



**VGIS
HANDBOOK**

**PART 3 - GUIDELINES
SECTION M**

**ArcSDE Configuration and
Management Guidelines**

Vermont Geographic Information System



PART 3: GUIDELINES - SECTION M

Enterprise VGIS System: ArcSDE Configuration and Management Guidelines

Standard History

Version	Date	Description
4a	7/21/2006	Initial version adopted VCGI Technical Advisory Committee.
5b	12/22/2006	Revised SDE layer naming convention. Addressed FDS performance question.

Acknowledgments

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Statutory Authority

Vermont Statutes: Title 10: Conservation & Development – Chapter 8: Geographic Information – 10 V.S.A. § 123. Powers and duties

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Enterprise VGIS System: ArcSDE Configuration and Management Guidelines

1. Introduction

1.1. **Purpose:** This guideline is designed to help agencies in the State of Vermont who plan to configure and manage an ArcSDE¹ installation. It includes a set of guidelines that will help ensure greater compatibility between Agencies in the State of Vermont. The hope is that this will lead to improved data sharing and exchange, and create the foundation for an *Enterprise VGIS System*².

1.2. **Getting Help:** Contact VCGI’s Database Administrator at 1-802-882-3000 (dba@vcgi.org).

1.3. **Terminology:** Terms used in this document include

Enterprise VGIS System	Refer to “Vermont’s Geographic Information System – Moving GIS into the Enterprise”. http://www.vcgi.org/techres/white_papers/egis/VGIS_FutureVision_v2a.pdf
VGIS data	Data shared within the Enterprise VGIS System.
ArcSDE	ESRI ArcGIS Spatial Database Engine
Enterprise/Multi-user Geodatabase	ArcGIS geodatabase stored in a RDBMS (eg: SQL server)
Personal Geodatabase	ArcGIS geodatabase stored as a Microsoft Access file (*.mdb)
DBA	Database Administrator
GIS	Geographic Information System
GIT	Geographic Information Technology
GDB	Geospatial Database

1.4. **Review and Modification of this Guideline:** Proposed amendments to this document must be provided in writing to the VCGI TAC. This group will consider amendments to this Guideline. The VGIS community will be provided with an opportunity to comment.

1 ArcSDE is a database API developed by Environmental Systems Research Institute (ESRI) designed to enable storage, management, and retrieval of geospatial data within a Relational Database Management System (RDBMS). Its primary role is to act as the GIS gateway to spatial data stored in a RDBMS.

2 Refer to “Vermont’s Geographic Information System – Moving GIS into the Enterprise”.
http://www.vcgi.org/about_vcgi/tac/evgis/Enterprise_VGIS_Brochure.pdf



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2. ArcSDE Deployment and Configuration Guidelines

2.1. Overview: This section includes guidelines for the proper deployment and configuration of ArcSDE within the context of Vermont's Enterprise Geographic Information System (VGIS). The goal is to define a common VGIS ArcSDE implementation strategy which facilitates data sharing, exchange, and distributed synchronization between state agency data servers.

2.2. Hardware and Software Guidelines

2.2.1. Hardware:

- 2.0 Gig RAM
- Hardware RAID controller
 - Level 0+1 RAID set for Operating System
 - Level 5 RAID set for data
- Backup system

2.2.2. Operating System and RDBMS:

- **Operating System:** Microsoft Windows Server
- **RDBMS:** Microsoft SQL Server³

2.3. ArcSDE Configuration: ESRI's ArcSDE (spatial database engine) is used to store and manage geospatial datasets. ArcSDE provides a robust API that enables many ESRI clients (ex: ArcInfo, ArcGIS) to create and manage geospatial datasets. It also enables other ESRI products such as ArcIMS and ArcView 3.x to view data.

2.3.1. Access Types and Security (Logins and Roles): MS SQL Servers (or Oracle, DB2, Informix, etc.) logins and database roles should be used to control access to ArcSDE databases (GDB_*). MS SQL Servers login accounts should be created using the conventions defined below.

³ ArcSDE can be used with other RDBMS packages (IBM DB2, Informix, and Oracle), however, VTrans, ACCD, and VCGI use MS SQL Server. It is anticipated that it will be easier to setup automated synchronization between servers if they are running the same RDBMS.



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2.3.1.1. Logins: Database administrator will need to create administrative and user logins. Login names should be a maximum of 20 characters⁴.

Administrative Logins: An administrative user account should be established to manage ArcSDE databases (GDB_*). The admin accounts should also own the tables and layers loaded into the various SDE databases identified in these guidelines. The following naming convention should be used:

<agency>_Admin, where <agency> = VCGI/ANR/VTrans/ACCD

For example, *VCGI_Admin* would be the administrative account used to manage the GDB_VCGI database.

SDE login account: The ArcSDE post-installation routine creates an “sde” login account. The “sde” login is used for special functions such as database compression. The “sde” login also owns all of the SDE_* and GDB_* tables in the database.

- Note: Do not grant the SDE login any server roles. Do not grant the SDE user any database roles, except for default of 'Public'⁵. However, the SDE login will need the following database-wide permissions (MS SQL Server 2000):
 - Create table
 - Create view
 - Create procedure
 - Create function

User Logins: Individual or shared user logins can be created. They should be agency specific accounts. Be sure to use session-based logging if you plan to have shared logins. The following naming convention should be used:

4 Testing conducted by VCGI has identified an ArcSDE (on MS SQL Server 2000) “limitation” which limits the combined “login name + database name” to 32 characters. This is not a MS SQL Server limitation; it’s an ArcSDE limitation. VCGI has consulted ESRI, however, they have not been able to confirm or deny the limitation. VCGI recommends that login names (and database role names) be limited to 20 characters, and database names be limited to 10 characters.

5 <http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=29320>



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Read only accounts:

- **<agency>_User** = shared user account (ex: ANR_User)
- **<agency>_<username>** = individual user account (ex: ANR_jdoe)

Read/Write accounts: *do not add these accounts to shared databases (refer to those in bold-italics in Table 1)*

- **<agency>_Editor** = shared editor account (ex: ANR_editor).
- **<agency>_<username>** = individual editor account (ex: ANR_ftuttle)

NOTE: These guidelines do not address the use of “domain” accounts. Domain accounts are Local Area Network (LAN) accounts administered by an agency or department’s Primary Domain Control (PDC). MS SQL Server and ArcSDE can be configured to use these domain accounts. This has certain advantages within the context of a single agency or department, however, it is of little or no value beyond the context of those individual agencies/departments. DBAs should feel free to use domain accounts, however, they should also create the MS SQL Server accounts defined above to ensure access by external agencies and departments.

2.3.1.2. Database Roles: The following MS SQL Server “database roles” should be created. Database role names should be a maximum of 20 characters. The user logins defined above should be allocated to these roles as appropriate:

- **sde_user** = Read-only access to SDE layers and tables.
- **sde_editor** = Read/Write access to specific SDE layers and tables. For example interns will be able to edit layers loaded by project managers into the GDB_DDev database. *NOTE: This database role should only be created within databases where direct editing is allowed, such as GDB_DDev. This database role should not be created within those databases which are shared within the Enterprise VGIS System (refer to databases in bold-italics in Table 1). Some DBAs may choose to deviate from these guidelines, however, they should use caution.*

2.3.2. ArcSDE Databases and Instances (Ports): Several databases should be configured within MS SQL Server to store and manage GIS data shared within the Enterprise VGIS System. The MS SQL Server built-in “sa” (system administrator)



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account should own these databases. The “sde” login account should never own the databases (or be assigned as a “dbo” or “db_owner”)*⁶.

Prior to ArcSDE 9.0, all previous versions required the use of the Spatial Database Engine “sde” database. The sde database served as the master database, a container for all SDE and geodatabase tables. All non-sde databases containing spatial data (eg: GDB_VCGI, GDB_ANR, etc.) depended upon the sde database. ArcSDE 9.x introduces a “single database” model, which no longer requires an sde database. The older multi-database model is still supported, however, the single database model is the recommended configuration for Enterprise VGIS System partners (and the default for new 9.0 installations). This new model allows databases to be independent, meaning that any spatial database (eg: GDB_VCGI, GDB_ANR, etc.) has its own set of supporting spatial system tables (which was stored in the sde database prior to 9.0). At 9.0, one ArcSDE instance is equal to one ArcSDE database, meaning that there will be a dedicated service and port for each database. The “single database” model has the following benefits:

- Easier administration since each database represents only one instance.
- User permissions apply to a single database only.
- Backup and restore is easier since it pertains to only a single database.
- Databases can be detached and distributed without worrying about the sde database.

Table 1 defines databases and instances/services (and associated ports) which should be created⁷ and used to store spatial data. Database names should be a maximum of 10 characters*⁸. Those in ***bold-italics*** are shared with other ArcSDE installations within the Enterprise VGIS System. *Note: The following ports have*

⁶  It is not good practice to have SDE own the database, because they will become the dbo user. Having the SDE user associated with the DBO user causes complications in ArcSDE administration tasks that this user must perform. The SA user is a good choice for the owner of user databases.”

<http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=30472>

⁷ Use the ArcSDE Post-Installer to create these databases. Refer to the *ArcSDE Configuration and Tuning Guide for Microsoft SQL Server (ArcSDE 9.0)* for details.

⁸ Testing conducted by VCGI has identified an ArcSDE (on MS SQL Server 2000) “limitation” which limits the combined “login name + database name” to 32 characters. VCGI has consulted ESRI, however, they have not been to confirm or deny the limitation. VCGI recommends that login names (and database role names) be limited to 20 characters, and database names be limited to 10 characters.



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been reserved for ArcSDE services within the Enterprise VGIS System.

```
# Enterprise VGIS ArcSDE services/ports (5156-5164 unassigned based on IANA)
vcgi_sde      5156/tcp      #Service servicing GDB_VCGI data
anr_sde      5157/tcp      #Service servicing GDB_ANR data
vtrans_sde   5158/tcp      #Service servicing GDB_VTrans data
rpc_sde      5159/tcp      #Service servicing GDB_RPC data
accd_sde     5160/tcp      #Service servicing GDB_ACCD data
# ports 5161→5169 are reserved for other agencies as they come online
#
# Other ArcSDE services and ports (5169-5189 unassigned based on IANA)
ddev_sde     5170→5172/tcp #Service servicing GDB_DDev data
gen_sde      5173→5175/tcp #Service servicing GDB_Gen data
proj_sde     5176→5178/tcp #Service servicing GDB_Proj data
hist_sde     5179→5181/tcp #Service servicing GDB_Hist data
web_sde      5182→5184/tcp #Service servicing GDB_Web data
```

Table 1

Database	Purpose	Users/Roles/Permissions
<p>GDB_VCGI</p> <p>Service Name: <i>vcgi_sde</i> Port: 5156</p>	<p>Used to store VGIS data managed/warehoused by VCGI. <i>Data in this database is shared with other ArcSDE installations within the Enterprise VGIS System.</i></p>	<p>Database Roles sde_user = Select (member of db_datareader)</p> <p>Database Users VCGI_User = Shared account. Member of sde_user</p> <p>VCGI_<username> = Optional individual account. Member of sde_user</p> <p><agency>_User = Shared user account for other Agencies, such as ANR, VTrans, ACCD, etc. Member of sde_user</p> <p>VCGI_Admin = Administrative account</p> <ul style="list-style-type: none"> • Select/Insert/Update/Delete • CreateTable /CreateView/CreateSP/CreateFunction • Alternatively the account can be assigned to the db_owner database role. <p>sde = Special SDE account</p>



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		<ul style="list-style-type: none">• CreateTable /CreateView/CreateSP/CreateFunction
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<p>GDB_ANR</p> <p>Service Name: <i>anr_sde</i> Port: 5157</p>	<p>Used to store VGIS data managed by ANR. <i>Data in this database is shared with other ArcSDE installations within the Enterprise VGIS System.</i></p>	<p>Database Roles sde_user = Select (member of db_datareader)</p> <p>Database Users ANR_User = Shared account. Member of sde_user</p> <p>ANR_<username> = Optional individual account. Member of sde_user</p> <p><agency>_User = Shared user account for other Agencies, such as VCGI, VTrans, ACCD, etc. Member of sde_user</p> <p>ANR_Admin = Administrative account</p> <ul style="list-style-type: none"> • Select/Insert/Update/Delete • CreateTable /CreateView/CreateSP/CreateFunction • Alternatively the account can be assigned to the db_owner database role. <p>sde = Special SDE account</p> <ul style="list-style-type: none"> • CreateTable /CreateView/CreateSP/CreateFunction
<p>GDB_VTrans</p> <p>Service Name: <i>vtrans_sde</i> Port: 5158</p>	<p>Used to store VGIS data managed by VTrans. <i>Data in this database is shared with other ArcSDE installations within the Enterprise VGIS System.</i></p>	<p>Database Roles sde_user = Select (member of db_datareader)</p> <p>Database Users VTrans_User = Shared account. Member of sde_user</p> <p>VTrans_<username> = Optional individual account. Member of sde_user</p> <p><agency>_User = Shared user account for other Agencies, such as ANR, VCGI, ACCD, etc. Member of sde_user</p>



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		<p>VTrans_Admin = Administrative account</p> <ul style="list-style-type: none"> • Select/Insert/Update/Delete • CreateTable /CreateView/CreateSP/CreateFunction • Alternatively the account can be assigned to the db_owner database role. <p>sde = Special SDE account</p> <ul style="list-style-type: none"> • CreateTable /CreateView/CreateSP/CreateFunction
<p>GDB_RPC</p> <p>Service Name: <i>rpc_sde</i> Port: 5159</p>	<p>Used to store VGIS data managed by RPCs. <i>Data in this database is shared with other ArcSDE installations within the Enterprise VGIS System.</i></p>	<p>Database Roles sde_user = Select (member of db_datareader)</p> <p>Database Users RPC_User = Shared account. Member of sde_user</p> <p>RPC_<username> = Optional individual account. Member of sde_user</p> <p><agency>_User = Shared user account for other Agencies, such as ANR, VTrans, ACCD, etc. Member of sde_user</p> <p>RPC_Admin = Administrative account</p> <ul style="list-style-type: none"> • Select/Insert/Update/Delete • CreateTable /CreateView/CreateSP/CreateFunction • Alternatively the account can be assigned to the db_owner database role. <p>sde = Special SDE account</p> <ul style="list-style-type: none"> • CreateTable /CreateView/CreateSP/CreateFunction
GDB_ACCD	Used to store VGIS	Database Roles



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<p>Service Name: <i>accd_sde</i> Port: 5160</p>	<p>data managed by ACCD. <i>Data in this database is shared with other ArcSDE installations within the Enterprise VGIS System.</i></p>	<p>sde_user = Select (member of db_datareader)</p> <p>Database Users ACCD_User = Shared account. Member of sde_user</p> <p>ACCD_<username> = Optional individual account. Member of sde_user</p> <p><agency>_User = Shared user account for other Agencies, such as ANR, VTrans, VCGI, etc. Member of sde_user</p> <p>ACCD_Admin = Administrative account</p> <ul style="list-style-type: none"> • Select/Insert/Update/Delete • CreateTable /CreateView/CreateSP/CreateFunction • Alternatively the account can be assigned to the db_owner database role. <p>sde = Special SDE account</p> <ul style="list-style-type: none"> • CreateTable /CreateView/CreateSP/CreateFunction
<p>GDB_DDev or GDB_<Agency>_DDev*</p> <p>Service Name: <i>ddev_sde</i> Port: 5170 → 5172</p> <p><i>* It should be noted that this naming convention does not comply with the 10 character database naming limitation recommended earlier in these guidelines.</i></p>	<p>Used to store data under development. Data in this database is <u>not</u> part of the Enterprise VGIS System. The data must be copied to one of the databases in <i>bold-italics</i> if its to be part of the Enterprise VGIS System. <i>Data in this database is <u>not automatically</u> part of</i></p>	<p>Database Roles sde_user = Select (member of db_datareader) sde_editor =</p> <ul style="list-style-type: none"> • Select/Insert/Update/Delete • CreateTable /CreateView/CreateSP/CreateFunction <p>Database Users <agency>_User = Shared account. Member of sde_user</p> <p><agency>_<username> = Optional individual account. Member of sde_user</p>



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	<i>the Enterprise VGIS System.</i>	<p>and/or sde_editor</p> <p><agency>_Admin = Administrative account</p> <ul style="list-style-type: none">• Select/Insert/Update/Delete• CreateTable /CreateView/CreateSP/CreateFunction• Alternatively the account can be assigned to the db_owner database role. <p>sde = Special SDE account</p> <ul style="list-style-type: none">• CreateTable /CreateView/CreateSP/CreateFunction
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<p>GDB_Gen or GDB_<Agency>_Gen*</p> <p>Service Name: <i>gen_sde</i> Port: 5173 → 5175</p> <p><i>* It should be noted that this naming convention does not comply with the 10 character database naming limitation recommended earlier in these guidelines.</i></p>	<p>Used to store other GIS data for general purpose use by host agency users (in-house users). For example, if VTrans wanted to provide data to its users which VTrans didn't want to share with the rest of the Enterprise VGIS System, VTrans would store it in this database. <i>Data in this database is <u>not</u> part of the Enterprise VGIS System.</i></p>	<p>The Agency managing this database can choose from one of the following scenarios:</p> <p>Less restrictive option</p> <ul style="list-style-type: none"> • Same as GDB_DDev <p>More restrictive option</p> <ul style="list-style-type: none"> • Same as “shared” databases such as GDB_VCGI/ANR/VTrans/ACCD
<p>GDB_Proj or GDB_<Agency>_Proj*</p> <p>Service Name: <i>proj_sde</i> Port: 5176 → 5178</p> <p><i>* It should be noted that this naming convention does not comply with the 10 character database naming limitation recommended earlier in these guidelines.</i></p>	<p>Used to store project specific data. <i>Data in this database is <u>not</u> part of the Enterprise VGIS System.</i> The data must be copied to one of the databases in <i>bold-italics</i> if its to be part of the Enterprise VGIS System. <i>Data in this database is <u>not automatically</u> part of the Enterprise VGIS System.</i></p>	<p>Same as GDB_DDev.</p>



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<p>GDB_Hist or GDB_<Agency>_Hist</p> <p>Service Name: <i>hist_sde</i> Port: 5179 → 5181</p> <p><i>* It should be noted that this naming convention does not comply with the 10 character database naming limitation recommended earlier in these guidelines.</i></p>	<p>Used to store historical “snapshots” of data. <i>Data in this database is <u>not</u> part of the Enterprise VGIS System.</i></p>	<p>The Agency managing this database can choose from one of the following scenarios:</p> <p>Less restrictive option</p> <ul style="list-style-type: none"> • Same as GDB_DDev <p>More restrictive option</p> <ul style="list-style-type: none"> • Same as “shared” databases such as GDB_VCGI/ANR/VTrans/ACCD
<p>GDB_Web or GDB_<Agency>_Web</p> <p>Service Name: <i>web_sde</i> Port: 5182 → 8184</p> <p><i>* It should be noted that this naming convention does not comply with the 10 character database naming limitation recommended earlier in these guidelines.</i></p>	<p>Used to store data specifically designed to supported web mapping applications. This would include data which isn’t included in any of the other databases because they do not support a general set of requirements, or they have been customized specifically for a given web mapping application. <i>Data in this database is <u>not</u> part of the Enterprise VGIS System.</i></p>	<p>The Agency managing this database can choose from one of the following scenarios:</p> <p>Less restrictive option</p> <ul style="list-style-type: none"> • Same as GDB_DDev <p>More restrictive option</p> <ul style="list-style-type: none"> • Same as “shared” databases such as GDB_VCGI/ANR/VTrans/ACCD

NOTE: Those Agencies who are part of the Enterprise VGIS System will have their data stored in separate databases (ex: GDB_VTrans for data that VTrans has agreed to maintain in compliance with Enterprise VGIS Standards). Otherwise data provided to VCGI by other organizations will be loaded into GDB_VCGI.



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2.3.3. ArcSDE Log Files: There are three ArcSDE logfile configuration options; 1) standalone, 2) shared, and 3) session-based. These guidelines recommend the use of session-based logfiles. When using MS SQL Server, session-based logfiles should be configured to use the tempdb database. This scenario has the following benefits:

- Does not increase transaction log load.
- Transaction logging is more efficient in tempdb.
- There are no additional tables to manage.
- All temporary tables are deleted on disconnect.

Session-based logging using the tempdb database can be configured via the “sdeconfig” command. Use sdeconfig to set the following parameters as follows:

- ALLOWSESSIONLOGFILE = TRUE
- LOGFILEPOOLSIZE = 0

Verify that the SESSION_TEMP_TABLE keyword is set to 1 in the SDE_dbtune table (use the “sdedbtune” command to export the configuration). Update as needed (set SESSION_TEMP_TABLE = 1).

2.3.4. Memory Configuration & Management: The DBA needs to properly configure and manage both server memory (RAM) and SQL server’s utilization of memory. DBA’s should consider the following recommendations:

- **Server Memory:** The server hosting MS SQL Server should contain at least 2.0 GIGs of RAM. The DBA should also consider the following formula when determine how much RAM they will need:
 - $((\text{Number_of_concurrent_Users} * \text{Number_of_connections}) * 12\text{mb}) = \text{Total_RAM_for_SDE}$
 - Each SDE instance results in a “giomgr” process, and each user connection to SDE creates a “gsrv” process. So here is a scenario.
 - Joe needs to create a map using ArcMap
 - Joe connections to GDB_VCGI + GDB_ANR + GDB_VTrans. 3 separate connections to 3 different instances/ports.
 - Each connection spawns a “gsrv” process, making 3 “gsrv”

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processes for Joe.

ESRI recommends allocating 12mb per “gsrv” process. So if you have a maximum of 30 simultaneous users on the system (connecting to 3 databases), you would need to allocate the following amount of memory.

Example: $(30 * 3) * 12\text{mb} = 1080\text{mb}$

- **Setting the Windows SharedSection:** “If an error message window entitled “gsrvr.exe – DLL Initialization Failed” is displayed on the ArcSDE application server stating that “Initialization of the dynamic link library WINNT\system32\COMCTL32.dll failed. The process is terminating abnormally”, you need to increase the Windows SharedSection for noninteractive desktops.



On Windows, the ArcSDE service is started as a noninteractive desktop. The maximum amount of heap memory allocated to noninteractive desktops is limited by a Windows initialization parameter called SharedSection. This parameter is altered using the Windows registry editor.

To change the SharedSection, click Start, then Run. Enter regedit in the input line, then click OK. Navigate to the following registry path and double-click the Windows registry.

\\HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Session Manager\SubSystems\Windows

This string contains startup parameters for Windows. Within the string you



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will find the SharedSection parameter.

The default value is 1024,3072,512. The third argument is the maximum amount of heap memory allocated to noninteractive desktops. By default it is set to 512 kilobytes or one megabyte. At this setting, an ArcSDE application server will accept approximately 56 connections. Increasing the maximum heap size of noninteractive desktops to two megabytes allows the ArcSDE application server to accept up to 270 connections. The SharedSection value would be 1024,3072,2048 when the noninteractive heap size is set to two megabytes.

The maximum amount of heap memory available for all desktops both interactive and noninteractive is 48 megabytes. Since the amount of memory is finite, you should take care in adjusting the SharedSection parameter.

The Windows server must be rebooted to accept a new SharedSection value.

For more information, consult the "Kernel32.dll initialization failure" or "User32.dll initialization failure" in the Microsoft Development Network (MSDN)."

- **Limit SQL Server memory consumption*⁹:** By default, SQL Server will use as much memory as it requires. On busy systems, SQL Server can force other applications, including ArcSDE, to page, compromising their response time and scalability. Consider limiting SQL Server's memory consumption by using a fixed memory size or setting a maximum memory size. To do this, right-click the server in the Enterprise Manager and click Properties. Within the Properties page, click the Memory tab and hard code a memory limit or set an upper boundary to 50 percent of total RAM. Adjust up or down as necessary.

2.4. GIS Data Layers

2.4.1. Data Layer Tiling Schemes: There are cases in which VGIS data is tiled

⁹ This information came from ESRI's "ArcSDE Configuration and Tuning Guide for MS SQL Server".



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(chopped up into chunks). This is usually done for either data management reasons (eg: VHD tiled by SUBBASIN), or to support faster/easier downloads (for large datasets, or in cases where users prefer a certain tile structure).

The following tiling schemes are used:

<u>Tile Scheme</u>	<u>Description</u>
QUAD	Individual 7.5-minute USGS quadrangles based on NAD83 coordinates.
QQUAD	7.5 minutes USGS quadrangles divided into quarters
QUAD16	Blocks of sixteen 7.5-minute USGS quadrangles (4 X4); based on NAD83 coordinates.
TOWN	One layer for each town (including cities and gores)
COUNTY	One data layer for each county.
RPC	One data layer for each RPC area.
STATE	Statewide data layers (single layer, no tiles)
SUBBASIN	NRCS eight digit Cataloging Units corresponding to major sub_basins in Vermont.
NONE	No tile structure; a single data layer that is not statewide and does not conform with any of the schemas listed above.

2.4.2. Data Layer Storage Formats: GIS data layers should be managed as either *feature datasets* (FDS) or *standalone feature classes* within ArcSDE. Feature datasets support more advanced storage and management options (such as topology) ESRI documentation indicates that feature datasets can degrade overall application performance*¹⁰. As a result, administrators should avoid overloading feature datasets with many feature classes (generally 3 or less feature classes per FDS)*¹¹.

¹⁰ “Use feature data sets to group classes that have topological relationships with each other (i.e., geometric networks and shared boundaries). Beyond that, don't overload feature data sets with lots of feature classes. Having stand-alone feature classes (at the database level) is perfectly acceptable. If you do want to group your classes into feature data sets, try to group feature classes based on those that are used together in your applications.” http://downloads.esri.com/support/whitepapers/ao/Multiuser_GIS_with_AI8.pdf - “Designing Your Database: Feature Data Sets”

¹¹ Feature datasets (FDS) can also introduce “table locking” issues. For example, a user will be denied an attempt at deleted the first feature class (FC) within an FDS which contains two feature classes while another user is accessing the second feature class. However, in practice these kinds of scenarios don't occur very often (based on VCGI's experience). VCGI has also conducted some testing which shows that ArcSDE “views” can be used as a workaround to this problem (if a user access the “view” instead of the FC, the table/FC will not be locked). VCGI has hypothesized that ArcSDE “views” could also be used to eliminate the FDS “performance issue” for FDS's containing many FCs. However, VCGI has not tested this theory.



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Note: Data layers stored within those databases that are shared within the Enterprise VGIS System (eg: GDB_VTrans, GDB_ANR, GDB_ACCD, GDB_VCGI) should always store feature classes (FCs) *within* feature datasets (FDS). The FDS and FC names must comply with the specifications define in section 2.4.4 *Data Layer Naming Convention*.

There are cases in which the “master” may be managed as an ArcInfo coverage, shapefile, or Personal Geodatabase, and only a copy is stored in ArcSDE for use by VGIS users.

2.4.2.1. Geodatabase Subtypes, Domains, and Relationships: Geodatabases provide advanced functionality including the ability to define feature subtypes, domains, and relationships. Subtypes are used to define default field values and valid domains. Relationships were used to define associations between spatial objects and nonspatial objects. Relationships can be used to define associations between features classes and tables (refer to the *Associated Tables* section below).

2.4.2.1.1. Domain Storage Conventions: Domains are available globally within each ArcSDE database. For example, lets say you setup a domain for TOWNNAME, this domain would become available globally, enabling all users to associate the domain with a TOWNNAME field in their own layer. It eliminates the need to create duplicate domains for each layer which shares a common attribute. Given this reality, the following naming convention should be used for data that is shared between ArcSDE servers.

Domain Name = <LayerName>_<FIELDNAME>

An example, if I created a domain for bike path TYPE in the Trans_BIKEPATH_line layer, I would call the domain
Trans_BIKEPATH_TYPE

or if the Domain will be used as a generic domain, such as TOWNNAME, then use the following convention



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Domain Name = Generic_<FIELDNAME>

An example would be Generic_TOWNNAME

Notes:

- When a new domain is created, the owner of that domain—that is, the user who created it—is recorded. Only the owner of an attribute domain can delete or modify it.
- Domains can be associated with particular fields for a feature class or table, or for a subtype of a feature class or table. While a domain is being used by a table or feature class, it can't be deleted or modified.
- You should remove domains once they are no longer in use.

2.4.2.2. ArcSDE Views: Views are stored queries or virtual tables that essentially render derivative data layers (“views”) on the fly (ex: TOWNBND is derived from BNDHASH based on the stored query parameters). If BNDHASH is updated TOWNBND will be automatically updated. This approach enables alternative views of the same dataset while ensuring that they are kept up-to-date whenever the parent dataset is updated. *NOTE: It should be noted that ArcSDE views are not transferred when data is exchanged between ArcSDE servers (depending on how the transfer is made). The host agency managing the ArcSDE server may need create their own ArcSDE views. However, scripts (BAT files) used to create ArcSDE views can be shared between partner organizations.*

2.4.3. Data Layer Theme Categories: Data layers can be assigned to one or more theme categories based on the top level ISO 19115 theme categories. Refer to Attachment A for a listing of themes and sub-themes.



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2.4.4. Data Layer Naming Convention: The following naming conventions are used for ArcSDE feature datasets and feature classes.

Feature Dataset: <Theme><Theme_sub>_<NAME>

For example the BNDHASH layer has the following *feature dataset* layer name: BoundaryOther_BNDHASH. This naming convention groups data by theme, making it easier for users connecting to an ArcSDE instance using ArcInfo, ArcView, ArcGIS, or ArcExplorer.

Standalone feature classes or the individual *feature classes* within each *feature dataset* have the following naming convention;

Feature Class: <Theme>_<NAME>_<featuretype>_<subtype>

For example, the line feature class in BNDHASH is named Boundary_BNDHASH_line. Feature types include poly, line, point, region, route, anno, and raster. _<subtype> handles cases in which a *dataset* has more than one feature type (ex: more than one route subclass, annotation subclass, annotation arrows, etc.).

Note: A slightly different naming convention is recommended for the following databases. However, DBA's may choose to deviate from these conventions since these databases will not be shared within the VT Enterprise GIS System.

- *Layers stored in the GDB_RPC SDE database will have a slightly modified naming convention (<Theme><Theme_sub>_<RPC><NAME>). An example would be DemoHousing_CCHOUSEPTS04 (feature class would be Demo_CCHOUSEPTS04_points).*
- *Layers stored in the GDB_Proj SDE database should have a slightly modified naming convention (<Project short name>_<NAME>). An example would be CAP_BIKEPATHS.*
- *Layers stored in the GDB_Web database use a similar naming convention (<WebAppName>_<NAME>). An example would be*



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VEM_CAROADS for the feature dataset and VEM_CAROADS_line for the feature class.

Names cannot exceed 32 characters according to ESRI documentation. Therefore <Theme>, <Theme_sub>, and <NAME> are limited to 10 characters each (2 characters will be saved for the underscore “_” spacers). It is recommended that the <NAME> be unique database wide. Tiled data sets must include the tile number as part of the <NAME>. Appended feature class associated with a tiled data set do not include the tile number part of the <NAME>.

2.4.5. Associated Tables: In the “good old days” lookup tables (INFO files) could be associated with ArcInfo coverages by using the following naming convention; **<covername>.<table>** (ex: LRS2000.MRDTABLE). This ensured that associated tables were maintained with the data whenever a coverage was copied or exported. There is no exact equivalent within a geodatabase (free tables can’t be stored within a feature dataset), however, *relationships* can be defined between feature classes and tables. Associated lookup tables can be linked to specific feature classes using a combination of defined *relationships* and the following naming conventions; **Table_<NAME>_<Tablename>**. For example, the associated LRS2000.MRDTABLE coverage INFO file would be renamed to **Table_LRS2000_MRDTABLE** and associated with **Trans_LRS2000_line** with a geodatabase *relationship*.

2.5. Managing end user ArcSDE connections with ArcGIS layer files (*.lyr): Most GIS end users would get confused by having to connect to a bunch of ArcSDE databases. They would also be confused by the database structure and naming. The solution is to create a library of ArcGIS layer files (*.lyr) which are pointers to the data with defined symbology, aliasing, labeling, joins, etc. Users can load layers by loading the LYR files instead of trying to browse for data in ArcSDE. Refer to section 3.5 for additional details.

3. ArcSDE Data Management Guidelines



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- 3.1. Overview:** An Enterprise Geodatabase (ArcSDE) is supported by a complex arrangement of hardware, software, databases, and applications. All of these components must be maintained. This includes maintaining and updating hardware, installing OS patches, upgrading software (eg: ArcSDE, MS SQL Server, etc.), updating and loading new data, etc. Without consistent maintenance the system becomes outdated. This section of this document outlines procedures (“best practices”) used to maintain all of these components.
- 3.2. ArcSDE Management:** Data must be maintained using tools and procedures that ensure the integrity of the data over time. ESRI has developed tools that can be used to administer ArcSDE. ArcSDE software must be upgraded from time to time. Regular tuning of the databases is also a good idea.
- 3.2.1. ArcSDE Admin tools:** There are two primary tools for ArcSDE administrator; 1) ArcCatalog and 2) command-line ArcSDE. ArcCatalog is used for most tasks, however, there are certain tasks which ArcCatalog can’t fulfill (eg: creating ArcSDE “views”, stop/starting ArcSDE, etc.). The SDE admin (example “vgisadmin”) account should be used to administer data layers. The “sde” account should be used when compressing ArcSDE databases and installing upgrades/patches.
- 3.2.2. ArcSDE Upgrades:** ArcSDE should be upgraded as needed to keep up with the latest releases or patches available from ESRI. Caution should be used when upgrading to ensure compatibility with other ESRI products, such as ArcGIS and ArcIMS. Agencies participating in the Enterprise VGIS System should coordinate upgrades whenever possible. Doing so will reduce version compatibility issues.
- 3.2.3. ArcSDE Performance tuning:** Regular tuning and tweaking ensures that ArcSDE is optimized to provide the best performance. Refer to the “ArcSDE Configuration and Tuning Guide for MS SQL Server” for details.
- 3.2.4. ArcSDE Database Compression:** ArcSDE databases should be compressed on a periodic basis. Databases which are used for data development (eg:GDB_DDev,



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GDB_Proj, etc.) tend to have more insert/update/delete transactions. These should be compressed more often than those databases that tend to be read only (eg: GDB_VCGI, GDB_ANR, GDB_VTrans). The DBA can compress the databases using ArcCatalog and specialized MS SQL Server scripts.

3.2.5. **ArcSDE Views:** ArcSDE views are layers derived from other layers “on-the-fly”. They are regular table views in MS SQL Server that are registered with the enterprise geodatabase as a layer. For example, Boundary_TWNBNDSPoly is an ArcSDE view created from Boundary_BNDHASH_region_towns. Views make it possible to create subsets without duplicating data or adding additional storage requirements. VCGI uses views in support of specific GIS applications.

ArcSDE views are created/deleted using ArcSDE command-line tools. The “sdetable” command is used to create/delete views and register them as geodatabase layers. Windows “Scheduler” can be used to setup jobs that periodically run BAT files which refresh all ArcSDE views. Each ArcSDE view is deleted and re-created to ensure that they are fully synced with the parent layer. That is usually only necessary when the parent layer has been updated or changed.

3.3. Loading, Updating, and Archiving Data

3.3.1. **Procedures:** ArcSDE database administrators should establish procedures to ensure that data is loaded, updated, and archived consistently. These procedures are especially critical for databases (eg: GDB_VCGI, GDB_ANR, GDB_VTrans, GDB_ACCD) which are shared within Enterprise VGIS System. The administrative accounts (eg: VCGI_Admin) defined in section 2.3.1.1 should be used to load data (they should own the tables/layers). VCGI has established a number of procedures, including

- Load/Update data procedures and checklist
 - *Note: Procedures should ensure consistent geodatabase ‘spatial domain and precision’ settings. This is critical!! VCGI uses a template layer (its actually a standalone feature class called “template_layer”) to enforce consistency. VCGI uses a statewide layer. The spatial domain and precision of any new feature dataset or feature class is set by importing the “template layer settings” into the new target data layer. Enterprise partners are encouraged to use the template layer*



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established by VCGI.

- Archiving data procedures and checklist.

VCGI can provide example procedure documents and checklist.

- 3.3.2. **VGIS data:** VGIS data includes data shared within the context of the Enterprise VGIS System. For example, data stored in the GDB_VCGI, GDB_ANR, GDB_VTrans, GDB_ACCD databases include only a subset of data layers which have been selected for sharing within the VGIS system. Other data used for specific applications or internal agency use is not considered VGIS data.

Database administrators should make sure they have a way of keeping track of the “master” data. For example, VCGI uses the VGIS Data Warehouse cataloging database to keep track of the “master” (format and location) for those datasets which are shared within the VGIS system. This helps to ensure that if the data needs to be updated that the master is updated, and not a rough copy.

- 3.3.2.1. **Geodatabase as master:** If the master dataset is stored within a geodatabase (ArcSDE Enterprise Geodatabase or Personal Geodatabase) then the data should be maintained using ArcGIS tools. This means that ArcGIS tools such as ArcCatalog and ArcMap (ArcEditor) should be used to manipulate the data. Database administrators (DBAs) should discourage direct editing of “live” production data (eg: stuff in GDB_VCGI, GDB_VTrans, GDB_ANR, GDB_ACCD etc.). Instead ArcCatalog should be used to copy the data to GDB_DDev or GDB_Proj, or into a temporary personal geodatabase. The data can then be updated via ArcMap/ArcEditor and then reposted to the production database.

Note: In certain circumstances DBAs may choose to enable direct editing of production data. This is best handled within the context of an Enterprise Geodatabases (aka: ArcSDE), however the DBA should use caution. A detailed understanding of ArcSDE versioning is critical to successful administration.

- 3.3.2.2. **ArcInfo Coverage as master:** If the master dataset is stored as an ArcInfo



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coverage you should use Workstation ArcInfo to manipulate the coverage. Once the data has been updated you can then load a revised copy into ArcSDE.

3.3.2.3. Shapefile as master: If the master is a SHP file you should use ArcView 3.x or ArcMap/ArcEditor to manipulate the file. A copy should then be loaded into ArcSDE.

3.3.2.4. Raster File as master: VCGI generally maintains raster data in ArcInfo GRID format. Sometimes its maintained in TIFF or some other image format (eg: BIP). Once updated the revised raster should be loaded into ArcSDE.

3.3.2.5. Historical Snapshots: One of the following methods should be used to retain historical snapshots (*The method used will be based on the best option relative to the nature and origins of the data*):

- The parent feature dataset/class can be renamed with a date stamp.
- *ArcSDE 9.2+ archive*¹² functionality can be used to retain history.

The following naming convention will be used in either case: Hist_<NAME><yyyymm>. For example a historical snapshot of EmergencyE911_ESITE would be named Hist_ESITE200103. The point feature class would be renamed from Emergency_ESITE_point to Hist_ESITE200103_point. Historical snapshots should be loaded into GDB_Hist.

3.3.3. Non -VGIS Data

3.3.3.1. Project specific data: In some cases ArcSDE is used to store and manage project specific data. The GDB_Proj database is used to store and manage such layers. Procedures should be established for project managers who wish to use ArcSDE for their project data.

3.3.3.2. Web mapping application data: ArcSDE can be used to store and manage data used by custom web mapping applications. The GDB_Web database is

¹² <http://www.esri.com/news/arcnews/summer05/articles/managing-spatial-data.html> - "Archiving Geodatabase History"



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used to store and manage such layers.

3.4. Data Exchange and Replication between Enterprise ArcSDE Servers:

3.4.1. Overview: As stated in the introduction of these guidelines, one of the primary goals of this document is to facilitate data exchange between Enterprise VGIS servers (ArcSDE servers). Agencies responsible for managing ArcSDE servers (such as ACCD, ANR, VTrans, and VCGI) have a need to share/exchange data. Moving and duplicating spatial data across an enterprise GIS has historically been a challenging endeavor. Exchanging and replicating data in an enterprise geodatabase (ArcSDE) environment adds additional requirements and challenges.

3.4.2. Data Exchange via PGDB/FileGDB option: The easiest and most simplistic way of exchanging data is to use import/export methods. A Personal (PGDB) or File (FileGDB) Geodatabase can be used as the “data exchange vehicle”. ArcCatalog can be used to copy/paste data from an Enterprise Geodatabase (eg: GDB_VCGI) into a PGDB/FileGDB (eg: GDB_VCGI.mdb). The PGDB/FileGDB can be transferred to another ArcSDE server by copying it over a network or using standard digital media (eg: DVD). The data can then be copy/pasted into the target ArcSDE database via ArcCatalog. The copy/paste routines can be automated, allowing import/export to be done during off-peak hours. There are some pros/cons to this approach:

- **Pros**
 - Simple “low tech” solutions.
 - Very reliable and low-risk method.
 - Copying the data directly to disk can minimize network impact.
 - Can be very secure since it does not require moving information across a WAN.
 - Good for data that is read-only and doesn’t change very often.
- **Cons**
 - Does not provide synchronous/real-time data replication.
 - No way of incrementally updating copies of the data.
 - Target database must be “flushed” before the new/revised data can be imported.
 - MS SQL Server “table locks” can sometimes preclude “flushing”, meaning that the connection(s) establishing the lock(s) need to be



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dropped before the data could be flushed.

- ArcGIS clients tend to establish table locks. ArcIMS services can sometimes establish “table locks”.
- Access permissions to the tables/layers must be reestablished.

3.4.3. Distributed Geodatabase Replication (ArcSDE 9.2): ESRI plans to support “distributed geodatabase replication” with the release of ArcSDE 9.2. It will extend the Distributed Editing capability to allow multiple version checkout and check-ins. The child replicas can be personal (PGDB) or enterprise geodatabase (ArcSDE). Figure 2 illustrates one scenario. There are some pros/cons to this approach:

- **Pros**
 - Incremental synchronization from parent to child geodatabases should reduce network bandwidth requirements.
 - Provides the potential for synchronous/near-real-time data replication.
 - No need to “flush” data before new data can be posted.
 - Access permissions are retained.
- **Cons**
 - New and unproven technology.
 - More complex implementation requiring greater coordination between partner agencies.
 - Higher-risk scenario (eg: sync problems).
 - Any “customizations” made to the target database would be overwritten.

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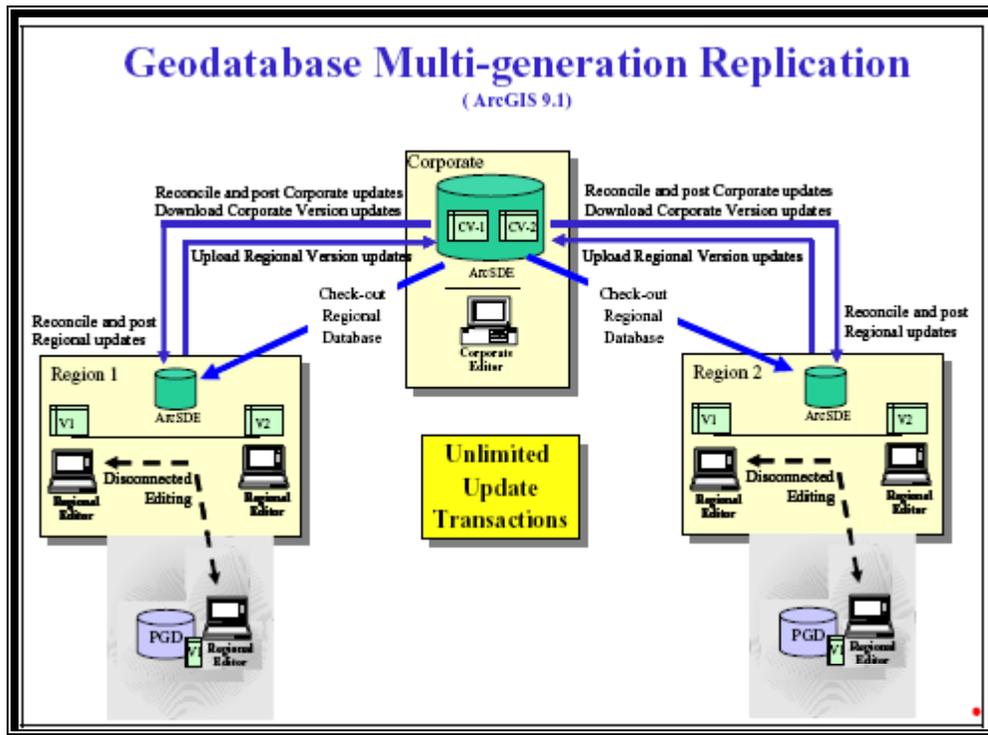


Figure 1 – Source: ESRI Systems Integration Technical Brief – “ArcSDE Geodatabase Replication Overview”

3.4.4. ArcSDE Import and Export Command Line Option: ArcSDE includes numerous command line tools, two of which enable exchange data between ArcSDE servers; 1) SDEEXPORT and 2) SDEIMPORT. SDEEXPORT and SDEIMPORT can be used with geodatabase simple featureclasses. However, SDEEXPORT and SDEIMPORT will not transfer geodatabase domains, rules, relationship classes, annotation featureclasses, complex edge featureclasses, simple edge featureclasses, dimension featureclasses, topology, or geometric networks¹³.

- **Pros**
 - Simple “low tech” solutions.

¹³ <http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=23427>



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- Reliable low-risk method.
- Copying the data directly to disk can minimize network impact.
- Can be very secure since it does not require moving information across a WAN.
- Good for data that is read-only and doesn't change very often.
- **Cons**
 - Does not support the transfer of certain geodatabase classes such as feature datasets, domains, rules, relationship classes, annotation feature classes, complex edge feature classes, simple edge feature classes, dimension featureclasses, topology, or geometric networks.
 - Does not provide synchronous/real-time data replication.
 - MS SQL Server “table locks” can sometimes preclude overwriting of data, meaning that the connection(s) establishing the lock(s) need to be dropped before the data could be flushed.
 - ArcGIS clients tend to establish table locks. ArcIMS services can sometimes establish “table locks”.
 - Access permissions to the tables/layers must be reestablished.

3.4.5. MS SQL Server Exchange & Synchronization option:

3.4.5.1. Detach/Attach: MS SQL Servers includes tools which enable DBAs to “detach” a database and then “reattach” it to another instance of SQL Server on another machine. This is a common data exchange and recovery strategy. Pros/Cons include:

- **Pros**
 - Relatively simple implementation.
 - Fast (much faster than export/import).
 - No need to “flush” the database being replaced. Just “detach” the old and “attach” the new.
 - Detached database can be copied to digital media, reducing network loads. Can be very secure since it does not require moving information across a WAN.
 - Proven methodology and technology.
 - Good for data which is read-only and doesn't change very often.

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- **Cons**
 - Logins must be synchronized (sp_change_Users_login) with the master database’s sysxlogins table.
 - Logins specific to the receiving agency (where the database is being attached) must be recreated. Unnecessary logins from the source agency (where the database was detached) would need to be deleted. All of this could be scripted.
 - Any “customizations” made to the target database would be overwritten.
 - Does not provide synchronous/real-time data replication.

3.4.5.2. Snapshot Replication: This option distributes data exactly as it appears at a specific point in time and does not monitor for updates to the data. Snapshot replication consists of Publishers and Subscribers. Publishers “publish” snapshots that Subscribers “subscribe” to. Snapshot replication is best used for replicating data that changes infrequently or where the most up-to-date values are not required. When synchronization occurs, the entire snapshot is generated by the Publisher and sent to Subscribers.

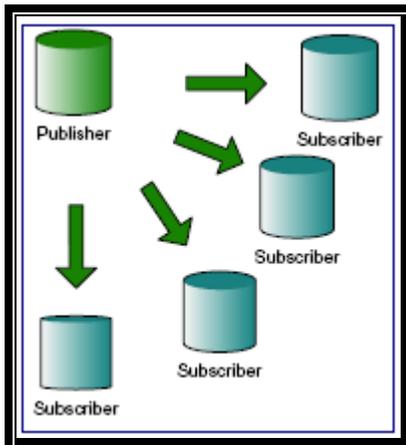


Figure 2 - Source: ESRI Systems Integration Technical Brief – “ArcSDE Geodatabase Replication Overview” – Rev 3

- **Pros**
 - Good for data that is read-only and doesn’t change very often.



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- Fully automated process, reducing DBA handling.
- Good for changes which are substantial but infrequent (eg: revised E911 data).
- **Cons**
 - Snapshots can be large, creating network load issues.
 - Not appropriate for sites that need real-time data replication.
 - More complex implementation requiring greater coordination between partner agencies.
 - Limited to read-only databases. Subscribers would not be able to “customize” their copy (eg: create ArcSDE “views, etc.).

3.5. ArcMap layer files and templates: Most ArcGIS users have trouble browsing and using data in ArcSDE. The best approach is to create ArcMap “layer files” and “templates”.

3.5.1. ArcMap Layer Files: ArcMap layer files reference geographic data stored on disk. They can reference many different kinds of data sources, including ArcSDE feature classes. Layer files can also include defined symbology, table joins, and queries. You can think of them as cartographic views of your data. They are separate files on disk that have a .lyr extension.

3.5.1.1. Creating layer files: Layer files can be created for each feature class stored in ArcSDE. It is also possible to create layer files from ArcMap “group layers”. Layer files should be given descriptive user names (eg: “VT County Boundary (No Fill).lyr”). The files should also be organized into a logical directory structure. Theme-based organizational schemas to be the most intuitive. Figure 4 is an example of an ISO 19115 theme-based (refer to Attachment A) directory structure. VCGI and ANR currently use this schema.

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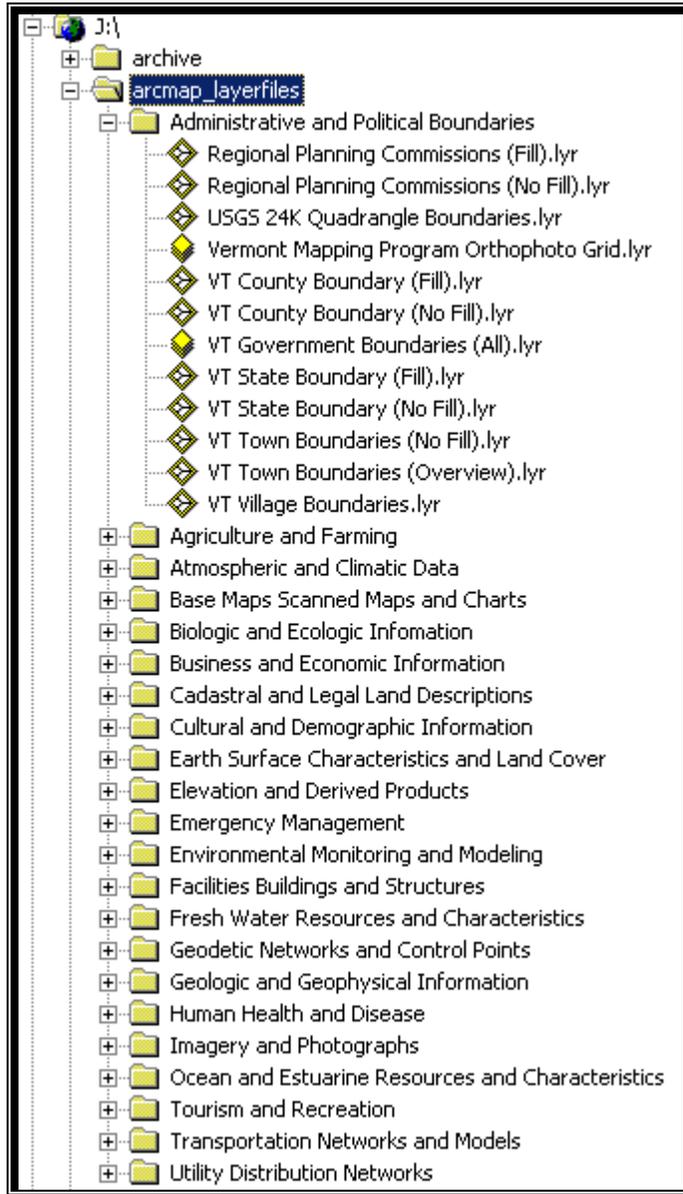


Figure 3 - Source: VCGI



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3.5.1.2. Maintaining layer files: Layer files should be revised whenever the name or schema (eg: field names) of a particular feature class changes.

3.5.1.3. Sharing layer files: Layer files can be shared across a network (eg: GovNet) or transferred on portable media (eg: CD). However, the underlying data referenced by the layer files must still be accessible. For example, shared layer files will fail if they are shared with an organization which does not have access to the same data source (eg: same ArcSDE server/instance or file system). It is still possible to share layer files in this kind of situation, however, the GIS administrator will need to re-point the layer files to the correct data source.

3.5.2. ArcMap basemap templates: An ArcMap template (*.mxt) includes a predefined set of GIS layers, symbology, scale rendering settings, layout settings, etc. It is the perfect solution for your typical GIS user, since it eliminates the need to manually load individual layers every time the users wants to create a new map. It essentially jump-starts their map session. It also allows agencies to apply a common look-and-feel to their maps (by deploying consistent symbology, logos, and layouts).

3.6. Backup and Recover: VCGI employs a two-tiered backup strategy for the ArcSDE data server. 1) SQL2000 backup tools (“BACKUP DATABASE” t-sql command) is used to backup database to disk, 2) NT Backup is used to backup the entire data server (including the SQL2000 backup files) to tape.

Backup System and Schedule: MS SQL Server transaction logs are backed-up and truncated after each database backup. Backups are saved to pre-defined backup devices (file devices). The following schedule is used

- **System databases** (master, model, and msdb): Full backup daily.
- **SDE databases:** Full backup on Friday; differential on Monday, Tuesday, Wednesday, Thursday.

The entire server is backed-up on a daily basis. NT Backup software is used to schedule and run the backups. Backups are written to tape. The following schedule is used:

- Full backup on Friday; differential on Monday, Tuesday, Wednesday, Thursday.



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- A separate tape is used for each Friday full. The last full Friday backups will be retained off site and kept for archival for 5 years.

Recover and Offline Storage: VCGI maintains offsite copies of the previous months last full backup. This helps to ensure that the servers can be restored in the event of fire or other catastrophic damage. Norton Ghost can be used to create disk images to augment standard tape backups. Rescue disks (emergency disks) are updated whenever new software is loaded onto the server (or other significant changes are made).

4. References:

- 4.1. *VGIS Data Warehouse – Backend Design* document (October, 2002) – VT Center for Geographic Information
- 4.2. *ESRI Systems Integration Technical Brief – ArcSDE Geodatabase Replication Overview* – May 2005 - Rev 3 – Environmental System Research Institute, Inc.
- 4.3. *Microsoft SQL Server Online Books* – Microsoft Corporation.
- 4.4. *ArcSDE Configuration and Tuning Guide – ArcGIS 9* - Environmental System Research Institute, Inc.



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Attachment A VGIS Themes and Sub-Themes

List of adopted ISO 19115 Categories

- **Administrative and Political Boundaries:** 003 (Boundary)
 - (ISO metadata keyword = “boundaries”)
 - County: 003-0005 (County)
 - Regional: 003-0010 (Region)
 - State: 003-0015 (State)
 - Town: 003-0020 (Town)
 - Tiles: 003-0025 (Tile)
 - Other: 003-9999 (Other)
- **Agriculture and Farming:** 001 (Farm)
 - (ISO metadata keyword = “farming”)
 - Land: 001-0005 (Land)
 - Statistics: 001-0010 (Stats)
 - Other: 001-9999 (Other)
- **Atmospheric and Climatic Data:** 004 (Climate)
 - (ISO metadata keyword = “climatologyMeteorologyAtmosphere”)
 - Precipitation: 004-0005 (Precip)
 - Temperature: 004-0010 (Temp)
 - Other: 004-9999 (Other)
- **Base Maps, Scanned Maps and Charts:** 200 (Basemap)
 - (ISO metadata keyword = “imageryBaseMapsEarthCover”)
 - Landmarks: 200-0010 (Landmarks)
 - Nautical Charts: 200-0015 (Charts)
 - Scanned Maps: 200-0020 (Scanmaps)
 - Other: 200-9999 (Other)
- **Biologic and Ecologic Information:** 002 (Ecologic)
 - (ISO metadata keyword = “biota”)
 - Fauna: 002-0005 (Fauna)
 - Flora: 002-0010 (Flora)
 - Habitat: 002-0015 (Habitat)
 - Statistics: 002-0015 (Stats)



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- Other: 002-9999 (Other)
- **Cadastral and Legal Land Descriptions: 015 (Cadastral)**
 - (ISO metadata keyword = “planningCadastre”)
 - Conserved Lands: 015-0005 (Conserved)
 - Parcels: 015-0010 (Parcels)
 - Public Lands: 015-0015 (Publands)
 - Other: 015-9999 (Other)
- **Cultural and Demographic Information: 016 (Demo)**
 - (ISO metadata keyword = “society”)
 - Agricultural: 016-0005 (Farm)
 - Archeological: 016-0007 (Archeo)
 - Economic: 016-0010 (Economic)
 - Education: 016-0015 (Education)
 - Historical: 016-0017 (Historical)
 - Housing & Property: 016-0020 (Housing)
 - Natural Resources: 016-0025 (Natres)
 - Public Health: 016-0030 (Health)
 - Transportation: 016-0035 (Trans)
 - US Census: 016-0040 (Census)
 - Other: 016-9999 (Other)
- **Business and Economic Information: 005 (Econ)**
 - (ISO metadata keyword = “economy”)
 - Statistics: 005-0005 (Stats)
 - Other: 005-9999 (Other)
- **Earth Surface Characteristics and Land Cover: 201 (Land)**
 - (ISO metadata keyword = “imageryBaseMapsEarthCover”)
 - Land Use: 201-0005 (Landuse)
 - Land Cover: 201-0010 (Landcov)
 - Other: 201-9999 (Other)
- **Elevation and Derived Products: 006 (Elevation)**
 - (ISO metadata keyword = “elevation”)
 - Contours: 006-0005 (Contours)
 - DEMs: 006-0010 (DEM)
 - Slope: 006-0015 (Slope)
 - Other: 006-9999 (Other)



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- **Emergency Management: 991 (Emergency)**¹⁴
 - (ISO metadata keyword = “emergency”)
 - E911 Related: 991-0005 (E911)
 - Flood Plains: 991-0010 (Flood)
 - Natural Hazards: 991-0015 (Hazards)
 - Other: 991-9999 (Other)
- **Environmental Monitoring and Modeling: 007 (Environ)**
 - (ISO metadata keyword = “environment”)
 - Pollution: 007-0005 (Pollution)
 - Hazardous Materials: 007-0010 (Hazmat)
 - Managed Areas: 007-0015 (Mangareas)
 - Water Supply Source Protection Areas: 007-0020 (SPA)
 - Other: 007-9999 (Other)
- **Facilities, Buildings and Structures: 017 (Facilities)**
 - (ISO metadata keyword = “structure”)
 - Buildings (general): 017-0005 (Buildings)
 - Hospitals: 017-0010 (Hospitals)
 - Schools and Colleges: 017-0015 (Schools)
 - Other: 017-9999 (Other)
- **Fresh Water Resources and Characteristics: 012 (Water)**
 - (ISO metadata keyword = “inlandWaters”)
 - Hydrography - Rivers, Streams, Lakes and Ponds: 012-0005 (Hydro)
 - Wetlands: 012-0010 (Wetlands)
 - Other: 012-9999 (Other)
- **Geodetic Networks and Control Points: 013 (Geodetic)**
 - (ISO metadata keyword = “location”)
 - Benchmarks: 013-0005 (Benchmark)
 - Other: 013-9999 (Other)
- **Geologic and Geophysical Information: 008 (Geologic)**
 - (ISO metadata keyword = “geoscientificInformation”)
 - Bedrock Geology: 008-0005 (Bedrock)
 - Surficial Geology: 008-0010 (Surficial)
 - Soils: 008-0015 (Soils)

¹⁴ This category was created by VCGI. It isn't part of the ISO19115 standard.



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- Other: 008-9999 (Other)
- **Human Health and Disease:** 009 (Health)
 - (ISO metadata keyword = “health”)
 - Statistics: 009-0005 (Stats)
 - Other: 009-9999 (Other)
- **Imagery and Photographs:** 202 (Imagery)
 - (ISO metadata keyword = “imageryBaseMapsEarthCover”)
 - Aerial Photography: 202-0005 (Photos)
 - Satellite Imagery: 202-0010 (Satellite)
 - Other: 202-9999 (Other)
- **Ocean and Estuarine Resources and Characteristics:** 014 (Ocean)
 - (ISO metadata keyword = “oceans”)
 - Fauna: 014-0005 (Fauna)
 - Flora: 014-0010 (Flora)
 - Habitat: 014-0015 (Habitat)
 - Other: 014-9999 (Other)
- **Tourism and Recreation:** 203 (Tourism)
 - (ISO metadata keyword = “society”)
 - Recreational Sites: 203-0005 (Recreation)
 - Trails: 203-0010 (Trails)
 - Other: 203-9999 (Other)
- **Transportation Networks and Models:** 018 (Trans)
 - (ISO metadata keyword = “transportation”)
 - Air: 018-0005 (Air)
 - Marine: 018-0010 (Marine)
 - Pedestrian: 018-0015 (Pedestrian)
 - Rail: 018-0020 (Rail)
 - Road: 018-0025 (Road)
 - Statistics: 018-0030 (Stats)
 - Structures: 018-0035 (Structures)
 - Other: 018-9999 (Other)
- **Utility Distribution Networks:** 019 (Utility)
 - (ISO metadata keyword = “utilitiesCommunication”)
 - Power Generation: 019-0005 (Power)
 - Transmission: 019-0010 (Transmit)



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- Telecommunications: 019-0015 (Telecom)
- Other: 019-9999 (Other)