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UNITED STATES
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JUNE 1989

OSD CALS
Architecture Master Plan Study

CONCEPT PAPER

INDEXING

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SECTION 1 - INTRODUCTION

1.1 PURPOSE

An index identifies and references information which is exchanged between multiple users and systems. The increased automation that will take place as CALS evolves will dictate an increased use of indexes for the successful exchange of information. Therefore, indexing issues must be addressed as an integral component of the overall CALS infrastructure development.

This paper examines the ways in which the use of indexes can support CALS and DoD objectives. Specifically, the purpose of this paper is to:

- identify major issues related to indexing,
- survey current proposals to address these issues, and
- make recommendations for DoD directions.

This section provides a brief introduction to indexing in DoD, as a basis for the subsequent consideration of the issues related to indexing.

1.2 INDEXES IN DOD

DoD and Industry are concerned with the effective management of large volumes of information about weapon systems. The ability to identify, find and update information within the CALS structure will be partly dependent on the strength of the supporting indexes. The basic purpose of an index is to provide a capability for organizing data to enable effective storage, retrieval and distribution of that data.

Indexes are necessary to provide the structure for the creation, management and use of the information in any large system. Indexing procedures, in combination with other information management techniques like data dictionaries, configuration management and data security schemes, provide the control capabilities for managing data in the CALS environment.

In addition, indexing permits access, delivery, and presentation of information. The inherent structure of an index allows the relationships between data in diverse environments to be understood. For example, an index can establish a relationship between assemblies and subassemblies of a weapon system. Indexes also enable the linking of appropriate data such as a part drawing, the part itself, the part manufacturing processes, and the maintenance activities needed to keep the part operational. Formalizing these relationships, which is achieved by the indexing system, is critical to the management of the Weapon Systems Life Cycle (WSLC).

1.3 VALUE OF INDEXES

The evolution and use of indexing systems within DoD and Industry has paralleled the evolution and use of technology. As weapon systems became more complex and the application of

information technology became necessary, more comprehensive indexing schemes were designed and employed to manage inventories (national stock number), manufacturing processes (work center operation codes for computer numerical control machining centers), and technical data (engineering drawing numbers).

Examples of the potential benefits derived from specific indexing applications are summarized below:

- An index can increase productivity by enabling the faster retrieval of relevant information.

  For example, a warehouse design can be based on an indexing system which allows for the storage and retrieval of information by frequency of use of the component parts.

- An index can improve the decision-making process by providing the required information in a useful order.

  For example, a decision support system relies on the orderly classification and indexing of the information needed to make a decision. This can include historical, current and projected data for consumption, prices, leadtimes to delivery, and alternative sources to improve the quality and speed of reprocurement decisions.

- An index can support effective execution of plans by providing a common reference to information that everyone uses in communications, information transfer and the performance of their tasks.

  For example, manufacturing planning and scheduling systems, parts ordering systems and automated manufacturing systems can all refer to the same or related information through the same indexes.

SECTION 2 - CALS & INDEXING REQUIREMENTS

An important thrust of CALS is the emphasis on automation for information transfer and exchange. This information exchange is complicated by the large volume of data associated with the acquisition of weapon systems, and rapid identification and interpretation of exchanged information is essential. As automation becomes more advanced, the demands upon indexes to support this digital information transfer becomes more pronounced.

In order to effectively achieve the CALS automation objectives and more particularly the indexing capabilities required to support those objectives, indexing issues and requirements should be approached from business and technology perspectives.

2.1 BUSINESS RELATED INDEXING REQUIREMENTS

Business related requirements address the prudent management of the existing technical information that supports the weapon systems life cycle. These include:

- preserving existing information,
- exchanging information between Services and Industry, and
- integrating information across Services.

2.1.1 Preserving Existing Information

Most of the existing weapon systems now in use will still be operational in the year 2000 and beyond. These weapon systems are supported by a large base of technical information, which is essential to keeping the systems operational. These existing weapon systems will be modified and their supporting information will be updated to reflect the changes. Preserving the investment in the unchanged portions of the weapon system and its technical information is essential.

Indexes provide the means to preserve this existing information base. They are an information tool that assists in the management and use of the weapon system's technical information and are themselves a special kind of information because they make the rest of the technical information accessible. Without access to the information, the support of the weapon system is at risk.

2.1.2 Exchanging Information between Services and Industry

The creation and modification of weapon systems involves a continuing dialogue between the Services and Industry until the final equipment and technical information are delivered. Dialogue, in the form of reviews, provides Industry with feedback and historical information on weapon system performance. Industry provides the Services with the information required for the review cycles in the WSLC. Before a weapon system is delivered, technical information containing trade-off choices is presented by Industry so that the Service can make inputs into the design and refinements can be made. At the end of the WSLC, Industry provides the

Services with the information that has been generated by the process which in turn is stored for future use and modifications. As CALS evolves, the ability to provide a continuous information exchange between the Services and Industry will become necessary and will rely heavily on indexes.

The precise identification of the exchanged information is assisted by the use of information indexes. Indexes are, therefore, instrumental in the exchange of technical information between services and Industry and thereby in the creation and modification of the weapon systems.

2.1.3 Integrating Information across Services

Integrated information accross services supports interoperability. This interoperability enables services to exchange information about commonly used systems and parts (used in one or more services). This will help prevent duplicate data purchase, maintenance and indexing, while also supporting duplicate data processing activities.

2.2 TECHNOLOGY RELATED INDEXING REQUIREMENTS

Indexing needs to support both the evolution of CALS from a paper intensive environment to an integrated information environment and the creation, management and use of information throughout the WSLC. The role of indexing technology in the WSLC is based on the changing functional requirements as the data evolves from its creation to use. These functional requirements define the primary characteristics needed in an indexing approach to effectively support the WSLC.

The evolution of CALS requires the development of technology strategies that will support increasingly complex data interchange, and higher levels of performance resulting from the need to retrieve information from a distributed database environment. These technology related requirements must be supported by approaches to indexing that compliment, support and adapt to escalating requirements.

2.2.1 Indexes and CALS Evolution

FIGURE 1 depicts four steps in the evolution of the CALS environment from paper based processes to an integrated information infrastructure and shows the indexing support required for accessing information at each step. The paper environment calls for simple sequential indexing schemes to support manual searching. The digital exchange environment needs to be supported with automated indexing schemes for data stored on electronic media. The move to shared databases will require an index with a more complex search and retrieval capability based on a distributed database environment. This creates an additional requirement to translate and interpret data stored in a variety of indexing schemes that have been adapted for the specific use of various functional areas. The progression to a completely integrated information structure, characterized by the absence of manual intervention in the data exchange, will require logical indexing schemes which support high performance data access.

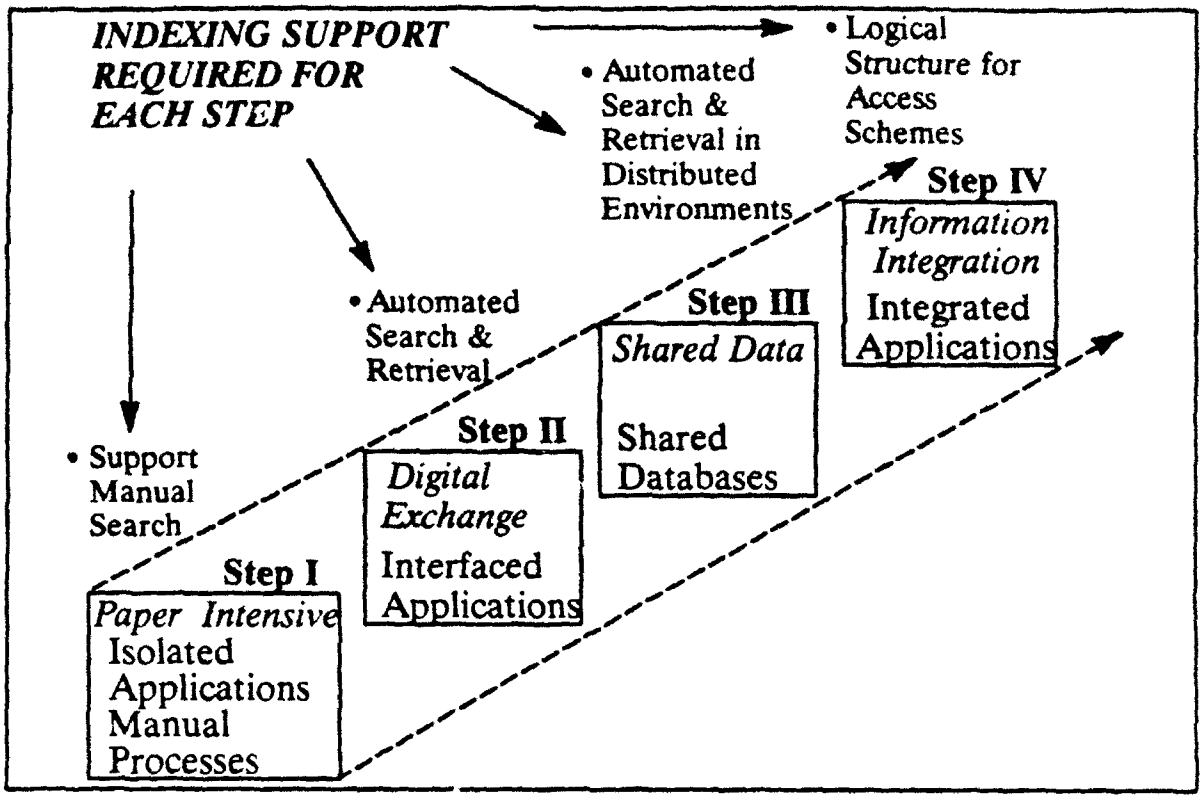

FIGURE 1. INDEXES & CALS EVOLUTION STEPS

2.2.2 Indexes and Weapon System Data Management Requirements

The weapon system data management life cycle reflects the WSLC and the technical information activities that support it. Data management across the WSLC involves the creation, interface, storage, distribution and use of data. To support data management across the WSLC, the requirements for indexing technology include the identification, reference, linkage, segregation and location of data.

The relationship between the major data management functions and the technology requirements are depicted in FIGURE 2. When data is created, the primary concern is to uniquely identify and "tag" the data. As the data is transferred to repositories the major technical requirement is correct reference - asking, "did you get what you asked for?" In storing data, the major requirements are linkage - relating and integrating the new information with the existing information and segregation - providing for the security of DoD and Industry data. Distribution requires correct data reference - a precise interpretation of data requested versus data sent. The primary concern in attempting to use the data in application is location - identifying "where is the information?"

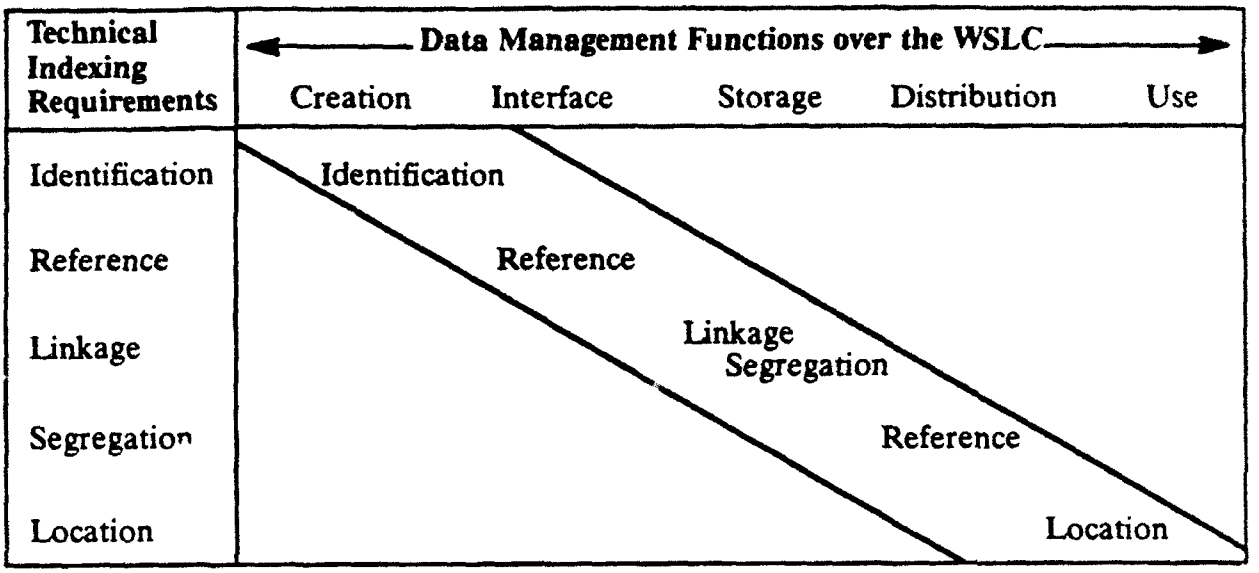

FIGURE 2. INDEXING REQUIREMENTS & THE WSLC

The indexing requirements shown in FIGURE 2 are discussed below.

Identification

Proper identification of data as it is created is crucial to its effective management and use. Thus a basic requirement for an index is to be able to uniquely tag an item of data. An index must also provide a structure for the identification approach. This identification structure, in turn, must be consistent with the requirements for logical storage and retrieval of data. The structure for identifying data must be extendible to accommodate future requirements without disrupting existing data identification structures. Thus the identifying characteristics of the index should assist in the effective employment of information throughout the WSLC.

The use of an index to identify data is essential to:

- eliminate or reduce duplicate acquisition of data, and
- promote rapid availability of data when needed.

Reference

The ability to reference any created and changed technical data is required for its transfer to and from storage. Referencing includes the precise interpretation of data requested and sent. Referencing of data is also necessary to combine identical data in different databases and, therefore, helps provide the bridge from one database to another.

Referencing facilitates the interface between different systems using separate indexes but the same data. Multiple indexes have evolved historically for the same bodies of information within different organizations and functions. It is therefore expedient and necessary to preserve these indexes and by so doing we protect the organizational investments in the use and management of those indexes.

The reference requirement for indexes is necessary for:

- sending data to and retrieving data from databases with related data, and
- correctly interpreting data from other databases.

Linkage

In the context of indexing, linkage is concerned with:

- the need to connect related sets of information within one database; for example, linking the graphics image of a part to its related technical specification,
- modeling related information and providing the means to implement the models,
- providing the structure for storage of data in repositories,
- providing the means to navigate within the information repositories,
- the ability to support configuration management.

Segregation

The need to move towards integrated digital information is complicated by the potential elimination of information security afforded by the current isolated automated information systems. Information security is accomplished in the current isolated environments by physical segregation of data and control over user access. In an integrated information environment, which needs to take into account all security considerations, an ability to logically segregate data and an ability to isolate users to access particular information is essential.

Indexing provides the means to segregate information and users in order to implement security requirements. Information in an index can be assigned a security classification. Indexes are instrumental in classifying users and organizations so that they can be assigned access privileges to different compartments of information.

The use of indexes to support security requirements will provide the ability to:

- implement levels of security for data,
- regulate user access on an as needed basis, and
- protect proprietary and special security data in digital storage.

Location

The ability to locate technical information is critical to its use. From a user's perspective it is all that counts.

The requirements on indexes to support location include the ability to:

- establish data's existence – finding if data exists and where it exists,
- efficient retrieval – employ logical constructs to increase search speed, and

- support multiple functional perspectives – allow different functional users to readily access the information they need based upon their differing entry points to and requirements from the information.

2.2.3 Technical Requirements Summary

FIGURE 3 summarizes the CALS technical indexing requirements. The indexing proposals which are under consideration for CALS are summarized in Section 3 of this report, and are measured against these requirements to help determine to what extent they answer the CALS needs.

REQUIREMENT	DEFINITION
IDENTIFICATION	
Builds unique ID	Unambiguous identification of each item of data
Defines a structure	Structure is built on familiar and comprehensible concepts
Easily accepts change	Easily extend or update index for new requirements
REFERENCE	
Supports data transfer	Promotes transfer of data to and from repositories
Establishes bridges between databases	Establishes relationship between data in different databases
Supports multiple indexes	Preserves existing indexes to protect organizational investments
LINKAGE	
Connects related data	Provides links between data items in the same information repository
Implements data models	Provides the structure for data storage and the ability to navigate the data models
Supports configuration management (CM)	Ability to identify multiple versions and provide change control
SEGREGATION	
Assists data security	Implements security schemes in an integrated, automated environment
Limits user access	Defines the boundaries for user access
LOCATION	
Establishes existence of data	Finding if and where data exists
Enables efficient retrieval	Facilitate rapid information retrieval
Supports multiple perspectives	Allow different functional users to approach data based on their unique needs

FIGURE 3. CALS TECHNICAL INDEXING REQUIREMENTS

SECTION 3 - CURRENT INDEXING PROPOSALS

Four proposals are summarized in this section, each of which addresses the CALS automation objectives. The proposals are:

- Technical Reference Index Metaset - TRIM
- Logistics Data Indexing - LDI
- Rosen Schneck Index - RS-Index
- Universal Numbering Structure - UNS

Each indexing proposal focuses on a particular area of concern. The first, TRIM, is focused on linking indexes. LDI is attuned to the needs of logistics support functions and their use of indexes. RS-Index concentrates on creating a new unique index composed of manufacturing and hardware information. UNS extends an existing hardware hierarchy index with configuration management information deemed essential to weapon system management.

3.1 TECHNICAL REFERENCE INDEX METASET - TRIM

The primary focus of TRIM is to provide a means to identify, transfer and access digital information between databases. The TRIM methodology proposes that once a database is identified as a candidate for the transfer of information from one database to another, then it would be included in the TRIM "metaset." The metaset would include standard data keys, current values of those keys, a dictionary of data elements indicating linkages to standard keys and a library of cross references to other data elements which would be used used in building translators. TRIM maintains the existing database and does not establish a unique identification for each information element, independently of that which has been provided by the existing indexes.

Without TRIM, databases would require individual customized translators from each source database to each target database. The TRIM concept provides a way to manage individual translation efforts and create a more generalized and reusable translation capability. The transfer of data from a government or Industry database to a target database would require two translation steps if TRIM was utilized rather than customized translation. The source database information would be translated into information readable by the second translator using the standard TRIM metaset. The second translator then converts the information into a form useable by the target database. FIGURE 4 represents the data transfer path within the TRIM concept.

TRIM allows for retrofitting existing databases to a new standard by a proposed metaset standard as a conversion link between a limited set of databases. This dictates the need to create and manage a very large data set (the TRIM metaset), whose constituent users may have conflicting requirements that impose a significant management burden on the system.

TRIM addresses one practical obstruction to data transfer - the lack of consistency and uniformity in indexes. TRIM overcomes the obstruction by proposing a system to translate in-

dexes and data between files, systems and functions. TRIM accomplishes this only for databases registered in the TRIM system.

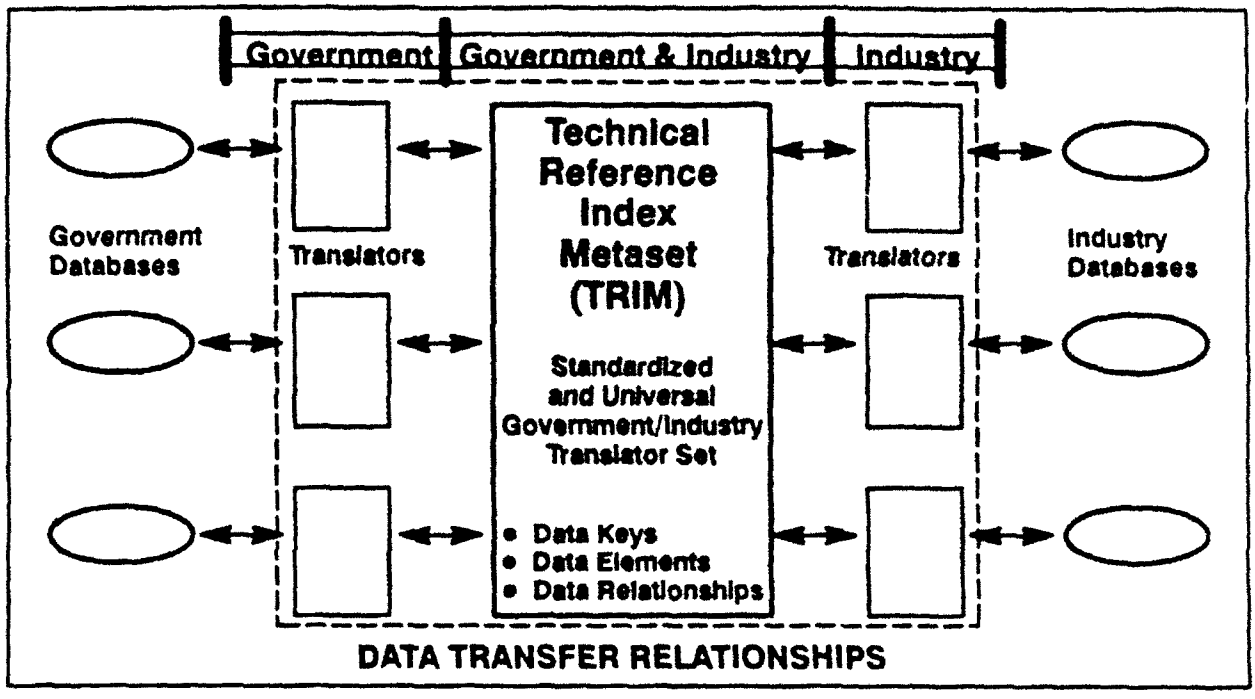

FIGURE 4. TRIM

3.2 LOGISTICS DATA INDEXING - LDI

LDI proposes a universal structure to index and identify all logistics data and to support its management and use throughout the WSLC. Without LDI, different logistics functions use their own indexes to refer to the same piece of hardware and different functions have difficulty exchanging information about the same piece of equipment. LDI overcomes these difficulties by creating a hardware/function combination index.

FIGURE 5 gives an example of how LDI works by combining a hardware identifier for hydraulic activator with a function identifier for provisioning to create an LDI record identifier for provisioning of hydraulic activators. The information related to the record identifier includes the detailed logistics information.

Using the same hardware ID (e.g. platform, assembly, subassembly or part), it is possible to find the information from all the functions for a particular part. When assessing or making changes to a part, if the weapon system uses LDI, it is possible to find all the logistics interactions associated with that part.

LDI creates a new logistics oriented composite ID. LDI will require that all logistics functions standardize upon a common means of identifying hardware for a weapon system and a common way of identifying functions. This could be problematic. In addition, the LDI concept

can be extended to define standardized manufacturing and engineering functions. This functional standardization can then become the basis for an index to support an integrated database.

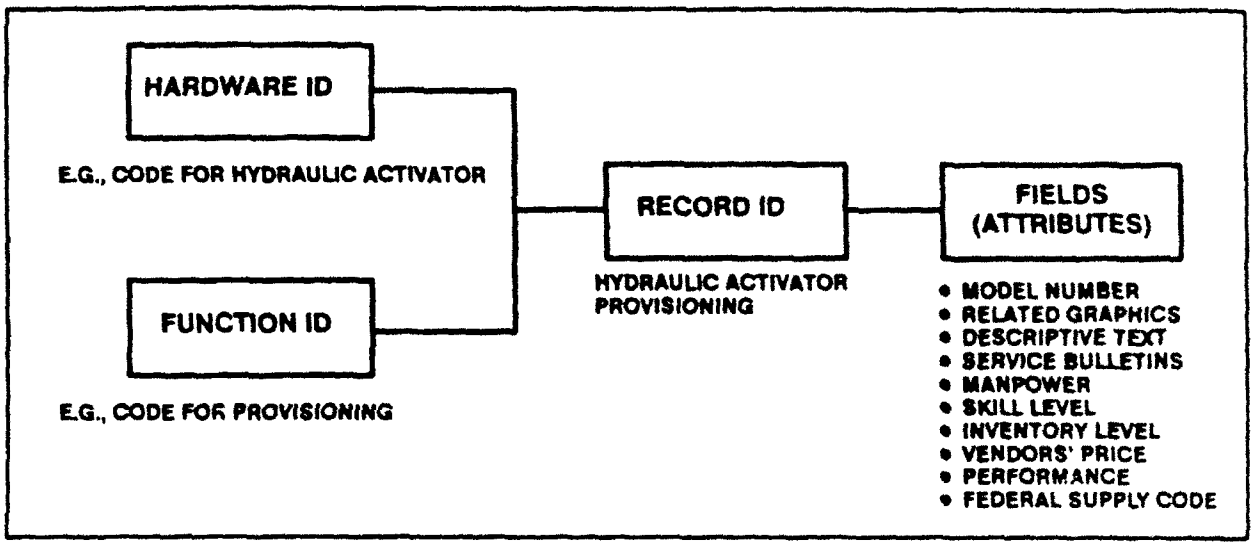

FIGURE 5. LDI INDEX AND RECORD CONCEPT

LDI presumes a commonality of functions related to the maintenance of each piece of hardware. While there is a similarity between functions across systems, the differences can be so significant that they could result in system unique indexes. The hardware function index structure may not result in unique identification of data which could lead to redundant data storage.

The LDI strategy for storage is based on four files that structure functionally related information rather than product data relationships. The LDI product data model merges what has been traditionally viewed as a product dta model with a functional model. Problems of managing configuration of system and subsystems are also not directly addressed.

The combination of hardware and functional capabilities within LDI make it difficult to isolate access to information and provide boundaries for user access. However, LDI provides efficient functional retrieval and does allow functional users to approach the data based on their unique needs.

Converting a weapon system's database to accept this index would require a major data restructuring effort. LDI is, however, conceptually and technically feasible for new weapon systems if consensus on the index structure can be found.

3.3 ROSEN SCHNECK INDEX - RS-INDEX

RS-Index scheme proposes that an index with multiple components be created to support the data transfer needed to enhance weapon system data automation and improve DoD and In-

dustry productivity. As depicted in FIGURE 6, the index would span industrial production and DoD operations. The proposal defines the following requirements for an indexing scheme: identification which requires uniqueness; classification which requires exclusivity; and structural contents which requires nodal identification. Additionally, the proposal identifies the need to include time and space elements and the need to be all inclusive, efficient and flexible. The scheme is, according to the proposal, designed to be fully compatible with IGES/PDES. The proposal delves deeply into the conceptual problems related to translating what it refers to as human knowledge or human information processing into machine knowledge or machine information processing and stresses the importance of establishing standards for databases.

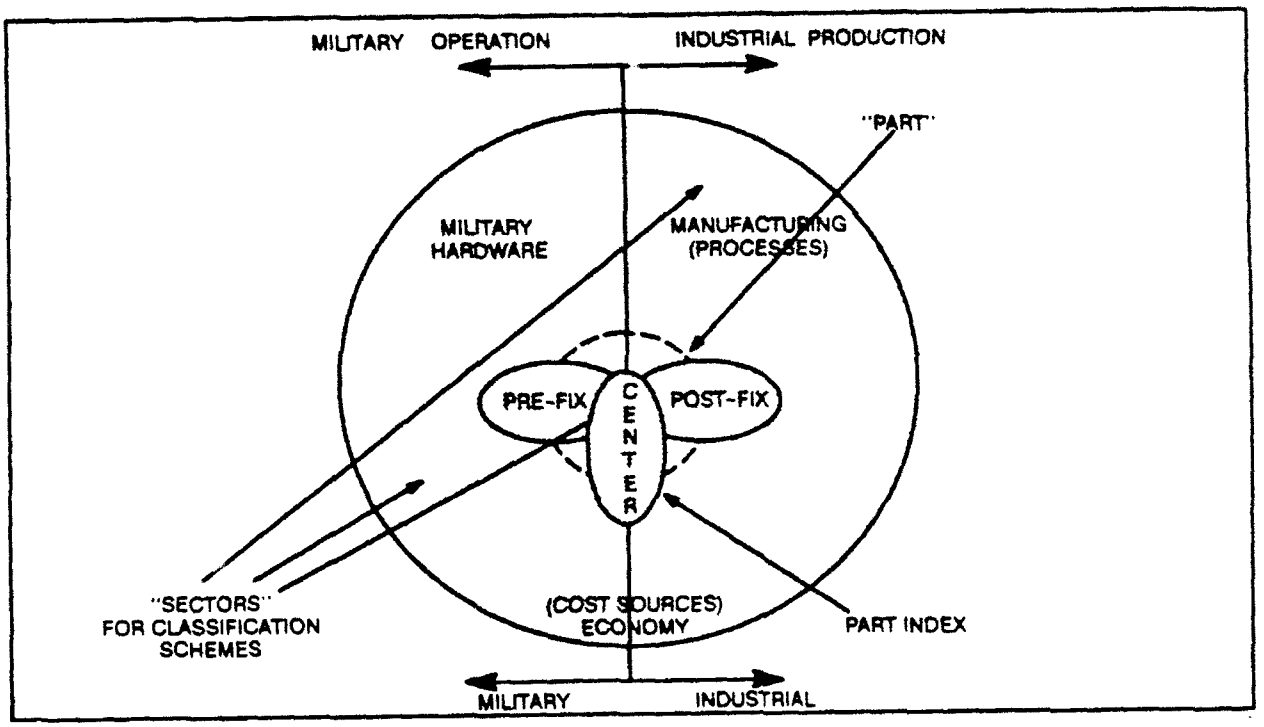

FIGURE 6. RS-INDEX

The RS-Index is based on an iterating logical inference scheme which allows for the development of a Universal Numbering Scheme. The Universal Numbering Scheme described in the RS-Index proposal would consist of an identification code, known as a part index, designed to be hardware or software specific with four blocks identified as:

- Prefix – which contains the complete assembly structure of the unit
- Time – which identifies an event in time
- Space – which identifies the place of an action or event
- Postfix – which contains the complete production structure of the unit

The proposal suggests that a Universal Numbering Scheme in and of itself is not a solution, it is only the enabling technology that permits the diversity of databases in computer systems to be organized and integrated. The proposal addresses the way in which Industry and government interrelate in producing and using information. The interaction between these two areas dictates a need for developing standards for data and databases.

3.4 UNIVERSAL NUMBERING STRUCTURE - UNS

UNS or Universal Numbering Structure is a proposal to improve weapon system support through better configuration management (CM). UNS proposes an extendible, multi-element index whose components are illustrated in FIGURE 7. UNS is composed of elements that are in common use in the Air Force and builds on the knowledge, training and experience of AF personnel with its index components. In addition, UNS provides configuration status accounting to information associated with a weapon system and a part.

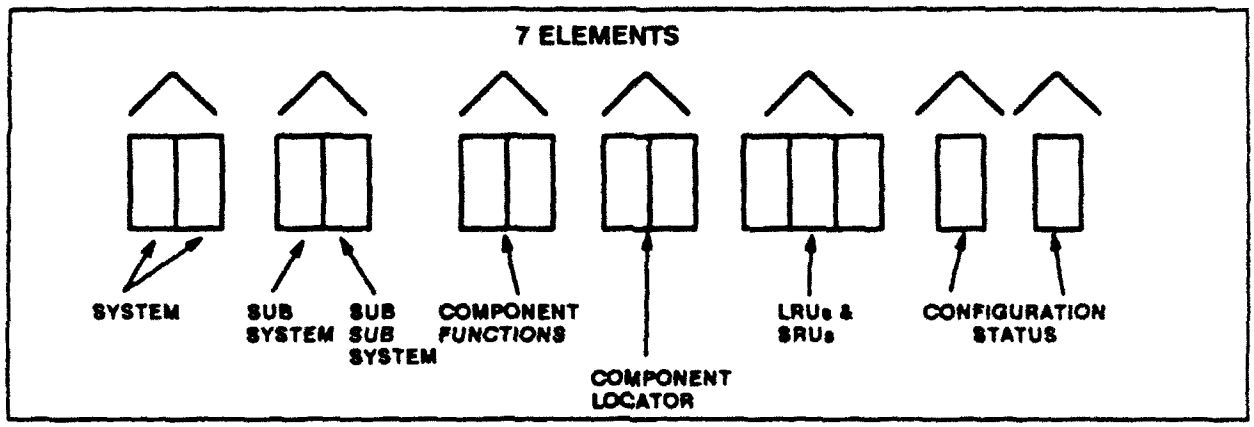

FIGURE 7. UNIVERSAL NUMBERING STRUCTURE - UNS

The first four elements together are in current use. The first two elements identify the system, subsystem, and sub-subsystem. The third element encodes the function that the component performs. The fourth element locates the component on the weapon system. The last three elements have been added to identify the level where a component is serviced and its configuration status. This index identification information provides manual and automated systems with an enhanced ability to perform their assigned duties with greater certainty by providing a tool that helps to keep information current with weapon systems configurations.

UNS recognizes that multiple numbering (indexing) schemes are used by different disciplines to identify the same object and that each of them has a configuration management concern. A UNS was proposed in order to better integrate shared information among these indexing schemes and reduce or eliminate configuration management problems.

UNS uniquely identifies a component in a weapon system by using a composite of existing indexes and a strong configuration management approach. It provides for the transfer of in-

formation between databases structured by weapon system functional hierarchy and allows for the connections of a component to its higher assemblies and to its system. The index is designed to provide information on the physical location of a component within a weapon system. The need for security is not directly addressed but the structure of the indexing scheme does not preclude the inclusion of codes to address security.

UNS is best applied to new systems or systems that already use the main UNS index component. UNS cannot be applied to existing databases or weapon systems that do not use UNS' basic component.

SECTION 4 - COMPARATIVE ANALYSIS OF THE INDEXING PROPOSALS

Each indexing proposal highlights some aspect of the indexing requirements. This section compares each of the proposals to each other and to the indexing requirements. The proposals are also measured against overall objective criteria to better understand their strengths and distinctions. The comparisons of the proposals will be built upon to draw conclusions and recommendations in the final section.

4.1 COMPARISON OF INDEXING REQUIREMENTS

FIGURE 8 compares the four indexing proposals in terms of how they meet indexing requirements and how complete they are. Some of the findings are summarized here:

Identification

- UNS provides the most interpretive index structure allowing users to relate the structure to specific weapon systems and subsystems. It identifies the hierarchy and use of a component within the related systems and subsystems. RS-Index, through its four index component approach, also provides a unique ID.
- LDI and RS-Index propose creating new unique indexes that will not preserve existing investments in indexes nor do they enable transfer of information with indexes other than their own, without some form of translation.
- None of the index formats accept change readily. The UNS proposal appears to accept change most easily because it allows an extension to existing index structures.

Reference

- TRIM is the only indexing scheme that directly addresses the requirement for data transfer across several existing databases without a major restructuring of current information.
- UNS and TRIM both could facilitate the bridging of information between heterogeneous data residing in separate databases. UNS through its approach of building on the common existing index structure and TRIM through building a standard cross reference.

Linkage

- The mapping and linking of databases in each indexing scheme is limited to those databases included in their universe and those databases that are mapped to their supported index(es).
- Each indexing proposal establishes the database links and the navigation paths within information repositories.

Requirement \ Proposal	TRIM	LDI	RS-Index	UNS
IDENTIFICATION				
Builds unique ID	TRIM accepts IDs provided by underlying index	Record identification dependent on combining indexes but ID is not unique	Multiple components make a composite unique ID possible	Seven element composite unique ID based on familiar concept
Defines a structure	Structure relies on existing database indexes	Achieving consensus on indexing structure very difficult	Structure is defined but only one (of three) indexing components uses familiar concepts	UNS is defined by its simple and easily understandable structure
Easily accepts change	Adding databases involves retrofitting a large data set	Index structure makes extension difficult	Complexity of index makes change acceptance difficult	Extends existing familiar index and allows for addition of new information
REFERENCE				
Supports data transfer	Data transfer supported for a limited set of TRIM mapped databases	Only supports data transfer from one LDI index to another	Data transfer supported for RS indexed databases only	UNS designed to integrate shared information through supporting data transfer
Establishes bridges between databases	Two step translation provides bridge between TRIM mapped databases	LDI indexes provide for bridges to other LDI indexes in the same weapon system	Specifically designed to provide budgets for information transfer between military and industrial sectors	By building a common index for different databases, UNS facilitates bridging information
Supports multiple indexes	Supports only those indexes included in TRIM database	Creates new single source index. Does not support existing indexes	New RS indexes are not based on and do not support existing indexes.	UNS concept recognizes multiple indexing schemes
LINKAGE				
Connects related data	Connects data in TRIM DBs	Different logistic functions can use same logistics data using LDI	Design to link hardware and process information	UNS makes identification of similar information possible
Implements data models	Establishes database links and supports database navigation for TRIM registered databases	LDI structured data provide navigation paths for DBs	Provides structure for data storage and ability to navigate in three component indexes	UNS provides simple but rigorous structure for data storage and clear paths for navigating data
Supports configuration management (CM)	TRIM does not independently provide CM	CM is indirectly addressed by LDI	CM issues not addressed by CM	Good CM is integral to the UNS approach
SEGREGATION				
Assists data security	TRIM mapped indexes can be tagged with security level	LDI indexes can be assigned security levels	RS indexes can be given security levels	UNS indexes can have security levels
Limits user access	TRIM indexes can define boundaries for user access	LDI can set user access boundaries	RS defined boundaries can be applied to users	UNS indexes can establish user boundaries
LOCATION				
Establishes existence of data	Easy access to TRIM indexed data	Product support in LDI for funding data	RS indexed data can be found	UNS data can be readily found
Enables efficient retrieval	Use of familiar indexes already in use support rapid access	Functional data retrieval is efficient but unfamiliar LDI indexes may hinder rapid access	Unfamiliar RS index may reduce speed of access	Familiar and easily understandable index helps speed access
Supports multiple perspectives	TRIM database indexes reflect multiple functions	LDI only supports its own view of data. Does not allow users to approach data for own unique needs	Multicomponent index supports access from different areas	UNS index components support several views of data

FIGURE 8. KEY CAPABILITIES OF INDEXING PROPOSALS

- TRIM and LDI do not contain configuration management information in their index. They rely on other data elements to contain that information. RS–Index and LDI possess configuration information embedded in their index structures. This assists users in data identification and use.

Segregation

- Although requirements for information segregation is not directly addressed by any of the proposals, they can all support an automated data security system.
- User access to information can be supported by any indexing proposal to classify boundaries and grant user access privileges that are needed in an overall information security system.

Location

- TRIM and UNS both enable the use of familiar indexes that are in current use. This simplifies the identification and location of the required data. The LDI and RS–Indexes are based on unfamiliar index components.
- Although each index enables the user to find data items, its usefulness depends on how easily and quickly this can be done.
- TRIM provides the means to access information from different functional perspectives, whereas, the other three indexing proposals do not support this need.

4.2 ANALYSIS OF PROPOSALS

FIGURE 9 reviews each proposal from the perspective of nine other criteria deemed to reflect the indexing requirements. The following analysis highlights how each of the indexing schemes address these criteria.

- **Major Objective** – The major objective of each indexing proposal is different ranging from linking existing databases (TRIM), assisting logistics functions (LDI), creating a unique universal index (RS-Index), and adding configuration management to an existing index (UNS)
- **Major Weakness** – A common weakness is that with the exception of UNS, they do not absorb change or extension well. All proposals are limited in the number of indexes they can link.
- **Application Domain** – LDI, RS-Index and UNS can apply well to new weapon systems. UNS and TRIM apply well to existing weapon systems which use their indexes.
- **Feasibility** – All indexing proposals are feasible but only TRIM and UNS seem practical as they can link existing databases without adding any major new burdens, and provide a basis for integrating new weapon system data.

Indexing Proposals / Characteristics	TRIM	LDI	RS-Index	UNS
MAJOR OBJECTIVE	Link existing indexes & databases	Assist logistics functions	Create a unique universal ID	Extended an existing index to cover CM
MAJOR WEAKNESS	Limited number of indexes - not extendible. Need to create a very large data set to translate indexes	Only applies to LDI indexed databases. LDI assumes a commonality of functions related to hardware maintenance	Cumbersome to create and apply	Only if UNS index has been created for new weapon system. Not useful for existing weapon system
APPLICATION DOMAIN	Any databases can be included in TRIM metaset	Logistics function databases	Only applicable to new weapon systems	New weapon system indexes are prime candidates for UNS
FEASIBILITY	Technically possible but limited to data sets that have been included in TRIM metaset	Technically possible but requires all logistic functions to standardize identification of hardware and function	Technically possible but unfamiliar index may block its use	A technically possible, practical extension to an existing index
STANDARDS REQUIREMENTS	TRIM metaset imposes standards for each included index	The LDI index structure and contents are its standard	Each component of the RS Index contains its own standards	Each UNS index component is governed by standards
SECURITY	Can be adapted to address security needs	Can set boundaries for users and data security	RS index can be used for data & user security	UNS & components can support security
DATA MANAGEMENT	TRIM creates a new data set with additional data management needs	Data managed by current functions after new indexes are set	Data management remains the same after new RS indexes are introduced	Current functions continue to manage data. UNS contains powerful configuration status accounting capability
DATA TRANSFER	Data transfer supported for a limited set of TRIM mapped databases	Supports transfer from one LDI index to another	Data transfer support for RS indexed databases only	UNS designed to integrate shared information through supporting data transfer
CONFIGURATION MANAGEMENT (CM)	TRIM does not independently provide CM	CM is indirectly addressed by LDI	CM issues not addressed by CM	Good CM is integral to the UNS approach

FIGURE 9. INDEXING PROPOSALS ANALYSIS SUMMARY

- **Standards Requirements** – There are no currently accepted standards for indexing, and as yet no clear set of requirements for indexing standards have been defined. As a result, each index proposal attempts to define its own standards.
- **Security** – No indexing proposal contains a well defined security component but indexes from all proposals can be instrumental in assigning security classifications for information and users.

- **Data Management** – TRIM creates a new layer of data management requirements which will require cross-functional coordination. The management and use of the other indexing schemes can be done at the local user level.
- **Data Transfer** – Each proposal is restricted to data transfer within its indexed bases. Links are needed to transfer data to new databases.
- **Configuration Management** (CM) – RS-Index & UNS include configuration management information in their index structure. TRIM and LDI rely upon data present in their databases to track CM.

SECTION 5 - CONCLUSIONS AND RECOMMENDATIONS

This report has examined four current indexing proposals against the indexing requirements formulated in this analysis. The conclusions are summarized in this section and are followed by recommendations based on the analysis.

5.1 CONCLUSIONS

In FIGURE 10 each proposal is mapped against the data management functions over the WSLC. By proposing to build a cross-reference that allows linking of diverse databases, the TRIM approach can provide the near-term capability for information exchange. The UNS approach provides a good alternative based on an index structure built around the weapon system functional hierarchy. An index approach based on a combination of these two ideas where the TRIM metaset includes the weapon system breakdown could meet a broad range of indexing requirements. This would enable the acquisition of new data to be integrated with existing data and cross referenced through the TRIM metaset.

Indexing Proposals	← Data Management Functions over the WSLC →				
	Creation	Interface	Storage	Distribution	Use
TRIM		●	○	●	●
UNS	●	○	●	○	○
LDI	○				●
RS-INDEX	○				○

● - Meets indexing requirement in this area
○ - Partly meets indexing requirement in this area

FIGURE 10. INDEXING PROPOSALS & DATA MANAGEMENT FUNCTIONS

The findings summarized in FIGURE 10 are highlighted in a brief overview of each proposal.

TRIM

- The TRIM concept specifically addresses a near-term CALS priority of facilitating information exchange between existing databases.
- TRIM provides the possibility for the broadest interface for existing databases through its concept of building a "cross-reference" table based on a standardized TRIM metaset.

- The components (data elements, keys and relationships) of the metaset can be adapted to develop new conceptual schemes for future data acquisitions and storage.
- Through its ability to link various data structures, TRIM can support a wide range of data distribution requirements.
- The metaset concept provides strong support to the user who, for example, has access to information which is structured according to a local requirement (such as a workplan), and who wishes to access information from another database structured to a different local requirement (such as a part number). Using the metaset concept, the user can then build a local database that combines the relevant information (e.g., workplan and part number).
- The benefits of having a metaset would have to be measured against the cost of maintaining and processing this kind of data structure on an ongoing basis.

LDI

- Using the hardware component of LDI as a bridge to the LDI indexing scheme could be very effective in linking a product database to a functional database such as maintenance and procurement.
- The hardware/function index structure may not result in a unique identification of data which may lead to redundant data storage requirements.
- While it may be conceptually possible to extend LDI to include other functional areas such as design and manufacturing, in practice LDI may not be readily adaptable to support databases structured along product data models such as PDES.
- Restructuring existing databases to conform to LDI would require extensive effort.

RS-Index

- RS-Index scheme has a manufacturing orientation and attempts to provide a structure that includes the relationship between technical data in both the government and Industry domains.
- RS-Index scheme does establish a unique identifier but the nature of the component modules of this index needs more definition. The rationale for including the time and space module in the index is not clearly established.
- The RS–Index notion of multiple components is valuable, but the proposal does not go beyond outlining them and leaves the question of how it would work in specific situations unanswered.

UNS

- The UNS scheme extends index structure which is already in use within the Air Force.

- The UNS index is designed to completely identify a part by its location within the weapon system.
- Because each part is identified within a specific weapon system, it is difficult to uniquely identify parts in common use across weapon systems.
- Because UNS builds on the existing Air Force index, it is possible to connect existing databases structured on the hierarchy of systems and subsystems.
- UNS proposal integrates the configuration status of the part in the index structure.
- UNS proposal provides the means to extend indexes.

5.2 RECOMMENDATIONS

This paper has examined essential requirements related to indexing in a CALS environment, and reviewed some existing proposals for addressing these requirements. While each of the proposals might be applicable to a specific situation, none can completely meet the broad requirements for information exchange in the highly automated environment envisioned by CALS. In addition, indexing is only one aspect of data management in an integrated data structure. The following near term and longer term recommendations provide guidelines for developing an indexing capability that addresses the existing and emerging needs as the CALS environment evolves

NEAR TERM RECOMMENDATIONS

- **Link existing systems:**
  Building a cross reference of specific information that will allow users access to related information resident in diverse databases. Specific steps to accomplish this task should include:
  - Identifying CALS significant databases that contain technical data that need to be linked to support the transfer of information.
  - Identifying the keys currently used to index these databases.
  - Establishing appropriate relationships between keys to support data access requirements.
- **Prototype specific proposals:**
  Proposals that specifically address the need to cross-reference data, (namely TRIM and UNS), may be prototyped in the current environment of an operational locator system like MEDALS (Military Engineering Data Asset Locator System) to demonstrate the utility of linking different databases. Specific tasks to support this prototyping include:
  - Identifying functional areas within a system that require data from multiple sources.

- Developing a prototype cross reference, an enhanced index, and a schema which will facilitate data exchange.
- Hosting the prototype on an operating environment that supports a specific activity to demonstrate the utility of linking the data bases.

LONGER TERM RECOMMENDATIONS

- **Develop Indexing Concepts:**
  Additional effort is required to completely define and validate DoD requirements for an indexing scheme. This paper provides an initial framework for considering the value of indexing in a functional context. Specific additional tasks that should be considered include:
  - Validating the indexing requirements identified in this paper.
  - Establishing important components that should be included in the index to support a variety of user perspectives on data access.
  - Determining the nature of an index "kernel" – the least common denominator which should be included in an index. This "kernel" becomes the core standard from which the rest of the index is built.
  - Defining how an index "kernel" will support specific functional area requirements for customized indexes while enabling the exchange of information with other CALS compliant data bases. This "kernel" becomes the core standard from which the functional areas will be able to build their own customized indexes.
- **Define Indexing Standards:**
  The first step towards developing and indexing standard is to define which elements of an index must be included in a standard. An indexing standard must be developed that will allow new indexes to meet specific functional requirements within a well defined index structure. This steps to achieve this would include:
  - Developing standard specifications.
  - Developing tests for index standards
    - Conformance testing
    - User testing
  - Coordinating with Industry
- **Integrate Indexing Strategy with the CALS Data Management Infrastructure:**
  Indexing strategy must be considered in the context of overall data management infrastructure. This includes other data management concepts such as data dictionaries, configuration management and data security. There is a

need to coordinate standards development in all data management areas. This would include:

- Including index standards in defining data dictionary standards
- Assessing the relevance of including data security elements in indexing structures.
- Ensuring index support for configuration management.