

A Geodatabase Design and Maintenance using ArcSDE for Oracle A Real Property Geodatabase Model

Yingjie Wang and Amir Razavi

Abstract

The Real Property Geodatabase Model (RPGM) is developed by the Office of Chief Technology Officer (OCTO) to support the daily work processes for the agencies in the District of Columbia. RPGM organizes the projects created from customer submissions into the project workspaces that are the physical separations of layers from the production database.

RPGM ensures data integrity through a custom GIS application developed as the RPGM Extension of ArcGIS 9. The RPGM Extension is flexible and scalable and constructed in a multi-tiered Client/Server architecture. The maintenance activities also include the processes by which the database is versioned, edited, reviewed, approved, and posted. The application supports versioning and multi-users through the ArcSDE and Oracle database. This presentation describes the design, methodology, and lessons learned in developing the GIS application for maintaining the Real Property Geodatabase.

Key Words: Geodatabase, ArcSDE, Real Property, ArcObjects, ArcGIS.

1. Introduction

1.1 Background and Scope

The Real Property Geodatabase Model (RPGM) includes a geodatabase, i.e., the Real Property Geodatabase (RPG), and the RPGM Extension of ArcGIS 9 that provides all the tools necessary to manage the geodatabase. RPG is designed and constructed on the platform of ArcSDE and Oracle. The RPGM Extension maintains several layers and tables, such as Tax Lots feature class, Record Lots feature class, Air Rights Lots feature class, All Lots table, Lot Tree table, and Project Tracking table. Maintenance edits can be uploaded from its project workspace to an edit version that is automatically generated for reconciliation and posting to the geodatabase. The Quality Control processes are conducted on the edit version to ensure that the edits are topologically correct, accurate, and meet the project requirements

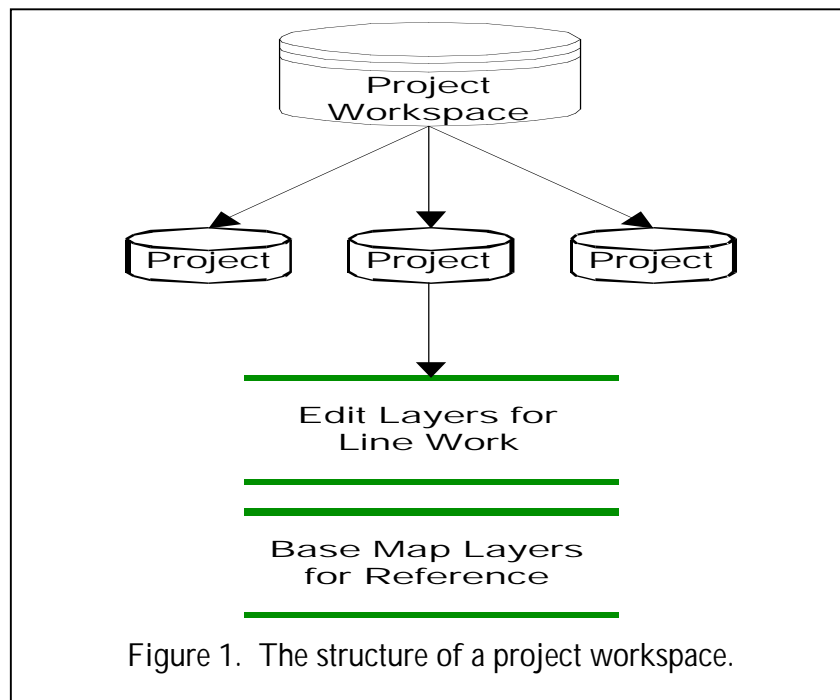
The RPGM Extension is constructed in a multi-tiered Client/Server architecture using ArcObjects and Component Object Model (COM) technology. The maintenance activities were identified and turned into the client and server components. The client components include a graphical user interface that facilitates the communication between users and the server processes as well as the database. The server processes accept the users' requests and provide maintenance services for users. Editing tasks are conducted based on projects in project workspaces. A user needs to customize his/her project and project workspace. Then the related squares are used to

copy all the features contained from the database into the base layers of the customized project and project workspace. The features to be edited and adjacent features are copied again from the base layers into the edit layers. Users only edit the features in the edit layers and use the base layers for reference.

1.2 Definitions of the Terms

Project Workspace

A project workspace is the physical separation of layers that store information and shapes that may be applied to change the geodatabase. The layers are stored in the production geodatabase but under a different dataset. A project under a project workspace is a collection of layers created from a customer submission. Figure 1 shows the structure of a project workspace.



Base Layers

A project within the project workspace consists of the following layers that structurally are the same as the production layers, but contain only a subset of data needed for the maintenance work. The purpose of base layers is to provide the base map that can be used as reference for creating the line work in edit layers. For example, Squares, current Record Lots, current Tax Lots, Building Restrictions, Reservations, and Highway Plan are referred as base layers. User has the option of loading other map layers from external sources such as aerial photography if needed.

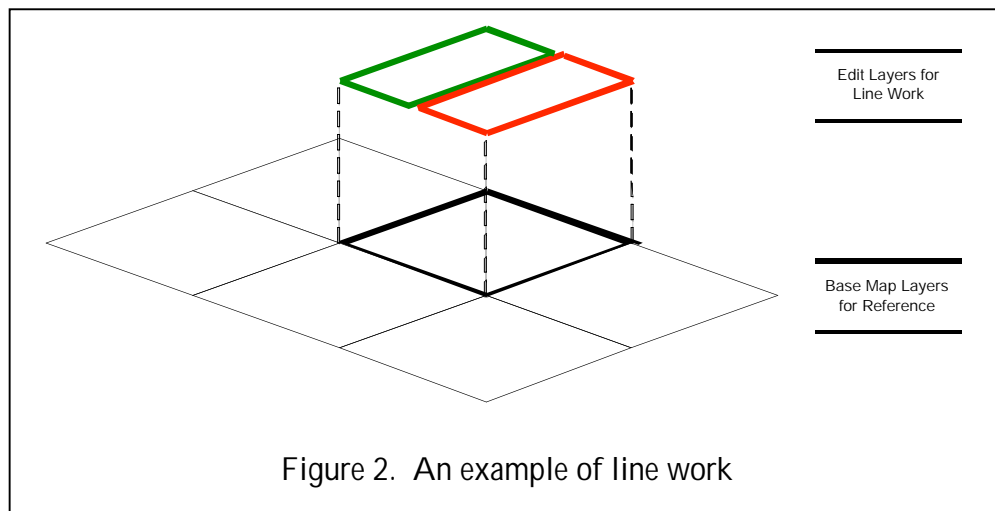
Edit Layers

A project within the project workspace also has the layers for any new line work that will be applied to the geodatabase. In other words, the subdivision edit work, such as

geometric edits and attribute edits, will be conducted in edit layers. These edit layers are structurally the same as their corresponding production layers and referred to as edit layers. For the current version of RPGM, the edit layers include Record Lots, Tax Lots, and Air Rights Lots. The maintenance application searches the edit layers for the line work that is used to modify the geodatabase.

Line Work

Line Work refers to any new line segments added to the edit layers so that they can be created as new features in the production geodatabase. All new line segments are placed in the edit layers of a project. Property boundary lines may overlap but are not shared between lots. An example of line work is shown in Figure 2. In this example a single lot is split into two lots (shown in red and green). As shown in the figure, each new lot has its own lines that form its boundary.



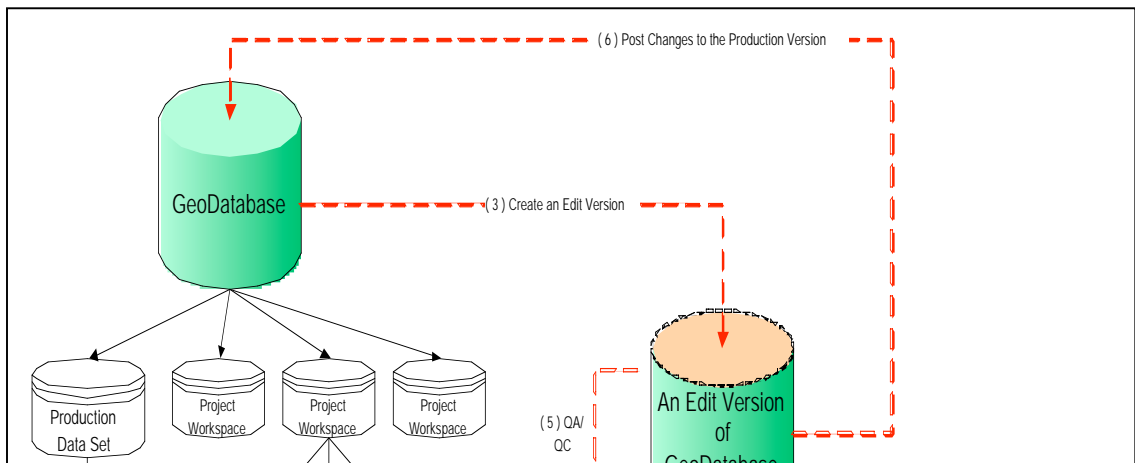
Property Table

Each project also has a set of properties that will be stored in the Project Property Table, which includes Project Workspace, Project ID, Project Name, Edit Action, Customer Name, User Name, Date Created, Date Approved, Date QCed, Date Uploaded, Fee Paid, Date Paid, Affected SSL(s), and Comments. The Edit Action property indicates the desired change, for instance, an editing action can be splitting a record lot or combining two tax lots.

2. Methodology

RPG is generally maintained in two stages. In the first stage, A user needs to create a project workspace and at least one project in the project workspace before doing the actual database maintenance work. The line work depicting the changes are prepared and a plat is produced so that the customer can obtain the required approvals. The second

stage is applying the line work to the geodatabase. The tools and commands packaged in RPGM Extension are specifically designed to conduct the work in each maintenance stage. Figure 3 shows the work flow of the real property geodatabase maintenance.



2.1 Creating Line Work

The tools are built for users to create project workspaces, projects, duplicate the structures of linear feature classes in the production geodatabase, and edit feature geometry and attribute. One project, containing the feature classes copied from the production database, is produced for one job. The job number on the receipt, for instance, can be used for the project ID. Project layers are named based on the Project ID. Initially when a new project is created, the feature classes in that project contain no features. The features involved in a specific editing task are copied from the production geodatabase into the feature classes during an edit session. The squares that contain the related features are used as a container to copy the features. The geometry and attribute editing activities are conducted within the project workspace. A Project Property table is globally maintained to enable users to track the progress of a project. The line work with the edits can be labeled and printed out for approvals by the related government agencies.

2.2 Uploading Changes

2.2.1 Uploading Process

In geodatabases, a version is an alternative representation of the database, which is not affected by changes occurring in other versions of the database. The Upload command is completely an automatic process that uses versioning and lets users to move a copy of their line work from the active edit layers into an edit version of the geodatabase. The name of the edit version, which is created during run time of the uploading process, is identical with the active project ID. The uploading edit layers are automatically identified using the active project workspace and the active project that must be selected before uploading.

The edit version of the geodatabase is where the final edits are made prior to posting to the production geodatabase. The feature classes, attribute tables, and history feature classes in the edit version are updated during an uploading session based on the line work in the project workspace and the project specifications.

The Quality Control (QC) processes are required to be conducted on the edit version to ensure it meets the product requirements and specifications in terms of topology, geometry, and attribution. Once the edit version passes the QC processes, it can be posted to the production database.

2.2.2 Uploading Activities

- Create an edit version from the default version of the geodatabase.
- Upload the linear features produced from the line work in the active project workspace to the associated linear data layer of the edit version.
- Populate the attributes of the lines, such as GIS_ID, CREATION_DT, and RECORDATION_DT.
- Build polygons (lots) based on the line work and verify their validations.

- Insert the Polygons (lots) into the associated polygon data layer of the edit version.
- Populate the attributes of the polygons (lots), such as GIS_ID, areas of lots, CREATION_DT, and RECORDATION_DT.
- Compute the center points of the polygons (lots) and insert them into the point data layer of the edit version.
- Populate the attributes of the points such as GIS_ID, CREATION_DT, and RECORDATION_DT.
- Move the old (affected) lines from the linear data layer to historic linear data layer of the edit version.
- Move the old (affected) polygons (lots) from the polygon data layer to historic polygon data layer of the edit version.
- Delete the old (affected) center points from the point data layer of the edit version.
- Add the new polygons (lots) into the AllLots table.
- Assign the GIS_ID values of the polygons (lots) in the polygon data layer to the LOT_ID in the AllLots table and carry over the values of CREATION_DT.
- Search the old (affected) polygons (lots) in the AllLots table and invalidate them and set the expiration date.
- Update the LotTree table with the attributes of PARENT_LOT_ID, CHILD_LOT_ID, and CREATION_DT. PARENT_LOT_ID is the GIS_ID of old (affected) lots. CHILD_LOT_ID is the GIS_ID of the new lots. Parent lots and child lots are many-to-many relationship.
- The DATEUPLOADED field in the Project Property Table is assigned with the current uploading system date to flag the project that is uploaded.

2.2.3 Reconciling and Posting

Reconciliation must be done before posting changes from the edit version to the default version of the database. Reconciliation is the process of merging features and objects from a target version into the current edit version. A target version can be any version in the direct ancestry of the version being edited. In this case the target version is the default version. After reconciliation, you can post a version to the default version. The posting operation synchronizes the row state of the edit version with the default version. The changes or edits you made are reflected in the production database and are visible to other authorized users.

3. Implementation

The RPGM Extension comprises the component objects that are implemented in *ESRI ArcMap of ArcGIS 9.0 with ArcEditor or above license*. The application is designed to support multi-users and versioning through ArcSDE and Oracle database. The component objects are developed based on the basic requirements of data editing, such as splitting a record lot, combine two tax lots, and lots conversions from one type to another. The application interface includes three toolbars, i.e., Geodatabase Management, Line Edit, and Attributes Edit. Each toolbar contains the various tools and commands a user needs to edit geographic features in the geodatabase and conduct the maintenance tasks.

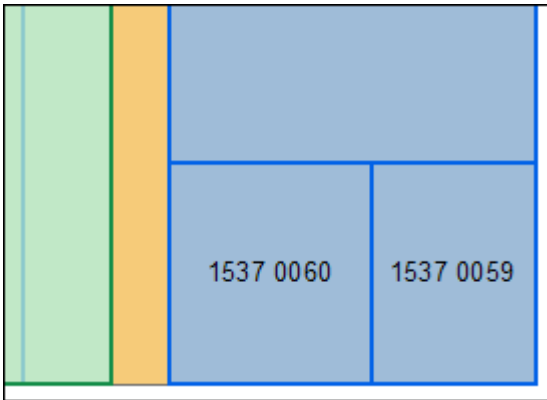
The Geodatabase Management toolbar includes the commands for communications and operations with the geodatabase. These commands can be used to make connection to ArcSDE geodatabase, to create a project workspace, to setup active project and project workspace, to manage projects and modify project properties, to delete the version that is no longer used, and to upload approved edits to the production geodatabase. The new geometries and new attributes being maintained in the project workspace and the Project Property table are the essential data sources for the uploading process.

The Line Edit toolbar has the functionalities to conduct the basic line edits for building or modifying a lot in a linear feature class. This toolbar includes the existing tools, buttons, and menus provided in ArcEditor 9.0 and the tools and commands that were developed and packaged in the RPGM Extension. The customized tools, such as the Copy Square tool lets you copy features from the production geodatabase into the active project under a project workspace, the Zoom To tool lets you zoom to features based on Square Suffix Lot (SSL), the Duplicate tool duplicates selected features, the Line Work QA process is to assist users in checking closure of the line work for a selected project prior to uploading, and the Copy Lot tool lets you copy lot based on SSL between different data layers. The features for a selected SSL can be copied from a base layer to an edit layer using the Copy Lot tool. This activity can be either between different types of lot or same type of lot. In other words, A user can copy a tax lot in the base layer into a record lot feature class in the edit layer, or a record lot in the base layer into a record lot feature class in the edit layer. The Copy Lot tool is provided to assist users in creating a lot based on the existing lot boundaries of same or different lot type. For example, a new record lot can be created based on the geometries of a existing tax lot.

The Attribute Edit toolbar includes the tools for new line attribution, assigning new lot number, projects status query, annotation command, and new lot number registry and un-registry control. The manual line attribution tool is ArcMap built-in tool that a user can use to update the attribute values of features. The auto attribution tool lets you automatically populate the recorded and computed length and bearing angles of a selected feature. The assign lot number tool provides users with the range of numbers that are available for new lots within the square that contains the new lot. The projects query command accesses the Project Property table and query the status of projects based on request from an user.

4. A Case Study - Create a New Tax Lot Covering Two Record Lots

In the southeast corner of square 1537, there are two record lots (0059 and 0060). This example shows you step-by-step how to create a new tax lot covering these two record lots.



Step 1

Start ArcMap. If RPGM Extension toolbars are not displayed, use the View | Toolbars menu to select them. RPGM Extension Toolbars are shown in the following figures.

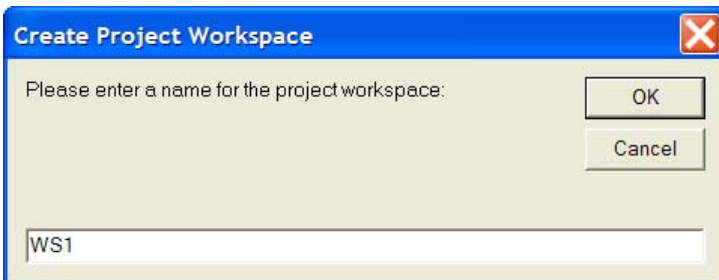


Step 2

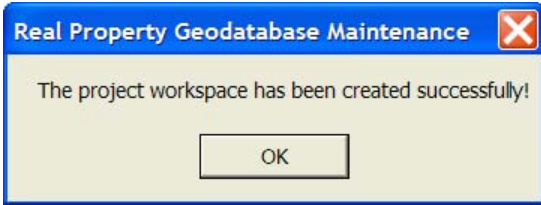
Optionally create a new Project Workspace. You may use an existing Workspace. To create a new one, select the Create Project Workspace tool button from RPGM's Geodatabase Management toolbar as shown in the following figure.



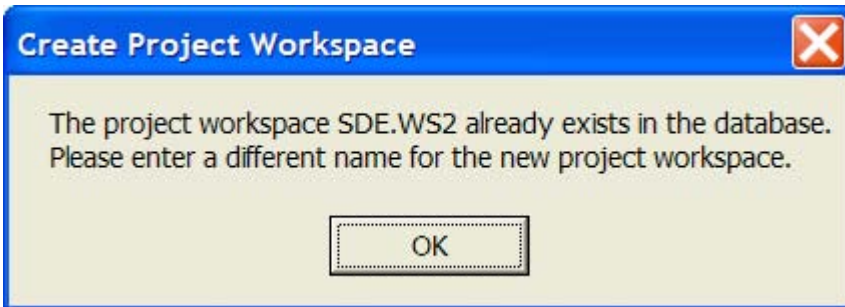
Selecting this button displays the following dialog box. Enter WS1 as the name of the new Workspace and select the OK button.



The following message is displayed when a new Workspace is created successfully.

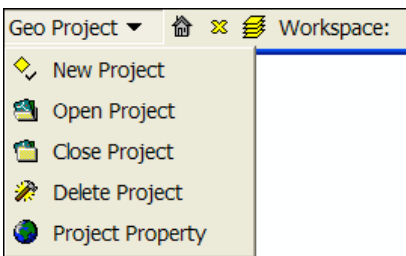


Workspace names must be unique. If you attempt to create a new Workspace that already exists, you see the message in the next figure. In that case, select the OK button and try again with a new name.

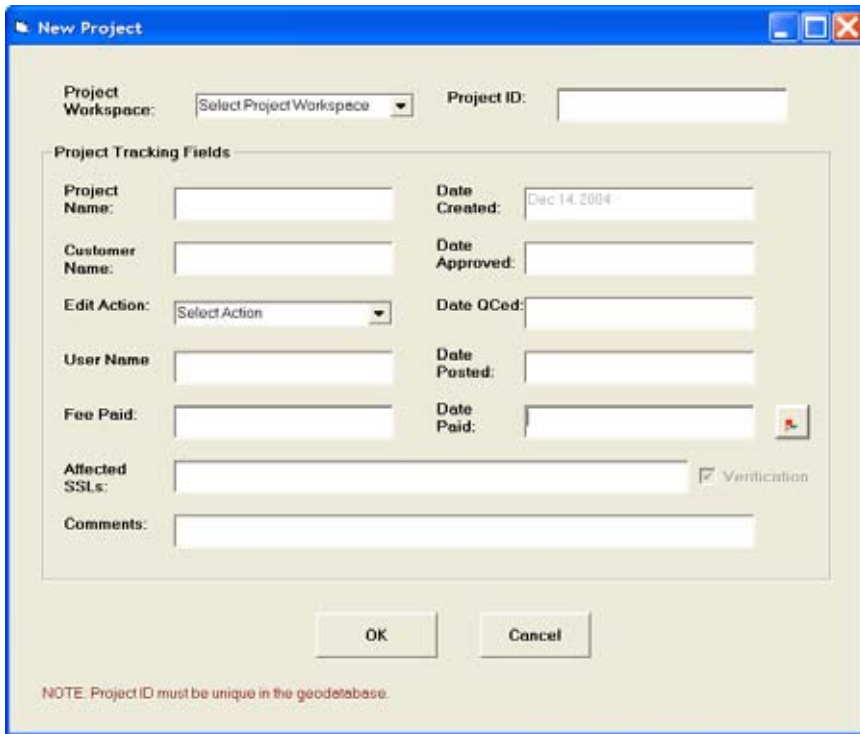


Step 3

Create a new project by selecting the Geo Project tool menu from the RPGM's Geodatabase Management toolbar and then New Project menu item, as shown in the following figure.



The following window opens to accept the basic information regarding your new project.



Enter the following information into this window.

Project Workspace: Select WS1 from the drop down list, or select your workspace if you named it differently.

Project ID: Provide a unique name for the project ID. Although projects are organized into workspaces, the project ID must be unique among all workspaces and users. Enter S15370059 for this example.

Project Name: Smith Properties

Customer Name: Linda Smith

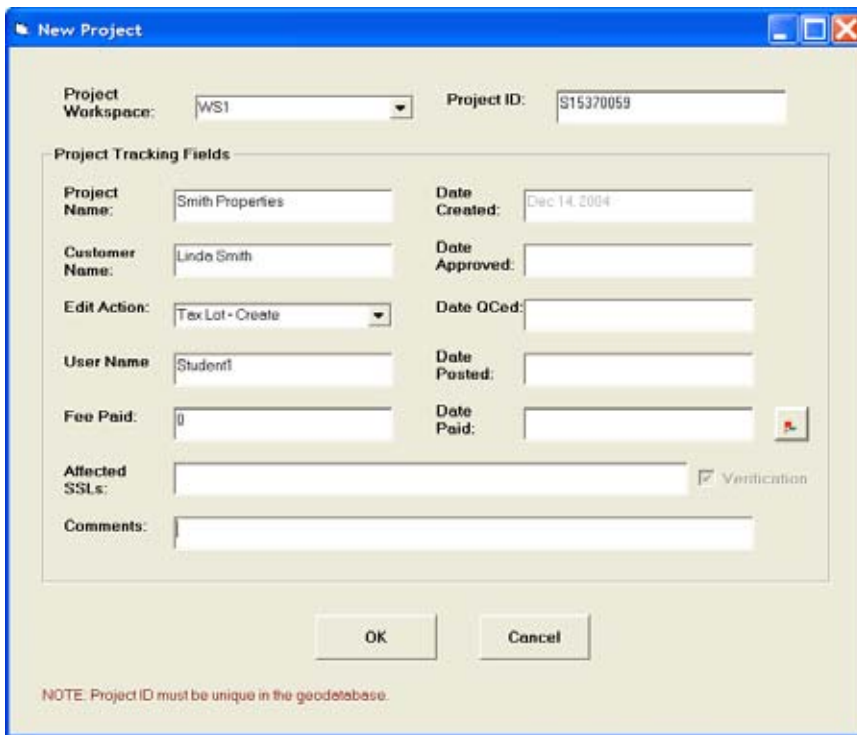
Edit Action: Select "Tax Lot – Create" from the drop down list. The reason for selecting this action is that we are creating new tax lots. If we were combining two existing tax lots the action would have been Tax Lot – Combine.

Username: Enter Student1 or your assigned user ID.

Fee Paid: 0

Affected SSLs: Leave this field blank for this example. The affected SSLs are the lots that are replaced. After the successful operation, the affected SSLs are removed from the active layers and moved to the history. For example if you were combining two tax lots into one, then the two tax lots would have been listed here. However, since we are creating new tax lots without replacing any old tax lots, this field remains blank.

The following figure shows the completed form for the New Project. Select the OK button.



Project Workspace: WS1 Project ID: S15370059

Project Tracking Fields

Project Name:	Smith Properties	Date Created:	Dec 14, 2004
Customer Name:	Linda Smith	Date Approved:	
Edit Action:	Tax Lot - Create	Date QCed:	
User Name:	Student1	Date Posted:	
Fee Paid:	0	Date Paid:	

Affected SSLs: Verification

Comments:

OK Cancel

NOTE: Project ID must be unique in the geodatabase.

If successful, you get the following message after a few seconds. Select the OK button.

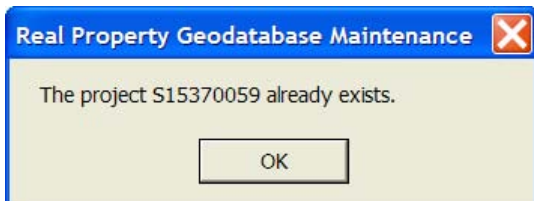


Real Property Geodatabase Maintenance

The project has been created successfully!

OK

If you entered a project ID that already exists, the following message is displayed. In that case, select the OK button, and change the project ID.



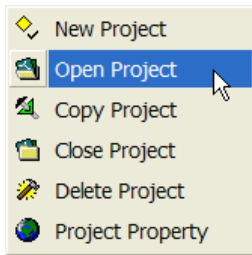
Real Property Geodatabase Maintenance

The project S15370059 already exists.

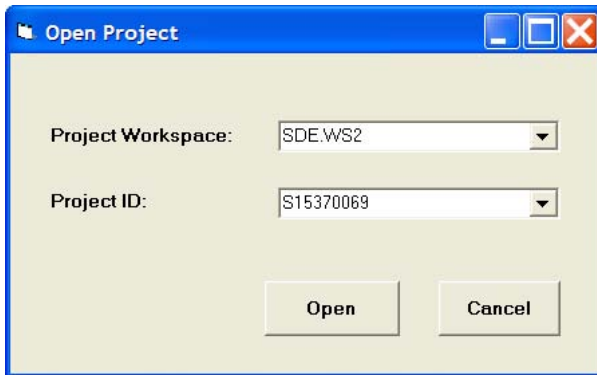
OK

Step 4

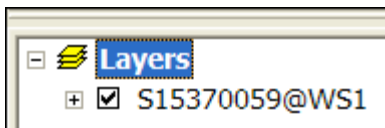
Open the project you just created. Select the Open Project menu item from the Geo Project tool menu on the RPGM's Geodatabase Management toolbar as shown in the following figure.



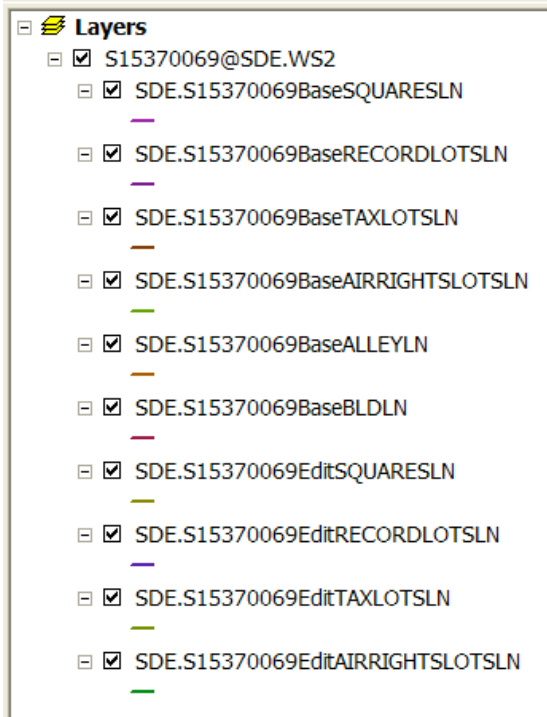
The following window is displayed. Select your workspace and project ID as shown. Next, select the Open button.



This action loads the project layers into your ArcMap document. The project layers are grouped under a name composed of the project ID and workspace. The following picture shows the project opened in the ArcMap's table of content.



Click on the plus-box next to the project group. The following figure shows the expanded project layers in the ArcMap's table of contents.



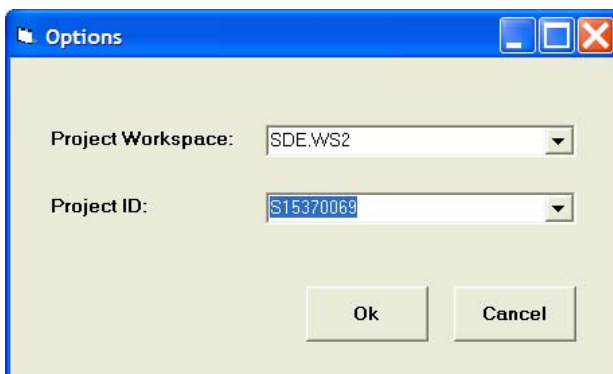
The project layer names begin with the project ID and consist of two layer sets. One layer set has the word “Edit” in every layer name (known as edit layers), the other set has the word “Base” in every layer name (known as base layers). You will copy the current data into the base layers and you will prepare your line work for editing in the edit layers.

Step 5

Set the active workspace and project on the RPGM’s Geodatabase Management toolbar. Select the Options tool button on the same toolbar as shown below.



This action opens the Options window. Select the active workspace and project as shown in the following figure. Select the OK button.



The active workspace and project are shown on the toolbar. Although you can have multiple projects open in your ArcMap document, you can work only with one project. The Active project indicates the project that you are working with.

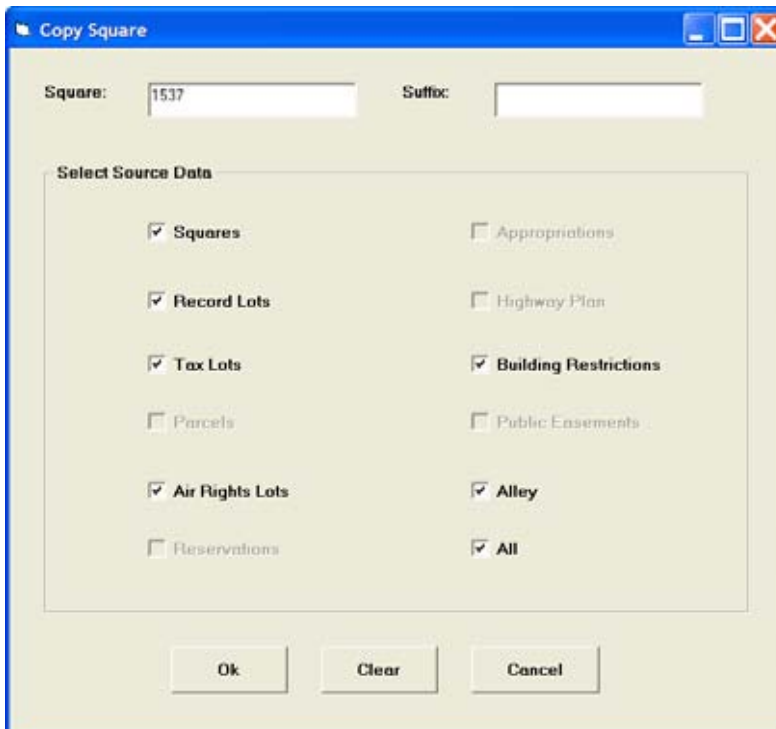


Step 6

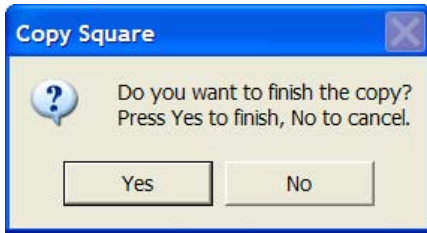
Copy relevant data from the production layers into your project's base layers. Select the Copy Square tool button as shown below on the RPGM's Geodatabase Management toolbar.



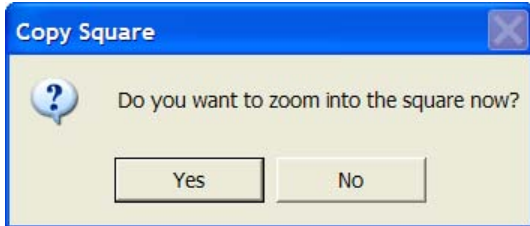
This action opens the Copy Square window. Enter 1537 for the square. Make sure "All" checkbox is marked, and then select the OK button.



You can copy multiple squares by repeating this process. While the application is copying the square, a progress bar appears in the lower left corner of ArcMap window. Once copying is completed, the following message is displayed.



Select the Yes button to complete the copying. Next you see the following message.



Select the Yes button to display the Zoom To window as shown in the next figure. Select one of the base layers and enter the Square number as shown below. By leaving the lot number blank, you zoom to the entire square. Select the Zoom To button.



At this time, you should see the square and its lots on your ArcMap display.

Step 7

Prepare your ArcMap document for creating the new tax lot. Turn off the display of every layer except for the base record lot, base tax lot, and edit tax lot layers. You turn off the layer display by removing the mark from the checkbox next to the layer name. Next, make sure that the line colors for the three displayed layers are distinguishable. You can change the line color by clicking on the line symbol of a layer in the table of contents.

Turn on the annotation for the base record lots, by selecting the Annotation On/Off tool from the Attribute Edit toolbar.

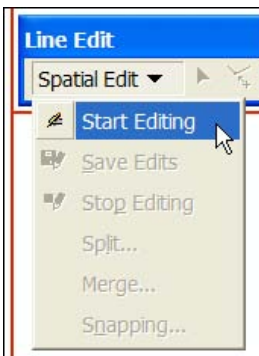
The following figure shows how the three layers will be displayed in this example.



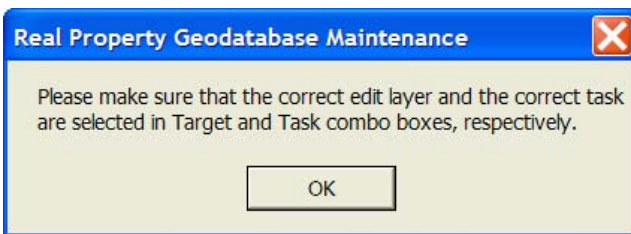
This confirms that there are no tax lots overlaying our 0059 and 0060 record lots, and that is the reason no lot was entered in the Affected SSLs list on the New Project window.

Step 8

Start an edit session. By selecting the Start Editing menu item from the Spatial Edit tool menu on the RPGM's Line Edit toolbar as shown below.



Application displays the following message. Select the OK button.



Make sure that the correct edit layer and the correct task are selected on the ArcMap's Editor Toolbar. If this toolbar is not displayed, open it by selecting the View | Toolbars | Editor Menu. For this example, set the task to "Create New Feature" and set the Target to "S15370059EditTAXLOTSLN" layer, as shown in the next figure.

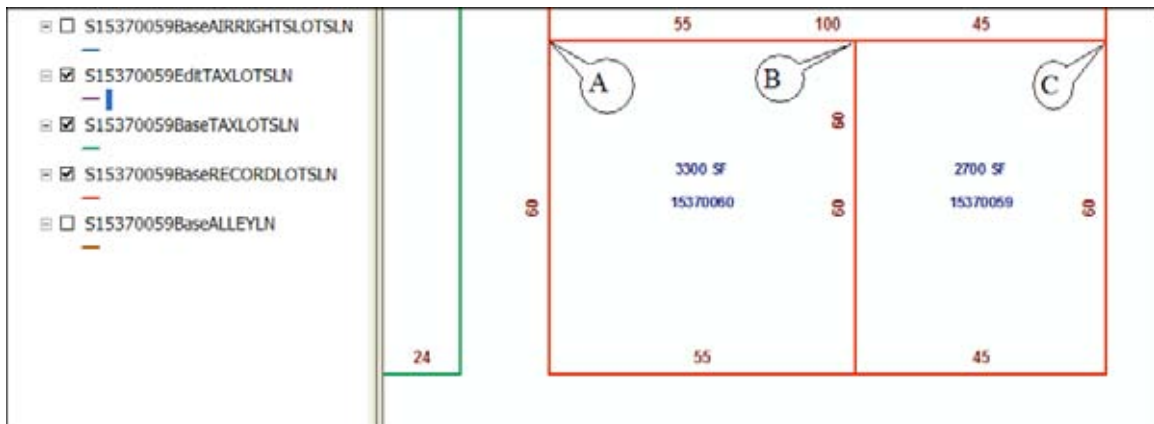


Setting the above parameters is critical to your edit operation.

Step 9

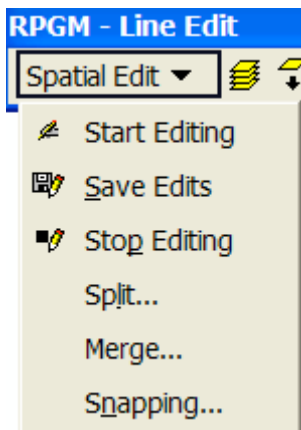
Create the new tax lot in the tax lot edit layer. You can create new lot(s) in two different ways. You can copy lot(s) from the base layers into the edit layers and edit them, or you can create the lot lines by snapping to the features of the base layers. Since we are creating a relatively simple tax lot, we will use the later method.

When constructing the boundary lines for a lot, each side must be a simple two-point line without any vertex. When you draw the tax lot line between points A and C as shown below, you should have a straight line unless the bearings of AB and BC are not the same. In that case you would need two lines for your tax lot on the north side.

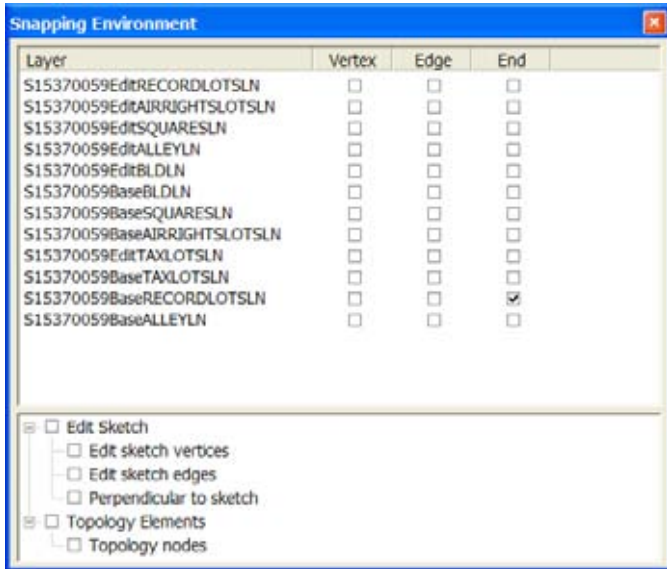


You can verify that the AB and BC bearings are the same by using ArcMap's Identify tool and examining the bearings' values. In this case they are the same; therefore we will have only one line from A to C for the north side of our tax lot.

Next you will set the snapping properties so that we can draw the lines that make up the tax lot. Select the Snapping menu item of the Spatial Edit menu on the RPGM – Line Edit toolbar as shown below.



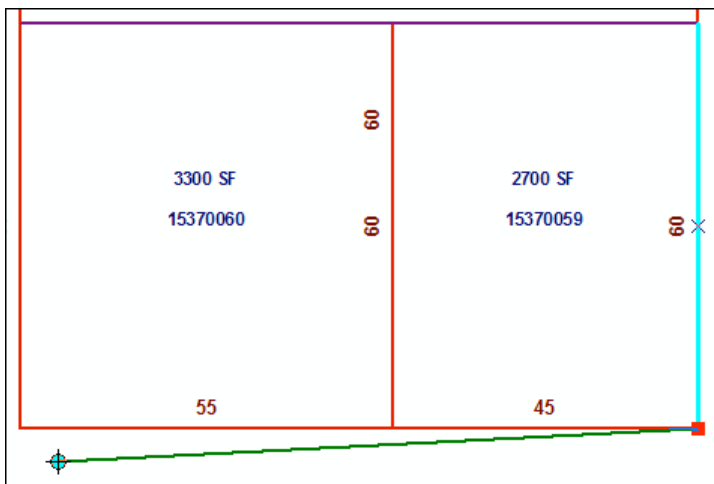
ArcMap displays the Snapping environment window. Mark the checkbox for snapping to the ends of base layer for Record Lots as shown in the following picture. Then close this window.



Select the Sketch tool from the RPGM's Line Edit toolbar. The sketch tool button is shown in the next figure.



Snap to the upper left corner of lot 0060 and then double click on the upper right corner of the lot 0060 to create one line of the new tax lot. Boundary lines are all simple-two-points lines, therefore you must double click on the second point of each line to make sure that you do not create lines with vertices. The following figure shows the ArcMap display as the tax lot boundaries are being created.



Once you have drawn all four lines of the new tax lot around the two record lots, turn off the display of the base layer for record and tax lots. The ArcMap display should show the following four lines.

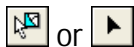


The last line drawn is always selected, that is the reason the last line of your new tax lot is highlighted in blue. At this point you have completed creating the new tax lot lines.

The final task in this step is to save your new lines. Select Spatial Edit tool menu from RPGM's Line Edit toolbar, then select the Save Edits menu item.

Step 10

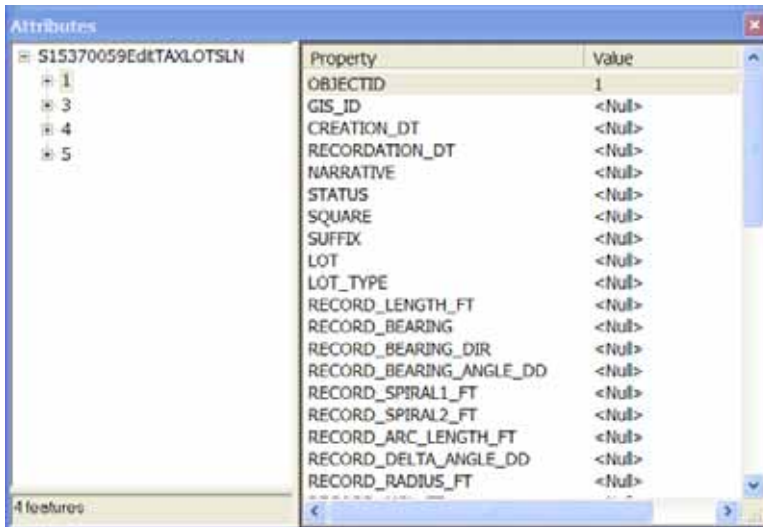
Edit the attributes for each line. Each line has several mandatory fields that you must provide values for. Since we draw these lines, instead of copying from existing ones, all field values are empty. Select all four lines by using the Select Features tool from the Tools toolbar or the Edit Tool from the RPGM – Line Edit toolbar. The Select Features tool and Edit Tool is shown below.



While this tool is selected draw a rectangle around all tax lot boundaries to select all four lines. Make sure that you are still in the Edit mode. If not, select Start Editing from the tool menu of the Spatial Edit. Next select the Attributes tool from the RPGM's Attribute Edit toolbar. This tool is shown below.



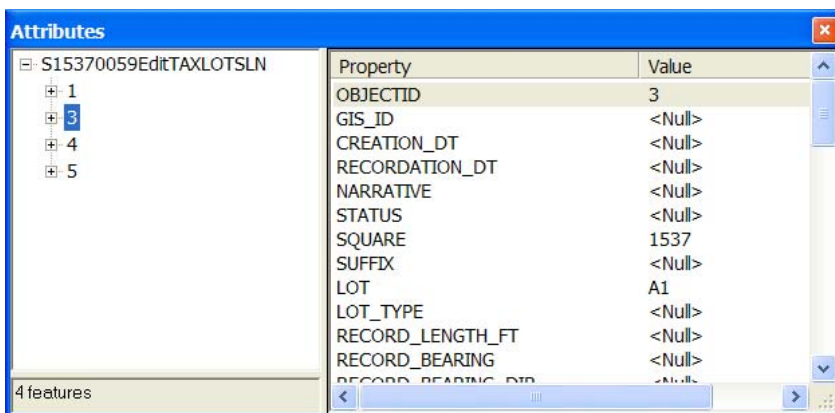
This action opens the Attributes window as shown in the next figure.



In the Attributes window you see four records, one for each boundary line of the new tax lot line. In left pane of the window the four lines are represented by their Object ID. When you select an Object ID from the left pane two things happen. The corresponding line on the map blinks, and then the corresponding fields are listed on the right pane.

As shown in this window, all fields are <Null> which means no value. You can edit and enter a value by clicking on the field value. You need to enter the square number and a temporary lot number for each record. The temporary lot number is later changed to the appropriate tax lot number.

The next figure shows the square of 1537 and temporary number of A1 has been entered for one of the lines. Make sure the same values are entered for the other three lines.



Close the attribute window. Select Spatial Edit tool menu from RPGM's Line Edit toolbar, then select the Save Edits menu item to save changes to the attributes.

Step 11

Set the attributes that can be updated automatically. Select Auto Attribution tool from RPGM's Attribute Edit toolbar. The tool button is shown below.



While this tool is selected, draw a rectangle around all lines to select them. Next press the space-bar so that the computed attributes are stored for each line.

You can open the Attributes window to see which fields have been populated automatically. Primarily, the values for the “computed” fields are automatically entered.

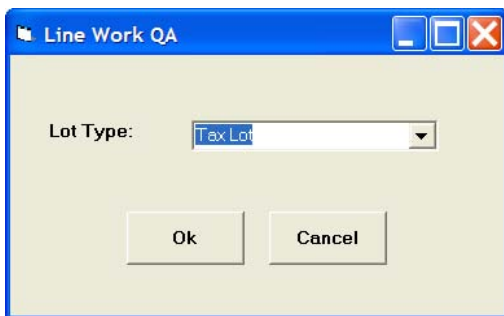
Select Spatial Edit tool menu from RPGM’s Line Edit toolbar, then select the Save Edits menu item to save changes to the attributes.

Step 12

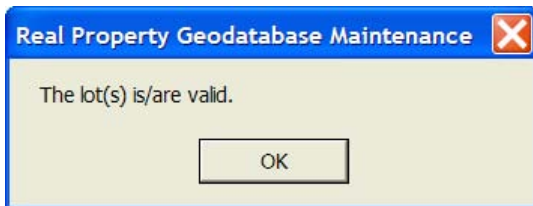
Check to make sure that your lines can produce a closed polygon. Select the Line Work QA tool from the RPGM’s Line Edit toolbar as shown below.



This tool button opens the Line Work QA window. Select Tax Lot as the Lot Type. Select the OK button.



If the tax lot lines can form a polygon you will get the following message. Otherwise, you are informed which lines do not form a polygon.

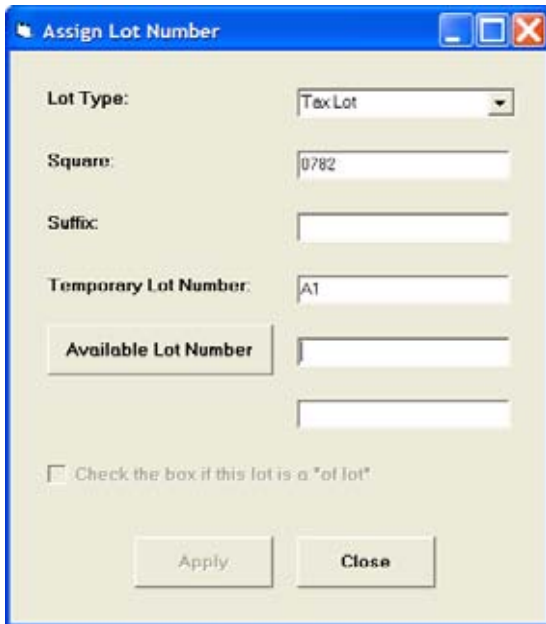


Step 13

Replace the temporary lot number with a valid permanent number. Select the Assign Lot Number tool from RPGM’s Attribute Edit toolbar as shown below.



This action opens the Assign Lot Number window. Select Tax Lot as the Lot Type and enter the square number and the temporary number used as the lot number.



Next, click on the Available Lot Number. The next available tax lot number is displayed. Select Apply to replace the temporary A1 with a valid lot number. Application asks for your confirmation to replace the lot number. Afterward, click on the Close button.

Assigning lot numbers is the final task. Therefore, this action saves all changes and stops the editing session.

Step 14

You have completed the process of creating the line work required for this change. The next step is to upload and post the project. The upload and post processes, which are discussed in the previous sections, are same for all project types and automatically upload the edits into an edit geodatabase version and post to the production geodatabase. At this point you can save your ArcMap document and exit ArcMap application.

5. Conclusion

The Real Property Geodatabase will be used by many agencies in the District of Columbia, such as the Office of Chief Technology Officer (OCTO), the Office of Surveyor, the Department of Consumer and Regulatory Affairs (DCRA), the Office of Tax and Revenue (OTR), the Office of Zoning (OZ), and the Office of Planning (OP). The Office of Surveyor and OTR will use the RPGM Extension in the District's daily work to conduct data maintenance activities for tax and record lots and associated information. When designing and developing the application, the algorithms used in constructing the tools and commands are optimized to enhance user interactive performance. The concepts of Project Workspace, Edit Layer, and Base Layer are critical

in the performance-related optimization. Data integrity is enforced through predefined topological rules that are built in the quality control modules of the RPGM Extension.

Using the application will significantly enhance the database maintenance accuracy and efficiency. With the application, once a lot is created, there is no need to recreate it again. Without the application, the Office of Surveyor and OTR would have to draw their own record lots and tax lots based on the requests from their customers. Every drawing must be made from scratch for every task that needs to be done even though the same set of lots is involved in a new subdivision task. The RPGM Extension provides the capability to copy and edit existing lots and therefore eliminates duplicate efforts. The testing result shows that the application would save the DC agencies from hours to several weeks of work for each submission depending on the complexity of work.

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About the Authors

Yingjie Wang is the Director of GIS Application Developments of Razavi Application Developers, Inc., a consulting firm based in Centreville, Virginia. Dr. Wang's expertise includes a wide range of disciplines, such as Software Engineering, GIS, Algorithms and Applications Development, and Spatial Data Modeling. His major focus is in the areas of implementation of advanced GIS technology in federal and local government and development of spatial data models. He is a Certified GIS Professional approved by the Urban and Regional Information Systems Association.

Corresponding Address:

2200 Columbia Pike, #502,
Arlington, VA 22204
Phone: 703-203-1187
Fax: 703-486-0585
Email: ywang@razavi.com

Amir Razavi is the founder and President of Razavi Application Developers, Inc. He has over 20 years of experience in software and Geographic Information System (GIS) development, design, implementation and management. He was the senior developer of NASD's (parent company of NASDAQ) very large scale Oracle database for the Broker-Agent registry. He designed the Oracle Geodatabase that stores all real properties in Washington, DC. He was Chairman of the GIS Committee of the American Society for Photogrammetry and Remote Sensing – Potomac region. He is the recipient of ASPRS's 2000 Service Award. He is the author of many books and papers that have appeared in professional journals and conference proceedings.

Corresponding Address:

Razavi Application Developers, Inc.
14489 Store House Drive
Centreville, VA 20121
Phone: (703) 932.0736
Fax: (703) 830.9155
Email: arazavi@razavi.com