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Modelling and Analysis of Emitter Geolocation using Satellite Tool Kit

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ABSTRACT

This paper considers geolocation of a stationary radio frequency emitter which is being steered by multiple antennas installed on a geostationary satellite using received signal strength metric. The difference in the signal strengths is measured by the antennas and subsequently plotted as lines of position on the surface of the earth. Intersection of these two or more lines of position indicates the location of the terrestrial radio frequency transmitters. This problem is appropriately modelled using a satellite tool kit that simulates the space environment involving satellites, antennas, emitters, etc in a realistic and integrated manner. Accuracy and size of the geolocation area depend on the distance between emitters and the receiver and also on the contour widths geometry. Results of geolocation accuracy are compared by installing the radio frequency emitter at increasing latitudes and at varying contour widths. It is observed that the emitters placed at lower latitudes and having smaller contour widths provided higher accuracy in geolocation that validates the proposed formulation.

Keywords: Received signal strength; RSS; Emitter geolocation; Geostationary satellite; Satellite tool kit; Lines of position

NOMENCLATURE

c	Speed of light
$EIRP$	Equivalent isotropic radiated power
f	Frequency of the signal
G_{Rx}	Gain of the receiving antenna
G_{Tx}	Gain of the transmitting antenna
L_{FS}	Free space loss
L_{Tx}	Losses associated with transmitting antenna
P_{Tx}	Power radiated by transmitter
r	Distance between transmitting and receiving antenna
S_{Rx}	Total power of signal

1. INTRODUCTION

Geolocation of radio frequency (RF) transmitters/emitters is gaining attention among various civilian and military users as it provides vital information for various search and rescue operations. It covers diverse platforms such as land, sea, air and even space. Geolocation of stationary RF transmitter placed on the surface of the Earth as seen from space based platform can be addressed in a variety of ways. Among the most common methods include time of arrival (TOA), time difference of arrival (TDOA)[1-2], angle of arrival (AOA), frequency difference of arrival (FDOA) and received signal strength (RSS)[3]. Geolocation using TDOA and FDOA require at least two geostationary satellites[4] simultaneously observing the same RF transmitter placed on the ground. In case of TDOA, the time difference is translated into line of position (LOP) which passes through the emitter location. In the similar manner in case of FDOA change in motion of the satellites causes Doppler shift. This is then converted into another LOP. Intersection of these LOP estimates the position of RF transmitter. Among all the said algorithms for emitter geolocation, RSS based localisation is the preferred algorithm as it does not require any time reference as in the case of GPS localisation and depends only on signal strength received at antenna. Also the receivers used are less complex in nature, lower in cost and consume less power. RSS has no phase information associated with it. This does not insist on phase coherency among the receivers which simplifies the underlying calculations involved.

Geolocation of RF emitters using RSS technique has already been considered in past and is available in several technical literatures. Picard & Weiss[5] addresses the problem of locating stationary emitter with known receiver locations. In this the measurements are based on Maximum likelihood cost function. But this method has not carried out any analyses and modelling of the scenario before arriving at the solution. Wang & Inkol[6] provides near-optimal least square solution to RSS based geolocation and Juang & Lin[7] utilises least squares solution to both RSS and TDOA methods. These methods are based on linearising the system equations. But they greatly suffer from errors in many scenarios. Gemayel[8], *el al.* used a hybrid TDOA and RSS method of geolocation utilising the Unscented Kalman Filter. But these methods are less accurate as they are based on approximation as compared to more complex RSS based techniques. Also the geometry of emitters and sensors have not received much attention. Ureten[9], *et al.* presents an iterative grid search technique for

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RSS based emitter localisation in cognitive radio networks. For accuracy in geolocation estimates this method requires small grid sizes. This increases the computational complexity. Even though extensive works on geolocation has been carried out using the RSS techniques and its hybrid versions using TDOA techniques using various statistical methods, however none of the literature covers simulation and modelling using satellite tool kit (STK) for RSS technique. Also, all the above mentioned literatures do not generate graphs to visualize the system performance dynamically in 2D and 3 D views by varying the system parameters.

This paper covers geolocation of a RF transmitter which is placed on the surface of the Earth using three parabolic antennas installed on single geostationary satellite. Such an arrangement of transmitter and receivers in space domain[10] is modelled using STK. Throughout the modelling, we have considered Ka band as the region of EM spectrum with frequency of operation as 28 GHz. High gain Parabolic antennas are used as they have more focused beams, have ability to overcome atmospheric and weather attenuation and provides high power. The concept presented in the paper can be used to cater geolocation for other frequencies in Ka band or for other frequency bands with appropriate antenna elements.

Throughout the modelling it is assumed that satellite is geostationary[11] and is at a distance of 35,786 km from the emitter. Its exact location i.e., latitude and longitude is known in advance. All the antennas considered are parabolic in nature and tuned to same frequency. Latitude and Longitude of transmitting and receiving antennas are also known in advance.

This geostationary satellite is located such that if a vector drawn from the center of Earth to the geosynchronous satellite (at an altitude of 35786 km) would intersect the surface of the Earth at 0° latitude and 240° longitude. The center of the satellite panel facing towards earth surface is taken as reference point. Three steerable parabolic dish antennas (each with beam of 2.5° and diameter of 0.250 m) are mounted in the form of an equilateral triangle (0.500 m each side) with reference to above center point. This arrangement of antennas mounting ensures that their footprints are overlapped on an intended area in such a way that the emitter is located within the Field of view (FOV) of minimum two adjacent antennas.

The contributions of this paper are as follows:

- Geolocating the stationary transmitter/emitter using received signal strength (RSS) algorithm[12].
- Simulating the Earth and space environment using satellite tool kit in 2D and 3D graphics window.
- Varying the emitter latitude locations and measuring the error in the estimated location using STK.
- Measuring the geolocation area by varying LOP contour widths.

2. PROBLEM FORMULATION

Received signal strength[14-15] based geolocation system consists of a geostationary satellite with three parabolic antennas. It is assumed the latitude and longitude position of satellite and antennas are known in advance. RF emitter with associated antenna is placed on the surface of the earth. Emitter is located in the field of view of three receiving satellite antennas. With such an arrangement, the space satellite scenario is modelled using STK software.

Total power of signal S_{Rx} received by the antenna[16] on satellite is given by

$$S_{Rx} = P_{Tx} + G_{Tx} - L_{Tx} - L_{FS} + G_{Rx} \tag{1}$$

where P_{Tx} is the power radiated by transmitter, G_{Tx} is the gain of the transmitting antenna, L_{Tx} is the losses associated with transmitting antenna, L_{FS} is the free space loss, G_{Rx} is the gain of the receiving antenna. Equation (1) can be rewritten in the form of Eqn. (2)

$$S_{Rx} = EIRP - L_{FS} + G_{Rx} \tag{2}$$

where $EIRP$ is the equivalent isotropic radiated power EIRP and *LFS* is given by Eqn. (3).

$$EIRP = P_{Tx} + G_{Tx} - L_{Tx}$$

$$L_{FS} = \left(\frac{4\pi rf}{c}\right)^2 \tag{3}$$

where *r* (35,786 km) is the distance between transmitting and receiving antenna, f is the frequency of the signal, *c* (3×10^8 m/s) is the speed of light.

Signal strength received by three antennas placed on satellite is given by Eqns. (4), (5) and (6).

$$S_{Rx_1} = EIRP - L_{FS_1} + G_{Rx_1} \tag{4}$$

$$S_{Rx_2} = EIRP - L_{FS_2} + G_{Rx_2} \tag{5}$$

$$S_{Rx_3} = EIRP - L_{FS_3} + G_{Rx_3} \tag{6}$$

where $S_{Rx1}, S_{Rx2}, S_{Rx3}$ represents the signal power at antennas 1, 2, and 3 and $G_{Rx1}, G_{Rx2}, G_{Rx3}$ are the associated antenna gains. *EIRP* is same for each receiving antenna. Difference in the signal strengths between the antenna 1 and 2 is given by Eqn. (7)

$$S_{Rx_1} - S_{Rx_2} = \left(L_{FS_2} - L_{FS_1}\right) + \left(G_{Rx_1} - G_{Rx_2}\right) \tag{7}$$

As the distance *r* for two receiving antennas are almost equal, the loss difference is very small which is assumed to be zero. So, the above equation is written as Eqn. (8)

$$S_{Rx_1} - S_{Rx_2} = G_{Rx_1} - G_{Rx_2} \tag{8}$$

As seen from Eqn. (8), the difference in received signal is equivalent to difference in gain across each antenna. Similarly, same can be said for other antenna combinations also.

$$S_{Rx_1} - S_{Rx_3} = G_{Rx_1} - G_{Rx_3} \tag{9}$$

$$S_{Rx_2} - S_{Rx_3} = G_{Rx_2} - G_{Rx_3} \tag{10}$$

Antenna gain contours for three satellite antennas with given boresight is plotted on the surface of the earth. Intersection of three antenna contours gives the location of the RF transmitter.

3. SIMULATION OF SPACE ENVIRONMENT USING STK

The simulation of space environment requires the modelling of space platforms with on-board antennas and sensors. On-board three parabolic dish antennas and along with sensors are required to provide their respective footprints on the Earth in which the transmitter is located. The emitter on the Earth is modelled by considering path losses of the signal strength between emitter and the antennas mounted on the satellite. Based on the footprint of the on-board antennas on the earth and signal level received at three antennas at satellite platform the geolocation is computed. It is to be ensured that satellite and space based sensors are modelled and are moving as per the realistic orbit parameters. Also, it is ensured that terrestrial antenna is modelled appropriately so that a communication link between transmitter and receiver can be established. Simulation of such space environment is very complex and challenging in nature. However, same can be easily modelled using STK tools.

The Analytical Graphics, Inc. satellite tool kit (STK)[17] is used throughout to simulate the satellite, its positions and orbits. STK is an analytical tool used by scientists and engineers to build realistic scenarios involving spacecraft, heavenly orbits and earth based objects in an integrated manner. It empowers the users to analyse the detailed satellite communication links coupled with pre defined transmitter, receiver and antenna properties. Using STK, users can generate detailed link budget reports, graphs and visualise system performance dynamically in 2D and 3D windows and carry out perform analysis. Figure 1 is a flowchart that shows all the steps involved in modelling of geolocation system using STK.

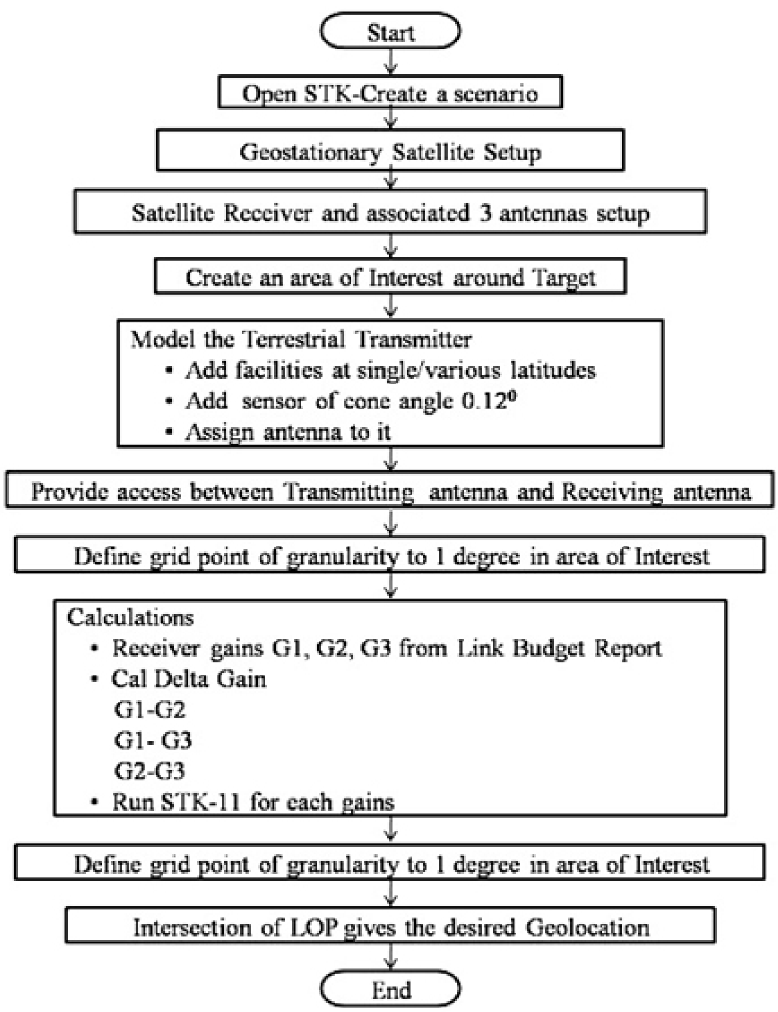

Figure 1. Flowchart for modelling of space environment using STK.

3.1 Satellite Model Setup

The geostationary satellite is modelled as single geostationary satellite with three antennas to receive the signal strengths from the transmitter. Using orbit wizard, satellite object has been inserted at sub satellite point 240° and 0° inclination in a geosynchronous orbit which was set up for 48 h time duration. This satellite intersects the surface of the earth at 240° longitude and 0° latitude. This is as shown in Fig. 2.

3.2 Antenna setup on the satellite

After satellite initialisation, three antennas setup has been installed on satellite. All antennas were parabolic in nature operating at a frequency of 28 GHz and beam width 2.5°. Antennas have been mounted at known azimuth and elevation.

3.3 Setup of Area of the Target

After the antennas on receivers are modelled, the three boresight and respective footprints on the surface of the earth can be seen. Figure 3 shows three antenna footprints intersecting the curvature of earth in 2D graphic window. This figure also shows half power beam width overlaid on three antennas gain pattern at 28 GHz down to 22 dB. These three antenna patterns intersect and form a common area bounded by three boresights. Transmitter is assumed to be located within the geographical area bounded by the area of target created by intersection of field of view of each antenna.

Grid points are defined on the surface of the earth within the set area of the target with 1° resolution. STK does geolocation by considering that transmitters were located at each of the grid points in defined area of target. Using rigorous grid search techniques the transmitter can be located.

3.4 Modelling of Transmitter on the Earth

To enable complete communication link between transmitter and the receiver, transmitter has to be modelled accordingly. A facility object in form of transmitter was randomly inserted inside the area of interest. This facility can either be ship, aircraft or vehicle. Facility/Transmitter was inserted at varying range of 5° to 12.2° latitude and fixed -119° longitude.

Sensor was attached to the transmitter with a cone angle of 0.12° having an antenna which is parabolic in nature and diameter of 1 m, targeted towards the satellite and placed at known and varying latitudes and fixed longitude. The sensor points the transmitting antenna placed on the surface of the earth to the receiving antennas mounted on the satellites. In this stage, the satellite orbit and its position with respect to the transmitter along with cone pointing from transmitter to receiver is observed using STK. The antenna at the receiver of the satellite was selected as type embedded to enable it create only spot beams on the surface of

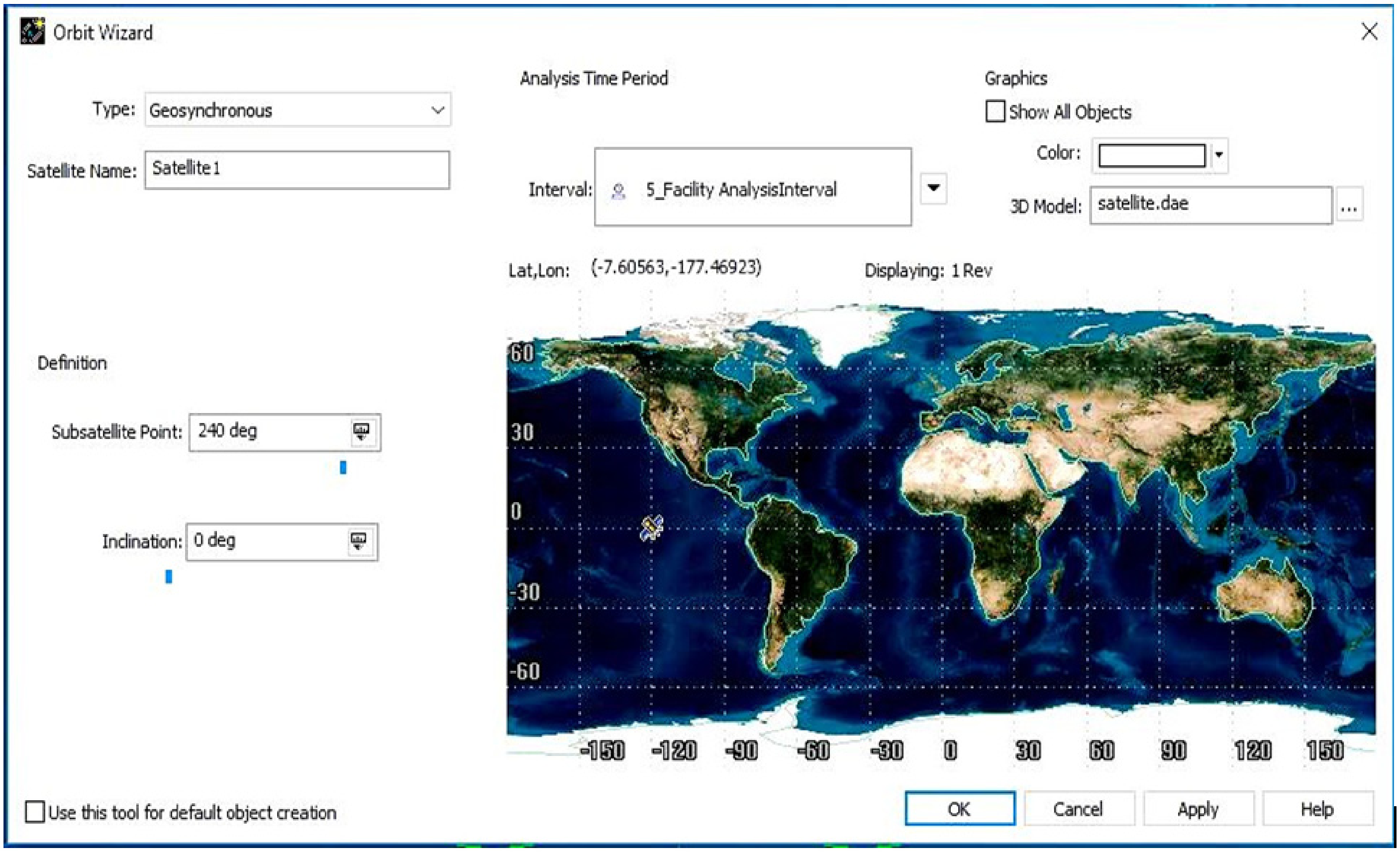

Figure 2. Snapshot of sub satellite point.

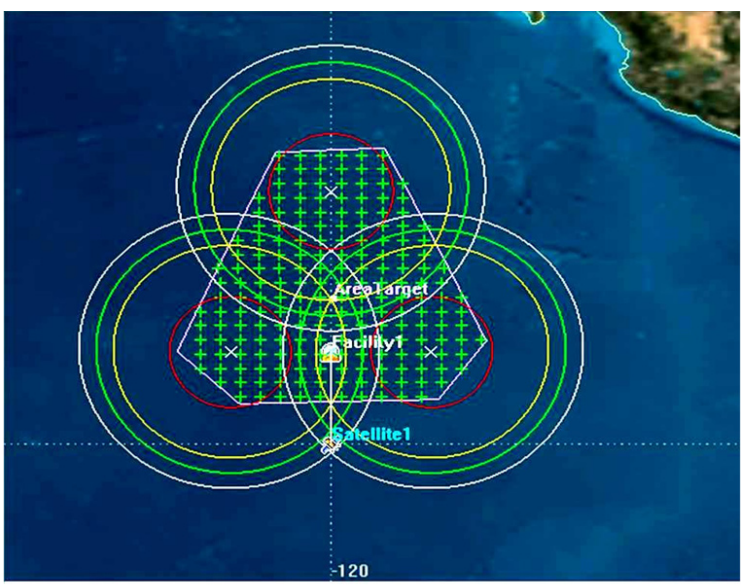

Figure 3. Grid points in area of interest.

earth whereas the antenna on the transmitter was attached to the sensor as a link antenna in order to target it towards satellite for creating complete communication link.

3.5 Create Access between Transmitter and Receiver objects

To create access between transmitter and receiver using STK it is ensured that transmitter and receivers both are in each other line of sight. Subsequently, in the area of interest, assets are assigned using three receivers. STK accesses each grid point using grid search algorithm embedded and computes link information. The receiver gain values are contained in each grid point. Using the access window in STK, detailed access link report is generated. The report consists of various columns such as *Tx* gain, EIRP , Free space loss, E_0/N_0, BER and receiver gain.

Using "compute access" command of STK, three scalar calculations i.e., gain difference across each receivers within coverage area is calculated. After the gains across each antenna is completed, next step is to calculate the gain difference between the antennas using the function (x,y) components using STK. Delta gain between Rx_1 and Rx_2 is calculated using

$$DeltaGain\_1\text{-}2 = a*x+b*y \tag{11}$$

where a and b are constants having values 1, -1 respectively and x is gain the at Rx_1 and y is the gain at Rx_2 . In the similar manner, delta gain between Rx_1 and Rx_3 and also between Rx_2 and Rx_3 is computed. Intersection of three LOPs generated by calculating delta gains using other receiver sets gives the location of the stationary RF emitter/transmitter. These delta gains are plotted as LOPs on surface of earth.

4. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

This section covers quantitative results to analyse and demonstrate emitter geolocation accuracy using STK. For

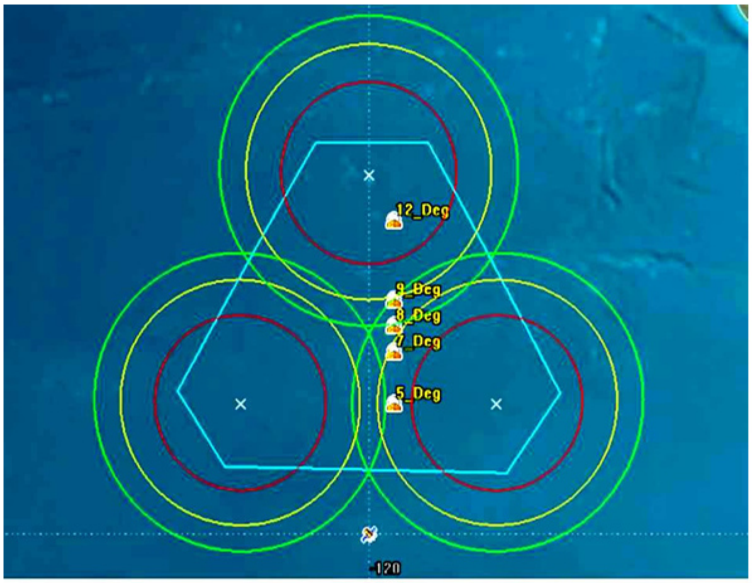

Figure 4. 2D view of five STK facilities.

satellite set up, it is positioned at latitude of 0^0 and longitude of 240°. Sensors are mounted on-board satellite with three parabolic dish antennas at known azimuth and elevation. The frequency of operation is fixed at 28 GHz. Frequency of operation is selected as 28 GHz as the size of antennas define the gain. For satellite based platform it is always preferred to have smaller antennas with high gains. Smaller antennas on-board satellite can be realised in high frequency bands of operation such as Ka band which meets the requirement of geolocation. The target RF on ground is also assumed to be working in Ka band. However, any frequency band of operation could have been taken up for simulation in Ka band instead of 28 GHz as RSS technique is not dependent on frequency of operation.

To test the geolocation accuracy, two cases are considered. Firstly, transmitter is initially placed in known location (at 5° latitiude and -119° longitude). For a given known location, the position of the transmitter is estimated using STK simulation kit in terms of latitude and longitude. Distance between the actual location and the computed geolocation is tabulated. The experiment is repeated for several positions of the transmitter with variation in position of latitude and fixed longitude values. The position of transmitter at various latitude position is displayed using STK 2D view. From experimental point of view, in this work, the latitude positions are considered at 5°, 7°, 8°, 9°, and 12° with fixed longitude positions. It is concluded that smaller the distance between the actual and observed emitter location, better will be the geolocation accuracy. Figure 4 shows such a 2D geolocation model with five transmitters on it corresponding to physical location of each transmitter.

Secondly, widths of lines of positions that correspond to error tolerance in the measurement of signal strengths are varied. Intersection of three lines of position with its associated widths will form an irregular shape hexagon. The centroid of the hexagon is declared as the position of the transmitter on ground. Thicker the lines of position on contour width will correspond to bigger areas of hexagon in which the emitter lies. The contour widths considered in this work are 1 dB, 0.5 dB, and 0.1 dB. Each contour width corresponds to an error tolerance in the measurement of signal strengths (e.g 1 dB

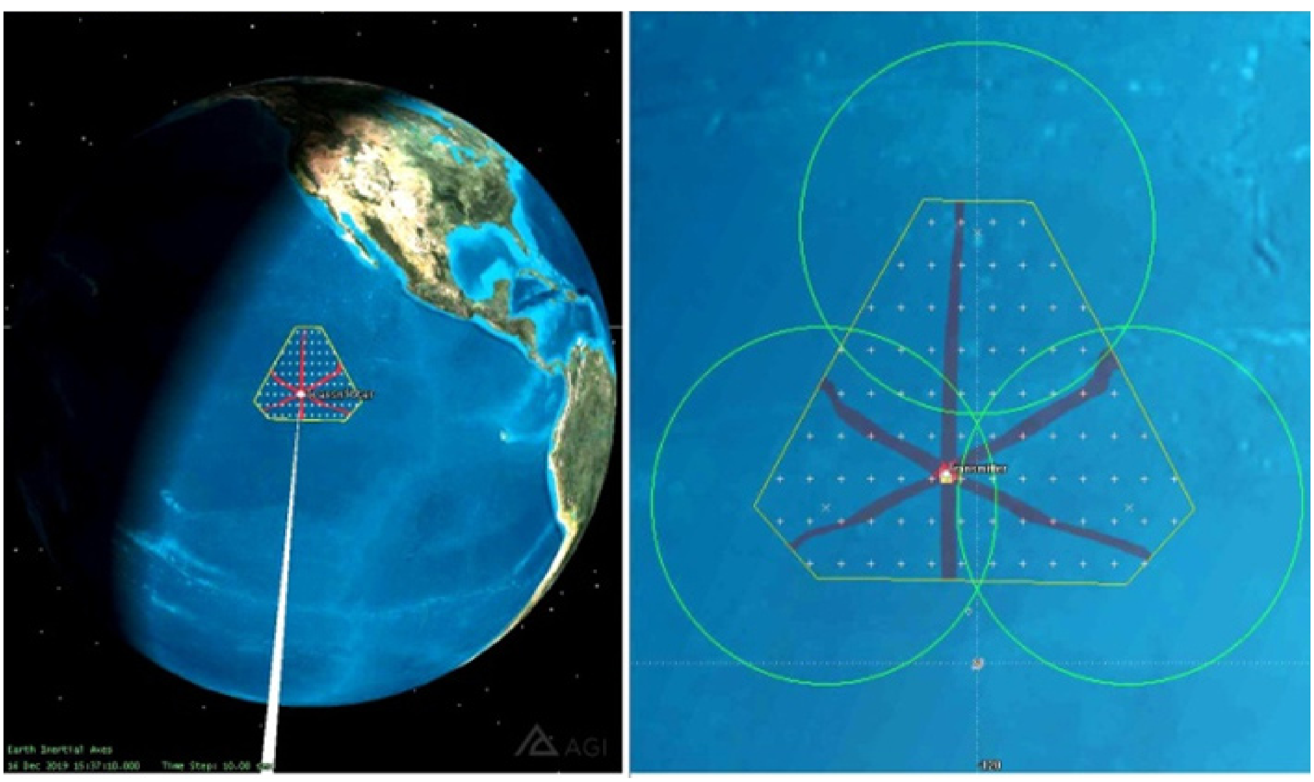

Figure 5. Intersection LOP and subsequent display at transmitter position at 50 latitude, -1190 longitude.

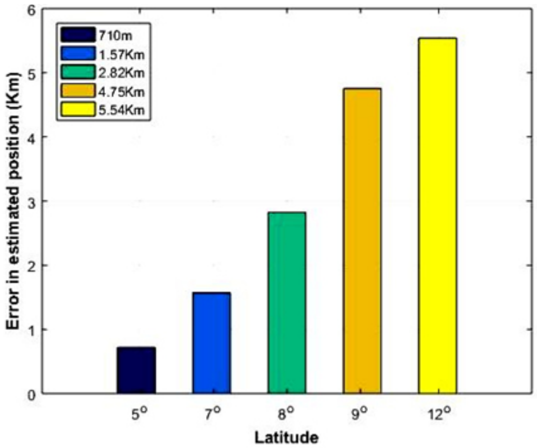

Figure 6. Error in estimated location at various latitudes.

contour width corresponds to ± 0.5 dB variation in received signal strength). At each latitude positions for all the three contour widths, simulation is carried out using STK.

4.1 Results of Observed Geolocation Accuracy by Varying Transmitter Positions

2D graphics window of STK is shown in Fig. 5. The left side of Fig. 5 shows the earth and the transmitter along with marked area of interest. It also shows the cone angle pointing between the transmitter and the receivers. The right side of the Fig. 5 shows the corresponding details with three bore sights and the footprints of the receivers. From the delta gains, LOPs are obtained. It displays the intersection of lines of position with transmitter in the centre of intersection. The observed value is displayed underneath the window. Results of observed transmitter position for varying latitudes are measured. Apart from varying the longitude positions for taking up measurements, the contour widths i.e the widths of lines of intersection is also varied. Table 1 corresponds to contour width of 1 dB.

Table 1 displays observed transmitter position for varying input latitudes and fixed longitudes. It is observed that geolocation accuracy depends on the placement of the transmitter at a given latitude. Satellite is positioned at fixed 0° latitude. The transmitter closer to satellite will give better localisation accuracy as compared to farther away from it for a fixed longitude. Plot of localisation accuracy in (km) at various latitudes is shown in Fig. 6. At 5° latitude, accuracy of 719 m is observed compared to 12° latitudes with an accuracy of 5.54 km.

Table 1. Observed transmitter position and geolocation accuracy

Input transmitter position		Observed transmitter position using STK (1dB)		Geolocation accuracy (km)
Lat.	Long.	Lat.	Long.	
5°	-119°	5.0051°	-119.004°	0.719
7°	-119°	7.0076°	-119.012°	1.571
8°	-119°	8.0249°	-118.995°	2.823
9°	-119°	8.9599°	-118.985°	4.754
12°	-119°	11.9786°	-118.954°	5.54

4.2 Results for Geolocation area at varying contour widths

Results for geolocation area at varying contour widths are tabulated in Table 2. At 0.1 dB the transmitter is located within an area of 6 km at 5° latitude and is located within an area of 36 km at 12° latitude. These areas are the best possible approximation of the irregular shaped polygons formed by intersecting line of position. These polygons containing emitters were close to a hexagon but never a perfect hexagon. The areas calculated and displayed using STK are tabulated for each position of latitude and at each contour width.

Two observations can be made from Table 2. Firstly, size of geolocation area increases as the error in the signal strength measurement (i.e. contour width) increases. Size of the area increases from 0.1dB to 1 dB width. Secondly, across any contour width, size of the geolocation area varies with changing latitude of the transmitter position. Latitudes closer to the satellites have more precise measurement of signal strengths and corresponding smallest geolocation area.

Table 2. Geolocation area (km^2) at various contour widths using STK

Latitude	Geolocation area (km^2)		
	0.1 dB	0.5 dB	1 dB
5°	6	388	1213
7°	12	450	1491.87
8°	19	520	1931.64
9°	27	610	2194.58
12°	36	698	2408.02

Figure 7 gives a MATLAB plot of Geolocation area at various contour widths on a semi-log graph for the same. From the point of view of geostationary satellite as we move higher in latitudes, more elliptical footprints are created on the ground which results in larger area containing the emitter.

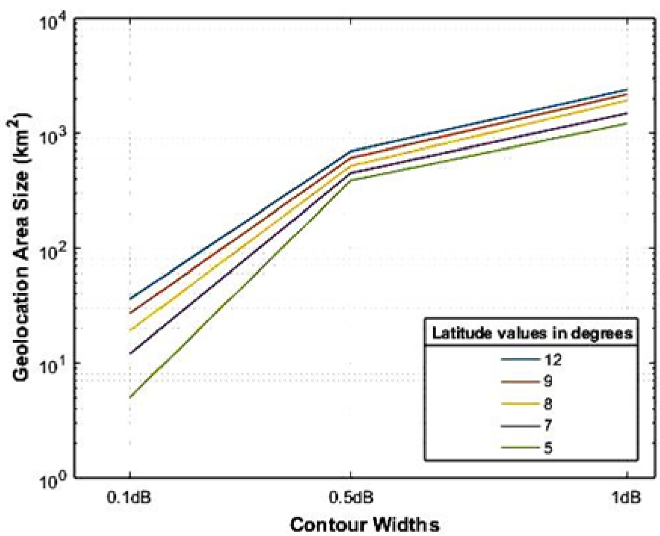

Figure 7. Geolocation area at various contour widths.

5. CONCLUSION

In this paper, the authors presented the RSS-based geolocation method using STK. RSS measurements are advantageous when high degrees of synchronization is unavailable or impractical. Geolocation accuracy from single Geostationary satellite multiple antennas was measured by placing five facilities/transmitters at latitudes ranging from 5° to 12.2° on coverage area and varying contour widths. Results show that lower latitudes provided high accuracy as compared to higher latitudes. This was because lower attitudes contain more focused antenna footprints on the surface of the earth compared with other latitudes. Optimization has to be made in terms of contour widths and target area coverage. Even though 0.1 dB gives better accuracy but it is worth mentioning that it covers only 75 % of the transmitter predicted area whereas 0.5 dB and 1 dB covers 100 % of the transmitter predicted area. In the future, it is expected to test with operational satellites and with online data sets over increased latitudes. This will provide a better understanding and further applicability of the proposed method.

REFERENCES

1. He, J.; Pahlavan, K.; Li, S. & Wang, Q. A testbed for evaluation of the effects of multipath on performance of TOA-based indoor geolocation. *IEEE Trans. Instr. Measurement,* 2013, **62**(8), 2237-2247.
   doi**:** 10.1109/TIM.2013.2255976
2. Fan, E.; Xie, W.; Liu, Z. & Li, P.F. Range-only target localisation using geometrically constrained optimisation. *Def. Sci. J.,* 2015, **65**(1), 70.
   doi: 10.14429/dsj.65.5474
3. Aziz, M.R.K.; Karimah, S.N.; Yoshio, N.; Anwar, K. & Matsumoto, T. Achieving accurate geo-location detection using joint RSS-DOA factor graph technique. *In* IEEE 10th International Conference on Telecommunication Systems Services and Applications, 2016.
   doi: 10.1109/TSSA.2016.7871076
4. Zhao, J.; Li, L. & Gong, Y. Joint navigation and synchronization in LEO dual-satellite geolocation systems. *In* IEEE 85th Vehicular Technology Conference, 2017.
   doi: 10.1109/VTCSpring.2017.8108339
5. Picard, J.S & Weiss A.J. Theoretical facts on RSSI based geolocation. *In* Proceedings of IEEE 27th Convention of Electrical and Electronics Engineers, Israel, Eilat, 2012, pp. 1-5.
   doi :10.1109/EEEI.2012.6377085
6. Wang, S. & Inkol, R. A near- optimal least squares solutions to received signal strength difference based geolocation. *In* IEEE International Conference on Acoustics, speech and signal processing ICASSP, Prague Congress Center, Prague, Czech Republic, 2011, **05**, 2600-2603.
   doi: 10. 1109/ ICASSP. 2011. 5947017
7. Juang, R. & Lin, H. Hybrid SADOA/TDOA mobile positioning for cellular networks. *IET Communications*, 2007, **1**, 282-287.
   doi:10.1049/iet.com: 20050523
8. Gemayel EL, N.; Jakel, H. & Jondral, F.K. A Hybrid/ RSSD geolocation system (VTC Fall). Las Vegas, NV, USA; 2013, 1-5.
   doi: 10.1109/VTCFall.2013.6692038
9. Ureten, S. Yongacoglu, A. & Petrik, E. A reduced complexity iterative grid search for RSS based emitter geolocation. *In* 27th Biennial Symposium on communications QBSC, Kingston, ON, Canada, 2014, 149-152.
   doi: 10.1109/QBSC.2014.6841203
10. Whiting, Samuel. Radio-frequency transmitter geolocation using non-ideal received signal strength indicators Utah State University, All Graduate Theses and Dissertations, 7038, 2018 (MS Thesis).
11. Yang, H.; Li, H. & Wu, Q. An integrating unicast and multicast solution by extending content delivery network to satellite. *In* IEEE 14th International Wireless Communications & Mobile Computing Conference, 2018.
    doi: 10.1109/IWCMC.2018.8450502
12. Ying, J.; Pahlavan, K. & Li, X. Precision of RSS-based indoor geolocation in IoT applications. *In* IEEE 28th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications, 2017.
    doi: 10.1109/PIMRC.2017.8292750
13. Shen, Z.; Li, J. & Wu, Q. Data-driven interference localization using a single satellite based on received signal strength. *IEEE Trans. Veh. Technol.*, 2020.
    doi: 10.1109/TVT.2020.2998795.
14. Ture, M. & Hatipoglu, A. Indoor location finding of the transmitter based on bluetooth received signal strength. IEEE *ISNCC,* 2019, 1-5.
    doi: 10.1109/ISNCC.2019.8909095
15. Jung, S.; Im, C.; Eom, C. & Lee, C. A Localization method with Insufficient RSS samples using neural network. IEEE *ICAIIC,* 2020, 272-275.
    doi: 10.1109/ICAIIC48513.2020.9065087
16. Whiting, S.; Moon, T.K. & Gunther, J.H. Geolocation from received signal strength. *In* IEEE 52nd Asilomar Conference on Signals, Systems, and Computers, 2018.
    doi**:** 10.1109/ACSSC.2018.8645525
17. Satellite Tool Kit: http://www.agi.com/products/by-producttype/applications/stk/ (Accessed on 8 July 2019).

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Contribution in the current study: Carrying out development of algorithms for geolocation of systems from space based platforms.

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Contribution in the current study: Carrying out experiments and realisation on space based platform.

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Contribution in the current study: Guiding and defining all the experiments and scrutinising the results.

Prof. D.S. Chauhan, completed his post doctoral work at Goddard Space Flight Centre, Greenbelt Maryland, USA. Presently working as Pro-Chancellor GLA University Mathura. He has published 267 research papers in Journals and Conferences. His are of research includes advanced computing and algorithm development.
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