UNIQUE STRATEGIES FOR TECHNICAL INFORMATION MANAGEMENT AT JOHNSON SPACE CENTER

Vijay Krishen
Documentation Data Management Systems, Inc.
4127 Long Grove Drive, Seakbrook, TX. 77586

Abstract

In addition to the current NASA manned programs, the maturation of Space Station and the introduction of the Space Exploration programs are anticipated to add substantially to the number and variety of data and documentation at NASA Johnson Space Center (JSC). This growth in the next decade has been estimated at five to ten fold compared to the current numbers. There will be an increased requirement for the tracking and currency of space program data and documents with National pressures to realize economic benefits from the research and technological developments of space programs. From a global perspective the demand for NASA's technical data and documentation is anticipated to increase at local, national, and international levels. The primary users will be government, industry, and academia. In our present national strategy, NASA's research and technology will assume a great role in the revitalization of the economy and gaining international competitiveness. Thus, greater demand will be placed on NASA's data and documentation resources. In this paper the strategies and procedures developed by DDMS, Inc., to accommodate the present and future information utilization needs are presented. The DDMS, Inc., strategies and procedures rely on understanding user requirements, library management issues, and technological applications for acquiring, searching, storing, and retrieving specific information accurately and quickly. The proposed approach responds to changing customer requirements and product deliveries. The unique features of the proposed strategy include: (1) To establish customer driven data and documentation management through an innovative and unique methods to identify needs and requirements. (2) To implement a structured process which responds to user needs, aimed at minimizing costs and maximizing services, resulting in increased productivity. (3) To provide a process of standardization of services and procedures. This standardization is the central theme of the strategic approach. It will allow Division level Data and Documentation Libraries (DDLs) to function independently and optimize efficiency at the Directorate level. This process also facilitates interconnectivity between Division level DDLs and makes them transparent to the users, (4) To implement the process of "cost savings", and at the same time the objective is to gain substantial improvement in the organization, categorization, and preservation of JSC-generated data and documentation, and (5) To find, locate, retrace, restore, and preserve the Center-generated crucial scientific and technical information that has been and is being provided by the engineers and scientists of JSC. This is important to the preservation of "lessons learned". Preliminary estimates of the possible cost savings which will result from the implementation of this process will also be discussed in this paper.

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I. Introduction

Access to data and documentation generated by NASA Johnson Space Center (JSC) programs is increasing rapidly; however, efficient access to the information is not increasing proportionally. This effect gives rise to the personal office library, which is common throughout (JSC) and contractor community. Such a library is highly focused, not updated properly, haphazard, and consumes crucial office space and professional time. These limitations are commonly accepted as a matter of convenience and necessity. To improve this condition each Division/Office of JSC has embarked on a program to develop a Division/Department level Data and Documentation Library (DDL). The goals are to reduce dependence on office libraries and to deliver an easily accessible resource whose total value offsets the office style convenience.

At the present time, there are more than 45 DDLs, in addition to the JSC Scientific and Technical Information Center (STIC) located in building 45. Out of these, more than 17 are outside JSC, establihsed by support contractors and more than 28 are in throughout JSC Divisions/Offices. These DDLs contain information related to programs/projects for which a Department/Division/Office is responsible. The types of information residing in these DDL's includes: paper documents, video, audio, photos, magnetic tapes, CDs/CD-ROM Systems, optical disks, microfilm, blueprints, drawings, slides, viewgraphs. Books, journals, periodicals, and international publications are contained in the STIC and not generally in the DDLs.

Tables I and II provide approximate numbers of of video recordings, photographic images, and printed materials at only one of the distribution sites at JSC. The retaped and reprinted data is estimated for the 45 DDL's. In addition to this estimate there are closet and office libraries containing valuable information. On the basis of an average of 25K documents per DDL, the overall estimate of documents in and around JSC is 112.5 M, assuming that each document has only 100 copies distributed throughout these libraries. The personal distribution copies are not included in this estimation.

Table I. Current scope of data and documentation

APPROXIMATE NUMBERS	
CURRENT SCOPE	**YEARLY INCREASES**
• **VIDEO**	
- 4,750 Hours Recorded	- 2,500 Hours Mission Recorded
- 4,000 Hours of Retaped Data	- 700 Hours of Retaped Data
• **PHOTOGRAPHIC IMAGES**	
- 1 Million Images	- 30,000 Images
- 2 Million Reprints	- 20,000 Images
• **PRINTED PUBLICATIONS/MATERIALS**	
	- 22,800 Documents
	- 112 Million Impressions
	- More than 200 Million Xerox copies
* Audio Data Estimates Not Available	

Table II. Estimated contents of DDLs

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│                                                                   │
│                    APPROXIMATE NUMBERS                            │
│                                                                   │
│   •  EXAMPLES OF CURRENT DDL CONTENT                              │
│      - JSC Mission Operations Directorate        -  83 K         │
│      - JSC Engineering Directorate               -  79 K         │
│      - JSC History Library                       -  696 K        │
│      - Loral's 5 area Documentation Centers      -  210 K        │
│                                                                   │
│   •  ESTIMATED CURRENT DATA AND DOCUMENT CONTENT OF 45           │
│      DDL's                                                        │
│      - Average Content 25 K                                      │
│      - Total Content 1.125 M                                     │
│                                                                   │
│   •  ESTIMATED DUPLICATION/MULTIPLICATION RATE                   │
│      - Average 100                                               │
│                                                                   │
│   •  TOTAL CONTENT IN OFFICES & DDL's 112.5 M                    │
│                                                                   │
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Several support contractors operate the DDLs. As a result of organizational and contractor differences, there are diverse management and operating procedures among the DDL functions. Such diversity has introduced non-standard storage and retrieval features, confusing data and document structuring, cataloging, distribution, record keeping, and limited on-line viewing of the DDL contents. As a result, the quality of services has suffered, and costs are unreasonably high. Figure 1 presents an analysis of the current situation in regard to information status and considerations. The main feature of this diagram is the CONSEQUENCE of the situation.

In addition to the current NASA manned programs of Space Station, the introduction of the space exploration programs are anticipated to add substantially to the number and variety of data and documentation at JSC. This growth is being estimated at seven to ten fold compared to current situation. With the national presures there is an increased requirement to realize economic benefit from the research and technological developments of space programs. Moreover, the accountability for data and documents will continue to grow as the space technologies find their uses in our commercial sector. We believe that the investing in information infrastructure or highways, as referred to in the Presidents technology policy, will provide greater demand for space information.

Unique strategies and procedures relying on understanding of user requirements, library management issues, and technological applications for acquiring, searching, storing, and retrieving specific information accurately and quickly will be needed to provide services and achieve significant cost savings. Our vision is to have all this information collected, organized, categorized according programs and projects, and networked within Divisions/Departments/Offices, Directorates, and JSC, and contractor community. To achieve this, we need to establish a strategy that defines an organization's directions and requirements.
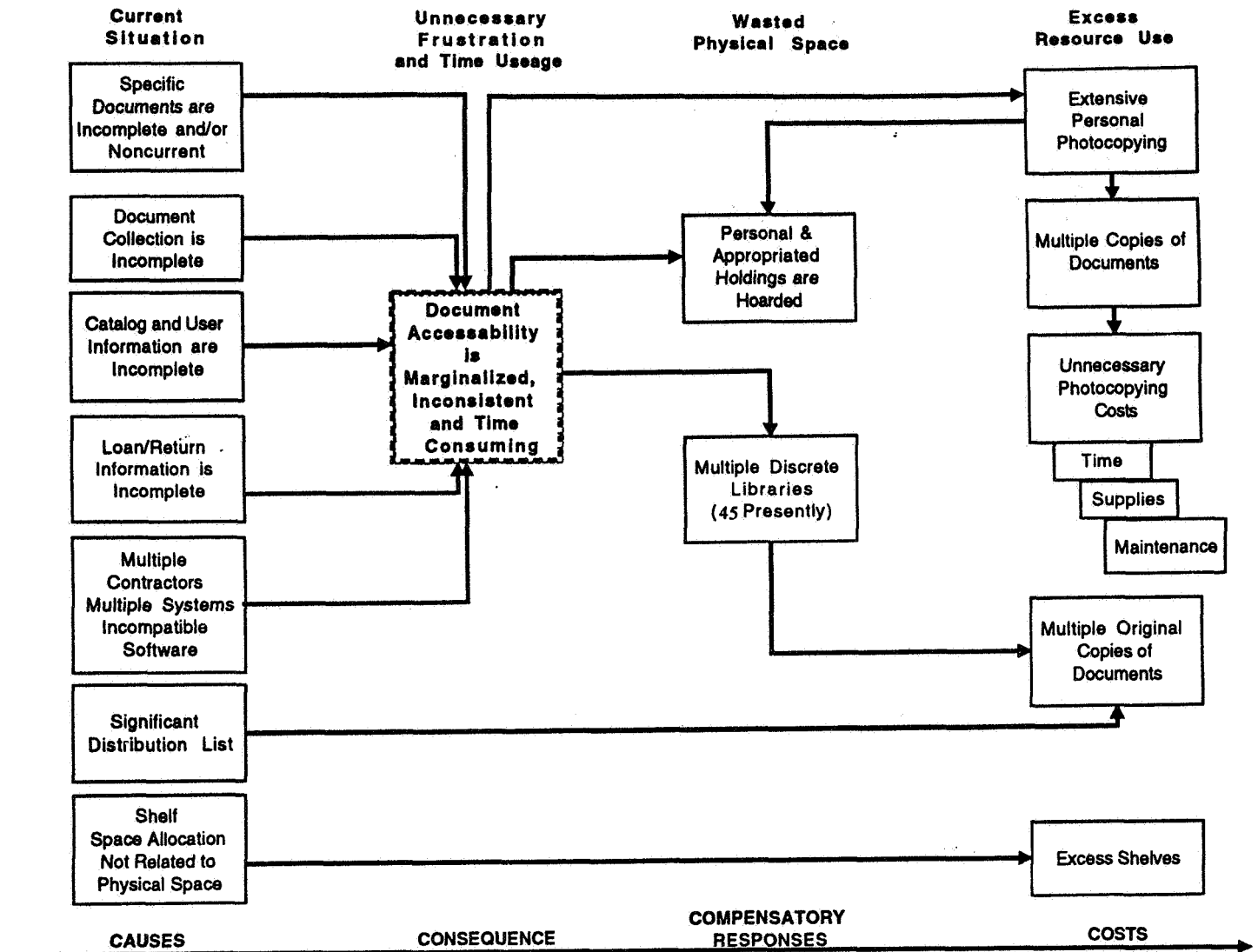
Figure

Current Situation | **Unnecessary Frustration and Time Useage** | **Wasted Physical Space** | **Excess Resource Use**

Specific Documents are Incomplete and/or Noncurrent

Document Collection is Incomplete

Catalog and User Information are Incomplete

Loan/Return Information is Incomplete

Multiple Contractors Multiple Systems Incompatible Software

Significant Distribution List

Shelf Space Allocation Not Related to Physical Space

Document Accessability is Marginalized, Inconsistent and Time Consuming

Personal & Appropriated Holdings are Hoarded

Multiple Discrete Libraries (45 Presently)

Extensive Personal Photocopying

Multiple Copies of Documents

Unnecessary Photocopying Costs

Time

Supplies

Maintenance

Multiple Original Copies of Documents

Excess Shelves

CAUSES   CONSEQUENCE   COMPENSATORY RESPONSES   COSTS

Figure 1. Data and Document status, consideration and consequence

II.   Strategy For Information Management

The strategy for managing information through the DDLs will consist of the following key components:

(1)   Development of DDL for each Division/Department which is responsive to the needs and requirements of users. Each DDL should contain data and documents for the projects and programs for which the Division/Department is responsible. Each DDL should be physically located such that it is easily accessible to the Division/Department users. This will help to reduce the need for "personal" office libraries, cut down duplication/multiplication of information, and it will also reduce the access distribution.

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(2) Implementation of flexible management and utilization approaches which uses existing infrastructure and assets. The flexibility is needed to reflect the changing needs and requirements for information. In particular, changes in projects, programs, and technology should be accommodated in the process. Use of existing facilities and assets is a part of cost savings goal.

(3) Development and implementation of a standardized process in the management and operation of the DDLs. The elements of the process include acquisition, organization, distribution, categorization, retrieval, database design, interconnectivity, storage, and physical structure of the DDLs.

(4) Development and implementation of performance measurement procedures. This includes customer feedback, frequent surveys, and analysis of the data to provide a "customer driven" process (Figure 2).

(5) Incorporating a deliberate procedure to ensure improved services and/or reduced costs for each activity related to the development and operation of DDLs. This process is captured in Figure 3.
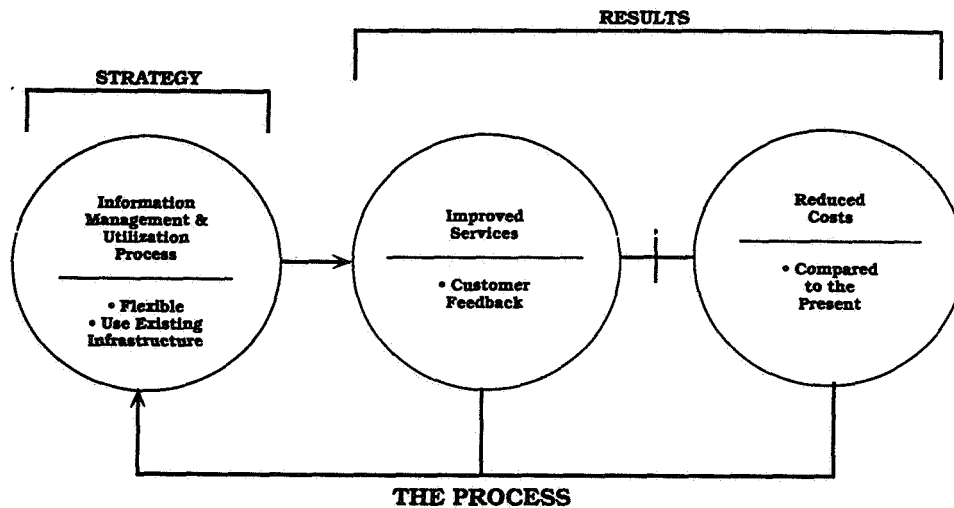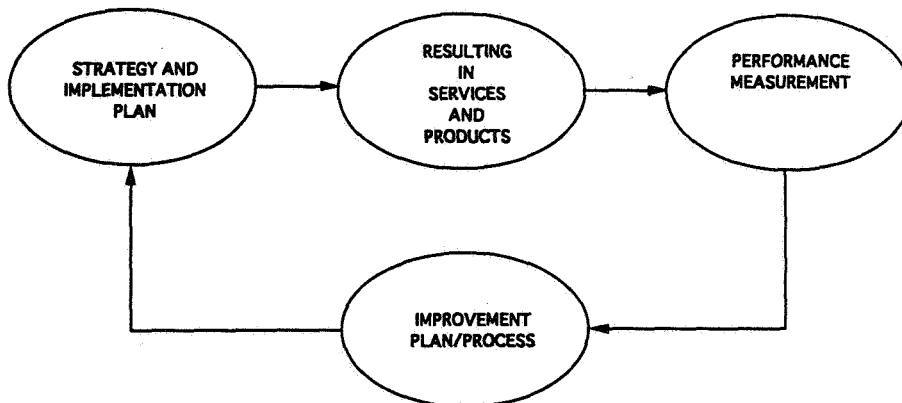

Figure 2. Customer driven strategic process

Figure 3. Process for continuous improvement

The key to a successful strategy is the formulation of present and future data and documentation needs and requirements for each Division/Department at JSC and within the contractor community. A structured approach to evolve a DDL management system which will satisfy these requirements then forms the core of the strategy. A crucial part of the strategy is to introduce appropriate procedures and technology which will enhance the services and reduce the costs. The result of improved services will be increased productivity from engineers, scientists, and managers. The process adopted should use existing infrastructure and be flexible. The result of the strategy should be reduced costs and/or improved services.

Information management and utilization process includes knowledge capture, transfer, and change/update of data and documentation. Additional aspects include, standardization, search/research, acquisition, updating, database design, networking, structured physical layout of the DDL, and streamlining of reception/distribution of data and documentation

The current assessment of the DDLs leads to the areas of improvement which include:

(1)   Identification of needs and requirements at Division level
(2)   Overall configuration control
(3)   Intercontractor communication for standardization and configuration control
(4)   Interface and integration of multiple contractor software design implementation at Division level
(5)   Efficient physical storage and retrieval
(6)   Standardized computer logging and retrieval
(7)   Streamlined approach to distribution and duplication/multiplication of data and documentation
(8)   Accurate records of loan and hold
(9)   Archival and preservation of critical information
(10)   Division, Directorate, and contractor level interconnectivity
(11)   Provide process to incorporate new information such as Space Station, new and advanced programs
(12)   Provide periodic performance assessment/measurement

A part of the strategy is to gain control over the current situation by implementing enhancement procedures. Several such steps are shown in Figure 4.
The progress through the improvement process adds successive levels of value through: 1) the increased utilization of the libarial system; 2) more efficient use of space; 3) reducing storage requirements for data and documents; 4) using relevant procedures to expedite the time required to log, store, and retrieve data and documents; 5) reducing photocopying requirements; 6) capitalizing on configuration control to standardize the operating features among DDLs; 7) establishing a systematic process for managing revisions of information for each DDL; 8) removing obsolete documents and maintaining only required number of copies. In parallel with the near-term improvements, an activity leading toward refining the advantages and disadvantages of keeping the existing information system posture; pursuing a standard operating system for all 45 libraries which relies on unifying current technologies within JSC; or modernizing with outside data management processing tools. A considerable number of these modern tools have proven features for reliably, accurately, and rapidly retrieving and integrating a great volume of topical information represented by a wide variety of media. The gateway to the formulation of options is a cost/benefit analysis and assessment.

LAN/CD-ROM DATABASE SYSTEM
CATALOG and FULL TEXT INFORMATION

Current Situation	Improvements	Improved Situation	Wasted Physical Space	Excess Resource Use

Current Situation:
- Specific Documents are Incomplete and/or Noncurrent
- Document Collection is Incomplete
- Catalog and User Information are Incomplete
- Loan/Return Information is Incomplete
- Multiple Contractors Multiple Systems Incompatible Software
- Significant Distribution List
- Shelf Space Allocation Not Related to Physical Space

Improvements:
- Make Documents Complete and/or Current
- Make Document Collection Complete
- Make Catalog and User Information Complete
- Make Loan/Return Information Complete
- Standardized Process Local On-Line Database System
- Reduce Distribution Lists
- Bind Documents to Optimize Shelf Space Allocation

Improved Situation:
- Catalog and Document Accessability is Greatly Improved and Consistant
- Decrease Multiple Copies
- Reduce Needed Shelf Space

Wasted Physical Space:
- Reduce Hoarding of Personal & Appropriated Holdings
- Multiple Discrete Libraries (45 Presently)

Excess Resource Use:
- Reduce Personal Photocopying
- Reduce Multiple Copies of Documents
- Reduce Unnecessary Photocopying Costs
- Time
- Supplies
- Maintenance
- Multiple Original Copies of Documents
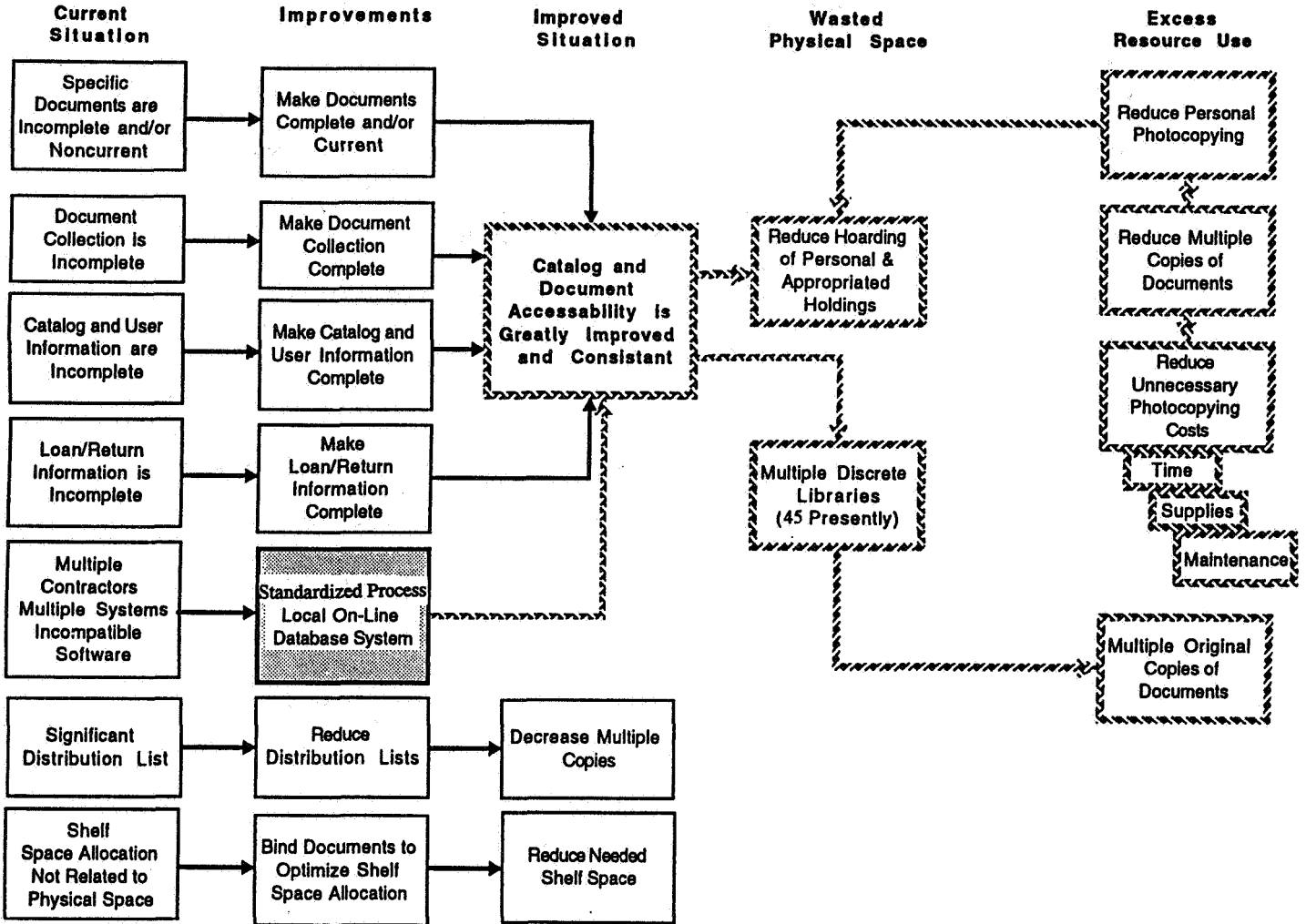
Figure 4. Information accessibility

III.   Implementation Strategy

The plan is to implement the project in the following manner: Data and documents for manned flights are to be categorized under specific projects such as National Space Transportation System (NSTS), Space Transportation System (STS), Assured Crew Return Vehicle (ACRV), Space Station (SS), Lunar Outpost/Mars Missions (LO/MM), and Research and Technology Development (R&TD). Subdivisions of these categories will reflect breakdown in terms of the disciplines such as power, propulsion, tracking, communications, data systems, crew systems, thermal systems, automation, robotics, aeronautics, navigation, control, software, systems engineering and others. We believe that the overall flow of the relational and hierarchial organizational process will be cost effective. The benefits will be obtained by the following procedures; 1) Make documents complete or current by incorporating changes, and revising and updating the information. 2) Make information collection complete by finding /locating program/project related documentation required by users, and order it from various distributors. 3) Make categorization complete by analysis of programs and projects and needed information, categorize it by the subjects and Division functions, then sort out the information for inputting process.

Phased approach has been used to implement this strategy. It has been devided in four phases, I through phase IV. This approach can be applied to a single Division/ Department, however, the phases and tasks can be extended to several Divisions/ Departments, and then to the Directorates. The ultimate goal is to extend this strategy to entire JSC and to support contractors to realize center-wide benefits. This phased approach is employed to lead to standardized procedures for the development and operation of DDLs. These phases are described briefly in the following:

Phase I
In this phase, a procedure is developed to conduct a study/survey of needs/ requirements of each Division/Department. The results of the survey (s) will be prepared for each Department/Division. A report identifying steps, procedures, and processess to alleviate problems and respond to customer needs will be generated. Specifically, the following areas need to be covered: 1) survey current capabilities (strengths and weaknesses); 2) survey user needs; 3) formulate requirements; 4) develop trade reports assessing cost/benefit/analysis and options; 5) identify impacts and benefits of savings that can be obtained from specific approaches. The forecast of information needs/requirements allows; a) to scope information infrastructure b) to formulate Division/Department level strategy, and c) to have realistic estimate of resources needed to develop and operate the DDL. Figure 5 shows the strategy for the identification of the requirements.

Phase II
In this phase, the option of a standardized database design program and its inter- connectivity within the Division/Department is researched. This option includes modification of existing database or incorporating new or advanced software system, such as CD-ROM or scanning-based data input. The pros and cons of each option are described and documented. Figure 6 depicts the features of database design which will enable interconnectivity and standardization.
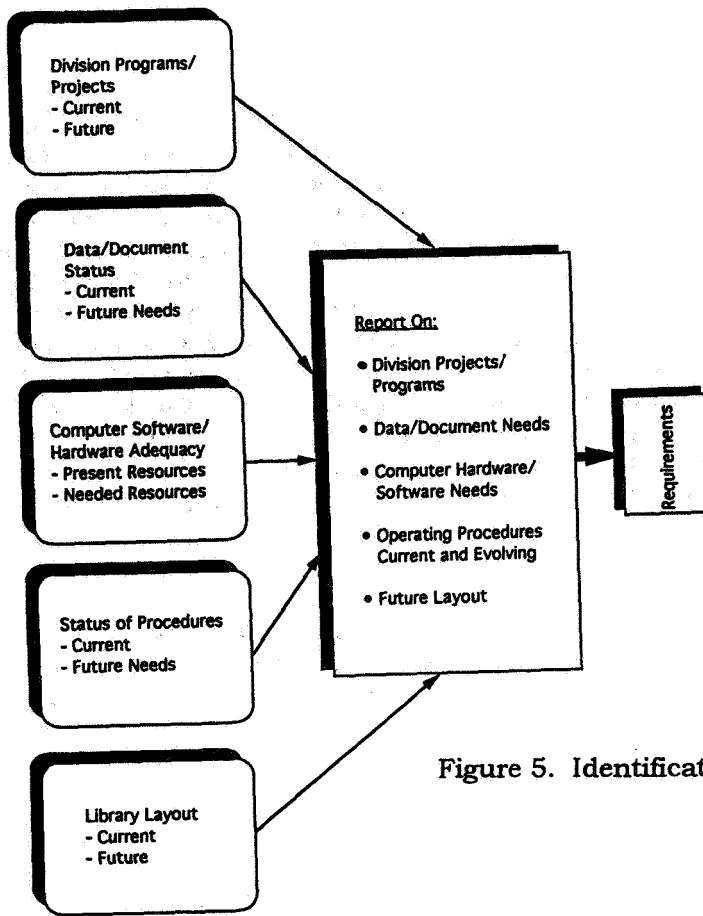
Division Programs/ Projects
- Current
- Future

Data/Document Status
- Current
- Future Needs

Computer Software/ Hardware Adequacy
- Present Resources
- Needed Resources

Status of Procedures
- Current
- Future Needs

Library Layout
- Current
- Future

Report On:

• Division Projects/ Programs

• Data/Document Needs

• Computer Hardware/ Software Needs

• Operating Procedures Current and Evolving

• Future Layout

Requirements

Figure 5. Identification of needs/requirements at Division level

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Unique Library Number

Categorization (CAT)
- Program
- Project
- Discipline
- Subject
- Title
- Acronym/Nickname
- Type of Data/ Document
- Size of Information

Computer Entry (CE)
- Subject
- Project
- Program
- Acronym/Nickname
- Physical Location
- Label Print Routine

Data and Document Search (DDS)
- Title
- Acronym
- Keywords
- Subject
- Physical Location

Special Features (SF)
- Duplicates
- Hold and Loan
- Requestors/ Borrowers
- Location Information
- Statistical Data

Printouts
- Labels
- Transaction Lists
- Data/Document Lists
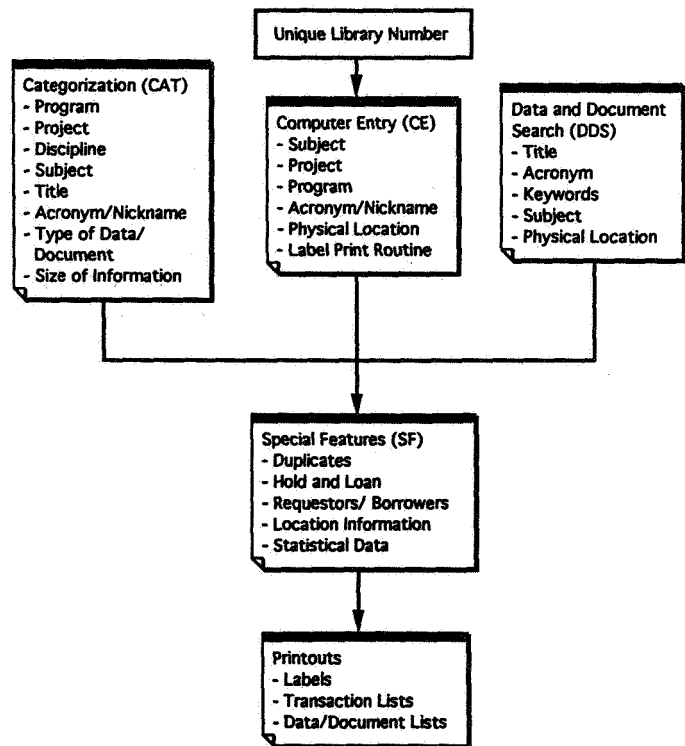
Figure 6. Database program-menu design (DBP-MD) and fields

Phase III

This phase contains a series of tasks which end with an operational DDL system. The phase is analogous to a conventional Design, Development, Test, and Evaluation (DDT&E) activity. It follows a set of milestones from a Preliminary Design Review (PDR) through a customer acceptance review. Verification/acceptance tests will demonstrate the success of implementing the approved system recommendations. The DDL will be put under formal configuration control at the completing of the Critical Design Review (CDR). The configuration management file will contain hierarchical information extending from Phase I and Phase II requirements (approved recommendations) to the system design standards and operating policies. Specifically the following tasks are to be accomplished: 1) Implement the database standardized menu design and software for interconnectivity; 2) verify and check data/documents to capture/retrieve information; 3) plan, develop, design, structure, maintain, and operate Division/Department data and documentation library (DDL) management system; 4) Provide ongoing support to maintain currency, and refine end-to-end procedures to follow.

Phase IV

A standardized process has already been developed, implemented, and established at the Division/Department level during previous phases. In this phase Program Office/ Directorate level implementation of DDL interconnectivity will then be extended to entire JSC and contractor community (Figure 7).
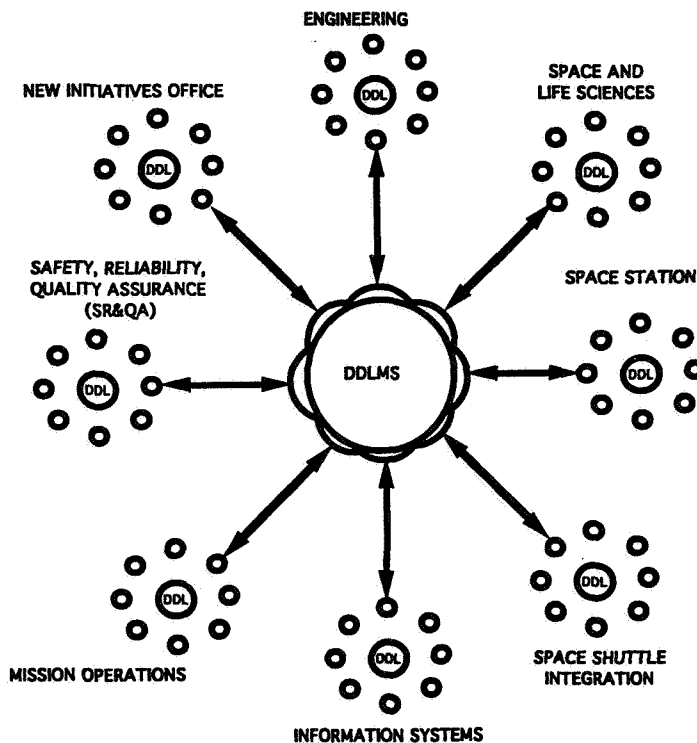

Figure 7. Inter-Directorate DDL implementation strategy

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A key task in this phase is to implement a standardized document request, receive and distribution method. Figure 8 and 9 shows a coordinated efficient process to handle incoming and outgoing data and document distribution diagram. This process will include providing a list of possible sources for documents, change requirements, and new revisions to each DDL. These DDLs will then process their requests electronically or manually. A coordinated information requesting, receiving, and distributing system will be designed according to programs/projects of each Division/Department and implemented. The result will be to provide improved customer service while at the same time reduce multiplication of documents and associated handling efforts (Figure 8 and 9).
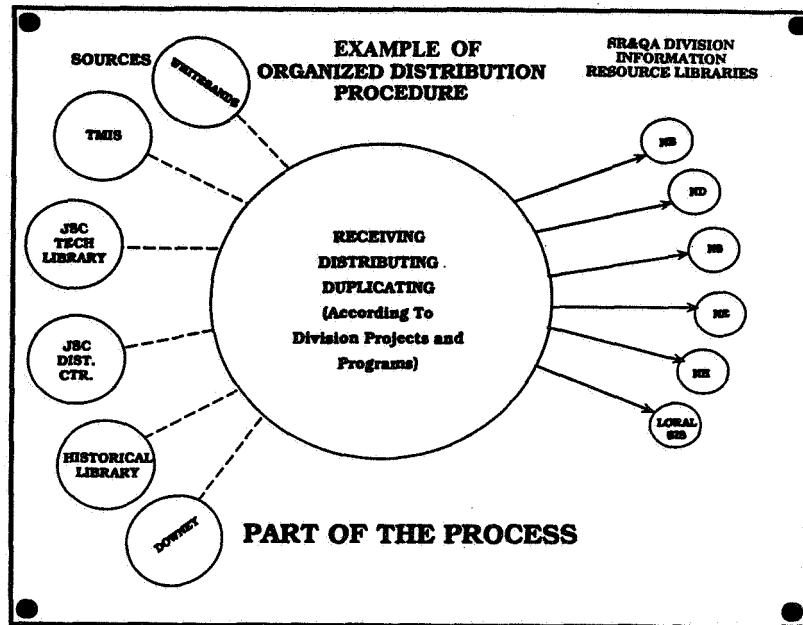

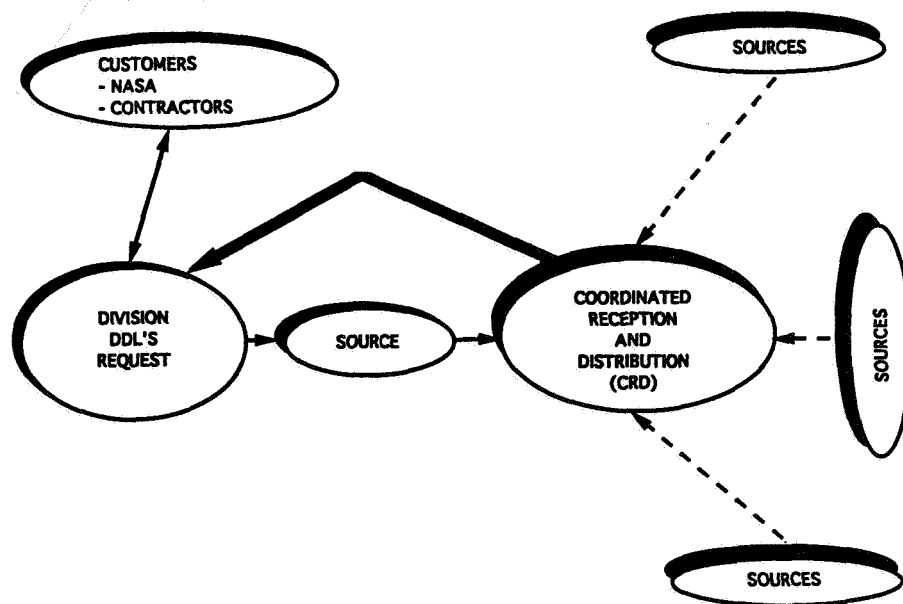Figure 8. Organized/categorized distribution procedure

Figure 9. Coordinated process of reception and distribution

Specifically, this phase also includes the following areas: 1) design efficient networking approach at Directorate level; 2) link Division/Department level DDLs with rest of the Divisions and contractor DDLs; 3) provide NASA JSC and contractor personnel of each Division an easy access to all information, and 4) to find/locate, retrace, restore, and preserve information that has been and is being provided by discipline specialists, software specialists, engineers and scientists of Johnson Space Center (JSC) in the past and at present.

The benefits of the implementation approach described in this section of the paper can be summarized as follows: 1) reduction in resources to upgrade and maintain systems software and documentation; 2) reduction in duplication of documentation; 3) reduction in space to house libraries; 4) improved availability to user; 5) decreased user search and acquisition time; 6) all information in most updated form; 7) traceable history of cost-savings and productivity enhancement; 8) and lessons learned preserved with knowledge capture.

IV.   Impacts of Technology Advancements

NASA and many other organizations are developing new technologies to manage information. Electronic capture, transfer, and retrieval of all kinds of information is progressing at a fast pace. In particular, NASA JSC is involved in the following research areas: 1) NASA JSC Electronic Library System (NELS); 2) Cooperating Network Systems (CNS); 3) Hyperman - a Hypermedia Viewing System (HVS); 4) Multimedia Presentation of Text, Audio, and Vedio from large Multimedia Libraries; 5) The Wide Area Information Server (WAIS); 6) Digital Document Storage and Retrieval Wavelet Technology; 7) Artificial Intelligence and Expert Systems, Knowledge Capture, Transfer, Display and Processing; 8) Highspeed and Parallel Information Processing. The early phasing in of this technology is one of the important areas of implemention flexibility for the DDLs. Utilizing new technology options for accessibility, database, cataloging, indexing, display, and retrieval will be constantly evaluated. Cost-effective approaches will then be implemented through trade off studies. The options available are given in Figure 10. The trend will be to develop electronic information sharing architectures for DDLs.

V.   Conclusion

The Clinton - Gore technology policy identified technology transfer from federal laboratories as a key factor for the economic revitalization of this Nation. To enable this transfer, NASA JSC has to share information with industries and academic institutions. It is vital that DDLs provide the necessary information to enable technology transfer. The approach to enhancing DDLs is to use disciplined methods to preserve and disseminate data and documentation. Furthermore, the objective is to provide cost-effective and quality controlled process, so that Divisions/Departments have control over their information needs and uses. NASA JSC is an ideal organization to develop and test an organized approach to information management. The overall network will consist of more than 45 DDLs serving more than ten thousand users. Once this interconnectivity and accessibility is established and optimized, the process can then be transferred to the industry to realize commercial benefits.
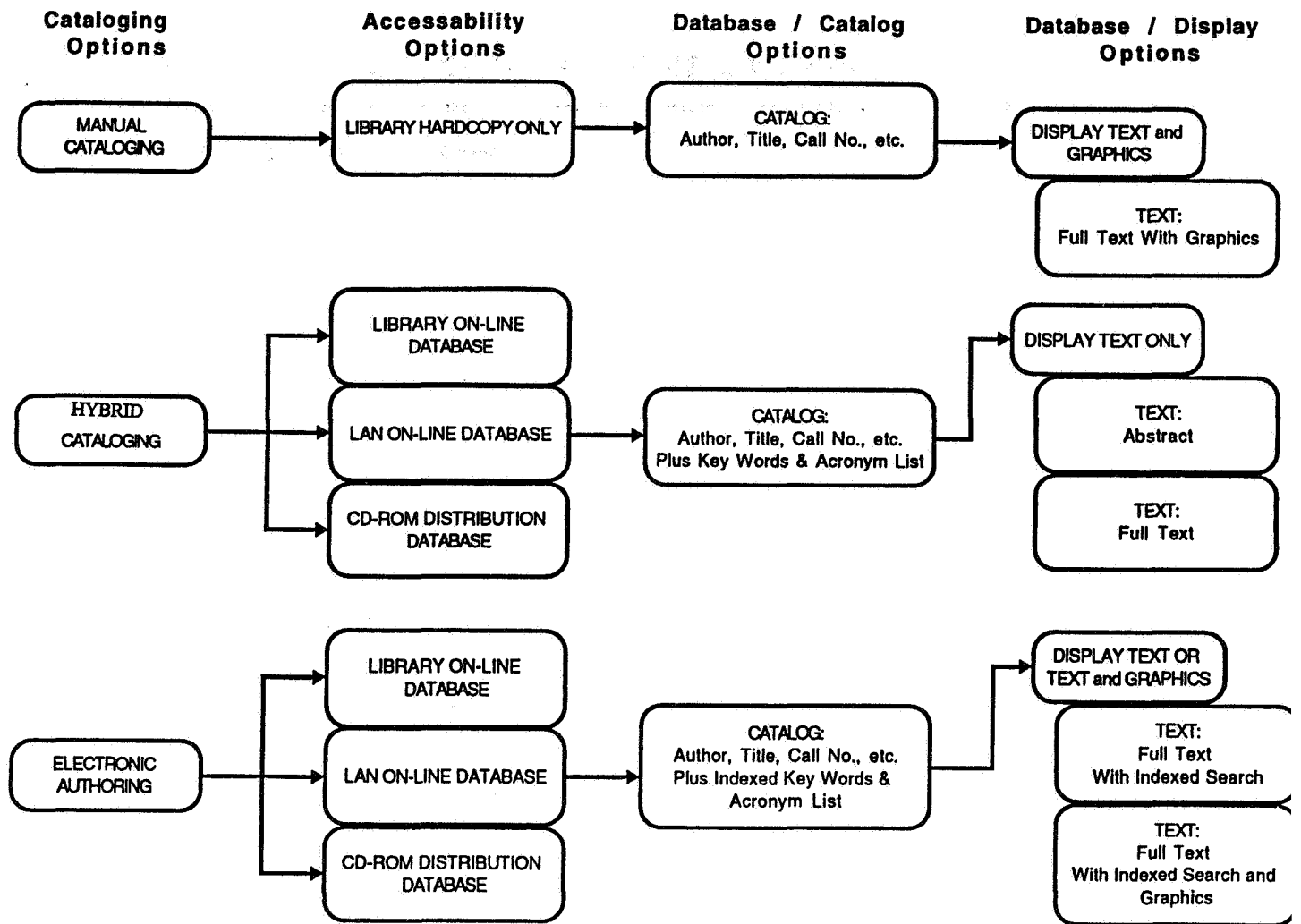
Cataloging Options	Accessability Options	Database / Catalog Options	Database / Display Options

MANUAL CATALOGING → **LIBRARY HARDCOPY ONLY** → **CATALOG: Author, Title, Call No., etc.** → **DISPLAY TEXT and GRAPHICS**

TEXT: Full Text With Graphics

HYBRID CATALOGING →
- **LIBRARY ON-LINE DATABASE**
- **LAN ON-LINE DATABASE**
- **CD-ROM DISTRIBUTION DATABASE**

→ **CATALOG: Author, Title, Call No., etc. Plus Key Words & Acronym List** → **DISPLAY TEXT ONLY**

TEXT: Abstract

TEXT: Full Text

ELECTRONIC AUTHORING →
- **LIBRARY ON-LINE DATABASE**
- **LAN ON-LINE DATABASE**
- **CD-ROM DISTRIBUTION DATABASE**

→ **CATALOG: Author, Title, Call No., etc. Plus Indexed Key Words & Acronym List** → **DISPLAY TEXT OR TEXT and GRAPHICS**

TEXT: Full Text With Indexed Search

TEXT: Full Text With Indexed Search and Graphics

Figure 10. Technology implementation options

VI.   Acknowledgments