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Enforcing Dilution of Precision in Global Positioning System (GPS)

O.J. Unogwu
Research Scholar, Department of IT
Sikkim Manipal University
Accra, Ghana
Omega.unogwu.2014@ieee.org
+234 706 786 3838, +233 543 844 062

K.H. Kamal
Head, Department of IT
Sikkim Manipal University
Accra, Ghana
kamalhiran@gmail.com
+233 574 974 212

ABSTRACT

This paper considers the robustness of space-based systems with specific example of GPS to faults in providing accurate positional data. Recent advances in navigation technologies enabled the infusion of information technology into physical processes. One of the keys to obtaining high-accuracy position and time keeping with GPS is the use of redundant atomic clocks onboard GPS satellites and in the GPS control segment. Time is the cornerstone of GPS technology because distances are measured at the speed of light. Atomic clocks provide the means for estimating satellite orbits and satellite clock correction parameters. Therefore, in order to achieve a high degree of accuracy, error source of GPS signal broadly categorized into three classes of 1Receiver noise errors, 2Orbital and Clock errors and 3Propagation errors are to be well contained to achieve a high degree of precision. Generating GPS applications for extracting and enforcing dilution of precision made positioning accuracy feasible using the understanding of Geometric Dilution of Precision (GDOP) deals with both navigation position as well as error in time estimation; Vertical Dilution of Precision (VDOP) for the quality of the calculated vertical position as well as the Time Dilution of Precision (TDOP) for the mean error of the current time estimation using the GPS constellation. All DOP measurements are packaged into the $GPGSA sentence every few seconds. Using ParseGPGSA method extracts DOP values and reports them through HDOPReceived, VDOPReceived and PDOPReceived. The result shows that adopting suitable programming language like VB.Net infrastructure produces a highly accurate precision fix in radio signal transmission between satellites in space and terrestrial receivers.

Keywords- Global Positioning System (GPS); Geometric Dilution of Precision (GDOP); Positional Dilution of Precision (PDOP); Horizontal Dilution of Precision (HDOP); Vertical Dilution of Precision (VDOP) and Time Dilution of Precision (TDOP).

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I. INTRODUCTION

Global Positioning System [2] is a satellite-based navigation system providing precise three-dimensional position, navigation, and time information to suitably equipped users. It is made up of three segments namely; the ground control stations, 24+ satellites in earth orbit and receiver units on the earth surface. The initial intention was to use this system mainly for navigation purposes of the US military. Due to the tremendous accuracy potential of this system, and the latest improvements in receiver technology, there is a growing community which utilizes the GPS for a variety of civilian applications [6].

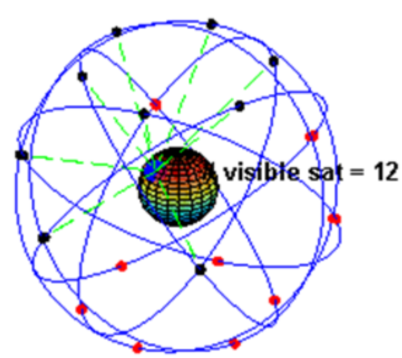

Fig 1: Constellation of GPS Satellites over Earth

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The Global Positioning System (GPS) is a constellation of 24 active (and a number of spare) earth-orbiting satellite navigation system with associated tasks in a wide variety of applications operated by the United States Government through the US Air Force. GPS provides worldwide twenty four hours a day positioning in three dimensions and time services. Primarily designed for land, maritime and aviation navigation services, GPS applications [5] have evolved into other areas including space navigation, surveying, mapping, geographic information system geo-referencing, automatic vehicular tracking as well as emergency services dispatching. Signals are transmitted from GPS satellites at two frequencies L1 and L2 at 1575.42MHz and 1227.60MHz respectively.

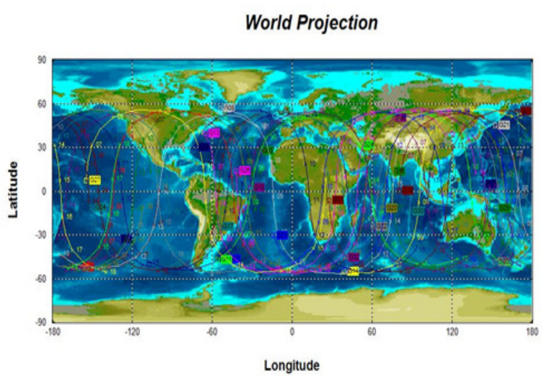

Fig 2: World Projection of GPS Satellites

Satellites are constantly in motion, which is good because it prevents the existence of "blind spots" in the world with little or no satellite visibility. Just like finding stars in the sky, satellite locations are described as the combination of an azimuth and an elevation [7]. As mentioned above, azimuth measures a direction around the horizon. Elevation measures a degree value up from the horizon between 0° and 90°, where 0° represents the horizon and 90° represents "zenith", directly overhead.

GPS programming guidelines follows a set of collections of rules that, with all the parameters made available, eliminates positioning errors [9]. In programming, to access GPS information to a high degree of reliability, information of the following attributes of the satellite needs to be present.

- Latitude
- Longitude
- Altitude
- Time Stamp
- Travel Direction
- Altitude Uncertainty
- Speed Uncertainty

With these, GPS positions can be retrieved and its status can be obtained.

Trimble wrote: "in order to compute a receiver's solution (location and time), the receiver algorithm selects four satellites from all of the satellites in the receiver's view. In mathematical terms, the user's receiver solves a system of equations with four equations and four unknowns; the four equations represent the four satellites selected by the receiver to compute a solution and the four unknowns represent the latitude, longitude, altitude, and time". With an aggressive period of research, empirical or mathematical and simple models were generated to mitigate the effects of the errors in GPS positioning. The following equation represents a good example of such models where the algorithm is used to model GPS error solutions with emphasis on the Ionosphere, Troposphere and measurements of the carrier phases on L1/L2 frequencies.

$$Ø1\,\lambda1 = R + c\,(\delta tu - \delta ts) + T - Ip1 + MØ1 + N1\lambda1 + ƐØ1 \quad (1)$$

$$Ø2\,\lambda2 = R + c\,(\delta tu - \delta ts) + T - Ip2 + MØ2 + N2\lambda2 + ƐØ2 \quad (2)$$

Where,

Ø1 = Carrier phase measured on L1 frequency (C/A or P(Y) parts)
Ø2 = Carrier phase measured on L2 frequency
R = Geometric range from satellite s to user u
δtu = User/receiver clock error
δts = Satellite clock error
T = Tropospheric Delay
Ip1, Ip2 = Ionospheric delay in measurement on L1/2
MØ1, MØ2 = Multipath delay in carrier phase measurement on L1/2
N1, N1= Carrier phase ambiguity or bias
λ1, λ2 = Carrier wavelength
ƐØ1, ƐØ1 = Other delay/errors in carrier phase measurement on L1/2

In computing Dilution of Precision, the unit vector from the receiver to satellite is given by the equation.

$$i = \left(\frac{(p_i - p)}{s_i}, \frac{(q_i - q)}{s_i}, \frac{(r_i - r)}{s_i}\right) \quad (3)$$

Where,

$$s_i = \sqrt{(p_i - p)^2 + (q_i - q)^2 + (r_i - r)^2} \quad (4)$$

and, the variables p, q and r represent the GPS receiver's position and $\boldsymbol{p_i}$, $\boldsymbol{q_i}$ and $\boldsymbol{r_i}$ represent the position of satellite $\boldsymbol{i}$. A matrix "A" for a set of satellites is given as:

$$\mathbf{A} = \begin{bmatrix} \frac{(p_1-p)}{s_1} & \frac{(q_1-q)}{s_1} & \frac{(r_1-r)}{s_1} & -1 \\ \frac{(p_2-p)}{s_2} & \frac{(q_2-q)}{s_2} & \frac{(r_2-r)}{s_2} & -1 \\ \frac{(p_3-p)}{s_3} & \frac{(q_3-q)}{s_3} & \frac{(r_3-r)}{s_3} & -1 \\ \frac{(p_4-p)}{s_4} & \frac{(q_4-q)}{s_4} & \frac{(r_4-r)}{s_4} & -1 \end{bmatrix} \quad (5)$$

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In each row of A, the first three elements are the components of a unit vector from the GPS receiver to the designated satellite. Supposing the elements in the fourth column denotes the speed of light c then the time dilution factor σ_t always equals 1. However, if the elements here is -1 then the σ_t can effectively be calculated. The matrix Q is formulated as:

$$Q = (A^T A)^{-1} \quad (6)$$

In accordance with the Principles of Satellite Positioning document, where the weighting matrix "*M*" is set to the identity matrix.

In Q the elements are denoted as:

$$Q = \begin{bmatrix} \sigma_p^2 & \sigma_{pq} & \sigma_{pr} & \sigma_{pt} \\ \sigma_{pq} & \sigma_q^2 & \sigma_{qr} & \sigma_{qt} \\ \sigma_{pr} & \sigma_{qr} & \sigma_r^2 & \sigma_{rt} \\ \sigma_{pt} & \sigma_{qt} & \sigma_{rt} & \sigma_t^2 \end{bmatrix} \quad (7)$$

And, PDOP, TDOP and GDOP are denoted by:

$$\text{PDOP} = \sqrt{\sigma_p^2 + \sigma_q^2 + \sigma_r^2}, \quad (8)$$

$$\text{TDOP} = \sqrt{\sigma_t^2} \quad \text{and} \quad (9)$$

$$\text{GDOP} = \sqrt{PDOP^2 + TDOP^2} \quad (10)$$

This agrees with the principles of Satellite Positioning. Consequently, the Horizontal Dilution of Precision designated as:

$$\text{HDOP} = \sqrt{\sigma_p^2 + \sigma_q^2}, \quad (11)$$

and the Vertical Dilution of Precision:

$$\text{VDOP} = \sqrt{(\sigma\text{-}r^2)} \quad (12)$$

are both reliant on the coordinate system used.

2. METHODOLOGY

Solving GPS precision problems is done by using more sophisticated GPS receivers which use real-time correction data such as WAAS (for North America) and EGNOS (for Europe). Yet, these problems cause relatively small inaccuracies when compared with Geometric Dilution of Precision [4], which can cause a receiver to be inaccurate by more than a football field. Fortunately, Geometric DOP is the easiest to manage with the right programming techniques. The idea of Geometric DOP is to state how errors in the measurement will affect the final state estimation. Knowing the location of satellites is important when determining how precise readings are and how stable a GPS fix is.

Computationally, this can be defined [9] as:

$$\text{GDOP} = \frac{\Delta(Output\ Location)}{\Delta(Measured\ Data)} \quad (13)$$

Conceptually, errors on a measurement resulting in the $\Delta(\text{Measured Data})$ term changing can be imagined. Ideally little changes in the measured data should not significantly result in large changes in output location as such a result would imply the solution is very sensitive to errors.

In this work construction of VB.Net application takes the distance between satellite in orbit and a receiver at any point on the earth's surface, the satellite's azimuth and elevation angles and acceleration, as well as each satellite's precise location in space as attributes. Controlling GDOP [17] is the key to writing accurate GPS applications. This is informed by the understanding of the ratio of position error to the range error of each satellite.

3. DESIGN

This novel research design is to add to modern precision standards involving identification of the various components of the error sources, with particular emphasis on the atmospheric segments - ionosphere and troposphere. This, it is hoped has added to push advances in GPS technology precision to new levels.

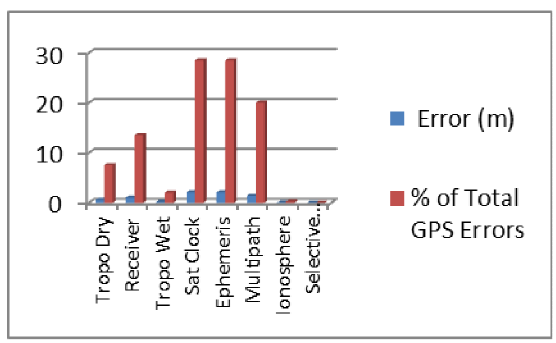

Fig 3: Magnitude/percentage distribution of all GPS Errors

Enforcing DOP by using of VB.Net [besides other programming languages as java and C#] would address GPS errors that are inherent by the effects of the atmosphere. It utilizes the distance, elevation, orbits and acceleration of the satellites from the receiver's position on the surface of the earth. Considering a scenario with lines joining four satellite positions and receivers form a tetrahedron, the smaller the volume of the tetrahedron, the worse Geometric Dilution of Precision, likewise, the better the Geometric Dilution of Precision when there is a larger Dilution of Precision values.

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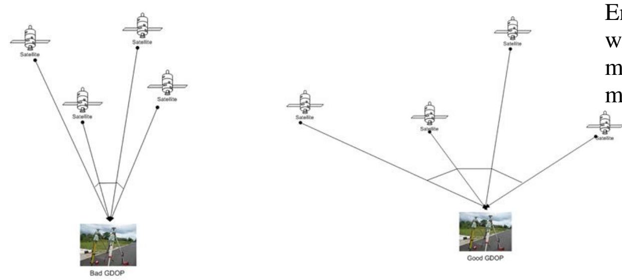

Fig 4: Illustration of bad and good DOP

DOP values range between 1 to >20 with rating decreasing in quality from IDEAL to POOR starting from 1. A high DOP does not produce an accurate position; though it could still be good. However, the position is probably closer to being right with a low DOP.

There are a number of ways to improve accuracy:

- Use DGPS to reduce the errors in the inputs.
- Improve DOP by using more satellites.
- Take your measurements when the satellites are spread out over the sky.
- Average the GPS position readings over time.

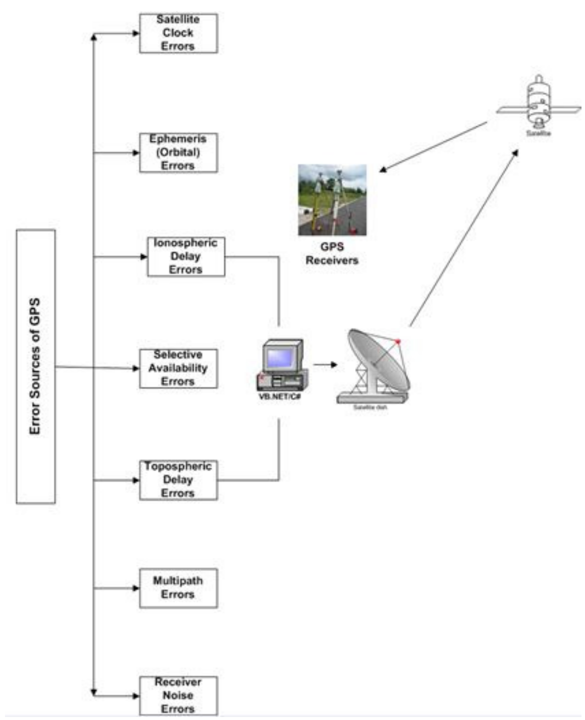

Fig 5: Step for Dilution of Precision in GPS

Enforcing maximum DOP values is the easiest part of the whole programming process because enforcing precision is a matter of ignoring positional measurements above the maximum allowable DOP amount.

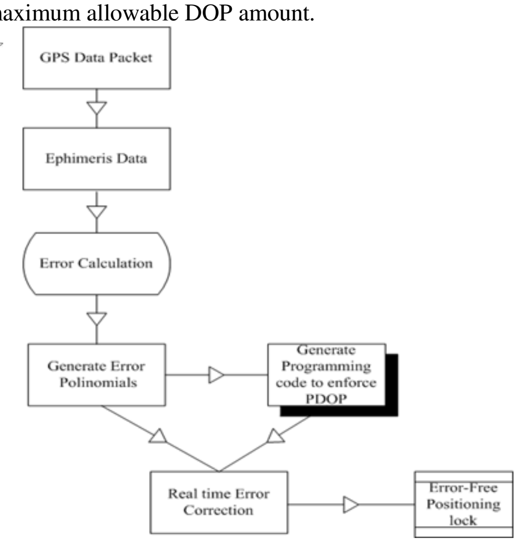

Fig 6: **Process logic for Programming GPS Solutions**

Implementation of the methodology was carried out having in mind the need to construct appropriate codes that will extract and enforce maximum DOP values. DOP can be expressed as a number of separate measurements; HDOP, VDOP, PDOP, and TDOP representing Horizontal, Vertical, Positional (3D), and Time Dilution of Precision respectively. Mathematically, they follow from the positions of the usable satellites. Signal receivers allow the displays of sky plots of these positions in addition to the DOP values. All DOP measurements are packaged into the $GPGSA sentence every few seconds. By generating programming codes to enforce Dilution of Precision, as earlier stated, the thrust of the code project is hinged on the use of VB.Net. Also, a method called ParseGPGSA is added which extracts all DOP values and reports them via three events: HDOPReceived, VDOPReceived PDOPReceived.

Satellite

The system architecture starts from the satellite in space sending positional data through the earth's atmosphere which gets distorted by the ionosphere and troposphere amongst others, resulting to positional fix errors.

Satellite Dish

The satellite dish receives the distorted data packets and sends it to the VB.NET/C# workstation where inconsistencies are eliminated and retransmitted back to the satellite, Field receiving stations and communications towers.

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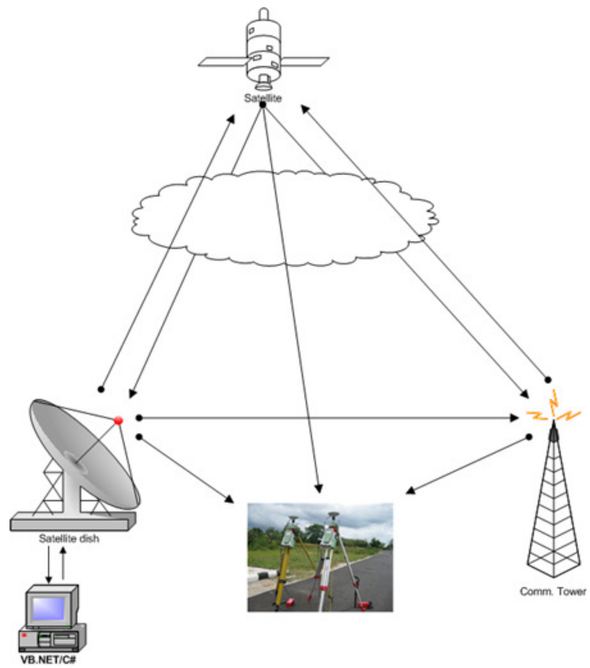

Fig 7: System Implementation

Communication Towers
The communications tower forms an important segment of the transmission system as it serves as validation point for both distorted and corrected GPS position fix data to the satellite in space and the GPS field receivers on the ground.

GPS Receivers
This is the primary reason for the system. These are equipment fitted to hand held devices, auto motives, aircrafts, stationary structures and many others for the purpose of obtaining accurate positional fixes as well as other relevant data for specialized functions.

4.THE ALGORITHMS

Pr oblem: Find and Extract GPS Dilution of Precision

Step 1: Start

Step 2: Public Class HighPrecision Test

Step 3: Private Withevent as New NmeaInterpreter where NMEA = National Maritime Electronics Association

-Private Maximum DOP Allowed As Integer = 6 (on the event to interpreting all components of Dilution of Precision: GDOP, TDOP, PDOP, HDOP, VDOP and Time)

Step 4: Public Sub Test ()
Parse satellite Information (HDOP is 0.9)

Step 5: With ParseGPGSA DOP values are extracted and reported via three events – HDOPReceived, VDOPReceived, and PDOPReceived.

Step 6: MyInterpreter.Parse("$GPRMC, 060000,A,0533.000,N,&_00013.000,E,022.4,084.4,010714,4.433,W*6A

Step 7: MyIntrepreter.Parse("$GPGSA,A,3,28,26,,1.8,0.8,1.6*14")
Step 8: $GPRMC (Recommended Minimum sentence) contains nearly every component GPS applications require – latitude, longitude, speed, bearing, satellite-driven time, fix status and magnetic variations.
Step 9: End sub

Step 10: Private Sub OnHDOPReceived(ByVal value As Double

- Handles MyInterpreter.HDOPReceived
- CurrentHDOP = value

Step 11: End Sub

Step 12: Private Sub OnPositionReceived(ByVal latitude As String_ByVal longitude As String) Handles MyInterpreter.PositionReceived
'Is the HDOP at least six?

Step 13: If CurrentHDOP <= MaximumDOPAllowed then
'Yes. Display the current position
Debug. WriteLine("You are here: "&latitude &", "& longitude)

Step 14: Else
- 'No. Discard this positional measurement
- Debug. WriteLine("The received location is not precise enough to use").

Step 15: End If

Step 16: End Sub

Step 17: End Class

5. PERFORMANCE EVALUATION

Implementing dilution of precision was executed using GNSS online Planning and Planning software tools from Trimble to analyse Dilution of Precision.

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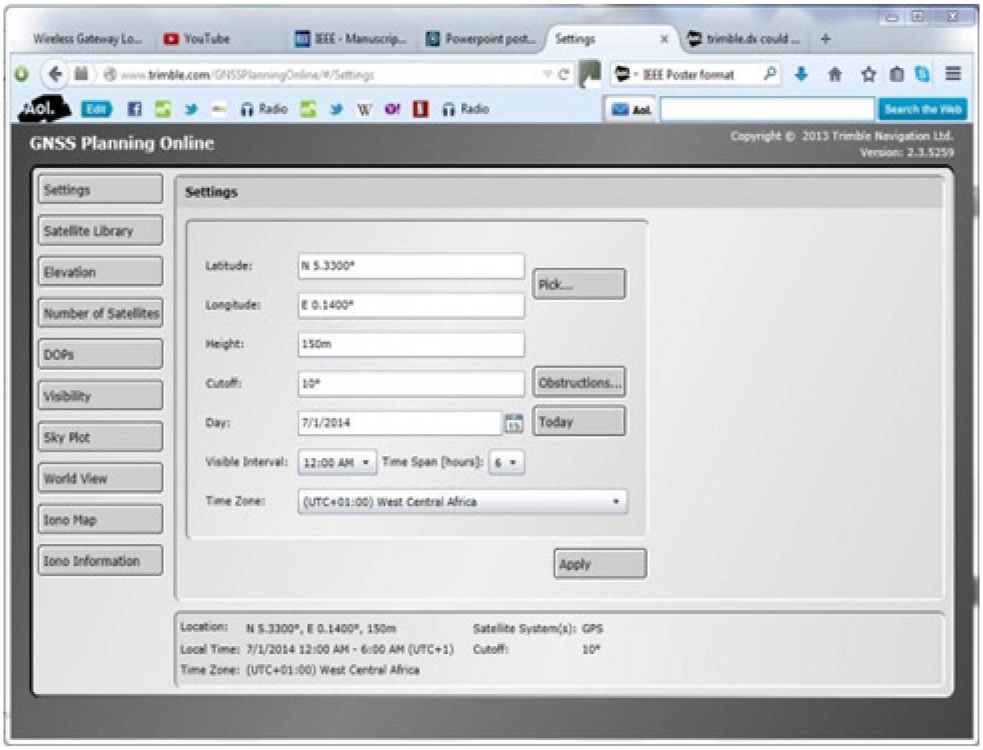

Fig 8**: GNSS (GPS) Planning software to enforce DOP**

The planning interface was used to set the satellite almanac where visible satellites are selected based on visibility at Latitude 5^0 $33^{//}0^{/}$ N and Longitude $0^0 13^{//} 0^{/}$ E) at 10 days intervals starting from the 1^{st}, 10^{th}, 20^{th} and 30^{th} in the month of July, 2014.

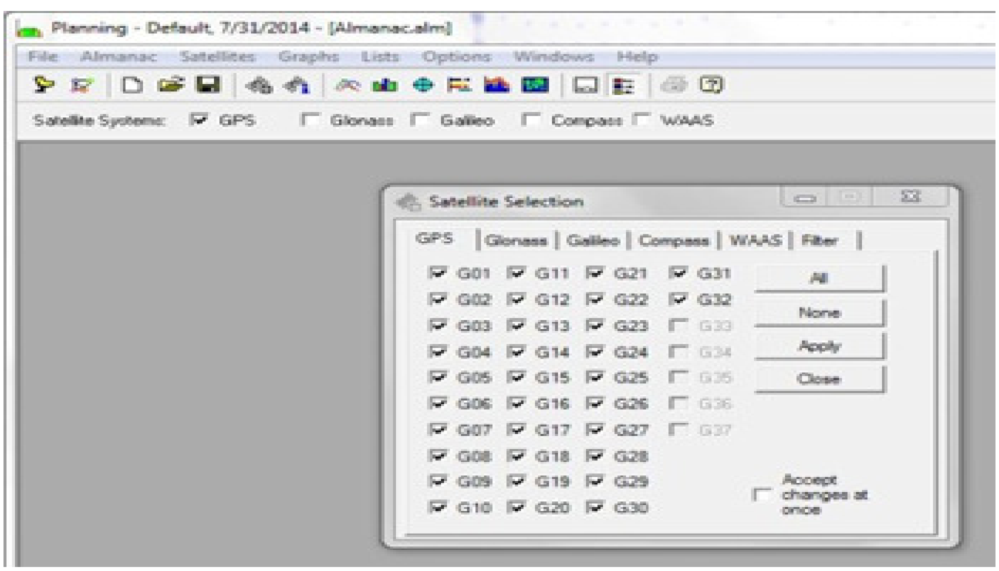

Fig 9: Satellite availability selection

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TABLE VIII. **DOP VALUES FOR 1ST OF JULY 2014**

Time *(Hr)*	**GDOP** *(Units)*	**TDOP**	**PDOP**	**HDOP**	**VDOP**
6:00	2.06	0.93	1.84	0.99	1.55
6:30	3.04	1.51	2.64	1.29	2.3
7:00	2.65	1.27	2.32	1.21	1.98
7:30	1.94	0.86	1.74	0.94	1.47
8:00	2.75	1.37	2.39	1.32	1.99
8:30	2.4	1.06	2.16	0.92	1.95
9:00	3.66	1.58	3.3	0.95	3.16
9:30	2.17	0.84	2	0.73	1.86
10:00	2.28	1	2.05	0.79	1.9
10:30	2	0.89	1.79	0.8	1.6
11:00	1.78	0.79	1.6	0.84	1.37
11:30	1.84	0.84	1.63	0.9	1.37
12:00	1.89	0.87	1.67	0.88	1.42
12:30	2.01	0.93	1.78	0.86	1.55
13:00	2.04	0.89	1.84	0.78	1.67
13:30	2.61	1.12	2.36	0.76	2.23
14:00	3.12	1.27	2.85	0.75	2.75
14:30	3.92	1.5	3.62	1.02	3.47
15:00	7.01	3.332	6.17	1.96	5.85
15:30	5	2.41	4.38	1.65	4.06
16:00	3.18	1.28	2.91	0.94	2.76
16:30	3.79	1.46	3.5	1	3.35
17:00	3.81	1.46	3.52	1.02	3.37
17:30	3.98	1.61	3.64	0.85	3.54
18:00	3.78	1.63	3.41	0.98	3.27

The table gives the output of GDOP, TDOP, PDOP, HDOP and VDOP values of Accra, Ghana (Latitude $5^0 33^{//} 0^{/}$ N and Longitude $0^0 13^{//} 0^{/}$ E) Starting from 0600 hours to 1800 hours for the 1st of July, 2014, computed from broadcast satellite ephemeris set at 13^0 elevation mask angle.

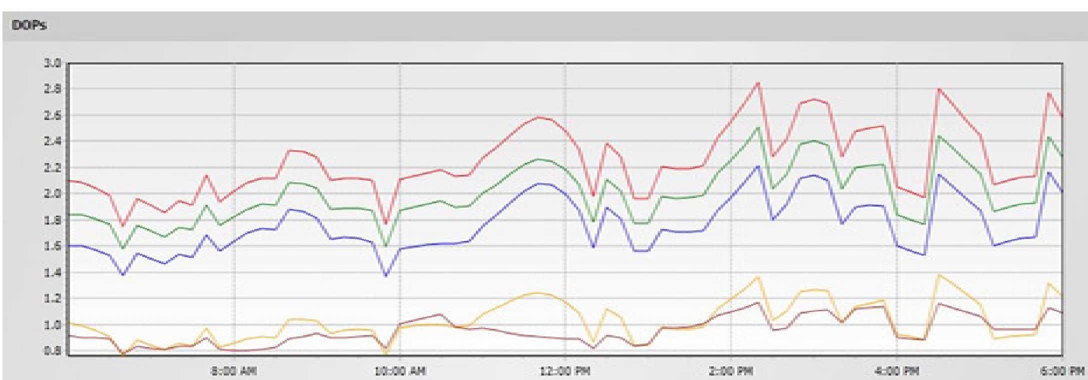

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Fig 10: Dilution of Precision Plot from broadcast satellite ephemerides for 1st July, 2014

TABLE IX. **DOP VALUES FOR 10TH OF JULY 2014**

Time *(Hr)*	**GDOP**	**TDOP**	**PDOP**	**HDOP**	**VDOP**
	(Units)				
6:00	2.97	1.49	2.57	1.23	2.26
6:30	1.89	0.84	1.69	0.85	1.46
7:00	2.11	0.96	1.88	0.96	1.62
7:30	2.16	0.97	1.93	1.04	1.63
8:00	2.62	1.16	2.35	0.92	2.16
8:30	2.56	1.04	2.34	0.97	2.2
9:00	2.23	0.89	2.05	0.74	1.91
9:30	2.24	0.98	2.01	0.78	1.65
10:00	1.95	0.87	1.74	0.8	1.55
10:30	1.76	0.77	1.58	0.84	1.34
11:00	1.85	0.86	1.64	0.88	1.39
11:30	1.92	0.89	1.69	0.87	1.46
12:00	1.95	0.88	1.73	0.83	1.52
12:30	1.95	0.83	1.76	0.72	1.61
13:00	2.78	1.18	2.51	0.75	2.4
13:30	3.06	1.23	2.81	0.76	2.7
14:00	3.9	1.48	3.61	1.06	3.45
14:30	7.12	3.42	6.24	2.06	5.89
15:00	4.65	2.21	4.09	1.46	3.82
15:30	3.03	1.17	2.8	0.87	2.66
16:00	3.44	1.3	3.19	0.95	3.04
16:30	3.57	1.38	3.29	0.85	3.18
17:00	3.73	1.52	3.4	0.84	3.29
17:30	3.55	1.56	3.19	0.96	3.04
18:00	2.54	1.17	2.25	0.89	2.07

The table gives the output of GDOP, TDOP, PDOP, HDOP and VDOP values of Accra, Ghana (Latitude $5^0\ 33^{//}\ 0^{/}$ N and Longitude $0^0\ 13^{//}\ 0^{/}$ E) Starting from 0600 hours to 1800 hours for the 20th of July, 2014, computed from broadcast satellite ephemeris set at 13^0 elevation mask angle.

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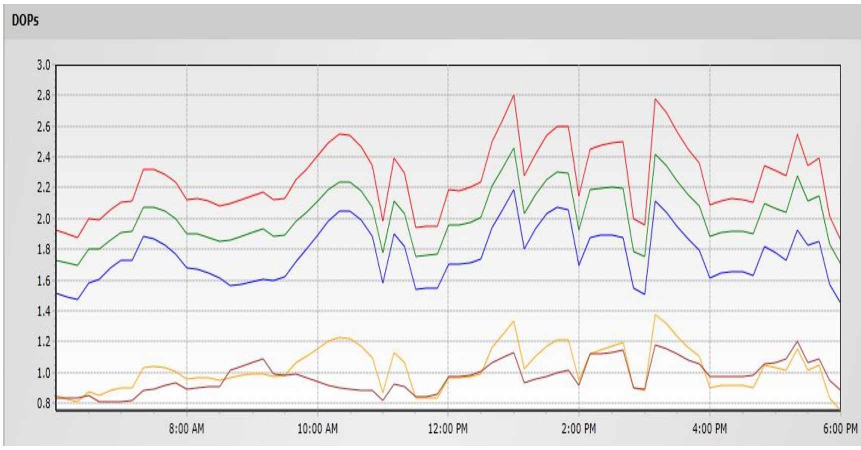

Fig 11: Dilution of Precision Plots from broadcast satellite ephemerides for 10th July, 2014

TABLE X. **DOP VALUES FOR 20TH OF JULY 2014**

Time *(Hr)*	**GDOP**	**TDOP**	**PDOP**	**HDOP**	**VDOP**
	(Units)				
6:00	1.97	0.89	1.76	0.86	1.54
6:30	2.62	1,26	2.3	1.05	2.04
7:00	1.93	0.79	1.76	0.8	1.57
7:30	3.02	1.34	2.71	0.92	2.55
8:00	2.63	1.07	2.41	0.78	2.28
8:30	2.36	1.01	2.13	0.78	1.99
9:00	2.14	0.95	1.92	0.78	1.75
9:30	1.87	0.83	1.68	0.8	1.47
10:00	1.72	0.76	1.54	0.83	1.3
10:30	1.83.	0.87	1.66	0.86	1.41
11:00	1.97	0.92	1.74	0.85	1.52
11:30	2.05	0.94	1.83	0.82	1.63
12:00	2.26	0.96	2.04	0.75	1.9
12:30	3.01	1.25	2.74	0.75	2.63
13:00	2.83	1.1	2.61	0.77	2.49
13:30	3.61	1.35	3.35	1.06	3.18
14:00	6.49	3.15	5.68	1.95	5.33
14:30	3.02	1.24	2.75	0.98	2.57
15:00	2.93	1.12	2.71	0.84	2.57
15:30	5.65	2.25	5.18	1.3	5.01
16:00	4.11	1.62	3.78	0.86	3.67
16:30	3.16	1.32	2.87	0.84	2.75
17:00	3.12	1.4	2.79	0.93	2.63
17:30	2.33	1.08	2.07	0.89	1.87
18:00	2.21	1.02	1.96	0.97	1.7

The table gives the output of GDOP, TDOP, PDOP, HDOP and VDOP values of Accra, Ghana (Latitude 50 33// 0/ N and Longitude 00 13// 0/ E) Starting from 0600 hours to 1800 hours for the 20th of July, 2014, computed from broadcast satellite ephemeris set at 130 elevation mask angle.

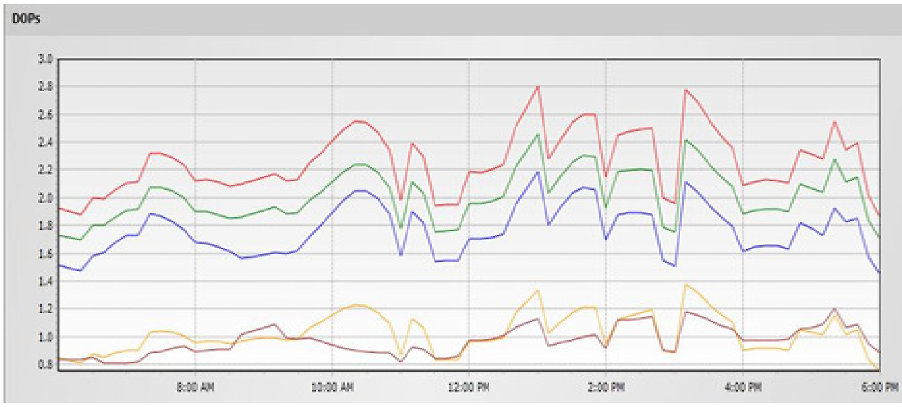

Fig 12: Dilution of Precision Plots from broarddcast Satellite ephemerides for 20th July, 2014

TABLE XI. **DOP VALUES FOR 30TH OF JULY 2014**

Time *(HR)*	**GDOP**	**TDOP**	**PDOP**	**HDOP**	**VDOP**
	(Units)				
6:00	2.37	1.12	2.09	0.98	1.85
6:30	1.95	0.8	1.78	0.73	1.62
7:00	3.25	1.42	2.92	0.91	2.78
7:30	2.58	1.04	2.36	0.77	2.23
8:00	2.32	1.01	2.08	0.77	1.94
8:30	2.03	0.9	1.82	0.78	1.64
9:00	2.18	1.03	1.92	0.9	1.7
9:30	1.71	0.76	1.53	0.82	1.29
10:00	1.9	0.89	1.68	0.85	1.45
10:30	2.04	0.96	1.8	0.84	1.59
11:00	2.18	0.99	1.94	0.82	1.76
11:30	2.38	0.99	2.17	0.75	2.03
12:00	3.1	1.26	2.84	0.76	2.74
12:30	2.86	1.05	2.66	0.85	2.52
13:00	3.15	1.16	2.93	1.01	2.75
13:30	2.96	1.19	2.71	0.99	2.52
14:00	2.92	1.21	2.66	0.95	2.48
14:30	3.37	1.45	3.44	1.03	3.28
15:00	6.68	2.69	6.12	1.38	5.96
15:30	4.2	1.69	3.84	0.87	3.74
16:00	4.29	1.91	3.84	1.04	3.7
16:30	2.76	1.26	2.46	0.91	2.28
17:00	2.18	1.01	1.94	0.89	1.72
17:30	2.22	1.03	1.96	0.98	1.7
18:00	2.24	1.05	1.99	0.92	1.76

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The table gives the output of GDOP, TDOP, PDOP, HDOP and VDOP values of Accra, Ghana (Latitude $5^0\ 33^{//}\ 0^{/}$ N and Longitude $0^0\ 13^{//}\ 0^{/}$ E) Starting from 0600 hours to 1800 hours for the 30th of July, 2014, computed from broadcast satellite ephemeris set at 13^0 elevation mask angle.

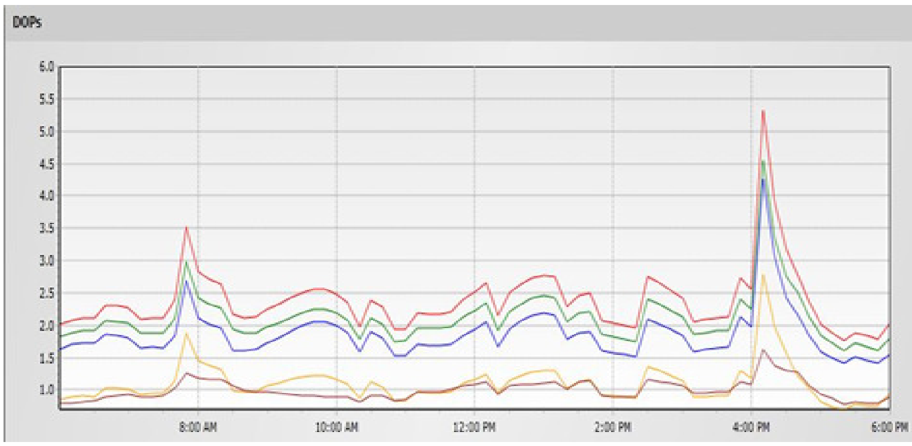

Fig 13: Dilution of Precision Plots from broadcast satellite ephemerides for 30th July, 2014

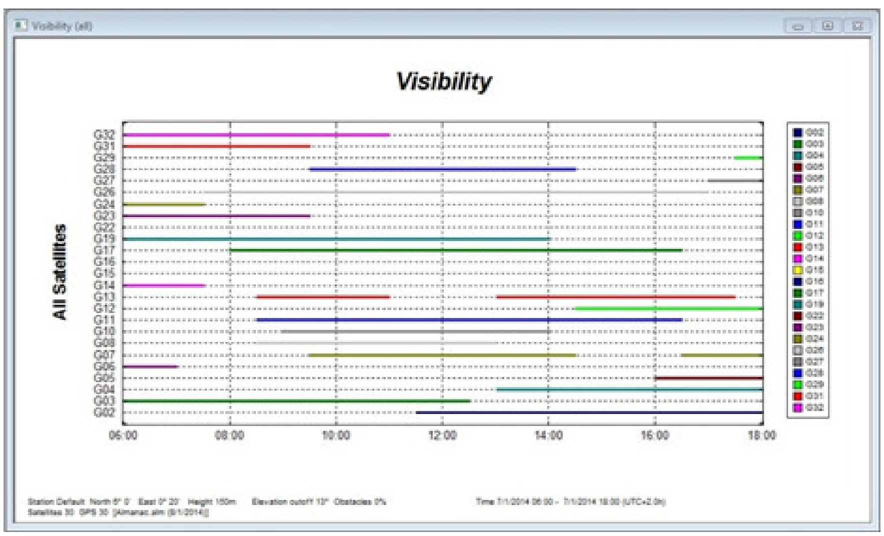

Fig 14: Visibility of GPS satellites over Accra from 0600hrs to 1800hrs

6. CONCLUSION

GPS satellite signal have several ways of being distorted. Some are corrected by the Department of Defense and others can be corrected in your GPS receiver using real-time ground station correction signals. The only precision problem which is left to be controlled is Dilution of Precision (GDOP, TDOP, PDOP, HDOP and VDOP). Being an indicator that show how well GPS satellite constellation is organized, controlling DOP using applications as VB.NET greatly enhances the effect of the atmospheric error sources of GPS signals and is the key to writing commercial-grade GPS applications.

A small mathematical formula can be applied also to determine the maximum allowable DOP for a particular application. The maximum allowable error should be the greatest possible value which minimizes accuracy problems while maximizing operational conditions. Hence, the smaller the DOP the more accurate positioning fix gets. Relatively, the more the number of evenly spread satellites, the better the impact on good DOP.

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Time is another factor which helps developers. Advances in GPS receiver technology are pushing precision to new levels. While precision can be questionable with any consumer GPS device, there will soon be a time when precision to a centimeter is possible and that is what VB.Net is poised to achieve.

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