# Software Product Description

**PRODUCT NAME: VAX DBMS, Version 4.2 (Database Management System)** **SPD 25.48.21**

## DESCRIPTION

VAX DBMS is a multi-user, general purpose CODASYL-compliant database management system that runs under the VMS Operating System. VAX DBMS is used to access and administer databases ranging in complexity from simple hierarchies to complex networks with multi-level relationships. It supports full concurrent access in a multi-user environment without compromising the integrity and security of the user's databases.

VAX DBMS is based upon the March, 1981 Working Document of the ANSI Data Definition Language Committee.

### Features

- Full concurrent access capabilities (storage, retrieval, update, and deletion) in a multi-user environment
- Record locking and journaling
- Automatic transaction and verb rollback
- Multiple database support (one or more databases per process)
- Two Phase Commit capability atomically commits or rolls back updates across multiple databases in one transaction (Optional - see SSA 25.48.21-x for details)
- Full VAXcluster support, including automatic recovery upon node failure
- Integrated with VAX Common Data Dictionary/Plus (CDD/Plus) facility
- Schema, Subschema, Storage Schema, and Security Schema Data Definition Languages (DDLs)
- FORTRAN Data Manipulation Language (FDML)
- COBOL DML statements supported by the VAX COBOL compiler
- Generic DML preprocessor for BASIC, BLISS, C, DIBOL, PASCAL, PL/I and VAX Ada
- Callable interpretive interface for any VAX language that adheres to the VAX calling standard
- Automatic subschema definition extraction from the CDD/Plus for BASIC, BLISS, C, COBOL, DIBOL, MACRO, PASCAL, PL/I, and VAX Ada when using the high-level call interface or generic DML preprocessor
- Easy-to-use utility command language (DBO)
- Database Restructuring Utility (DRU) the ability to change many database characteristics without unloading and reloading the database.
- Interactive Database Query Utility (DBQ) with video display of subschema structure diagrams on VT100, VT200, or VT300 compatible terminals
- On-line and incremental database verification including verification by set
- Full and incremental database backup with or without concurrent database users
- Full and incremental database restore of the entire database, or individual areas
- Ability to redo a sequence of committed transactions (roll forward)
- Initial Load utility; Unload utility for data extraction; functionality for database restructuring with Unload/Load
- BATCH RETRIEVAL ready mode (database snapshots) for increased concurrency in large retrieval applications
- Space Area Management (SPAM) pages which improve database free-space search performance
- Boolean record selection expression with index optimization on FIND and FETCH DML statements
- Data compression of data items and database key (DBKey) pointers
- Direct record access through the use of database key (DBKey) pointers
- Automatic expansion of large records across multiple database pages

- Simple restructuring, including adding AREAS and initializing AREAS, without unloading and reloading a database
- Sorted sets implemented with B-trees or simple chains; prefix and suffix compression for sort keys with the B-tree implementation
- DECnet database access to provide full remote read/write access to non-redundant distributed databases.

*Data Definition*

VAX DBMS has a four-part data definition language. The schema DDL defines the logical structure of the database, the storage schema DDL defines the physical structure of the database, the subschema DDL defines application program views of the schema, and the security schema DDL defines access rights to database objects.

The schema DDL is the only DDL that must be written. By default, the DDL compiler produces a default subschema, storage schema, and security schema for every schema it compiles.

The schema DDL defines the records, sets, and areas composing the database. A record is a collection of data items. A set is a relationship between records having one owner record and one or more member records in some specified order. An area is a logical and physical subdivision of the database that contains records.

The storage schema DDL defines the representation of storage records, storage sets, and storage areas (which are equivalent to VMS files). It also defines the placement of records within the database, the storage set parameters, and the representation of data items within a storage record. Most database tuning is accomplished by changing the storage schema.

The subschema DDL defines a logical subset of the database in terms of records, sets and realms (a collection of one or more areas). Many subschemas can be written to provide different views of the database for different application programs.

The security schema DDL defines the access rights to all database objects. DML statement access rights can be defined for each DML statement on areas, records, items, and sets.

All database structure definitions are established and maintained by the DDL compiler and stored in the VAX Common Data Dictionary/Plus (CDD/Plus), where they can be retrieved by VAX DBMS Utilities, VAX COBOL and VAX DATATRIEVE.

*Data Manipulation*

Application programs must call the Database Control System (DBCS) for all database operations. The specific database operations supported are: CONNECT, DISCONNECT, ERASE, FETCH, FIND, GET, MODIFY, RECONNECT, and STORE for manipulating database records and sets; FREE and KEEP for saving and purging database currencies and keeplists; COMMIT, READY, and ROLLBACK for controlling the permanence in non distributed transactions; ALSO, EMPTY, MEMBER, OWNER, TENANT, NULL, and WITHIN conditions for testing the state of the database, currencies, and keeplists. A Boolean expression with EQ, NE, LE, LT, GT, GE, AND, OR, NOT, MATCHES, or CONTAINS operators can be used on the FIND and FETCH statements.

Application programs written in COBOL and FORTRAN perform database operations with a set of Data Manipulation Language (DML) statements included in the source code. COBOL DML statements are compiled by the VAX COBOL compiler. FORTRAN DML statements are translated by the VAX DBMS FORTRAN DML Preprocessor into FORTRAN source code that is compiled by the VAX FORTRAN compiler. Application programs written in BASIC, BLISS, C, DIBOL, PASCAL, PL/I, and VAX Ada can access a database through a generic DML preprocessor. DML statements can be included directly into the program. The source file is then passed on to the appropriate host language compiler.

*Run-Time Environment (Integrity and Consistency Features)*

The Database Control System (DBCS) controls access to VAX DBMS databases. The DBCS ensures the integrity of user databases by automatically locking records that have been modified, records representing currencies, and records on keeplists. Optionally, the DBA can request that all records read in a particular database be locked for the life of the database transaction. Users cannot modify data in records that are locked by another user. Moreover, users cannot read data that another user has modified but not yet committed. When a user process terminates or executes a ROLLBACK or COMMIT operation, all locks are released. When a user process executes a COMMIT RETAINING operation, all record locks not in currency indicators or keeplists are released and all records locked for update are changed to read locks. Locking of entire areas can be used to improve performance in certain applications. The VMS lock manager services ($ENQ and $DEQ) are used for locking.

All database changes between READY and COMMIT or ROLLBACK operations are recorded in a recovery-unit journal. When a user performs a COMMIT operation, all database changes are made permanent. A ROLLBACK operation will undo all database changes. The DBCS automatically performs a ROLLBACK operation on any uncommitted database changes if a program error or system failure occurs. Recovery-unit journaling can be disabled by readying an AREA in BATCH UPDATE mode which can result in improved performance. A risk of disabling the recovery-unit journaling is that the database might be corrupted should a system failure occur.

The BATCH RETRIEVAL ready mode, also called a snapshot, can be used by retrieval transactions that read many records, require a consistent view of the database, and do not handle deadlock conditions. A database must have snapshots allowed to enable transactions in BATCH RETRIEVAL mode; snapshots may be enabled per area.

Long-term after-images can optionally be saved and used by the DBO utility to recover from storage device or system software failures and is recommended strongly.

*VAXcluster Environment*

VAX DBMS databases can operate in a VAXcluster environment, thus allowing for concurrent, multiple-node database access. VAX DBMS automatically recovers the database if a processor in the VAXcluster fails and provides optional after-image journaling to further protect the integrity of the VAXcluster database.

VAX DBMS uses the VMS distributed lock manager to synchronize cluster-wide updates to the database root file, to initiate the automatic recovery process when a node fails, and to coordinate concurrent updates to the same database from processes running on different nodes. VAXclusters offer higher availability to VAX DBMS databases in a properly configured VAXcluster environment.

*Security Features*

VAX DBMS provides security on database objects via the security schema, on DBO commands via access control lists, on files via the VMS file protection features, and on metadata in the CDD/Plus dictionary via the CDD/Plus security features.

Application programs access the database through a security schema. The security schema controls the access to areas, records, items, and sets for each DML statement. The security schema for a given user is controlled by the User Execution List (UEL), which is an access control list.

The UEL consists of user identification codes (UIC) and the security schema through which they are allowed access to the database. UELs are manipulated by the database administrator through the use of the DBO/PERMIT_USER command.

For compatibility with VAX DBMS, Version 1.0, a NULL security schema can be used. The NULL security schema allows any DML statements on any database object.

Access to DBO commands is controlled by an access control list for each DBO command. The Command Authorization Lists (CALs) are manipulated by the Database Administrator with the command DBO/GRANT_COMMAND. There is a CAL for every DBO command except MONITOR, SHOW, and CONVERT. There is no CAL for the CDD commands.

The DBCS runs in EXEC mode, securing its code and data structures from the user's user mode applications.

VAX DBMS uses standard VMS file security (SYSTEM, OWNER, GROUP, WORLD) to protect database storage areas (files). An application program can only access records defined in its SUBSCHEMA. It is the responsibility of the Database Administrator (DBA) to define storage areas and realms plus set up file protection and access control lists and security schemas to prevent unauthorized access to sensitive data.

Metadata security and protection can be provided by preventing access to metadata definitions stored in the VAX Common Data Dictionary/Plus (CDD/Plus). The CDD supports a hierarchical security system based on access control lists. It is the responsibility of the DBA to define CDD access control lists to prevent unauthorized access to sensitive database definitions.

**Utilities**

*Interactive DML Utility (DBQ)*

Provides on-line procedural database access capabilities by interactively processing generic Data Manipulation Language (DML) statements.

- Provides DISPLAY,EDIT, IF-THEN-ELSE, INITIALIZE, LOOP, MACRO, MOVE, SET, SHOW, PRINT, and SHIFT statements
- Allows DCL commands from within the image

The current position in a subschema is optionally displayed graphically (on a VT100, VT200, or VT300 compatible terminal) as the user navigates through the database.

*Database Operator Utility (DBO)*

Provides the Database Administrator with all of the functions required to create, maintain, delete, and control VAX DBMS databases. It provides the following major features:

- Creating, initializing, and deleting databases.
- Loading and unloading databases.
- Restructuring databases; RECALCing records into expanded areas.
- Controlling access to DBO commands and to the database through ACLs and security schemas.
- Reporting on VAX DBMS information in the VAX Common Data Dictionary/Plus.
- Extracting DDL information from the VAX Common Data Dictionary/Plus.
- Deleting DDL information in the VAX Common Data Dictionary/Plus.
- Verifying the integrity of internal database structures on-line. (Verification of the database is performed more efficiently on lightly loaded or inactive databases.)
- Modifying the contents of corrupted database storage areas. (This function is not recommended or required for normal use.)
- Producing formatted dumps of the database, AIJ, or RUJ files.
- Providing the spooling of after-image journal files by backing them up to another device.
- Producing full and incremental database backup, on-line and off-line.
- Restoring the database from backup and long-term journals.
- Controlling and displaying the status of the DBCS Monitor process.
- Providing for orderly database shutdown on a single node or across a VAXcluster.
- Creating static analysis of database space usage (DBO/ANALYZE) on- or off-line.
- On-line or replay of DBMS statistics in the form of a histogram, a columnar chart, a time plot on a single node basis for active databases, or areas (DBO/SHOW STATISTICS). Statistics include: summary I/O, database verb, database index, virtual memory usage, summary locking, summary after-image journal, summary page I/O, I/O stall time, stall messages, and transaction durations.
- Generating a User Work Area (UWA) for application programs using the callable interpretive interface.

*Database Restructuring Utility (DRU)*

Provides the ability to change many database characteristics without unloading and reloading the database. It provides the following major features:

- Removing areas from record WITHIN clauses.
- Changing set insertion and retention modes to AUTOMATIC MANDATORY or AUTOMATIC FIXED.
- Specifying that duplicates are not allowed on sorted sets.
- Changing the sort key and sort order on sorted sets.
- Changing set ORDER and MODE clauses.
- Changing B-tree node size, reset the B-tree fill factor, and for SYSTEM-owned set, change the B-tree location.
- Remote items from the database that are no longer needed.

*Product Assistance Facilities*

VAX DBMS provides extensive help facilities for the interactive DML Utility (DBQ), the DML precompiler(DML), the Database Operator Utility (DBO), and the DDL compiler. The help files contain all necessary information on the use of each of these facilities.

VAX DATATRIEVE provides an optional interface to VAX DBMS database structures. This provides the VAX DBMS user with a high-level, nonprocedural query and report generating facility.

*Components*

DDL Compiler (DDL) - Used by the Database Administrator (DBA) to create and maintain database structure definitions including records, sets, areas, and realms in the VAX Common Data Dictionary/Plus. It compiles the schema, subschema, storage schema, and security schema DDLs, and generates default subschemas, storage schemas, and security schemas. The VMS DCL command ‘‘DDL’’ invokes the compiler.

Database Control System (DBCS) - Controls access to VAX DBMS databases. The DBCS is a shareable image that is linked with any application program that accesses the database.

FORTRAN DML Preprocessor (FDML) - Preprocesses FORTRAN DML application programs. It translates FORTRAN DML statements into FORTRAN calls to the DBCS and data definition statements and passes the complete FORTRAN source program to the VAX FORTRAN Compiler.

Generic DML Preprocessor - Preprocesses application programs written in BASIC, BLISS, C, DIBOL, PASCAL, PL/I, and VAX Ada. It converts DML statements into calls to the DBCS and passes the complete source program to the host language compiler.

Database Monitor Process - Controls all interprocess database communication and recovery.

Database Recovery Process (DBR) - Provides the database recovery capability.

Interactive DML Utility (DBQ) - Provides interactive DML access to any VAX DBMS database. The VMS DCL command "MCR SYS$SYSTEM:DBQ" invokes the utility.

Database Operator Utility (DBO) - Used by the DBA to create, maintain, delete, and control all VAX DBMS databases. The VMS DCL command "DBO" invokes the utility.

Database Restructuring Utility (DRU) - Enables the DBA to make user-data dependent changes to the database.

DBMSERVER - Provides access to local databases for remote DECnet users.

Installation Verification Procedures (IVP) - Verifies the correct installation of all VAX DBMS components and builds the PARTS database that is used in examples throughout the documentation.

Demonstration (DEMO) - A demonstration package which uses the PARTS database.

*Limits and Parameters*

- Maximum length of a sort key is 255 bytes.
- Maximum number of sort key items is limited by the total sort key length.
- Maximum length of a calc key is 32K bytes.
- Maximum number of calc key items is limited by the total calc key length.
- Maximum length of database object name is 31 bytes.
- Other schema size (complexity) parameters are limited by machine address space and disk space.
- Minimum database page size is 512 bytes.
- Maximum database page size is 32K bytes.
- Maximum number of pages per area is 2**32 pages.
- Maximum number of areas (files) per database is 32K files (VMS resources and typical SYSGEN parameters will constrain this to be much lower).
- Maximum length of a storage record, including DBMS overhead, is 32K bytes.
- Minimum interval between SPAM pages is 256 pages.
- Maximum interval between SPAM pages is 64K pages.
- Maximum number of concurrent users per database is 2032 (not all database maintenance functions can be performed efficiently with large numbers of active users).

*Optional VAX DBMS Run-Time Only Environment*

A Run-Time Only version of VAX DBMS is available. It provides all features and facilities except the DDL compiler, the FORTRAN Data Manipulation Language (FDML) preprocessor, and the Generic DML preprocessor. The purpose of the Run-Time Only version is to support the execution of applications on one machine that have been developed on other machines using the development version of the product. Program development is not supported under the Run-Time Only version.

**HARDWARE REQUIREMENTS**

VAX, MicroVAX, VAXstation or VAXsever configuration as specified in the System Support Addendum (SSA 25.48.21-x).

**SOFTWARE REQUIREMENTS***

- VMS Operating System

*Layered Products*

- VAX CDD/Plus
- VMS Workstation Software

* Refer to the System Support Addendum for availability and required versions of prerequisite/optional software (SSA 25.48.21-x).

**ORDERING INFORMATION**

Software Licenses: QL-899A*-**
Run-Time Only: QL-915A*-**

Software Media: QA-899A*-**
Run-Time Only: QA-915A*-**

Software Documentation: QA-899AA-GZ
Run-Time Only: QA-915AA-GZ

Software Product Services: QT-899A*-**
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