A Project Report On

MAP ANALYSIS FOR ESM SYSTEM DEPLOYMENT

1. INTRODUCTION

Electronic warfare (EW) is any action involving the use of the electromagnetic spectrum or directed energy to control the spectrum, attack of an enemy, or impede enemy assaults via the spectrum. The purpose of electronic warfare is to deny the opponent the advantage of, and ensure friendly unimpeded access to, the EM spectrum.

Deployment and map analysis of EW system is analysis and study of selected area and positioning of the subsystems i.e ESM systems based on the target locations so that they can get good signal strength to identify and extract the signal information by ESM systems and to clear viewing angle to EA systems to jam the enemy radars.

ESM system's primary objective is to intercept enemy electronic system in a tactical, i.e., real time environment. Interception of hostile electronic environment is generally attempted to achieve three basic functions. They are:

1. Detection. 2. Frequency estimation 3. Direction finding

Therefore, a part of the project includes checking whether the path between the sub systems is clear or not. This can be done by using Line Of Sight and Radio Line Of Sight algorithms. More explanation about Electronic Warfare system is given in chapter 2.

1.1. OVERVIEW OF PROJECT

The project uses Geotools which is an open source Java Library. The file format used to load map in the application is a shape file(.shp).More explanation of requirements is given in chapter 3.

Application should provide GUI to plot or deploy ESM systems, a sub system in EW system that involves the following features:

a) Provision to select operational Area.
b) Application should provide tool bar to perform analysis
c) Based on the operational area selected , positioning of systems done considering

    1) LoS between transmitter and receiver
    2) Signal strength receivable to ESM systems from transmitter.

d) Features to provide distance calculation between any two locations.

e) Store the results in a text file and summarize to select best area of operation.

2. LITERATURE SURVEY

2.1 ELECTRONIC WARFARE:

Electronic Warfare is ongoing war between active systems that attack and defensive systems which protect. Electronic warfare (EW) is any action involving the use of the electromagnetic spectrum or directed energy to control the spectrum, attack of an enemy, or impede enemy assaults via the spectrum. The purpose of electronic warfare is to deny the opponent the advantage of, and ensure friendly unimpeded access to the EM spectrum. EW can be applied from air, sea, land, and space by manned and unmanned systems, and can target humans, communications, radar, or other assets.

Electronic warfare includes three major subdivisions as shown in Fig 2.1.They are Electronic support measure (ESM), Electronic Counter Measure (ECM) and Electronic Counter Counter Measure (ECCM).

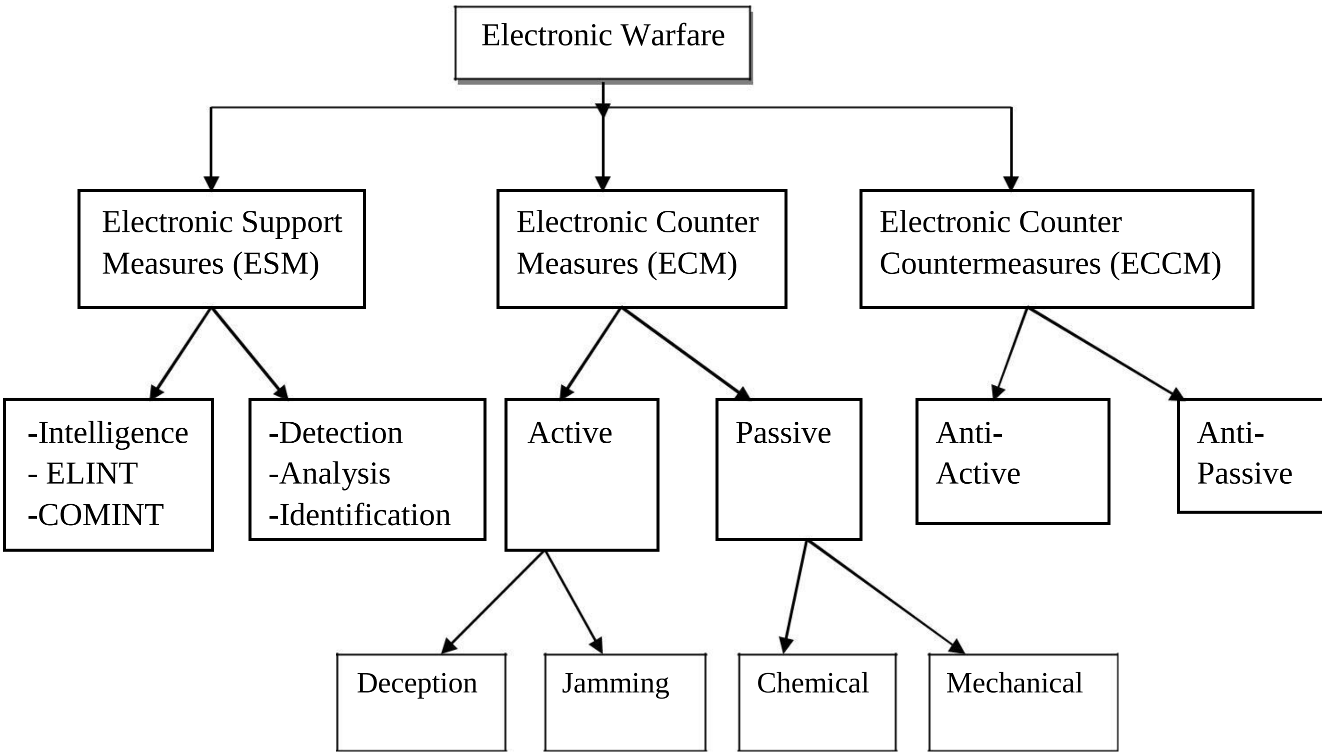


Fig 2.1 Types of E/W system

2.1.1 ELECTRONIC SUPPORT MEASURES (ESM):

Electronic Support Measures (ESM) describe the division of electronic warfare involving actions taken under direct control of an operational commander. Main intention is detect, intercept, identify, locate, record, and/or analyse sources of radiated electromagnetic energy for the purposes of immediate threat recognition. Thus, Electronic Support provides a source of information required for decisions involving Electronic Protection (EP), Electronic Attack (EA), avoidance, targeting, and other tactical employment of forces.

ESM collection platforms can remain electronically silent and detect and analyse RADAR transmissions beyond the RADAR detection range because of the greater power of the transmitted electromagnetic pulse with respect to a reflected echo of that pulse.

Electronic support measures gather intelligence through passive "listening" to electromagnetic radiations of military interest. Electronic support measures can provide initial detection or knowledge of foreign systems, a library of technical and operational data on foreign systems and tactical combat information utilizing that library.

ESM is for 'tactical' purposes that require immediate actions as contrasted with similar functions which are performed for intelligence gathering, such as Signal Intelligence (SIGINT), which has Electronic Intelligence (ELINT), Communications Intelligence (COMINT) and Radiation Intelligence (RINT) as its constituent parts.

a) Electronic Intelligence (ELINT).

This is defined as intelligence information that is the product of activities not in the collection and processing, for subsequent intelligence purposes, of potentially hostile,non-communications electromagnetic radiations which emanate from other than nuclear detonations and the radioactive sources.

b) Communications Intelligence (COMINT).

This is defined as intelligence derived from potentially hostile communications by persons other than the intended recipients. COMINT receivers directed against communication transmissions are similar in concept to those designed to intercept radar transmissions (i.e., non-communication collection of electromagnetic data using ELINT or ESM nun receivers) except that a different approach is required to accommodate the communication signal structure. Communication systems generally operate on discrete channels, are relatively powerful, employ wide-beam antennas with poor side lobes, and use modulated continuous wave transmissions. To avoid jamming, encryption and frequency hopping (i.e., changing frequency randomly) transmissions are normally used.

c) Radiation Intelligence (RINT).

This is defined as intelligence derived from potentially hostile communications and weapons systems by virtue of their unintended spurious emissions, even when they are in a non-transmitting mode of operation.

In brief, ELINT is intelligence derived about the emitter, COMINT is intelligence derived from the emitter, and RINT is intelligence derived about and from the enemy electromagnetic radiation (i.e., activities) utilizing active techniques.

The principal job of an ESM receiver is to provide information on the existence and nature of various signals usually in the minimum possible time. An intercept system (i.e.,ESM receiver) can answer one or more of the following questions:

- Are there any signals present?
- What are the electrical characteristics of and directional bearing to those signals present?
- Is there a particular signal present having certain prescribed characteristics?
- Is there a signal present which is tracking the location of the intercept receiver?
- Is there any new signal added in the general signal environment?
- Is there an unusual signal present?
- Is there a signal present that shows the characteristics of motion of a target?
- Are there CW signals, FM signals, single sideband (SSB) signals?

The list is almost endless. No single ESM receiver will answer all such questions. However, the aim of an ESM system remains the same, i.e., to provide a source of information.

2.1.2 ELECTRONIC COUNTER MEASURES (ECM) OR ELECTRONIC ATTACKS (EA):

An electronic counter measure (ECM) is an electrical or electronic device designed to trick or deceive radar, sonar or other detection systems, like infrared (IR) or lasers. It may be used both offensively and defensively to deny targeting information to an enemy. .The system may make many separate targets appear to the enemy, or make the real target appear to disappear or move about randomly. It is used effectively to protect aircraft from guided missiles. Most air forces use ECM to protect their aircraft from attack. It has also been deployed by military ships and recently on some advanced tanks to fool laser/IR guided missiles. It is frequently coupled with stealth advances so that the ECM systems have an easier job. Offensive ECM often takes the form of jamming. Defensive ECM includes using blip enhancement and jamming of missile terminal homers. Radio jamming or communications jamming is the deliberate transmission of radio signals that disrupt communications by decreasing the signal-to-noise ratio to the point where the target communications link is either degraded or denied service.

There were two main ways of accomplishing active ECM. The first was "jamming" which involved using foil dropped from planes to interfere with radar data. This made it difficult to figure out where the actual aircraft was located. The other method of ECM was using signals to confuse enemy radar or communications.
While on the same frequency, a signal could be used to mask the information being received by the enemy. Sample jamming is shown in Fig No. 2.1.2.1

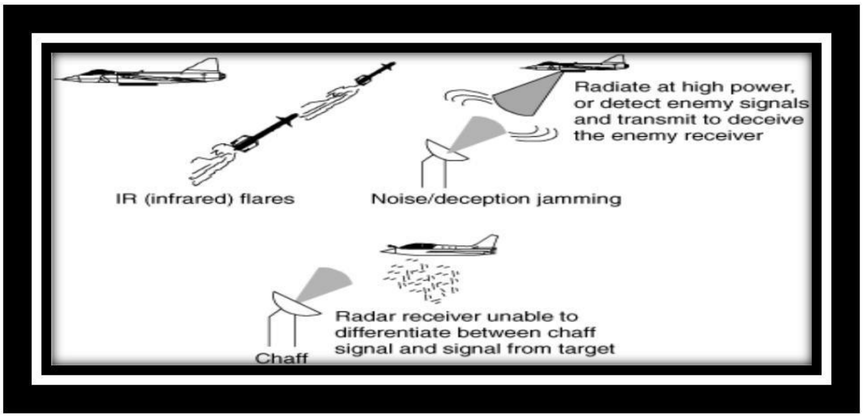


Fig 2.1.2.1 Jamming in of Electronic Counter Measure

Radar:

The electronic principle on which radar operates is very similar to the principle of soundwave reflection. Radar uses electromagnetic energy pulses. Radar is an object-detection system that uses radio waves to determine the range, angle, or velocity of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain.

A radar system as shown in Fig 2.1.2 consists of a transmitter producing electromagnetic waves in the radio or microwaves domain, an emitting antenna, a receiving antenna to capture any returns from objects in the path of the emitted signal, a receiver and processor to determine properties of the object.

Fig 2.1.2.2 Radar

2.1.3 ELECTRONIC COUNTER-COUNTERMEASURES (ECCM) OR ELECTRONIC PROTECTION (EP):

Electronic Protection (EP) or Electronic Protective Measures (EPM) or Electronic Counter Countermeasures (ECCM)) involves actions taken to protect personnel, facilities, and equipment from any effects of friendly or enemy use of the electromagnetic spectrum that degrade, neutralize, or destroy friendly combat capability. Jamming is not part of EP, it is an EA measure.

2.2 AREA OF OPERATION

An area selected in the map for operation. The area is shown inside a polygon where the systems are deployed. A line of sight line drawn between the systems if no obstruction found.

Within an Area of Operation there will be typically main supply route along which vehicles, personnel and supplies will be transported.

2.3 LINE OF CONTROL

Line of Control refers to military control line between two points selected by giving latitude and longitude values.

2.4 LINE OF SIGHT

Line-of-sight propagation refers to electro-magnetic radiation or acoustic wave propagation. Electromagnetic transmission includes light emissions travelling in a straight line. The rays or waves may be diffracted, refracted, reflected, or absorbed by atmosphere and obstructions with material and generally cannot travel over the horizon or behind obstacle.

It is a type of propagation that can transmit and receive data only where transmit and receive stations are in view of each other without any sort of an obstacle between them.

Applications:

1) FM radio 2) Microwave 3) Satellite transmission

Therefore, it can be said that LoS is the clear path for travelling of signals between the control centre and ESM system in the context of the project.

2.4.1 LINE OF SIGHT ALGORITHM:

1. This feature uses ground elevation (height) given latitude and longitude as basis for finding whether the receiver gets the signal at that location.

2. It finds elevation at different points from transmitter to receiver, and if it finds elevation greater than the target height then it indicates there is no line of sight since the signals may reflect at higher elevation area.

2.4.2 RADIO LINE OF SIGHT ALGORITHM:

1. This is another way of finding line of sight based on radio signals.

Radio horizon

The radio horizon is the locus of points at which direct rays from an antenna are tangential to the surface of the Earth. If the Earth were a perfect sphere and there were no atmosphere, the radio horizon would be a circle.

The radio horizon of the transmitting and receiving antennas can be added together to increase the effective communication range.

2. The main parameters used here are

a) Transmitter Power

It is the amount of power of radio frequency energy that a transmitter produces.

b) Transmitter frequency

It is any of the electromagnetic wave frequencies which include those frequencies that are used for communication.

c) Receiver sensitivity

It is the minimum magnitude of input signal required to produce a specified output signal having a specified signal-to-noise ratio, or other specified criteria.

3. Path loss calculated for the signals from transmitter to receiver and deducted from Transmitter Power to find amount of signal strength at the receiver.

Path Loss:

Path loss is the reduction in power density of electromagnetic wave as it propagates through space. Path loss is a major component in the analysis and design of the link budget of a telecommunication system.

This term commonly used in wireless communications and signal propagation. Path loss may be due to many effects, such as free space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption.

Formula: Path loss=33+20logd+20logf

d=distance between entities

f=frequency of transmitter

4. If the amount of power received called Effective Radiated Power is more than the sensitivity of receiver then it indicates there is radio line of sight. Otherwise no RLOS.

Effective Radiated Power:

It is the output power of the transmitter minus the losses incurred in between the transmitter and antenna.

3. REQUIREMENTS AND ANALYSIS FOR ESM SYSTEM

3.1 GUI REQUIREMENTS

3.1.1 GEOTOOLS:

It is an open source Java library that provides tools for geospatial data. GeoTools is used by a number of projects including web services, command line tools and desktop applications. The GeoTools library data structures are based on Open Geospatial Consortium (OGC) specifications.

GeoTools installation require a java JDK and an IDE like Netbeans.

Libraries available from GeoTools open source are added to the given project. Jar files added is shown in Fig No. 3.1.1.

1) commons-codec-1.2.jar

The codec package contains simple encoder and decoders for various formats such as Base64 and Hexadecimal. In addition to these widely used encoders and decoders, the codec package also maintains a collection of phonetic encoding utilities.

2) commons-io-2.4.jar

The Commons IO library contains utility classes, stream implementations, file filters, file comparators, Endean transformation classes, and much more. It depends on JDK.

3) commons-lang-2.6.jar

Lang provides a host of helper utilities for the java.lang API, notably String manipulation methods, basic numerical methods, object reflection, concurrency, creation and serialization and System properties. Additionally it contains series of utilities dedicated to help with building methods, such as hashCode, toString and equals.

4) core-0.26.jar

A fast and easy to use dense matrix linear algebra library written in Java.

5) gt-api-16.0.jar

Definition of interfaces for working with spatial information .The api module contains the GeoTools public interfaces that are used by other GeoTools modules. Where possible we make use of standard interfaces from projects such as GeoAPI and JTS.

6) gt-brewer-16.0.jar

Generation of styles using color brewer.

7) gt-coverage-16.0.jar

Implementation for accessing raster information

8) gt-cql-16.0.ja

Implements of Common Query Language for filters

9) gt-data-16.0.jar

Implements for accessing spatial data

10) gt-geotiff-16.0.jar

Access the information from geotiff using java.

11) gt-main-16.0.jar

Implements filter, feature, etc...

12) gt-metadata-16.0.jar

Implementation of identification and description.

13) gt-opengis-16.0.jar

Definition of interfaces for common spatial concepts.

14) gt-referencing-16.0.jar

15) gt-epsg-hsql-16.0

Implementation of co-ordinate location and transformation.

16) gt-render-16.0.jar

Implements of Java2D rendering engine to draw a map.

17) gt-swing-16.0.jar

Swing interactive map.

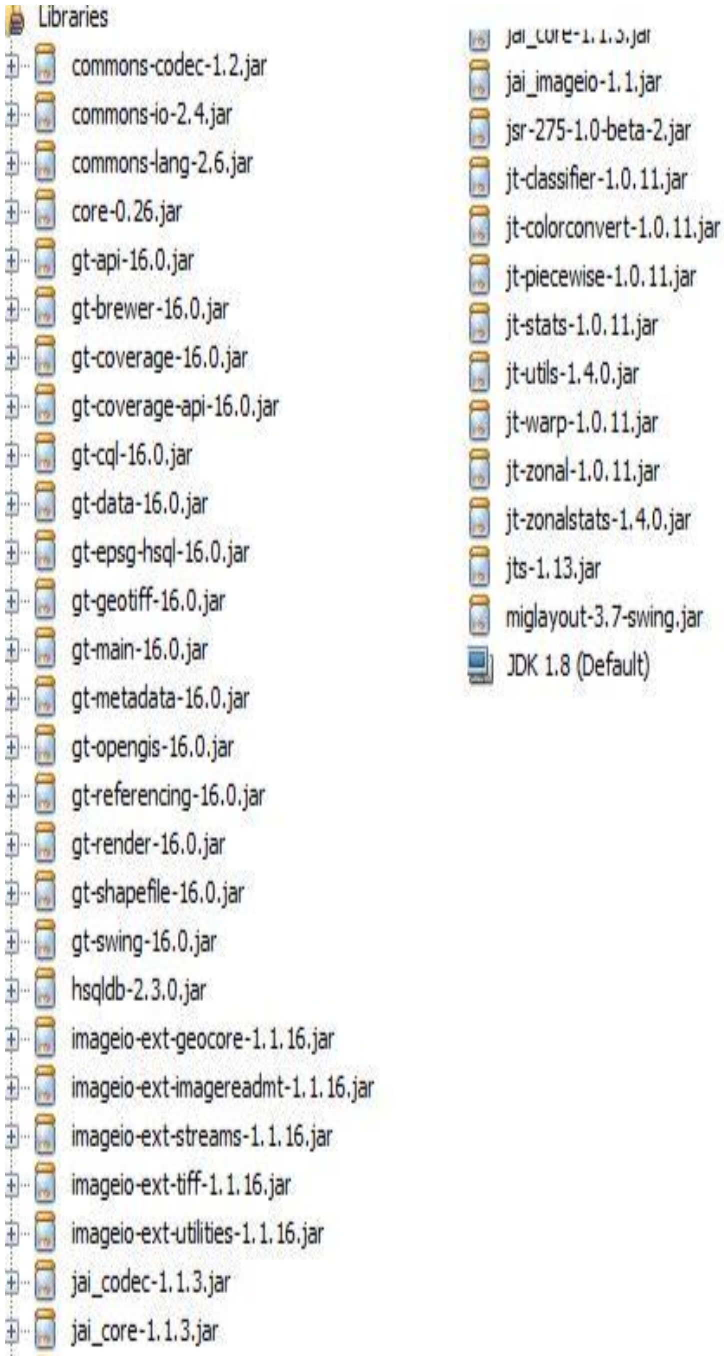


Fig 3.1.1 Libraries added to the project

3.1.2 JAVA SWINGS:

Swing is a set of program components for Java programmes that provide the ability to create graphical user interface (GUI) components, such as buttons and scroll bars. Swing Framework contains a large set of components which provide rich functionalities and allow high level of customization.

GUI consisting of a main frame is divided into panels. They are three panels. The panels are created by using border layout.

A) NORTH PANEL

The first panel contains the information about the toolbar.The toolbar provides features such as map zoom in,zoom out,pan,point a location and add line between locations on map.

B) CENTRE PANEL

The map is loaded into the centre panel. All of the actions are performed on this map only. The map can be loaded downloading .shp files from open source .

1) **.shp**

The shape file is a common standard for representing geospatial vector data. The shape file is in fact a grouping of several files formatted to represent different aspects of geodata

.shp — shape format; the feature geometry itself.

.shx — shape index format; a positional index of the feature geometry to allow seeking forwards and backwards quickly.

.dbf — attribute format; columnar attributes for each shape, in dBase IV format.

There are also several optional files in the shape file format. The most significant of these is the .prj file which describes the coordinate system and projection information used.

2) **.tif**

The specification indicates the Digital Raster Graphic files distributed by USGS will use .tif as the extension for the GeoTIFFimages. A DRG as TIFF is a georeferenced raster image of a published map saved in GeoTIFF format. Files distributed in this format are scanned images of USGS topographic maps. USGS DRG images are stored in TIFF version 6.0. DRGs are georeferenced to the plane ground coordinates of the Universal Transverse Mercator (UTM) coordinate system. The DRG product contains Georeferencing information in three places for convenience of end users with different software tools: in the TIFF file following the GeoTIFF standard in a separate metadata file; and in an optional world file (*.tfw) which contains partial Georeferencing information. The USGS DRG product consists of two mandatory physical files: the TIFF image and a text file of metadata. Shape file and tiff files are different from each other.

Therefore, a map loaded in the center panel using geotools and shp files available.

C) SOUTH PANEL

The southpanel is a status bar panel. It displays latitude and longitude values when mouse clicked or pointed at any location.

3.1.3 FUNCTIONAL REQUIREMENTS:

1) Point a location:

A feature must be provided to point a location given latitude and longitude positions.

2) Feature to add line between locations:

After creating the points we can draw a line between any two points by entering the point numbers between which user desires to draw line.

3) Distance:

Distance between two points or a line distance can be calculated. This uses the “haversine” formula to calculate the great circle distance between two points i.e., the shortest distance over the earth’s surface.

Haversine formula: This is basic formula used to calculate distance between locations from spherical trigonometry.

a= $^{2}(\Delta\ \emptyset_2) + \emptyset 1.\ \emptyset 2.\ - \ ^{2}(\Delta\ _2)$

Formula:c=2.atan2($\sqrt{\ }$,$\sqrt{(1 - \ )}$)

D=R*C

∅ is latitude, is longitude , R is earth's radius.

4) Area of Operation:

Area of operation can be calculated based on latitude and longitude positions of top left and right bottom values. When user enters the values a polygon must be displayed on map representing area of operation where the analysis can be done.

5) Check Line of Sight:

After deploying subsystems on the map the line of sight feature checks whether the path between transmitter and receiver is to have communication based on ground elevation.

If there is line of sight a green line displayed else red line.

6) Check Radio Line Of Sight:

1. This feature checks radio line of sight based on radio signals reachable to receiver from transmitter.

2. As discussed in 2.4.2 the main parameters to be used for RLoS checking are:

a) Transmitter Power

b) Transmitter frequency

c) Receiver sensitivity

These values are required for calculating pathloss.

3. Path loss calculated for the signals from transmitter to receiver and deducted from Transmitter power to find amount of signal strength at the receiver.

4. If the amount of power received called Effective Radiated Power is more than the sensitivity of receiver then it indicates there is radio line of sight and displays orange line between entities else a red line indicating no line of sight.

3.2 HARDWARE REQUIREMENTS

1. HARDDISK-100MB
2. RAM-512MB
3. CPU: Intel core-I5

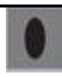
3.3 SOFTWARE REQUIREMENTS

1. java swings, JDK1.7
2. IDE: NetBeans IDE 7.3
3. Geotools
4. Operating system: windows 8.1

Therefore after analysis of requirements done, design is necessary for implementing the project discussed in chapter 5.Design includes designing modules, UML diagrams which are discussed in chapter 4.

4. SYSTEM DESIGN

4.1 FUNCTIONALITIES

S.No	Module Name	JButton	Description
1.	Zoom In		It can magnify the mapupto the smallest detail required by user.
2.	Zoom Out		It can mitigate the map upto the original size of the image of map.
3.	Pan or Drag		It can move the map in the positon specified by user.
4.	Info		It gives information of any location.
5.	Reset		It can reset the map i.e display full extent of layers.
6.	MouseClick		It displays the latitude and longitude positions on map.
7.	Point a location		It displays a point on map on location where latitude and longitude values are given by the user.
8.	Line between two point locations		It displays a blue line between two point locations along with calculated distance in status panel.

9.	Area Of Operation		It create an area where the map analysis done.
10.	ESM deployment for analysis		It provides features like add,update,delete entity values, check line of sight , radio line of sight and deployment of entities.
11	Store values in Text file		Entity deployed at latitude, longitude, LoS ,RLoS values are stored in a text file format.
12	Result		It displays the text file where analysis values are stored and summarizes the best area of operation.

Table No. 4.1 Functionalities

4.2 UML diagrams:

4.2.1 Class diagram:

The structural diagrams represent the static aspect of the system. These static aspects represent those parts of a diagram which forms the main structure and therefore stable. These static parts are represents by classes, interfaces, objects, components and nodes.

Class diagrams are the most common diagrams used in UML. Class diagram consists of classes, interfaces, associations and collaboration. Class diagrams basically represent the object oriented view of a system which is static in nature.

Active class is used in a class diagram to represent the concurrency of the system. The class diagram for map analysis for ESM system deployment is shown in Fig 4.2.1.

Class diagram represents the object orientation of a system. So it is generally used for development purpose. This is the most widely used diagram at the time of system construction.

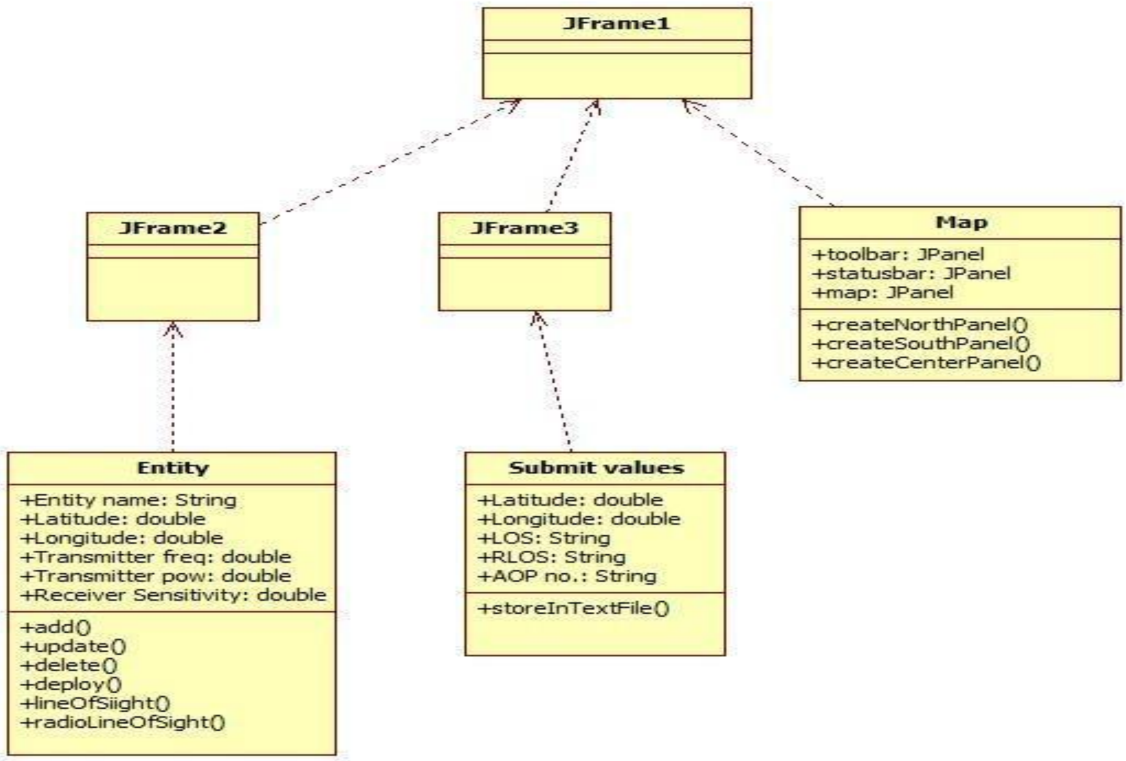


Fig 4.2.1 Class diagram for map analysis for ESM system deployment

Any system can have two aspects, static and dynamic. So a model is considered as complete when both the aspects are covered fully.

4.2.2 Use case Diagram:

Behavioural diagrams basically capture the dynamic aspect of a system. Dynamic aspect can be further described as the changing/moving parts of a system.

Use case diagrams are a set of use cases, actors and their relationships. They represent the use case view of a system.

A use case represents a particular functionality of a system.

So use case diagram is used to describe the relationships among the functionalities and their internal/external controllers. These controllers are known as actors.

As described in Fig 4.2.2 the actors and uses cases for Map analysis for ESM system deployment are:

1) ACTORS:

1. GUI

2. User

2) USE CASES:

1. Zoom in

2. Zoom out

3. Pan or drag

4. Point a location

5. Information and reset

6. Mouse click

7. Add line between location points

8. Find distance

9. Create area of operation

10. Check line of Sight

11. Check radio line of sight

12. Deploy Esm system

13. Store values in text file

14. Summarize from results the best area of operation

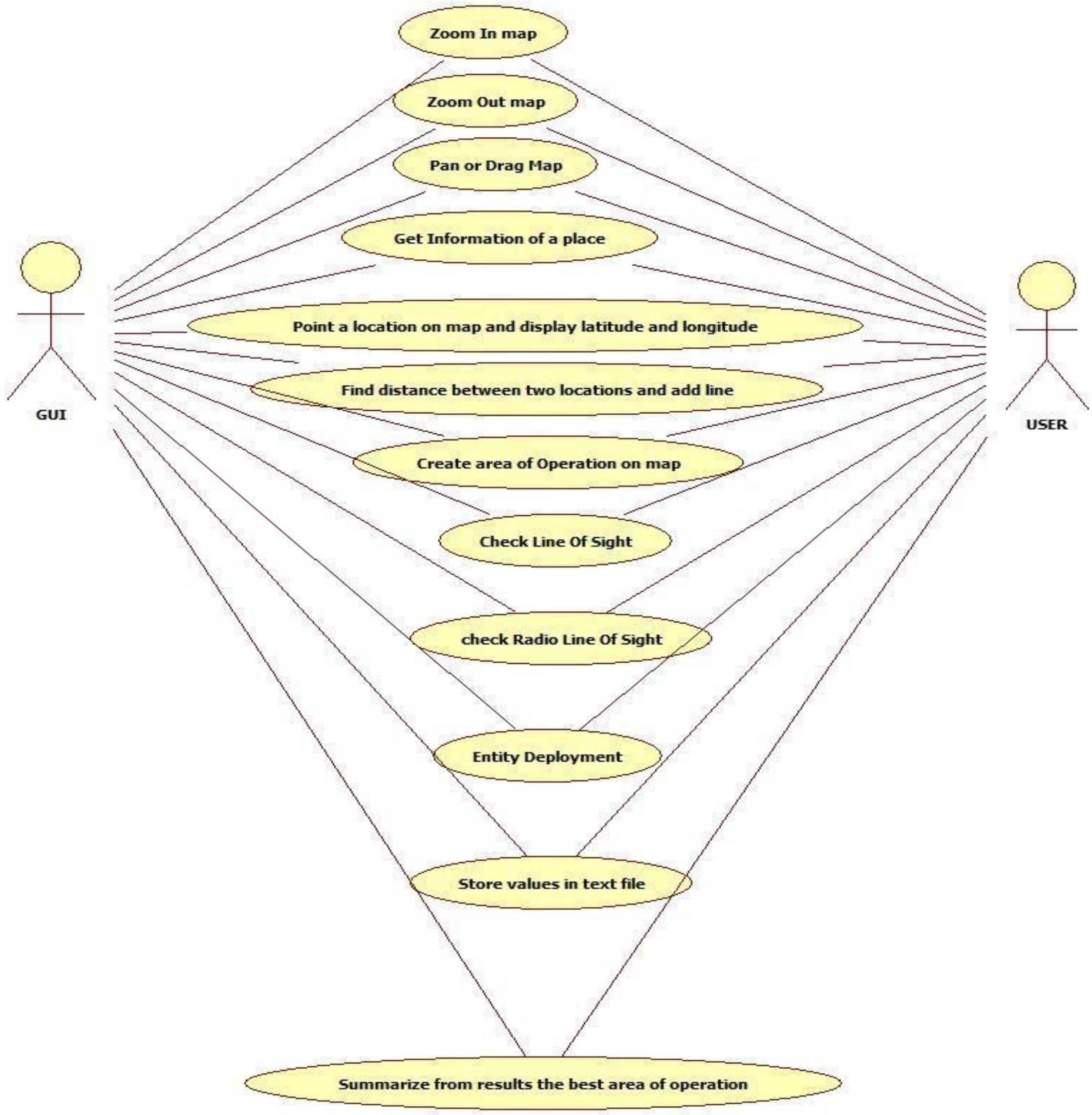


Fig 4.2.2 Use case diagram for map analysis for ESM system deployment

5. IMPLEMENTATION

5.1 SAMPLE CODE

1) Creation of Frame:

```
public map(Entity1 en1) {
frame = new JFrame("MAP");
frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
panel = new JPanel(new BorderLayout(5, 5));
frame.setSize(5000, 5000);
frame.add(panel);
frame.setVisible(true);
   }
```

2) Creation of Panels:

```
public void initComponents() {
 p1 = new JPanel();
        p2 = new JPanel();
        p3 = new JPanel();
panel.add(centerPanel(), BorderLayout.CENTER);
panel.add(toolbar(), BorderLayout.NORTH);
panel.add(createSouth(), BorderLayout.SOUTH);
  }
```

3) Sample code for creation of JButton using Default Packages in Geotools: Package for Zoom In:

importorg.geotools.swing.action.ZoomInAction;

Creating Zoom In Button:

JButtonzinButton = new JButton(new ZoomInAction(map));

Package for Zoom Out:

importorg.geotools.swing.action.ZoomOutAction;

Creating Zoom Out Button:

JButtonzoutButton = new JButton(new ZoomOutAction(map));

Package for Pan:

importorg.geotools.swing.action.PanAction;

Creating Pan Button:

JButtonpanButton = new JButton(new PanAction(map));

Package for Info:

importorg.geotools.swing.action.InfoAction;

Creating Info Button:

JButtoninf = new JButton(new InfoAction(map));

Package for Reset:

importorg.geotools.swing.action.ResetAction;

Crating Reset Button:

JButtonrs = new JButton(new ResetAction(map));

4) Display latitude and longitude positions on map:

```
DirectPosition2D pos = ev.getWorldPos();

System.out.printf(" world: x=%.2f y=%.2f \n", pos.x, pos.y);

l1.setText("longitude: and latitude:" + pos.x + "," + pos.y);
```

5) Implementation of Line Of Sight algorithm:

```
if(height1<eht)   //then check

if(height2<eht)  //then check

if(height3<eht) //then check

if(height4<eht)     //then check

if(height5<eht)     //then check

// then add green

line else

// add red line
```

Where eht – Target height

height1, height2, height3, height4, height5 are the ground elevation values in the path between transmitter and receiver.

Where comparison between the ground elevation points with target height (eht) made to check Line Of Sight.

6) Implementation for Radio Line Of Sight Algorithm:

```
pathloss=33+20*p1+20*p2;//p1- log(distance between transmitter and receiver)
double power;                    //  p2-log(Transmitter frequency)
power=erp-pathloss;
if(power<se1)
//add orange line
else
//add red line
```

power- signal strength at receiver undergoing some pathloss

se1-receiver sensitivity

7) Entity Specification Values in Default Table

Model: a) Add Entity Specification:

```
DefaultTableModel model=(DefaultTableModel)entityname.getModel();
if(!enname.getText().trim().equals(""))
model.addRow(new
Object[]{enname.getText(),lonname.getText(),latname.getText()});
```

b) Updating Entity Specification:

```
DefaultTableModel model=(DefaultTableModel)entityname.getModel();
if(entityname.getSelectedRow()==-1)
if(entityname.getRowCount()==0)
lmessage.setText("Table is empty");
```

Finally, after implementing the project the code is tested to find any errors present in code. More about testing is discussed in chapter 6.

6. TESTING

6.1 PURPOSE OF TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components.

Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

A primary purpose for testing is to detect software failures so that defects may be uncovered and corrected. Testing cannot establish that a product functions properly under all conditions but can only establish that it does not function properly under specific conditions. The scope of software testing often includes examination of code as well as execution of that code in various environments and conditions as well as examining the aspects of code: does it do what it is supposed to do and do what it needs to do. In the current culture of software development, a testing organization may be separate from the development team. There are various roles for testing team members. Information derived from software testing may be used to correct the process by which software is developed.

6.2 SOFTWARE VERIFICATION AND VALIDATION

Software testing is used in association with verification and validation:

Verification: Have we built the software right (i.e., does it match the specification?)? It is process based.

Validation: Have we built the right software (i.e., is this what the customer wants?)? It is product based.

1) Unit testing

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application .It is done after the completion of an individual unit before integration. This is a structural testing, that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application, and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.

Test strategy and approach

Test objectives

1. All field entries must work properly.
2. Pages must be activated from the identified link.
3. The entry screen, messages and responses must not be delayed.

Features to be tested

1. Verify the functioning of each module
2. Verify the output of each operation in GUI.
3. All links should take the user to the correct page.

2) Integration testing

Integration tests are designed to test integrated software components to determine if they actually run as one program. Testing is event driven and is more concerned with the basic outcome of screens or fields. Integration tests demonstrate that although the components were individually satisfaction, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects.

The task of the integration test is to check that components or software applications, e.g. components in a software system. Finally, results obtained from test cases are used for map analysis which is discussed in chapter 7.

6.3 TEST CASES

S.No	Test Case	Input	Expected Result	Result Obtained	PASS/FAIL
1.	ZoomIn Button	on click	Display map magnified	Displayed map magnified. When clicked again displayed map more magnified.	PASS
2.	ZoomOut Button	on click	Display map to smallest detail required	Displayed map mitigated When clicked again displayed map more mitigated.	PASS
3.	Pan Button	on click	Move map to desired position	Moved map to desired position i.e full extent of layers obtained.	PASS
4.	Ìnfo Button	on click	Display info tab	Displayed info tab	PASS
5.	Reset Button	on click	Set back to original.	Set back to original.	PASS
6.	Cursor Button	on click	Display latitude and longitude of	Displayed latitude and longitude of	PASS

			desired position in status bar.	desired position in status bar.	
7.	Point a Location	Latitude: 17.5 Longitude:77.5	Display point on map at that position	Point displayed at position with latitude:17.5 and longitude:77.5	PASS
8.	Point a Location	Latitude: op Longitude:77.5	Display error message to enter valid values.	No error message displayed and no point displayed on map	FAIL
9.	Add line between point Locations number displayed 1 and 2	“Enter point 1”:1 “Enter point 2”:2	Display blue line between them.	Given “Enter point number”:1 “Enter point number”:2 Displayed blue line between them.	PASS
10.	Add line between point Locations number displayed 1 and 2.	“Enter point 1”:1 “Enter point 2”:3	Display Error message	No error message displayed and no line displayed between locations.	FAIL

11.	Create Area of Operation on Map	Latitude of top left point:18.70 Longitude of top left point:74.338 Latitude of bottom right point:17.059 Longitude of bottom right point:76.27	Display a polygon on map.	Displayed a polygon on map	PASS
12.	Create Area of Operation on Map	Latitude of right bottom point:18.70 Longitude of right bottom point:74.338 Latitude of top left point:17.059 Longitude of top left point:76.27	Show error message since values are interchanged and output is not the desired area of operation.	No message displayed and created a wrong area of operation.	FAIL
13.	Add entity specification s to table	valid specifications of entity Entity name:RDFS2 Latitude:18.01 Longitude:75.7 Power:100 Frequency:50 Sensitivity:-35	Values display in default table model	Displayed in default table model	PASS
14.	Update	valid	Display	Displayed	PASS

	entity specifications in table	specifications of entity Entity name:RDFS2 Latitude:19.08 Longitude:78 Power:100 Frequency:50 Sensitivity:-35	changes made to specifications in table.	changes made to specifications in table.	
15.	Delete entity specifications of a row selected by user.	Select a row in default table model.	Data deleted	Data deleted	PASS
16.	Line Of Sight	On Click Elevation(height) values.	Perform analysis and display green line if there is line of sight else red line.	Displayed green line when there is line of sight between transmitter and receiver.	PASS
17.	Radio Line Of Sight.	On Click	Perform analysis and display orangeradio line if there is line of sight else red line.	Displayed green line when there is radio line of sight between transmitter and receiver.	PASS
18.	Deploy	On Click	Display the icon on map at given latitude and	Displayed the icon on map at given latitude and	PASS

			longitude from default table model.	longitude from default table model.	
19.	Submit Values	OnClick Enter AOP no.:1 AOP,Transmitter, Receiver latitude and longitude valid values Transmitter valid specifications Receiver valid specifications	Store all the values in text file.	All the values are stored in text file.	PASS
20.	Result	On Click	Display text file with stored values.	Displayed text file with stored values.When changes made while submitting and clicked again displayed the text modified	PASS

Table No. 6.3 Test Cases observed

7. RESULTS

7.1 OUTPUT SCREENS

The main frame displayed initially before any action performed is shown in Fig 7.1.1.

Shape file name: natural.shp

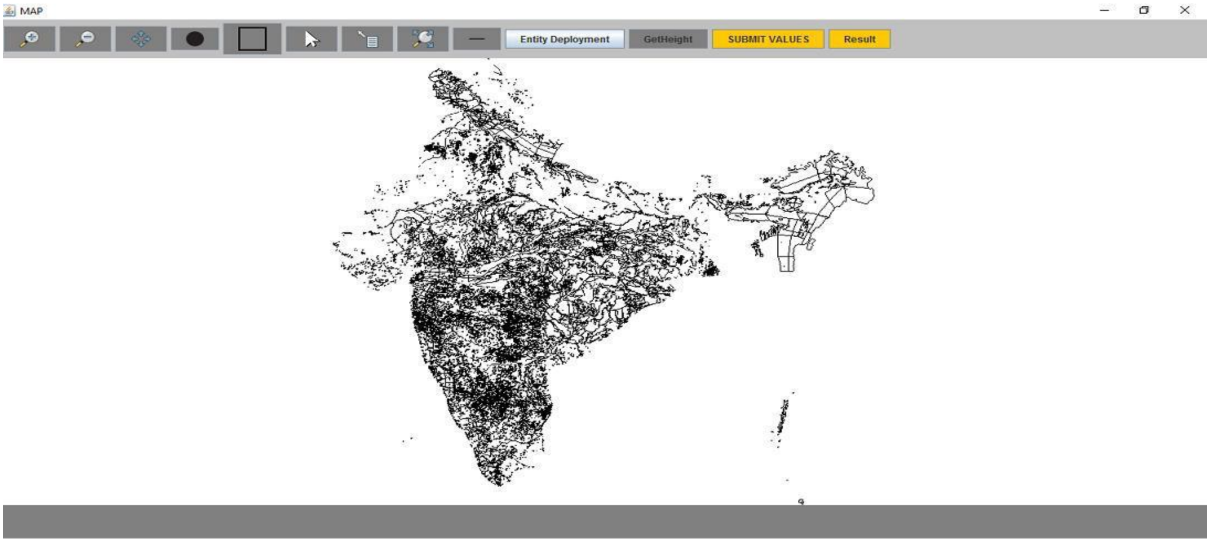


Fig 7.1.1 Main Frame

When user clicks on Zoom In Button map is magnified and displayed. When clicked again map displayed more magnified as shown in Fig 7.1.2

Shape file name: natural.shp

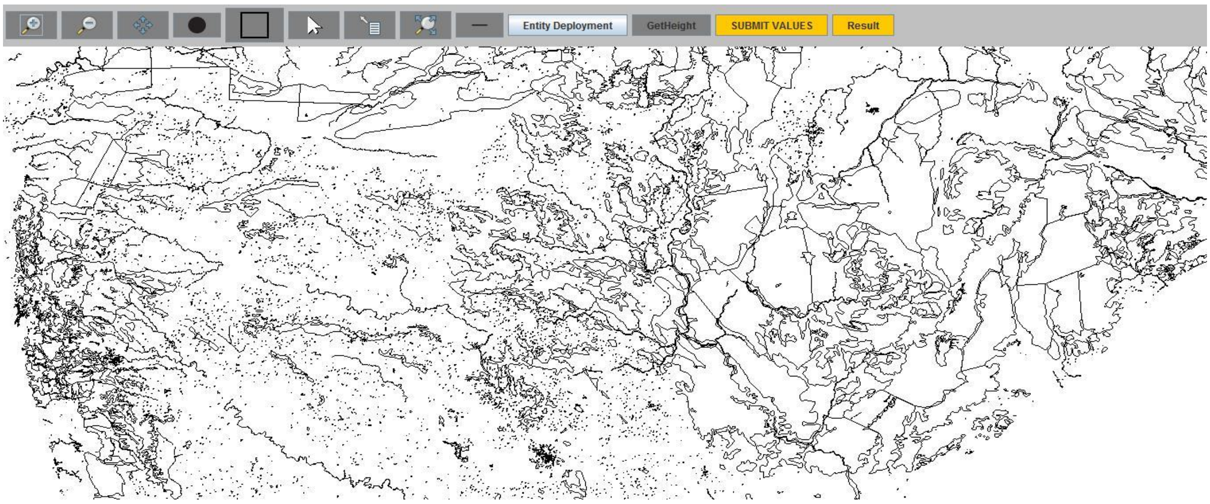


Fig 7.1.2 Zoom In action

When user clicks on Zoom Out Button map shown in Fig 7.1.2 is mitigated and displayed When clicked again map displayed more mitigated as shown in Fig 7.1.3.

Shape file name: natural.shp

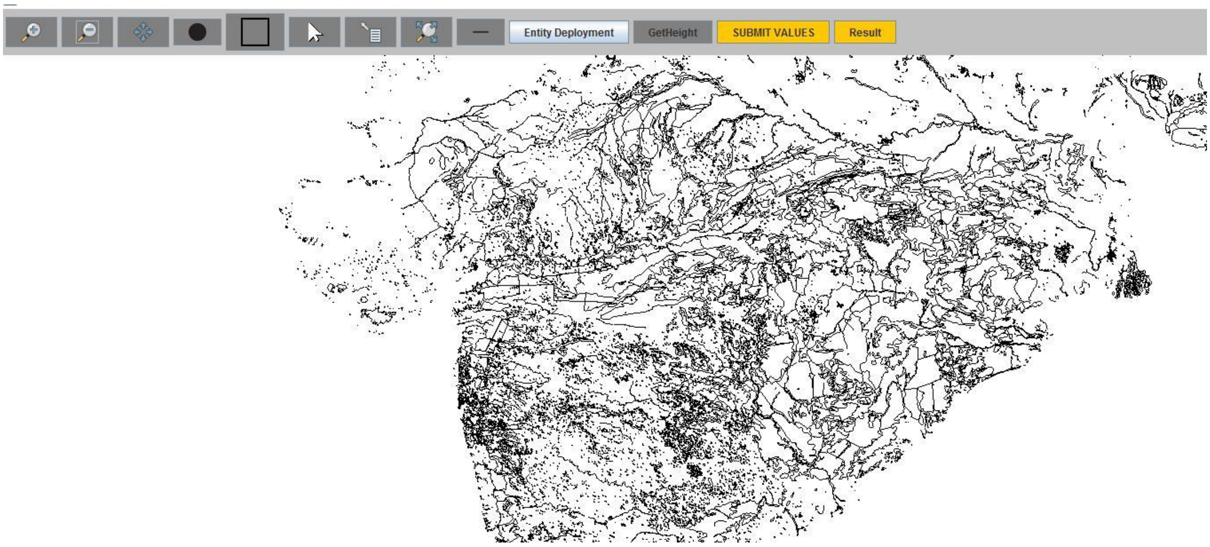


Fig 7.1.3 Zoom Out action

When user clicks on Pan Button map from desired position shown in Fig 7.1.3 is moved to position as shown in Fig 7.1.4.

Shape file name: natural.shp

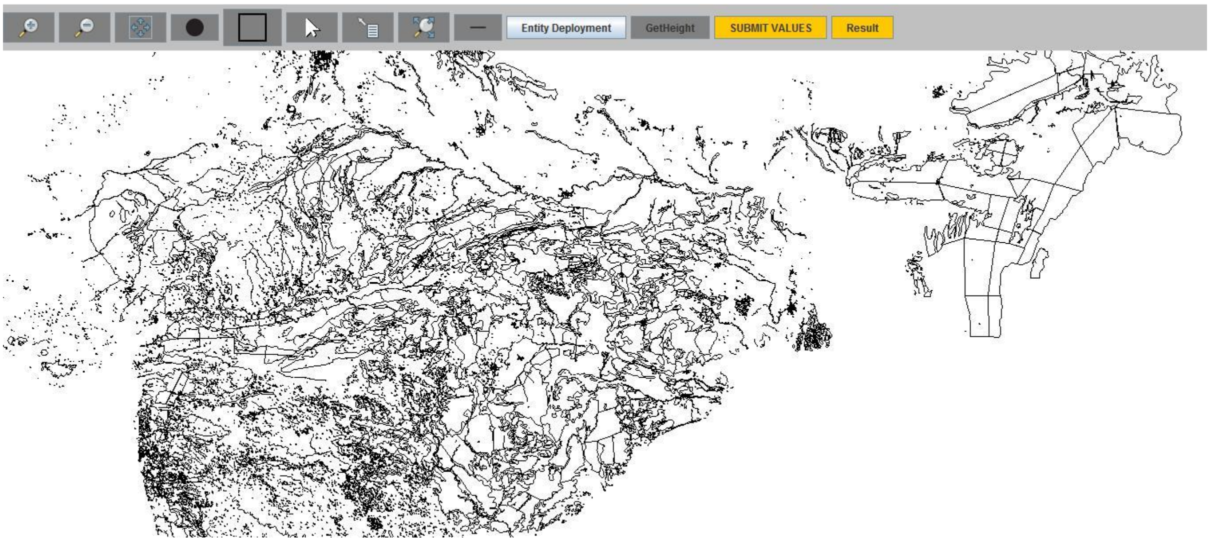


Fig 7.1.4 Pan (or Drag) action

When user clicks on Reset Button map changes made like zoom in, zoom out and pan are reset and displayed i.e full extent of all layers as shown in Fig 7.1.5.

Shape file name:natural.shp

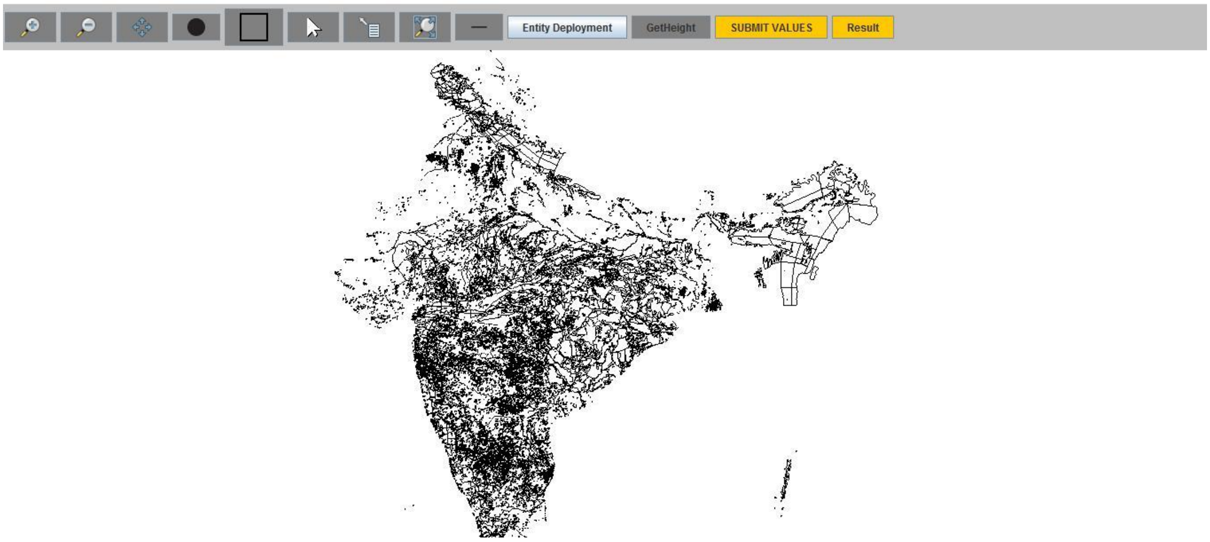


Fig 7.1.5 Reset action

When user clicks on Info Button map feature information available in the shape file displayed as shown in Fig 7.1.6.

Shape file name: natural.shp

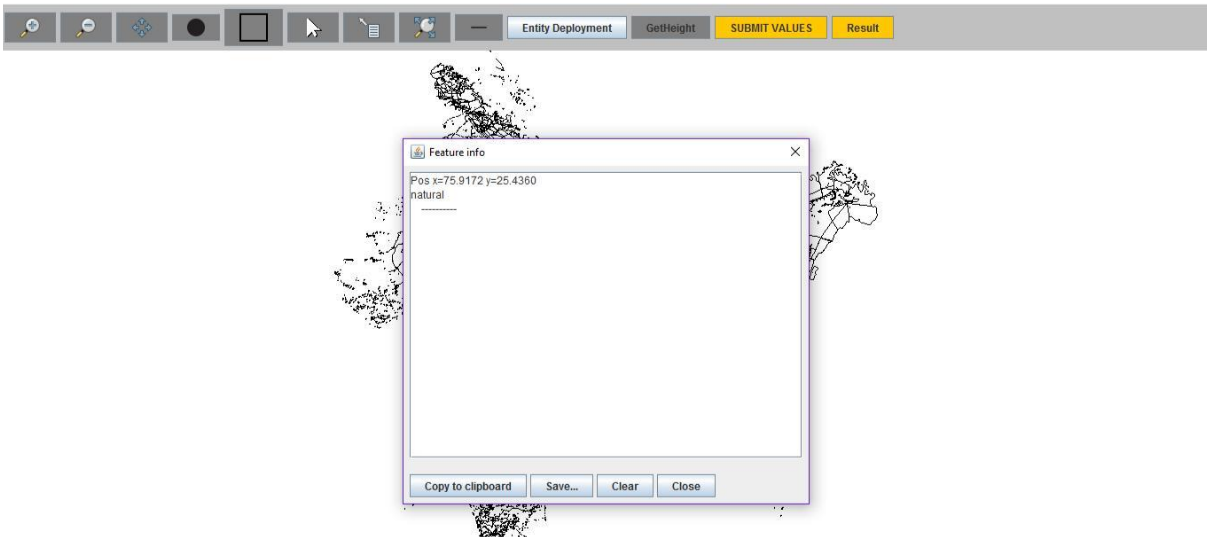


Fig 7.1.6 Info button action

When user clicks on cursor Button latitude and longitude positions of a location in map displayed in the status panel as shown in Fig 7.1.7.

Shape file name: natural.shp

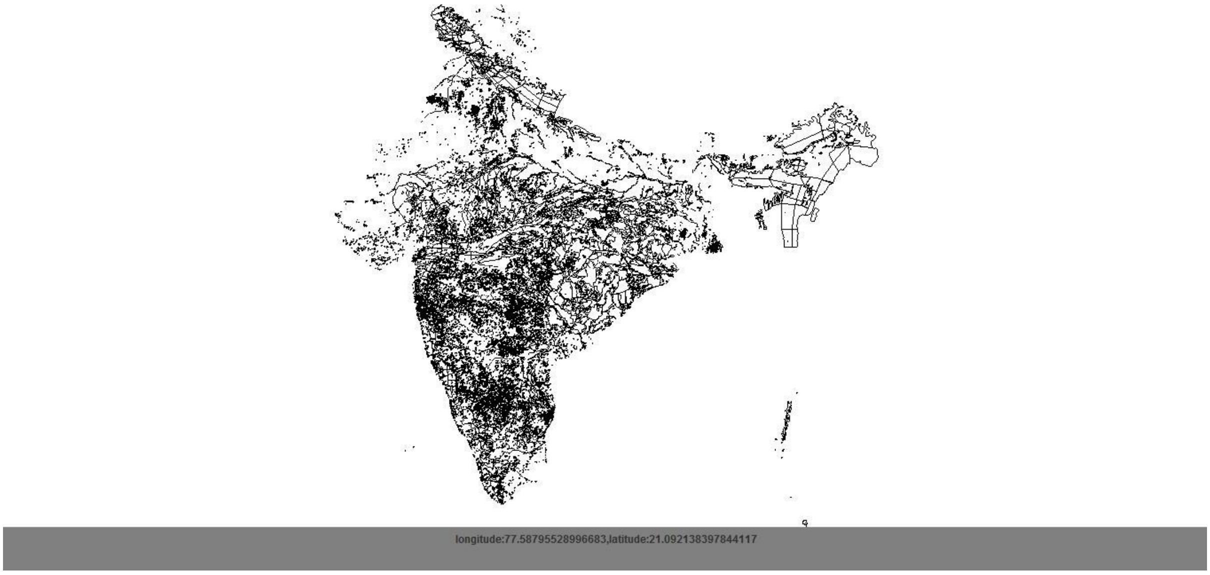


Fig 7.1.7 Cursor button action

When user clicks on point Button at desired latitude and longitude positions of a location in map a point displayed as shown in Fig 7.1.8.

Shape file name: natural.shp

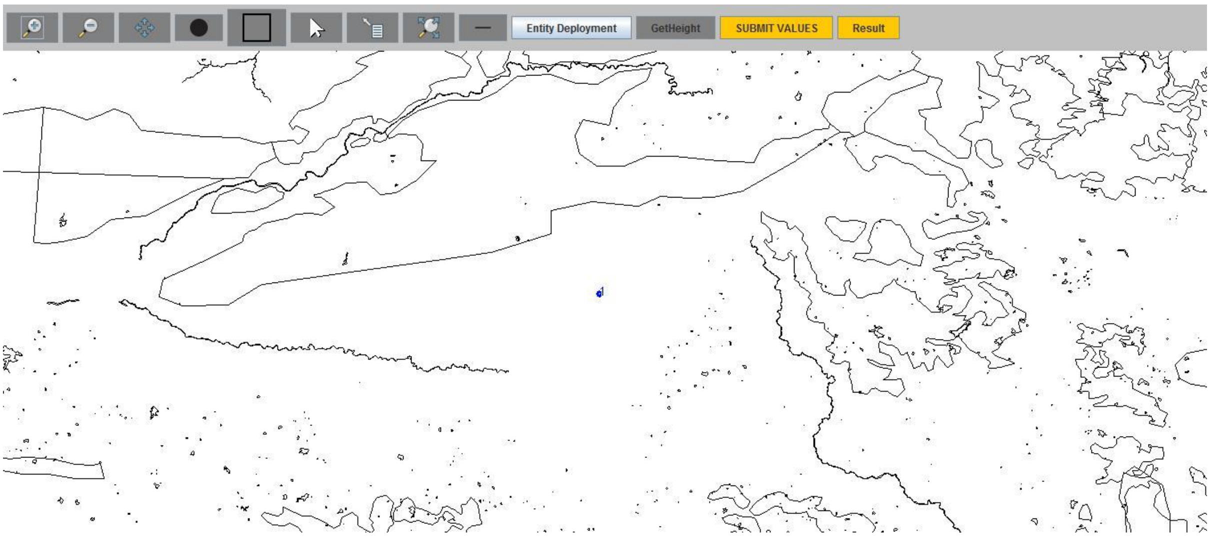


Fig 7.1.8 Point button action

When user clicks on line Button an input box display which asks to enter point numbers between which line must be displayed and when entered a blue line displayed between points as shown in Fig 7.1.9 and Fig 7.1.10 respectively.

Shape file name: natural.shp

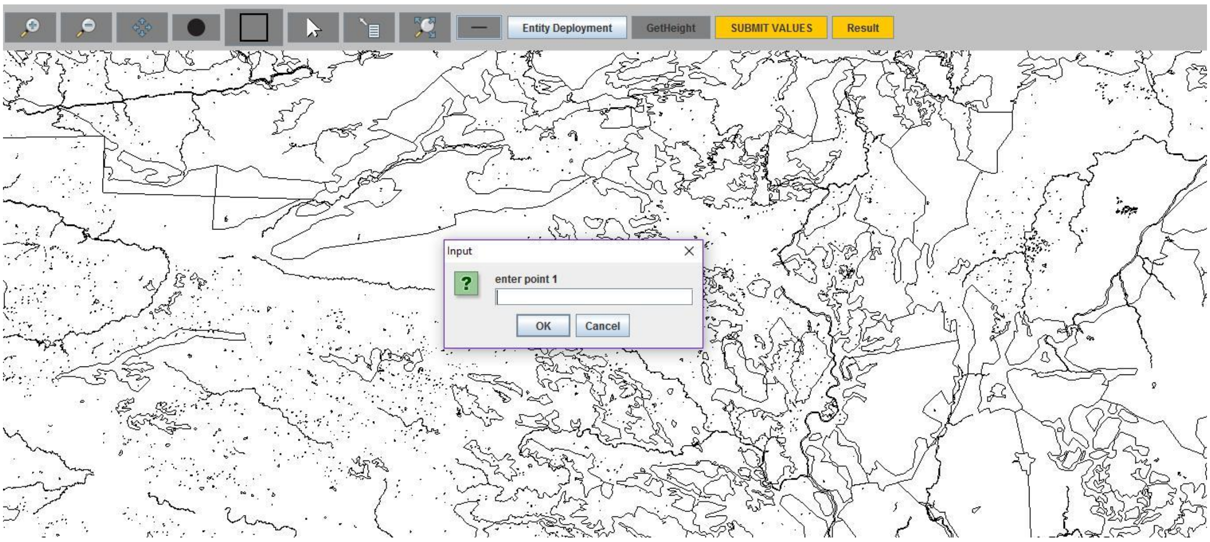


Fig 7.1.9 Line button action enter point number

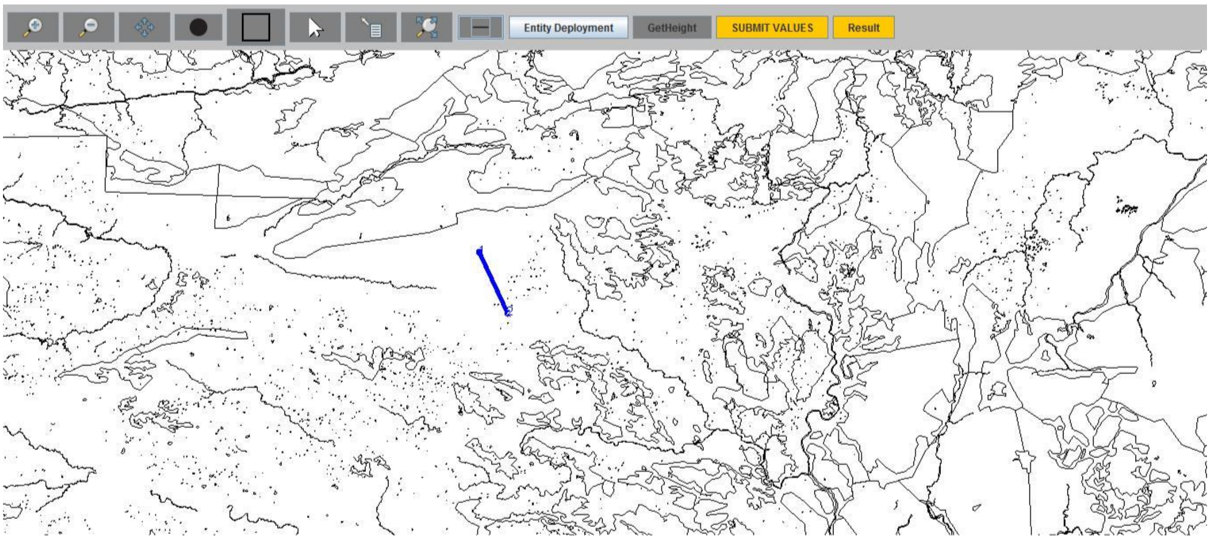


Fig 7.1.10 Line button action line displayed

When user clicks on Area of Operation Button an input box displayed which asks user to enter latitude and longitude positions of top left and right bottom points. A polygon displayed where the analysis can be done as shown in Fig 7.1.11 and Fig 7.1.12.

Shape file name: natural.shp

Fig 7.1.11 Enter top left and right bottom point values

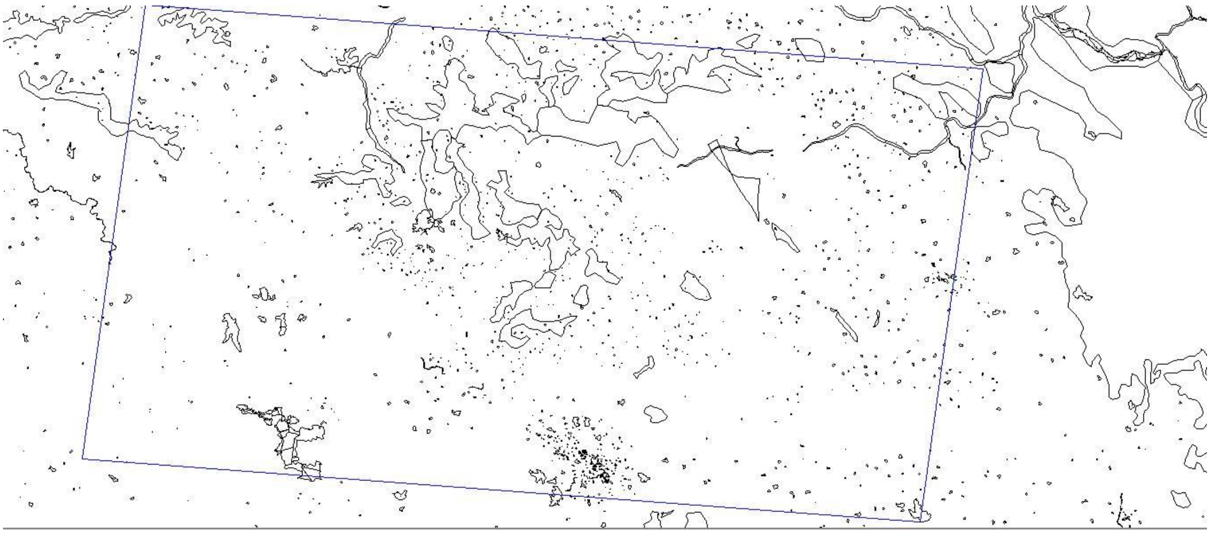


Fig 7.1.12Area of operation where analysis can be performed

When user clicks on Entity Deployment Button another frame containing entity specifications displayed as shown in fig 7.1.13 .A default table model with contents displayed where user can add, update, delete entity specifications as shown in Fig 7.1.14,Fig 7.1.15,Fig 7.1.16. Finally, from the data available in the table entities are deployed on map as shown in Fig 7.1.17

Shape file name: natural.shp

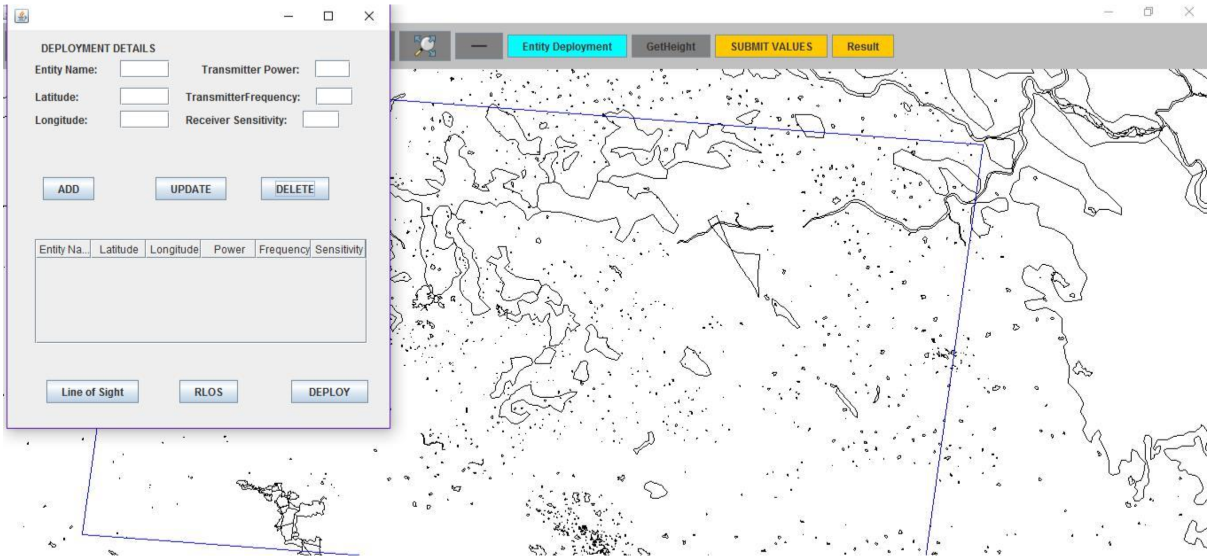


Fig 7.1.13 Displayed deployment details frame

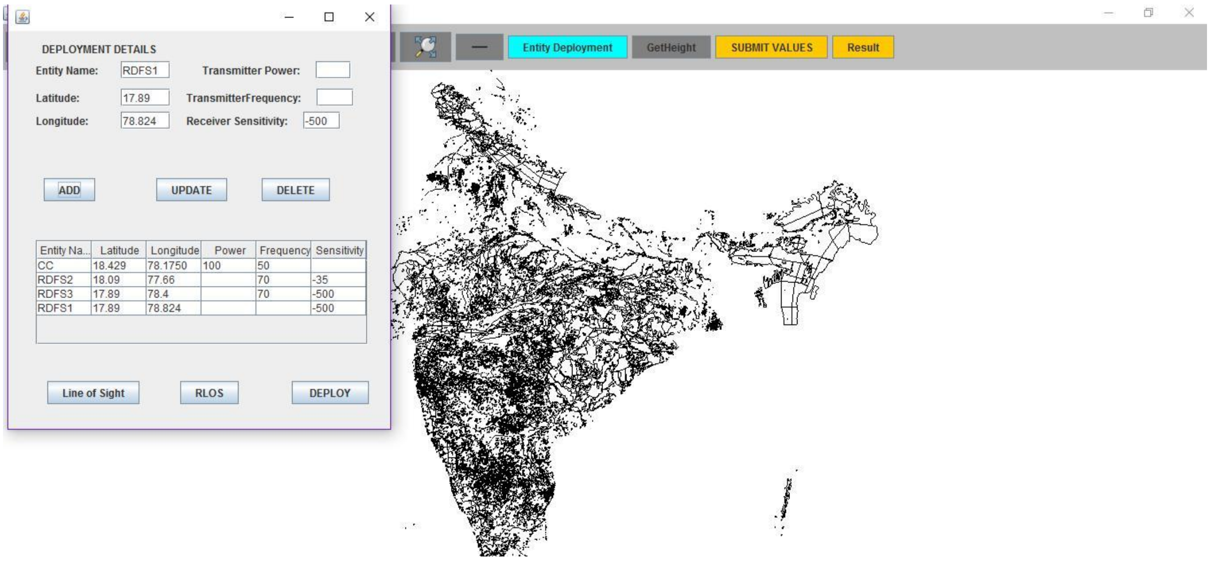


Fig 7.1.14 Add button on click displays the details entered in table below

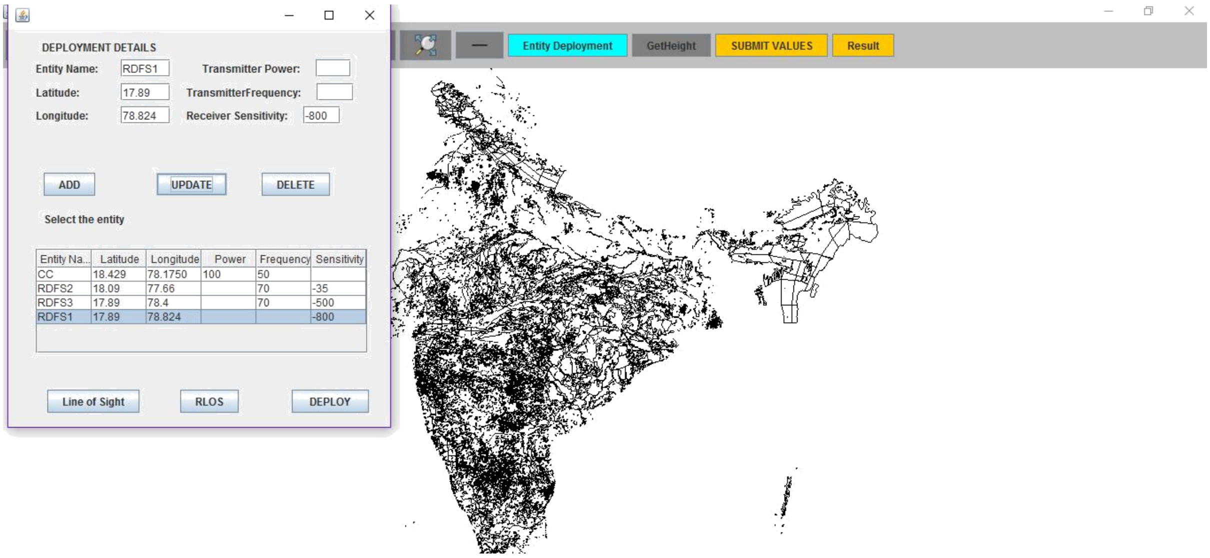


Fig 7.1.15 Update button on click updates the details in selected row

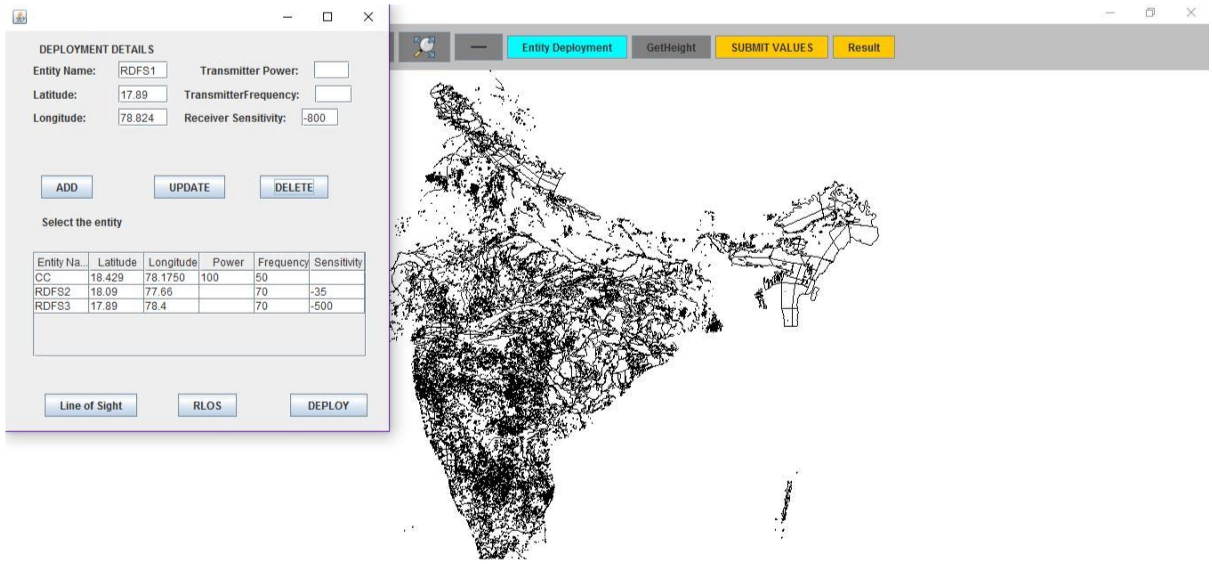


Fig 7.1.16 Delete button on click deletes the details in selected row

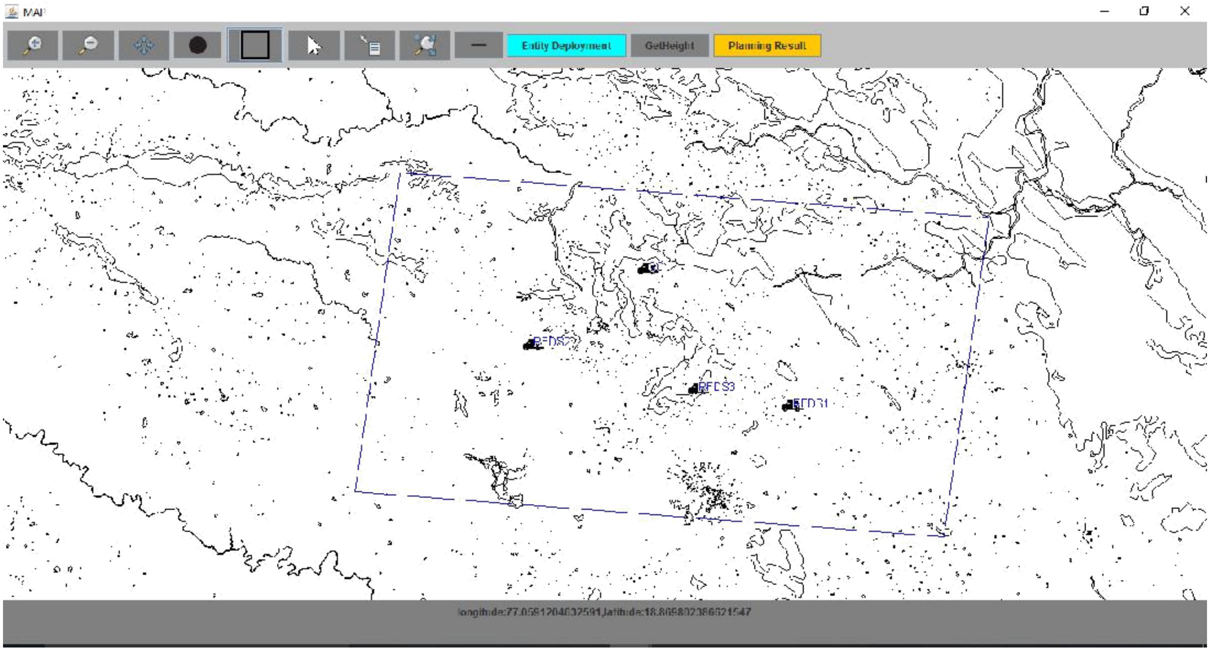


Fig 7.1.17 Deploy button action

When the user clicks on Line Of Sight button analysis done whether the path between the transmitter and receiver is clear using elevation values obtained from link provided in the path between them as shown in Fig 7.1.18.Therefore a green light displayed if there is line of sight else red line is displayed between entities as shown in Fig7.1.19.

Shape file name: natural.shp

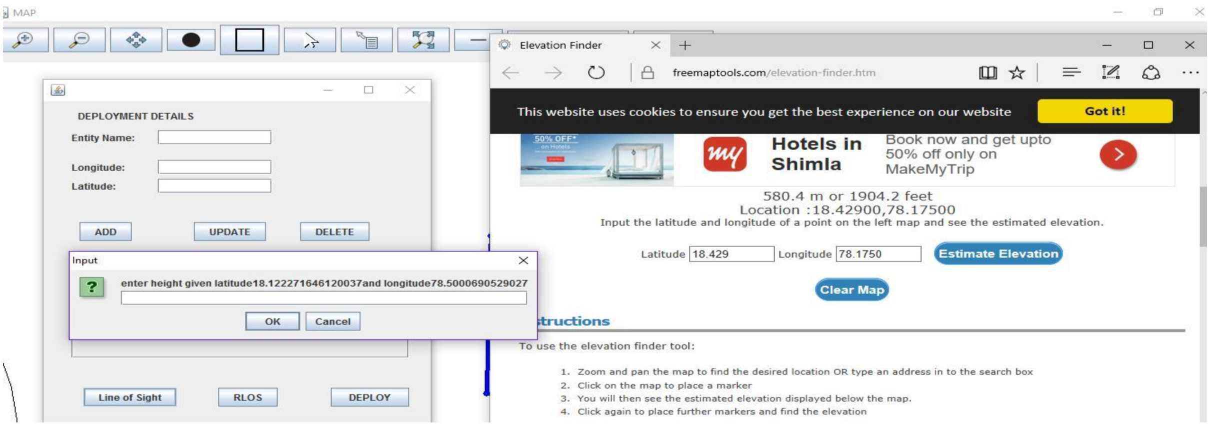


Fig 7.1.18. Entering measured elevation value from link provided

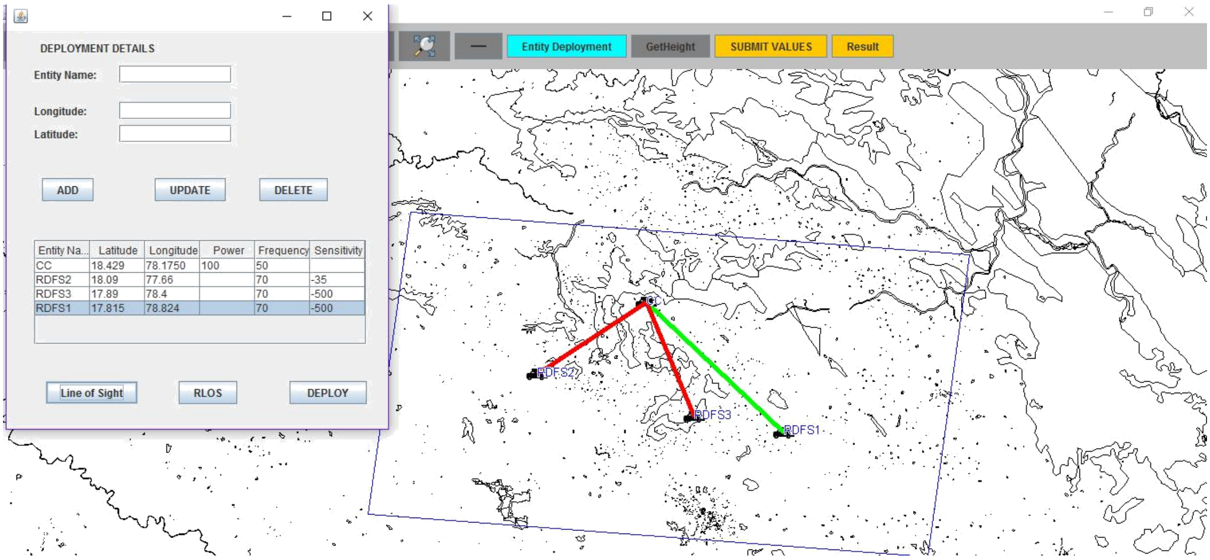


Fig 7.1.19 Displayed Line of sight with green line and non line of sight with red line

When user clicks on RLOS button, the user is asked to enter the names of transmitter and receiver as shown in Fig 7.1.20.Finally,after entering the entity names analysis is done between the transmitter and receiver and orange line is displayed if there is radio line of sight else red line displayed as shown in Fig 7.1.21.

Shape file name: natural.shp

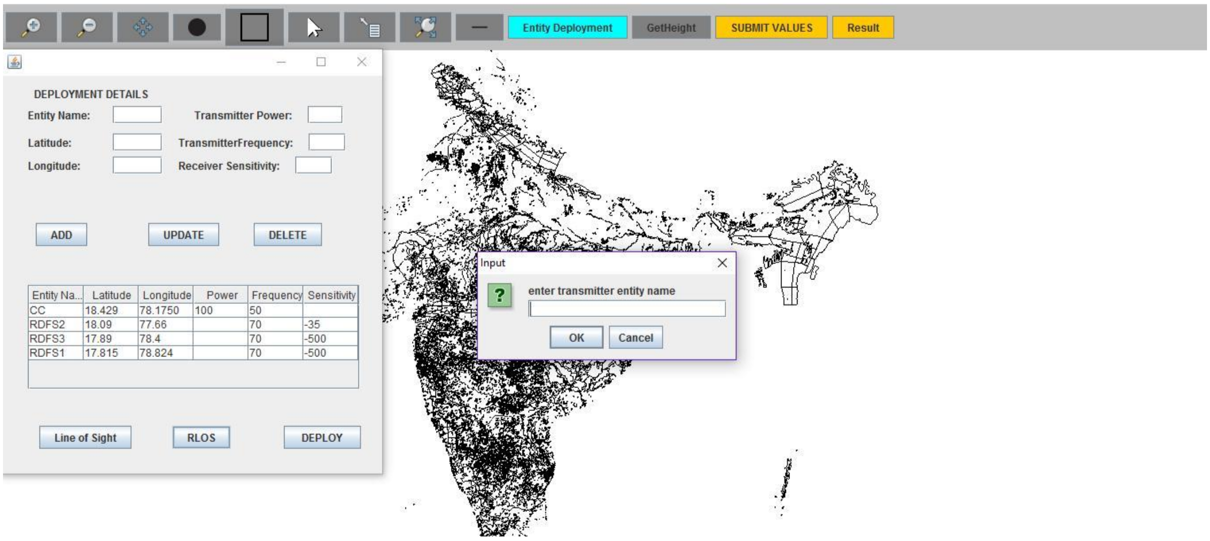


Fig 7.1.20. Entering transmitter entity name

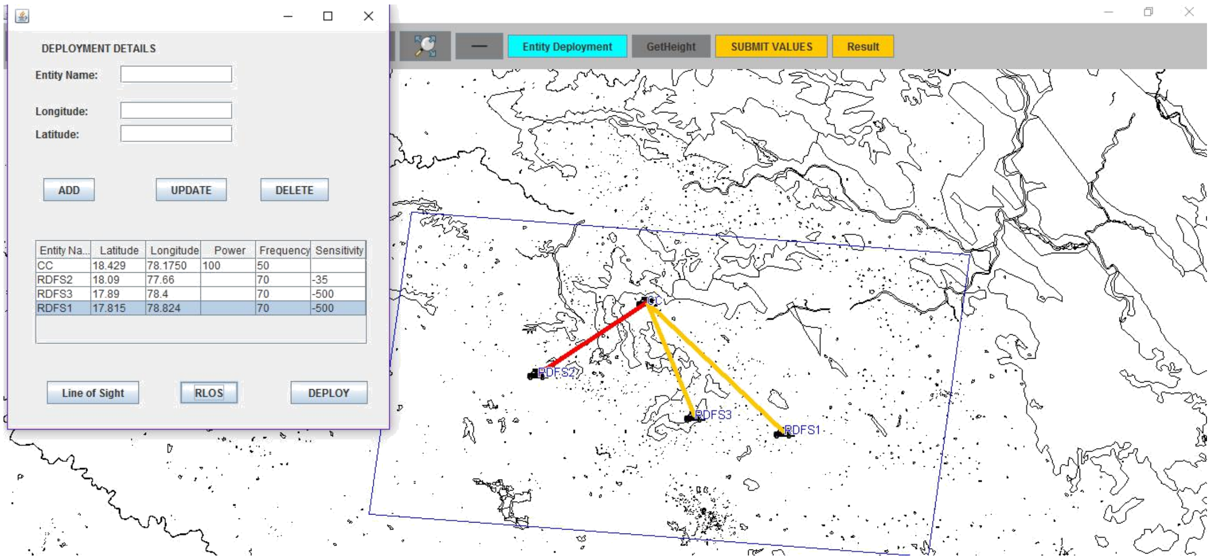


Fig 7.1.21 Displayed radioLoS with green line and non radioLoS with red line

When user clicks on submit value button another frame to enter analysis results is displayed as shown in Fig 7.1.22.

Shape file name: natural.shp

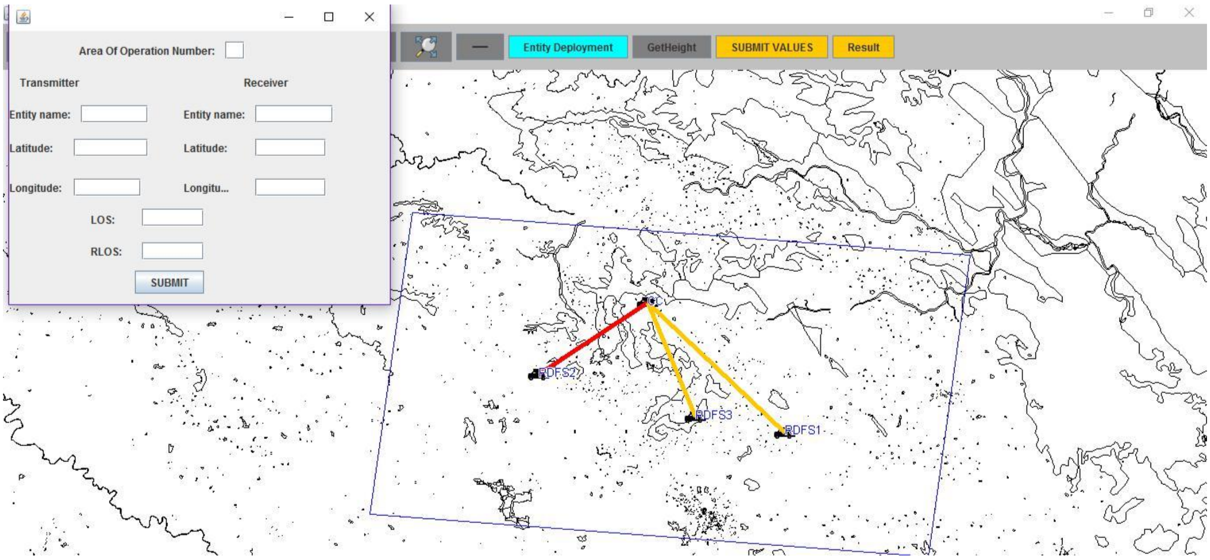


Fig 7.1.22. Entering analysis details

When user clicks on Result button Results stored in text file displayed as shown in fig 7.1.23.

Shape file name: natural.shp

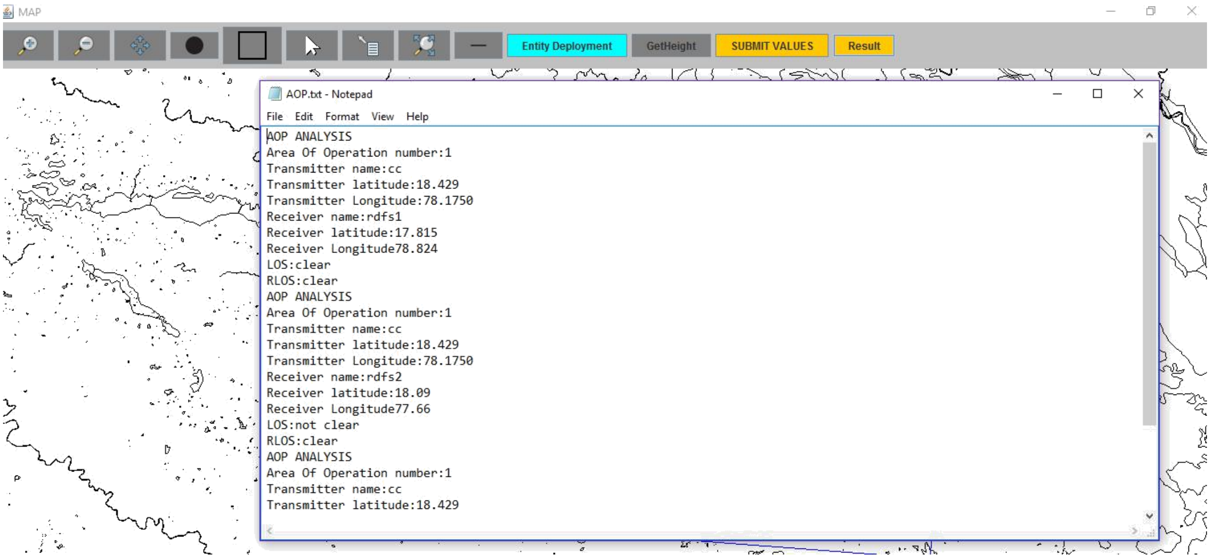


Fig 7.1.23. Displayed text file

7.2 RESULTS ANALYSIS

For analysing the best area of operation, the latitude and longitude positions are given by user to display a polygon where the operations can be performed. The values given for creating area of operation are shown in table 7.2.1 for **Area of operation 1**, and table 7.2.7 for **Area of operation 2.**

Next, The entities deployment details are observed i.e., the latitude and longitude positions at which the entities are deployed for checking line of sight and radio line of sight are shown in table 7.2.2 for **Area of operation1** and table 7.2.8 for **Area of operation 2**.

All the elevation values are obtained in the path between Transmitter and for each receiver from the link provided. The values obtained are shown in Table no. 7.2.3 between CC and RDFS1, Table no. 7.2.4 between CC and RDFS2, Table no. 7.2.5 between CC and RDFS3 for **Area of operation 1**and Table no. 7.2.9 between CC and RDFS1 , Table no.7.2.10 between CC and RDFS2, Table no.7.2.11 between CC and RDFS3 for **Area of operation 2**.These values are used to compare with target height to determine whether there is line of sight or not.

To check whether there is Radio Line of Sight the values calculated like distance between Transmitter (CC) and Receiver as shown in Table no. 7.2.6 for **Area**

of operation 1 and Table no. 7.2.12 for **Area of operation 2** .These values are used to calculate path loss. This is deducted from Emitter Radiated Power of transmitter using algorithm and finally signal strength at receiver is obtained as shown in Table no. 7.2.6 for **Area of operation 1** and Table no. 7.2.12 for **Area of operation 2**. It is compared with sensitivity of receiver and finally decision made whether there is Radio Line of Sight or not. The status of each receiver indicating whether there is LOS or RLOS or Both between Transmitter (CC) and Receiver is shown in Table no. 7.2.6 for **Area of Operation 1** and Table no.7.2.12 for **Area of operation 2**.

Area of operation 1:

Points used to create	**Latitude (decimals)**	**Longitude(decimals)**
Top Left	17.23	79.5
Bottom right	18.86	77.059

Table no 7.2.1. Area of operation1

Entity deployment details:

Entity name	**Latitude(decimals)**	**Longitude(decimals)**
CC	18.429	78.1750
RDFS1	17.815	78.824
RDFS2	18.09	77.66
RDFS3	17.89	78.4

Table no 7.2.2 Entity deployment details

Elevation values obtained for checking LoS in path between CC and RDFS1

Target Height: 565.7m

S.No	**Elevation value(m)**
1.	507
2.	529
3.	532.3
4.	530
5.	523.8

Table no 7.2.3 Elevation values observed in the path b/w CC and RDFS1

Elevation values obtained for checking LoS in path between CC and RDFS2

Target Height: 518m

S.No	Elevation values(m)
1.	391.5
2.	525
3.	447.3
4.	455
5.	423

Table no 7.2.4 Elevation values observed in the path b/w CC and RDFS2

Elevation values obtained for checking LoS in path between CC and RDFS3

Target Height: 497.6m

S.No	Elevation values(m)
1.	559
2.	565.7
3.	493
4.	583.5
5.	451.1

Table no 7.2.5 Elevation values observed in the path b/w CC and RDFS3

LoS/RLoS Status

Entity name	Distance to CC(m)	Signal Strength at receiver	Sensitivity	Status
RDFS1	96774.21	-240.84	-500	LoS , RLoS
RDFS2	66168.7	-233.23	-35	-
RDFS3	64476.58	-232.7	-500	RLoS

Table no 7.2.6 Los and RLoS status

Area of Operation : 2

Points used to create	**Latitude (decimals)**	**Longitude(decimals)**
Top Left	18.70	74.338
Bottom right	17.059	76.27

Table no 7.2.7 Area of operation 2

Entity deployment details

Entity name	**Latitude(decimals)**	**Longitude(decimals)**
CC	17.72	75.7
RDFS1	18.38	74.9
RDFS2	17.4	75.1
RDFS3	17.89	74.72

Table no 7.2.8 Entity deployment details

Elevation values obtained for checking LoS in path between CC RDFS1

Target Height: 580 m

S.No	**Elevation value(m)**
1.	527
2.	498
3.	493
4.	524
5.	536

Table no 7.2.9 Elevation values observed in the path b/w CC and RDFS1

Elevation values obtained for checking LoS in path between CC and RDFS2

Target Height: 515 m

S.No	Elevation values(m)
1.	480
2.	452
3.	478
4.	448
5.	486

Table no 7.2.10 Elevation values observed in the path b/w CC and RDFS2

Elevation values obtained for checking LoS in path between CC and RDFS3

Target Height: 579 m

S.No	Elevation values(m)
1.	481
2.	528
3.	510
4.	466
5.	464

Table no 7.2.11 Elevation values observed in the path b/w CC and RDFS3

LoS/RLoS Status

Entity name	Distance to CC(m)	Signal Strength at receiver	Sensitivity	Status
RDFS1	111978.72	-243.76	-500	LoS , RLoS
RDFS2	72883.96	-235.17	-35	LoS,RLoS
RDFS3	10549.42	-242.56	-500	RLoS

Table no 7.2.12 LoS and RLoS status

Comparison between Area Of Operation 1 and Area Of Operation 2:

Finally, comparison done between **Area of operation 1** and **Area of operation 2** shown in table 7.2.13.

Entity name	**Area of Operation 1 status**	**Area of Operation 2 status**
RDFS1	LoS, RLoS	LoS,RLoS
RDFS2	-	LoS,RLoS
RDFS3	RLoS	RLoS

Table no7.2.13 Comparison b/w AOP 1 and AOP 2

Therefore, from table 7.2.13 we can observe that **Area of operation 2** is showing better performance than **Area of operation 1**.

CONCLUSION AND FUTURE SCOPE

Planning is essential before deploying the ESM system directly. Doing it manually needs lots of people and effort and is expensive. Therefore, analysis on map based on latitude and longitude positions in a software provided with features to perform analysis can reduce the effort and cost.

After analysis for optimal area of operation is done the ESM systems can be deployed in the particular area after considering environmental conditions and also ensuring ESM receivers able to receive the signals. From the signals received by ESM systems detection and analysis for enemy radars is done. The analysis done is used for taking counter measures against the enemy radars.

The analysis done in the project can be extrapolated to Google Earth Maps containing advanced features.

REFERENCES

[1] Popular Science and Technology series, titled “Electronic Warfare”, published in 1988 by DESIDOC.

[2] https://www.freemaptools.com/elevation-finder.htm

[3] www.geotools.org

[4] https://sourceforge.net/projects/geotools/

[5] www.javatpoint.com/java-swing

[6] www.tutorialspoint.com/swing/

[7] https://www.gislounge.com/line-of-sight-in-gis/

[8] www.movable-type.co.uk/scripts/latlong.html

[9] http://www.radartutorial.eu/16.eccm/ja06.en.html

[10] http://www.programcreek.com/java-api-examples