Repeater Locations

SAR responders in both wilderness and urban settings often times rely on installed or ad hoc radio systems as their means of communication. These radio systems are typically composed of a base station radio, radio repeater (optional), antenna/tower and hand-held radio units. This system provides a vital link between management and responders that helps to ensure responder safety and communication. However, while terrain is not the only influential element impacting the performance of any radio system, it does play a major role. As shown in Figure 1, radio waves for the frequency of interest in most conventional handheld radio systems are transmitted by various mechanisms. Computational models have been developed that can emulate the behavior of radio wave transmissions and can be used to provide an estimate of coverage from a given systems based on a series of parameters. While a thorough description of these models is beyond the scope of this document, additional information is available from the US Department of Commerce – Institute of Telecommunications Sciences (http://www.its.bldrdoc.gov/).

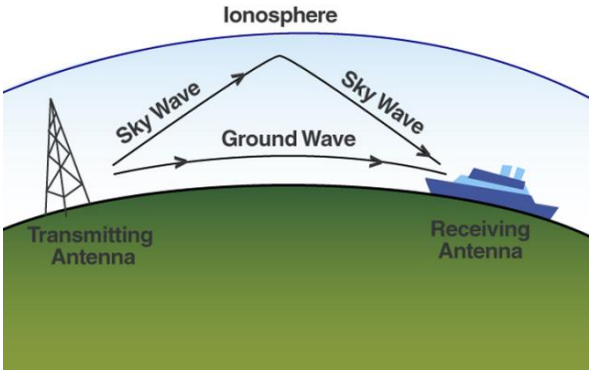


Figure 1: Radio Wave transmission mechanisms.

At the frequencies of interest, the Viewshed Analysis and Observer Points tool within ArcGIS can be used to provide a rough estimate of transmission area coverage. For example, Figure 2 shows the estimated coverage for a radio system based on a 15 meter (above ground level - AGL) antenna on the transmit side and a 2 meter (AGL) antenna on a receive side. Areas shown in "Green" are estimated to have "line –of-sight" coverage while areas in "Pink" do not based on bare Earth terrain. It should be noted that these tools only consider "line-of-side" and do not account for transmission power and antenna attenuation or gain. They can however be made to account for Earth curvature which Ground Waves are known to follow as depicted in Figure 1.

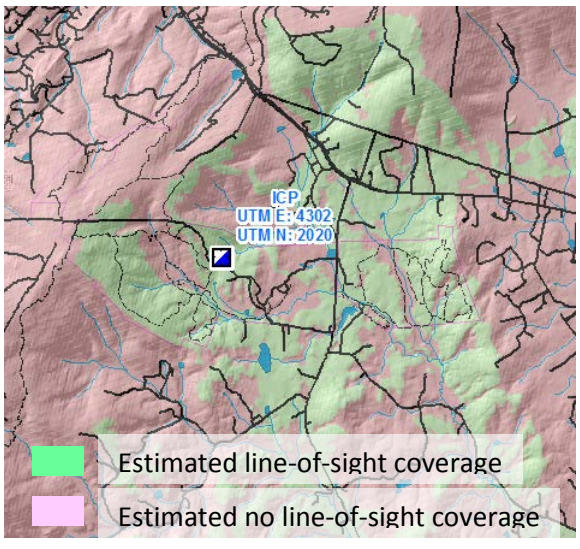


Figure 2: Estimate of Radio Coverage from a central base station.

These tools are available in the Spatial Analysis Toolbox and have been adapted for use in the "Repeater Locations" tool within the SAR_Toolx10b of the IGT4SAR map template. The general purpose of the "Repeater Locations" within IGT4SAR is to provide an estimate of the optimal locations to place a radio repeater and transmission station within a designated area. This designated area could be, for example, the search area although the computed optimal

locations may be outside of the designated area. The optimal locations for a transmission tower would be ones that provide radio coverage over the largest amount of area within the designated region (polygon). One approach to computing these locations would be to conduct Viewshed analyses at multiple locations through the designated area in hopes of finding a good location. This however, could result in a fairly length and time-consuming analysis. An alternative strategy would be to consider "Observer Points" throughout the designated area that are visible from every location within the desired area. These "Observer Points" would be akin to a search team in the field attempting radio contact. By considering multiple Observer Points distributed throughout the desired area, regions that have the most overlap is visibility from individual Observer Points could be identified. Comparing overlapping visibility from locations to the Observer Points would result in identifying locations that provide the best line-of-sight coverage.

The Repeater Locations tool resides in the SAR_Toolbox10b toolbox of IGT4SAR in the Logistics subset. Initiating this tool opens the dialog box shown in Figure 3. The user begins by selecting the Regional

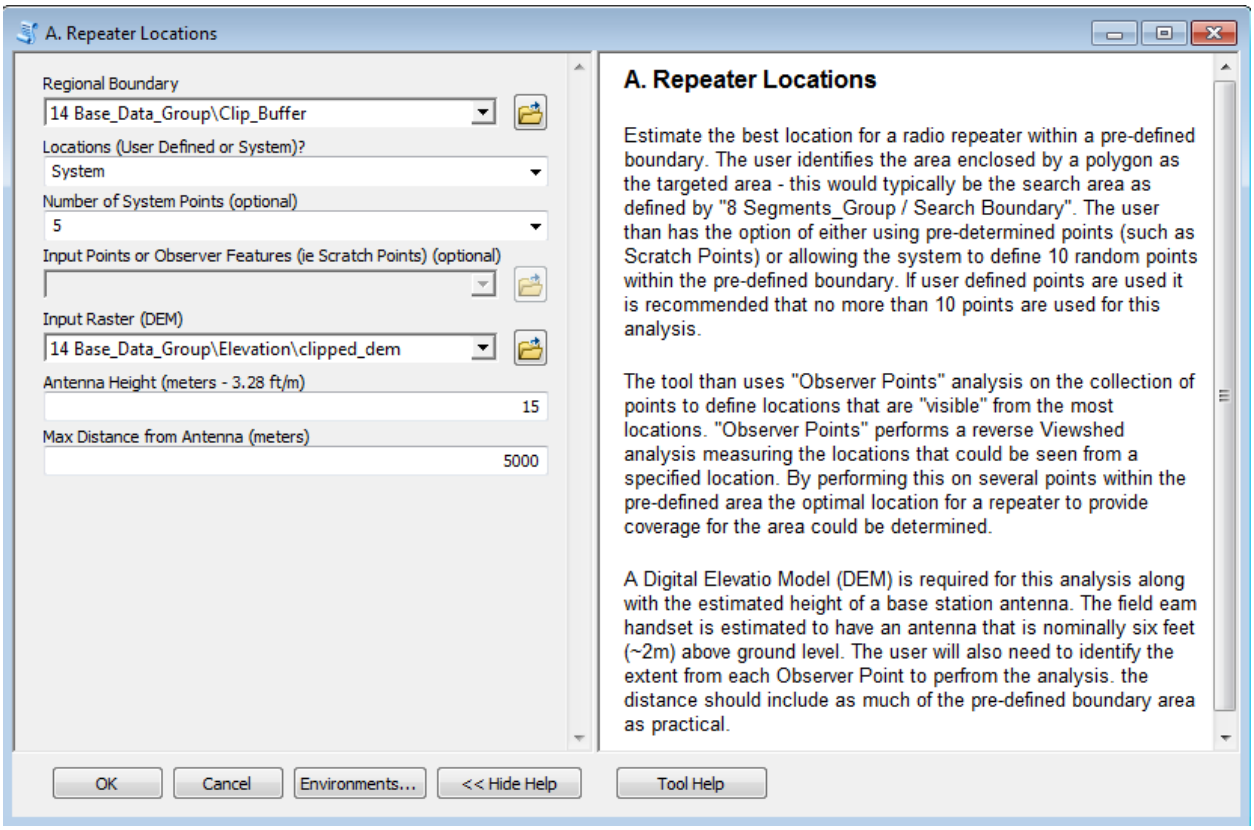


Figure 3: Repeater Locations tool dialog box in IGT4SAR

Boundary that defines their area of interest. This could be the extent of the Search Area (8 Segments_Group / Search Boundary) or any designated area defined by a polygon. As shown in Figure 3, a generic circular polygon that contains the search area is selected. However, it should be noted that

a closer approximation of my desired search area would provide a more accurate assessment for my ultimate area of interest (i.e. the search area).

Next the user must decide to use their own “Observer Locations” (User Defined) or to allow the system to generate either 5 or 10 random locations within the Regional Boundary. Randomly generated points have a minimum spacing of 250 meters and their use eliminated the need for the user to create temporary locations. However, if the user is interested in studying a particular area within the Regional Boundary than these could designate their own locations using any of the existing point feature classes or generated a new one. The user could even use a combination of both randomly generated points and user defined locations by running the tool multiple times.

If the user elects to use “User Defined” locations they will then need to select the desired Input Points / Observer Points which is greyed if Systems points are selected.

A raster representing elevation (i.e. Digital Elevation Model) is required for the execution of this tool. And finally the users specifies the desired Antenna Height and range (Max Distance from Antenna). Although indicated as “meters” in the tool dialog box, the units should match those of the Elevation Raster. Messages appear in the dialog box indicating the progress, Figure 4.

The following provides a general description of the process followed by the Repeater Locations tool. The tool works be first either identifying the point features used to desired to represent the Observer locations (such as the Scratch Points) or generating a series of 5 or 10 randomly placed points in the designated Regional Boundary

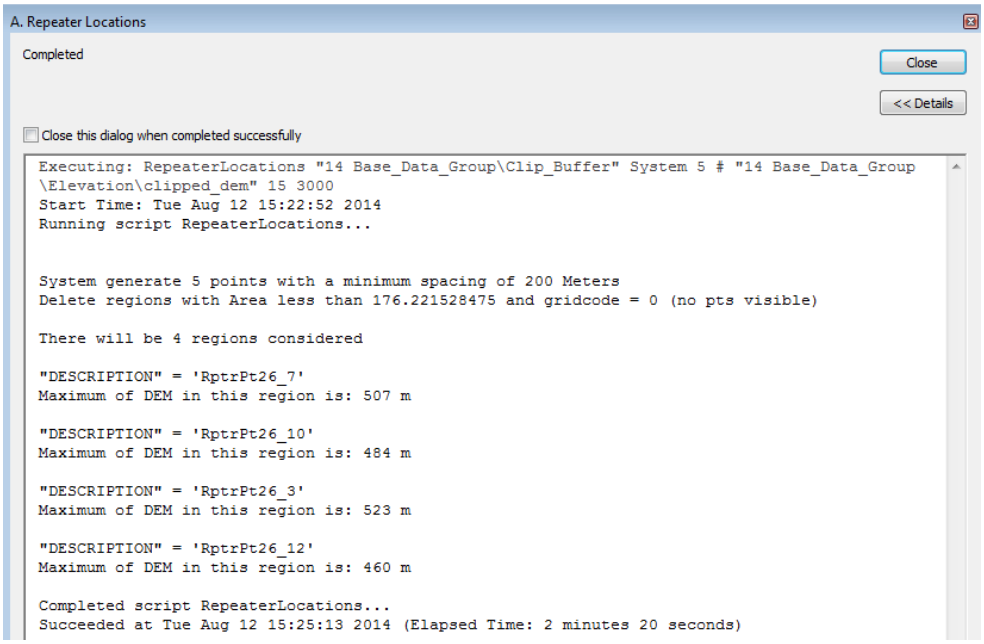


Figure 4: Repeater Locations tool dialog box

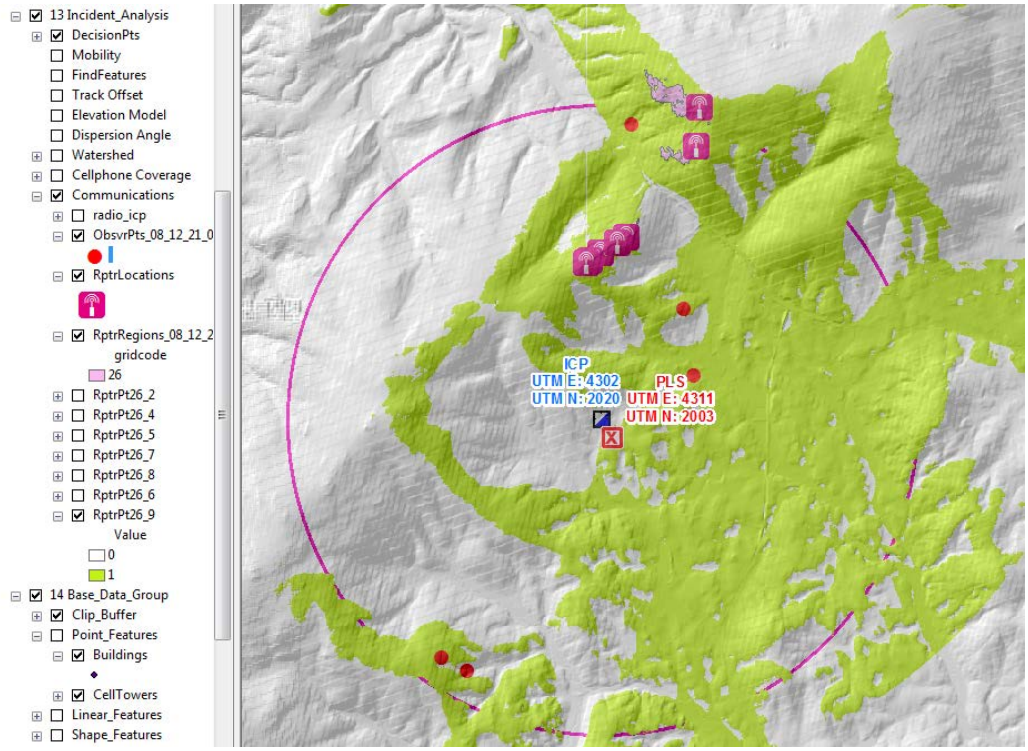
(i.e. Search Boundary). Next the tool performs an Observer Points analysis on the collection of points defining locations both inside and outside of the Regional Boundary that can be “seen” from the

Observer Locations. Regional locations are scored based on the number of Observer locations that they can "see" (the analysis is based on line of sight but actual vegetation and above ground obstacles such as buildings may impair the actual ability to see from one point to the next). The more Observer points that can be seen from a location, the higher the score is given to a region. The ultimate result is a Polygon region with a field titled "gridcode" that has the final score. A comparison of the scores results in the top seven areas being identified.

Each of the top seven polygons is probed to determine the peak elevation and a point is placed at that location which is used for further analysis. It should be noted that although the peak elevation is identified the entire area of a single polygon will have the same score. So placing a repeater at any location within the identified area should result in the same performance. The entire polygon is retained as output and can be used to determine the optimal location for a broadcast antenna considering the access (roads, trails, etc) to the area. From each of these top scoring points a Viewshed Analysis is performed to provide a graphical representation of the expected coverage from each location.

As previously noted, the user may elect to run this tool multiple times choosing System generated and User Defined locations in order to ensure proper coverage for an area. If a Repeater Locations point feature exists from a previous run, the new points will be appended thus retaining the previous results.

The final output from the tool includes point features for the Observer Locations (if System generated) and the optimal Repeater Locations, a Polygon Feature of the Repeater Areas with the "gridcode" field indicating the "score" of each polygon, and finally a raster for each Repeater Location representing the estimated coverage area from each Repeater Location, Figure 5.



In Figure 5 each of the top scoring Repeater Locations is shown in the RptrLocations Layer along with the random points generated by the system as Observer locations (Red dots) and the Regional Boundary (fuchsia colored circle). Only the raster for one of the highest scoring Repeater Locations is shown in green as multiple locations received the same score. The polygon shown in pink represents the Repeater regions in which the entire region had the same score as the point identified as the Repeater Locations. Combining these data layers with basemap features such as roads and trails provides the user with a decision support system for locating a transmission tower.

As previously stated, this tool incorporates a fairly simplistic line-of-sight analysis for radio wave propagation. It is estimated that an actual well designed radio transmission system would have greater coverage than estimated. Thus the estimates provided by this tool should be considered a worst case scenario as systems should at least cover these areas identified.