
Commonwealth of Virginia

Enterprise Technical Architecture (ETA)

Database Domain Report

Version 1.2, July 1, 2016

Prepared by:

Virginia Information Technologies Agency

ETA Database Domain Team

(This Page Intentionally Left Blank)

Database Domain Team Members

David Clark Virginia Department of Mental Health,
 Mental Retardation and Substance Abuse Services
 Chuck Crow VITA, Integration & Data
 Paul Dodson (Team Facilitator)..... VITA, Policy, Practice and Architecture
 David Froggatt VITA, Business Systems Services
 Todd Kissam VITA, Policy, Practice and Architecture
 Tony ShootNorthrop Grumman
 Eddie Wilmoth Virginia Department of Motor Vehicles

The Database Domain team began its work by delineating the team’s goals, objectives, and scope of work. Discussions included how the domain interfaces with other architecture domains, present and future directions, and how often the information provided in this document is to be updated. The team also reviewed input from publications and individuals with specialized knowledge. The results of the team’s efforts, research and deliberations are provided throughout this document.

Database Domain Report: Version History		
Revision	Date	Description
1.0	07-10-2006	Initial
1.1	09-11-2006	Reference added to text and Appendix A
1.2	07-01-2016	<i>Update necessitated by changes in the Code of Virginia and organizational changes in VITA. The changes are administrative. There are no substantive changes to the principles, recommended practices or requirements. However, Technology Component Standard in Table DB-S-01, Database and Other Data Access Methods was updated</i>

Review Process

Technology Strategy and Solutions Directorate Review

The domain report was reviewed and approved by ~~Jerry Simonoff, Director and Paul Lubie, the Associate Director of Policy, Practices, and~~ the Manager of the Enterprise Architecture Division.

Online Review

Participation of all Executive Branch agencies was encouraged through a review and comment period via VITA’s Online Review and Comment Application (ORCA). Technology businesses and the general public were also actively encouraged to use ORCA to provide comments. All comments were considered and many resulted in modifications to the final document. Additionally, the Domain team provided the reviewers with responses to their comments.

Identifying Changes in This Document

- See the latest entry in the revision table above
- Vertical lines in the left margin indicate the paragraph has changes or additions.
- Specific changes in wording are noted using italics and underlines; with italics only indicating new/added language and italics that is underlines indicating language that has changed.

The following examples demonstrate how the reader may identify requirement updates and changes:

EXA-R-01 **Technology Standard Example with No Change** – The text is the same. The text is the same. The text is the same.

EXA-R-02 **Technology Standard Example with Revision** – The text is the same. *A wording change, update or clarification is made in this text.*

EXA-R-03 **Technology Standard Example of New Standard** – *This standard is new.*

(This Page Intentionally Left Blank)

Table of Contents

Executive Summary of Database Domain	1
Overview	3
Commonwealth of Virginia: To-Be ETA	6
Definition of Key Terms	7
Agency Exception Requests	9
Database Domain Scope	11
Overall Database Domain Scope	11
Scope of this Report	12
As-Is Database Architecture	12
To-Be Database Architecture	14
Future Database Domain Initiatives	14
Domain-wide Principles, Recommended Practices and Requirements	15
Domain-wide Principles	15
Domain-wide Recommended Practices	15
Domain-wide Requirements	17
Database Domain Technical Topics	19
Database and Other Data Access Methods	19
Hierarchical Database	19
Networked Database	20
Relational Database	20
Object Oriented (Object) Database	21
Other Data Access Methods	21
Data Management	23
Data Recovery and Backup	23
Data Dictionary	25
Database Administration	25
Enterprise Information Integration (EII)	28
Database Design (Standards and Tools)	29
Data Modeling	30
Glossary	33
Appendix A: References and Links	35

(This Page Intentionally Left Blank)

Executive Summary of Database Domain

The Database Domain describes the technical topics and components for the software systems that support storage and retrieval of data; and for the types of database software that will support applications.

The mission of the database domain team was to create the Commonwealth principles, standards, requirements and recommended practices that address the technical topics and components for the software systems that support storage and retrieval of data; and for the types of database software that will support applications.

The audiences for the domain report are the business and technical leaders in state and local agencies (universities, colleges, and agencies from all branches of government) and those involved in agency application development and support activities. This information will assist those who make technical decisions related to databases and data management in being responsive to changing business needs and services.

Database requirements, standards and recommended practices are necessary to provide:

- a consistent growth direction for the Commonwealth as new applications are developed and to assist agencies who are planning to change existing applications and
- a common access through which agencies will be able to share information.

Although having single database products/tools might be the ideal, the reality is that agencies have unique information management needs. The application requirements, technical and economic environments of each business unit will have a strong influence upon database choices. Over time, hierarchical and networked databases will be migrated to or replaced with applications utilizing relational database technology. N-tiered and 3-tiered applications will decouple business logic from the data and accessing method allowing the Commonwealth to choose the most cost effective database product solutions and supporting platforms.

(This Page Intentionally Left Blank)

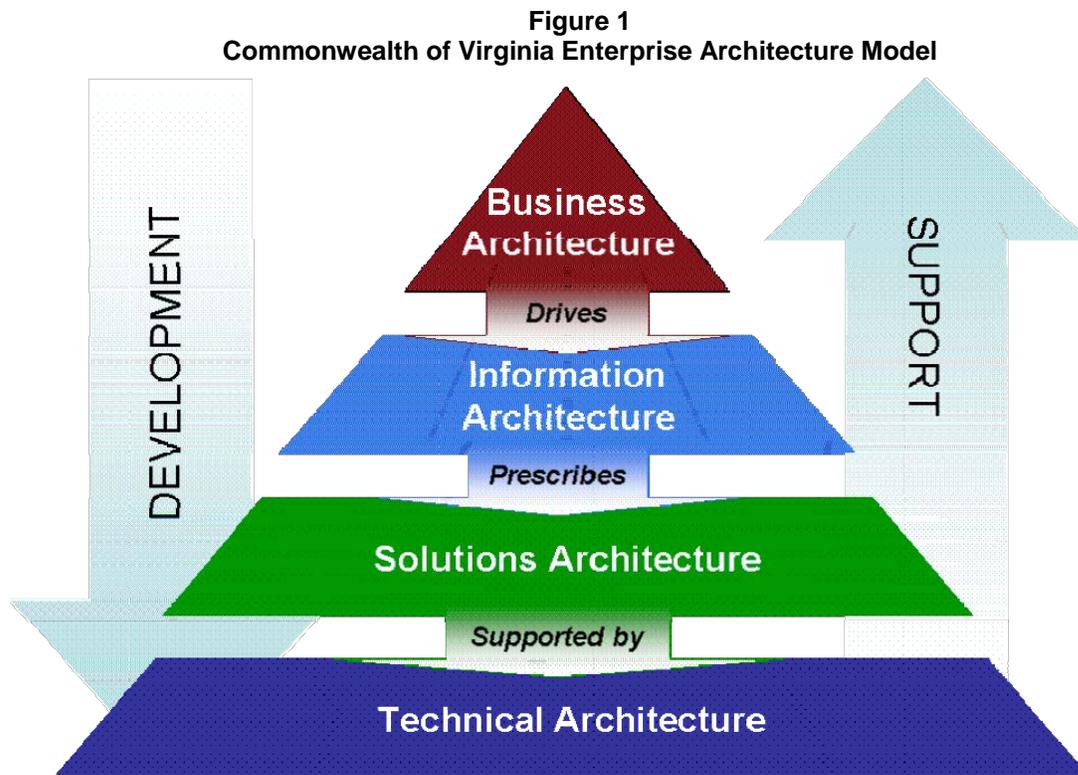
Overview

The Commonwealth's Enterprise Architecture is a strategic asset used to manage and align the Commonwealth's business processes and Information Technology (IT) infrastructure/solutions with the State's overall strategy.

The Enterprise Architecture is also a comprehensive framework and repository which defines:

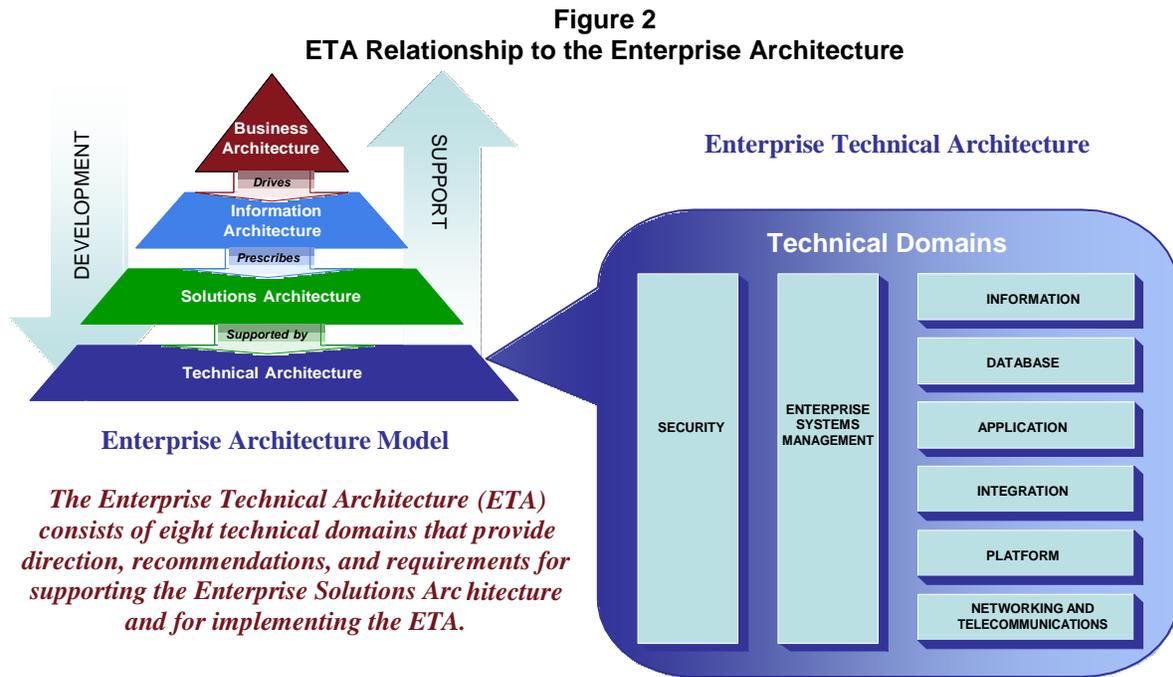
- the models that specify the current ("as-is") and target ("to-be") architecture environments,
- the information necessary to perform the Commonwealth's mission,
- the technologies necessary to perform that mission, and
- the processes necessary for implementing new technologies in response to the Commonwealth's changing business needs.

The Enterprise Architecture contains four components as shown in the model in Figure 1.



The Business Architecture drives the Information Architecture which prescribes the Solutions Architecture that is supported by the Technical (technology) Architecture.

The Enterprise Technical Architecture (ETA) shown in Figure 2 consists of eight technical domains that provide direction, recommendations and requirements for supporting the Solutions Architecture and for implementing the ETA. The ETA guides the development and support of an organization’s information systems and technology infrastructure.



Each of the domains is a critical piece of the overall ETA. The Networking and Telecommunications and Platform Domains address the infrastructure base and provide the foundation for the distributed computing. The Enterprise Systems Management, Database, Applications, and Information Domains address the business functionality and management of the technical architecture. The Integration Domain addresses the interfacing of disparate platforms, systems, databases and applications in a distributed environment. The Security Domain addresses approaches for establishing, maintaining, and enhancing information security across the ETA.

This report addresses the Enterprise Technical Architecture Database Domain and includes requirements and recommended practices for [Virginia’s agencies](#)^{1, 2}.

¹ This report provides hyperlinks to the domain report Glossary in the electronic version. In the electronic and printed versions, the hyperlinks will have the appearance established by the preferences set in the viewing/printing software (e.g., Word) and permitted by the printer. For example, the hyperlinks may be blue and underlined in the screen version and gray and underlined in the printed version.

²The Glossary entry for agency is critical to understanding ETA requirements and standards identified in this report and is repeated here. **State agency or agency** - Any agency, institution, board, bureau, commission, council, or instrumentality of state government in the executive branch listed in the appropriation act. ETA requirements/standards identified in this report are applicable to all agencies

This report was developed by the Database Domain team, which was commissioned to identify domain related requirements and recommendations. Identified requirements and technology product standards from this domain report ~~will~~ *were* be combined with requirements and technology product standards from other technical domain reports into a single ETA Standard in 2006 for review and acceptance by the Information Technology Investment Board (ITIB). *In 2010 the ITIB was replaced by the Information Technology Advisory Council (ITAC).*

Concerning local governments, courts, legislative agencies, and other public bodies, while they are not required to comply with a requirement unless the requirement is a prerequisite for using a VITA service or for participating in other state-provided connectivity and service programs, their consideration of relevant requirements is highly recommended. This architecture was designed with participation of local government and other public body representatives with the intent of encouraging its use in state and local interconnectivity efforts.

including the administrative functions (does not include instructional or research functions) of institutions of higher education, unless exempted by language contained in a specific requirement/standard.

Commonwealth of Virginia: To-Be ETA

The to-be Enterprise Technical Architecture envisioned for the Commonwealth will be one where the Commonwealth's citizens and other customers who wish to access Virginia services will do so by utilizing an Enterprise Portal via standard web browsers.

Where appropriate, these online government services will be developed, delivered and supported using a Service-Oriented Architecture (SOA) based on open and industry standard solutions. Selected legacy applications will be exposed to the SOA using web services.

The SOA will be supported by an Enterprise Service Bus that provides Orchestration and Choreography Services to the agencies.

Central integration and coordination will be managed by an Integration Competency Center (ICC) that supports agency needs such as: asynchronous message queuing and persistence.

Large complex *mission critical* applications that need to be reliable, scalable, secure and highly available will be n-tiered and will utilize business rule and workflow engines.

Enterprise application software for the core government administrative business functions will be consolidated and the underlying business processes modernized. An Application Management Center of Excellence will service and manage the new enterprise applications that replace existing legacy and silo-based applications.

Data will be exchanged among systems, agencies, institutions of higher learning, localities, the federal government, and partners using XML based standards such as the Global Justice XML Data Model and the National Information Exchange Model.

The number and types of software tools and products used by the Commonwealth will be decreased to reduce complexity. This will create the opportunity for agencies to refocus their current in-house IT resources to achieve higher levels of expertise on the fewer required products resulting in, among other benefits, a lower dependence on outside contractors.

Agency software applications and customer services will be delivered and supported by an IT infrastructure that will:

- Be responsive, agile, modular, scalable, reliable, secure, and highly available (24x7)
- Utilize ITIL (IT Infrastructure Library) best practices
- Have extensive and proactive technology refreshment
- Utilize a shared services model for technology delivery
- Have a single secure state-wide [network](#) and Intranet
- Have a state-of-the-art data center and back-up facility
- Consolidate agency servers in their most cost-effective locations

- Unify statewide electronic mail services
- Employ innovative procurements, supplier partnerships, and financing arrangements to fund, expedite, and ensure the performance of future initiatives
- Provide a statewide customer care center
- Improve the cost performance of IT utilized by the Commonwealth

Transition:

The Commonwealth will transition from silo-based, application centric and agency centric information technology investments to an enterprise approach where applications are designed to be flexible. This allows agencies to take advantage of shared and reusable components, facilitates the sharing and reuse of data where appropriate, and makes the best use of the technology infrastructure that is available.

The implementation of the to-be architecture will take some time. It is not the intent of the Commonwealth to force agencies to replace their existing systems. The migration to the to-be architecture will occur as Agencies consider new information technology investments or make major enhancements/replacements to their existing systems. It is important to note that the Commonwealth ETA is not static; it needs to continue to evolve to support changing business strategies and technology trends.

Rationale:

Agencies can achieve the following benefits resulting from the Commonwealth's implementation of the ETA:

- Better responsiveness to changing business needs and rapidly evolving information technologies.
- Greater ease of software application integration and application interfacing.
- Easier secure access to data and information to enable interagency collaboration and sharing.
- Increased levels of application interoperability within the Commonwealth, with other states and municipalities, and with the Federal government.
- Increased sharing and re-use of current information technology assets.
- Faster deployment of new applications.
- Reduction in costs required to develop, support and maintain agency applications.

Definition of Key Terms

All of the Database Domain ETA standards and requirements considered to be critical components for implementing the Commonwealth's ETA are included in this report.

The report presents three forms of technical architecture guidance for agencies to consider when planning or when making changes or additions to their information technology:

- Requirements – mandatory enterprise technical architecture directions. All requirements are included within the ETA Standard.
- Technology Component Standard Tables - indicate what technologies or products that agencies may acquire at a particular point in time. These are mandatory when acquiring new or replacing existing technology or products. All technology component standard tables are included within the ETA Standard.
- Recommended Practices - provided as guidance to agencies in improving cost efficiencies, business value, operations quality, reliability, availability, decision inputs, risk avoidance or other similar value factors. Recommended Practices are optional.

The following terminology and definitions are applicable to the technology component standard tables presented in this report:

Strategic:

This technology is considered a strategic component of the Commonwealth's Enterprise Technical Architecture. It is acceptable for current deployments and shall be used for all future deployments.

Emerging:

This technology requires additional evaluation in government and university settings. This technology may be used for evaluative or pilot testing deployments or in a higher education research environment. Any use, deployment or procurement of this technology beyond higher education research environments requires an approved *Commonwealth Enterprise Technical Architecture Exception*. The results of an evaluation or pilot test deployment should be submitted to the **VITA Technology Strategy and Solutions Relationship Management and Governance: Policy, Practice and Enterprise Architecture Division** for consideration in the next review of the Enterprise Technical Architecture for that technology.

Transitional/Contained:

This technology is not consistent with the Commonwealth's Enterprise Technical Architecture strategic direction. Agencies may use this technology only as a transitional strategy for moving to a strategic technology. Agencies currently using this technology should migrate to a strategic technology as soon as practical. A migration or replacement plan should be included as part of the Agency's IT Strategic Plan. New deployments or procurements of this technology require an approved *Commonwealth Enterprise Technical Architecture Exception*.

Obsolescent/Rejected:

This technology may be waning in use and support, and/or has been evaluated and found not to meet current Commonwealth Technical Architecture needs. Agencies shall not make any procurements or additional deployments of this technology. Agencies currently using this technology should plan for its replacement with strategic technology to avoid substantial risk. The migration or replacement plan should be included as part of the Agency's IT Strategic Plan.

Agency Exception Requests

Agencies that desire to deviate from the requirements or the technology component standards specified in this report shall request an exception for each desired deviation and receive an approved *Enterprise Technical Architecture Change/Exception Request Form* prior to developing, procuring, or deploying such technology or not complying with a requirement specified in this report. The instructions for completing and submitting an exception request are contained within the *Commonwealth Enterprise Architecture Policy*.

(This Page Intentionally Left Blank)

Database Domain Scope

Overall Database Domain Scope

The mission of the database domain team was to create the Commonwealth principles, standards, requirements and recommended practices that address the technical topics and components for the software systems that support storage and retrieval of data; and for the types of database software that will support applications.

Database requirements, standards and recommended practices are necessary to provide:

- a consistent growth direction for the Commonwealth as new applications are developed and to assist agencies who are planning to change existing applications and
- a common access through which agencies will be able to share information.

The audiences for the domain report are the business and technical leaders in state and local agencies (universities, colleges, and agencies from all branches of government) and those involved in agency application development and support activities. This information will assist those who make technical decisions related to databases and data management in being responsive to changing business needs and services.

The domain report represents the work and decisions of the 2005-2006 Database Domain Team. The domain team identified two technology topics:

- 1) Database and Other Data Access Methods
- 2) Data Management

Each of these topics was sub-divided into components as follows:

Database and Other Data Access Methods Topic Components:

- Hierarchical
- Networked
- Relational
- Object-oriented (Object)
- Other data access methods

Data Management Topic Components:

- Data Recovery and Backup
- Data Dictionary
- Database Administration
- Enterprise Information Integration (EII)
- Database Design (Standards and Tools)
- Data Modeling

In general, the document provides assistance to agencies in the following ways:

- Recommendations that will improve future data management
- Recommendations that will improve the future choice and utilization of database access methods
- Descriptions of the current state of database and other access methods
- A glossary
- Web links for more information

Scope of this Report

This report addresses all of the technology topics and components identified above.

As-Is Database Architecture

The data available for describing current database and other data access methods in the Commonwealth is from information compiled for the 2003 and 2004 due diligence effort in preparation for negotiating partnerships with several companies interested in helping the Commonwealth modernize its infrastructure (this data does not include higher education). The agencies reported that 800 of their over 1,600 applications used database or other data access methods.

<i>Database, Other Data Access Product</i>	<i>Vendor Product Description</i>	<i>Reported Agency Usage</i>	
		<i>2002</i>	<i>2003</i>
Access	Access provides a powerful set of tools for rapidly building complete database management systems.	365	113
Adabas	Adabas is Software AG's advanced database management system that delivers high transaction throughput while ensuring integrity and flexibility.	32	76
Advanced Revelation	Advanced Revelation is a DOS development environment that combines a powerful and flexible database management system with a suite of professional development tools including: forms designer, report writers, and a Basic compatible programming language.	2	2
DB2	DB2 Universal Database is the database management system that delivers a flexible and cost-effective database platform to build robust on demand business applications. DB2 UDB further leverages your resources with broad support for open standards and popular development platforms like J2EE and Microsoft .NET.	5	6
dBase	dataBased Intelligence, Inc. (dBI) is the legal heir to the dBASE legend. Created over a quarter century ago, by the founders of Ashton-Tate, and popularized by Borland, dBASE is the world's most accepted database standard.	1	1

Database, Other Data Access Product	Vendor Product Description	Reported Agency Usage	
		2002	2003
DMS 2200	Networking Database on Unisys Platform (usually accessed by Cobol applications)	3	3
Filemaker Pro	FileMaker Pro is a easy-to-use database software that effortlessly manages all your information.	3	1
FoxPro	Visual FoxPro 9.0 includes a data-centric, object-oriented language gives you a robust set of tools for building database applications for desktop computers, client-servers, or Web services.	66	11
IMS	IBM's premier transactional and hierarchical database management system for critical on-line operational and e-business applications and data.	4	4
Informix	IBM Informix® software delivers superior application performance for transaction intensive environments.	4	7
KB_SQL	KB_SQL is a high-performance, SQL/ODBC and reporting environment for M Technology (MUMPS) databases.	0	2
MAPPER	Now called BIS - Business Information Server: Business Information Server software stores data in folders containing reports in drawers of "electronic file cabinets".	29	25
MySQL	The MySQL database server is the world's most popular open source database. Over six million installations use MySQL to power high-volume Web sites and other critical business systems	0	1
Oracle	With Oracle Database 10g, the first relational database designed for Grid Computing, your information is always available and secure. Oracle Database 10g lowers the cost of ownership through automated management while providing the highest possible quality of service.	136	310
Paradox	Paradox - relational database with power and programmability (formally a Borland Product)	1	2
Pervasive.SQL	Pervasive PSQL is a powerful, embeddable, low TCO database engine featuring navigational access through the Btrieve API.	0	1
Rbase	The industrial-strength, multi-user, multi-platform, true-relational database management system.	0	3
SQL Server	SQL Server 2000 provides a powerful and comprehensive data management platform. Every software license includes extensive management and development tools, a powerful extraction, transformation, and loading (ETL) tool, business intelligence and analysis services, and new capabilities such as Notification Services.	137	209
Sybase (SQL Anywhere)	Market-leading data management and enterprise data synchronization solution. It enables the rapid development and deployment of database-powered applications for mobile, remote, and small- to medium-sized business environments.	4	2

Database, Other Data Access Product	Vendor Product Description	Reported Agency Usage	
		2002	2003
TurboImage	ALLBASE/SQL provides a functionally rich, high-performance relational database management system for HP e3000 business servers.	0	13
UniVerse	IBM UniVerse® is an extended relational database designed for embedding in vertical applications.	1	13
VMS RDB	Oracle Rdb is a full-featured, relational database management system for mission-critical applications on OpenVMS platforms.	0	2
VSAM	VSAM is a file system used in IBM's MVS, OS/390 and ZOS operating systems. It offers standard sequential files, keyed or indexed files, and files whose records are retrieved by number, as well as other types used primarily by database management systems.	4	9

To-Be Database Architecture

Although having single database products/tools might be the ideal, the reality is that agencies have unique information management needs. The application requirements, technical and economic environments of each business unit will have a strong influence upon database choices. Over time, hierarchical and networked databases will be migrated to or replaced with applications utilizing relational database technology. N-tiered and 3-tiered applications will decouple business logic from the data and accessing method allowing the Commonwealth to choose the most cost effective database product solutions and supporting platforms.

Future Database Domain Initiatives

Future versions of this report may expand on the following Data Management components by exploring products and tools, techniques, practices, and examples:

- Data Dictionary
- Enterprise Information Integration (EII)
- Database Design (Standards and Tools)

Domain-wide Principles, Recommended Practices and Requirements

The following principles, recommended practices and requirements pertain to all components, in all situations and activities related to the ETA Database Domain. Component specific principles, recommended practices and requirements will be discussed in the next section of the report.

Domain-wide Principles

There were no domain-specific principles identified by the Database Domain team in addition to the principles identified in the “[Commonwealth of Virginia Enterprise Architecture – Conceptual Architecture](#)”.

Domain-wide Recommended Practices

The following seven domain-wide recommended practices were identified:

DB-RP-01: Centralize Shared Data. Data that needs to be shared and current should be centralized.

Rationale:

- High-volume transaction data shared across locations and needing to be current for all locations should be centralized so all locations have access to the live data.
- Replicating frequent updates to distributed databases increases systems complexity and network traffic.
- Data should be centralized when one or more of the following criteria occur:
 - Many users need access to latest changes (i.e., OLTP systems).
 - There is a lack of skills and tools at multiple sites to manage distributed data.
 - There is a need to provide a consolidated and integrated database for federated data on an open platform.

DB-RP-02: Data Replication Based on Needs. Replication of data should be based on needs such as availability, security, performance, or decision support.

Rationale:

- Data quality and integrity is more manageable when replicated and distributed data are read-only.
- Replication can insure uninterrupted access to critical data.
- Replication can isolate production data from external users.
- Replication can facilitate load balancing through synchronization of distributed databases.

- Replication allows separation of OLTP data from information required for decision support without degrading performance of source systems.

DB-RP-03: Replicated Data Read Only. Replicated data should be read only whenever possible.

Rationale:

- Read only access eliminates the need for multidirectional replication.
- One way replication is easier to implement and requires less planning.
- One way replication requires less system resources.

DB-RP-04: Replicated Data Updates. Updates to replicated data should occur through the authoritative source (database of record) where the data originates to facilitate the ease of data management. The exception is when it is clearly indicated that a discrepancy in data updates at distributed locations would not adversely affect the business.

DB-RP-05: Update Authoritative Source. Updates should be directed back to the authoritative source (database of record) if a distributed site has a requirement to make updates to replicated data.

OLTP vs. OLAP³:

On-Line Transaction Processing (OLTP) and On-line Analytical Processing (OLAP) activities are quite different from their aims and their data access requirements:

- OLTP activities provide a detail audit of single events in the observed system, while OLAP gives a picture of the system as a whole.
- OLTP tracks the changes caused by these events and supports the resulting operations on the database while OLAP supports analytical processes of a database.
- OLTP needs detailed information of the observed entities, which are not relevant for analysis. OLAP mainly requires aggregate data of a group of entities.

DB-RP-06: Separate OLTP and OLAP Data. Agencies should segregate OLTP data and OLAP data into separate databases on separate servers (if practical).

Rationale:

- OLTP databases are used by online users for mission critical day-to-day operations.

³ <http://apuuli.de/publications/ic-dss/Sa-2000-06/slide05.htm#Slide> *Using the Concept of Info-Cubes to Facilitate Data Analysis in Demographic Surveillance Systems: Slide 5, Oral Presentation , International Network of field sites with continuous Demographic Evaluation of Populations and Their Health in developing countries (INDEPTH), General Meeting, Alpha Conference Centre, Johannesburg, South Africa ,June 2000, Authors: Yazoumé Yé - Centre de Recherche en Santé de Nouna, Burkina Faso; Uwe Wahser*

- Segregating OLTP data and OLAP data in separate databases reduces the impact of ad hoc and large queries from decision support systems.
- Separating OLTP and OLAP data also aligns the Data Architecture with the Application Architecture, thus separating decision support applications from operation support applications.
- OLTP requires high performance to spot single datasets in the database, while OLAP needs high performance when evaluating groups of datasets or all datasets.
- OLTP systems function best on relational database systems, while OLAP systems function best with multi dimensional database systems (although there also exist relational and hybrid OLAP systems)
- The typical query in an OLTP environment is asking the database for specific information like the name of a person, while OLAP systems ask for frequencies, averages or sums within groups, like the number of people living in a town.
- OLTP and OLAP databases should reside on separate servers when practical to allow production to utilize all available resources.

DB-RP-07: Operational Transactions Directed to Operational Databases. Operational transactions should be directed to operational databases only, not to OLAP databases.

Rationale:

- [Operational data](#) concerns current values (data is quickly purged), Data is dynamic, Detail level is transaction, Data structure is optimized for transactions (normalization), Access frequency is high, Access type is read/update/delete field-by-field and Response time is sub-second to 2-3 seconds.
- [Analytical data](#) has a historical perspective (Possibly years), Data stability is static until refreshed, Detail level is summary level, Data structure is optimized for complex queries, Access frequency is medium to low, Access type is read/aggregate added-to and response time is several seconds to minutes.

Domain-wide Requirements

The following four domain-specific requirements:

DB-R-01: Security, Confidentiality and Privacy Policies. Production databases shall be implemented in adherence with all security, confidentiality and privacy policies and applicable statutes.

Rationale:

- Safeguards sensitive and proprietary information
- Enhances public trust
- Enhances the proper stewardship over public information
- Ensures the integrity of the information

DB-R-02: Support Tools Version/Release Levels. The version/release levels of all databases and related tools used to develop or support Commonwealth and/or agency “*mission critical applications*” shall have vendor or equivalent level support.

Rationale:

- Unsupported software that is no longer being updated to fix newly discovered security vulnerabilities or other problems that occur due to environmental changes increases risk.

DB-R-03: Assess Business Recovery Requirements. An assessment of business recovery requirements is mandatory when acquiring, developing, enhancing or outsourcing database solutions. Based on that assessment, appropriate disaster recovery and business continuity planning, design and testing shall take place.

Rationale:

- The pressure to maintain availability will increase in importance. Any significant visible loss of system stability could negatively impact our image.
- Continuation of business activities without IT is becoming harder.
- Application systems and data are valuable State assets that must be protected.

DB-R-04: Restrict Free-Form Data Entry/Update. Data entry and update to production databases using direct database access shall be restricted, logged and reported to business owners or other appropriate staff. Production database owners shall provide written delegated authority for this type of access.

Database Domain Technical Topics

The Database Domain contains two technical topics: 1) Database and Other Data Access Methods; and, 2) Data Management.

Database and Other Data Access Methods

A database is a collection of information organized in such a way that a computer program can quickly select (access) desired pieces of data. A database management system (DBMS) is a software application providing management, administration, performance, and analysis tools for databases. The Database and Other Data Access Methods topic has the following components:

- Hierarchical
- Networked
- Relational
- Object-oriented (Object)

Requirements

The following two topic-wide requirements were identified:

DB-R-05: Minimize DBMS Number/Version. Agencies shall minimize the number and versions of database management systems utilized.

Rationale:

- Allows effective and efficient utilization of common information resources (people, hardware, software, support services, data and documentation).

DB-R-06: Support Connectivity. Newly deployed database technologies shall support Java Database Connectivity (JDBC) and Microsoft connectivity technology (such as Open Database Connectivity (ODBC) or Object Linking and Embedding Database [OLEDB]).

Hierarchical Database

A hierarchical database is a kind of database management system that links records together in a tree data structure such that each record type has only one owner, e.g. an order is owned by only one customer. Hierarchical structures were widely used in the first mainframe database management systems. However, due to their restrictions, they often cannot be used to relate structures that exist in the real world.

en.wikipedia.org/wiki/Hierarchical_database

There were no recommended practices and no requirements identified. See DB-S-01 Table below for component standards.

Networked Database

A networked database is a database model conceived as a more flexible alternative to the hierarchical model. Where the hierarchical model structures data as a tree of records, with each record having one parent record and many children, the network model allows each record to have multiple parent and child records, forming a lattice structure.

[en.wikipedia.org/wiki/Network_database]

There were no recommended practices and no requirements identified. See DB-S-01 Table below for component standards.

Relational Database

A relational database is a database model in which the database is organized and accessed according to the relationships between data items without the need for any consideration of physical orientation and relationship; relationships between data items are expressed by means of tables. [www.orafaq.com/glossary/faqglosr.htm]

Recommended Practice

The following recommended practice was identified:

DB-RP-08: Use of Nonstandard SQL. Nonstandard SQL language features should be used only when the needed operation or function cannot reasonably be implemented with the standard features alone.

Rationale:

- Use of vendor-specific SQL extensions creates database vendor dependence.

Requirements

The following two requirements were identified:

DB-R-07: Relational DBMS for New Applications/Solutions. A Relational DBMS shall be used as the "Database and Other Data Access Method" for newly developed or acquired applications/solutions.

DB-R-08: Support Security Using Database Access Controls. The SQL implementation and relational database products shall support database security using the following database access controls: GRANT and REVOKE privilege facilities, the VIEW definition capabilities, and some Discretionary Access Control (DAC) mechanisms.

Object Oriented (Object) Database

An object database (more correctly referred to as ODBMS or OODBMS for Object DBMS or Object Oriented DBMS, respectively) is a DBMS that stores objects as opposed to tuples (one row of a database table...one record) or records in a RDBMS (Relational Database Management System) or record-based DBMS. As data is stored as objects it can be interpreted only using the methods specified by its class. The relationship between similar objects is preserved (inheritance) as are references between objects. [en.wikipedia.org/wiki/Object-oriented_database]

There were no recommended practices or requirements identified. See DB-S-01 Table below for component standards.

Other Data Access Methods

Indexed Sequential Access Method (ISAM): a common disk access method that stores data sequentially, while maintaining an index of key fields to all the records in the file for direct access; the sequential order would be the one most commonly used for batch processing and printing (account number, name, etc.). [TechEncyclopedia definition]

Virtual Storage Access Method (VSAM): an IBM access method for storing data, widely used in IBM mainframes; it uses the B+tree method for organizing data. [TechEncyclopedia definition]

There were no recommended practices or requirements identified. See DB-S-01 Table below for component standards.

Technology Component Standards

The technology component standard table below provides strategic technology directions for agencies that are acquiring database and other data access method products.

Table DB-S-01: Database and Other Data Access Methods Technology Component Standard <i>(Updated July 1, 2016 to maintain compliance with DB-R-02)</i>	
Strategic:	Microsoft SQL Server: versions 2012 and 2014 Oracle: 12.X DB2: versions 10.x and 11.x MySQL (shall have vendor or equivalent quality level support if used for <i>Mission Critical Applications</i>)
Emerging:	Microsoft SQL Server 2016
Transitional/Contained:	Microsoft SQL Server: Version 2005 – extended support ends 4/12/2016 Version 2008 – extended support ends 7/9/2019 Oracle: Version 11.1 – extended support ends 8/2015 DB2: Version 9.7 - support ends 9/30/2017 Version 9.8 – extended support ends 4/30/2019 Version 9.5 – extended support ends 4/30/2108 VSAM Adabas
Obsolescent/Rejected:	All versions/release levels of Database and Other Data Access Methods that do not have vendor or equivalent level quality support Desktop database products (Such as Microsoft Access, Lotus Approach, or Paradox, are considered desktop productivity tools. <i>They shall not be used for multi-user applications.</i>) All Networked Databases All Hierarchical Databases not categorized as "Transitional/Contained" All other non-specified Database and Other Data Access Methods
	Notes: <ul style="list-style-type: none"> • Oracle Version 10.2 – extended support ended 7/31/2013; version 11.1 extended support ended 9/2015 • Microsoft SQL Server Version 2000 – extended support ended 4/09/2013

Data Management

Data Management defines the set of capabilities that support the usage, processing and general administration of unstructured information. The Data Management topic has the following components:

- Data Recovery and Backup
- Data Dictionary
- Database Administration

- Enterprise Information Integration (EII)
- Database Design (Standards and Tools)
- Data Modeling

Data Recovery and Backup

Data Recovery and Backup defines the set of capabilities that support the restoration and stabilization of data sets to a consistent, desired state

Recommended Practices

The following four recommended practices were identified:

- DB-RP-09: Consider Availability Requirements.** Application availability requirements should be considered when determining backup strategies.

Rationale:

- With online backups, the database can be backed up while users or applications are connected.
- With offline backups, no users or applications can be connected to the database.
- More frequent backups with smaller recovery logs will result in shorter down time vs. having to restore using older backups with longer recovery logs.

- DB-RP-10: Include Backup Media in Retention Schedules.** Backup media should be included on the agency's records retention schedules, with retention periods long enough to support recovery operations but no longer than that of the official records.

- DB-RP-11: Transaction Logging.** Use transaction logging on databases that require roll-forward recovery to point of last transaction.

Rationale:

- In this method, changes made to the database are retained in logs. You first restore the database using a backup image; then you use the logs to reapply changes that were made to the database since the backup image was created.

DB-RP-12: Transaction Logs on Different Disks. Put the log on a different hard drives from the database when using database transaction logging.

Rationale:

- In the event of a disk failure on the disk containing a database, the database can be restored from the last backup and the log is still available for roll forward recovery.

Requirements

The following six requirements were identified:

DB-R-09: Test Production Databases. Production databases shall be periodically tested for recoverability according to requirements for their use and preservation.

DB-R-10: Business/Recovery Strategies Shall Address Business Requirements. All backup and recovery strategies shall address the business requirements of the data regarding availability, accuracy, and timeliness of data.

DB-R-11: Backup Metadata. Metadata (database schemas, structures, data definitions, etc.) shall be backed up along with the data.

DB-R-12: Recover to Point-In-Time and Point-Of-Failure. Production databases supporting *mission critical applications* shall be recoverable to a point-in-time and point-of-failure.

DB-R-13: Define High Availability Strategy. Databases requiring 24 x 7 availability shall have a high availability strategy such as failover, mirroring, and/or the use of online backups.

Rationale:

- Provides for uninterrupted data access.

DB-R-14: Production Databases. Production databases shall be on different physical machines than the test and development databases.

Data Dictionary

A Data Dictionary is a database about data and databases. It holds the name, type, range of values, source, and authorization for access for each data element in the organization's files and databases. It also indicates which application programs use that data so that when a change in a data structure is contemplated, a list of affected programs can be generated. The data dictionary may be a stand-alone system or an integral part of the DBMS.

Recommended Practices

The following two recommended practices were identified:

DB-RP-13: COTS Solution Data Dictionaries. All agency contracts with COTS solution vendors should require that the vendor supply an approved application Data Dictionary as a deliverable.

DB-RP-14: Data Dictionary Contents. Data Dictionaries should include (but not be limited to): Data Element Definitions, Table definitions, Trigger definitions, Database security model, Stored Procedure definitions, Database schema, and an Entity-relationship model of data.

Requirement

The following one requirement was identified:

DB-R-15: Implement a Data Dictionary. A Data Dictionary is required for any development that results in new databases and any enhancement activities that result in new tables being added to existing databases.

Database Administration

Database administration is the process of establishing computerized databases and insuring their recoverability, integrity, security, availability, reliability, and performance.

Recommended Practices

The following six recommended practices were identified:

DB-RP-15: Service Level Agreement (SLA). Agencies should implement a Service Level Agreement (SLA) and track/report SLA performance measurements for each production database.

DB-RP-16: Assign responsibilities for database deployment and support. Agencies should create, document, implement, and assign responsibilities for database deployment and support processes and practices.

Examples of DBA tasks that can benefit from documented process and practices:

- Install/test new DBMS releases
- Apply DBMS fixes/service packs
- Configure DBMS per application requirements
- Performance monitoring/tuning
- Capacity planning
- Recovery planning
- Database security administration
- Backup/recovery
- Load/unload
- Database reorganization
- Data propagation/replication administration
- Database design (consultation and review)
- Administer database objects (including stored procedures and triggers)
- Production on-call support
- Test and development environment support

DB-RP-17: Integrate Database Deployment with Problem Tracking and Change Management. Where possible, the agency's database deployment and support processes should be integrated with Problem Tracking and Change Management tools.

DB-RP-18: Establish shared libraries and workflow processes. Database Administration groups should establish shared libraries and workflow processes for reusable DBA scripts, tools, procedures and utilities.

DB-RP-19: Database Purge criteria. Purge criteria should be established for all production databases and should be in accordance with agency record retention schedules.

Rationale:

- Improves performance.
- Reduces hardware and support costs.
- Data that is no longer needed should be purged or archived to a less expensive media in accordance with data retention requirements, policies, or historical significance.

DB-RP-20: Monitor System or Database Administration. A process should be put in place to monitor the activity of those with System or Database Administration authority.

Rationale:

- Employees or contractors who are granted the System or Database Administration authority role have the authority to do anything in the DBMS.

- Application programs or interfaces could be modified to perform unauthorized updates.

Requirements

The following six requirements were identified:

- DB-R-16: Assign DBA (Database Administrator) Responsibilities.** Agencies shall formally assign the responsibilities for database administration.
- DB-R-17: Limit DBA Permissions.** Database permissions must be granted at the minimum level required. Limit the members of the System or Database Administrators role to trusted DBAs. Create custom database roles, if required, for better control over permissions. Business data manipulation by DBAs shall not be permitted.
- DB-R-18: Control Application Access and Passwords. Reset Default Access.** Production application programs or interfaces shall never be given System or Database Administration authority. Default accounts shall be changed. Production passwords shall be changed from test and development environments.
- DB-R-19: Limit Query/Reporting Database Access to Read-Only.** Direct production database access for ad-hoc queries and end-user reporting shall be read-only.
- DB-R-20: Evaluate and Apply Patches.** DBAs shall evaluate the latest service packs and *security* patches released by DBMS vendors. When the DBMS is utilized by a 3rd party application, all patches shall be certified by that application vendor before being applied. *Security* patches *shall* be applied and the other service packs and patches should be applied according to DBMS and related 3rd party application vendor recommendations as needed.

Rationale:

- Known vulnerabilities can easily be exploited by hackers.
- Requiring patches to be vendor certified ensures that applied patches will not “break” the application.

- DB-R-21: Monitor Databases for Planning and Availability.** Databases for *mission critical applications* shall be monitored proactively for capacity planning purposes and to maintain high availability.

Rationale:

- A database should never stop functioning from foreseeable events.

Enterprise Information Integration (EII)

EII is the industry acronym for **Enterprise Information Integration**. It describes the process of using data abstraction to address the data access challenges associated with data heterogeneity and data contextualization. Data is the foundation upon which the "Information Age" and critical components such as the burgeoning Web 2.0 and a future Semantic Web are being built. Uniform data access and uniform information representation are critical aspects of this journey.

An EII product offers virtualization of heterogeneous data where data takes the form of SQL, Extensible Markup Language (XML), Data-returning Web services, and other Universal Resource Identifier (URI)-referencable resources. Such SQL data is typically accessible via Open Database Connectivity (ODBC, Java Database Connectivity (JDBC), ActiveX Data Objects (ADO.NET), Object Linking Embedded Database (OLEDB). XML is generally URI based, and is thus accessible via (Web-based Distributed Authoring and Versioning) WebDAV.

EII products enable loose coupling between homogenous-data consuming client applications and services and heterogeneous-data stores. Such client applications and services include desktop productivity tools (spreadsheets, word processors, presentation software, etc.), development environments and frameworks (J2EE, .NET, Mono, Simple Object Access Protocol [SOAP] or RESTian [Representational State Transfer] web services, etc.), Business Intelligence (BI), Business Activity Monitoring (BAM), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Business Process Management (BPM) and/or Business Process Execution Language (BPEL), and Web Content Management. [EII. *Wikipedia, The Free Encyclopedia*. Retrieved 14:08, January 25, 2006 from <http://en.wikipedia.org>] There were no recommended practices identified.

Requirement

The following one requirement was identified:

- DB-R-22: Enterprise Information Integration (EII) Tool.** Agencies (excluding institutions of higher education) shall not purchase an EII tool without VITA approval.

Rationale:

- The selection of a Commonwealth EII tool is considered an Enterprise Initiative.
- EII tools represent a large investment.

- The Commonwealth needs a single enterprise solution that meets all agency current and anticipated needs.

Database Design (Standards and Tools)

Database design is the process of producing a detailed data model of a database. This model contains all the needed physical design choices and physical storage parameters needed to generate DDL which can then be used to create a database. A fully attributed data model contains detailed attributes for each entity.

en.wikipedia.org/wiki/Database_design

Recommended Practices

The following three recommended practices were identified:

DB-RP-21: Third Normal Form. The Entity-relationship model for relational databases should be in third normal form. The model may be denormalized where necessary for performance, but this should be documented within the Data dictionary.

Rationale:

- The third normal form is the most commonly recommended relational database form.
- A denormalized database can perform faster in some cases because there can be fewer joins and/or reduced access to multiple tables.

DB-RP-22: Indexes and Relationships. Indexes and relationships should be carefully created. Adjust the number of indexes to minimize performance issues.

Rationale:

- Limit the number of indexes on tables that will have significant insert and update activity.
- Increase the number of indexes on databases where retrieval time can be a performance issue.
- Verify that all relationships have been documented before creating indexes.

DB-RP-23: Separate database designs and data storage. Separate database designs and data storage should be used when OLAP (On Line Analytical Processing) requests will adversely impact the performance of an OLTP (On Line Transaction Processing) application.

Rationale:

- Separate database designs may be required in order to optimize either type of database for performance.
- Data structures, such as star or snowflake schemas, multidimensional databases, and flat files are better suited for OLAP applications.

Requirements

There were no requirements identified.

Data Modeling

Using modeling tools to describe (usually graphically) the attributes and tables (fields and records) of the organization of a database; it is often created as an entity relationship diagram. In many tools, the SQL code that defines the data structure (schema) in the database is automatically created from the visual representation.

Recommended Practices

The following four recommended practices were identified:

- DB-RP-24: Data modeling tools.** Data modeling tools used in conjunction with relational and hierarchical database technologies should be Extensible Markup Language (XML) and Extensible Markup Language Metadata Interchange Format (XMI) compliant.

Rationale:

- XML is the universal format for structured documents and data on the Internet. XML is a set of rules (guidelines or conventions) for designing text formats to structure data.
- XML is extensible, platform-independent, and it supports internationalization and localization.
- XML is intended for the storage and manipulation of text making up human-readable documents like Web pages.
- Extensible Markup Language Metadata Interchange Format (XMI) is a model-driven XML integration framework for defining, interchanging, manipulating, and integrating XML data and objects.
- XMI-based standards are in use for integrating tools, repositories, applications, and data warehouses.
- XMI specifies an open information interchange model that is intended to give developers working with object technology the ability to exchange programming data over the Internet in a standardized way, thus bringing consistency and compatibility to applications created in collaborative environments.
- XMI allows translation of a UML model from one tool into a repository or into another tool for refinement as the next step in the development process.

- DB-RP-25: Perform Logical Before Physical Modeling.** The logical modeling process should be performed prior to the physical modeling process.

Rationale:

- The logical model is stabilized before the physical model is created.

DB-RP-26: Data Flows. Data flows should be created and maintained for top-level systems (parents) and subsystems (children). They should depict the application's data flows, data stores, data processes, and external entities (data sources/destinations).

Rationale:

- Data flows provide a holistic, graphical representation of the flow of data into and out of processes implemented by software application systems and their respective subsystems.
- Data flows focus on the data being passed through processes to identify origination, transformation, and destination of data; data stores; and entity relationships as a result of business events and activities.
- Data flows depict the way a software application system will implement and execute the processes, independent of specific hardware and software.

DB-RP-27: Data Models. Data models should be archived and version controlled.

Rationale:

- Data models store a wealth of agency and Commonwealth information.
- Data models should be catalogued with the agency's project

Requirement

The following one requirement was identified:

DB-R-23: Implement a Data Modeling Tool. Agencies shall select and implement a consistent data modeling tool.

Rationale:

- Data modeling techniques and tools capture and translate complex system designs into easily understood representations of the data flows and processes of an organization.
- Consistent tools facilitate changes and enhancements to models and resulting application systems, as well as advancing the sharing of information and promoting reusable program code.

(This Page Intentionally Left Blank)

Glossary

Following are Glossary entries pertaining to the Database Domain and required to support this document. Additional glossary definitions can be found in the ITRM Technology Management Glossary located on the VITA website here:

<http://www.vita.virginia.gov/projects/cpm/glossary.cfm>.

Some useful public glossaries can also be found at:

Wikipedia, the free encyclopedia at http://en.wikipedia.org/wiki/Main_Page

Loosely Coupled Glossary at <http://looselycoupled.com/glossary/azindex.html>

Another excellent glossary can be found at: <http://www.matisse.net/files/glossary.html>

Agency	Any agency, institution, board, bureau, commission, council, or instrumentality of state government in the executive branch listed in the appropriation act. ETA requirements/standards identified in this report are applicable to all agencies including the administrative functions (does not include instructional or research functions) of institutions of higher education, unless exempted by language contained in a specific requirement/standard.
Analytical Data	Analytical Data has a historical perspective (Possibly years), Data stability is static until refreshed, Detail level is summary level, Data structure is optimized for complex queries, Access frequency is medium to low, Access type is read/aggregate added-to and response time is several seconds to minutes.
Component	A readily accessible and observable aspect of a technology topic, such as Data Dictionary is a component of the Data Management topic. A component is not the individual pieces such as tables, SQL scripts, etc. and other many similar pieces which make up the component.
Domain	The Enterprise Technical Architecture (ETA) is typically divided into logical groups of related technologies and components, referred to as “domains”. The purpose of a Domain Architecture is to provide a combination of domain principles, best practices, reusable methods, products, and configurations that represent “reusable building blocks”. Thus, the Domain Architecture provides the technical components within the Enterprise Architecture that enable the business strategies and functions. Note, the Conceptual Architecture serves as the foundation for the Domain Architectures, and ensures that they are aligned and compatible with one another. ⁴

⁴ COTS Enterprise Architecture Workgroup, “*Commonwealth of Virginia Enterprise Architecture – Common Requirements Vision*”, v1.1, December 5, 2000, p 26.

Enterprise	As used in this document and generally when discussing Enterprise Architecture topics, the <i>enterprise</i> consist of all Commonwealth of Virginia <u>agencies</u> as defined above.
ETA	The Enterprise Architecture has business and technical components. All of the technical components taken together are called the Enterprise Technical Architecture.
Operational Data	Operational Data concerns current values (data is quickly purged), Data is dynamic, Detail level is transaction, Data structure is optimized for transactions (normalization), Access frequency is high, Access type is read/update/delete field-by-field and Response time is sub-second to 2-3 seconds.
ORCA	<u>O</u> nline <u>R</u> eview and <u>C</u> omment <u>A</u> pplication is a web based application managed by VITA to allow public comment and review of proposed policies, standards, and guidelines. ORCA may be accessed through the Commonwealth Project Management Web page or by pointing your Web browser to the URL http://apps.vita.virginia.gov/publicORCA .
Principles	High-level fundamental truths, ideas or concepts that frame and contribute to the understanding of the Enterprise Architecture. They are derived from best practices that have been assessed for appropriateness to the Commonwealth Enterprise Architecture. ⁵
Product Standards	Are specifications for the use of specific hardware and software relative to the particular component.
Recommended Practices	Are activities which are normally considered leading edge or exceptional models for others to follow. They have been proven to be successful and sustainable and can be readily adopted by agencies. They may or may not be considered the ultimate “best practice” by all readers but for this place and time they are recommended practices and should be used and implemented wherever possible.
Requirements	Are activities that are considered strategic components of the Commonwealth’s Enterprise Technical Architecture. They are acceptable activities for current deployments and must be implemented and used for all future deployments.
Topic	A topic is simply a logical subdivision of the domain. All components relevant to the Commonwealth’s Technical Architecture are included within one of the identified topics. Within the Database domain topics include Database and Other Data Access Methods and Data Management.

⁵ COTS Enterprise Architecture Workgroup, “*Commonwealth of Virginia Enterprise Architecture – Conceptual Architecture*”, v1.0, February 15, 2001, p 5.

Appendix A: References and Links

State and Federal Sites:

The database domain team would like to publicly thank their counterparts in the many states and federal government agencies whose excellent work preceded this. We could not have completed this report as quickly as it was done without the tireless energies obviously expended to complete their Enterprise Architecture documents. We also hope that other states will find this document useful in the design and updating of their own Enterprise Architecture. Significant contributions, references, and insights were derived from the following documents and web sites.

E-Gov: Federal Enterprise Architecture (FEA)

<http://www.whitehouse.gov/omb/egov/a-1-fea.html>

FEA Consolidated Reference Model Document: May 2005

<http://www.whitehouse.gov/omb/egov/documents/CRM.PDF>

Department of Interior

Data Management Architecture, Version 2.0, October 15, 2003

<http://www.doi.gov/ocio/architecture/documents/chapter3.doc>

Housing and Urban Development:

Enterprise Architecture Practice

<http://www.hud.gov/offices/cio/ea/newea/index.cfm>

Arizona:

Data Modeling: Statewide Standard: October 31, 2005

<http://azgita.gov/policies%5Fstandards/pdf/P740-S740%20Data%20Modeling%20Standard.pdf>

Database Access: Statewide Standard: October 31, 2005

<http://azgita.gov/policies%5Fstandards/pdf/P740-S742%20Database%20Access%20Standard.pdf>

Connecticut:

Data Management and Data Warehouse Domain Technical Architecture:

http://www.ct.gov/doit/lib/doit/DATA_ARCHITECTURE_ver_20_6-6-2002.pdf

Application Development Domain Technical Architecture:

http://www.ct.gov/doit/lib/doit/Application_Architecture_5-8-2003_ver_2-5.pdf

Kentucky:

Enterprise Standards: Database Management Software

<http://gotsource.ky.gov/dsweb/Get/Document-9358/2400+-+Database+Mnagement+Software.doc>

Louisiana:*Enterprise Systems: Relational Database Management Systems*

<http://www.state.la.us/oit/docs/it-std-013.pdf>

Massachusetts:*Enterprise Technical Reference Model - Version 3.5*

<http://www.mass.gov/?pageID=itdsubtopic&L=5&L0=Home&L1=Policies%2c+Standards+%26+Legal&L2=Documents+by+Type&L3=Enterprise+Technical+Reference+Models&L4=Enterprise+Technical+Reference+Model+-+Version+3.5&sid=Aitd>

ETRM Version 3.5 Information Domain:

http://www.mass.gov/Aitd/docs/policies_standards/etrm3dot5/etrmv3dot5informationdomain.pdf

ETRM Version 3.5 Application Domain:

http://www.mass.gov/Aitd/docs/policies_standards/etrm3dot5/etrmv3dot5applicationdomain.pdf

Commonwealth Database Community of Interest Project Charter

http://www.mass.gov/Aitd/docs/presentations/commonwealth_database_user_charter.doc

Minnesota:*Enterprise Technical Architecture: **Error! Reference source not found.***

http://www.state.mn.us/mn/externalDocs/OT/OT_EA_DataRecordsDoc_04292002_04%20Data%20&%20Records%202.0.doc

North Carolina:*Statewide Technical Architecture: Data Domain*

<http://www.ncsta.gov/docs/Principles%20Practices%20Standards/Data.pdf>

Implementation Guidelines: Data Architecture

<http://www.ncsta.gov/docs/Implementation%20Guidelines/domain/Data%20Domain%20Implementation%20Guidelines.pdf>

Pennsylvania:

Database Management Systems: Production and Operational Standards: February 23, 2005

http://www.oit.state.pa.us/oaoit/lib/oaoit/STD_INF001B.doc

Virginia:

Virginia Department of Social Services

Enterprise Architecture: Draft Documentation Standard: Data Dictionary

Other Information References:

Gartner Group:

<http://www.gartner.com/>

“Database Administration Best Practices” by Jon Rubin; Publication Date: 2 January 2001; ID Number: DF-12-6444

“Data Architecture: Why, What and How” by Greta A. James and Ted Friedman; Publication Date: 3 February 2003: TU-19-1328

The Open Group: <http://www.opengroup.org/architecture/togaf8-doc/arch/toc.htm>

The Data Warehouse Institute:

<http://www.tdwi.org>

Microsoft:

http://www.microsoft.com/resources/sam/Implementing_Policy.msp

Other:

"Using the Concept of Info-Cubes to Facilitate Data Analysis in Demographic Surveillance Systems", Oral Presentation , International Network of field sites with continuous Demographic Evaluation of Populations and Their Health in developing countries (INDEPTH), General Meeting, Alpha Conference Centre, Johannesburg, South Africa June 2000, Authors: Yazoumé Yé - Centre de Recherche en Santé de Nouna, Burkina Faso; Uwe Wahser
<http://apuuli.de/publications/ic-dss/Sa-2000-06/>