structured motion open area)	0.031851	0.03615
Range(Error of structured motion partially occluded area	0.313491	0.014542

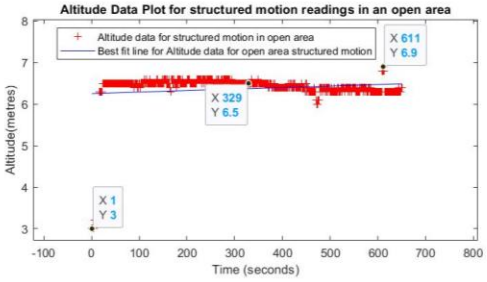
Here, the error values are calculated as the euclidean distances between the actual data points and best fit curve points. In the error plots, we see that the distribution follows a sinusoid and in further induced a **white noise**. The sinusoidal pattern can be attributed to the fact that the plot is best-fitted with a cart2pol function which travserses across the actual data in a sinusoidal fashion, on a closer observation of the plot:

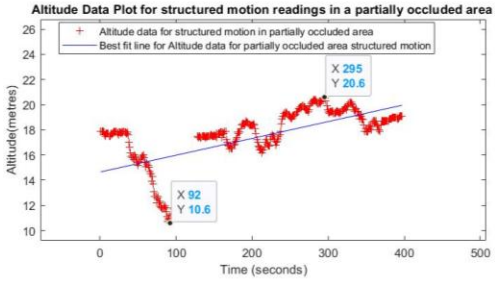


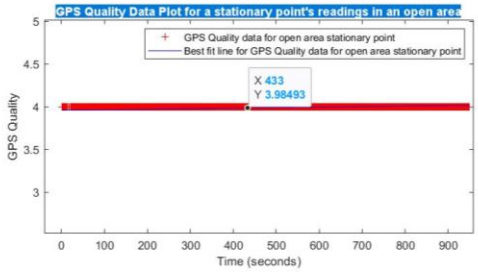
Further, the altitude and GPS fix quality were plotted as shown below:

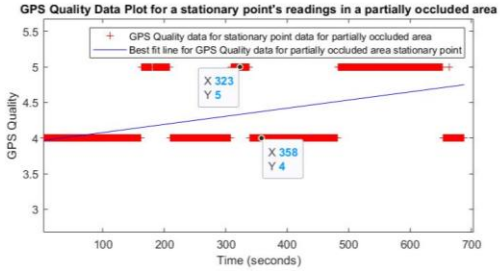


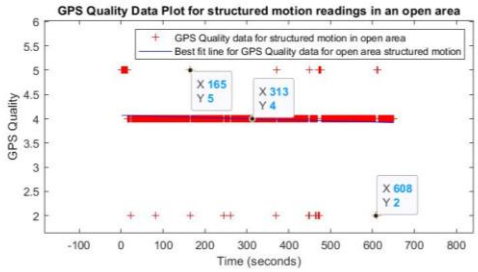


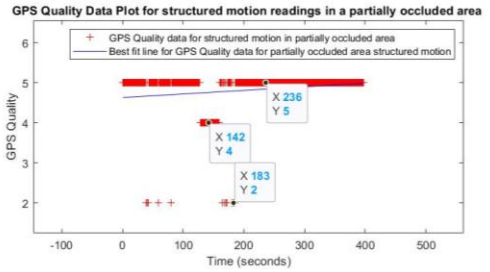












The changes in altitude and fix quality could be due to the following reasons:

1) The ellipsoidal shape of the earth does account for some of the variations in altitude. So the data does not turn out to be a constant but a varying curve. This, in addition to the error gives rise to the plot as shown above
2) The RTK GPS sensor was not held perfectly level or still while on the straight line motion. This could also have contributed to the plot as shown above.

Further, some of the common factors that affect the GPS sensor readings are clock timing errors, prevalent atmospheric and environmental condition, the geometry of arrangement of the satellites in space etc. It can be concluded that RTK GNSS navigation is much more accurate and precise than simple GPS receiver navigation such as with the GlobalSatBU-353-S4 hardware

References:

- https://www.vboxautomotive.co.uk/index.php/en/how-does-it-work-rtk#:~:text=How%20accurate%20is%20RTK%3F,an%20RTK%20enabled%20GNSS%20receiver.
- https://novatel.com/an-introduction-to-gnss/chapter-5-resolving-errors/real-time-kinematic-rtk
- https://ww2.mathworks.cn/matlabcentral/answers/565277-how-to-apply-a-fit-on-this-shape?s_tid=prof_contriblnk