Integrating ArcGIS to Enterprise Oracle Spatial Using Direct Connect

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Abstract: *Many organizations are adopting Enterprise Oracle Spatial as their core database, thereby migrating their traditional methods of maintaining spatial components to a relation data model. This is because Enterprise Oracle Spatial allows various applications to connect and interact with the database directly, instead of through some other interface. While it is recognized that ArcSDE can be used to manage the connectivity between Enterprise Oracle Spatial and ArcGIS, many organizations, including Navigation Technologies, are opting to use the Direct Connect capabilities in order to support a read-only query of these Enterprise Oracle Spatial tables. This paper describes the methodologies used by Navigation Technologies to integrate ArcGIS via Direct Connect to Enterprise Oracle Spatial databases. The issues encountered and resolved while integrating ArcGIS to Enterprise Oracle Spatial will also be discussed.*

Introduction

Organizing and maintaining data in general is a major undertaking within any organization. Adding the maintenance of the spatial component of many datasets increases this complexity. Systems have been available for some time to manage the spatial component, requiring indirect/external links and duplicate data efforts to maintain a high quality spatially attributed database. The integration of spatial data into relational database management systems has only been available within the last 5 to 10 years. Major database leader in this area (including Oracle), previously relied on third party applications to address the spatial component, and organizations such as Navigation Technologies wrote their own spatial/data handling routines to address this issue.

ArcGIS developed an industry leading approach to this issue. Not only does the ArcGIS suite of products include its own proprietary method for creating and maintaining spatially attributed databases, it also includes support for "Direct Connection" to Oracle Spatially enables databases. Looking at these solutions poses interesting questions to many organizations, including Navigation Technologies. The purpose of this paper is to present the issues and solutions faced by many organizations in deciding to use Oracle Spatial as its core database product for spatially attributed databases versus using a third party application.

Why Oracle Spatial?

Oracle Spatial opened up the spatial component of relational databases by providing the ability to attach a spatially enabled column to a relational database table. This spatially enabled column allows the user to build and maintain spatial data without the dependency of a third party Applications Program Interface (API). Development languages such as JAVA and C++ can be used to create, maintain and extract from these spatially enabled databases. It was no longer necessary to use a Spatial Database Engine (SDE) API such as ArcSDE. Although many organizations continue to use SDE type APIs in their implementation, Oracle Spatial allows both Spatial and Non Spatial users equal access to their data.

Direct Connect with Oracle Spatial provides one of several access points into an Oracle Spatial database for ArcGIS. Appendix A describes a set of requirements for using Direct Connect with Oracle Spatial. While researching this paper, it became evident that Direct Connect works best as a Read Only Connection. As will be described later in this paper, a Read/Write connection using Direct Connect is possible, but this type of connection currently lacks the performance required for an efficient Read/Write application.

SDO vs. SDEBINARY Geometry Objects

What is a SDO or SDE_BINARY geometry object? These two types of geometry objects are what is primary used in Oracle to support linear, polygonal, and point features.

- SDEBINARY is ESRI's proprietary object for storing geometry features. The SDE API creates this as a numeric field of 38 positions. The contents of this field are primarily accessible through the SDE API and ArcObjects. Standard ArcGIS tools default to this geometry type.

- SDO is Oracle's object for storing geometry features. Oracle stores these objects in a special table related to the primary table (MDSYS.SDO_GEOMETRY). A major advantage of this object type is that it is accessible through the same methods used by SDEBINARY (SDE API and ArcObjects), SQL Queries, and programming languages such as JAVA and C++. Use of this geometry type requires special configuration to the ArcSDE tables configured within Oracle and the keyword: SDO_GEOMETRY.

The Challenge

Project 1:   Direct Connect to an Existing Oracle Spatial Database.
Navigation Technologies is completing a migration project from mainframe VSAM files to Oracle Spatial Tables. ArcGIS Direct Connect could be used to provide an inexpensive read-only access to our new database. This functionality would be used to enhance current ad-hoc query capabilities with a spatial display.

Project 2:   Direct Connect with a Read/Write Connection to an Oracle
*   Spatial Database*
This is a Navigation Technologies in house project to develop an editing tool for high precision geometry and advanced attribution of streets and street lanes. The project included deployment of this tool to the Navigation Technologies Production Organization for use in developing prototype databases.

Direct Connect to an Existing Oracle Spatial Database

The challenge was adapting to a database design that was not optimized for use with ArcGIS or ArcSDE. In order to use Direct Connect we discovered the following:

1. An ArcSDE license must be available in order to configure your Oracle Spatial instance for Direct Connect. This could be as simple as the ArcSDE entry in your license manager file. This is because ArcGIS uses the ArcSDE API to create the Oracle Spatial tables necessary to properly operate.

2. You must configure your Oracle Spatial instance for use with ArcGIS. Refer to Appendix B for further information. Once the configuration is complete, the ArcSDE license is no longer necessary (but recommended).

3. Although ArcGIS suggests that a standard installation is all that is required to use Direct Connect, our research has shown that the ArcSDE API and tools installation is recommended. You do not need to set up an ArcSDE Server, just have the API and tools available.

4. The spatial table must contain a unique ID field. When ESRI tools are used to create tables, this field is generally called "OBJECTID" and is defined in Oracle as a NUMBER(38). The field and the definition of the field is a requirement, but it does not have to be named "OBJECTID".

5. The spatial table must contain a spatial geometry field. ArcSDE prefers that the field be named "SHAPE", but it is not a requirement.

6. ArcCatalog will try and silently fail when registering an Oracle Spatial table that is not to ArcSDE standards. Each table you wish to register will require a manual registration method (refer to Appendix C which outlines the suggested manual registration process).

7. Once the registration is complete, the Oracle Spatial Tables registered for ArcGIS are now available in both ArcMAP and ArcCatalog.

Project Results

This project showed that using ArcGIS as a read-only entry point to the Navigation Technologies database is possible. ArcGIS can be used as an Ad-Hoc query tool and adds the visualization aspect to what was previously tabular access only. The performance of this connection will be dependant on spatial table size, database table relates and views created on the table.

The full functionality of the out-of –the-box ArcMap is available, whether at ArcView, ArcEditor, or ArcInfo licensing levels. Caution, the connections used for this database are Read-Only. ArcGIS recognizes the Read-Only connection and will issue a warning when attempting to update the spatial table. A key piece of functionality utilized was the creation of "Personal Geodatabases" and "Shapefiles" from this connection.

Direct Connect with a Read/Write Connection to an Oracle Spatial Database

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2. Configure your Oracle Spatial instance for use with ArcGIS. Refer to Appendix B for further information.

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4. Before a Spatial Layer can be accessed through ArcMap in Read/Write mode, the layer must be versioned using ArcCatalog.

Versioning and Direct Connect

Versioning is used to ensure the integrity of a spatial layer edited within ArcMap. Add the complexity of Direct Connect plus Oracle Spatial and you end up with a disaster. ArcGIS's versioning implementation does not work well with Oracle Spatial[1]. ArcMap has no issues tracking the changes within a version in Read/Write mode using versioning, but the changes are not visible from Oracle until the entire database is compressed using ArcCatalog.

Project Results

Direct Connect is not the answer when working with large datasets with many spatial layers. When we attempted to use this methodology in the editing application, not only was editing response time not acceptable, post processing of the data required cumbersome work-a-rounds. To work around this, we moved the editing application to operate under Personal Geodatabases. The project was broken into workable areas of interest, created, edited, and edge matched. Once this was complete, the Personal Geodatabases were recombined into Oracle Spatial tables for post processing. This allowed us to work around the versioning issues.

Future Possibilities

Traditionally, Navigation Technologies depends on in-house tools to create and maintain their database. Implementation of ArcGIS tools within Navigation Technologies has opened many more possibilities. Figure 1 illustrates one possibility that is under consideration.

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[1] ESRI and Oracle are familiar with these issues and hope to resolve some of them in future releases. Oracle has discussed with ESRI a decoupling of "versioning" when using Oracle Spatial as the database.
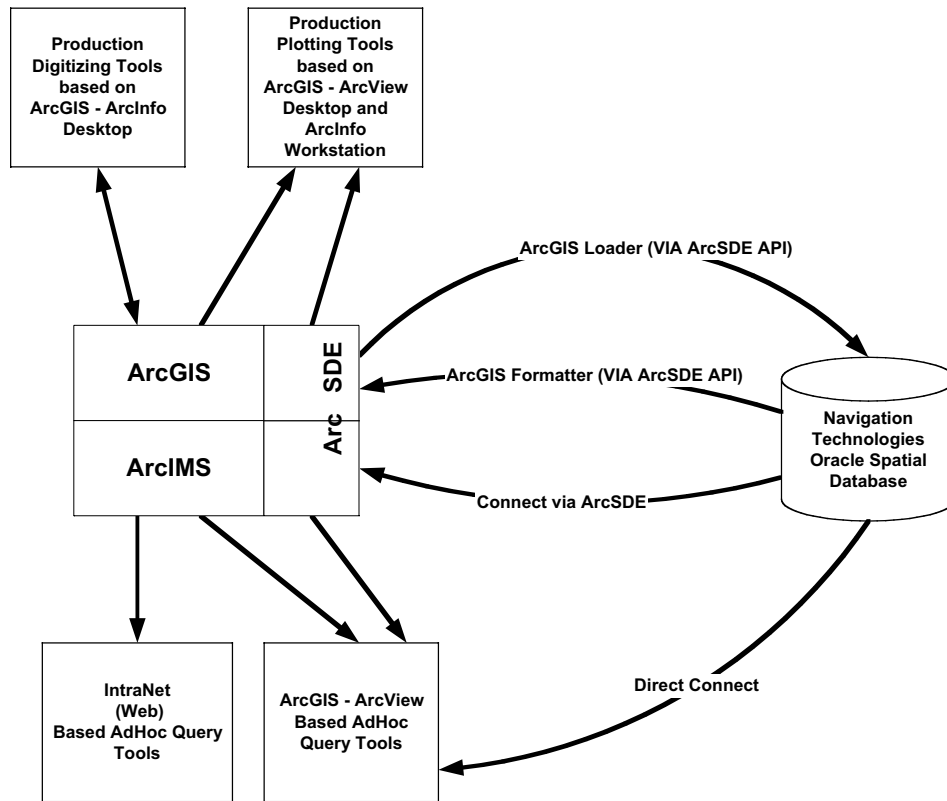
Figure 1

Conclusions

There is no single solution for accessing Oracle Spatial Data through the Direct Connect functionality. The best approach to providing a solution is a combination of tools based on a clear set of requirements. This paper is not intended to steer you away from using Direct Connect to Oracle Spatial, but to encourage you to try it where appropriate. No solution is complete without a little bit of research, a little bit of prototyping, a good design, a well-timed implementation, and a lot of patience.

Append A - Direct Connect Requirements

When initially looking at using Direct Connection to Oracle Spatial, the requirements are not readily apparent. The minimal requirements are:

- An ArcGIS support version of Oracle Spatial.
  - Supported versions (tested by Navigation Technologies) include
    - Oracle8i Enterprise Edition Release 8.1.7.2.1 - Production[2]
    - Oracle9i Enterprise Edition Release 9.0.1.3.0 - 64bit Production
    - Oracle9i Enterprise Edition Release 9.2.0.1.0 - 64bit Production[3]
  - Corresponding Oracle Client installed and configured on your desktop
- ArcGIS installed on your desktop; the following versions have been evaluated by Navigation Technologies:
  - Version 8.1.2 worked well
  - Version 8.2 required patches from ESRI (downloadable from the ESRI Technical Support Web Site).
  - Version 8.3 is available but has not been tested by Navigation Technologies.
- Appropriate Oracle Client installed on the same desktop as ArcGIS.
- Oracle user "sde" with special access permissions is required.
- If Write Access to an Oracle Spatial database is required, and ArcSDE Server license is required (the ArcSDE API and tools should be installed but an ArcSDE server is not required.)
- If planning on using Oracle Spatial storage method (SDO Geometry) as your geometry storage method (as opposed to SDEBINARY which ArcGIS defaults to), modifications to ArcSDE configuration tables are required.

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[2] Oracle Spatial patches are required at Oracle Spatial Version 8.1.7.X.
[3] Caution should be used with this version, as there are problems with 3-D objects in Oracle.

Appendix B – Configuring ArcGIS Direct Connect with Oracle Spatial

The following procedures are required to properly configure an Oracle Spatial instance for use with ArcGIS (it is important that all steps are completed or potential errors could occur):

1. Create an Oracle User according to the following specifications (to be completed by the Database Administrator):

   - Identified by "sde"
   - Default tablespace "sde" with at least 100 MB of space
   - Temporary space to temp.
   - Quota unlimited on sde
   - Quota unlimited on temp
   - The following permissions are required:
     - Select any table
     - Create table
     - Create sequence
     - Create any sequence
     - Drop any sequence
     - Select any sequence
     - Create procedure
     - Create any procedure
     - Execute any procedure
     - Drop any procedure
     - Create any view
     - Drop any view
     - Create trigger
     - Create any trigger
     - Create session
     - Unlimited tablespace
     - DBA
   - The following object privileges must be granted to PUBLIC:
     - Grant execute on dbms_pipe to public
     - Grant execute on dbms_lock to public

2. Run the ESRI SDE Oracle Table Creation script (to be completed on the Desktop with ArcGIS installed):

   Depending on the target Oracle Spatial version, the following ArcGIS command should be executed[4]:

   - For Oracle Spatial 8:
       Open a DOS Command Window
       cd \arcgis\arcexe82\bin
       sdesetupora8i –o install

   - For Oracle Spatial 9:

       Open a DOS Command Window
       cd \arcgis\arcexe82\bin
           sdesetupora9i –o install

   - The executed program will ask for the "DBA password". Enter the password for the "sde" user with the instance name in the following format: *<password>@<Oracle Instance>*

   - The program will ask if you wish to install SDE8.2. Respond with "Y".

3. Create the ArcCatalog "Direct Connect to Oracle" Database Connection for user "sde" (to be completed on the Desktop with ArcGIS installed). Note, the format for the "Account Password" is: *<password>@<Oracle Instance>*

   Figure B-1 illustrates a Spatial Database Connection window for connecting to an Oracle 8i Spatial database. Figure B-2 illustrates a Spatial Database Connection window for connecting to an Oracle 9i Spatial database. The difference lies in the undocumented feature for the "service:" entry. Where sde:oracle will work for either, we recommend using "sde:oracle9i: for 9i databases.

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[4] The examples below are for ArcGIS 8.2. For later versions, substitute the version (e.g. 83) where appropriate.
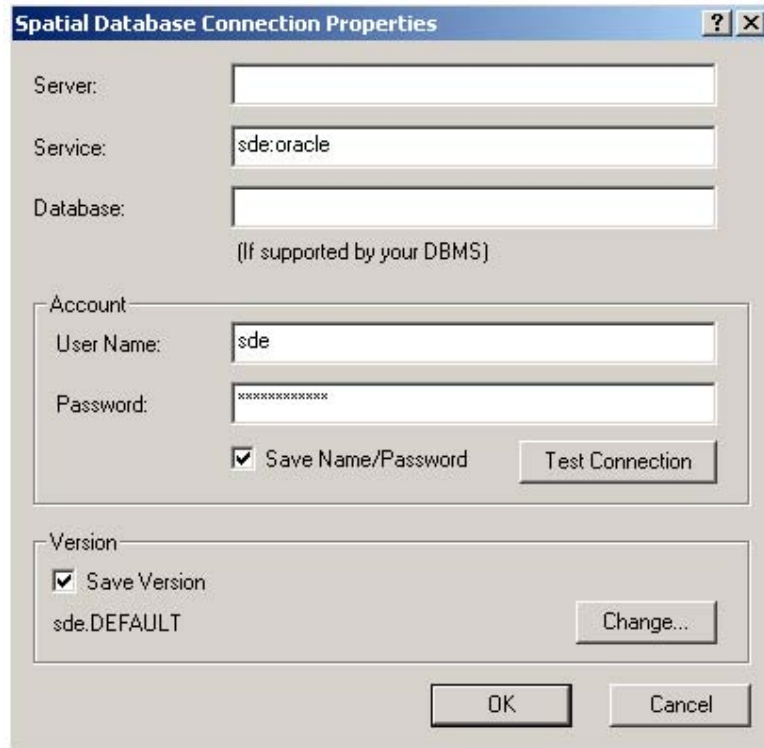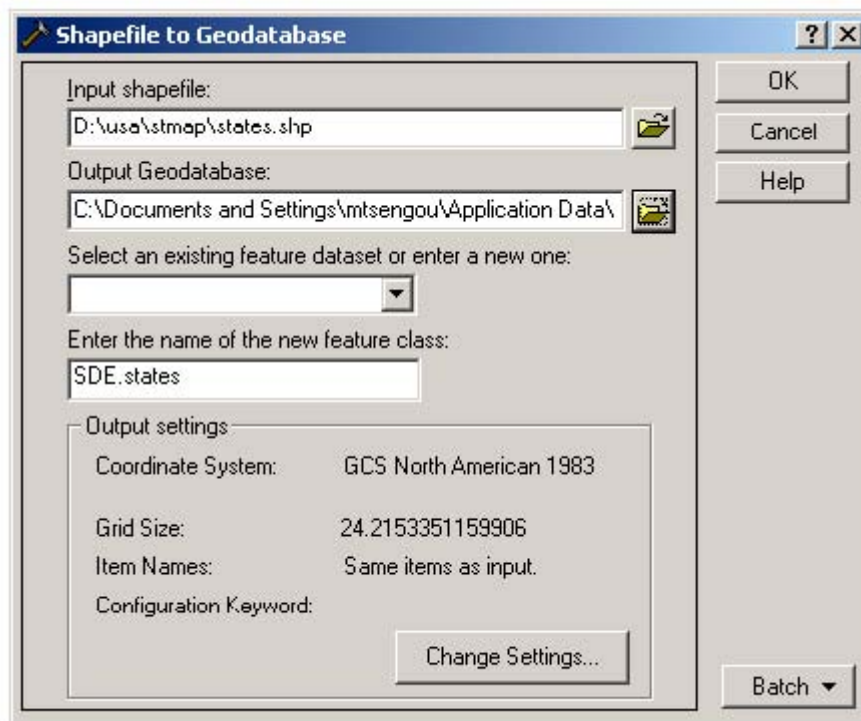
Figure B-1
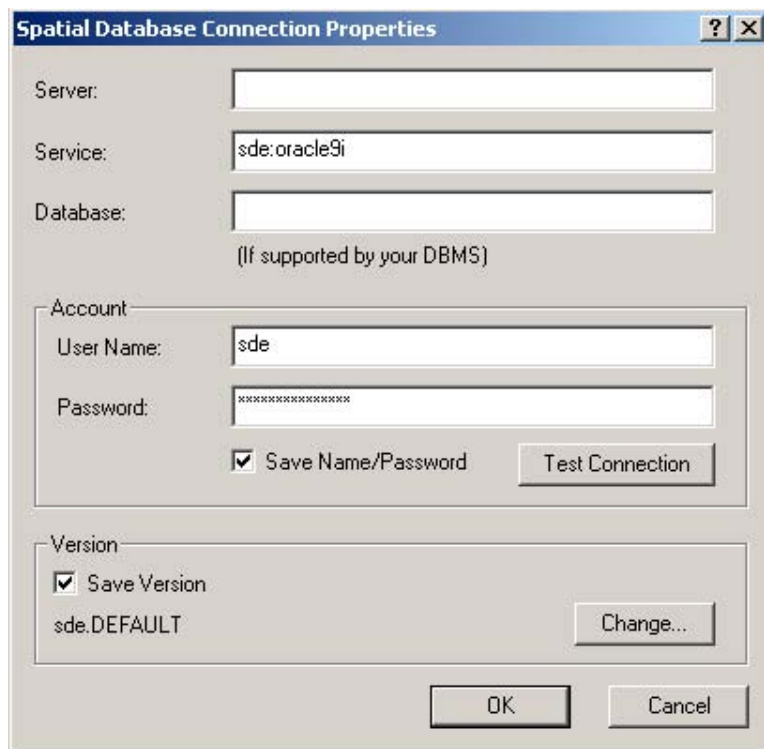
Figure B-2

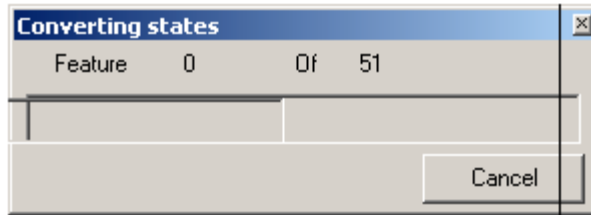4. Initialize the Direct Connection functionality (to be completed on the Desktop with ArcGIS installed).

A requirement for use of the Direct Connect functionality is to load an SDEBINARY layer into your Oracle Spatial database. The simplest way to do this is to select a shapefile from the ESRI Data & maps disks included with your installation. Using ArcTools, select "Shapefile to Geodatabase" (refer to Figure B-3)

Figure B-3

Input Shapefile:	Navigate and select the shape file desired.
Output Geodatabase:	This is the database connection specified in Step 3
Feature Class Name:	Accept the default

Press "OK" to load. The window illustrated in Figure B-4 will show the progress of loading the shapefile to the Oracle Spatial geodatabase.

Figure B-4

5. Update SDE Oracle Tables for use with SDO_GEOMETRY objects (to be completed by the Database Administrator):

    The following entry should be added and committed using the SQL interface as the "sys" user (full DBA account):

    INSERT INTO SDE>DBTUNE VALUES ('SDO_GEOMETRY','GEOMETRY_STORAGE', 'SDO_GEOMETRY');

6. Initialize the Direct Connect functionality for SDO_GEOMETRY (to be completed on the Desktop with ArcGIS installed):

    In order to activate Oracle Spatial Geometry (SDO_GEOMETRY) for Direct Connect functionality, load a shapefile using the SDO_GEOMETRY keyword. The simplest way to do this is to select a shapefile from the ESRI Data & maps disks included with your installation. Using ArcTools, select "Shapefile to Geodatabase" (refer to Figure B-3)

    Prior to pressing OK, you will need to specify the keyword "SDO_GEOMETRY". Pressing "Change Settings" will provide the necessary window to specify the keyword (refer to Figure B-5).

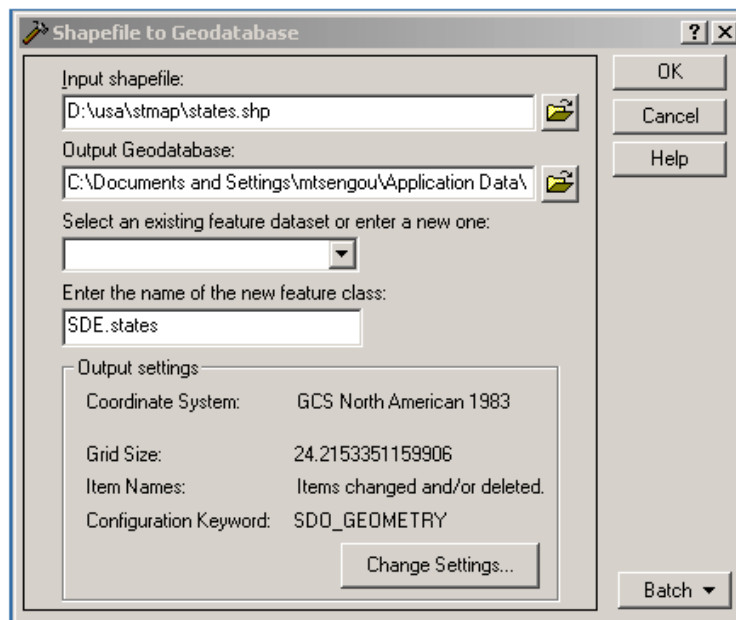   Click the "Keywords" tab at the top of the window.

    Click the radio button "Use configuration keyword" and enter SDO_GEOMETRY into the entry field.

    Press "OK" to accept the setting

    Figure B-6 illustrates the change to this loader window. Press OK to accept and load the shapefile using SDO Spatial objects.
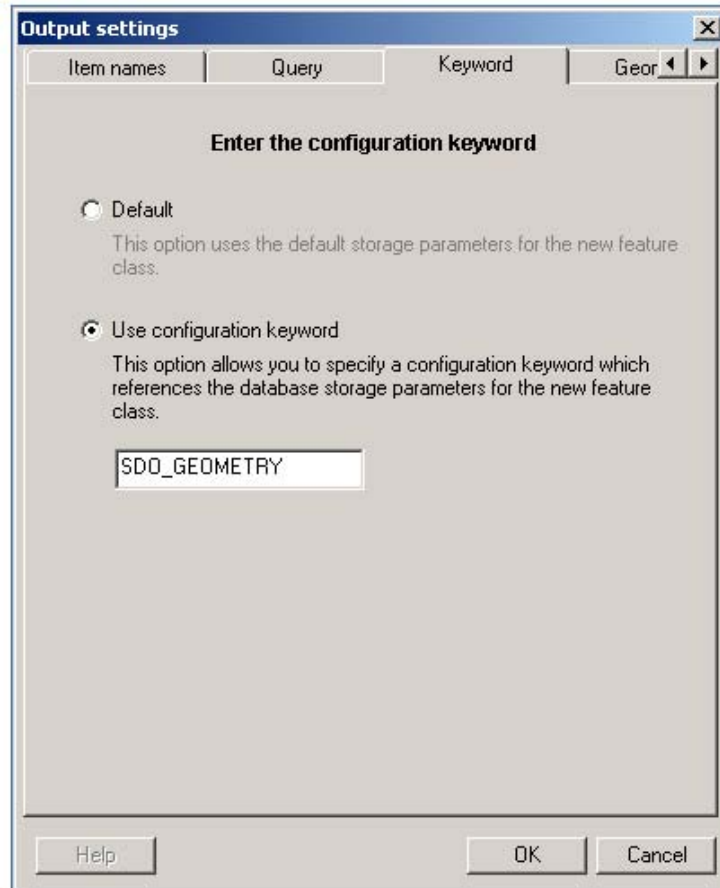
Figure B-5

Figure B-6

7. Update the SDE Oracle tables using the same programs described in Step 2, using the –UPGRADE option (to be completed on the Desktop with ArcGIS installed).

Depending on the target Oracle Spatial version, the following ArcGIS command should be executed[5]:

- For Oracle Spatial 8:

  Open a DOS Command Window

  cd \arcgis\arcexe82\bin

  sdesetupora8i –o upgrade

- For Oracle Spatial 9:

  Open a DOS Command Window

  cd \arcgis\arcexe82\bin

  sdesetupora9i –o upgrade

- The program executed will ask for the "DBA password". Enter the password for the "sde" user with the instance name in the following format: *<password>@<Oracle Instance>*

- The program will ask if you wish to install SDE8.2. Respond with "Y".

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[5] The examples below are for ArcGIS 8.2. For later versions, substitute the version (e.g. 83) where appropriate.

Appendix C – Manually Registering Existing Oracle Spatial Tables for use by ArcGIS

A combination of ArcGIS/ArcSDE tools[6] and SQL will be required to manually register an existing Oracle Spatial table.

For example purposes, the following existing Oracle 9i Spatial Table will be used:

```
Name                                     Null?    Type
---------------------------------------- -------- -------------------
LINK_ID                                  NOT NULL NUMBER(38)
HIGHWAY_NAME                                      VARCHAR2(80)
LANG_CODE                                         VARCHAR2(3)
DIRONSIGN                                         VARCHAR2(1)
FUNC_CLASS                                        VARCHAR2(1)
ROUTE_TYPE                                        VARCHAR2(1)
BOATFERRY                                         VARCHAR2(1)
RAILFERRY                                         VARCHAR2(1)
GEOMETRY                                          MDSYS.SDO_GEOMETRY
```

Requirements, which have been met:

The spatial table must contain a unique id field: LINK_ID
The spatial table must contain a spatial geometry field: GEOMETRY

1. Allow ArcCatalog to register the existing Oracle Spatial Table (to be completed on the Desktop with ArcGIS installed).
   - With all the connectivity defined, access the Oracle instance (using a pre-created database connection) through ArcCatalog. The first time this is done, ArcCatalog will attempt to register all Oracle Tables with a spatial component. Some key table entries to the ArcSDE tables will be created but the registration will not be complete. Although this will appear to have worked[7], attempting to preview a spatial table will produce an Error similar to Figure C-1.

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[6] ArcGIS/ArcSDE tools are fully documented in the ArcSDE Administration Guide included with the ArcGIS installation
[7] This has been discussed with ESRI Technical Support and Development Support and is being looked into.
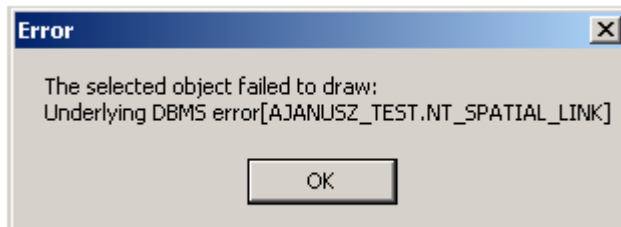
Figure C-1

2. Capture a copy of the metadata entry for the existing table (to be completed from an SQL Interactive Session).

   - Start SQL, attaching as the owner of the spatial table to be manually registered.
   - At the SQL prompt, enter the following SQL statement:

```
create table majhwys_meta as select * from
user_sdo_geom._metadata where table_name = 'NTC_MAJHWYS';
```

   - This will create a copy of the metadata entry for the table in a temporary table (which will be used later).
   - Exit SQL

3. Delete the table from the ArcSDE Tables (to be completed on the Desktop with ArcGIS installed).

   - This is done using an ArcSDE tool from windows command prompt. Select "Start" and "Run" (refer to Figure C-2). A Windows command prompt window will appear (refer to Figure C-3).

Figure C-2

   - At the Windows command prompt, enter the following ArcSDE tool command:

```
sdelayer -o delete -l <layername>,<spatial column>
-u <username> -p <password> -i sde:oracle9i
```
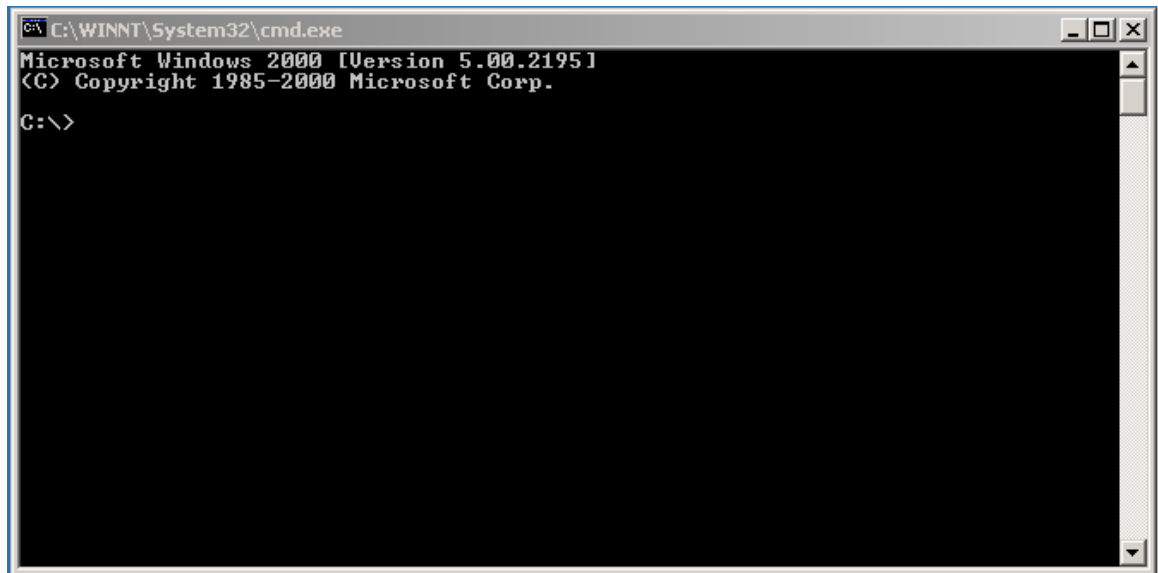
Where:

```
<layername>      = The name of the layer
<spatial column> = The Spatial Column Name
<username>       = Oracle User name
<password>       = Oracle Password as password@instance
```

For this example:

```
sdelayer –o delete –l ntc_majhwys,geometry –u mtsengou2
–p password@instance -i sde:oracle9i
```


Figure C-3

4. Unregister the table from ArcGIS (to be completed on the Desktop with ArcGIS installed).

   ▪ At the Windows command prompt, enter the following ArcSDE tool command:

```
sdetable –o unregister –t <layername> –u <username> –p
<password> -i sde:oracle9i
```

Where:

```
<layername>   = The name of the layer
<username>    = Oracle User name
<password>    = Oracle Password as password@instance
```

For this example:

```
sdetable –o unregister –t ntc_majhwys –u mtsengou2
–p password@instance -i sde:oracle9i
```

5. Re-enter the metadata entry into the ArcSDE tables (to be completed from an SQL Interactive Session).

- Start SQL, attaching as the owner of the spatial table to be manually registered.
- At the SQL prompt, enter the following SQL statement:

```
insert into user_sdo_geom._metadata select * from
majhwys_meta;
```

- This will inset the metadata entry back to the ArcSDE tables.
- Exit SQL

6. Register the table with ArcGIS (to be completed on the Desktop with ArcGIS installed).

- At the Windows command prompt, enter the following ArcSDE tool command:

```
sdelayer –o register –l <layername>,<spatial column> –u
<username> -p <password> -i sde:oracle9i –e <entity type>
-c <unique column name> -C USER
```

Where:

```
<layername>        = The name of the layer
<spatial column>   = The Spatial Column Name
<username>         = Oracle User name
<password>         = Oracle Password as password@instance
<entity type>      = l for Simple Line, p for point shapes
<unique column name> =  The unique defined as Number(38)
```

For this example:

```
sdetable –o register –t ntc_majhwys,geometry –u mtsengou2
–p password@instance -i sde:oracle9i –e l –c LINK_ID
–C USER
```

Manual registration is complete.