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Methodology for Augmenting Existing Paths with Additional Parallel Transects

Visual Sample Plan

September 2013

JE Wilson

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Visual Sample Plan (VSP) is sample planning software that is used, among other purposes, to plan transect sampling paths to detect areas that were potentially used for munition training. This module was developed for application on a large site where existing roads and trails were to be used as primary sampling paths. Gap areas between these primary paths needed to found and covered with parallel transect paths. These gap areas represent areas on the site that are more than a specified distance from a primary path.

These added parallel paths needed to optionally be connected together into a single path—the shortest path possible. The paths also needed to optionally be attached to existing primary paths, again with the shortest possible path. Finally, the process must be repeatable and predictable so that the same inputs (primary paths, specified distance, and path options) will result in the same set of new paths every time. This methodology was developed to meet those specifications.

Acronyms and Abbreviations

TA	target areas
VSP	Visual Sample Plan

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1.0 Background

Typically, a site being sampled to detect unexploded ordnance target areas (TA) is evaluated by having a sensor pass over the site in a series of parallel transects. Transects are spaced at a distance necessary to traverse and detect a TA of a certain size and shape and containing a minimum density of metallic anomalies spatially distributed in a predictable pattern.

However, some areas are difficult to access with complete coverage of such parallel transects. Additionally, the sites may have existing roads and paths that could be used as survey transects. Therefore, is the spacing and pattern of these existing paths sufficient to provide the necessary coverage to traverse and detect the TA, or are additional transects needed?

A new augmentation method was developed in VSP for these sites. This document describes the process for augmented existing paths with additional parallel transects.

2.0 Methodology

Generally, the spacing needed to traverse and detect a particular TA is computed by VSP, and the parallel transects are placed on the map to cover the site (Figure 1).

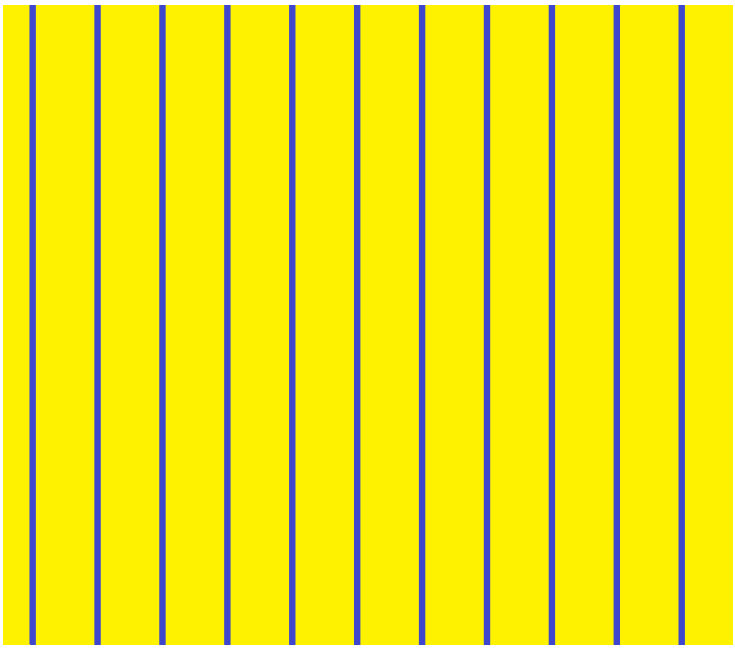

Figure 1. Site Covered by Parallel Transects

If some transects were missing, the area needing additional transects would be represented by the green area in Figure 2.

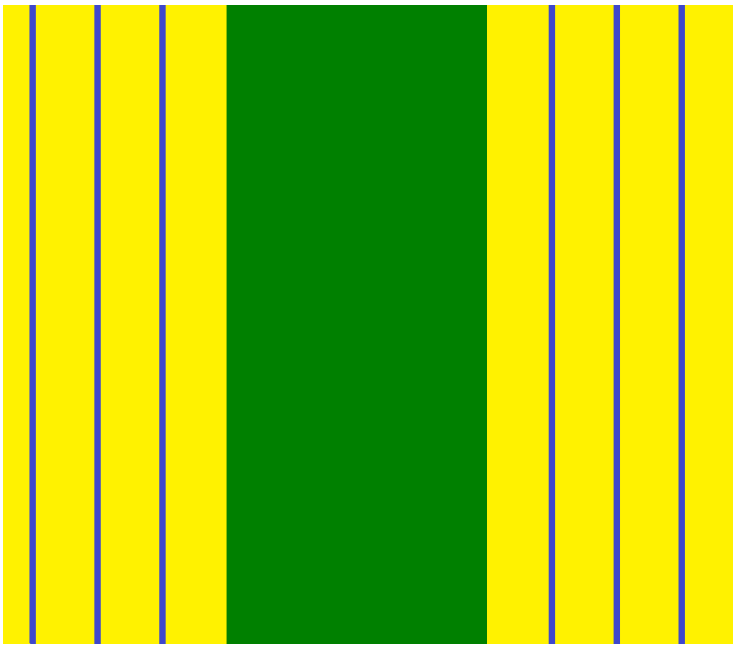

Figure 2. Area that Needs Additional Transects

Missing transects placed into the gap area would be represented by the red lines in Figure 3. Note that these transects need to be placed at the edges of the gap area in order to maintain the maximum allowable spacing needed to traverse and detect the TA.

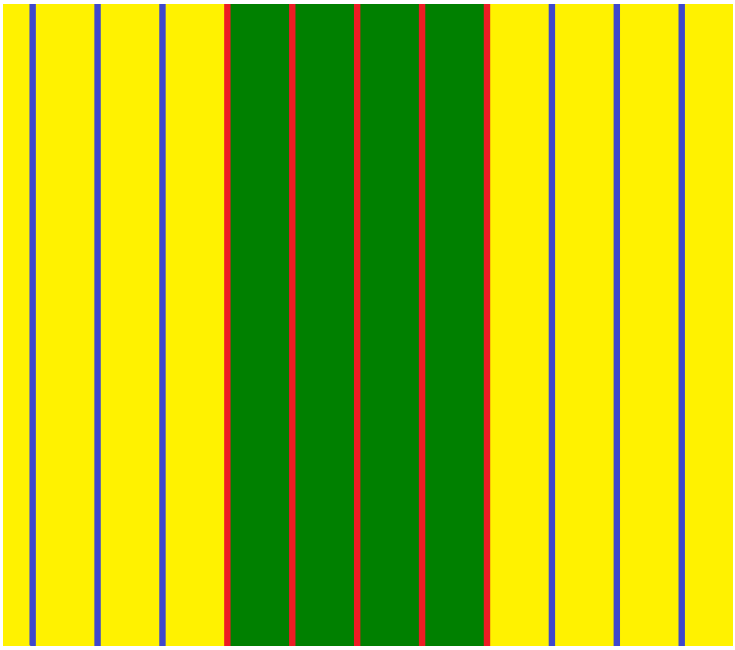

Figure 3. Transects Added Gap Area

For the new method, the general methodology needs to be extended from one dimension into two dimensions. In Figure 4, the existing paths would represent transects (though not straight and parallel), and the green areas would represent the "gap" area where transects are missing. For this example, the gaps are areas that are 1,000 feet or more from an existing path.

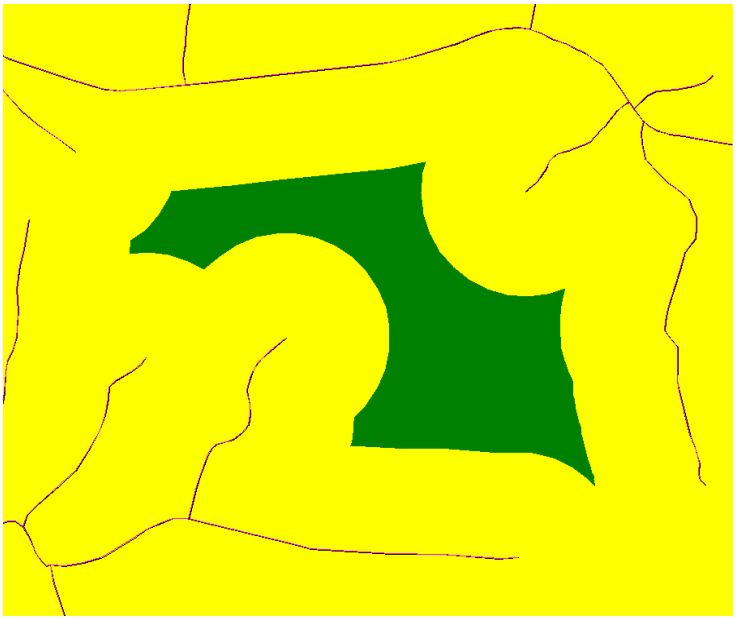

Figure 4. Gap Area that is More Than 1,000 Feet from Existing Paths

How should transects be placed to fill in those gaps? The simplest placement method is to cover the area with parallel transects. In deciding how to orient transects, the first step is to create a bounding rectangle around the gap area. The minimum area bounding rectangle is used to enclose the gap (Figure 5).

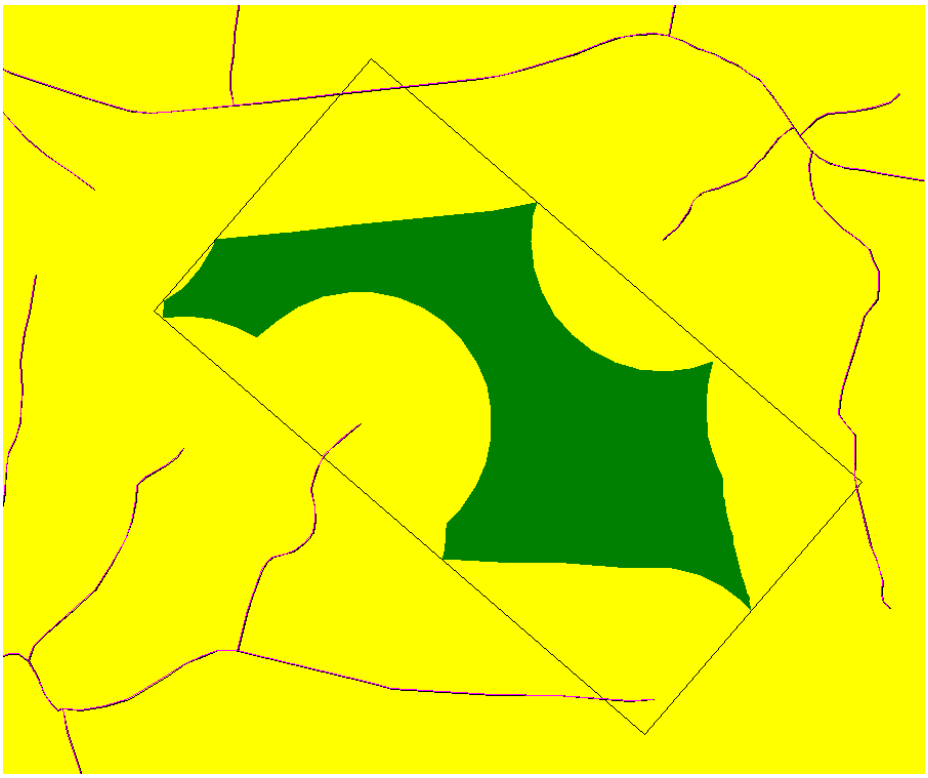

Figure 5. Minimum Area Bounding Rectangle for Gap Area

This bounding rectangle is used as the framework for placing transects. Transects can be aligned parallel to the shorter sides or the longer sides of the rectangle. In deciding which way to orient transects, VSP tries both directions and uses the orientation that has the shortest total path. Parallel transects are placed at each side of the rectangle and then evenly spaced between to make sure that the spacing is no greater than the distance specified by the user (1,000 feet for this example). For the middle transects, the ends are set at the edges of the gap area. The first and last transects may only touch the edge of the gap area at one point, so the edge method will not work there. On the other hand, it would not be good to make transects that are the entire length of the rectangle side as they would often cross existing paths. So, transects are created on the rectangle sides for sections that have a perpendicular distance to the gap that is less than half the transect spacing (500 feet for this example). Figure 6 shows the resulting parallel transects from this method. Note that they have been enhanced to make them more visible.

Figure 6. Parallel Transects Added to Gap Area

If the user chooses to connect transects to each other, VSP finds the minimum length path of connections. This is done by checking all the connections between each transect end. Connections that cross other transects or existing paths are discarded. Connections that are greater than 1.9 times the spacing (1,900 feet in this example) are also discarded. Combinations of all the remaining connections are tried to find the minimum path length. Figure 7 shows the results of the connections.

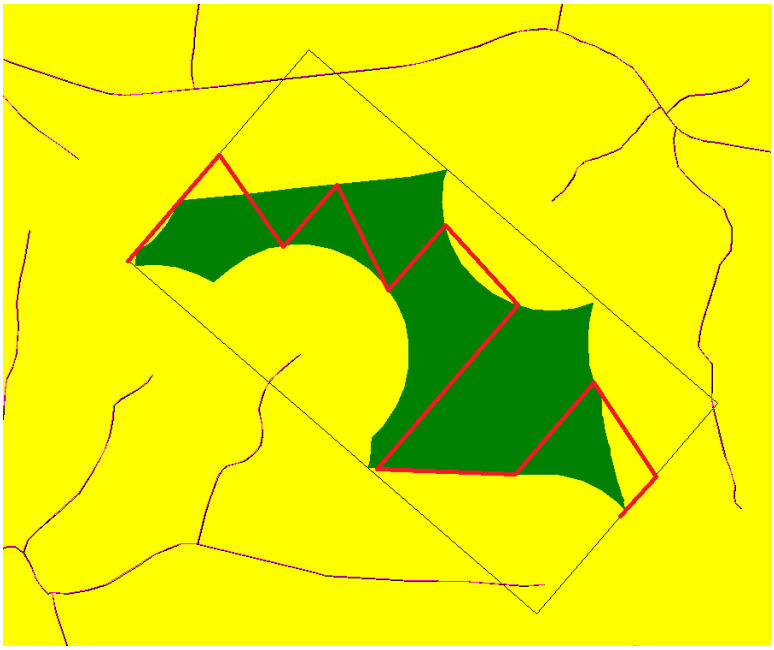

Figure 7. Parallel Transects Connected to Create the Shortest Path

The user may also choose to attach the ends of the transect paths to existing paths. If this is the case, these attachment connections are added to the list of connections in the process described above, so that the minimum total path length is found. Figure 8 shows the result. When attaching to existing paths, the connections between the parallel transects may change in order to make the overall path length shorter.

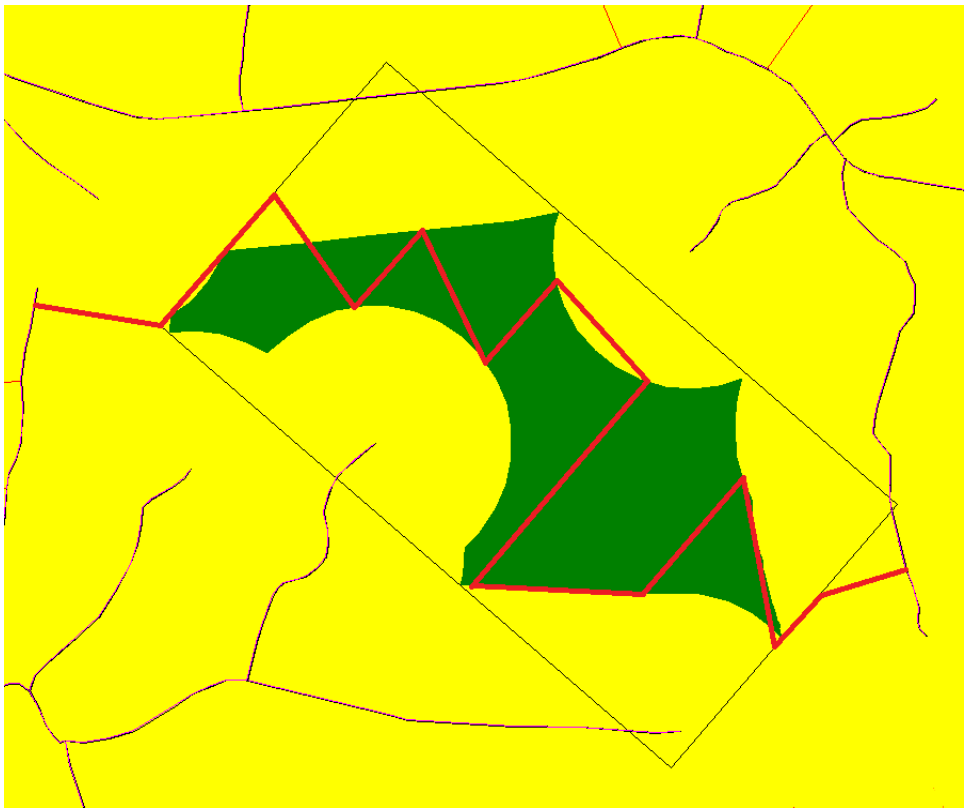

Figure 8. Parallel Transects Connected Together and Attached to Existing Paths

Sometimes, the gap includes or is adjacent to holes or exclusion areas where transects may not be placed. In such cases, additional optional points near the corners of the holes are added to the list of connections. These optional points may be used as needed, but any or all of them may be ignored in the minimum path length computations. Figure 9 shows where four such points (indicated by blue arrows) are used to navigate around the holes (white areas).

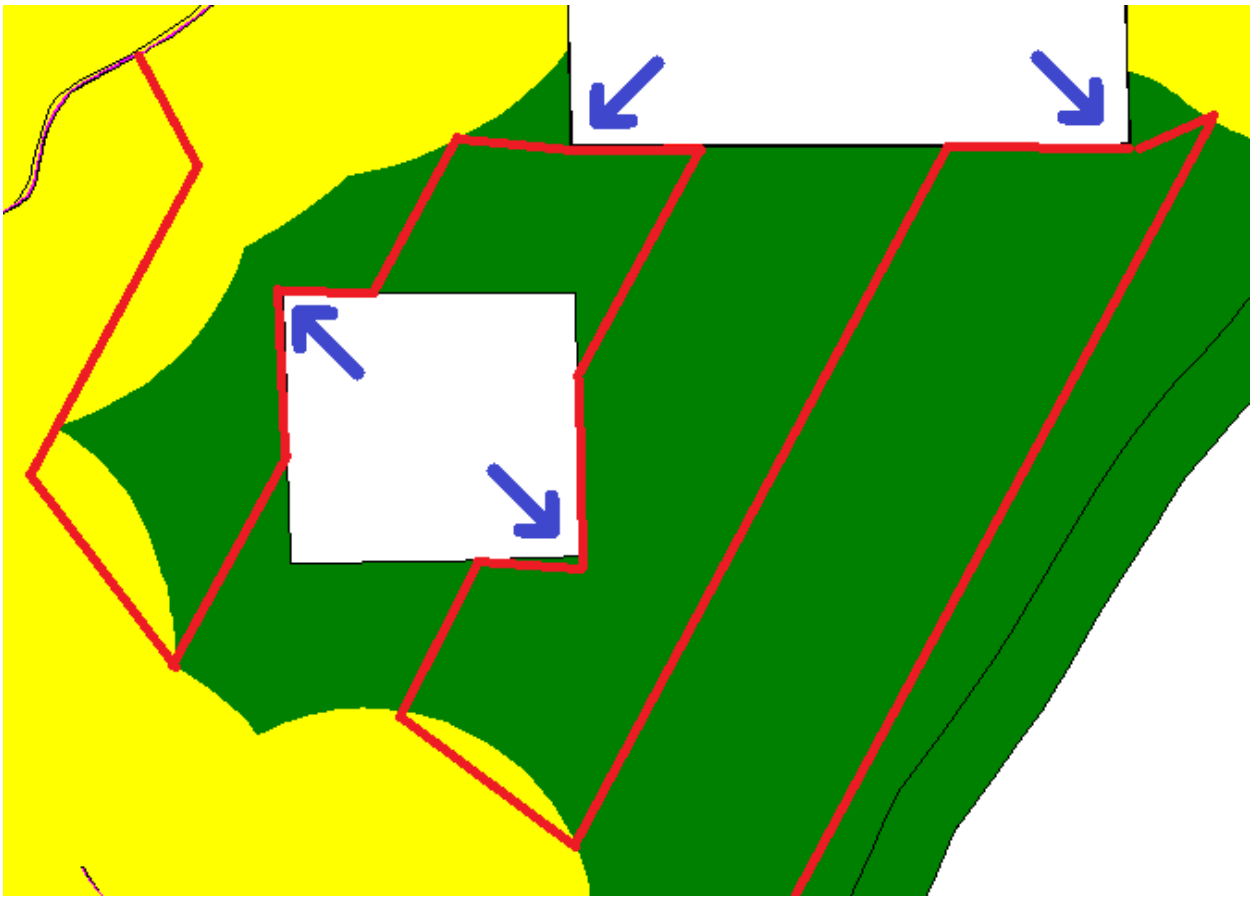

Figure 9. Locations of Additional Points Needed to Navigate Path Around Exclusion Areas

3.0 Conclusions

This methodology adds transects to gap areas between existing paths and trails in a predictable and repeatable fashion. Unless the number of parallel transects is quite large, the connected path should be the shortest path possible. VSP dynamically ceases to optimize the path length when the number of combinations becomes computationally infeasible. In such cases, the difference between the resulting path length and the theoretical shortest path length (if it could be found) should be inconsequential in comparison to the overall scale of the problem.

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