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TECHNOLOGY OVERVIEW FOR ADVANCED AIRCRAFT ARMAMENT SYSTEM PROGRAM

May 1981

Prepared for
AAAS TECHNICAL PROGRAM OFFICE
U.S. NAVAL WEAPONS CENTER
CHINA LAKE, CALIFORNIA 93555
under Contract N60530-80-C-0270

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Presented herein are overviews of state-of-the-art technologies applicable to the Stores Management System and Suspension and Release Equipment of the Advanced Aircraft Armament System. Technology briefs are presented for selected areas, and references are made to detailed sources of desired information.

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Presented herein are overviews of state-of-the-art technologies applicable to the Stores Management System and Suspension and Release Equipment of the Advanced Aircraft Armament System. Technology briefs are presented for selected areas, and references are made to detailed sources of desired information.

NOTICE

A

FOREWORD

This report documents the results of a Technology Overview Project for the Advanced Aircraft Armament System (AAAS). The project was performed for the AAAS Technical Program Office of the U.S. Naval Weapons Center, China Lake, California, under Contract N60530-80-C-0270.

Described in this report are the approach to performing the project and the resultant technology interpretations. These interpretations are applicable to Suspension and Release Equipment and the Stores Management Systems for the AAAS Program.

The effort described herein covered the period from October 1980 through mid-May 1981, and was performed at the Santa Ana Branch of ARINC Research Corporation.

Our company wishes to thank Mr. Tom Leese of the AAAS Program Office and his staff for their earnest support to the Technology Review Project. In particular, we extend our appreciation to Messrs. Phil Gill, Don Piazza, Ron Jones, Clay Panlaqui, Ray Smith, Joe Mendiola, Curt Sandberg, and John Haney.

We further extend our thanks to those persons and organizations who granted permission to reproduce the data and material supporting the technology briefs.

SUMMARY

A technology overview of Suspension and Release Equipment (S&RE) and the Stores Management System (SMS) of the Advanced Aircraft Armament System (AAAS) was conducted. A comprehensive investigation was made of the state of the art of a variety of technology disciplines that could potentially be implemented in the Advanced Development Model for the AAAS Program, as well as for future aircraft armament systems. Results are presented in this report, which has been prepared as a guide for those involved in future design and development efforts for S&RE and SMS.

The study involved a thorough search of computerized data sources, technical reports by U.S. and foreign government agencies, trade and technical journals, manufacturer literature, and documented results of developmental programs for Navy Participating Field Activities. Several thousand abstracts were evaluated for latest information relative to risk, cost, and development trends of the selected technology disciplines. Selected abstracts from these sources were coded in accordance with an appropriate work breakdown structure for the AAAS. Detailed documentation was then collected and analyzed, and reference sheets prepared on those providing useful information.

From the detailed data, "technology briefs" presenting an overview of present and projected applications in each technological area were prepared. These briefs address the following technologies:

<u>Suspension and Release Equipment</u>

- Aerodynamics
- Controls
- Corrosion
- Fluidics
- Hydraulics
- Manufacturing
- Materials
- Pneumatics
- Pyrotechnics
- Reliability
- Safety

<u>Stores Management System</u>

- Computers
- Controls/Displays
- Data Bus
- Electrical
- Electromagnetic Environment
- Fiber Optics
- Languages
- Large Scale Integration
- Lasers
- Memory
- Packaging
- Reliability
- Software
- Switching

Premised on state-of-the-art information for the above technology disciplines, it appears that significant benefits, in terms of reduced life-cycle costs and overall system performance, are possible for the AAAS if the guidelines presented in the technology briefs are carefully considered in future S&RE and SMS developments.

ABBREVIATIONS

AAAS	Advanced Aircraft Armament System
A/D	Analog/digital
ADM	Advanced Development Model
A^2I^2	Advanced Aircraft Interoperable Interface
AFAL	Air Force Avionics Laboratory
AIDS	Avionics Integrated Display System
ALOFT	Airborne Light Optical Fiber Transmission
APD	Avalanche photo diode
ATR	Air transport rack
BIT	Built-in test
BITE	Built-in test equipment
CAD/CAM	Computer-aided design/computer aided manufacturing
CCD	Charge-coupled device
CDRL	Contract data requirements list
CERT	Combined environmental reliability test
CMOS	Complementary metal oxide semiconductor
CMS-2M	Compiler Monitor System - 2M (high-order language)
CRT	Cathode ray tube
D/A	Digital/analog
dB	Decibel
DB	Diffusion bonding
DIP	Dual in-line package
DMOS	Double-diffused metal oxide semiconductor
DoD	Department of Defense
DTE	Data transfer equipment

EAPROM	Electrically alterable programmable read-only memory
EDB	Engineering data bank
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EMP	Electromagnetic pulse
EMUX	Electrical multiplex
EOS	End of stroke
FEDB	Failure Experience Data Bank
FET	Field effect transistor
FORTRAN	Formula Translation (high-order language)
GaAlAs	Gallium aluminum arsenide
GaAs	Gallium arsenide
GIDEP	Government-Industry Data Exchange Program
HIP	Hot isostatic pressing
HMOS	High performance metal oxide semiconductor
HOL	High-order language
HSD	Horizontal situation display
HUD	Heads up display
IC	Integrated circuit
ICP	Integrated control panel
InGaAsP	Indium gallium arsenide phosphide
I/O	Input/output
I-SEM	Improved SEM
JOVIAL	Jules Own Version of International Algorithm Language
KOPS	Thousands of operations per second
LCD	Liquid crystal device
LED	Light emitting diode
LMPV	Liquid metal plasma valves
LOCOSST	AFAL program for developing low-cost aircraft alloys
LSI	Large-scale integration
MAP	Modular Avionics Packaging (program)
MDB	Metrology Data Bank
MDI	Multipurpose display indicator
MDRI	Multipurpose display repeater indicator

MOS	Metal oxide semiconductor
MOSFET	Metal oxide semiconductor field-effect transistor
MSG-2	Maintenance Steering Group (Second)
MSI	Medium-scale integration
MUSE	Modular unit suspension equipment
NASC	Naval Air Systems Command
NATO	North Atlantic Treaty Organization
NMOS	N-channel metal oxide semiconductor
NWC	Naval Weapons Center
OMSI	HOL developed by Oregon Minicomputer Software, Inc.
PABST	Primary Adhesively Bonded Structures Technology
PCB	Printed circuit board
PCE	Process control equipment
PFA	Participating Field Activity
PHP	Power hybrid package
PROM	Programmable read-only memory
RAM	Random access memory
RCM	Reliability Centered Maintenance
R&D	Research and development
RFI	Radio frequency interference
RFP	Request for proposal
RIW	Reliability Improvement Warranty
RMDB	Reliability-Maintainability Data Bank
ROM	Read-only memory
SAM	Standard avionics module
S&RE	Suspension and Release Equipment
SCR	Silicon-controlled rectifier
SEM	Standard electronic module
SMA	Standard military approval
SMS	Stores Management System
SOW	Statement of Work
SPF	Superplastic forming
SSI	Standard stores interface
TAB	Tape automatic bonding
TCM	Technical coordination meeting

TFEL	Thin-film electroluminescent
TMOS	A power MOS structure
TTL	Transistor-transistor logic
UVEPROM	Ultraviolet erasable programmable read-only memory
VHSIC	Very-high-speed integrated circuit
VLSI	Very-large-scale integration
WBS	Work breakdown structure

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Section 1

INTRODUCTION

ARINC Research Corporation, under contract with the Advanced Aircraft Armament System (AAAS) Technical Program Office, Code 31403, performed a Technology Overview Project encompassing Suspension and Release Equipment (S&RE) and the Stores Management System (SMS) of the AAAS. The project was performed from 1 October 1980 through 15 May 1981 under Contract N60530-80-C-0270, issued by the Avionics Division of the Aircraft Weapons Integration Department, Laboratory Directorate, of the Naval Weapons Center (NWC), China Lake, California.

1.1 BACKGROUND

The AAAS evolved from requirements presented by Navy operational commanders during the mid-1970s. Their assessments of future aircraft missions indicated that, in the mid-1990 timeframe, substantially advanced armament capabilities in the areas of performance, safety, reliability, and maintainability will be required. Another important need for future aircraft armament systems will be the interoperability of various types of aircraft and stores.

In response to these needs, the Navy has initiated the Advanced Aircraft Armament System Program. The specific objective of the AAAS Program is to design, develop, and test new equipment that will satisfy future operational requirements for Navy aircraft. Prototype hardware/software will be developed and an Advanced Development Model (ADM) of the system will be fabricated and validated. The final product of the system will be a compendium of military specifications and standards that define the physical and functional characteristics of the AAAS.

The AAAS includes the major subelements identified in the WBS shown in Figure 1. However, for the technology overview described herein, only the S&RE and SMS are of concern. The S&RE includes elements such as primary stations, missile launchers, special stations, multiple stores adapters, and the necessary integration equipment. The SMS includes such equipment as process control, control/display, stores station, data transfer, and power conditioning; and the necessary operational software to make the AAAS function properly. Because of the diversity of the elements of the AAAS, a wide range of

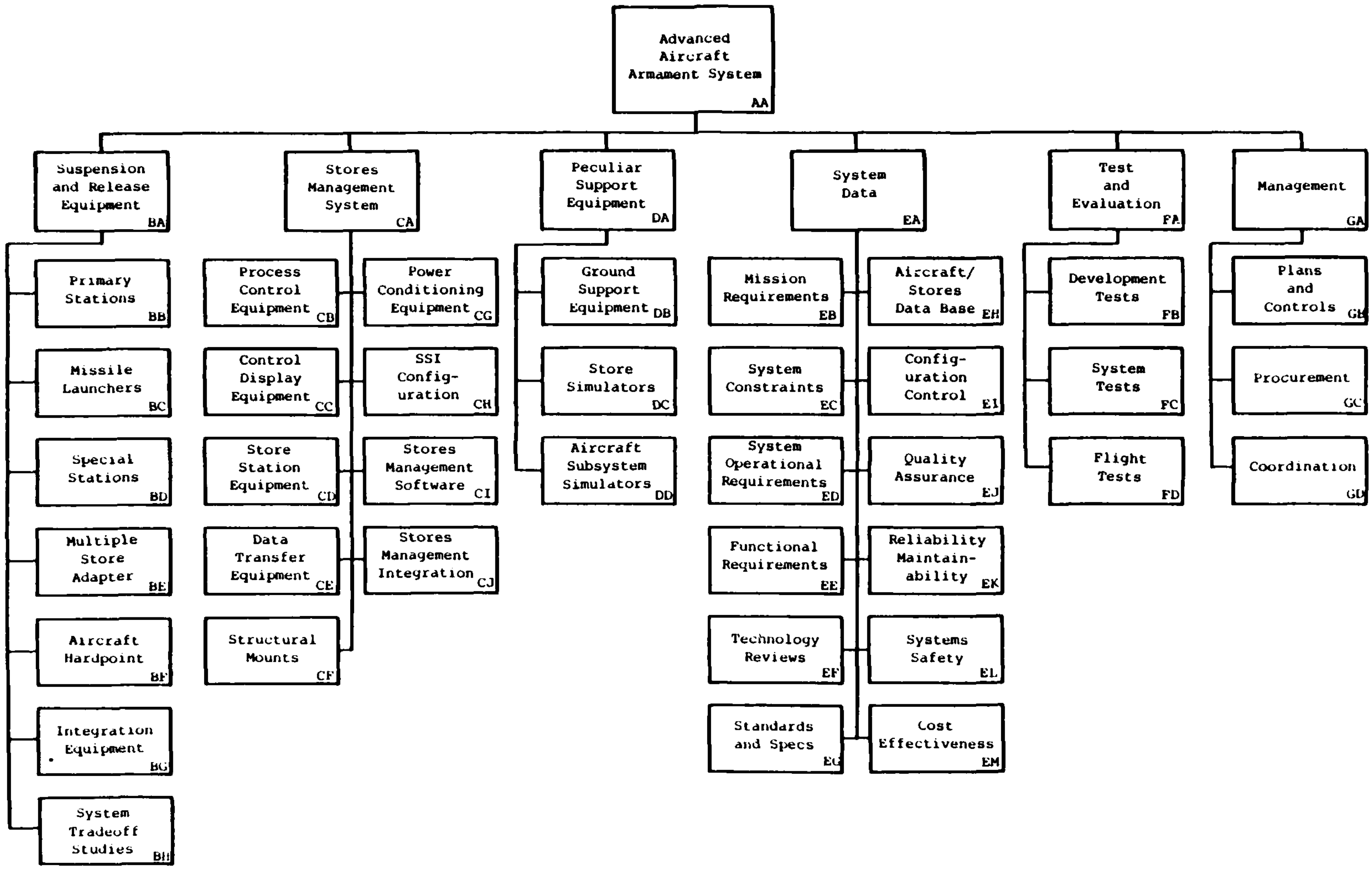


Figure 1. SUMMARY PRODUCT WORK BREAKDOWN STRUCTURE FOR ADVANCED AIRCRAFT ARMAMENT SYSTEM

technologies will be applicable to the system. It is also anticipated that many technologies will have application in more than one AAAS element.

The AAAS is currently in the Requirements Definition Phase and will shortly move into the Design and Development Phase. The Navy plans to award contracts for competitive development of AAAS specifications. Based on the Government's assessment of those results, a contract will be awarded in the latter part of FY81 to develop an ADM. Feasibility, cost, risk, and performance assessments will be aspects of the selection of sources for the specification development and ADM development contracts.

As NWC plans the selection of contractors and manages the AAAS Program, it will be faced with many decisions that will impact the ultimate cost, performance, operational dates, and development risks associated with the AAAS. Such decisions will be required during both the source selection for the specification development contracts and the development of those specifications. Many decisions will require sound knowledge of multiple technological areas, both to establish the level of confidence to be assigned to competitive contractor inputs and to assess quantitative or qualitative factors beyond the scope of contractor consideration.

It was with the intent of obtaining state-of-the-art technology information for potential application to the SMS and S&RE that NWC contracted for the project performed and described in this report.

1.2 PROJECT OBJECTIVES

The overall objective of the Technology Overview Project was to acquire accurate, up-to-date information regarding aircraft armament technologies. The technology information provided, along with projections of their development trends, application risks, and cost directions, will permit NWC technical personnel to evaluate alternatives associated with development of the S&RE and SMS subelements of the AAAS.

In addition to this overall objective, a number of specific objectives were defined:

- Preparation of a comprehensive master plan to guide and direct the conduct of the project.
- Identification, search, and interpretation of appropriate technologies and their application to S&RE and SMS.
- Compilation of technology information into WBS data packages that reflect an accurate summation of the latest technologies and estimates of their development trends, application risks, and cost directions.
- Conduct of technical coordination meetings (TCMs) with authorized NWC technical representatives to permit review and approval of project results and provide direction between major phases of the project.

- Documentation of completed phase activities in a series of progress reports, and preparation of a Technology Review Report to present the detailed results of the project.

1.3 PROJECT SCOPE

The Technology Overview Project included the acquisition, interpretation, and documentation of technology data concerning S&RE and SMS of the AAAS Program. Technology data were obtained from unclassified, confidential, and secret sources of information produced as far back as 1970 and most currently in March 1981.

1.4 ORGANIZATION OF REPORT

This Technology Overview Report is organized as follows:

- Section 1 — Describes the background of, rationale for, and scope of this study, and outlines specific project objectives.
- Section 2 — Describes the technical approach to performing the study.
- Section 3 — Presents the results of the study in the form of technology briefs for S&RE and SMS technologies.
- Appendixes — Provide support information. Appendix A presents technology profiles and matrices, Appendix B contains key word/phrase lists, and Appendix C identifies data sources.

Section 2

TECHNICAL APPROACH

This section addresses the technical approach to the AAAS Technology Overview Project. A summation of the approach is presented in Section 2.1, with details provided in Section 2.2.

2.1 SUMMATION OF APPROACH

To accomplish the project objectives listed in Section 1, ARINC Research formulated a seven-phase technical approach based on the corresponding number of phases identified in paragraph 4 of the Statement of Work (SOW). Each of these phases was divided into specifically defined tasks, as follows:

- Phase I — Project Plan
  - Task I-1: Identify requirements.
  - Task I-2: Prepare project plan.
- Phase II — Search Strategy
  - Task II-1: Formulate technology profiles.
  - Task II-2: Prepare technology matrices.
  - Task II-3: Prepare key word/phrase lists.
- Phase III — Technology Search
  - Task III-1: Perform technology information search.
  - Task III-2: Document technology information.
- Phase IV — Technical Interpretation
  - Task IV-1: Assess technology information.
  - Task IV-2: Prepare WBS data packages.
  - Task IV-3: Prepare Technology Review Report outline.
  - Task IV-4: Formulate supplemental effort recommendations.
- Phase V — Supplemental Search-Interpretation
  - Task V-1: Develop additional search words.
  - Task V-2: Perform supplementary technology search.
  - Task V-3: Conduct detailed interpretation.

- Phase VI — Draft Technology Report

  Task VI-1: Prepare draft Technology Overview Report.

  Task VI-2: Submit draft Technology Overview Report.

- Phase VII — Technology Overview Report

  Task VII-1: Prepare final Technology Overview Report.

  Task VII-2: Submit final Technology Overview Report.

The schedule for performing the above tasks is shown in Figure 2.

2.2 DETAILED TECHNICAL APPROACH

The phases and tasks of this study are discussed below under four major headings: Project Master Plan, Search Strategy, Technology Search, and Technical Interpretation.

2.2.1 Project Master Plan

Preparation of the Project Master Plan was the first step in the conduct of the Technology Overview Project. This plan provided an overall statement of project objectives, defined the tasks required to meet the objectives, and presented associated schedule and funding information. Approval of the plan was obtained from NWC (Code 31403) early in the program and prior to proceeding with the study.

2.2.2 Development of Search Strategy

The search strategy formulated provided for:

- Identification of fourth-level WBS elements of S&RE and SMS
- Identification of technologies having potential application to those elements
- Preparation of technology profiles and matrices reflecting the spectrum of technologies potentially applicable to appropriate WBS elements
- Generation of key words/phrases for search guidance.

2.2.2.1 Derivation of WBS Elements

The third-level WBS items (e.g., Primary Stations, WBS BB) were identified from the SOW. These elements were further defined to the next WBS level (e.g., Ejector Rack) to help select technological areas of importance to S&RE and SMS. That is, while it is clear what a primary station is, the specific applicable technologies cannot be accurately identified unless more details of primary-station elements are available. For example, by knowing that ejector racks are part of primary stations, it is reasonable to assume that various types of power sources for weapon/store ejection would be applicable technologies.

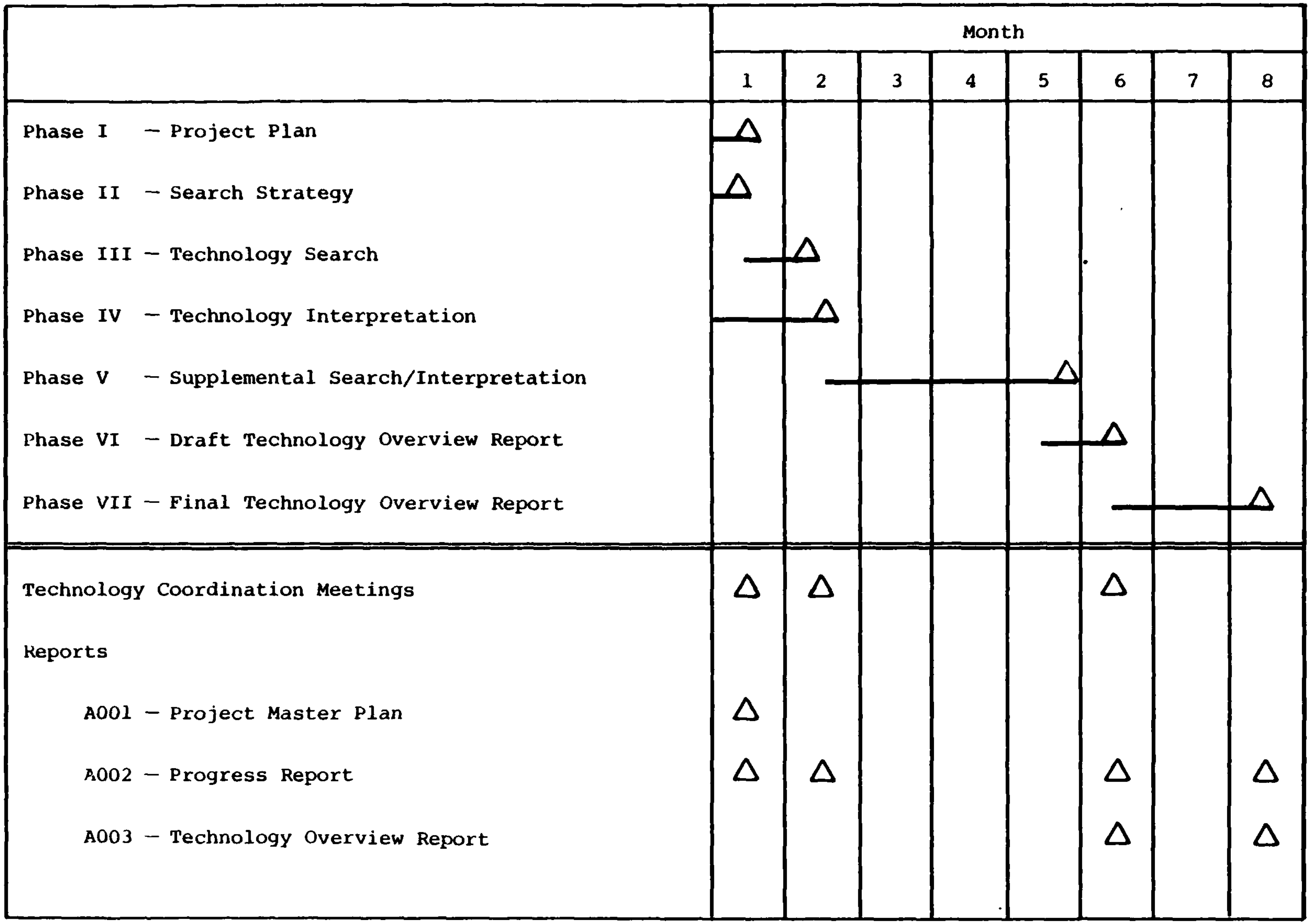


Figure 2. TECHNOLOGY REVIEW PROJECT SCHEDULE

The lower-level WBS elements were identified from AAAS documentation (see listing, Appendix C) for all S&RE and SMS items, and are shown in Figure 3.

For WBS element BH, System Tradeoff Studies, no further breakdown was made to lower level elements nor was any effort expended in this study under that specific category since those lower level elements represent tasks being performed by various contractors directly for the AAAS Program. However, much of the information obtained in this study and documented herein is relevant to system tradeoff evaluations.

2.2.2.2 Technology Disciplines

Based upon the WBS element descriptions, it was practical to establish suitable technology disciplines having likely applicability to the AAAS. This was done by reviewing program documentation and conducting technical discussions with NWC specialists in the S&RE and SMS areas. For example, the knowledge that power sources are used for ejector racks of primary stations led to the decision that hydraulics and pneumatics would be technologies of importance to the power-source function.

After the candidate technologies were selected, their scope relative to the AAAS Program was defined. These definitions are given in the following paragraphs for S&RE and SMS.

2.2.2.2.1 S&RE Technology Definitions

For S&RE, definitions were prepared for the following technology disciplines: aerodynamics, control, corrosion, fluidics, pneumatics, hydraulics, manufacturing, materials, pyrotechnics, reliability, and safety. The definitions, as tailored specifically to S&RE, follow.

- Aerodynamics. This technology was defined in relationship to the aerodynamic impact of the S&RE station and related elements. Important areas of this technology include wind tunnel facilities and tests, analytical modeling techniques, and structural design effects on aircraft and weapons operation.
- Control. The control technology encompasses the components utilized for direct use with the weapon control and launching. These controls include such items as couplers, hydraulic and pneumatic valves for regulating pressure, and other elements such as sensors.
- Corrosion. The corrosion technology is of a general nature, relating to all aspects of saltwater and stress corrosion that could be experienced by S&RE. Important to this technology are means of precluding or lessening corrosion.
- Fluidics. Fluidics include power sources for weapon launching that might be premised on hydraulic or some other fluid system design. Important issues for fluidics include controls, sensors, and relevant equipment and materials.
- Pneumatics. Pneumatics include materials, equipment, and methods having potential application in powering weapon launching operations.

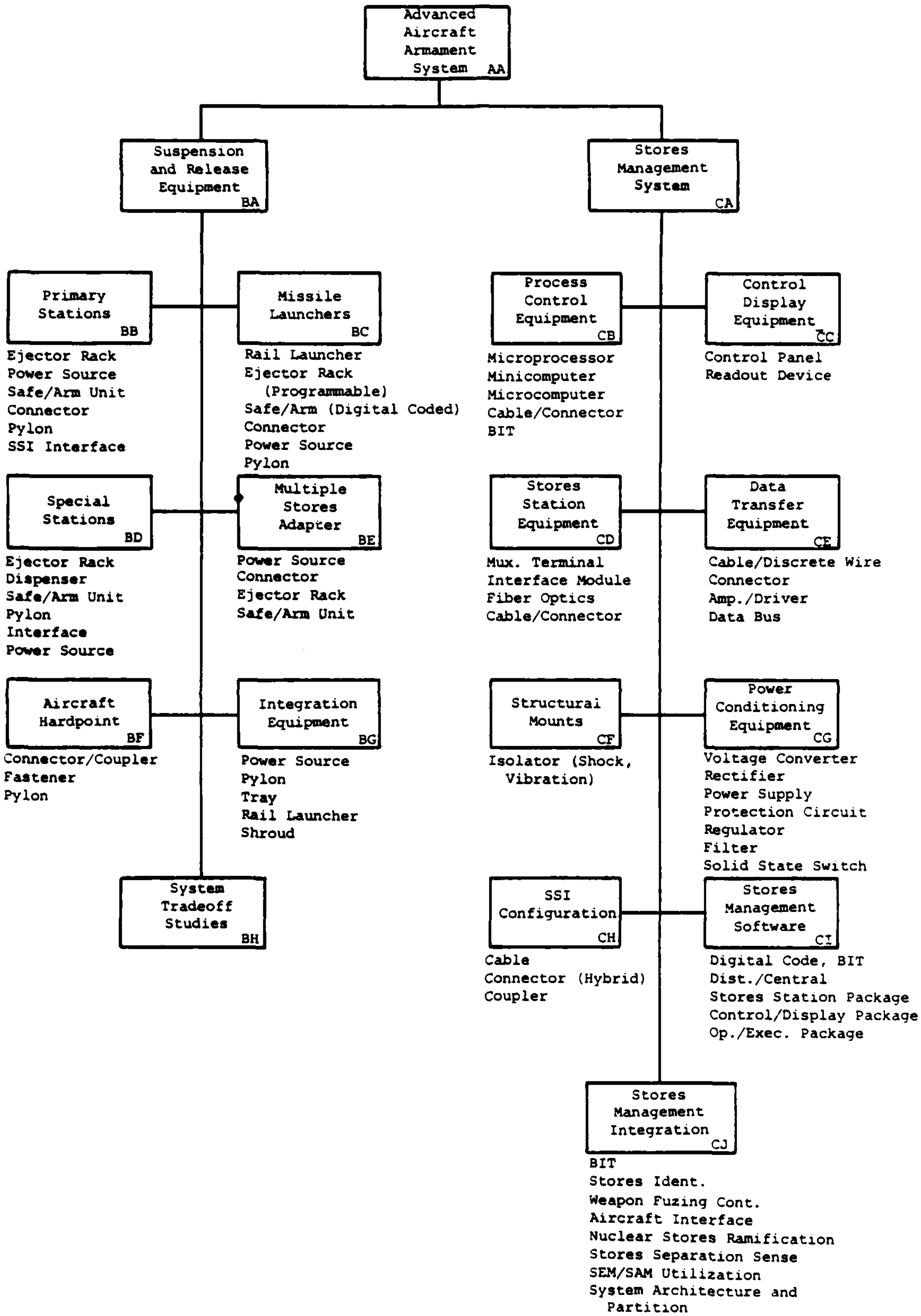


Figure 3. AAAS FOURTH-LEVEL WBS

Valves, actuators, pumps, and other components are considered important to this technology. The ability of materials to withstand the airborne environment as well as the high pressures of the power source needed for launching are also considered critical.

- Hydraulics. Hydraulics encompass the materials, equipment, and methods having potential use in powering weapon launching operations. Components such as valves, actuators, and fluids, and their ability to operate under high pressures, are important aspects of this technology.

- Manufacturing. The manufacturing technology includes any technique or process that could be used in the development and fabrication of S&RE. These might include manufacturing methods of forging, brazing, bonding, and superplastic forming and other processes for fabrication of composite structures and alloys.

- Materials. This technology covers those materials that might be used for constructing all or part of S&RE. Important materials include composites, high-strength alloys, and bonding adhesives.

- Pyrotechnics. This technology concerns the devices used to launch or release the weapons or stores. Of importance are clean-firing power sources, greater uniformity and reliability, and more power per area from propellants.

- Reliability. Technology relating to reliability pertains in this study to S&RE systems. Current practices for assuring and improving reliability are considered important since new techniques in the areas of pneumatics, hydraulics, and fluidics could be employed in the S&RE design.

- Safety. Safety was defined in terms of the availability of methods or systems for improving stores and armament safety. Of particular importance are aspects of safety involving hazards analysis.

2.2.2.2.2 SMS Technologies

For the SMS, definitions were generated for the following areas of technology: computers, control and display equipment, data bus, electrical, electromagnetic environment, fiber optics, languages, large-scale integration, lasers, memory, packaging, reliability, software, and switching. The definitions follow.

- Computers. Computer technology encompasses the hardware for potential implementation of the process control equipment (PCE) that handles executive functions, and provides the "handshake" or arbitration between other SMS modules and between the SMS and the other aircraft avionics. PCE of major interest are minicomputers, microcomputers, and microprocessors for central or distributed processing applications. The potential use of microprocessors for system interfacing and signal processing is also an important part of computer technology.

- Controls and Displays. This technology relates to the hardware needed for aircrew-to-aircraft interface. Of interest to the SMS are displays capable of providing status indications and cues to the aircrew, and the necessary controls and displays to manage the stores load during the mission cycle.

  The controls of importance are conventional types such as the slewing handle, master arm and bomb button, and those used for selecting modes, deploying stores, and conducting tests and checks. Programmable multifunction controls are considered of interest in performing SMS functions.

  In the area of displays, important features are multifunction CRTs with panels, and discrete indicators for stores operations. Also important are CRT devices used in support of radar, infrared, and optical imaging seekers.

- Data Bus. This technology is critical to data transfer equipment in terms of data buses. Key aspects include bus controllers and remote terminals, twisted shielded pairs and/or fiber optics data buses, conventional wiring, and safety or security devices. All aspects of the MIL-STD-1553B data bus are of significance to this technology.

- Electrical. This technology, although very general in scope, was defined to encompass hybrid microcircuits and connector components for potential application to the SMS. Hybrid components of particular interest are amplifiers, voltage regulators, power supplies, and A/D and D/A converters.

- Electromagnetic Environment. This technology covers electromagnetic compatibility (EMC), electromagnetic pulse (EMP), and electromagnetic interference (EMI) aspects relative to their impact on airborne electronic systems. Design/fabrication techniques, materials, and specifications are considered key elements of this technology.

- Fiber Optics. The fiber optics technology was defined as the alternative method to the electric-wire approach for transmitting and receiving signals and data for the SMS. Of importance are devices such as connectors, emitters, receivers, cables and others that could be implemented for potential use in data transfer equipment of the SMS.

- Language. This technology encompasses the higher order languages applicable to stores management, and includes all operational and executive software required to develop and integrate SMS modules. Important issues for language technology are maturity, documentation, modularity, specification, and system compatibility.

- Large-Scale Integration. Large-scale integration (LSI) covers a generalized category of devices or circuits applicable to the SMS. Circuits such as microprocessors, A/D and D/A converters, and others for interfacing SMS modules with the data bus are important areas of LSI technology. Tradeoffs and benefits of different LSI structures in terms of advantages for SMS application are also important.

- Lasers. Laser technology was defined as that portion of the technology applicable to the use of high-performance emitter capability for fiber optics applications. Reliability and availability are important issues of laser technology.

- Memory. This technology embraces the different memory structures having potential application to airborne data storage requirements, such as that of the process control equipment or microprocessor interfaces for the SMS. Important aspects of memory devices include erasability, programmability, reprogrammability, nonvolatility, and performance in terms of storage capacity and access times.
- Packaging. This technology encompasses potential methods for enclosing, fabricating, structuring, and/or implementing the various SMS modules. Standard electronic modules (SEMs), standard avionic modules (SAMs), and other packaging concepts including printed circuit boards being used in current airborne environments are of importance to this technology.
- Reliability. This technology comprises state-of-the-art practices for enhancing the reliability of airborne electronic systems. Built-in test (BIT) availability, maintainability, failure prevention, and other aspects of reliability are considered important to this technology.
- Software. The software technology is a generalized area defined to encompass fault tolerance computing, digital code safing, distributed processing architecture, and other current software practices that could be implemented for the SMS.
- Switching. The switching technology includes components and elements applicable to the power conditioning function of the SMS. This function includes power conversion switching and interfacing with aircraft power systems; and comprises interlocks, circuit breakers, load switches, relays, protection circuitry, and transient devices.

2.2.2.3 Technology Profiles and Matrices

From the information obtained for the WBS elements of S&RE and SMS, primary-interest technology profiles were prepared. These profiles represent a breakdown of third-level WBS elements into categories equatable to technology disciplines. Each profile thus represents a matrix of potentially applicable technology disciplines versus WBS elements below the third level. Figure 4 is an example of a technology profile. The full set of profiles generated for this project is presented in Appendix A.

2.2.2.4 Key Word/Phrase Lists (Search Words)

To facilitate the search of information in the computerized data bases, it was necessary to prepare descriptors for use in searching the abstracts contained in the data bases. These descriptors were prepared as key words and phrases (search words). These words are in the form of names, titles, or other modifiers describing or defining particular topics of interest within the applicable technologies.

The key word/phrase lists were prepared during Task II of Phase II. Supplemental search words were prepared during Phase V, the Supplemental

TECHNOLOGY MATRIX,
STORES MANAGEMENT SYSTEM,
DATA TRANSFER EQUIPMENT PROFILE

WBS Element	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
																Technology Spectra
CE Data Transfer Equipment	X			X	X		X		X			X				
Cable - Discrete Wire				X	X		X									
Connector				X	X		X									
Amplifier/Driver					X		X		X			X				X
Data Bus	X			X			X					X				

Figure 4. EXAMPLE OF TECHNOLOGY PROFILE

Search Activity, under the guidance of engineering personnel at NWC. The key word/phrase listings are presented in Appendix B.

2.2.3 Technology Search

The key words and phrases were used to guide the acquisition and compilation of information applicable to the selected technology spectra identified for S&RE and SMS. The principal source of information was the computerized Lockheed DIALOG Information Retrieval Service. Other sources included the Government-Industry Data Exchange Program (GIDEP), technical magazines and periodicals, ARINC Research reports, and interviews with DoD Participating Field Activities (PFAs) and industry technical personnel. Appendix C provides a more comprehensive explanation of data bases and a listing of PFAs and industry personnel contacted.

2.2.3.1 Data Acquisition

Both computerized and manual techniques were used to acquire data. The data searches concentrated on obtaining information that would identify the latest advances in the technological areas of interest. For some of the selected technologies, the search yielded what appeared to be dated information; however, a review with NWC technical representatives established that these technologies had not advanced to the point where the information was outdated. For example, only limited information on aerodynamics was identified for recent years (1979-1981). However, NWC personnel expressed the opinion that the state of the art of some technologies, such as aerodynamics, progresses at a much slower pace than that of other technologies, such as fiber optics. Hence, the search for best available information on aerodynamics was extended back to 1969.

2.2.3.2 Data Selection and Compilation

As information (abstracts, magazine articles, government and industry data, etc.) was acquired, it was reviewed and screened for applicability to study objectives. From the thousands of abstracts acquired, mainly through the Lockheed DIALOG system, selected backup documents were obtained for additional detail in the areas pertaining to development trends, cost, and risk. Each selected piece of information was then assigned codes (see Section 3) identifying it with applicable S&RE and SMS WBS elements along with the technology involved. For each piece of selected information, the next step was the preparation of reference summaries for all relevant technologies. These reference summaries list the technology (e.g., fiber optics), title of article, author(s), date of article, source, and applicable WBS codes. An example of a reference summary is presented in Figure 5.

2.2.4 Technical Interpretation

This task consisted of the preparation of a technology brief, based on analyses of the previously mentioned relevant documents, for each technology designated as applicable to S&RE and SMS. The briefs are not intended to provide information to the detail required by designers, but rather to

AERODYNAMICS

Code: 1.1 – BB, BC, BD, BE

Title: Inflight Captive Store Loads Compared with Wind-Tunnel and Mathematical Simulations

Author: Maddox, A.R.; Dix, R.E.; Mattasits, G.R.
NWC, China Lake, CA

Date: May 1979

Source: Journal of Aircraft, Vol. 16, No. 5, pages 289-295

Code: 1.2 – BB, BC, BG

Title: Decoupler Pylon. A Simple, Effective Wing/Store Flutter Suppressor

Author: Reed, W.H. III; Foughner, J.T., Jr.; Runyan, H.L., Jr.
NASA, Langley, Hampton, VA

Date: March 1980

Source: Journal of Aircraft, Vol. 17, No. 3; pages 206-211

Code: 1.3 – BB, BC, BD, BG

Title: Air Force Academy Aeronautics Digest

Author: Jumper, E.J.; Tower, M.M.
Air Force Academy, CO

Date: July 1979

Source: NTIS AD-A075 419/2; PC A08/MF A01

Code: 1.4 – BB, BC, BD, BG

Title: Flow Reattachment (Bibliography)

Author: Habercom, Guy E., Jr.
NTIS, Springfield, VA

Date: November 1979

Source: NTIS PB80-800345; PC N01/MF N01

AERODYNAMICS

Code: 1.5 – BG

Title: Technical Evaluation Report on the Fluid Dynamics Panel Symposium on High Angle of Attack Aircraft

Author: Polhamus, Edward C.

Date: August 1979

Source: NTIS AD-A074 692/5; PC A02/MF A01

Code: 1.6 – BB, BC, BD, BE, BG

Title: Store Separation Trajectory Analysis

Author: Maddox, A.R.
Naval Weapons Center, China Lake, CA

Date: January 1980

Source: NTIS AD-A086 704/4

Code: 1.7 – BE

Title: Mutual Interference of Multiple Bodies in the Flow Field of the F-4C Aircraft in the Transonic Speed Range

Author: Hesketh, A.A.
Arnold Engineering Dev. Center, Tullahoma, Tenn

Date: December 1979

Source: NTIS A084 704

Code: 1.8 – BC, BD, BF, BG

Title: Flight Test Performance of the F-4 Conformal Weapons Carriage

Author: Smith, Daniel L.
Boeing Aerospace Company

Date: June 1973

Source: NTIS AD-530 710, 103 pages

Figure 5. EXAMPLE OF REFERENCE SUMMARY

present an overview of the state of the art in that area. Sources that can provide more detailed information are identified at the end of each brief.

Information is presented in the technology briefs under the following headings:

- Applications. Identifies potential applications of the technology to the S&RE and SMS WBS elements shown in Figure 3.
- Advantages. Lists major advantages offered by the technology.
- Disadvantages. Enumerates disadvantages associated with the technology.
- Risk. Provides a qualitative assessment of the technology risks based on the information analyzed. Risk is divided into three categories:

  Low — Demonstrated operational success reported for related applications.

  Medium — Technology is in developmental phase with promising success based on preliminary testing and evaluation.

  High — Technology is in the early laboratory or early developmental phase.
- Trends and State of the Art. Summarizes trends in application and development of the technology.
- Cost Direction. Discusses economic advantages/disadvantages and cost trends.

Where appropriate, supplementary charts, graphs, and tables are presented that support the information given in the technology brief. Also included are the associated reference summaries.

The technology briefs are presented in Section 3.

Section 3

RESULTS

This section presents the technology briefs resulting from the AAAS Technology Overview Project. Briefs applicable to S&RE are presented in Section 3.1, and to SMS in Section 3.2.

3.1 SUSPENSION AND RELEASE EQUIPMENT

3.1.1 Technologies Investigated

The technologies investigated for S&RE are listed below. The number preceding each technology name is a unique code assigned in this study to that specific technology.

1. Aerodynamics
2. Bacteria*
3. Controls
4. Corrosion
5. Environment*
6. Fluidics
7. Pneumatics
8. Hydraulics
9. Lasers
10. Manufacturing
11. Materials
12. Packaging*
13. Pyrotechnics
14. Reliability
15. Structures*
16. Safety

It is to be noted that certain briefs describe more than one technology area, and other briefs overlap technologies. For example, Code 10 (Manufacturing) and Code 11 (Materials) are combined in one brief since the pertinent technical information is common to both disciplines. Further, controls are described in one brief specifically devoted to that topic, and as part of fluidics, hydraulics, and pneumatics technologies.

Certain of the above-listed categories, as denoted by asterisks, were not made the subject of technology briefs. As the study progressed, modifications to the originally assigned categories became indicated. For example, laser technology was originally assigned Code 9 under S&RE because of its known application as a pyrotechnics initiator. However, this technical category was reassigned to SMS under the fiber optics category when it became evident that the latter technology was the area of the most useful information.

Two other technologies considered for S&RE, Bacteria (Code 2) and Environment (Code 5) were amalgamated with Corrosion (Code 4) since the latter reflected the major area of interest to NWC for the AAAS.

Packaging and Structures were incorporated into Materials and Manufacturing since insufficient information pertinent to S&RE was identifiable for the first two areas.

3.1.2 Technology Matrix

Table 1 is a coded matrix that relates the applicable S&RE technologies investigated, the associated WBS elements (from Figure 3), and number-coded sources of technology information. The coded sources are identified following each brief.

The matrix is intended to permit quick reference by the user to information that may impact or influence his specific WBS areas of concern. For example, an engineer responsible for the Primary Station (BB) of S&RE may want to review the latest information on new materials in greater detail than provided in the applicable technology brief. Referring to the matrix of Table 1, he will observe under the heading "Materials" (Technology Code 11) a block of numbers (1, 3, 5, 8-17, 19-25) corresponding to WBS element BB. These numbers are read as 11.1, 11.3, 11.5, 11.8, etc., and designate the reference summaries provided with the technology brief on Materials.

Certain sources of detailed information may apply to more than one technology or WBS element. For example, reference 11.1 for Materials is the same as reference 3.1 for Controls.

3.1.3 Technology Briefs

Technology briefs applicable to S&RE follow. They are presented in the order listed in Section 3.1.1.

Table 1

CODED TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT

WBS Element	Aerodynamics 1	* Bacteria 2	Controls 3	Corrosion 4	* Environment 5	Fluidics 6	Pneumatics 7	Hydraulics 8	* Lasers 9	Manufacturing 10	Materials 11	* Packaging 12	Pyrotechnics 13	Reliability 14	* Structures	Safety 16
								Technology Spectra								
BB Primary Station	1-4,6, 9-19, 21-26, 28-31		1,3-20	1-3, 5-24		1-17	1,3-21	1-3, 5-12, 14-16, 18-27		1-17	1,3,5, 8-17, 19-25		1-13	1-7, 9-16		1-3, 5-7, 10,11
BC Missile Launcher	1-4,6, 8-19, 22-26, 28-30		1,3-20	1-3, 5-24		1-17	1-21	1-12, 16-27		1,4, 7-13, 16	1,3,5, 8-17, 20, 22-25		1-13	1-7, 9-16		1,2,5, 6,10, 11
BD Special Station	1,3,4, 6,8-12, 14-18, 21-26, 28-31		1,3-20	1-3, 5-11, 18-24		1-17	1,3-22	1-3, 5-12, 16,18, 20-27		1,4,5, 7-13, 16,17	1,3,5, 8-14, 16,17, 19-25		1-13	1-7, 9-16		1-3, 5-7, 10,11
BE Multiple Stores Adapter	1,6-19, 21-26, 28-31		1.4-20	1-3, 5-24		1-17	1,3-21	1-3, 5-13, 15,16, 18-27		1,4, 7-14, 16,17	1,3,5, 8-14, 16,17, 19-25		1-13	1-7, 9-16		1-7, 10,11
BF Aircraft Hardpoint	27			2-5, 9-24				5,19		1,4	2-4,7, 18					
BG Integration Equipment	2-6,8, 14,17, 20, 26-31		2,5, 14-16	1,5-11, 18-24		1-17	1-2, 4-21	1-3, 5-12, 15-18, 20-27		1,4, 11-13, 16	3,6, 10-14, 16,17, 20, 22-25		1-13	1,2, 5-16		1,2,6, 8-11

*See page 3-1 for explanation of blank columns.

Code 1

AERODYNAMICS TECHNOLOGY

This technology brief addresses the aspects of aerodynamics relating to flutter suppression, conformal weapons carriage, and stores separation.

Potential AAAS Applications

- Wing/stores flutter suppression
- Conformal carriages
- Stores separation (delivery and jettisoning)

Advantages/Disadvantages

- Active Wing/Stores Flutter Control Systems

  Advantages

  - Possible weight savings
  - Versatility to accommodate a variety of stores
  - Reduced drag with attendant fuel saving
  - Potentially less costly in terms of redesign
  - Offer potential for being integrated with flight control systems, and for being tied to special-purpose computers responding in adaptive manner to counteract structural response

  Disadvantages

  - Complexity is a reliability concern
  - Lack of accurate knowledge of unsteady aerodynamic forces produced by the control surfaces, particularly in the transonic speed range where theoretical predictions are least reliable and flutter concerns are usually most critical
  - Much development effort yet to be accomplished

- Quasi-Active Wing/Stores Flutter Control Systems

  Advantages

  - Combine desirable features of conventional passive methods with more advanced active control methods
  - Relatively simple system
  - Associated flutter virtually insensitive to inertia and center-of-gravity location of store
  - Simplifies and reduces analysis and testing required to flutter-clear aircraft that must carry a variety of stores
  - Potential for reduced drag with attendant fuel savings
  - Possible weight savings

Disadvantages

- Demonstration of concept limited to analyses and wind tunnel model studies

- Conformal Weapons Carriage

  Advantages

  - Uniform flow field in proximity of fuselage minimizes weapon perturbations associated with underwing and clustered multiple carriage
  - Reduced radar cross-section resulting in improved aircraft survivability
  - Structural rigidity
  - Reduced drag with significant attendant fuel savings
  - Permits supersonic carriage of stores, compared to subsonic carriage of external stores
  - Offers significant potential for improvement of separation and delivery characteristics for unguided weapons

  Disadvantages

  - Access to and selective replacement of stores difficult.
  - Different size stores require different attachment arrangements
  - Stores with different size fins require different positions for attachment.

- Stores Separation

  Refer to "Trends and State of the Art".

Risk

Risk is generally considered high for early application of most of the concepts identified above due to unproven operational applications and additional investigations required to validate their practicality. The conformal carriage concept appears to be relatively mature, with low-to-medium risk.

Trends and State of the Art

— Flutter Suppression. Considerable research has been made on active and quasi-active aircraft wing/store flutter suppression systems. An example of progress on each is discussed below.

- Active Systems — A wind tunnel test at the NASA Langley 16-foot transonic tunnel on a scale model of a lightweight fighter was completed in mid-1978 for three stores configurations to demonstrate an active system. These configurations were:

  A. TLR: AIM-9E; TP (95% span): NI; IP (65% span): AIM-7 (3 in. aft)

  B. TLR: Empty; TP: AIM-7 (3 in. aft.); IP: NI

  C. TLR: Empty; TP: AIM-9E (6 in. aft.); IP: NI

  where TLR = Tip launcher rail; TP = Tip pylon; NI = Not installed; IP = Inboard pylon

Figure 1-1 illustrates Configuration A. Figure 1-2 shows analytical results for the three configurations. Figures 1-3 through 1-5 illustrate damping trends with and without the Active Flutter Suppression System (AFSS) in wind tunnel testing.

. Quasi-Active Systems — Quasi-active wing/store flutter systems offer an alternative to passive systems or the more advanced active systems. One such concept, called the decoupler pylon, is illustrated schematically in Figure 1-6. The effectiveness of the concept was recently demonstrated by analyses and wind-tunnel tests at subsonic speeds at the NASA Langley Transonic Dynamics Tunnel. Basic study conclusions were as follows:

- For all cases studied, the flutter speed of the wing with the decoupler-pylon-mounted store was higher than the flutter speed of the wing without a store.
- The decoupler pylon made flutter relatively insensitive to inertia and c.g. location.
- Predicted flutter trends generally agreed well with results of wind tunnel model experiments.
- Wing/store decoupling and attendant flutter speed increase occurred when uncoupled store pitch frequency was less than approximately 0.7 times the fundamental bending frequency of the wing with the store rigidly attached.

The parameters investigated in the above study are given in Table 1-1. Figures 1-7 through 1-13 show the influence of various parameters affecting wing/store flutter.

— Conformal Weapons Carriage. The conformal carriage concept offers attractive potential for improved weapons release (particularly for unguided weapons), reduced carriage drag, and increased aircraft performance/handling qualities based on a Navy/Air Force program using the F-4 aircraft. The program included wind-tunnel and flight-test demonstrations in which approximately 200 various weapons were safely released at speeds up to Mach 1.6. With one exception — high-speed pitch problems with aft-row located MK-82 bombs — excellent release characteristics in general were reported. The MK-82 aspect was indicated to be a minor problem that can be corrected by future pallet designs and/or proper "tuning" of the bomb ejector racks.

— Store Separation

. Jettison. The aft pivot release system seems to offer the best solution to safely jettisoning aerodynamically unstable items such as pylons, fuel tanks, and MERs. This system is reported to be used for the B-58 external fuel tank and all pylons of the F-15. The F-111 pylons and fuel tank/pylons employ a limited version of the system.

. Delivery. Delivery of target stores such as unguided bombs and dispenser munitions requires safe aircraft separation and relatively unperturbed release for delivery accuracy. Promising approaches to improve delivery include store staggering, dual ejector "tunable" bomb racks, self-compensating bomb ejector racks, vertical store separation techniques, and conformal carriages. Both the store staggering and conformal carriage approaches offer reduction in drag.

Cost Direction

No specific data concerning costs was observed in the literature. However, eventual implementation of the concepts should result in significant life-cycle cost reductions in terms of aircraft fuel savings due to reduced inherent drag in some of the concepts, more effective delivery of weapons, etc.

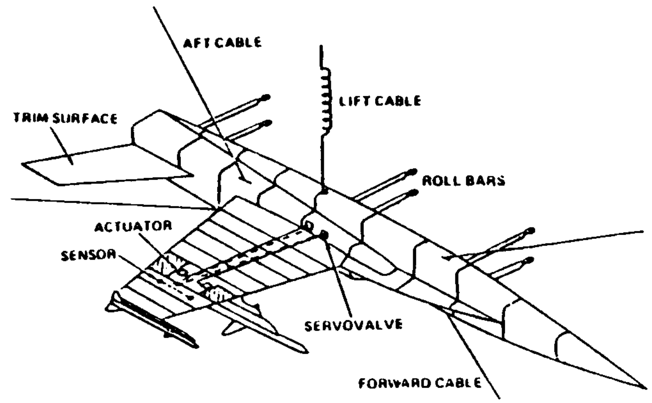


Figure 1-1. WING/STORE MODEL WITH ACTIVE FLUTTER CONTROL, CONFIGURATION A

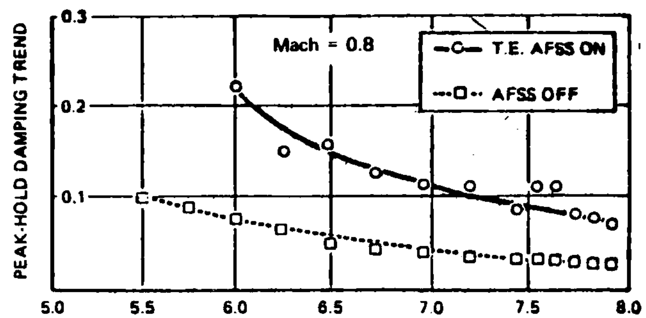


Figure 1-3. DAMPING TREND, TRAILING-EDGE SYSTEM, CONFIGURATION A

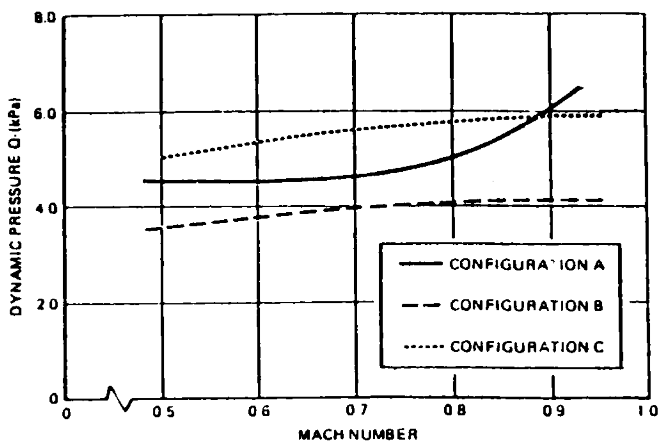


Figure 1-2. MODEL FLUTTER BOUNDARIES

(NOTE: Terms are defined following Figure 1-13.)

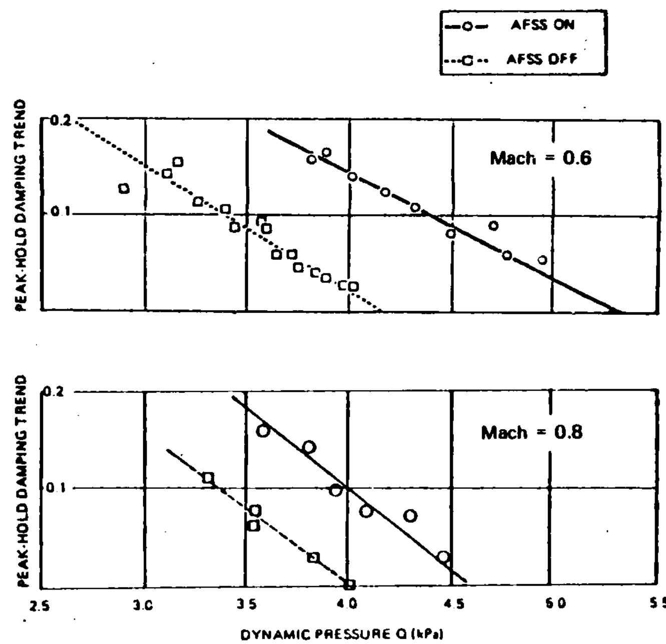


Figure 1-4. DAMPING TREND FOR CONFIGURATION B, LEADING EDGE SYSTEM

– All figures courtesy Journal of Aircraft (© 1979, AIAA)

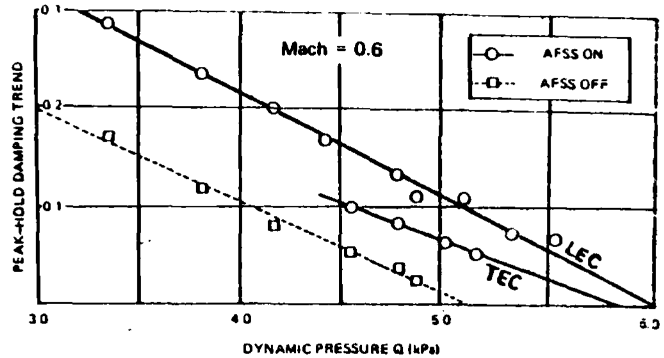


Figure 1-5. DAMPING TRENDS FOR CONFIGURATION C, USING EITHER LEADING-EDGE CONTROL (LEC) OR TRAILING-EDGE CONTROL (TEC)

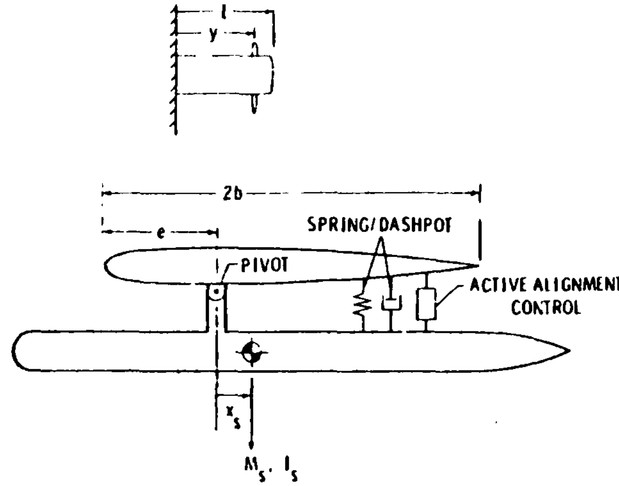


Figure 1-6. DECOUPLER PYLON SYSTEM

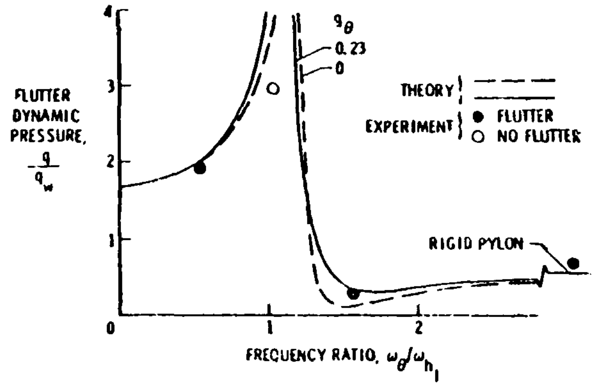


Figure 1-7. EFFECT OF STORE PITCH FREQUENCY

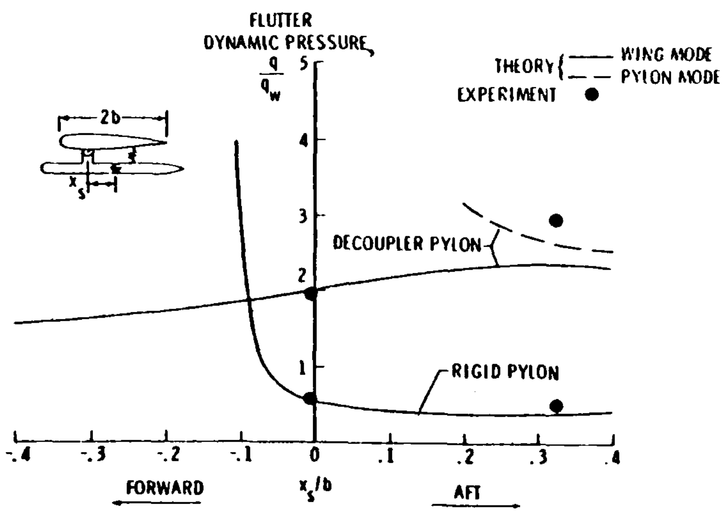


Figure 1-8. EFFECT OF STORE c.g. LOCATION

(NOTE: Terms are defined following Figure 1-13.)

– *All figures courtesy Journal of Aircraft (Fig. 1-5 © 1979, others © 1980, AIAA)*

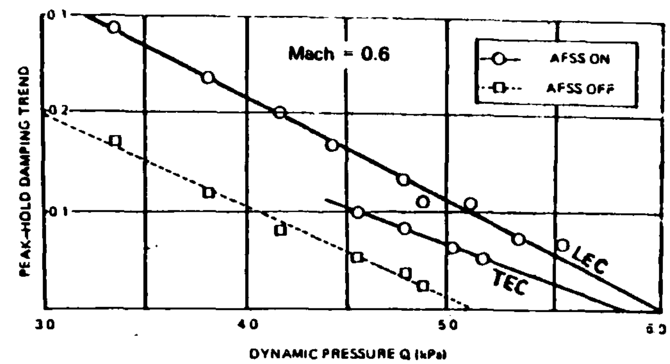


Figure 1-5. DAMPING TRENDS FOR CONFIGURATION C, USING EITHER LEADING-EDGE CONTROL (LEC) OR TRAILING-EDGE CONTROL (TEC)

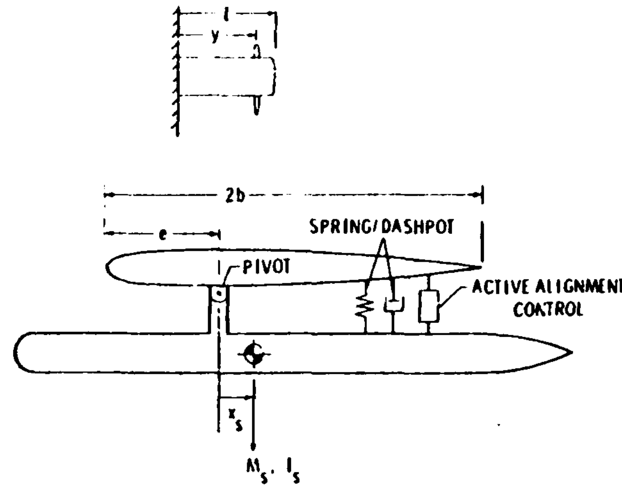


Figure 1-6. DECOUPLER PYLON SYSTEM

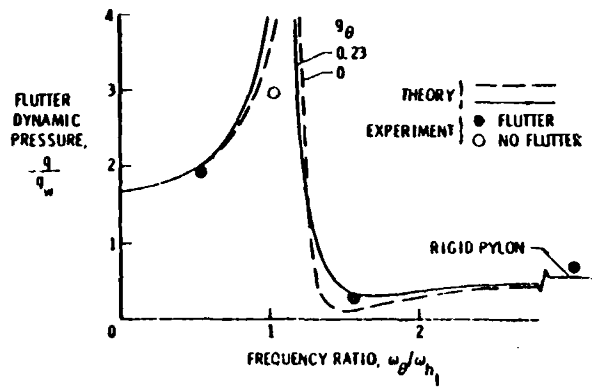


Figure 1-7. EFFECT OF STORE PITCH FREQUENCY

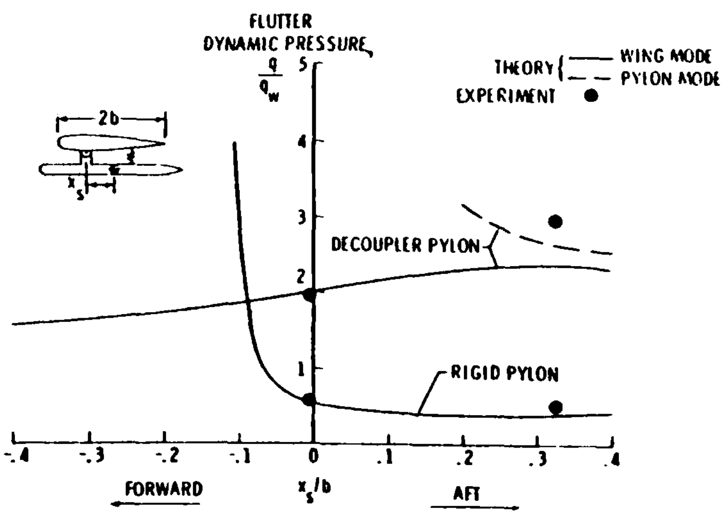


Figure 1-8. EFFECT OF STORE c.g. LOCATION

(NOTE: Terms are defined following Figure 1-13.)

– All figures courtesy Journal of Aircraft (Fig. 1-5 © 1979, others © 1980, AIAA)

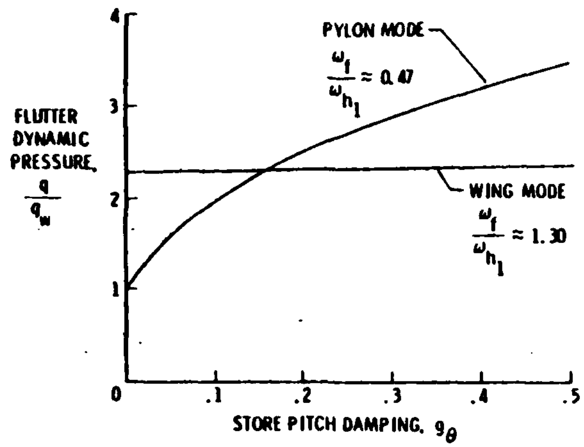


Figure 1-9. EFFECT OF STORE PITCH DAMPING (CONFIGURATION 2)

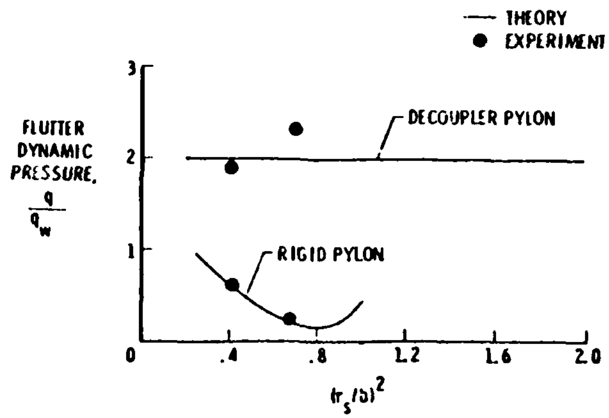


Figure 1-10. EFFECT OF STORE RADIUS OF GYRATION

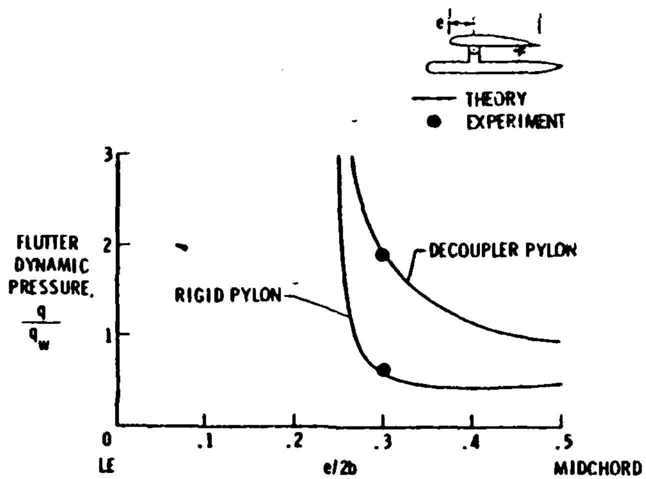


Figure 1-11. EFFECT OF STORE PIVOT LOCATION

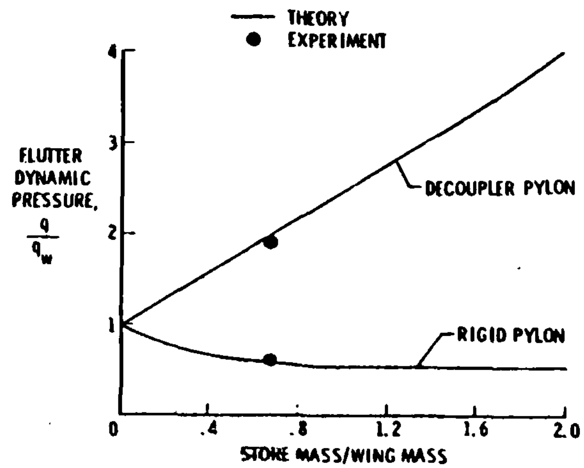


Figure 1-12. EFFECT OF STORE MASS

(NOTE: Terms are defined following Figure 1-13.)

— *All figures courtesy Journal of Aircraft* (© 1980, AIAA)

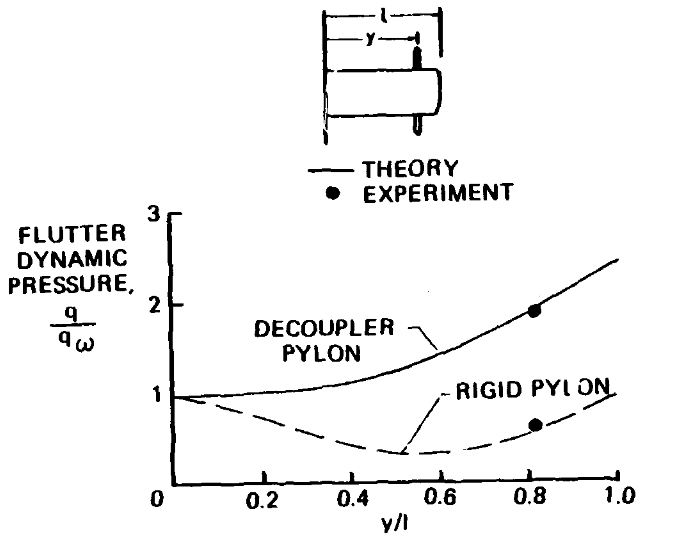


Figure 1-13. EFFECT OF SPANWISE STORE LOCATION

– Courtesy Journal of Aircraft (© 1980, AIAA)

NOMENCLATURE

b	= wing semichord
e	= store pivot location measured from leading edge of wing
g_θ	= damping of store pitch mode
I_s	= mass moment of inertia of store about pivot
M	= wing mass
M_s	= store mass
q	= flutter dynamic pressure of the wing with store
q_ω	= flutter dynamic pressure of the wing without store (clean wing)
r_s	= store radius of gyration about pivot
x_s	= store center of gravity (c.g.) location measured from store pivot, positive aft
y	= spanwise location of store measured from wing root
	= wing span
l	= flutter frequency
ω_f	= fundamental wing bending frequency with rigidly
ω_{hl}	mounted store
$\omega_{\alpha l}$	= fundamental wing torsion frequency
ω_a	= uncoupled store pitch frequency
LE	= leading edge
TE	= trailing edge
$AFSS$	= Active Flutter Suppression System

Table 1-1. WIND TUNNEL MODEL CONFIGURATIONS AND FLUTTER CHARACTERISTICS

Store configuration (• ballast weight)		x_s/b	$(r_s/b)^2$	$\frac{\omega_\theta}{\omega_{h_l}}$	$\frac{\omega_{\alpha_l}}{\omega_{h_l}}$	q/q_ω Experiment	q/q_ω Theory
1	LE TE	−0.010	0.416	Rigid	1.29	0.61	0.57
				1.56	1.11	0.29	0.36
				1.04	1.34	2.98[b]	4.30
				0.54	2.59	1.89	1.96
2		0.325	0.577	Rigid	1.45	0.49	0.39
				0.44	2.29	2.92	2.32
3		−0.413	0.692	0.89	...[a]	2.32	1.96
4		−0.010	0.684	Rigid	1.15	0.23	0.17
				0.42	2.63	2.32	1.98
5	Wing without store	...	...	...	2.1	...	1.0

[a] Not measured [b] No flutter.

– Courtesy Journal of Aircraft (© 1980, AIAA)

Code:	1.1 – BB, BC, BD, BE
Title:	Inflight Captive Store Loads Compared with Wind-Tunnel and Mathematical Simulations
Author:	Maddox, A.R.; Dix, R.E.; Mattasits, G.R. NWC, China Lake, CA
Date:	May 1979
Source:	Journal of Aircraft, Vol. 16, No. 5, pages 289-295

Code:	1.2 – BB, BC, BG
Title:	Decoupler Pylon. A Simple, Effective Wing/Store Flutter Suppressor
Author:	Reed, W.H. III; Foughner, J.T., Jr.; Runyan, H.L., Jr. NASA, Langley, Hampton, VA
Date:	March 1980
Source:	Journal of Aircraft, Vol. 17, No. 3; pages 206-211

Code:	1.3 – BB, BC, BD, BG
Title:	Air Force Academy Aeronautics Digest
Author:	Jumper, E.J.; Tower, M.M. Air Force Academy, CO
Date:	July 1979
Source:	NTIS AD-A075 41?/2; PC A08/MF A01

Code:	1.4 – BB, BC, BD, BG
Title:	Flow Reattachment (Bibliography)
Author:	Habercom, Guy E., Jr. NTIS, Springfield VA
Date:	November 1979
Source:	NTIS OB80-800345; PC N01/MF N01

AERODYNAMICS

Code:	1.5 – BG
Title:	Technical Evaluation Report on the Fluid Dynamics Panel Symposium on High Angle of Attack Aircraft
Author:	Polhamus, Edward C.
Date:	August 1979
Source:	NTIS AD-A074 692/5; PC A02/MF A01

Code:	1.6 – BB, BC, BD, BE, BG
Title:	Store Separation Trajectory Analysis
Author:	Maddox, A.R. Naval Weapons Center, China Lake, CA
Date:	January 1980
Source:	NTIS AD-A086 704/4

Code:	1.7 – BE
Title:	Mutual Interference of Multiple Bodies in the Flow Field of the F-4C Aircraft in the Transonic Speed Range
Author:	Hesketh, A.A. Arnold Engineering Dev. Center, Tullahoma, Tenn
Date:	December 1979
Source:	NTIS A084 704

Code:	1.8 – BC, BD, BF, BG
Title:	Flight Test Performance of the F-4 Conformal Weapons Carriage
Author:	Smith, Daniel L. Boeing Aerospace Company
Date:	June 1973
Source:	NTIS AD-530 710, 103 pages

Code: 1.9 – BB, BC, BD, BE

Title: Prediction of Six-Degree-of-Freedom Store Separation Trajectories at Speeds up to the Critical Speed. Volume I.

Author: Goodwin, Frederick K.; Dillenius, Marnix F.E.; Nielsen, Jack N.
Nielsen Engineering and Research Inc.

Date: October 1972

Source: NTIS AD-B004 413L, 181 pages

Code: 1.10 – BB, BC, BD, BE

Title: Data Report for an Extensive Store Separation Test Program Conducted at Supersonic Speeds

Author: Goodwin, Frederick, K.; Dyer, Calvin L.
Nielsen Engineering and Research Inc.

Date: December 1979

Source: NTIS AD-B083 848, 297 pages

Code: 1.11 – BB, BC, BD, BE

Title: Technique for Predicting Aircraft Aerodynamic Effects Due to External Stores Carriage. Volume I. Technical Summary Report.

Author: Gallagher, R. Dale; Jimenez, G.; Light, Les E.;
Thames, Frank C.
LTV Aerospace Corporation

Date: September 1975

Source: NTIS AD-B008 900L, 196 pages

Code: 1.12 – BB, BC, BD, BE

Title: Technique for Predicting Aircraft Aerodynamic Effects Due to External Stores Carriage. Volume II. User's Manual.

Author: Gallagher, R. Dale; Jimenez, G.; Light, Les E.; Thames, Frank C.
LTV Aerospace Corporation

Date: September 1975

Source: NTIS AD-B008 901L, 365 pages

AERODYNAMICS

Code: 1.13 – BB, BC, BE

Title: A Rapid Method for Flutter Clearance of Aircraft with External Stores. Volume I. Theory and Application.

Author: Ferman, M.A.
McDonnell Automation Company

Date: September 1973

Source: NTIS AD-915 579L, 143 pages

Code: 1.14 – BB, BC, BD, BE, BG

Title: Aircraft/Stores Compatibility Symposium Proceedings (4th) Held at Fort Walton Beach, Florida on 12-14 October 1977. Volume I.

Author: Bore, Clifford L.; Schmidt, Edward M.; Edmund J.; Smith, Keith G.; Dankievitch, Edward
Joint Technical Coordinating Group for Munitions Development

Date: October 1977

Source: NTIS AD-B082 875L, 510 pages

Code: 1.15 – BB, BC, BD, BE

Title: Supersonic Delivery Capability with Selected Conventional Munitions on F-4 and F-111 Aircraft

Author: Hume, Robert A., Jr.

Date: May 1975

Source: NTIS AD-B006 868L, 54 pages

Code: 1.16 – BB, BC, BD, BE

Title: An Extension of the Rapid Method for Flutter Clearance of Aircraft with External Stores. Volume I. Theory and Application.

Author: Ferman, M.A.
McDonnell Aircraft Co.

Date: November 1975

Source: NTIS AD-B009 583L, 192 pages

Code: 1.17 – BB, BC, BD, BE, BG

Title: Advanced Weapons Carriage Technology for Ground Attack Aircraft. Volume I. Weapon Carriage Trades and Optimum Weapon Configured Vehicle Selection

Author: Baullinger, Norman C.
Boeing Aerospace Company

Date: October 1976

Source: NTIS AD-B018 910L, 228 pages

Code: 1.18 – BB, BC, BD, BE

Title: Advanced Weapon Carriage Configured Vehicle (AWCCV) Study

Author: Gough, Melvin N.; Carlson, Davis
Grumman Aerospace Corporation

Date: April 1978

Source: NTIS AD-B029 581L, 189 pages

Code: 1.19 – BB, BC, BE

Title: Improved Aircraft External Store Flutter Prediction. Volume I: Theory and Application. Supplement 1.

Author: Ferman, M.A.
McDonnell Aircraft Company

Date: December 1979

Source: NTIS AD-B047 310L, 28 pages

Code: 1.20 – BG

Title: Inter-Laboratory Air-to-Air Missile Technology – An Innovative Approach

Author: Aden, Timmy C.
Guided Weapons Division, AF Armament Laboratory

Date: 1979

Source: NAECON, 8 pages

AERODYNAMICS

Code: 1.21 – BB, BD, BE

Title: Effect of Conventional and Square Stores on the Longitudinal Aerodynamic Characteristics of a Fighter Aircraft Model at Supersonic Speeds

Author: Monta, William J.
National Aeronautics and Space Administration, Langley Research Center

Date: June 1980

Source: NTIS HC A04/MC A01 CSCL 01A, 59 pages

Code: 1.22 – BB, BC, BD, BE

Title: Canadian Aircraft Validates New U.S. Facility

Author: Anon

Date January 1980

Source: Machine Design, 1 page

Code: 1.23 – BB, BC, BD, BE

Title: Model Tests Providing Data for Fighter Designs

Author: Anon

Date July 24, 1980

Source: Machine Design, 1 page

Code: 1.24 – BB, BC, BD, BE

Title: Tail Fin Saves Fuel

Author: Anon

Date 1980

Source: Machine Design, 1 page

Code: 1.25 - BB, BC, BD, BE

Title: Technology Options for an Advanced Tactical Fighter

Author: Anon

Date: 1979

Source: Interavia 3, 5 pages

Code: 1.26 - BB, BC, BD, BE, BG

Title: Store Separation

Author: Mathews, Charles B.
AF Armament Lab., Elgin AFB

Date 1979

Source: NTIS - AGARD, 8 pages

Code: 1.27 - BF, BG

Title: Measurement of Suspension Loads and Determination of Suspension Reliability for a Store in the F-111 Weapons Bay

Author: Meyer, S.E.; Paez, T.L.
Sandia Labs

Date October 12, 1977

Source: NTISDE NTIS SAND-77-0622C, 51 pages

Code: 1.28 - BB, BC, BD, BE, BG

Title: Aerodynamic Drag

Author: Anon
Advisory Group for Aerospace Research and Development (Paris)

Date October 1973

Source: NTIS AD-771 572/5 (Report #AGARD-CP-124), 484 pages

Code: 1.29 - BB, BC, BD, BE, BG

Title: Wing Store Active Flutter Supporession $EM Dash$ Correlation of Analyses and Wind-Tunnel Data

Author: Noll, T.E.; Hutsell, L.J.
AF Flight Dyn. Lab., Wright-Patterson AFB

Date: July 7, 1979

Source: Jet Aircraft, Volume 16, 7 pages (491-497)

Code: 1.30 - BB, BC, BD, BE, BG

Title: Demonstration of Aircraft Wing/Store Flutter Suppression Systems

Author: Hwang, Chintsum; Winther, Bertil A.; Mills, George R.; Noll, Thomas E.; Moses, G.
Northrop Corporation

Date August 8, 1979

Source: Jet Aircraft, Volume 16, pages 557 through 563

Code: 1.31 - BB, BD, BE, BG

Title: Wing/Store Flutter with Nonlinear Pylon Stiffness

Author: Desmarais, R.N.; Reed, W.H., III
NASA

Date April 1980

Source: NTISNASA NTIS N80-20280/7, 8 pages

Code:

Title:

Author:

Date

Source:

Code 3

CONTROLS TECHNOLOGY

Generalized information on controls is presented as part of the technical briefs for Fluidics (Code 6), Pneumatics (Code 7), and Hydraulics (Code 8). This brief provides more specific information on regulators, valves, couplings, and sensors for advanced armament systems.

Application

- Stores station interfaces
- Stores ejection systems

Advantages

- High reliability of couplings and regulators for advanced armament systems, based on use in space programs and supersonic aircraft
- Digitally controlled valves eliminate the need for D/A signal converters
- Servovalving can be implemented utilizing microprocessor technology
- Improved high-pressure capability of valves, regulators, and couplings due to advances in material technology
- High accuracy and reliability of sensing devices compared to mechanical types

Disadvantages

- High cost of valves and couplers due to the customized nature of design and extensive testing for space programs
- Need for more intensive investigation for direct applications of controls to S&RE

Risk

The risk in using the control components described herein for advanced aircraft armament systems is low, premised on their successful application in space programs.

Trends and State of the Art

— Couplings. The state of the art of fluid couplings has advanced rapidly as a result of space and supersonic aircraft programs. Unique fluid transfer couplings are available for cryogenic, pneumatic, and hydraulic systems. The couplings feature self-sealing and self-alignment, automatic latching, and remote activation. Various couplings are rated at burst pressures up to 13,500 psi, and are capable of meeting military specification requirements for advanced armament systems. Typical characteristics of couplings are given in Table 3-1.

— Regulators and Valves. Pressure regulators (see example, Figure 3-1) and other valves are available for use in high reliability environments. Some of these valves incorporate pressure transducers for venting and quick release operation.

New designs are emerging of Mil-qualified hydraulic, pneumatic, fuel, and other fluid systems that employ positive self-sealing techniques to prevent high-pressure leakage.

New types of high-pressure solenoid valves are evolving. A major driver in this area has been high-pressure nuclear power systems. Valves are being fabricated that have interiors unaffected by corrosive fluids, can withstand higher pressures, and can operate at faster rates.

A new family of digital hydraulic valves is emerging (see Figure 3-2). A significant trend in this area is the change from air-gap to wet-armature solenoids, providing improved reliability. These valves incorporate elements that control flow in either the forward or reverse direction, and have been successfully developed for direct use with microprocessor control signals.

Another interesting trend is the emergence of improved cartridge valves for hydraulic systems. These valves are flexible in installation, safe to operate, very serviceable, and of low cost. Cartridge valves (see example, Figure 3-3) are available for such functions as pressure relief, sequencing, regulating, pressure reduction, and checking.

Improved hydraulic system seals are being marketed. In some applications, filled PTFE piston-ring seals are replacing lip seals and metallic piston rings to provide less leakage and lower friction (see Figure 3-4).

— Sensors and Transducers. Capacitive transducers can handle measurements from 0.01 to 150,000 psi and provide both dynamic and static readings with good frequency response. A recent development is a transducer that compares the voltage across a sensing capacitor element with that of a reference capacitor. The device integrates the voltage difference to produce an output linear to pressure variations.

Some transducers employ integrated circuitry to convert analog signals to digital form without the need for separate A/D conversion.

Wider use of strain gauges is being made in aircraft and missile systems. These gauges employ thin-film techniques to provide stability and high accuracy. Strain gauges can operate at pressure ranges as high as 10,000 psi. Semiconductor piezoresistive strain gauges are supplanting wire and foil types, and can serve as accelerometer sensors.

Transducers housed in stainless steel for application in corrosive environments operate from -65° to +525°F. One of these types uses a silicon or sapphire diaphragm with epitaxially grown piezoresistive silicon strain gauges on the surface. The devices are isolated internally from thermal and mechanical stress.

A new family of semiconductor sensors has potential use in advanced armament systems. These sensors operate on a principle based on the linear negative temperature coefficient of the base-to-emitter diode voltage of a silicon transistor. Silicon device sensors such as thermistors have highly accurate temperature coefficients over the -55°C to +125°C range.

Optoelectronic sensors of many types appear suitable for potential S&RE sensing applications. These optical sensors are discretely packaged or incorporated as chips on substrates with processing circuitry.

Cost

No specific cost directions have been noted for the coupling, valve, and regulating components described in this brief. However, improved reliability should promote reduced life cycle costs of armament systems if these components are implemented. The cost of semiconductor sensors is expected to decrease significantly within the next few years, to the point where they are less expensive than comparable mechanical devices.

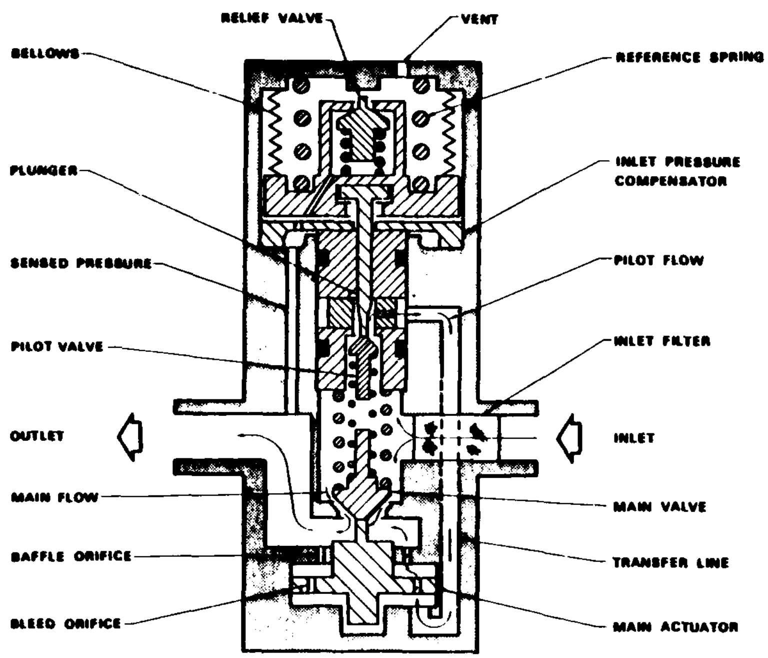


Figure 3-1. TYPICAL PRESSURE REGULATOR CONCEPT WITH INTEGRAL RELIEF VALVE

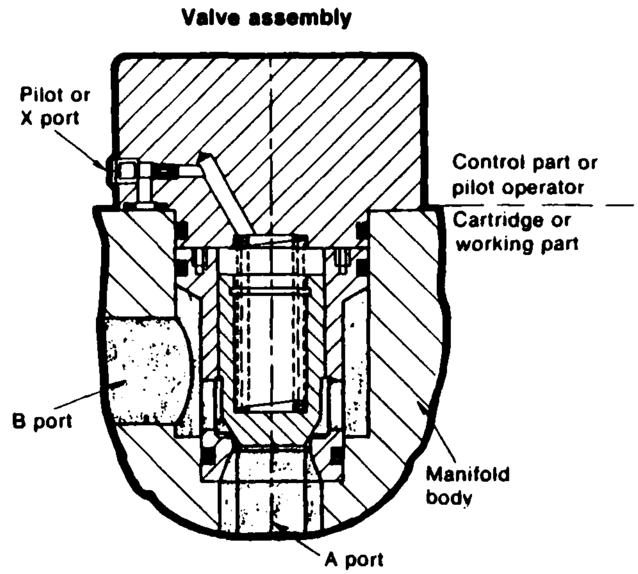


Figure 3-3. CARTRIDGE CHECK VALVE

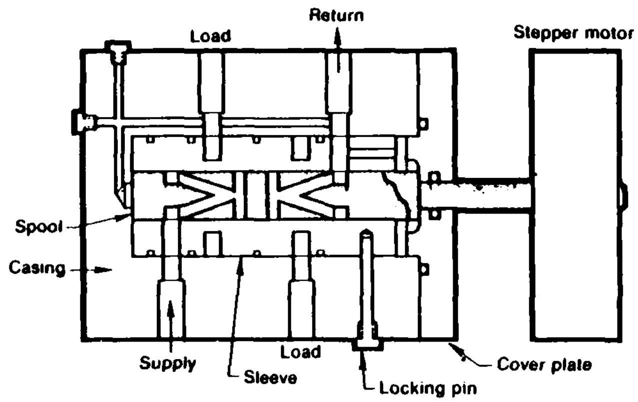


Figure 3-2. DIGITALLY CONTROLLED ROTARY-STEPPER FLOW-CONTROL VALVE

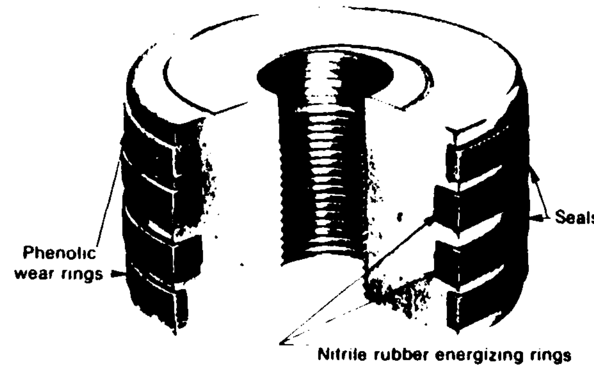


Figure 3-4. FILLED PTFE PISTON-RING SEALS REPLACING LIP SEALS AND METALLIC PISTON RINGS

– *All figures courtesy Machine Design Magazine (Penton/IPC, Inc.; Fig. 3-3 © 1980, others © 1979)*

Table 3-1. CHARACTERISTICS OF EXISTING COUPLINGS

	INTERSTAGE	PROPELLANT TRANSFER	PRSD - CRYOGENIC	PRSD - GAS	GHe/GN2 LOADING	LOX BLEED	FUEL CELL CRYOGENIC	HYPERGOLIC FILL & DRAIN	HYPERGOLIC SERVICING	HELIUM, HIGH PRESSURE LOADING
Space Vehicle	Lunar Module	Mariner Jupiter/Saturn	Orbiter	Orbiter	Orbiter	Orbiter	Apollo	Gemini/Titan	Orbiter	Orbiter
Application: Ground Servicing - (S) Flight Interface - (I)	I	I	S	S	S	S	S	S	S	S
Tube Size	3/8"	1/2"	3/8, 5/8, 3/4 & 1"	1/4, 1/2 & 5/8"	1/2 & 1"	1 1/2-inch	1/4, 3/8 & 3/4"	3/8, 1/2, 1 & 2	1/4, 3/8, 1/2 & 1"	1/4, 3/8 & 5/8"
Type of Disconnect	Breakaway	Breakaway	Breakaway & Manual Latching	Breakaway & Manual Latching	Breakaway & Manual Latching	Breakaway	Manual Latching	Manual Latching	Breakaway Latching Manual Latching	Breakaway Latching Manual Latching
Operating Fluid	O_2, Ethylene Glycol	Hydrazine, Monopropellant	GHe, GN_2, GOX, GH_2 LOX, LH_2	GHe, GN_2, GH_2 or GOX	GHe or GN_2	GHe, GN_2, LOX and GOX	LOX, LH_2	N_2O_4, MMH	N_2O_4, MMH	GHe, GN_2, N_2O_4 & MMH Vapors
Operating Pressures	Vacuum - 1575 psig	Vacuum - 460 psig	0 to 1035 psig	0 to 1035 psig	0 to 4500 psig	0 to 100 psig	Vacuum - 1275 psig	Vacuum - 300 psig	0 to 600 psig	0 to 8000 psig
Operating Temperatures	0°F to +160°F	0°F to +140°F	-423°F to +350°F	-160°F to +350°F	-250°F to +350°F	-297°F to +350°F	-423°F to +160°F	-35°F to +160°F	-20°F to +150°F	-300°F to +150°F
*Leakage Mated	1×10^{-4} sccs, He	1×10^{-3} sccs, He	2 sccs, He	2 sccs, He	-	40 scim GOX -255°F	1.5×10^{-3} sccs, He	4×10^{-4} sccs, N_2	1×10^{-4} sccs, He	1×10^{-2} sccs, He
Flight Half	1×10^{-4} sccs, He	1×10^{-3} sccs, He	2 sccs He @ 423°F **	2 sccs, He @-160°F **	1.0 scim He	40 scim GOX @ 255°F	2.5 sccs, H_2, O_2 **	4×10^{-4} sccs, N_2	1×10^{-4} sccs, He	1×10^{-4} sccs, He
Flight Pressure Cap	N/A	N/A	5×10^{-3} sccs He	N/A	N/A	N/A	5×10^{-4} sccs, H_2, O_2	3×10^{-10} sccs, He	1×10^{-4} sccs, He	1×10^{-4} sccs, He
Alignment	1/16" Offset with ± 5° Misalignment	1/32" Offset with ± 5° Misalignment	.06" Offset with + 1° Conical Misalignment	.06" Offset with ± 1° Conical Misalignment	1/16" Offset with 1/2° Misalignment	1/16" Offset with 1/2° Misalignment	N/A	N/A	.05" Offset with ±2 1/2° Conical Misalignment	.05" Offset with ±2 1/2" Conical Misalignment
Flight Half Leak Check thru Interface Cavity	N/A	N/A	YES	YES	N/A	N/A	N/A	N/A	YES	YES
Life Cycles, Minimum	200	250	4000	4000	2000	2000	200	250	600	600
Flow Factor "K"	3.4	1.78	4.0	4.0	1.40	0.5	4.0	1.80	4.2	4.0
Weight, Flight Half	Ascent Half 0.67 lbs. Descent Half 0.57 lbs.	Mission Module Half 0.41 lbs. Propulsion Half 0.61 lbs.	1.02 lbs.	1.02 lbs.	2.55 lbs.	1.10 lbs.	1/4: 0.30 lbs. 3/8: 0.65 lbs. 3/4: 1.30 lbs.	1": 1.6 lbs. 2": 4.3 lbs.	1/4 & 3/8": 0.41 lbs. 1/2": 0.56 lbs. 1": 1.10 lbs.	0.30 lbs.
FEATURES:										
Self-Sealing	X	X	X	X	X	X	X	X	X	X
Pneumatic Actuation	-	-	X	X	-	-	X	-	X	X
Manual Operation	-	-	X	X	X	-	X	X	X	X
Interlock	-	-	X	X	-	-	X	-	X	X
Pressure Cap	-	-	X	X	-	-	X	X	X	X
Position Indicator	X	X	X	X	-	-	X	X	X	X
Indexing	-	-	X	X	X	-	X	X	X	X

* Leakage rates noted are Specification limits. Actual leak rates are generally smaller by a considerable margin.

** Orbiter PRSD & Apollo Fuel Cell Disconnects incorporate metal-to-metal airborne poppets.

-- Courtesy Fairchild Stratos Division

NOTE: PRSD = Power Reaction Storage Distribution
SCCS = Standard cubic centimeters per second
SCIM = Standard cubic inches per minute

Code: 3.1 – BB, BC, BD, BE

Title: AFFDL Experience in Active Control Technology

Author: Johannes, Robert P.; Whitmoyer, Robert A.
AFFDL, Wright-Patterson AFB, OH

Date: May 1979

Source: AGARD Conference Proc., 10 pages

Code: 3.2 – BG

Title: Status Report on the Advanced FIREFLY Assessment Program

Author: Longmire, D.E.
Northrop Corp.

Date May 1979

Source: IEEE Proceedings National Aerospace Electronics Conference, 1979; IEEE (Cat No. 79CH1449-8 NAECON), pages 170-175

Code: 3.3 – BB, BC, BD

Title: Motor Controls and Protectors

Author: Anon

Date 15 May 1980

Source: Machine Design - Pages 87-100

Code: 3.4 – BB, BC, BD, BE

Title: Star Flight Control System

Author: Carlock, Gaylord W.; Gatlin, Charles M.; Guinn, Kenneth F.; Borgeson, Roger D.
Bell Helicopter Textron, Hydraulic Research Textron

Date July 1979

Source: Journal of the American Helicopter Society, Volume 24, #4, 9 pages

Code: 3.5 – BB, BC, BD, BE, BG

Title: A Comparison of Hydraulic, Pneumatic, and Electro-Mechanical Actuators for General Aviation Flight Controls

Author: Roskam, J.; Rice M.; Eysink, H.
University of Kansas

Date: April 3-6, 1979

Source: Society of Automotive Engineers, Inc., 11 pages

Code: 3.6 – BB, BC, BD, BE

Title: Fire-Control and Sensor System for AAH

Author: Anon
Martin Marietta Aerospace

Date 1980

Source: Interavia 8, 1 page

Code: 3.7 – BB, BC, BD, BE

Title: Hyrologic Actuator for Tactical Weapon Delivery Control Augmentation System

Author: Durbin, James J.

Date April 1971

Source: NTIS, AD-894; 118 pages

Code: 3.8 – BB, BC, BD, BE,

Title: Valve Actuators Determine Control

Author: Osthues, R.
Worchester Control Corp.

Date June 1975

Source: Instruments and Control System, Vol. 47, No. 5, pages 23-26

Code:	3.9 – BB, BC, BD, BE
Title:	Combat Vehicle and Aircraft Stabilization Systems
Author:	Witczak, C.W. Rock Island Arsenal, Rodman Lab.
Date:	July 1974
Source:	Fluidics Quarterly, Vol. 6, #3, pages 43-52

Code:	3.10 – BB, BC, BD, BE
Title:	Hydraulic Control Handle/Elevation Axis Closed-Loop System Evaluation #Fluidic Armament Control System, Final Report, May 1974 – January 1975
Author:	Burton, R.V. Honeywell, Inc.
Date	May 1975
Source:	Report 45891 RIA-R-CR-75-026

Code:	3.11 – BB, BC, BD, BE
Title:	Digital Hydraulic Valving System: Final Report
Author:	Anon HLM, Inc.
Date	August 1974
Source:	NASA CR-12466, 55 pages

Code:	3.12 – BB, BC, BD, BE
Title:	Weapon Delivery Impact on Active Control Technology
Author:	Smith, H.; Carleton, Dave AF Armament Lab, Eglin AFB
Date	October 14-17, 1974
Source:	AGARD Conf. Proc. #157, June 1975, 14 pages

CONTROL

Code:	3.13 – BB, BC, BD, BE
Title:	Coming: Smart Hydraulic Valves
Author:	El Ibiary, Yehia University of Sask, Saskatoon
Date:	November 23, 1978
Source:	Machine Design, Volume 50, #27, pages 99-103

Code:	3.14 – BB, BC, BD, BE, BG
Title:	GN2 Accumulator Powered Shaftless Piston for Dependent Dual Ejector Bomb Rack
Author:	Holt, Lloyd Jr. Department of the Navy
Date	July 18, 1977
Source:	NTIS AD-D004 248/1ST, 15 pages

Code:	3.15 – BB, BC, BD, BE, BG
Title:	*Flight Test of an 8000-PSI Lightweight Hydraulic System (LHS)*
Author:	Demarchi, Joseph N.; Haning, Robert K. Rockwell International
Date	April 1977
Source:	NTIS AD-A039 717/4ST, 87 pages

Code:	3.16 – BB, BC, BD, BE, BG
Title:	A New Approach to Proportional Motion Control
Author:	Walters, R. Sperry Vickers European Group (England)
Date	
Source:	Hydraul. and Pneum. (USA), Vol. 33, No. 6, 104, 106 June 198NTATIO

Code:	3.17 – BB, BC, BD, BE
Title:	Verification of the Space Shuttle Ascent Flight Control
Author:	Chambers, T.V. NASA
Date:	July 2-6, 1979
Source:	IFAC

Code:	3.18 – BB, BC, BD, BE
Title:	Pneumatic Control Device for the Persing II Adaption Kit
Author:	Anon Raymond Engineering, Inc.
Date	March 14, 1979
Source:	NTIS AD-A082 564/6, 189 pages

Code:	3.19 – BB, BC, BD, BE
Title:	Power System Control Study, Phase I – Integrated Control Techniques
Author:	Lautner, D.E.; Marek, A.J.; Perkins, J.R. Vought Corporation – AF Aero Propulsion Lab.
Date	June 1979
Source:	NTIS AD-A078 629/3, 240 pages

Code:	3.20 – BB, BC, BD, BE
Title:	Thermal Response Turbine Shroud Study
Author:	Anon Pratt and Whitney Aircraft Group (West Palm Beach)
Date	July 1979
Source:	NTIS AD-A080, 620/8, 135 pages

Code 4

CORROSION TECHNOLOGY

Primary interest in corrosion technology lies in AAAS structures and electronic connectors, as discussed in this technology brief.

Potential AAAS Applications

- S&RE structures and mechanical elements
- Electrical connections, such as those of the Stores Station interfaces (see Code 30)

Advantages and Disadvantages

Corrosion-prevention techniques and materials for advanced armament programs offer obvious benefits of reduced cost and increased system availability. Disadvantages of the materials described in this subsection are covered under Codes 10, 11, and 30 for the Manufacturing, Materials, and Electrical Technology disciplines, respectively.

Risk

The risk associated with applying the various corrosion prevention technologies described herein to advanced aircraft armament systems is considered low to medium. Each technology area offers significant promise, and if properly evaluated could prove beneficial to selective areas of the AAAS.

Trends and State of the Art

The following corrosion technologies are considered of interest for the AAAS:

- Composites. Composites such as graphite/epoxy and Kevlar/epoxy have demonstrated acceptable levels of chemical and stress corrosion resistance, and suitable strength for high-performance military aircraft structures. A "bottoms up" approach to designing the S&RE mechanical structures might consider a composite for the conformal carriage and/or rack.

- Alloys. New lightweight alloys of aluminum, steel, and titanium have improved chemical- and stress-corrosion properties over those of conventional alloys used for aircraft structures. Advances in production methods such as vacuum processing, casting, and molding enhance the availability of aluminum and titanium alloys for large-area structures such as advanced armament systems. Aluminum-copper and aluminum-zinc alloys have demonstrated successful performance in supersonic aircraft of NATO countries.

- Coatings. New techniques are emerging for coating metallic and nonmetallic materials for prevention of corrosion. These techniques include vacuum and vapor deposition processes for plating alloys of titanium and aluminum with coatings such as cadmium, chromium, and titanium nitride. Ion plating is an example of the above technology.

Another process, electrodeposition of aluminum, is utilized in the aircraft industry for protection of wings, steel and titanium fasteners, and composite materials.

A new epoxy coating for protecting naval shipboard antennas utilizes four separate applications consisting of three primers and a top coating. Total thickness is 12 to 20 mils.

Numerous paint systems have been developed by the aircraft industry, such as polyurethane topcoating over an epoxy primer, that provide the durability and corrosion resistance needed for advanced armament systems.

– Adhesive Bonding. The recent use of adhesive bonding by the Air Force in the PABST program has resulted in the elimination of sources of stress and chemical corrosion (e.g., rivets and welded joints). Adhesive bonding has also been implemented in several programs for NATO aircraft, with a good history of success, and might be suitable for AAAS structures such as conformal carriages.

– *Corrosion-Resistant Connectors*. New connector types are highly resistant to corrosion. The devices are moisture sealed in the following manner: when the connector is exposed to pressure extremes, its mating surfaces are forced together and the sealing effectiveness is increased. These devices can function at pressures up to 250 psi. This technique, along with the use of contact plating materials of higher purity, improved surface-preparation methods prior to plating, and other improvements including chromate and cadmium plating and aluminum alloys for shells, are major trends in connector manufacturing.

Cost

Relevant cost information for composites and alloys appears in the technology briefs for Codes 10 and 11. For all trends discussed herein, decreased corrosion for advanced aircraft armament systems should result in attendant reductions in life cycle costs. Both material and maintenance labor requirements will be reduced.

Code: 4.1 – BB, BC, BD, BE, BG

Title: Materials Evaluation. Part II Development of Corrosion Inhibitors

Author: Khobaib, M.
Systems Research Labs Inc., Dayton, OH

Date: September 1979

Source: NTIS AD-A080 905/3, 65 pages
SRL-6909-02-PT-2 Report for AFML (TR-79-4127-PT-2)

Code: 4.2 – BB, BC, BD, BE, BF

Title: Materials System Approach to the Concentric Neutral Corrosion Problem

Author: Haynes, G.S.; Baboian, R.
Texas Instruments, Inc., Attleboro, Mass.

Date: January 1980

Source: Material Performance, Vol. 19, No. 1, pages 44-47

Code: 4.3 – BB, BC, BD, BE, BF

Title: Corrosion Control for Electrical Contacts in Submarine Based Electronic Equipment

Author: Guttenplan, Jack D.; Hashimoto, Leonard N.
Rockwell International, Anaheim, CA

Date: December 1979

Source: Material Performance, Vol. 18, No. 12, pages 49-55

Code: 4.4 – BF

Title: Replacement of Cadmium for the Coating of Fasteners in Aerospace Applications

Author: McLoughlin, V.C.R.
R. Aircraft Establ., Farnborough, England

Date: Autumn 1979

Source: Trans Inst Met Finish, Vol. 57, Part 3, pages 102-104

CORROSION

Code: 4.5 – BB, BC, BD, BE, BF, BG

Title: Corrosion Resistance of Brazed Joints

Author: Cole, Nancy C.
Combust Eng. Inc., Chattanooga, TE

Date: April 1979

Source: Weld Res Counc. Bulletin No. 247, 41 pages

Code: 4.6 – BB, BC, BD, BE, BG

Title: Applying Critical Potential Data to Avoid Stress Corrosion Cracking of Metals

Author: Uhlig, H.H.
MIT, Cambridge, MA

Date: Mar 1979

Source: Journal Appl. Electrochem (GB), Vol. 9, No. 2, pages 191-199

Code: 4.7 – BB, BC, BD, BE, BG

Title: Applications of Sprayed Coatings

Author: Steffens, H.D.; Malik, M.
Deutsche Lufthansa A.G. (Dortmund University)

Date: March 1980

Source: NTIS HC A09/MF A01, 12 pages

Code: 4.8 – BB, BC, BD, BE, BG

Title: Materials Coating Techniques

Author: Anon.
Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine', France

Date: March 1980

Source: NTIS HC A09/MF A01, 186 pages

Code: 4.9 – BB, BC, BD, BE, BF, BG

Title: Report on Corrosion Resistance/Airborne

Author: Defense Technical Information Center

Date: November 14, 1980

Source: DDC Report No. CLQ25N, 32 pages

Code: 4.10 – BB, BC, BD, BE, BF, BG

Title: Corrosion Information in NATO Nations

Author: Promisel, Nathan E.

Date July 1979

Source: AGARD Avisory Report No. 141, 1 page

Code: 4.11 – BB, BC, BD, BE, BF, BG

Title: Corrosion Control by Coatings

Author: Anon
Lehigh University Center for Surface and Coatings Research

Date February 2, 1979

Source: Lehigh University, 29 pages

Code: 4.12 – BB, BC, BE, BF

Title: Studies on Corrosion Prevention of Mardan Connectors by Organic Coatings

Author: Kenzig, B.J.; Murday, J.S.
Naval Research Lab

Date June 9, 1980

Source: NTIS AD-A086 730/9, 41 pages

CORROSION

Code: 4.13 – BB, BC, BE, BF

Title: Precious Metal Cost Reduction Without Loss of Reliability. A Comparative Study of New and Approved Contact Materials for Connectors

Author: Schiff, K.L.
W.C. Heraeus Gmbh, Hanau, Germany

Date: October 20-21, 1976

Source: Electronic Connector Study Group

Code: 4.14 – BB, BC, BE, BF

Title: NAVAIR Problems in Military Connectors

Author: Hood, R.D.
Naval Air Station Command

Date November-December 1978

Source: Electron Prod., Vol. 7, #11

Code: 4.15 – BB, BC, BE, BF

Title: Development of a Nickel-Containing Beryllium Copper Alloy for Connector Applications

Author: Guha, A.; Spiegleberg, W.D.
Brush Wellman, Inc.

Date October 17-18, 1979

Source: Electronic Connector Study Group, Inc.

Code: 4.16 – BB, BC, BE, BF

Title: Electrolytic Erosion in Connectors – Causes and Cures

Author: Luca, V.A., Jr.; Schildkrault, A.L.
Bendix Corporation

Date October 17-18, 1979

Source: Electronic Connector Study Group, Inc.

Code:	4.17 - BB, BC, BE, BF
Title:	Significance of Contact Finish Requirements
Author:	Sard, R.; Baker, R.G.
Date:	April 1980
Source:	Plat. Surf. Finish, 67, (4), pages 42-47

Code:	4.18 - BB, BC, BD, BE, BF, BG
Title:	Corrosion Control/Prevention and Cleaning of Installed Shipboard Avionics Support Equipment
Author:	Munger, Richard K. Naval Air Development Center
Date	August 7, 1975
Source:	NTIS AD-B005 880/OST, 20 pages

Code:	4.19 - BB, BC, BD, BE, BF, BG
Title:	Corrosion and Fouling Study
Author:	McMann, John H.S. Naval Surface Weapons Center
Date	July 21, 1975
Source:	NTIS AD-A020 071/7ST, 43 pages

Code:	4.20 - BB, BC, BD, BE, BF, BG
Title:	Avionics Corrosion
Author:	Shaffer, Irving S. Naval Air Development Center
Date	December 1977
Source:	MCIC Rep #77-33, published by Battelle Lab, Met. and Ceram. Inf. Center, pages 317-326

Code:	4.21 - BB, BC, BD, BE, BF, BG
Title:	Stress Corrosion Cracking Problems in Naval Aircraft
Author:	Ketcham, S.J. Naval Air Development Center
Date:	March 22-26, 1976
Source:	Published by NACE, Houston, 8 pages

Code:	4.22 - BB, BC, BC, BE, BF, BG
Title:	Elastomers and Coatings for the Seventies
Author:	Johnson, W.P.
Date	March 1970
Source:	Rubber World, Vol. 16, #6, pages 79-83

Code:	4.23 - BB, BC, BD, BE, BF, BG
Title:	Corrosion Protection for Shipboard-Mounted Antennas
Author:	Kline, A.W. Lockheed Electronics Company
Date	November 1977
Source:	IEEE 1977, pages 210-211

Code:	4.24 - BB, BC, BD, BE, BF, BG
Title:	Influence of Cathodic Overprotection on Fatigue of Carbon Steel in Sea Water
Author:	Dvoracek, L.M. Union Oil Company of California
Date	September 1977
Source:	Mater Performance, Vol. 16, #9, pages 21-24

Code 6

FLUIDICS TECHNOLOGY

Recent advances in fluidics technology are described in this technology brief.

Potential AAAS Applications

- Sensing and control for stores ejection/release
- Power source control
- Release control for dispenser stores
- Sensing and actuation for safe/arm

Advantages

Fluid systems:

- Utilize simple devices that have no or few moving parts
- Are inherently explosion-proof
- Will operate in severe environments (temperature, vibration, radiation, and hazardous)
- Require less maintenance and have higher reliability than conventional hydraulic or pneumatic systems
- Are digital and analog compatible

Disadvantages

Fluidic systems:

- Are subject to contamination
- Have short control distances
- Are characterized by slow response time and high cost, compared to ICs

Risk

The risk of applying fluidics technology in the AAAS program is considered low because there have been a number of successful aerospace applications of fluidic devices since their introduction about 20 years ago. For example, fluidics are utilized for the thrust reverser actuator controls of the McDonnell-Douglas DC-10 and the European A300B Airbus; the thrust reverser and secondary nozzle actuator controls of the Concorde SST; the ram-air cooling pressure regulator of the Lockheed S-3A; and the surge control valve of the auxiliary power unit of the B-1 bomber.

Trends and State of the Art

Fluidic systems are being used or considered for aerospace applications involving the control of speed, temperature, pressure, angular rate sensing, and amplification. Some application examples are given below.

— Ejection Seats. Fluidic systems are being investigated for sequencing and two-axis control of ejection seats. Timing for chute deployment depends on altitude and speed. Sequencing is accomplished with a fluidic oscillator and counter circuits. Chute deployment squibs are initiated with the output of the fluidic counter by directing a jet of gas on a resonant tube. Pitch and yaw control of the seat is attained with vortex rate sensors and amplifiers to provide the signals for thrust vector control of a ball-and-gimbal nozzle.

— Engine Controls. Fuel controls with fluidic speed, temperature, and pressure-sensing circuits have been developed for gas-turbine engines. The circuit output is interfaced with the fuel shutoff valve for control of start-up, steady state, and transient load operations. A fluidic speed-sensing fuel shutoff system for free-turbine overspeed protection has operated in a 430°C environment. A low-pressure fuel flow distributor for jet engine combustors is designed to give a logarithmic pressure-flow relation by using vortex valves.

— Aircraft Environmental Control System. Feasibility has been demonstrated for fluidically controlled environmental systems for high-performance aircraft. The air conditioning system for the F-4 aircraft was used as the model for that design. The system provides temperature control in the cabin as well as protective functions, such as compressor inlet temperature control, turbine overspeed control, and water separator anti-ice control.

— Compressor Surge. In an investigation of compressor-blade surge sensing, taps were utilized on a stator blade and on a pitot tube between the rotor and stator blades. From tests on a particular compressor, the pressure-flow characteristics of the probes at the onset of surge can be used to switch a passive fluidic device.

— Brake Control. Fluidic implementation of the existing electronic anti-skid system for the Boeing 737 was found to be feasible. In that system, the wheel speed is differentiated and compared to a pilot-selected brake-pressure level. Full brake pressure is available until the selected level is reached.

— Flight Control Systems and Sensors. In the area of flight control systems, R&D programs have been funded for fly-by-tube as a backup to, and dissimilar redundant systems, for electronic fly-by-wire; low cost inertial grade gyros, an approach power compensator for carrier-based aircraft, and missile seeker torquing.

— General Aviation. Feasibility studies on low-cost and low-maintenance autopilots and stall warning devices for general aviation light aircraft are being conducted. The studies are aimed at providing increased capabilities for the relatively inexperienced pilot without significantly affecting his workload, particularly under adverse weather conditions.

Cost Direction

Fluidic systems are usually competitive in cost and performance with more conventional systems, but the higher reliability and resulting lower maintenance are major considerations in the total life-cycle cost of the applications.

Code: 6.1 – BB, BC, BD, BE, BG

Title: Fluid Dynamics of Multiple Nozzle Arrays and Radial Flow Diffusers

Author: Petrie, S.L.; Lee, J.D.
Ohio State Univ., Columbus, OH

Date: April 1980

Source: NTIS AD-A085 672/4, 28 pages for Air Force Officer of Scientific Research (AFOSR-TR-80-0456)

Code: 6.2 – BB, BC, BD, BE, BG

Title: Production Engineering Prospective . . . Fluid Actuators

Author: Anon

Date February 1980

Source: Production Engineering, 6 pages

Code: 6.3 – BB, BC, BD, BE, BG

Title: Development of a High Temperature Silicone Base Fire-Resistant Hydraulic Fluid

Author: Conte, Alfeo A.; Hammon, J. Lee
Naval Air Development Center

Date February 5, 1980

Source: Naval Air Systems Command – Report No. NADC-79248-60, 5 pages

---

Code: 6.4 – BB, BC, BD, BE, BG

Title: HYPOSH (Hydraulic Power Sharing System)

Author: Marino, Paul F.
Grumman Aerospace Corp.

Date 23 October 1978

Source: NTIS AD-A061-408; 25 pages

Code: 6.5 – BB, BC, BD, BE, BG

Title: Fluidic Acceleration Sensor

Author: Schmidlin, Albertus E.
Department of the Army

Date: December 23, 1974

Source: NTIS AD-D002 949/6ST, 7 pages

Code: 6.6 – BB, BC, BD, BE, BG

Title: Symposium on Aerodynamic Characteristics of Controls

Author: Thomas, H.H.B.M.
Advisory Group for Aerospace Research and Development (Neuilly-sur-Seine)

Date March 1980

Source: NTIS AD-A085 464/6, 21 pages

Code: 6.7 – BB, BC, BD, BE, BG

Title: Application of Fluidic Concepts to Hydraulic Control Systems

Author: Fashbaugh, R.H.; Durlak, E.R.
Civil Eng. Lab., Port Hueneme

Date September 30 - October 3, 1974

Source: Fluid State-of-the-Art Symp. Proc., Washington, D.C., Volume 5, pages 135-157

Code: 6.8 – BB, BC, BD, BE, BG

Title: Fluidic Displacement Sensing

Author: Chitty, A.; Lenaerts, P.
Hendon College of Technology

Date February 1972

Source: Fluid Power Int., Volume 37 #431, pages 25-28

Code: 6.9 – BB, BC, BD, BE, BG

Title: A Guide to Sensor Selection

Author: Bernhardt, Susanne J.
Emx Engineering Inc.

Date: September 1978

Source: NTIS AD-A061 435/4ST, 33 pages

Code: 6.10 – BB, BC, BD, BE, BG

Title: Pneumatic Circuits' New Possibilities II

Author: Anon

Date April 27, 1977

Source: Machine and Prod. Eng., Vol. 130 #3358, pages 395-398

Code: 6.11 – BB, BC, BD, BE, BG

Title: Fluidics

Author: McDonald, R.O.
Honeywell, Inc.

Date May-June 1971

Source: IEEE Trans., Ind. and Gen. Appl., Vol. IGA-7, #3, pages 367-373

Code: 6.12 – BB, BC, BD, BE, BG

Title: What's Happening in Fluidic Control?

Author: Elliott, T.C.

Date April 1971

Source: Power, Volume 115, #4, pages 64-66

Code: 6.13 – BB, BC, BD, BE, BG

Title: Nonpetroleum Hydraulic Fluids – A Projection

Author: Millett, W.H.
E.F. Houghton and Company

Date: May 1977

Source: Iron and Steel Eng., Vol. 54, #5, pages 36-39

Code: 6.14 – BB, BC, BD, BE, BF

Title: Electronics Plus Fluidics for V/STOL Flight Controls

Author: Hendrick, R.C.
Honeywell, Inc.

Date April 26-28, 1977

Source: NASA (AD-A047961; N78-19099, pages 363-383

Code: 6.15 – BB, BC, BD, BE, BG

Title: Fluidic Applications in Aerospace

Author: Goto, J.M.
Harry Diamond Labs

Date February 1978

Source: Jet Aircraft, Vol. 15, #2, pages 121-123

Code: 6.16 – BB, BC, BD, BE, BG

Title: Advances in Process Instrumentation and Control

Author: Flanagan, T.P.
SIRA Inst.

Date 1979

Source: Frontiers of Technol., Engrs. Dig. 1939-1979, pages 151-154

Code: 6.17 - BB, BC, BD, BE, BG

Title: Testing of Molded High Temperature Plastic Actuator Rod Seals for Use in Advanced Aircraft Hydraulic Systems. Technical Report June 1974 - July 1976

Author: Waterman, A.W.; Huxford, R.L.; Nelson, W.G.
Boeing Commercial Airplane Company

Date: July 1976

Source: NASA CR-135 059; Boeing Report #D6-49951, 61 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code

Title:

Author:

Date

Source:

Code 7

PNEUMATICS TECHNOLOGY

Pneumatic drive devices and control components, such as actuators, power valves, sensors, and control units for mechanization and automation, are described in this technology brief.

Potential AAAS Applications

Equipment of the Primary Station, Missile Launcher, Special Station, Multiple Store Adapter, and Integration Equipment for the following specific uses:

- Sensing and control for stores ejection/release
- Power source control
- Release control for dispenser stores
- Sensing and actuation for safe/arm

Advantages

- System components are relatively simple in design, installation, and servicing
- Components operate over a low-pressure air supply range
- Operating components are virtually impervious to environmental influences such as vibration, temperature changes, grit, dirt, and liquids
- Components do not present a threat to their surroundings.

Disadvantages

- Composite pneumatic control circuits built up using valves, sensors, cylinders, etc., tend to be rather bulky due to the physical size of the individual components.
- The absence of feedback in control units could create operational problems when they are used singly.

Risk

Premised on numerous successful applications of pneumatics, including one by NWC for S&RE, the risk of applying this technology to advanced armament systems is considered medium. Fully pneumatic power sources will necessitate considerable investigative efforts to obtain the desired characteristics, such as small size and other critical features, for the AAAS. The likelihood of achieving these advances in time for ADM implementation is considered low.

Following are two typical factors affecting the risk of applying pneumatics to advanced armament systems.

- With respect to operational speed, modern pneumatic control units are fully comparable with the electrical relay type. Pneumatic signals are transmitted at a lower rate than electrical signals, but do not experience the delays caused by solenoid-valve conversion of electric signals into air signals.

— Pneumatic system technology has still not achieved widespread recognition as a subject for engineering education courses. On the other hand, component manufacturers have organized courses for designers, fitters, and users, and widespread use of pneumatics in automated manufacturing processes is common worldwide.

Trends and State of the Art

Pneumatic technology is characterized by a wide assortment of components representing an ever-expanding building kit. This variety of components is divided into two separate but interrelated design application areas, the "power units" for providing the movement function and the "thinking units" for effecting the control sequences. Power units, better known as actuators, are available in many forms and sizes, and an even greater product variation exists for the thinking units. The latter units are built up using valves in their many operating modes and configurations, which include lever-operated and pushbutton devices and the more recently developed modular-moving-part logic control devices.

In recent years, pneumatic cylinder developments have been guided by the desire to standardize cylinder diameters, piston rod diameters, and piston rod thread size. Also, new materials and processing methods have reduced moving-part friction and therefore lubrication requirements.

The varied forms of modern control valves, such as power valves, sensors, control units, and moving-part logic devices, together with the hundreds of options and accessories available to combine these basic valves, will provide enhanced dynamic control capabilities.

Cost

In applications where the required output is of sufficient quantity, it is usually cost-effective to utilize automated process control systems. The relatively low cost per function of pneumatic components encourages their use in economically sound designs. It is reported that pneumatic controls still command nearly 50 percent of the dollar volume of all process control systems delivered on a worldwide basis.

Code: 7.1 – BB, BC, BD, BE, BG

Title: Tests on Pneumatically Powered Precision Force Generators

Author: Law, R.D.
Royal Aircraft Establishment, Farnborough, England

Date: January 1979

Source: NTIS AD 085 862/1; PC A03/MFA01

Code: 7.2 – BC, BG

Title: Boost Assisted Missile Launcher

Author: Holt, Lloyd J.; Panlaqui, Clayton
Dept. of Navy, Washington, D.C.

Date: December 1979

Source: NTIS AD-D007084/7; DC A02 MF/A01

Code: 7.3 – BB, BC, BD, BE

Title: Vehicle Launching Device

Author: Hammond, Joseph
Dept. of Navy, Washington, D.C.

Date: April 1979

Source: NTIS AD-D006 752/0; PC A02/MF A01

Code: 7.4 – BB, BC, BD, BE, BG

Title: Fluid Actuators

Author: Anon.

Date: February 1980

Source: Product(tion) Engineering, Vol. 27, No. 2, Feb. 1980, pages 36-41

PNEUMATICS

Code: 7.5 – BB, BC, BD, BE, BG

Title: Introducing Rotork's Quatral Actuator

Author: Anon.

Date: November 1979

Source: Ind. Luba, Tribal, Vol. 31, No. 6, Nov, Dec. 1979, pages 228-230, 241

Code: 7.6 – BB, BC, BD, BE, BG

Title: Optimizing Pneumatic Valves

Author: Fleischer, Henry
Numatics, Inc., Highland, Mich.

Date: October 1979

Source: Prod. Eng., Vol. 26, No. 10, Oct. 1979, pages 58-60

Code: 7.7 – BB, BC, BD, BE, BG

Title: What's Available in Air Power Valves

Author: Schneider, R.T.
National Automatic Tool Co., Richmond, Ind.

Date: May 1980

Source: Hyraulics and Pneumatics, Vol. 33, No. 5, pages 69-71, May 1980

Code: 7.8 – BB, BC, BD, BE, BG

Title: Pneumatic Logic

Author: Sharpe, C.

Date: January 1980

Source: Design Engineering (GB), pages 83, 85, 89, 91, 93

Code: 7.9 – BB, BC, BD, BE, BG

Title: Pneumatic Valves, Cylinders and Systems

Author: Read, C.G.
Atlas Copoc Ltd., Hemel, Hempstead, England

Date: 1979

Source: Engineers Digest LTD, London, England; Frontier of Technology, pages 105, 107-8, 1979

Code: 7.10 – BB, BC, BD, BE, BG

Title: Designing and Developing a Modern Pneumatic Valve

Author: Caldwell, T.A.

Date: August 1979

Source: OEM Design (GB) 22-3, Aug 1979

Code: 7.11 – BB, BC, BD, BE, BG

Title: Tubing, Valves and Connectors, The Backbone of Pneumatic Control

Author: Morris, H.M.

Date: July 1979

Source: Control Engineering, Vol. 26, No. 7, pages 52-52, July 1979

Code: 7.12 – BB, BC, BD, BE, BG

Title: Pneumatics, a Driving Force in Modern Automation Schemes

Author: Moss, K.T.

Date: February 1980

Source: Chart Mechanical Engineering, Vol. 27, No. 2, Feb 1980, pages 55-57

Code: 7.13 – BB, BC, BD, BE, BG

Title: Ejector Energy System

Author: Anon

Date:

Source: Alkan USA, Inc., 6 pages

Code: 7.14 – BB, BC, BD, BE, BG

Title: Valve Actuators Determine Control

Author: Osthues, R.
Worcester Controls Corporation

Date June 1975

Source: Instrum. and Control Syst., Vol. 47, #5, pages 23-26

Code: 7.15 – BB, BC, BD, BE, BG

Title: A Pneumatic Actuation System for a Large Ballistic Missile

Author: Jacobs, P.L.
U.S. Army Missile Research and Development Command

Date June 1980

Source: Fluidics Quarterly, Vol. 12, #2, pages 59-81

Code: 7.16 – BB, BC, BD, BE, BG

Title: Microcomputer-Controlled Precision Pneumatic Pressure Generator

Author: Ellis, G.; Gollomp, B.P.
Bendix Corporation

Date September 1977

Source: IEEE Trans. Instrum. and Meas., Vol. IM-26, #3, pages 214-217

Code: 7.1 – BB, BC, BD, BE, BG

Title: Tests on Pneumatically Powered Precision Force Generators

Author: Law, R.D.
Royal Aircraft Establishment, Farnborough, England

Date: January 1979

Source: NTIS AD 085 862/1; PC A03/MFA01

Code: 7.2 – BC, BG

Title: Boost Assisted Missile Launcher

Author: Holt, Lloyd J.; Panlaqui, Clayton
Dept. of Navy, Washington, D.C.

Date: December 1979

Source: NTIS AD-D007084/7; DC A02 MF/A01

Code: 7.3 – BB, BC, BD, BE

Title: Vehicle Launching Device

Author: Hammond, Joseph
Dept. of Navy, Washington, D.C.

Date: April 1979

Source: NTIS AD-D006 752/0; PC A02/MF A01

Code: 7.4 – BB, BC, BD, BE, BG

Title: Fluid Actuators

Author: Anon.

Date: February 1980

Source: Product(tion) Engineering, Vol. 27, No. 2, Feb. 1980, pages 36-41

PNEUMATICS

Code: 7.5 – BB, BC, BD, BE, BG

Title: Introducing Rotork's Quatral Actuator

Author: Anon.

Date: November 1979

Source: Ind. Luba, Tribal, Vol. 31, No. 6, Nov, Dec. 1979, pages 228-230, 241

Code: 7.6 – BB, BC, BD, BE, BG

Title: Optimizing Pneumatic Valves

Author: Fleischer, Henry
Numatics, Inc., Highland, Mich.

Date: October 1979

Source: Prod. Eng., Vol. 26, No. 10, Oct. 1979, pages 58-60

Code: 7.7 – BB, BC, BD, BE, BG

Title: What's Available in Air Power Valves

Author: Schneider, R.T.
National Automatic Tool Co., Richmond, Ind.

Date: May 1980

Source: Hyraulics and Pneumatics, Vol. 33, No. 5, pages 69-71, May 1980

Code: 7.8 – BB, BC, BD, BE, BG

Title: Pneumatic Logic

Author: Sharpe, C.

Date: January 1980

Source: Design Engineering (GB), pages 83, 85, 89, 91, 93

Code: 7.17 - BB, BC, BD, BE, BG

Title: Guide to Pneumatic and Hydraulic Actuators

Author: Hall, John

Date: December 1978

Source: Instrum. Control System, Vol. 51, #12, pages 31-36

Code: 7.18 - BB, BC, BD, BE, BG

Title: Direct Digital Flow Rate Measurement and Control Valves

Author: Langill, A.W., Jr.
Process System Incorporated

Date June 30 - July 2, 1976

Source: ISA (Instrum. in the Chem. and Pet. Ind., Vol. 12), pages 47-50

Code: 7.19 - BB, BC, BD, BE, BG

Title: Variable Orifice Gas Metering Assembly for Aircraft Bomb Rack Gas System

Author: Hoffman, Charles Jr.
Department of the Air Force

Date January 14, 1976

Source: NITS AD-D002 335/8ST, 9 pages

Code: 7.20 - BB, BC, BD, BE, BG

Title: Pulsed High Pressure Gas Generator for the LINUS-O System

Author: Ford, R.D.; Jenkins, D.J.; Turchi, P.J.
Naval Research Laboratory

Date June 1977

Source: NTIS AD-A041 826/9ST, 19 pages

PNEUMATICS

Code: 7.21 - BB, BC, BD, BE, BG

Title: Stepping Motors for Valve Actuation

Author: Usry, Joe D.
E-System, Incorporated

Date: March 1977

Source: Instrum. Technology, Vol. 24, #3, pages 58-63

Code: 7.22 - BD

Title: Sonobuoy Launcher System

Author: Dragonuk, Leo
Department of the Navy

Date February 28, 1979

Source: NITS AD-D006 161/4ST, 15 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 8

HYDRAULICS TECHNOLOGY

Hydraulic systems and their components are discussed in this technology brief.

Potential AAAS Application

- Power source for S&RE

Advantages

- Components are of rugged construction
- Excellent for high-torque, low-speed applications
- Can be used in harsh environments, such as vibration and corrosion; and in unclean environments
- Digital or analog compatible
- Eliminates the need for troublesome pyrotechnics
- Equipment available for reliable operation to 8,000 psi.

Disadvantages

- System leakage
- Slower control response than electronic
- Higher cost than electronic
- Certain hydraulic fluids are flammable

Risk

Operation at higher pressures has become feasible through continual advances in technology since the 1940s. Further, hydraulic power sources have been successfully demonstrated for advanced armament systems. The risk of applying new-technology hydraulics to the AAAS Program is thus considered low-to-medium.

Trends and State of the Art

Hydraulic power sources have been developed for use as stores ejector systems. A recent development for advanced aircraft armament systems employs a hydraulic pump connected to an accumulator and a control valve downstream from the accumulator. The valve and accumulator outputs connect to two cylinders (ejector pistons). The pump pressurizes the accumulator and fills it with fluid for activating the cylinders that push away the stores.

Other hydraulic launching systems employ a hot gas from a pyrotechnic source, or cold pressurized gas to activate hydraulic ejectors (see Figure 8-1). These types of hydraulic system otherwise have a similar principle.

Electrical control units have been developed for controlling the switching, sensing, safety interlock, BIT, and other functions of hydraulic systems (see

Figure 8-2). Other technology trends in hydraulic systems include the following:

– Filtration Techniques. Improved filtration is accompanying the move toward higher pressures. Actuators and control elements designed for high-pressure operation have smaller clearances between moving parts than the more traditional elements. Thus the hydraulic fluid designed to pass through the gaps between parts must be more carefully filtered. Major trends in this area include the growing acceptance of matching filtration methods to critical system components through a filtration-compatibility rating for those components. Within a few years, users should be able to choose filters and establish maintenance schedules by referring to a compatibility schedule for each type of component in the system, especially hydraulic motors and pumps.

Improvements are being made in hydraulic fluids and lubricating materials that provide safety against fire and cause less corrosion problems from spills or leakage. These fluids consist of oil-water emulsion and water-glycol solutions, and chemical compositions developed under DoD guidance such as the synthetic hydrocarbons, silicate esters, and fluorocarbons.

– Components. The trend toward hydraulic flight control systems has encouraged new developments in components that can operate at pressures up to 8,000 psi. These components include:

- Hydraulic pumps of piston, axial, and vane designs that deliver higher pressures than previously available. Piston pumps used in aircraft hydraulic systems are typically bent-axis types, built with jewel-like precision to deliver extremely high flows at rotating speeds up to 25,000 rpm.

  One type of axial piston pump used for aircraft hydraulic operations has a rating of 7,800 rpm at 8,000 psi. This pump uses a 5-micron fluid filter and provides constant pressure and variable delivery. A design feature that contributes to this high performance level is the isolation of rolling-element bearings from the pumped fluid, thereby eliminating failures due to anti-friction bearings. Improved packaging of axial-piston pumps has also led to improved flow-to-weight and power-to-weight ratios.

  A key design in pumps is the use of pressure-balanced, flexible side-plates that accommodate momentary peak loads and thermal expansion on startup. The plates are hydrostatically balanced by pressurized fluid to maintain optimum rotor clearance under changing pressure conditions (see Figure 8-3).

  An advanced type of hydraulic high-force motor employs rare-earth samarium-cobalt magnets to drive control valves that actuate aircraft hydraulics. This type of motor, with multiple coils, provides for direct interface with electronic driving circuitry and eliminates the redundant secondary servoactuators. The magnetic properties of samarium-cobalt materials provide for a significantly higher energy product than other magnet materials can produce (see Figure 8-4).

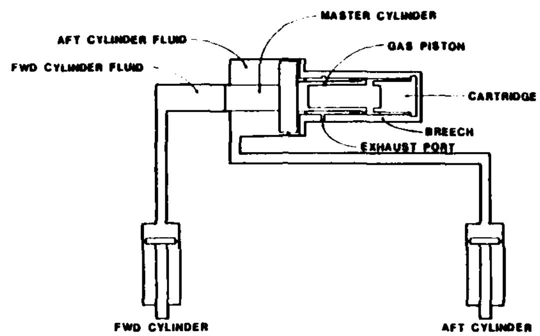
- Pump controls that match pump output more closely to load demand and reduce the power lost to heat by as much as 60 percent.

- Valves adaptable to computer control via digital-to-analog converters. Valves that can function without converters are under development.
- An electrohydraulic proportioned control valve that can control direction, velocity, acceleration, and deceleration of a linear or rotary hydraulic actuator with low-power electrical signals. Primary constituents of this valve are a flow sensor, main stage, and pilot module.
- Cylinders with better cushions, seals, and bearing arrangements for longer life.
- Threaded flare fittings, O-ring fittings, and brazed fittings specially designed for operation at high pressures. These fittings are crimped, swaged, or screwed together.
- Hydraulic hoses and tubing reinforced with materials such as wirebraid or synthetic fiber for use at high pressures.
- Quick-disconnect couplings of various designs (single poppet, double poppet, sliding seal, staples, or double rotating balls) for use with hydraulic tubing. These couplings, usually in two halves, contain leak-proof shutoff valves that close automatically when the coupling is separated.

Further information on hydraulic components is presented in the technology brief on Controls (Code 3).

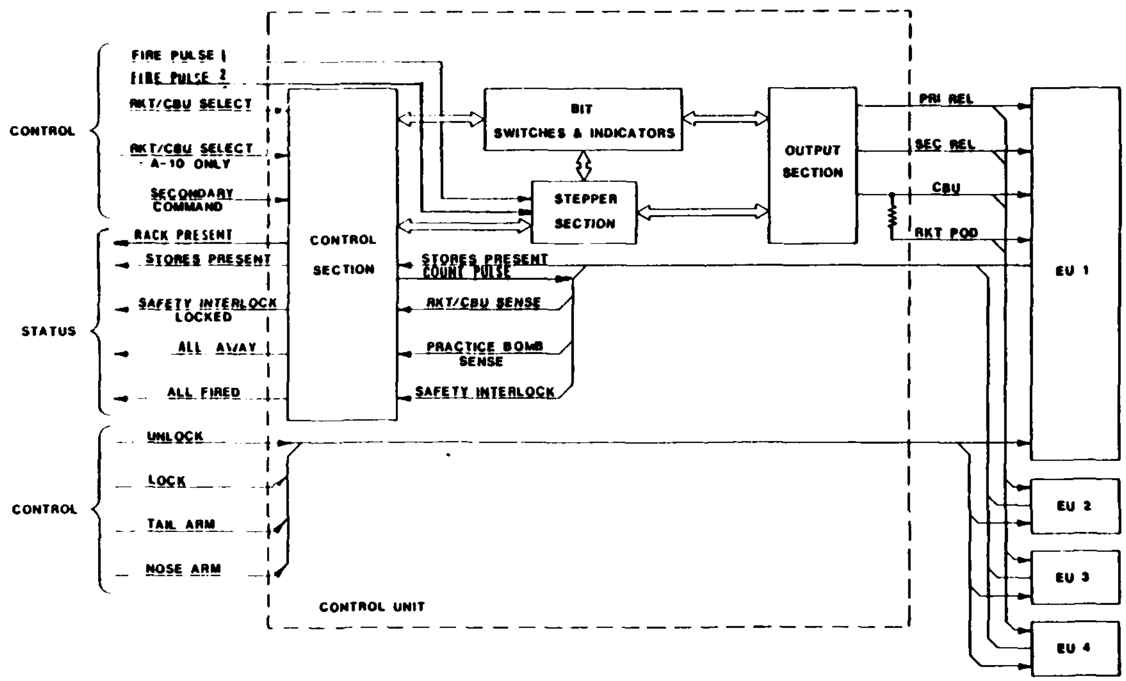
Cost Directions

Technology advances in hydraulic components, resulting in part from increases in operating pressure, have increased the cost of components capable of operating in the 4,000 to 8,000 psi range. However, the cost increases should be traded off against the component weight reductions realized through the use of reduced fluid volume, smaller lines and fittings, and physically smaller components. Also, savings would accrue from elimination of high costs of maintenance for cleaning and repair of pyrotechnic power sources. Because of these benefits, lower life-cycle costs could result for advanced armament systems employing full hydraulic systems.



– Courtesy Western Gear Corp.

Figure 8-1. HYDRAULIC POWER SOURCE



NOTE:
CBU = Cluster Bomb Unit
EU = Ejector Unit
PRI = Primary
RKT = Rocket
SEC = Secondary
REL = Release

– Courtesy Western Gear Corp.

Figure 8-2. CONTROL UNIT

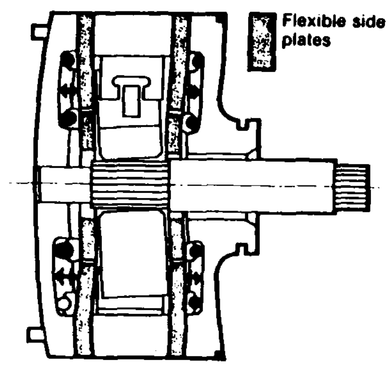


Figure 8-3. SAMARIUM COBALT DEMAGNETIZATION CURVE COMPARED WITH ALNICO V AND FERRITE

– *Courtesy Astronautics and Aeronautics Magazine* (© 1980, AIAA)

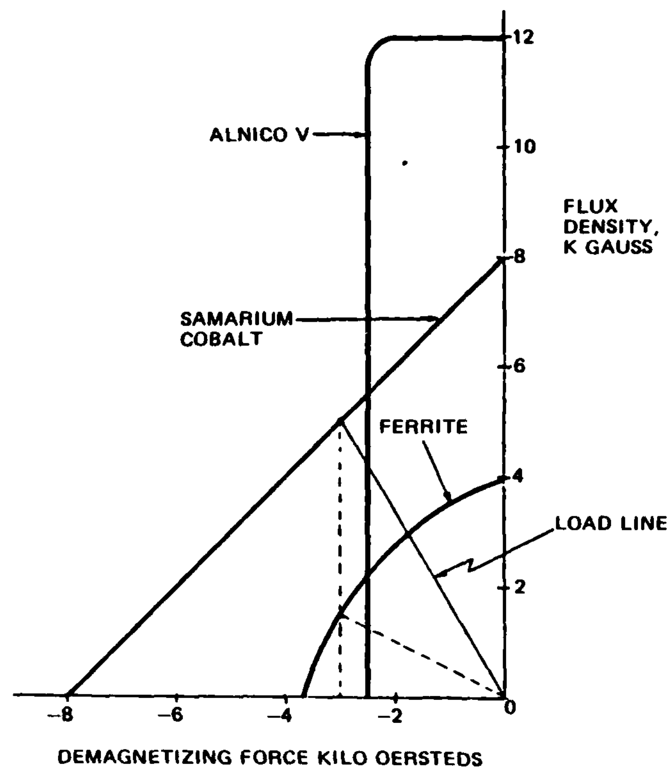


Figure 8-4. HIGH PRESSURE VANE PUMP SHOWING FLEXIBLE SIDE PLATES

– *Courtesy Machine Design Magazine* (© 1979, Penton/IPC, Inc.)

Code: 8.1 – BB, BC, BD, BE, BG

Title: Flight Verification of Direct Digital Drive for an Advanced Flight Control Actuation System in the T-2C Aircraft

Author: Kohnhorst, L.K.; Magnacca, D.A.
Rockwell International, Columbus, OH

Date: November 1979

Source: NTIS AD-A081 925/0; PC A07/MF A01
Rockwell Report for NADC

Code: 8.2 – BB, BC, BD, BE, BG

Title: Development of a High Temperature Reliance Base Fire Resistant Hydraulic Fluid

Author: Conte, A.A., Jr.; Hammond, J.L.

Date: February 1980

Source: NTIS AD A081 597/7; PC A04/MF A01

Code: 8.3 – BB, BC, BD, BE, BG

Title: Apparatus for Adjusting and Locking a Linear Actuator

Author: Wess, T.B.
Dept. of Air Force, Washington, D.C.

Date: December 1979

Source: Patent 4 177 681; Author: Wess, Thomas B.
AD-D006 796/7

Code: 8.4 – BC

Title: A Hydraulic Actuator Mechanism to Control Aircraft Spoiler Movements Through Dual Input Commands

Author: Irick, S.C.
NASA, Langley, Hampton, VA

Date: August 1979

Source: NTIS NASA N80-11065/3; PC A02/MF A01

HYDRAULICS

Code: 8.5 – BB, BC, BD, BE, BF, BG

Title: Hydraulic Diagnostic Monitoring System

Author: Duzich, John J.
Grumman, Bethpage, NY

Date: May 1979

Source: NTIS AD-A077 552/8; PC A11/MF A01
For NADC

Code: 8.6 – BB, BC, BD, BE, BG

Title: Fluidics - Feasibility Study Electro/Hydraulic/Fluidic Direct Servo Value

Author: Biafore, L.P.; Holland, B.
Rockwell International, Columbus, OH

Date: March 1979

Source: NTIS AD-A069 798/75T; PC A04/MF A01
Report for NADC

Code: 8.7 – BB, BC, BD, BE, BG

Title: Lightweight Hydraulic System Development

Author: Demarchi, J.M.; Ohlson, J.
Rockwell International, Columbus, OH

Date: August 1979

Source: Proceedings International, Society of Energy Conversion Engineering Conference 14th, Vol. 2, Aug 5-10, 1979

Code: 8.8 – BB, BC, BD, BE, BG

Title: Utilization of Synthetic-Based Hydraulic Fluids in Aerospace Application

Author: Snyder, Carl E.
AFML, Wright-Patterson AFB, OH

Date: March 1980

Source: Lubrication Engineering, Vol. 36, No. 3, March 1, 1980, pages 160-167

Code: 8.9 – BB, BC, BD, BE, BG

Title: Hydrofluidic Servovalve Development

Author: Kent, H.C.
Honeywell, Inc.

Date: June 1975

Source: NTIS AD-A012-235; 59 pages

Code: 8.10 – BB, BC, BD, BE, BG

Title: Modern Hydraulic Systems

Author: Beercheck, R.C.

Date: January 1980

Source: Machine Design, Vol. 52, No. 2, pages 81-85

Code: 8.11 – BB, BC, BD, BE BG

Title: Solid Rocket Booster Dewatering Set

Author: Fishel, Kenneth R.
NOSC, San Diego, CA

Date: September 19 [illegible]

Source: IEEE 79 CH 14[illegible] [illegible]EC

Code: 8.12 – BB, BC, [illegible] BG

Title: MSER Power Sc[illegible]

Author: Anon.

Date: 12 November 1980

Source: Western Gear Corporation, Jamestown, North Dakota
Company research and development activity

HYDRAULICS

Code: 8.13 – BE

Title: Ejector Release Units with Centralized Chocking Control and Twin Triple Store Carriers

Author: Anon

Date: November 1980

Source: Alkan, 34 pages

Code: 8.14 – BB

Title: Data and Information on the Hook Lifting Ejector Model 1216

Author: Anon

Date

Source: R. Alkan & Company, 48 pages

Code: 8.15 – BB, BE, BG

Title: Alkan Crutchless Release and Ejector Release Mechanisms for Saddle Suspension System

Author: Anon

Date July 1976

Source: Alkan Equipments Aeronautiques, 38 pages

Code: 8.16 – BB, BC, BD, BE, BG

Title: Power Source S&RE Design

Author:

Date

Source: Alkan, 3 pages

Code: 8.17 – BC, BG

Title: Boost Assisted Missile Launcher

Author: Holt, Lloyd J.; Panlaqui, Clayton
Office of Naval Research

Date: December 1979

Source: Navy Case #62877, 2 pages

Code: 8.18 – BB, BC, BD, BE, BG

Title: A Special Report on Developments in Electrical/Electronic, Hydraulic and Mechanical Technology to Help Keep Your Products and Manufacturing Processes Advancing in the 80's

Author: Anon
A Penton/IPC Publication

Date January 15, 1980

Source: Machine Design, 54 pages

Code: 8.19 – BB, BC, BE, BF

Title: Connectors That Need no Insertion Force

Author: Taylor, James D.
AMP, Inc.

Date January 24, 1980

Source: Machine Design, Volume 52 #2, 4 pages

Code: 8.20 – BB, BC, BD, BE, BG

Title: Cartridge Check Valves: New Option for Hydraulic Control

Author: Downs, David C.
Sperry Vickers

Date December 11, 1980

Source: Machine Design, 5 pages

Code: 8.21 – BB, BC, BD, BE, BG

Title: Electromagnetic Force Motor Design Using Rare Earth-Cobalt Permanent Magnets

Author: Mars, M.F.; Lewis, T.D.
General Electric Company

Date: May 17-19, 1977

Source: IEE, NAECON '77 1119-26

Code: 8.22 – BB, BC, BD, BE, BG

Title: Curbing the Energy Appetite of Hydraulic Systems (Design and Operations of New Components)

Author: Beercheck, R.C.

Date June 26, 1980

Source: Machine Design, Vol. 52, #15, pages 95-99

Code: 8.23 – BB, BC, BD, BE, BG

Title: Hydraulic Technology Stacks Up Gains in Power and Precision

Author: Dann, R.T.

Date January 11, 1979

Source: Machine Design, Vol. 51, #1, pages 84-89

Code: 8.24 – BB, BC, BD, BE, BF

Title: The Use of Power Adaptive and Power Reversible Flight Control Actuation Systems to Achieve Hydraulic Power and System Weight Savings

Author: Robinson, C.W.
Boeing Company

Date October 13-16, 1980

Source: Society of Automotive Engineers, Paper #801190

Code:	8.25 – BB, BC, BD, BE, BG
Title:	Tomorrow's Full Fluid Steering Using Today's Systems
Author:	Larson, B.; Yip, J.; Johnson, O. IIT – Fluid Power Society – National Fluid Power Association
Date:	October 26-28, 1976
Source:	IIT

Code:	8.26 – BB, BC, BD, BE, BG
Title:	En rgy Costs Forcing Fluid Power Trends
Author:	Henke, R. Russ Henke Association
Date	August 1978
Source:	Control Eng., Vol. 25, #8, pages 37-38

Code:	8.27 – BB, BC, BD, BE, BG
Title:	Cartridge Valves – Hydraulic Control Systems of the Future
Author:	Macklin, D. Sterliing Hydraulics, Ltd. (England)
Date	January 1979
Source:	Hydraul. Pneum. Mech. Power 5-7

Code:

Title:

Author:

Date

Source:

Codes 10 and 11

MATERIALS AND MANUFACTURING TECHNOLOGIES

This technology brief describes materials, such as composites and alloys, and manufacturing technologies of particular interest to the AAAS Program.

Potential AAAS Applications

- Conformal carriages
- Aircraft hardpoints
- Modular unit suspension equipment (MUSE)
- Multiple stores adapters

Advantages

- Composite materials are of lower mass density than pure metals or alloys, and their use where possible in aircraft structures could lead to substantial weight reductions, with attendant fuel savings and aerodynamic benefits (see Figure 10-1).
- Reduced levels of stress, fatigue, and chemical corrosion are evidenced when composites and new alloys are used. Further, the composites and new alloys exhibit higher strength and modulus (Figure 10-2), lower density, and improved fracture and fatigue resistance.
- A reduced radar cross-section is associated with the lower density of the composites and new alloys.
- Advanced manufacturing processes such as laser welding and superplastic forming/diffusion bonding DSPF/DB can be utilized to yield less wasted material, decreased use of energy, and reduced labor requirements.

Disadvantages

- Composite structures are subject to absorption of moisture and consequent reduction in compression strength. For several military aircraft applications, however, this condition has not been considered a problem.
- The initial investment in manufacturing technology is expensive, and can result in higher costs than anticipated for prototypes. However, projections indicate that the cost of composite structures will decrease as manufacturing experience grows.
- Some problems persist, such as nonrepeatability of bonding due to improper cure, and are being addressed by industry and DoD. Methods for nondestructive testing of composites need to be refined.
- Potential problems related to lightning effects, flammability, and safety are yet to be resolved for composites.

Risk

The risk in using the state-of-the-art composite and alloy materials for advanced armament structures is considered medium by virtue of demonstrated success in F-14, F-16, F-18, and SR-71 applications. Two successful NATO applications of composites are reported for S&RE.

Trends and State of the Art

— Composites. The trend is toward greater use of composites in military aircraft structures. The major composites used are a matrix-like resin such as epoxy or a polyimide reinforced with carbon (graphite), boron, and/or Kevlar fibers. Polyimide structures promise better repeatability in manufacturing than epoxies. Kevlar composites, while not quite strong enough for primary structures, are receiving significant attention as a substitute for glass fibers in the fabrication of secondary structures.

New composites are being developed that contain alumina or silica instead of, or in combination with, graphite and Kevlar.

Automated manufacturing for composites is expanding in the areas of robotics, programmed automatic cutters, programmed handling, automatic dispensing, and automated laminating. Automatic video inspection and automated clean rooms are becoming standard industry practices.

— Alloys. In the manufacturing of aircraft structural elements, the trend is toward using aluminum alloys containing lithium and magnesium. The alloys (e.g., 2224, 2324 and 7150) are of lower density and have greater stiffness and strength. Manufacturing methods such as hot isostatic pressing and isothermal rolling associated with powder metallurgy provide improved microstructures. The rapid solidification rate (RSR) aluminum alloys containing iron, molybdenum, and chromium are gaining considerable interest for aircraft structures.

New titanium alloys consisting of special combinations of metals such as chromium, aluminum, tin, iron, and vanadium have emerged as promising materials for aircraft structures. One alloy, CORONA-5, offers high strength, low density, and improved corrosion resistance. Manufacturing processes for fabricating structures of these alloys include cold rolling and forming, age hardening, and superplastic forming with diffusion bonding. (See Figure 10-3 for comparison of SPF/DF vs. conventional.) Electron-beam welded forgings of titanium alloys are becoming prevalent in aircraft applications.

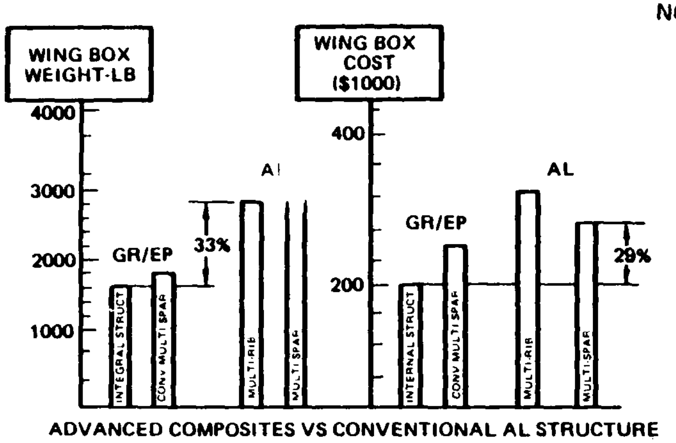
High-strength steels such as the AF1410 (containing cobalt, and nickel), used in the AFAL LOCOSST program yield weight and cost saving advantages relative to other alloys and metal (see Figure 10-4). In particular, the strength and toughness of steels containing such elements as vanadium, silicon, molybdenum, and carbon make them desirable for use as fittings, pins, and fasteners in future aircraft.

Some physical characteristics of the above alloys and composites are shown in Tables 10.1 through 10.3.

. Bonding Techniques. The success of the Air Force in the PABST program and commercial acceptance of adhesive bonding represents a significant advancement in material technology. Weld and diffusion bonding also show promise as rivetless bonding approaches.

Cost

A major cost reduction realized by DoD and industry, through the use of the materials and processes described above, results from reduced weight and the attendant decrease in fuel requirements. Other cost reductions noted in the literature relate to less waste and less human involvement in manufacturing; and ultimately, from using readily available materials such as carbon rather than dwindling resources such as titanium. Typical cost savings from using composites and new alloys can be observed in Figures 10-1 and 10-3 and Table 10-3.



NOTE:
GR = graphite
EP = epoxy

Figure 10-1. WINGBOX WEIGHT/COST COMPARISON

– Courtesy Journal of Aircraft (© 1979, AIAA)

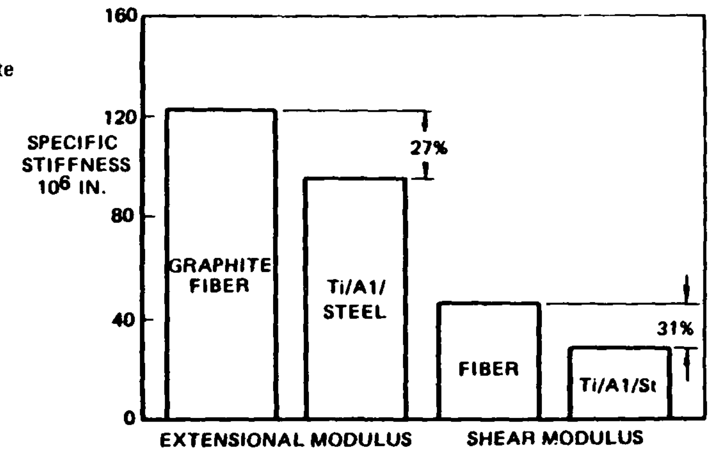


Figure 10-2. SPECIFIC STIFFNESS (0 = +45/90 GRAPHITE/EPOXY VERSUS METALS)

– Courtesy Journal of Aircraft (© 1979, AIAA)

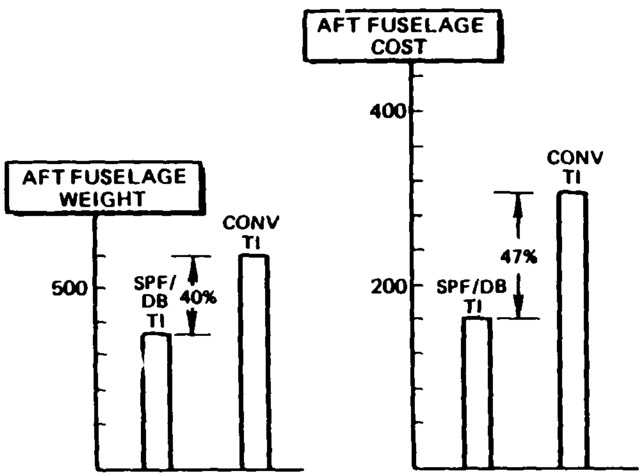


Figure 10-3. FUSELAGE STRUCTURE COMPARISON SPF/DB VERSUS CONVENTIONAL TITANIUM

– Courtesy Journal of Aircraft (© 1979, AIAA)

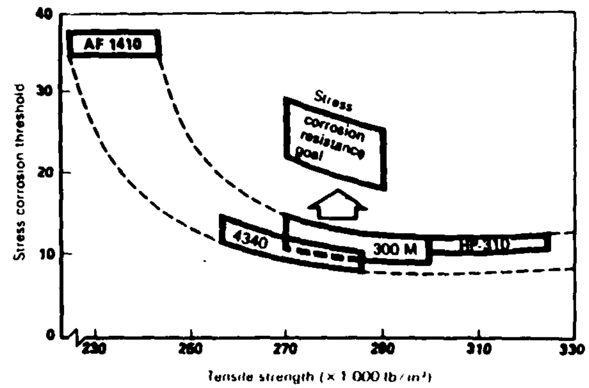


Figure 10-4. STRESS CORROSION RESISTANCE OF HIGH-STRENGTH STEEL ALLOYS

– Courtesy Interavia S.A. (© 1979)

Table 10-1. PROPERTIES OF CONVENTIONAL CAST, SINTERED-POWDER AND LITHIUM-CONTAINING ALUMINIUM ALLOYS COMPARED

Property	Cast alloy (7075-76)	Sintered powder (MA-87-T7E)	Al/Li
Ultimate tension strength	75	87 (+15%)	75
Compression yield	65	80 (+23%)	65
Compressive modulus	10.7	10.7	12 (+12%)
Fatigue cut-off	45	55 (+22%)	n/a
Stress corrosion threshold	25	25	35 (+40%)
Density	0.101	0.102 (+1%)	0.090 (−11%)

Source: Lockheed

Table 10-2. PROJECTED BENEFITS OF ADVANCED ALUMINIUM ALLOYS IN TRANSPORT AIRCRAFT

Structure	Weight savings kg	lb	%	Fuel savings Litres	US gal	$
Wing	2,863	6,310	13.3	851,600	225,000	90,000
Fuselage	2,576	5,677	11.2	764,600	202,000	80,800
Empennage	543	1,197	13.2	159,000	42,000	16,800
Shipset totals	5,982	13,184	12.2	1,775,200	469,000	187,600

Source: Lockheed

Table 10-3. BENEFITS OF LOW-COST, NO-DRAFT PRECISION FORGING IN TITANIUM 6Al-4V, WHICH ELIMINATES NEED FOR MACHINING

	Current method (machined from solid)	Conventional forging	Precision forging
Weight of metal required, kg (lb)	6.53 (14.4)	4.22 (9.3)	0.64 (1.4)
Cost of raw metal	$ 86	$ 90	$ 8
Weight of machined chips, kg (lb)	5.94 (13.1)	3.63 (8)	nil
Weight of finished part, kg (lb)	0.59 (1.3)	0.59 (1.3)	0.59 (1.3)
Total cost of part	$ 234	$ 238	$ 53

Material savings are 5.94 kg (13.1 lb) and cost savings $ 181/piece

Source Lockheed

– All tables courtesy Interavia S.A. (© 1979)

Code: 10.1 – BB, BC, BD, BE, BF, BG

Title: National SAMPE Tehnical Conference, 11th: New Horizons - Materials and Processes for the Eighties, Volume 11

Author: Anon.

Date: November 1979

Source: SAMPE (Vol. 11), Azusa, CA, 1979, 1051 pages

Code: 10.2 – BB

Title: Development and Demonstration of Manufacturing Processes for Fabricating Graphite/PMR-15 Polyimide Structures

Author: Sheppard, C.H.; Hoggatt, J.T.; Hunter, A.B.
Boeing, Seattle, WA

Date: November 1979

Source: National SAMPE Tech Conf (Vol. 11), Azusa, CA, pages 40-48

Code: 10.3 – BB

Title: Fabrication of Integrally Stiffened Graphite/Epoxy Components

Author: Suarez, J.A.; Povizromo, L.M.
Grumman Aerospace Corp., Bethpage, NY

Date: November 1979

Source: National SAMPE Tech Conf (Vol. 11), Azuza, CA, pages 49-64

Code: 10.4 – BB, BC, BD, BE, BF, BG

Title: Automated Manufacturing – The Future in Aerospace Composites

Author: Wehrenberg, Robert H., II

Date: January 1980

Source: Material Engineering (Vol. 91, No. 1), Jan 1980, pages 46-50

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Code: 10.5 – BB, BC, BD

Title: Design-to-Cost with Advanced Composites and Advanced Metallics

Author: Ascani, Leonard; Lackman, Leslie
Rockwell International, Los Angeles, CA

Date: October 1979

Source: J Aircraft (Vol. 16, No. 10), pages 714-719

Code: 10.6 – BB

Title: High Temperature – High Complexity Graphite/Polyimide Part Manufacturing

Author: Mace, W.C.; Wereta, A., Jr.; Sipes, C.L.; Edler, V.E.
Lockheed, Sunnyvale, CA

Date: May 1979

Source: National SAMPE Symposium Exhib. Proc. 24th, Vol. 24, 1979, Book 1, pages 217-231, Azusa, CA

Code: 10.7 – BB, BC, BD, BE

Title: Advances in Manufacturing Technology for Titanium Aircraft Structures

Author: Highberger, W.T.
NASC, Washington, D.C.

Date: March 1979

Source: Met. Prog, Vol. 115, No. 3, pages 56-59

Code: 10.8 – BB, BC, BD, BE

Title: Hot Isostatic Pressing – A New Heat Treating Technology with Tremendous Potential

Author: Price, Peter
Ind. Mater Technol., Inc., Woburn, Mass

Date: June 1979

Source: Industrial Heat, Vol. 46, No. 6, 1979, pages 8-10

Code: 10.9 – BB, BC, BD, BE

Title: Low Cost Advanced Titanium Airfame Structures Via Welding (Electron Beam Welding Applications)

Author: Messler, R.W., Jr.; Paez, C.A.
Grumman, Bethpage, NY

Date: March 1980

Source: Metal Progress, Vol. 117, No. 4, pages 36-40, Mar 1980

Code: 10.10 – BB, BC, BD, BE, BG

Title: A Study of the Effect of In-Service Composite Repair for the F-18 Airframe

Author: Coss, R.A.; Link, R.W.
ARINC Research Corporation

Date: February 1979

Source: ARINC Research Corporation publication 1722-01-2-1882

Code: 10.11 – BB, BC, BD, BE, BG

Title: Carbon Fibers

Author: Anon

Date: July 1979

Source: Interavia, Vol. 34

Code: 10.12 – BB, BC, BD, BE, BG

Title: Technology Options for an Advanced Tactical Fighter (F-18)

Author: Bratt, R.W.; Johnson, E.W.
Northrop, Hawthorne, CA

Date: 1979

Source: Interavia, Vol. 34

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Code: 10.13 – BB, BC, BD, BE, BG

Title: Metallic Composite Coating Yields Gains

Author: Lowndes, Jay C.

Date: November 24, 1980

Source: Aviation Week & Space Technology, 1 page

Code: 10.14 – BB, BE

Title: Manufacturing Methods Report, Static Switch

Author: Anon
FMC Corporation

Date 1976

Source: U.S. Army Missile Command, 150 pages

Code: 10.15 – BB

Title: New VFW Manufacturing Technique

Author: Anon

Date 1980

Source: Interavia 8, 1 page

Code: 10.16 – BB, BC, BD, BE, BG

Title: The Promise of High-Speed Machining

Author: Curry, David T.
Staff Writer

Date April 10, 1980

Source: Machine Design, 6 pages

MANUFACTURING

Code: 10.17 – BB, BD, BE

Title: Selecting Shaft Materials for High-Speed Pumps

Author: Schalla, Clarence A.
Lockheed Missiles & Space Co., Inc.

Date:

Source: Machine Design, 2 pages

Code:

Title:

Author:

Date:

Source:

Code:

Title:

Author:

Date:

Source:

Code:

Title:

Author:

Date:

Source:

Code:	11.1 – BB, BC, BD, BE
Title:	Flight Service Evaluation of Kevlar-49 Epoxy Composite Panels in Wide-Bodied Commercial Transport Aircraft
Author:	Stone, R.H. Lockheed, Burbank, CA
Date:	December 1979
Source:	NTIS N80-23371/1 Report prepared for NASA

Code:	11.2 – BF
Title:	Primary Adhesive Bonded Structure Technology (PABST)
Author:	Land, K.L.; Lennert, F.B. Douglas Aircraft Co., Long Beach, CA
Date:	October 1979
Source:	NTIS AD-A083 228/7 Report prepared for AFFDL

Code:	11.3 – BB, BC, BD, BE, BF, BG
Title:	Thin Anodic Oxide Films on Aluminum Alloys and Their Role in the Durability of Adhesive Bonds
Author:	McDevitt, Neil T.; Solomon, James S. AF Materials Lab, Wright-Patterson AFB, OH
Date:	February 1980
Source:	NTIS AD-A083 202/2; AFML-TR-79-4216

Code:	11.4 – BF
Title:	Design, Fabrication and Test of Graphite/Polyimide Composite Joints and Attachments for Advanced Aerospace Vehicles
Author:	Koumal, D.E. Boeing, Seattle, WA
Date:	October 1979
Source:	Boeing Aerospace Co. to NASA Rpt. No. NASA-CR-159110; QTPR-3; NTIS N80-20316/9

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Code:	11.5 – BB, BC, BD, BE
Title:	Composite Components on Commercial Aircraft
Author:	Dexter, H.B. NASA, Langley Station, VA
Date:	March 1980
Source:	AGARD Specialist Meeting on Effect of Service Environ. on Composite Matter, 13-18 April 1980; NTIS N80-18109/2

Code:	11.6 – BG
Title:	Costs of Graphite-Composite Fabrication and Repair
Author:	Bettner, Timothy J. Northrop, Hawthorne, CA
Date:	November 1979
Source:	National SAMPE Tech Conf 11th: New Horiz - Materials and Processes for the Eighties, SAMPE Azusa (Vol. 11), pages 857-869

Code:	11.7 – BF
Title:	Challenges in Aerospace Materials and Processes During the 80's
Author:	Chandler, H.E.
Date:	March 1980
Source:	Met. Prog., Vol. 117, No. 4, Mar 1980, pages 41-49

Code:	11.8 – BB, BC, BD, BE
Title:	Aircraft Shed Weight with New Alloys, Composites
Author:	Post, C.T.
Date:	July 1980
Source:	Iron Age, 14 Jul 1980, 223, (26), 39-42, 44-45

Code: 11.9 - BB, BC, BD, BE

Title: Optimizing Thermomechanical Processing of Ti-10v-2Fe-3Al Forgings

Author: Kuhlman, G.W.; Gurganus, T.B.

Date: July 1980

Source: Met. Prog, July 1980, 118, (2), pages 30-35

Code: 11.10 - BB, BC, BD, BE, BG

Title: Pioneering in Composites

Author: Gilson, Charles

Date: February 1980

Source: Interavia, Vol. 35, page 139
F/A-18 Hornet Status Report

Code: 11.11 - BB, BC, BD, BE, BG

Title: Future Trends in Aircraft Structural Materials

Author: Stauffer, W.A.; Wooley, J.H.
Lockheed Corp., Burbank, CA

Date: March 1979

Source: Interavia, Vol. 34

Code: 11.12 - BB, BC, BD, BE, BG

Title: Use of Composites for Bomb Racks

Author: Anon.

Date: 12 November 1980

Source: Western Gear, North Dakota
Company R&D activity

MATERIALS

Code: 11.13 - BB, BC, BD, BE, BG

Title: Automatic Sway Bracing for Racks

Author: Anon.
EDO Corporation, College Point, NY

Date: 12 November 1980

Source: EDO Corporation, College Point, NY
Company R&D activity.

Code: 11.14 - BB, BC, BD, BE, BG

Title: Evolution of Aerospace Materials and Technologies

Author: Sertour, G.; Hilaire, C.
Societe' Nationale Industrielle Aerospatiale, Paris

Date: June 6-8, 1979

Source: Association Aeronautique et Astronautique de France, 27 pages in French

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Code: 11.15 - BC

Title: Optimal Design Studies on Composite Wings with Static and Dynamic Constraints

Author: Venkayya, V.B.; Harris, T.; Khot, N.S.
USAF, Flight Dynamics Laboratory, Wright-Patterson AFB

Date: June 6-8, 1979

Source: Association Aeronautique et Astronautique de France, 39 pages

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Code: 11.16 - BB, BC, BD, BE, BG

Title: A Long European Experience - The Adhesive Bonding of Metals

Author: Jube, G.
Societe Nationale Industrielle Aerospatiale, Paris, France

Date: June 6-8, 1979

Source: Association Aeronautique et Astronautique de France, 19 pages in French

Code: 11.17 – BB, BC, BD, BE, BG

Title: F/A-18 Hornet – A Status Report

Author: Gibson, Charles

Date: February 1980

Source: Interavia, 7 pages

Code: 11.18 – BF

Title: 1980 Fastening & Joining Reference Issue

Author: A Penton/IPC Publication

Date November 13, 1980

Source: Machine Design, 208 pages

Code: 11.19 – BB, BD, BE

Title: New Wings Going on C-5A Fleet

Author: Anon

Date

Source: Machine Design, 1 page

Code: 11.20 – BB, BC, BD, BE, BG

Title: Metallic Composite Coating Yields Gains

Author: Lowndes, Jay C.

Date November 24, 1980

Source: Aviation Week and Space Technology, 1 page

MATERIALS

Code: 11.21 – BB, BD, BE

Title: The Quiet Revolution in Airframe Construction

Author: Bulloch, Chris

Date: 1979

Source: Interavia 3, 8 pages

Code: 11.22 – BB, BC, BD, BE, BG

Title: Symposium on Large-Scale Composite Structures – Applications of Carbon Fibre Composites to Military Aircraft Structures

Author: Sharples, T.
British Aerospace Aircraft Group

Date July 1980

Source: Aeronautical Journal, 6 pages

Code: 11.23 – BB, BC, BD, BE, BG

Title: Processes That Produce – Massive Plastic Parts

Author: Dreger, Donald R.
Staff Editor

Date January 24, 1980

Source: Machine Design, 7 pages

Code: 11.24 – BB, BC, BD, BE, BG

Title: More Metals Go Superplastic

Author: Dreger, Donald R.
Staff Editor

Date September 25, 1980

Source: Machine Design, 4 pages

Code: 11.25 - BB, BC, BD, BE, BG

Title: Development of Fire-Resistant, Low-Smoke Generating, Thermally Stable End Items for Commercial Aircraft and Spacecraft Using a Basic Polyimide Resin

Author: Gagliani, J.; Lee, R.; Sorathia, U.A.K.; Wilconxon, A.L.
Solar Turbines International

Date: April 15, 1980

Source: NASA (SR79-R-4674-38 NAS9-15484), 176 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 13

PYROTECHNICS TECHNOLOGY

This technology brief presents information relative to the state-of-the-art technology for solid-propellant actuated cartridges and propellant materials, and their application to advanced armament systems.

Potential AAAS Application

- Power source for S&RE ejectors

Advantages

For newer applications:

- Cleaner systems, lower maintenance, longer system life
- Improved safety for projected EMR/EMP environments
- Simplified design, increased flexibility, and increased reliability
- Reduced life cycle cost

Disadvantages

- Limited operational experience
- Need for advanced development and more extensive reliability testing of concepts and prototypes.

Risk

Electrically initiated power cartridges have been used extensively for bomb rack and missile launcher ejectors and other stores dispensing applications (countermeasure rounds, sonobouys, etc.). Except for the aspect of laser initiated cartridges and advanced miniaturized inductive coupling, technologies described in this brief represent innovative concepts of low-to-medium development risk in providing advanced ejector power source capabilities.

Trends and State of the Art

Efforts are continuing in industry to develop propellants that can operate reliably at high altitudes and low temperature and produce clean products of combustion. One material, designated as IS-29 and developed by Special Devices, Inc., has a flame temperature of 1285° Kelvin and produces a high-pressure gas yield of 4.3 moles per 100 grams of propellant. The material is very stable from -65° to +165°C, with no problems of aging, decomposition, or structural changes. High humidity does not affect the propellant characteristics. IS-29 has a highly uniform burn rate at temperature and pressure extremes, and contains no corrosive gases such as HCL that would affect surrounding armament structures.

— <u>Cartridge Output Cleanliness/Self-Contained Cartridge</u>. Several approaches are being pursued to provide cleaner cartridge output toward a significant reduction in, or the elimination of, ejector cleaning. These consist of the following:

1) The development by the Navy of a new series of stores ejection cartridges, designated as CCU-43/B, CCU-44/B, and CCU-45/B. These cartridges are considerably cleaner than the Navy Mk series cartridges (Mk 2, Mk 124/125, etc.) that they replace. For the CCU-type cartridges, cleaning intervals have been extended to 50 firings in several ejectors. These cartridges have been qualified, released to service, and placed into production.

2) The development of a filter that can be inserted into the breech system, ahead of the cartridge, to significantly reduce particulate matter in the downstream ejector components. NATO armament systems currently employ such filters. A U.S. source has also been developed for such a filter.

3) Ejector-system vent designs that provide rapid external venting of cartridge exhaust at the end of stroke, purging the system of particulate matter. Such a design utilizing a cartridge in a piston-actuated hydraulic ejector system has been demonstrated to provide more than 500 firings without cleaning.

4) A completely self-contained telescoping cartridge for use in a mechanically linked/hydraulic ejector. In this design approach, the cartridge case is sealed and remains sealed after firings, telescoping during firing and transmitting a tailored force-time profile to a moving piston. Since the cartridge remains completely sealed, no gas products enter the ejector system and internal cleaning is therefore completely eliminated. The Naval Ordnance Station, Indian Head, has conducted exploratory development of this concept, demonstrating functional capability of attaining a 24 ft/sec velocity with a 500-lb store in a mechanically linked/hydraulic ejector prototype. A condensible propellant is being developed to result in low (50 psi) residual pressure upon cooldown. Exploratory development with the condensible propellant is expected to be completed by October 1981.

— <u>Electric Initiator Safety, Reliability and Cost for Increasingly Severe Electromagnetic Radiation/Electromagnetic Pulse and Electrostatic Environments</u>. Current approaches utilize a 1-amp, 1-watt no-fire cartridge (CCU-series) in conjunction with proper firing-circuit shielding/connectors (and where necessary, firing circuit filters) to prevent induced current and provide the necessary degree of EMR protection. The following additional technology areas have been/are being pursued:

1) <u>Planar Bridge Element</u> — This design provides a low-cost means of protecting the bridge circuit from extraneous electrical charges. Multi-pin configurations (versus the standard center electrode/case ground configuration) of the Mk 17 type have been developed. A test program has been conducted at the Naval Ordnance Station, Indian Head, which has demonstrated design feasibility.

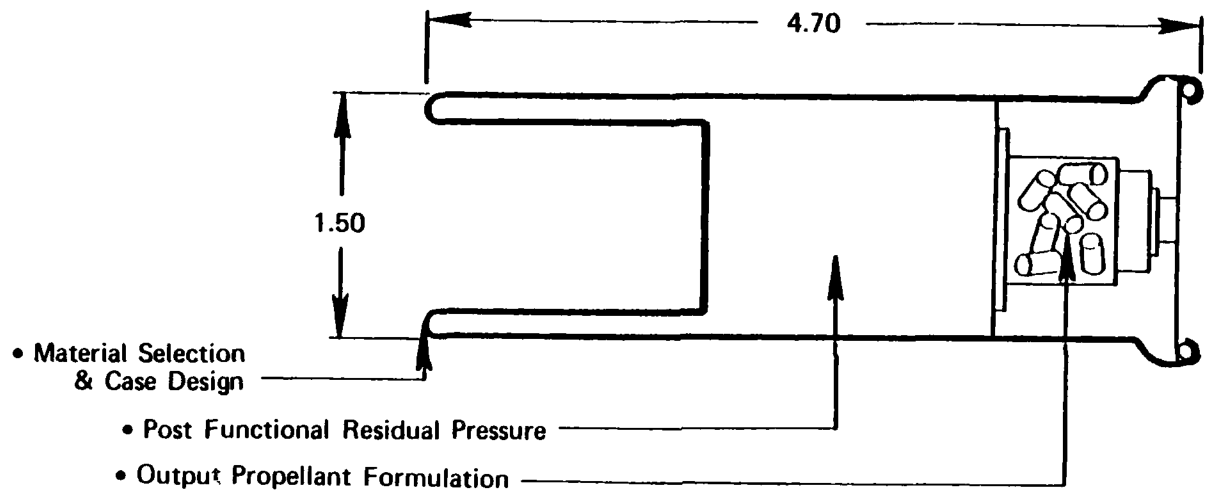
2) <u>Inductively-Coupled Initiator</u> — This design approach eliminates direct electrical contact between the firing circuit and the cartridge bridge circuit. Instead, the firing circuit contains a firing head with a driver circuit that would provide a magnetic coupling with a receiver in a completely shielded cartridge. This approach eliminates the need for

bulky, expensive filters and other firing circuit features that would be required in the more severe EMR/EMP environments. The ARBOC countermeasure rocket launcher contains an inductively-coupled firing circuit demonstrated to be suitable in the shipboard environment. To be considered for S&RE ejector applications, however, these components must be substantially reduced in size. An exploratory research and development program has been conducted by the Navy in which a miniaturized configuration suitable for use in S&RE ejectors has been developed. Initial testing has indicated suitability for initiation of low-power squib configurations. Development is continuing over the next 2 years to obtain a configuration that will meet all service environments and demonstrate protection in the EMR/EMP environments.

3) Laser/Fiber Optic Initiated Cartridge — This approach would completely eliminate any electrical/electromagnetic interface with the cartridge. Basic feasibility of initiating cartridges directly with a laser source has been demonstrated. The development of low-loss fiber optic lines has allowed initiation of pyrotechnic materials to be demonstrated over a line width of 300 feet from a compact laser course weighing about 4 pounds. Development/demonstration of this concept with hardware applicable to STS is planned over the next 2 years in the Navy exploratory research and development program.

Cost

No specific data relative to the cost of pyrotechnics was observed in the literature. However, by eliminating and/or reducing maintenance actions as a result of cleaner systems, reduced life cycle costs can be expected.



– Courtesy U.S. Navy, Naval Ordnance Station

Figure 13-1. INITIAL CASE FEASIBILITY DESIGN, SELF-CONTAINED CARTRIDGES

Code: 13.1 - BB, BC, BD, BE, BG

Title: Fuseless Explosive Propellant Cartridge

Author: True, Daniel G.; Taylor, Robert J.
Dept. of Navy, Washington, D.C.

Date: June 1980

Source: NTIS AD-D007 307/2, 11 pages

Code: 13.2 - BB, BC, BD, BE, BG

Title: Energetic Azido Compounds

Author: Frankel, M.B.; Wilson, E.R.; Woolery, D.O.; Hammermesh, C.; McArthur, C.
Rockwell International, Canoga Park, CA

Date: March 1980

Source: NTIS AD-A083, 770/8; 39 pages

Code: 13.3 - BB, BC, BD, BE, BG

Title: Improved Pyrotechnic Fuel

Author: Ward, J.R.
Dept. of Army, Washington, D.C.

Date: October 1979

Source: NTIS AD-D007 106/8, 21 pages

Code: 13.4 - BB, BC, BD, BE, BG

Title: A Power Source for Missile Launching

Author: Paul, B.E.
Scot Inc., Downers Grove, ILL

Date: 14 November 1980

Source: Scot Incorporated, Downers Grove, Ill.; Mr. B. E. Paul

PYROTECHNICS

Code: 13.5 - BB, BC, BD, BE, BG

Title: Ejectors for Bomb Racks

Author: Anon.

Date: 12 November 1980

Source: EDO Corp., College Point, NY, Company R&D activity

Code: 13.6 - BB, BC, BD, BE, BG

Title: Advances in Pyrotechnic Technology for S&RE Applications

Author: Anon.

Date 14 November 1980

Source: Naval Ordnance Station, Indian Head, MD, R&D Report

Code: 13.7 - BB, BC, BD, BE, BG

Title: Feasibility Demonstration of Propellant Dispersion Munition

Author: O'Conner, Denis L.
Armament Development and Test Center

Date September 1974

Source: NTIS AD-B922 969L, 28 pages

Code: 13.8 - BB, BC, BD, BE, BG

Title: Cartridge & Cartridge Actuated Device (CAD), Initiation and Sequencing Subsystem, Investigations for Aircrew Escape Systems (AES) (Enclosure 2)

Author: Brooks, David H.; Englander, Keith L.; Petrick, John T.; Rose, James E.; Valenta, Frank J.
Naval Ordance Station

Date March 1980

Source: 5123B:IBD 8900/4 Ser. 1164, 21 pages

AD-A107 680 ARINC RESEARCH CORP SANTA ANA CA F/G 1/3

TECHNOLOGY OVERVIEW FOR ADVANCED AIRCRAFT ARMAMENT SYSTEM PROGR--ETC(U)

MAY 81 H ROSENBERG, K BRAMAN, R BROOKS N60530-80-C-0270

UNCLASSIFIED 1789-01-1-2406 NL

2 OF 3

ADA
107680

Code: 13.9 – BB, BC, BD, BE, BG

Title: Cartridge and Cartridge Actuated Device (CAD) Exploratory Development Program Summary (Enclosure 3)

Author: Kovalenko, G.E.
Naval Air Systems Command

Date: August 1980

Source: DD-DR&E(AR)636 – 5123B:IBD 8900/4 Ser. 1164, 14 pages

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Code: 13.10 – BB, BC, BD, BE, BG

Title: Containment and Release Device for Fluids

Author: Carignan, D.J.; et al
Department of the Air Force

Date November 1979

Source: NTIS AD-D006 894, 10 pages

Code: 13.11 – BB, BC, BD, BE, BG

Title: Scot Oil Damped Ejector

Author: Anon
Scot, Incorporated

Date November 1980

Source: Scot, Incorporated, 3 pages

Code: 13.12 – BB, BC, BD, BE, BG

Title: CAD 6.2 Function – Overview – To Conduct Research and to Develop Technologies Leading to Applications For: Aircrew Escape Systems, Stores Separation Systems, Work and Safety Functions (Enclosure 3)

Author: Anon

Date

Source: 5123BIBD 8900/4 Ser. 1164, 33 pages

PYROTECHNICS

Code: 13.13 – BB, BC, BD, BE, BG

Title: Analysis and Design of a Pyrotechnic-Powered Self-Stopping Actuator

Author: Kopytoff, V.
University of California

Date:

Source: Univ. Microfilms, Ann Harbor, Order #75-15414

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Codes 14 and 16

RELIABILITY AND SAFETY TECHNOLOGIES

This technology brief considers new techniques, methods, and analytical concepts being implemented to improve reliability, maintainability, and safety. No specific information is presented relating these technologies to S&RE in terms of advantages, disadvantages, costs, or risks of application. However, this trend information can provide general guidance in the development of AAAS R&M and safety programs.

Potential AAAS Applications

Prior to the early 1970s, few military avionics acquistion programs were based on coordinated reliability elements or dedicated reliability disciplines. Reliability design elements were usually limited to classical engineering "best practices". Subsequently, the first clue to inadequate reliability design was seldom evidenced until system deployment. Dedicated reliability efforts were then often remedial in nature, consisting of selective circuit redesign with occasional empirical tests for assessing the effectiveness of design improvements. That is not to say that the reliability specialists were not active — many of the reliability disciplines recognized today originated well before 1970. However, the recommendations of these specialists were simply not widely followed.

In late 1973 and 1974, top military management initiated sweeping reforms with the intent of elevating reliability performance to critical parameter status. Nearly every existing reliability analysis and discipline that promised a positive return on reliability performance was drawn out, dusted off, and thrust upon the avionics community. Thus, DoD Directive 5000.40 of July 1980 establishes the policies, responsibilities and guidelines for R&M of DoD systems, subsystems, and equipment that apply to all military departments and defense agencies. The directive further provides DoD standard R&M terms, and mandates R&M accounting using terms related to operational effectiveness and ownership costs.

The list of reliability disciplines is long and many are overlapping and redundant. Some are limited in effectiveness for certain technologies. Others yield limited benefits for certain field applications. Many are familiar to most avionics developers as informal design procedures. Nearly all are expensive when formally documented. Not all reliability disciplines are cost effective on all avionics development programs. The following two state-of-the art disciplines may be appropriate in providing R&M requirements guidance regarding S&RE development.

— Integrated Testing. A typical development test cycle for a complex avionics system spans 2 to 3 years. It is possible to maximize reliability maturity with minimal cost and schedule impact by utilizing the test time and data for reliability development. This integrated test philosophy is being implemented in current engineering development test programs to achieve reliability growth.

— Combined Environmental Reliability Test. Combined environmental reliability test (CERT) facilities have been recently developed with improved capabilities for simulating the dynamic combined environments to which internally carried aircraft equipment is exposed in modern high-performance military aircraft. This test philosophy identifies an effective, low-cost method for the integration of operating environments and reliability assessment tests.

Safety

The long-recognized need for designing and building safety into aircraft systems is the subject of numerous government directives, most notably MIL-STD-882, Requirements for System Safety Programs for Systems and Associated Subsystems and Equipment. While the principles of system safety should be applied throughout all acquisition phases, the most important phase is undoubtedly the conceptual, when the Preliminary Hazard Analysis (PHA) should be conducted. Following are two examples of the application of PHA techniques to obtain required safety levels:

- A model was developed by the Army Armament R&D Command for evaluating the safety and reliability of electrical equipment in a lightning environment.

- The advent of LSI circuits for airborne computers has made the use of much higher levels of redundancy and replication economically possible. Economical use of replication is making fault-tolerant systems feasible, and more and more applications for safety critical systems such as active flight controls can be expected. In turn, the opportunity to use massive redundancy, fault-tolerance, and reconfigurable systems is stimulating the development of new analytical tools for establishing the safety and cost-effectiveness of the levels of replication proposed. As an example, one manufacturer has designed an advanced SMS based on a reconfigurable series/parallel duplex control system concept (Figure 14-1). That system is intended to meet the safety/reliability requirement that no single failure will cause an inadvertent stores release, and the need to achieve a high certainty of successful release of stores in time of war.

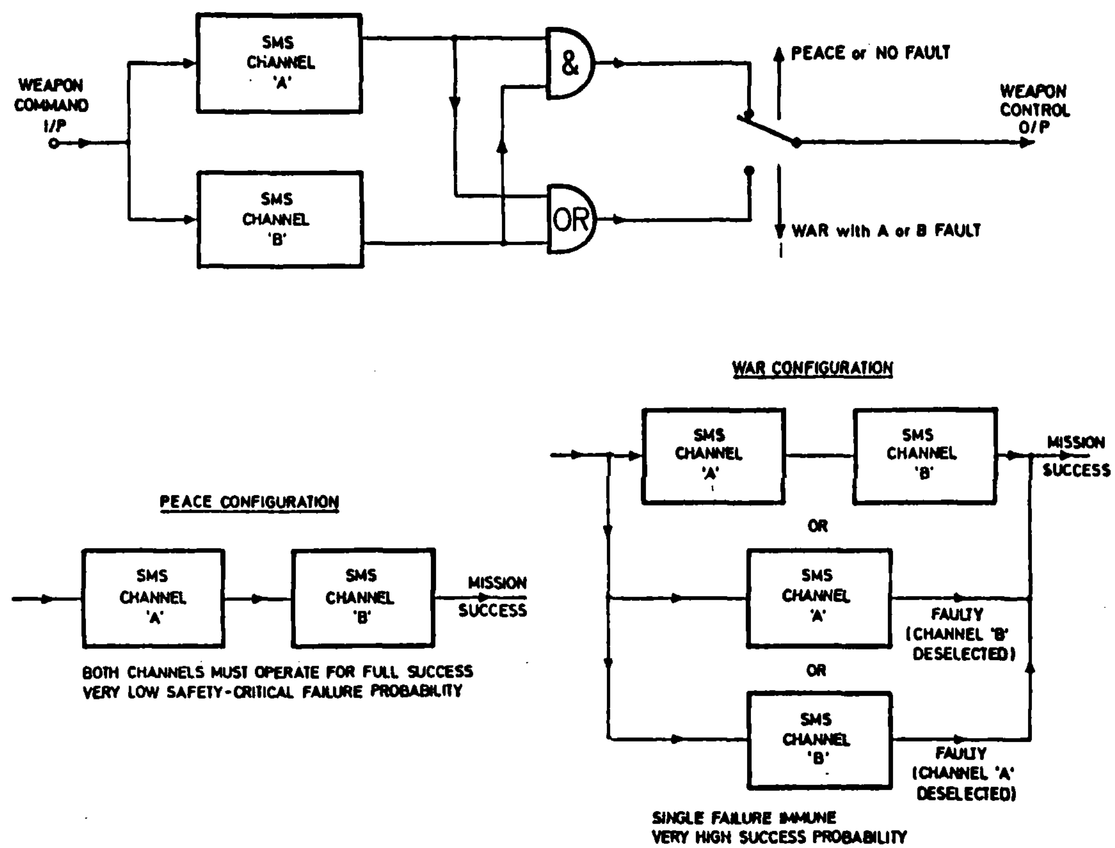

Figure 14-1. RECONFIGURABLE SERIES/PARALLEL DUPLEX CONTROL SYSTEM CONCEPT

– Courtesy Control Data Corp. (© 1980)

Code: 14.1 – BB, BC, BD, BE, BG

Title: Advanced Structures Concepts R and M Cost Assessments

Author: Cook, Thomas N.; Kay, Bruce, F.
United Technologies Corp., Stratford, CT

Date: September 1979

Source: NTIS AD-A077 373/9, 237 pages
Report prepared for Army R&T Labs.

Code: 14.2 – BB, BC, BD, BE, BG

Title: The Impact of Digital Avionics on Equipment Maintenance

Author: Reilly, W.T.
Westinghouse Electric Corp.

Date: November 6-8, 1979

Source: IEEE

Code: 14.3 – BB, BC, BD, BE

Title: New Technology Transport for Fuel Critical Economy

Author: Hudak, Paul A.; MacDonald, Kenneth, A.B.
Boeing Company

Date: 1980

Source: 1980 Proceedings Annual Reliability and Maintainability Symposium

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Code: 14.4 – BB, BC, BD, BE

Title: Nonoperating Failure Rates for Avionics Study

Author: Kern, G.A.; Quart, I.; Tung, S.S.; Wong, K.L.
Hughes Aircraft Co.

Date: April 1980

Source: NTIS AD-A087048; 150 pages

Code: 14.5 – BB, BC, BD, BE, BG

Title: A Study of Three Environmental Reliability Tests

Author: Warner, J.C.
AFFDL, WPAFB, OH

Date: January 1980

Source: 1980 Proceedings of Annual Reliability and Maintainability Symposium

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Code: 14.6 – BB, BC, BD, BE, BG

Title: Methodology for Estimating Mission Availability and Reliability for a Multimodal System

Author: Betz, H.P.

Date: May 1980

Source: NTIS AD-A087-755/5

Code: 14.7 – BB, BC, BD, BE, BG

Title: Estimating the System *Reliability Lower Confidence Limit from* Data Derived from System and Subsystem Test Results

Author: Cothran, J.L.

Date: September 1979

Source: NTIS AD-A082-510/9

Code: 14.8 – BG

Title: Contracting for Operational Availability: An Impossible Goal

Author: Residori, L.B.

Date: May 1976

Source: NTIS AD-A026-383/0ST

Code: 14.9 - BB, BC, BD, BE, BG

Title: Joint Design-to-Cost Guide. Life Cycle Cost as a Design Parameter

Author: Anon
Army Materiel Development and Readiness Command

Date: October 1977

Source: NTIS AD-A048-254/7ST

Code: 14.10 - BB, BC, BD, BE, BG

Title: Reliability/Maintainability

Author: Anon

Date: January 1981

Source: Aviation Week and Space Technology

Code: 14.11 - BB, BC, BD, BE, BG

Title: A Combined Environment Reliability Test (CERT) Facility for Testing of Airborne Equipment

Author: Reynolds, H.E.

Date: September 1978

Source: NTIS AD-A080-974/9; 32 pages

Code: 14.12 - BB, BC, BD, BE, BG

Title: Maintainability - A Design Parameter

Author: Thomas, C.R.

Date: July 1973

Source: 1973 Symposium of the Society of Electronic and Radio Technicians

RELIABILITY

Code: 14.13 - BB, BC, BD, BE, BG

Title: Development of a Combined Environment Test for Reliability Assessment of Avionics Systems

Author: Burkhard, A.H.; Earls, D.L.
AFFDL, WPAFB, OH

Date: May 1977

Source: NAECON 1977

Code: 14.14 - BB, BC, BD, BE, BG

Title: Reliability as a Dynamic System Development Tool

Author: Easterday, J.L.
Battelle, Columbus, OH

Date: May 1978

Source: Proceedings of the IEEE 1978 National Aerospace and Electronics Conference (NAECON)

Code: 14.15 - BB, BC, BD, BE, BG

Title: Reliability Program Planning and Avionics Systems

Author: Coy, R.I.
Naval Avionics Center, Indianapolis

Date: January 1980

Source: 1980 Proceedings of Annual Reliability and Maintainability Symposium

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Code: 14.16 - BB, BC, BD, BE, BG

Title: Life Cycle Testing for Avionics Development

Author: Hancock, R.N.
Vought Corp., Dallas, TX

Date: May 1977

Source: NAECON 1977

Code: 16.1 – BB, BC, BD, BE, BG

Title: Aircraft/Stores Compatibility Symposium Proceedings, Held at Arlington, Virginia on 2-4 September 1975, Volume 1

Author: Anon

Date: 1975

Source: NITS AD-A084 869/7, Report #JTCG/MD-WP-12-VOL-1, 508 pages

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Code: 16.2 – BB, BC, BD, BE, BG

Title: Aircraft/Stores Compatibility Symposium Proceedings, Held at Arlington, Virginia on 2-4 September 1975, Volume 2

Author: Anon
Joint Technical Coordinating Group for Munitions Development

Date 1975

Source: NTIS AD-A-84 870/5 Report #JTCG/MD-SP-12-VOL-2, 504 pages

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Code: 16.3 – BB, BD, BE

Title: A Fluidic Generator as an Environmental and Safety Device for the SUU-53/A Cartridge Dispenser

Author: Campagnolo, Carl J.; Duff, Harold S.; Lee, Henry C.; Blodgett, Frank E.; Scheinine, Leon
Harry Diamond Labs

Date March 1977

Source: NTIS AD-038-120/2ST, 29 pages

Code: 16.4 – BE

Title: Effects of Variations in Triple-Ejection-Rack-Fairing Geometry on Separation Characteristics of Two Stores from the F-4C Aircraft

Author: Summers, Willard E.
Arnold Engineering Development Center

Date December 1972

Source: NTIS AD-906 399/1ST, 104 pages

SAFETY

Code: 16.5 – BB, BC, BD, BE

Title: Wind-Tunnel Simulation of Store Jettison with the Aid of Magnetic Artificial Gravity

Author: Stephens, T.; Adams, R.
MIT

Date: February 1972

Source: NTIS N72-19000, 154 pages

Code: 16.6 – BB, BD, BD, BE, BG

Title: Safety and Environmental Protection. JANNAF Propulsion Meeting (1976) Specialist Session Presentations, Atlanta, GA

Author: Gaarder, Denise S.
John Hopkins University

Date February 1977

Source: NTIS AD-A041 146/2ST, 55 pages

Code: 16.7 – BB, BD, BE

Title: Fail-Safe Centrifugal Clutch

Author: O'Steen, James K.
Department of the Navy

Date July 31, 1975

Source: NTIS AD-D003 656/6ST, 7 pages

Code: 16.8 – BG

Title: Modeling the Effects of Lightning on Electronic Equipment

Author: Waxler, D.

Date November 1978

Source: NTIS AD-A064-591/1ST

Code: 16.9 - BG

Title: Safety Considerations in the Selections of Switches and Relays

Author: Huber, E.J.
Underwriters' Lab, Inc., Melville, NY

Date: April 1971

Source: American Society of Mechanical Engineers Paper #71-DR-33

Code: 16.10 - BB, BC, BD, BE, BG

Title: Safety and Environmental Protection

Author: Gaarder, D.S.
Johns Hopkins University

Date February 1977

Source: NTIS AD-A041-146/2ST

Code: 16.11 - BB, BC, BD, BE, BG

Title: Fault-Tolerant System Optimization

Author: Rose, J.
Boeing, Seattle, WA

Date January 1980

Source: 1980 Proceedings Annual Reliability and Maintainability
Symposium; 6 pages

Code:

Title:

Author:

Date

Source:

3.2 STORES MANAGEMENT SYSTEM

3.2.1 Technologies Investigated

The technologies investigated for the SMS portion of the AAAS are as listed below, each preceded by an assigned code as discussed for S&RE in Section 3.1.1.

26. Computers
27. (Not used)*
28. Controls/Displays
29. Data Bus
30. Electrical
31. Electromagnetic Environment
32. Fiber Optics
33. Languages
34. Large Scale Integration
35. (Not used)*
36. Memory
37. Packaging
38. Reliability
39. Software
40. Switching
41. Lasers

3.2.2 Technology Matrix

Table 2 is a coded matrix for SMS that relates the applicable SMS technologies investigated, WBS elements (from Figure 3), and technology information sources. The information in Table 2 is interpreted the same as discussed for S&RE in Section 3.1.2.

3.2.3 Technology Briefs

Technology briefs for SMS follow, presented in the order listed in Section 3.2.1.

*Left blank intentionally for purposes of potential expansion of technology.

Table 2
CODED TECHNOLOGY MATRIX,
STORES MANAGEMENT
EQUIPMENT

	Technology Spectra															
	Computers	(Not Used)	Controls/Displays	Data Bus	Electrical	Electromagnetic Environment	Fiber Optics	Languages	Large Scale Integration	(Not Used)	Memory	Packaging	Reliability	Software	Switching	Lasers
WBS Element	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
CB Process Control Equipment	1-22, 24-40, 42,43, 45-48		13,15, 19,28	2,3, 5-8, 11,16, 19	1,2, 6-10, 13,17	1-11, 13, 15-18	1,2, 4-9, 13-17	3,5,6	1-3, 5-8, 11, 13-26	1, 3-13, 16,17	2,4-12, 14-20	1,3-9, 11, 13-18	2,4, 5,8, 10,12, 14	1,3,9, 10,13-15,24	1,3-7, 9,11, 13	7,8
CC Control Display Equipment	1,2, 5-9, 13,22, 31,34, 35		1-29				23,25		3,10	6,8,9			6	18	3-5	
CD Stores Station Equipment	13,17, 18, 22-24, 32,33, 40-42, 44		13,16	1-8, 11,14-16,19	1-2, 5-10, 13	4,5,8-12,14, 16-18	1-6, 8-9,11, 13-26	5	1-5, 7-9, 11,12, 14-26	2,5, 7-9, 12,13, 16,17	1,3,4, 6,7, 13,18, 19	3,5, 7-9, 11, 13-18	4,5,10	20	1-6, 11,13	3-8
CE Data Transfer Equipment	13,18, 22-25, 29,40, 41		16	4-8, 10-19	6,10, 13,14	4, 8-11, 14, 16-18	1-5, 8-11, 13-24		4, 8-12, 14-26	3,5,8, 9,12, 13,16, 17		2,6, 10,12, 13,17, 18		20	7	7
CF Structural Mounts																
CG Power Conditioning Equipment				9,19, 20	1,3-5, 8-12, 15-17	12,14, 16			2,11, 14-17	10,11, 15		2,5, 7-10, 12-16		5	2-4, 6-14	1-6,8
CH SSI Configuration				1,3, 5-8		1-5, 8-11, 14-18	2,5,8, 10-12, 18,21, 24			7						7

Table 2. (continued)
CODED TECHNOLOGY MATRIX
STORES MANAGEMENT
EQUIPMENT

WBS Element	Computers 26	(Not Used) 27	Controls/Displays 28	Data Bus 29	Electrical 30	Electromagnetic Environment 31	Fiber Optics 32	Languages 33	Large Scale Integration 34	(Not Used) 35	Memory 36	Packaging 37	Reliability 38	Software 39	Switching 40	Lasers 41
CI Stores Management Software	20,21, 28,45			10,17, 18	14			1-4, 6-26	13				1-4, 7-14	1-28		
CJ Stores Management Integration (Dispersed with other specific technologies.)																

(Column heads are grouped under "Technology Spectra".)

Code 26

COMPUTERS

The application of computers to the AAAS is covered in this technology brief. Computer architectures and fault-tolerance techniques are given particular attention.

Potential AAAS Applications

- Process control equipment
- Aircraft interface equipment
- Stores station equipment

Advantages

- Use of computers in advanced armament systems allows the systems to function at a higher level of sophistication while minimizing crew workloads. This increased sophistication yields a flexibility that allows armament systems to readily accommodate numerous types of stores and variations in operational and mission scenarios; and permits possible use of standardized computer elements in different types of aircraft.
- The advent of microprocessors supports the incorporation of distributed processing and fault tolerance techniques in advanced armament systems.
- A centralized computer architecture tends to use less software and hardware than distributed architectures. Centralization facilitates the integration and management of system development, and forces a high degree of standardization of application programs and documentation.

Disadvantages

- Support of computer-oriented systems requires specialized test equipment and highly trained technicians with knowledge of both hardware and software. Software is inherently costly to document, test, and maintain.

Risk

As is true for most technologies, the risk associated with the utilization of computers increases as the state of the art is approached. Minimum risk would be incurred by using a proven minicomputer such as the AN/AYK-14. This approach, however, would not allow the exploitation of advantages inherent to the more recently developed minicomputers, microcomputers, and microprocessors. These advantages include reduced size, weight, and power consumption, with possible increases in speed and addressable memory.

Trends and State of the Art

— Minicomputers. The present Navy computer for airborne applications is the AN/AYK-14(V), XN-1 configuration. This 16-bit computer addresses up to 128,000 words of memory, operates at 675 KOPS, weighs 55 pounds, and requires 1,600 watts of input power.

Other 16-bit military airborne computers in development are targeted to operate at throughput speeds of up to 800 KOPS, to have an increased I/O capability (up to 64 channels), and to be lighter and consume less power than the AN/AYK-14(V).

Also in development, with availability projected in the mid to late 1980s, are 32-bit computers with a throughput of up to 2,000 KOPS and with approximately the same size, weight, and addressable memory capacity as the present 16-bit computers. The 32-bit machines are projected to have reduced power consumption, down to 100 watts.

— Microprocessors. The leading edge of MOS microprocessor technology is represented by such 16-bit devices as the Z8000, 68000, and 8086. The trend for the 32-bit processors is to bias the instruction sets toward implementing HOL compilers to reduce the software costs of large programs. The languages most frequently targeted are Pascal and Ada.

Single-chip microcomputer devices are established in the 8-bit controller area and are developmental for 16-bit microcomputers.

Considerable development is underway in the area of 8-bit CMOS microprocessors to take advantage of the low power, high noise immunity, and tolerance to power supply variations offered by this technology.

As an example of what can be achieved using a 16-bit MOS microprocessor to implement an airborne computer, some prototypes have a throughput of 350 KOPS, four I/O channels, weigh 6 pounds, and consume 50 watts.

Another microcomputer, the "i APX 432", is a 32-bit device implemented as a three-chip set (a two-chip main processor and one-chip interface processor). This system employs microcoded firmware and is programmed in Ada high order language.

— Computer Architecture. Microprocessors are being employed to an increasing extent to help satisfy requirements of a greater degree of subsystem-to-subsystem communication. Serial architectures of the past are being replaced with architectures that allow parallel flow through independent processors. The most likely architecture to evolve during the 1980s is a combination hierarchical-distributed system. For example, several subsystems may be interfaced independently with the operators, making the system appear distributed; while a single executive may be employed to provide common logical interfaces.

The use of distributed architectures (Figure 26-1) has given rise to the need for interelement communication. Distributed architecture will transfer data from one element to another through multiple paths via multiplex data buses to enhance system reliability.

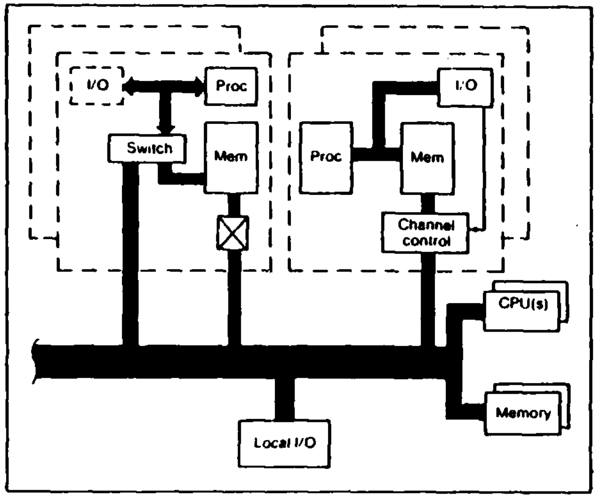
Skewed processing, a new computer architecture, incorporates distributed control functions and lends itself to implementation of fault-tolerant systems. That is, any processor that fails can be logically removed from the circuit and the remaining processors will distribute the task equally among themselves.

— Fault Tolerant Computing. Increasing attention is being given to the use of fault-tolerant computing techniques to achieve higher levels of safety and reliability in aircraft armament systems. At least two architectural concepts for fault-tolerance software are in development (see below). The fault-tolerance systems employ replication of computing tasks among processing units. Error correction and system reconfiguration are performed by the software, and thus a single failure can be tolerated and any subsequent failures can be tolerated after reconfiguration.

The two fault-tolerance systems referred to above are the Software Implemented Fault Tolerance (SIFT) and the Fault Tolerant Multiprocessor (FTMP) systems, products of flight-control research by NASA. The SIFT system utilizes a number of CPUs with associated memories and I/O processors, all interconnected by redundant buses. The software of the system allocates processors, memories, and buses to the total computational task and, in case of failure, reallocates these resources. FTMP uses triads of processors, memories, and buses, with a number of triads functioning as multiprocessors. Each triad element executes identical programs in synchronism, and a hardware monitor notes all results of the triads appearing on the buses. The triads can mask failures, detect faulty modules, and take over for failed items. Functional diagrams of these systems are shown in Figure 26-2.

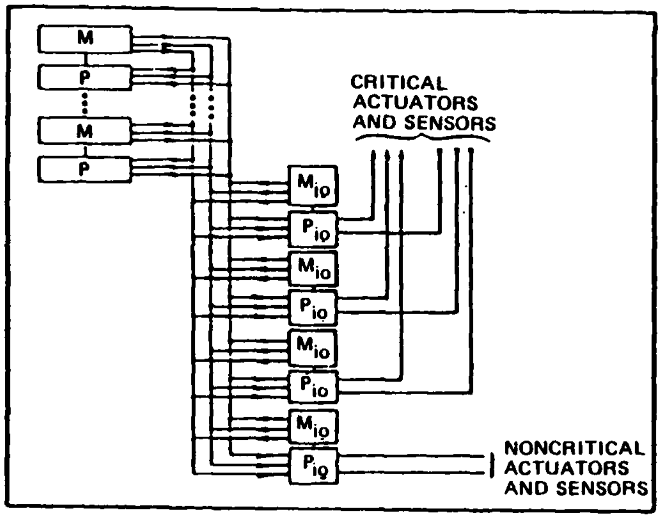
Cost Trends

The cost of developing a computer-based system is graphically depicted in Figure 26-3. As can be seen in this illustration, the cost of software represents the majority of the cost of development, with this ratio increasing with time since the trend is that software development costs are increasing at a rate of 12 percent per year while hardware costs are decreasing by 20 percent annually.

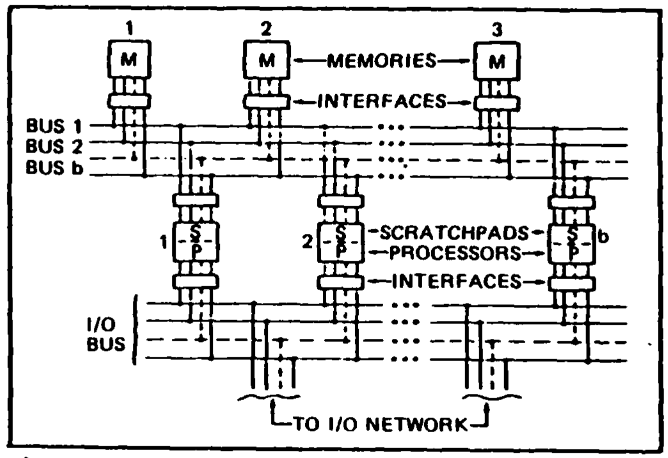


– Courtesy Electronic Design Magazine (© 1980, Hayden Publ. Co.)

Figure 26-1. DISTRIBUTED-PROCESSING SYSTEM. THE DISTRIBUTED INTELLIGENCE IS IN THE FORM OF ATTACHED COMPUTER MICROSYSTEMS.



a. SIFT



b. Fault-Tolerant Multiprocessor (FTMP)

Figure 26-2. APPROACHES TO SOFTWARE-IMPLEMENTED FAULT TOLERANCE (SIFT)

– Courtesy Astronautics and Aeronautics (© 1980, AIAA)

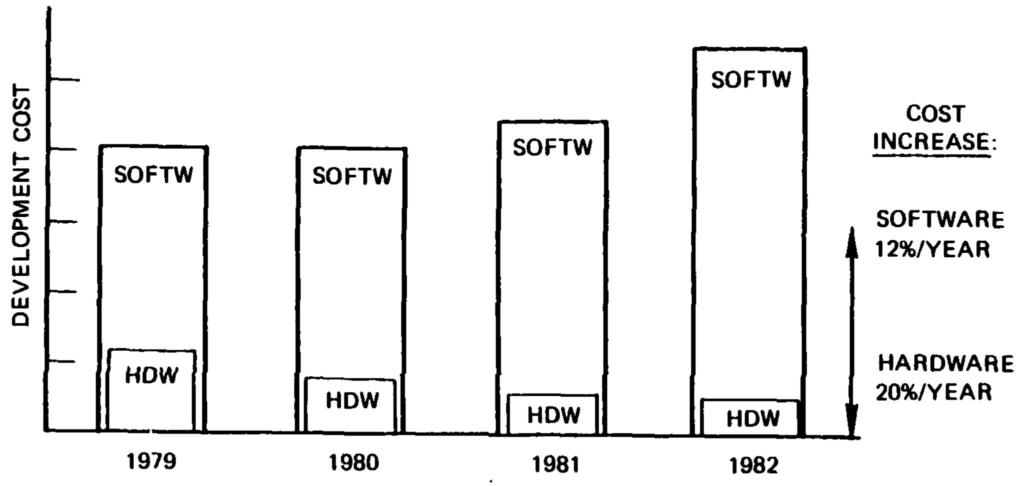


Figure 26-3. SOFTWARE VS HARDWARE DEVELOPMENT COST

– *Courtesy Digital Equipment Corp.*

Code: 26.1 – CB, CC

Title: DAIS Processor Instruction Set Extension Study

Author: Miller, L.G.
Westinghouse Electric, Baltimore, MD

Date: August 1977

Source: NTIS AD-A056-254; AFAL-TR-7-245; 160 pages

Code: 26.2 – CB, CC

Title: Controller Promises More Fight per Flight

Author: Brinton, James B.

Date: 17 July 1980

Source: Electronics, Vol. 53, No. 16, pages 46-48
U.S. Air Force

Code: 26.3 – CB

Title: LSI-Based Resource Controllers in Ties

Author: Nowicki, C.M.
NADC, Warminster, PA

Date: November 1979

Source: IEEE "Challenge of the 80's" 3rd Digital Avionics Systems Conference, pages 299-306

Code: 26.4 – CB

Title: Economic/Tradeoff Analysis: Common Hardware - Software Computer Resources for the AAH Fire Control System

Author: Brachman Associates, Havertown, PA

Date: April 1980

Source: NTIS AD-A085 084/2, 197 pages, Army Armament R&D Command

COMPUTERS

Code: 26.5 – CB

Title: Supermini Evaluation or Quantum Jump

Author: Wade, L.
Digital Equip. Corp., Maynard, MA

Date: July 1979

Source: Digital Design, Vol. 9, No. 7, pages 38, 425, July 1979

Code: 26.6 – CB, CC

Title: GPU Controller Development

Author: Posdick, R.; Chapman, T.; Gunn, R.
Tracor Inc., Austin, TX

Date: November 1979

Source: NTIS AD-A081 829/4
Tracor Report for AF AL, Wright-Patterson, OH

Code: 26.7 – CB, CC

Title: Avionics and Controls in Review

Author: Smyth, Richard K.
MILCO Int., Inc.

Date: April 1980

Source: Astronautics and Aeronautics, Vol. 18, No. 4, April 1980, pages 40-52

Code: 26.8 – CB, CC

Title: Single Chip Custom LSI Microcomputers for Avionic Applications

Author: Kantowski, J.W.
Bendix Corp.

Date: November 1979

Source: Digital Avionics Sept. Conference, 3rd, Nov. 6-8, 1979, IEEE (Cat. N79-CH1518-0), pages 32-36

Code: 26.9 – CB, CC

Title: Microprocessor System for Flight Control Research

Author: Seat, J.C.; Miller, G.E.; Stengel, R.F.
US Air Force

Date: May 1979

Source: NAECON Proceedings
National Aerospace Electronics Conference

Code: 26.10 – CB

Title: Application of LSI to Digital Systems, An Overview of Expectations and Reality

Author: Giles, D.M.; Nash, J.M.
TRW Inc., Redondo Beach, CA

Date: November 1979

Source: Digital Avionics System Conf., 3rd

Code: 26.11 – CB

Title: Stores Management Systems

Author: Anon
Computing Devices Company Limited

Date: August 1980

Source: Document #TP 908, 21 pages

Code: 26.12 – CB

Title: Integrated Fire/Flight Control Technology

Author: Various

Date: May 1980

Source: National Aerospace and Electronics Conference, Vol. 3,
pages 1001-1020

COMPUTERS

Code: 26.13 – CB, CC, CD, CE

Title: SMS 2000 and SMS 3000 Series Computer and Controller

Author: Anon

Date: 1979 and 1980

Source: Computing Devices, Control Data Corp.

Code: 26.14 – CB

Title: The USAFA/8086 - A State of the Art Microprocessor System, Volume I

Author: Pollard, Joseph J.
Air Force Academy

Date: June 1980

Source: NTIS AD-A091 722, 169 pages

Code: 26.15 – CB

Title: Electronic Digital Computers (Selected Chapters)

Author: Puchko, A.N.; Zhukov-Yemel'yanov, O.D.; Ksenofontov, I.S.
Foreign Technology Division Wright-Patterson AFB

Date: March 1980

Source: NTIS AD-B046 139L, 496 pages

Code: 26.16 – CB

Title: Minicomputers (Chapters 1-5)

Author: Brusentsov, N.P.
Foreign Technology Division, Wright-Patterson AFB

Date: May 1980

Source: NTIS AD-B048 472L, 223 pages

Code: 26.17 – CB, CD

Title: Advanced Onboard Signal Processor (AOSP), Volume I.

Author: Brookner, Eli; Groginsky, Herbert; Glass, Jerry; Barr, Paul; Works, George
Raytheon Company

Date: July 1980

Source: NTIS AD-C-022 672L, 265 pages

Code: 26.18 – CB, CD, CE

Title: Nuclear Weapon Multiplex Controlled Interface Design

Author: Anon
Hughes Aircraft Company

Date: April 1980

Source: NTIS AD-B-047 854L, 230 pages

Code: 26.19 – CB

Title: Digital Flight Control – The Generation of the 80's

Author: Lockenour, Jerry L.; Saworotnow, Ivan; Kesler, Don F.
Northrop Corporaton - Aircraft Division

Date: 1980

Source: NAECON, 9 pages

Code: 26.20 – CB, CI

Title: HOL Directed Avionics Computers – A Prediction

Author: Coffin, R.L.; Kress, C.E.; Stover, D.R.
Rockwell International

Date: 1979

Source: NAECON, 7 pages

COMPUTERS

Code: 26.21 – CB, CI

Title: The Advantages of Higher-Level Computer Architectures

Author: Myers, Glenford J.
IBM Systems Research Institute

Date: 1979

Source: NAECON, 5 pages

Code: 26.22 – CB, CC, CD, CE

Title: KC-135 Modernization Program

Author: Sweet, Charles; Morris, Gordon
Aeronautical Systems Division, Wright-Patterson AFB

Date: 1980

Source: NAECON, 6 pages

Code: 26.23 – CD, CE

Title: Categorization of Data Bus Architecture for Avionics and Flight Control Systems

Author: Crossgrove, Al; Blair, John D.
The Boeing Military Airplane Co.

Date: 1980

Source: NAECON, 6 pages

Code: 26.24 – CB, CD, CE

Title: A Distributed Command and Control System for Military Applications

Author: Anderson, Steven C.; Ruzick, Walter III
Sperry Univac

Date: 1980

Source: NAECON, 8 pages

Code: 26.25 — CB, CE

Title: Advanced Avionic Systems for Multi-Mission Applications

Author: Smith, Leroy, A.; Dewey, Donald E.
Boeing Military Airplane Co.

Date: 1980

Source: NAECON, 7 pages

Code: 26.26 — CB

Title: Top-Level Techniques for Integrated Control Design

Author: Jones, Arthur L.; Davison, John W.
Honeywell, Inc.
AF Flight Dynamics Lab, Wright-Patterson AFB

Date: 1980

Source: NAECON, 11 pages

Code: 26.27 — CB

Title: A Signal Processor for Communications Signal Analysis

Author: Nossen, S.J.; Imbesi, D.J.; Hampel, D.
RCA

Date: 1980

Source: NAECON, 4 pages

Code: 26.28 — CB, CI

Title: The Z8000 Provides the Basis for a Powerful New Airborne Computer

Author: Newby, Charles F.; Schmedake, James R.
General Dynamics Convair Division

Date: 1980

Source: NAECON, 8 pages

Code: 26.29 — CB, CE

Title: Microprocessor Based Control System

Author: Rizzo, Vincent J.; Bigley, William J.
Lockheed Electronics Company, Inc.

Date: 1980

Source: NAECON, 8 pages

Code: 26.30 — CB

Title: Dispersed Flight Control Computer Systems

Author: Newman, Thomas E.
Grumman Aerospace Corporation

Date: 1980

Source: NAECON, 6 pages

Code: 26.31 — CB, CC

Title: YC-14 Digital Flight Control Experience

Author: Martin, D.L.
The Boeing Military Airplane Co.

Date: 1980

Source: NAECON, 7 pages

Code: 26.32 — CB, CD

Title: IFFC Fire Control System Mechanization — Firefly III

Author: Meyer, D.W.; Crispino, N.
General Electric Co.

Date: 1980

Source: NAECON, 6 pages

Code: 26.33 – CB, CD

Title: Integrated Flight/Weapon Control System Concepts

Author: Murphy, William J.
McDonnell Douglas Corporation

Date: 1980

Source: NAECON, 8 pages

Code: 26.34 – CB, CC

Title: Controls and Displays Planning for Future Applications

Author: Waruszewski, Harry L.
Aeronautical Systems Division, Wright-Patterson AFB

Date: 1980

Source: NAECON, 3 pages

Code: 26.35 – CB, CG

Title: Integrated Flight and Fire Control Development and Demonstration on an Aircraft

Author: Landy, R.J.
McDonnell Aircraft Company

Date: 1980

Source: NAECON, 11 pages

Code: 26.36 – CB

Title: An Advanced Multiprocessor Architecture – Skewed Processing

Author: Berlin, Edwin P., Jr.
Grumman Aerospace Corp.

Date: 1980

Source: NAECON, 5 pages

Code: 26.37 – CB

Title: Fuze Function Control Technology

Author: Watts, Jack D.
General Dynamics

Date: 1979

Source: NAECON, 7 pages

Code: 26.38 – CB

Title: A State-of-the-Art Fault-Tolerant Computer

Author: Fernandez, Manuel
Litton Guidance and Control Systems

Date: 1979

Source: NAECON, 6 pages

Code: 26.39 – CB

Title: SIFT: Multiprocessor Architecture for Software Implemented Fault Tolerance Flight Control and Avionics Computers

Author: Forman, Phil; Moses, Kurt
Bendix Corporation

Date: 1979

Source: NAECON, 5 pages

Code: 26.40 – CB, CD, CE

Title: The U.S. Army Digital Avionics Technology Program

Author: Chandler, G.G.; Dasaro, J.A.; Youngblood, L.J.
U.S. Army Avionics Research and Development Activity

Date: 1979

Source: NAECON, 6 pages

Code: 26.41 – CD, CE

Title: Ties – An Integrated CNI System in Hardware Feasibility Demonstration

Author: Palatucci, G.; Bonanno J.; Ressler, E.; Smith L.; Nowicki, C.
Naval Air Development Center

Date: 1979

Source: NAECON, 8 pages

Code: 26.42 – CB, CD

Title: Preliminary Design of an Integrated Redundant Digital Flight Control System for the Maritime Patrol Aircraft

Author: Stern, Alan D.
Boeing Aerospace Co.

Date 1979

Source: NAECON, 16 pages

Code: 26.43 – CB

Title: Data Communications: Microcomputers are Supplanting Front-End Processors

Author: Ogdin, Carol Anne
Software Technique, Inc.

Date October 1980

Source: Mini-Micro Systems, 5 pages

Code: 26.44 – CD

Title: The Fine Points of Programmable Control

Author: Rusch, Bruce R.
Gould Incorporated

Date May 22, 1980

Source: Machine Design, pages 88-91

Code: 26.45 – CB, CI

Title: Hierarchically Structured Distributed Microprocessor Network for Control

Author: Greenwood, J.R.; Holloway, F.W.; Rupert, P.R.; Ozarski, R.G.; Suski, G.J.
Lawrence Livermore Laboratory

Date: July 6, 1979

Source: NTIS UCRL-82936, 2 pages

Code: 26.46 – CB

Title: Microcomputers – Technology is Changing the Issues

Author: Hughes, John
Digital Equipment Corporation

Date

Source: 11 pages

Code: 26.47 – CB

Title: Processor Design Options for 1990 Military Aircraft

Author: Redman, Paul; Kasser, Joseph
COMSAT Lab.

Date October 31 -November 2, 1977

Source: AIAA, Vol. 2, 7 pages

Code: 26.48 – CB

Title: The CDC 480-AN/AYK-14(V) Computer System

Author: Kenny, W.J.; May, C.D.
Control Data Corporation

Date September 6-9, 1977

Source: IEEE

Code 28

CONTROL/DISPLAY TECHNOLOGY

This technology brief on control and display systems gives emphasis to CRTs and digital controls currently employed in military aircraft.

Potential AAAS Applications

- Controls of the conventional type, such as bomb buttons; and controls for selecting modes.
- Displays such as discrete indicators and multifunction types.

Advantages

- CRT displays are still regarded as the best available means of displaying graphic and alphanumeric information. They have the highest resolution, contrast, and addressability; and the potential for full-color display (see Table 28-1).
- The F-18 multifunction CRT displays have reduced pilot scan time and stress, and have evidenced improved reliability and reduced life cycle costs relative to other display systems.
- Flat panel displays such as the electroluminescent and liquid crystal types require low operating voltages, provide direct digital compatibility, have high accuracy and edge focus capability, and are very good for small and large area focus (see Table 28-1). Flat panel displays also occupy less volume and are more shock resistant than CRT displays.
- LED displays are optimized for alphanumeric applications.

Disadvantages

For multipurpose display applications, flat panel displays are still emerging and have certain disadvantages (see Table 28-1). However, it is the opinion of experts in the field that inherent disadvantages of CRT displays (e.g., high operating voltages and susceptibility to physical damage) will result in their eventual replacement (in 10 to 20 years) with flat panel types.

Risk

The risk in using multifunction controls and graphic CRT displays is considered low due to the success and benefits observed in such applications as the Navy F-18 (see Figure 28-1) and the Air Force F-16 aircraft.

Flat panel displays are of low risk for alphanumeric applications not requiring the display of graphic information. However, flat panels are considered of medium risk for graphics applications because that technology has not matched CRT displays in terms of contrast, readability, and cost.

Trends and State of the Art

. Displays. (See Table 28-2 for projections of display implementation.)

- CRT displays are experiencing continually greater usage in aircraft armament system applications. Advanced CRT displays contain microcircuits that perform processing, I/O, and scan generation functions. In essence these displays are intelligent terminals capable of presenting both alphanumerics and graphics. One example is the multipurpose display indicator on the F-18 aircraft (Figure 28-2), a graphic terminal that displays such information as aircraft speed and weapon status. Superimposed on these displays are radar data from sensors (e.g., mapping and attack).

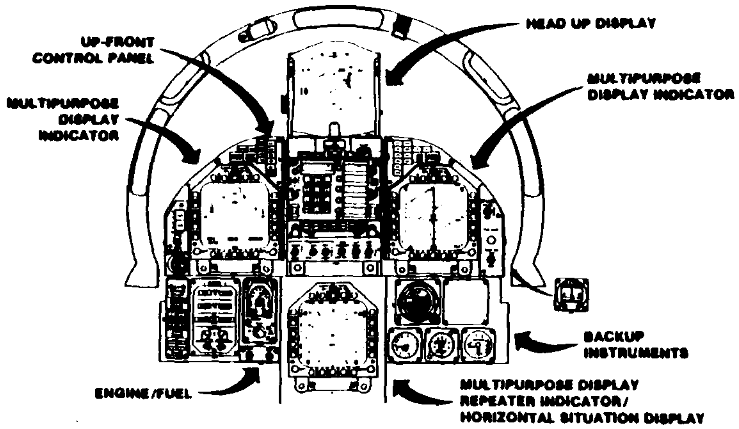
- A recent development in heads-up display (HUD) systems is one that utilizes holography to provide a wider field of view and improved brightness for symbol presentation. Relative to other HUDs, the instantaneous field of view for the new system is 35 versus 17 degrees azimuth and from 20 versus 11.5 degrees elevation. In addition, there is a reduction in the number of spurious images and reflections in the holographic system.
- Another CRT system is the horizontal situation display (HSD) in the F-18A (Figure 28-2), which combines a full color, moving map display with CRT overlays. This full color map capability is derived by optically projecting 35-mm color film through a beam-splitting mechanism in the HSD.
- Although new methodologies for improving viewing and digital conversion and generation are being pursued for CRT technology, trends are toward developing at least two flat panel technologies for eventual replacement of CRTs. These technologies — electroluminescent and varistor-addressed liquid crystal displays — are considered the most promising to date.
- One effort in the area of thin-film electroluminiscent display (TFEL) concerns incorporating integrated circuit drive and addressing circuitry. This system will consist of a video/graphic panel and exerciser having a 9 x 12 cm active area and 76,800 pixels (240 x 320 lines). The state of the art of TFELs is continually being advanced through increases in size, resolution, and contrast of the panels (see Table 28-3).
- A major activity in LCDs is being aimed at implementing a large area, multilegend, alphanumeric touch panel (integrated control panel, ICP; see Table 28-4).

. Controls. State-of-the-art controls for display systems include:

- Multifunction keyboard switches of the pushbutton type. These are found around the periphery of CRT displays and in essence are microprocessor I/O devices (see Figure 28-2).
- Solid-state membranes or contact switches that incorporate LEDs on electroluminiscent displays for multi-legend switch/display applications.
- Trim buttons and displacement switches such as those used on the throttle and stick of the F-18 aircraft for controlling CRT and aircraft functions.
- Pressure-actuated, zero-displacement switches, such as on the S-3 aircraft.
- Touch-sensitive switches such as the ICP described above.

Cost Direction

No specific data were obtainable concerning the cost of the various control and display systems described in this brief. However, information in the literature alludes to the fact that the lowest-cost display is the CRT. The primary reason is that CRT technology is well established in production, thus making it less expensive to manufacture than other, relatively new display types.



— Courtesy IEEE (© 1979)

Figure 28-1. F/A-18 HORNET COCKPIT DISPLAYS

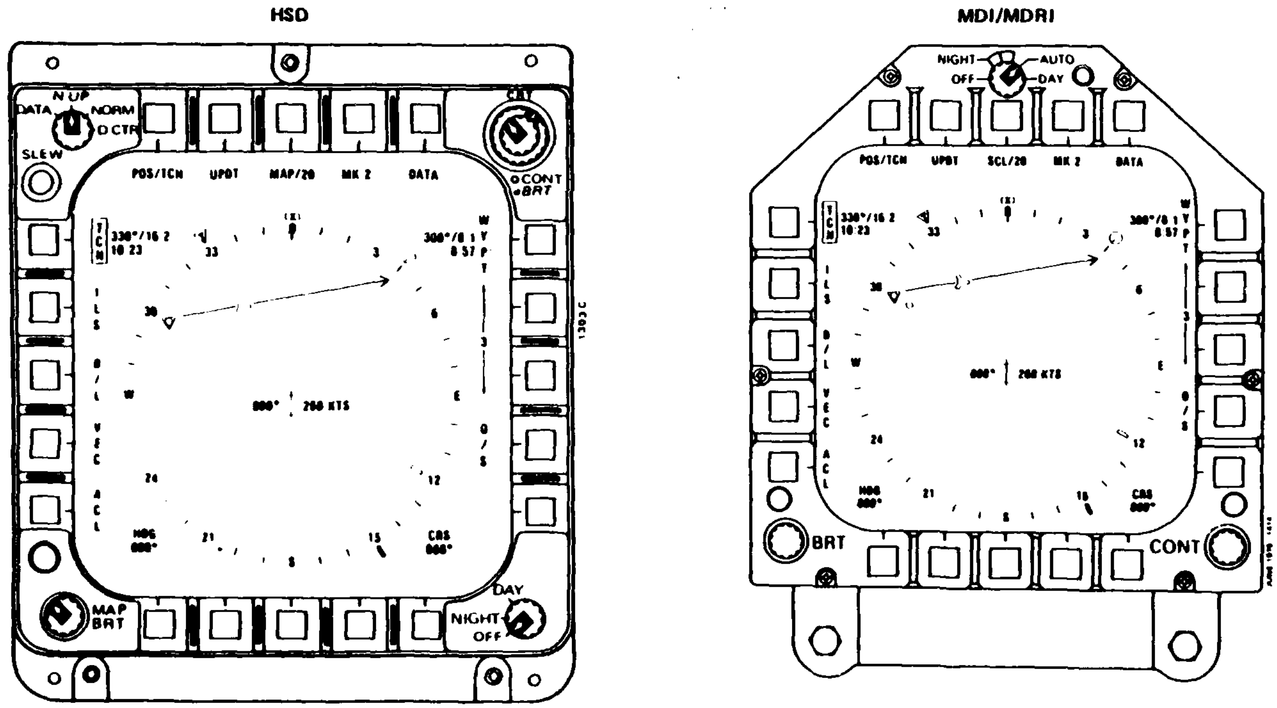


Figure 28-2. F/A-18 DISPLAY COMMONALITY AND CONTROLS

— Courtesy IEEE (© 1980)

Table 28-1. A COMPARISON OF ADVANCED ELECTRONIC DISPLAY MEDIA

CHARACTERISTIC	CRT	ELECTRO-LUMINESCENT	LED	LIQ. CRYSTAL/ TRANSISTOR	LIQ. CRYSTAL/ VARISTOR
1. SIZE (PIX DIAG.)	5-10"	6"	5"	1.4"	5"
2. DEPTH	10-12" MIN.	1.5"	4"	1"	1.5"
3. RESOLUTION	100 LINES/IN.	68 LINES/IN.	64 LINES/IN.	100-200 LINES/IN.	36 LINES/IN.
4. CONTRAST	10:1	2.5:1	5:1	30:1	10:1
5. HIGHEST VOLTAGE	25 KV	200 V	70 V	35 V	75 V
6. TEMP. RANGE	-20^{0} TO $+70^{0}$C	0^{0} TO $+45^{0}$C	-20 TO $+70^{0}$C	-15^{0} TO $+40^{0}$C	-20 TO 85^{0}C
7. HAZARDS	HIGH V, IMPLOSION X-RADIATION	NONE	NONE	NONE	NONE
8. RUGGEDIZATION REQ.	YES	NO	NO	NO	NO
9. VIEWING ANGLE	$\pm 80^{0}$	$\pm 80^{0}$	$\pm 80^{0}$	$\pm 15^{0}$	$\pm 70^{0}$
10. POWER (DISPLAY + DRIVERS)	5 WATTS/IN^2	0.8 WATTS/IN^2	4 WATTS/IN^2	0.1 WATTS/IN^2	0.1 WATTS/IN^2
11. ADDRESSING	ELECTRON BEAM (3 CONNECTIONS)	X-Y MATRIX (N+M CONNECTIONS)	X-Y MATRIX (N+M CONNECTIONS)	X-Y MATRIX (N+M CONNECTIONS)	X-Y MATRIX (N+M CONNECTIONS)
12. ELEMENT SWITCHING	ELECTRON BEAM	THRESHOLD OF EL MATERIAL	LED THRESHOLD	TRANSISTOR SWITCHING	VARISTOR SWITCHING
13. MTFB	3,000-15,000 HRS.	10,000 HRS. TO HALF BRIGHTNESS	12,000 HRS.	10,000 + HRS.	10,000 + HRS.
14. GREY SCALE	16 SHADES	16 SHADES	16 SHADES	16 SHADES	2 SHADES
15. COLOR	FULL-SPECTRUM	YELLOW-ORANGE	RED, GREEN, YELLOW	COLOR POTENTIAL	COLOR POTENTIAL

*NOTE: N = NUMBER OF ROW ELEMENTS M = NUMBER OF COLUMN ELEMENTS

– *Courtesy IEEE* (© 1979)

Table 28-2. PROJECTED IMPLEMENTATION SCHEDULE OF ADVANCED TECHNOLOGY

Technology	R&D Complete	Initial Operation	In General Use
Color CRT	1980	1983	1985
Flat Panel Display (Monochromatic)	1985	1988	1990
Flat Panel Display (Color)	1992	1995	1998
Multifunction Switches	1980	1983	1985
Multifunction Panels	1982	1987	1990
Integrated Controls and Displays	1985	1987	1989
Speech Synthesis	1982	1984	1986
Speech Recognition	1985	1990	1995

– Courtesy IEEE (© 1980)

Table 28-3. RESEARCH OBJECTIVES OF THE ARMY/ NASA TACTICAL VIDEO DISPLAY PROGRAM

PANEL RESOLUTION	512 x 640 Pixels
DRIVE & SCANNING CIRCUITRY -	INTEGRATED ON PANEL
SHADES OF GREY -	16
LEGIBILITY CONDITIONS -	Direct Sunlight
LUMINANCE UNIFORMITY -	20%
DIMMABILITY -	10^{-3} Foot Lamberts
POWER CONSUMPTION -	15 Watts
LIFETIME -	> 10,000 Hours
PANEL SIZE -	19.2 x 24.0 CM
DISPLAY GENERATION -	TV Compatible Exerciser

– Courtesy IEEE (© 1979)

Table 28-4. EXPECTED PERFORMANCE OF AIDS INTEGRATED CONTROL PANEL (ICP) FEASIBILITY MODEL

- READIBILITY - Sunlight (10,000 Ft. Candles)
- VIEWING ANGLE - >45°
- CONTRAST - >4:1
- RESPONSE TIME - 100 Milliseconds
- RESOLUTION - 14.2 Dots/Cm. (36 Dots/In.)
- BRIGHTNESS UNIFORMITY
- FLICKER-FREE

– Courtesy IEEE (© 1979)

Code: 28.1 – CC

Title: Application of Color Coding in Tactical Display S-3A

Author: Neil, Douglas E.
Naval Post Graduate School, Monterey, CA

Date: April 1980

Source: NTIS AD A086 517/0

Code: 28.2 – CC

Title: Electroluminescent Display Technology

Author: Miller, M.R.; Schlam, E.
Army ERDC, Fort Monmouth, NJ

Date: April 1980

Source: NTIS AD-A085 641/9

Code: 28.3 – CC

Title: Multicolor Electrochromic DOT-Matrix Display Investigation

Author: Nicholson, M.M.; Pizzarello, F.A.; La Chapelle, T.J.
Rockwell International, Anaheim, CA

Date: June 1980

Source: NTIS AD A083 453/9, Rockwell Inst.

Code: 28.4 – CC

Title: The Advantage of the Color-Code Modularity Versus Alphanumeric and Symbol-Code

Author: Hoops, Henning
Naval Postgrad School, Monterey, CA

Date: March 1980

Source: NTIS AD-A084 383/9

CONTROLS/DISPLAYS

Code: 28.5 – CC

Title: Development of an Electrophonetic-Image Display

Author: Liebert, Richard; Lalak, Joseph
Philips Labs, Briarcliff Manor, NY

Date: January 1980

Source: NTIS AD-A083 490/3

Code: 28.6 – CC

Title: Analog Frame Store Memory

Author:
Fairchild Imaging System, Syosset, NY

Date: January 1980

Source: NTIS AD A081 979/7

Code: 28.7 – CC

Title: Digital Screening and Halftone Techniques for Raster Processing

Author: Rosenthal, R.L.
AETL, Fort Belvoir, VA

Date: January 1980

Source: NTIS AD A081 090/3

Code: 28.8 – CC

Title: Development of a Color Alphanumeric Liquid Crystal Display

Author: Gunther, J.E.
Hughes Aircraft Co., Los Angeles, CA

Date: December 1979

Source: NTIS AD A079 289/5
Report prepared for NADC

Code: 28.9 – CC

Title: Legibility of Military Symbols on a Cathode Ray Tube Display

Author: McCann, Carol
Environmental Medicine, Downsview, Ontario, Canada

Date: September 1979

Source: NTIS AD A078 649/1

Code: 28.10 – CC

Title: A Direct Measure of CRT Image Quality

Author: Verona, R.W.; Task, H.L.; Arnold, V.C.; Brindle, J.H.
AARL, Fort Rucker, AL

Date: September 1979

Source: NTIS AD-A075 610/6

Code: 28.11 – CC

Title: Integrated Aircraft Controls and Displays

Author: Various

Date: May 1980

Source: NAECON

Code: 28.12 – CC

Title: Real-Time Systems and Displays Seminar (6th) Held at Patrick AFB, Florida on 3-6 October 1978

Author: Anon
White Sands Missile Range, NM
Data Reduction and Computing Group

Date: October 1978

Source: NTIS AD-A090 037, 418 pages

Code: 28.13 – CB, CC, CD

Title: Fighter Fire Control Requirements for Air Battles of the Future

Author: Manske, Robert A.; Duke, Arthur A., Jr.
AF Wright Aeronautical Labs.

Date: 1980

Source: NAECON, 3 pages

Code: 28.14 – CC

Title: F/A-18 Hornet Crew Station

Author: Adam, Eugene C.
McDonnell Aircraft Co.

Date: 1980

Source: NAECON, 5 pages

Code: 28.15 – CB, CC

Title: B-52 Offensive Avionics System (OAS) Control and Display Design, *Using a Dynamic Mockup*

Author: Sevick, George L.
Boeing Military Airplane Co.

Date: 1980

Source: NAECON, 9 pages

Code: 28.16 – CC, CD, CE

Title: Offensive Avionics System (OAS) Design

Author: Cameron, Alan G.
Boeing Military Airplane Co.

Date: 1980

Source: NAECON, 11 pages

Code: 28.17 – CC

Title: Boeing 757/767 Flight Management Computer System

Author: Banbury, John Q., II
Boeing Commercial Airplane Co.

Date: 1980

Source: NAECON, 7 pages

Code: 28.18 – CC

Title: Information Requirements for Airborne Electronic Terrain Maps

Author: Kuperman, Gilbert G.; DeFrances, Anthony J.;
Sander, Lt. Donald L.
AF Aerospace Medical Research Lab.,
Systems Research Lab.,
AF Wright Aeronautical Lab.

Date: 1980

Source: NAECON, 6 pages

Code: 28.19 – CB, CC

Title: Integrated Displays and Controls Design Factors for the 1990's Transport Aircraft

Author: Prince, M. David
Lockheed-Georgia Co.

Date: 1980

Source: NAECON, 8 pages

Code: 28.20 – CC

Title: Effects of Sunlight on Display Filters

Author: Yarger, Keith E.; Waruszewski, Harry L.
Aeronautical Systems Division, Wright-Patterson AFB

Date: 1980

Source: NAECON, 3 pages

CONTROLS/DISPLAYS

Code: 28.21 – CC

Title: F/A-18 Horizontal Situation Display

Author: Snow, Paul R.
McDonnell Douglas Corporation

Date: 1980

Source: NAECON, 8 pages

Code: 28.22 – CC

Title: F/A-18 Hornet Display System

Author: Juergens, Robert A.
McDonnell Aircraft Co.

Date: 1979

Source: NAECON, 9 pages

Code: 28.23 – CC

Title: Innovations in Control and Display of Avionics and Firepower Increase Cockpit Efficiency

Author: Hackmeister, R.

Date: June 1980

Source: High Technology, Volume I, 3 pages

Code: 28.24 – CC

Title: Advanced Crew Station Concepts, Displays, and Input/Output Technology for Civil Aircraft of the Future

Author: Hatfield, Jack J.; Robertson, James B.; Batson, Vernon M.
NASA Langley Research Center

Date: 1979

Source: NAECON, 10 pages

Code: 28.25 – CC

Title: Application of Advanced Digital Techniques & Displays to the L-1011 Flight Engineer's Station

Author: Beckman, W.R.
Lockheed

Date: 1979

Source: NAECON, 7 pages

Code: 28.26 – CC

Title: Electronic Flight Instrument System for B767/757 Aircraft

Author: Dandekar, A.J.
Rockwell International, Collins Air Transport Division

Date: 1979

Source: NAECON, 7 pages

Code: 28.27 – CC

Title: Flight Displays for the Next Generation Aircraft

Author: Dunn, Robert
Boeing Commercial Aircraft Co.

Date: November 29 - December 9, 1976

Source: SAE Prep. #760930, 9 pages

Code: 28.28 – CB, CC

Title: Two Types of System Control with an Interactive Display Device

Author: Herron, E.L.
Bunker-Ramo Corp.

Date: April 17-21, 1978

Source: Soc. International Display, pages 84-45

CONTROLS/DISPLAYS

Code: 28.29 – CC

Title: State-of-the-Art Displays for NASA's Space Shuttle

Author: Cooper, A.E.; Flanders, E.S.
IFB Federal Systems Division

Date: February 1979

Source: Electro-Opt. System Des., Vol. II, #2, pages 20-25

Code:

Title:

Author:

Date:

Source:

Code:

Title:

Author:

Date:

Source:

Code:

Title:

Author:

Date:

Source:

Code 29

DATA BUS TECHNOLOGY

This technology brief concerns state-of-the-art data bus technology, particularly the application and use of a MIL-STD-1553 multiplexed digital data bus.

Potential AAAS Applications

- Data transfer equipment
- Stores station equipment
- Control and display equipment
- Process control equipment

Advantages (Relative to Non-Bus Systems)

- Reduction in number of wires required to carry inter- and intra-system data, with a consequent reduction in system weight and EMI.
- Increase in the ease with which advanced aircraft armament systems can be integrated into the system, by relying more on the inherent flexibility of software rather than changes to the hardware, as shown in Figure 29-1 for the F-16.
- Increased interchangeability of similar black boxes through the adoption of a standard interface scheme (MIL-STD-1553).
- Increased operational reliability for armament systems through the use of redundant buses, with a small increase in additional hardware and control software.
- Simplified management of an overall system through utilization of a single standardized bus system.
- Capability to interface with many other aircraft systems using the same bus structure and protocol.
- Universal familiarity with interface techniques and bus structures, thereby facilitating maintenance and troubleshooting.

Disadvantages

- Message protocols may be different between aircraft because MIL-STD-1553 does not standardize protocols.
- The standard multiplexed data bus scheme usually requires a dedicated bus controller for operation.

Risk

The major risk in using the standard multiplex digital data bus for the AAAS is the differences that might be encountered in message protocols between aircraft types even though MIL-STD-1553B has been designated as the "standard" for all aircraft. That standard does not specify detailed message protocols.

Trends and State of the Art

— Bus Architecture. MIL-STD-1553B allows for dynamic bus control of the mux bus by other than the primary bus controller. The feature provides for bus control either in a command-response mode architecture or a polled contention mode architecture. Work has been done by NADC relative to these two types of architectures and it has been found that the latter type of mode architecture improves bus transmission efficiency by eliminating static refresh cycles.

— Multiplexed Data Bus Cables. Several current users have implemented the MIL-STD-1553 data bus by means of RG-108 cable in accordance with the requirements of MIL-C-17/45. Bus interconnections can be either direct coupled or stub coupled. Most users of the MIL-STD-1553 bus have chosen the transformer stub coupled architecture because of its flexibility in adding future systems.

— Transformers. Several manufacturers provide special miniature transformers for the mux bus as indicated in Table 29-1 with characteristics combined with those of the transceiver as shown in Table 29-4.

— Data Bus Receivers. The data bus receiver converts bipolar, biphase Manchester II data to TTL levels in accordance with MIL-STD-1553 requirements. Manufacturers' part numbers are provided in Table 29-1 and typical characteristics are shown in Table 29-2.

— Data Bus Transmitters. The data bus transmitter processes TTL biphase data from a Manchester II encoder for transmission on the mux bus in accordance with MIL-STD-1553 requirements. Manufacturers' part numbers are provided in Table 29-1 and typical characteristics are shown in Table 29-3.

— Transceiver Module. Hybrid transceiver devices are currently available from several sources, as shown in Table 29-1, that combine both multiplexed digital data bus receiver and transmitter functions in a single package. They feature low power dissipation and improved filtering on the receiver to enhance bit error rate of the system. Typical characteristics for these devices are provided in Table 29-4.

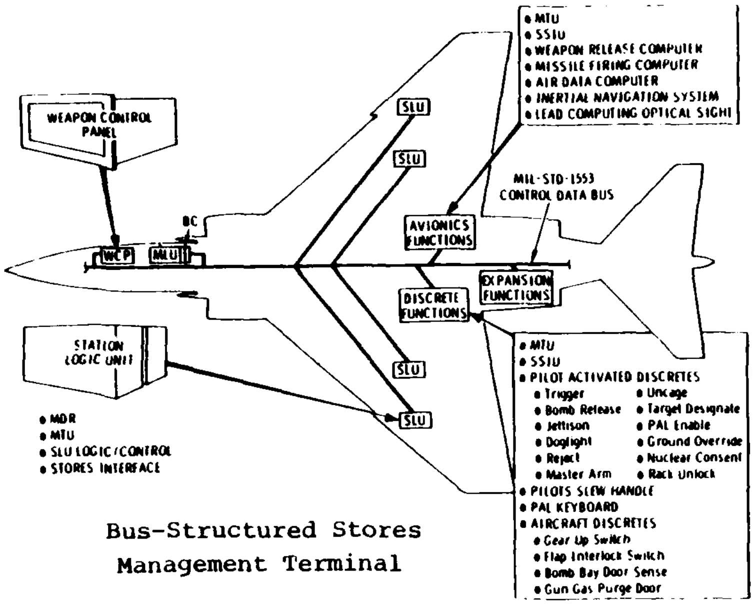
— Manchester II Encoder/Decoder Module. Single hybrid converter module packages are available from several sources, that include the necessary encoding/decoding, serial/parallel and parallel/serial conversion, address decoding and recognition plus tri-state double buffered output latches for the data bus. Typical parameters for such a module are provided in Table 29-5.

— Serial Parallel Converters. This device, identified in Table 29-1, is a double buffered serial/parallel and parallel/serial converter that provides all of the necessary "handshaking" required between a Manchester encoder/decoder and a subsystem microprocessor including the protocol handling for both a MIL-STD-1553 bus controller and remote terminal.

— Remote Terminal Unit Module. Several manufacturers of hybrid circuits offer MIL-STD-1553B interface modules, as shown in Table 29-1, that perform as complete remote terminal units (RTUs) by providing a transformer coupled input/output, a transceiver, encoding/decoding circuitry, and serial/parallel and parallel/serial shift registers in a single package, as shown in Figure 29-3. The devices can be employed as the mux bus interface for either a functional remote subsystem or master bus controllers. A functional block diagram for an RTU is also shown in Figure 29-2.

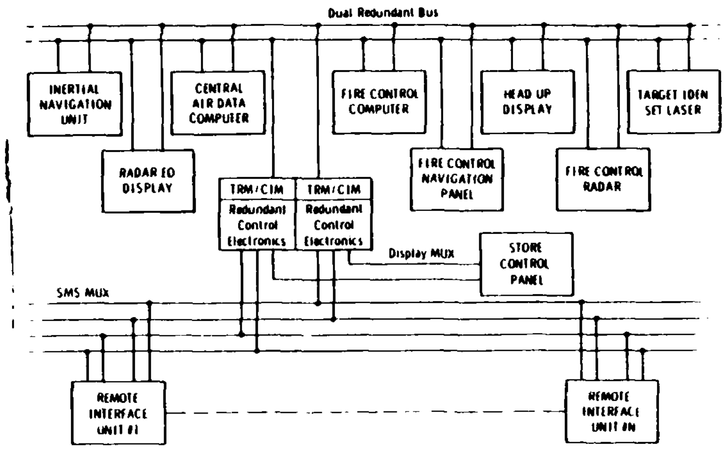
Cost Direction

AAAS life-cycle cost reductions may be realized through the incorporation of a multiplexed digital data bus because of its inherent flexibility for system reconfiguration and troubleshooting. Direct cost comparisons with current hardwired systems are difficult to make because of the limited use of MIL-STD-1553 data buses in stores management systems of active aircraft.



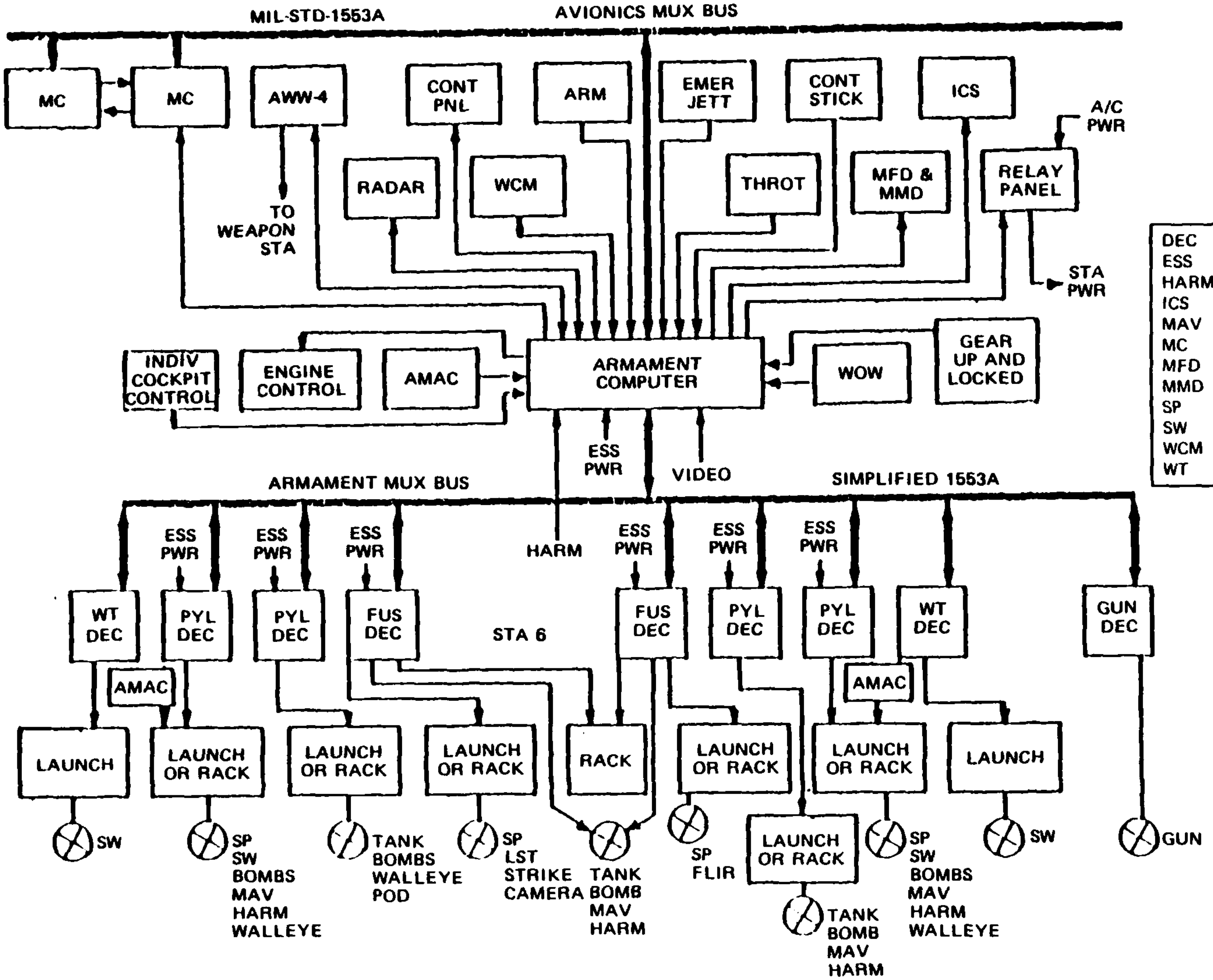
Bus-Structured Stores
Management Terminal

– Courtesy IEEE (© 1977)



F-16 Avionics and Stores Management Interfaces

Figure 29-1. SMS DATA BUS INSTALLATION



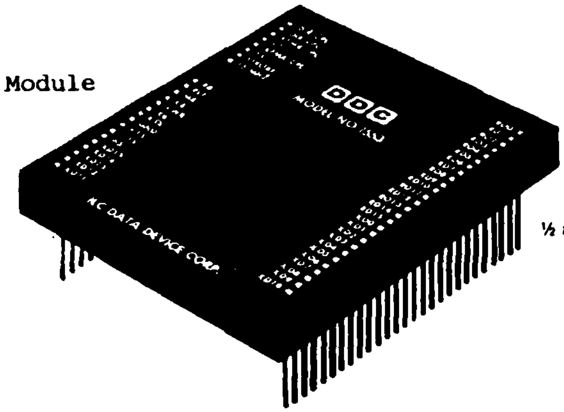
NOTE:

DEC	=	Decoder
ESS	=	Essential
HARM	=	High-Speed Anti Radiation Missile
ICS	=	Intercommunication System
MAV	=	Maverick
MC	=	Mission Computer
MFD	=	Multifunction display
MMD	=	Multimode display
SP	=	Sparrow
SW	=	Sidewinder
WCM	=	Weapon Control Monitor
WT	=	Wing tip

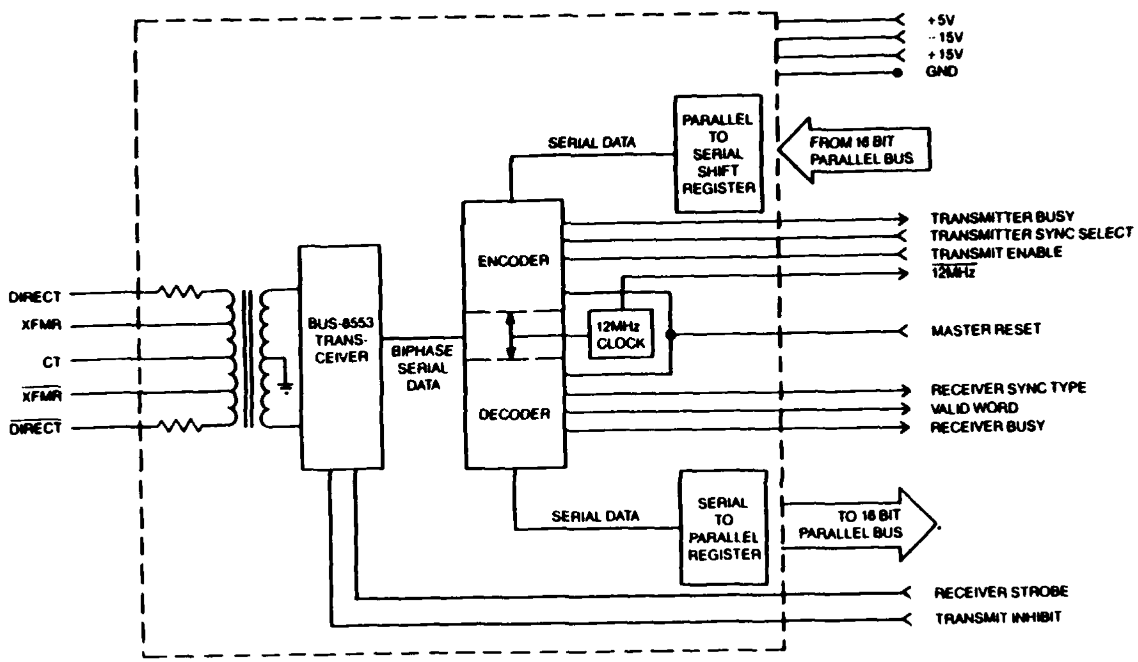
– Courtesy Conrac Corp. (© 1978)

Figure 29-2. F-18 SMS INTERFACE DIAGRAM

MIL-STD-1553 RTU Module



½ actual size.



Bus-1553 Block Diagram

– Courtesy ILC Data Device Corp.

Figure 29-3. BUS-1553 REMOTE TERMINAL UNIT

Table 29-1. MIL-STD-1553 DATA BUS COMPONENTS

Device	Manufacturers' Part Number			
	ILC/DDC	CTI	Harris	SMC
1. Transformer	BUS-25679	CT1231		
2. Data Bus Receiver	BUS-8555	CT3078		
3. Data Bus Transmitter	BUS-8556	CT2077		
4. Transceiver*	BUS-8553 BUS-8554**	CT3231		
5. Manchester II Encoder/Decoder	BUS-8937	CT1555	HD-15530 HD-15531	
6. Serial to Parallel Converter				COM-1553A***
7. Remote Terminal Unit	BUS-1553	CT1553-1		

*For MIL-STD-1553B applications
**F^3 replacement of CT3231; operates from ±12 to ±15 Vdc power
***Operates with HD-15530 or HD-15531 modules

(ILC/DDC = ILC Data Device Corp., Bohemia, NY; CTI = Circuit Technology, Inc., Farmingdale, NY; Harris = Harris Semiconductor Products Div., Melbourne, FL; SMC = Standard Microsystems Corp., Hauppauge, NY)

Table 29-2. DATA BUS RECEIVER PARAMETERS

SPECIFICATIONS FOR BUS-8555

PARAMETER	UNITS	VALUE
ANALOG INPUTS		
Bipolar (Differential) DATA and $\overline{DATA}$	V	40, p-p (max)
Input Impedance (Differential)	Ω	4 k (min)
Common Mode Rejection Ratio	dB	40 (min)
Threshold Levels		
Internal (preset)	mV	750, p-p (nom, with pins 18 & 20 grounded)
External Threshold Adjustment	V	0.0 to 2.0 (adjustable linearly with 0.0 Ω to 10.0 kΩ resistor respectively to ground.)
OUTPUTS		
DATA and $\overline{DATA}$ Output		TTL Level Manchester II (biphase) serial data
POWER SUPPLY CHARACTERISTICS		RANGE / CURRENT
Operating Voltage Range		+ 4.5 V to 5.5 V / 20 mA @ + 5 V
		- 10 V to - 18 V / 15 mA @ - 15 V
		+ 10 V to + 18 V / 15 mA @ + 15 V
THERMAL CHARACTERISTICS		
Temperature Range		
Operating	°C	- 55 to + 125 (Case)
Storage Temperature Range	°C	- 55 to + 135
PHYSICAL CHARACTERISTICS		
Size	in.	.895 X .950 X 0.15 max (22.7 X 24.1 X 3.8 mm max)
Weight	oz	0.3 (8.5g)

Table 29-3. DATA BUS TRANSMITTER PARAMETERS

SPECIFICATIONS FOR BUS-8556

PARAMETER	UNIT	VALUES
INPUT LEVEL		
DATA and $\overline{DATA}$		TTL (Driving logic must sink 0.7mA max)
Inhibit		TTL to inhibit transmitter (Driving logic must sink 0.36 mA max)
OUTPUT CHARACTERISTICS		
DATA and DATA (p-p differential	V	32, ±4
Output Impedance	Ω	<10 max when transmitting
Harmonic Content		Filtered to eliminate harmonics above 1MHz (see figure 3)
Differential Group Delay	ns	: 35
Output Noise	mV	10 p-p
POWER REQUIREMENTS		
Range/Regulation	V	+5±5% / ±12 to ±15
Current (see Figure 4)	mA	12max / 120 max† 40 max††
Power Dissipation	watts	2.9 (100% duty cycle)
		† Transmitting †† Standby
THERMAL CHARACTERISTICS		
Operating	°C	-55 to+125
Storage	°C	-55 to+150
PHYSICAL CHARACTERISTICS		
Size	in	1.25 x 1.25 x 0.20 (32 x 32 x 5.1mm)
Weight	oz	To be determined

Table 29-4. TRANSFORMER AND TRANSCEIVER PARAMETERS

SPECIFICATIONS— TRANSFORMER AND BUS-8553 HYBRID	
PARAMETER	**VALUE**
RECEIVER	
Input Level	40V p-p differential max
Input Impedance	4 KΩ differential min
Threshold Level	1V p-p nominal, internally set (direct coupled mode)
CMRR	40 dB min. up to 2 MHz Max
Output Level	TTL
Power Supply Requirements	±15V (±5%) @ 30 mA max +5V (±10%) @ 15 mA max
TRANSMITTER	
Input Level	TTL
Output Level	27V p-p nominal across 145Ω load 20V p-p nominal (measured at point C, Figure 2)
Rise/Fall Time	130 nsec typical
Output Noise	10 mV p-p differential max
Output Impedance (Receiver Mode)	4 KΩ differential min (at 1 MHz)
Power Supply Requirements (@ 25% Duty Cycle-Transmit Mode)	+15V(±5%)@70 mA max @25% Duty Cycle 150 mA max @ 100% Duty Cycle +5V (±10%) @ 15 mA max
GENERAL	
Operating Temperature Range	−55°C to +125°C (case temp.)
Storage Temperature Range	−55°C to +135°C
Size (24 pin DDIP hybrid)	1.4 x 0.8 x 0.2 inch
Weight	.4 oz. (typ)

NOTE: P/N BUS-8557 available for ±12V operation; consult factory.

— All tables courtesy ILC Data Device Corp.

Table 29-5. ENCODER/DECODER MODULE PARAMETERS

SPECIFICATIONS FOR HD-15531

ELECTRICAL CHARACTERISTICS V_{CC} = 5.0V ±5% T_A = Industrial or Military

	SYMBOL	PARAMETER	MINIMUM	TYPICAL	MAXIMUM	UNITS	TEST CONDITIONS
D.C.	V_{IH}	Logical "1" Input Voltage	70% VCC			V	
	V_{IL}	Logical "0" Input Voltage			20% VCC	V	
	V_{IHC}	Logical "1" Input Voltage (Clock)	VCC -0.5			V	
	V_{ILC}	Logical "0" Input Voltage (Clock)			GND +0.5	V	
	I_{IL}	Input Leakage	-1.0		+1.0	μA	0V < VIN < VCC
	V_{OH}	Logical "1" Output Voltage	2.4			V	IOH = -3mA
	V_{OL}	Logical "0" Output Voltage			0.4	V	IOL = 1.8mA
	I_{CCSB}	Supply Current Standby		0.5	2.0	mA	VIN = VCC = 5.25V Outputs Open
	I_{CCOP}	Supply Current Operating*		8.0	10.0	mA	VCC = 5.25V, f = 15MHz
	C_{IN}	Input Capacitance*		5.0	7.0	pF	
	C_O	Output Capacitance*		8.0	10.0	pF	
		*Guaranteed and sampled but not 100% tested.					
ENCODER TIMING							
A.C.	F_{EC}	Encoder Clock Frequency			15	MHz	C_L = 50pF
	F_{ESC}	Send Clock Frequency			2.5	MHz	
	T_{ECR}	Encoder Clock Rise Time			8	ns	
	T_{ECF}	Encoder Clock Fall Time			8	ns	
	F_{ED}	Data Rate			1.25	MHz	
	T_{MR}	Master Reset Pulse Width	150			ns	
	T_{E1}	Shift Clock Delay			125	ns	
	T_{E2}	Serial Data Setup	75			ns	
	T_{E3}	Serial Data Hold	75			ns	
	T_{E4}	Enable Setup	90			ns	
	T_{E5}	Enable Pulse Width	80			ns	
	T_{E6}	Sync Setup	55			ns	
	T_{E7}	Sync Pulse Width	150			ns	
	T_{E8}	Send Data Delay			50	ns	
	T_{E9}	Bipolar Output Delay			130	ns	
DECODER TIMING							
A.C.	F_{DC}	Decoder Clock Frequency			15	MHz	C_L = 50pF
	F_{DS}	Decoder Synchronous Clock			2.5	MHz	
	T_{DCR}	Decoder Clock Rise Time			8	ns	
	T_{DCF}	Decoder Clock Fall Time			8	ns	
	F_{DD}	Data Rate			1.25	MHz	
	T_{DR}	Decoder Reset Pulse Width	150			ns	
	T_{DRS}	Decoder Reset Setup Time	75			ns	
	T_{MR}	Master Reset Pulse Width	150			ns	
	T_{D1}	Bipolar Data Pulse Width	T_{DC} +10			ns	①
	T_{D2}	Sync Transition Span		18T_{DC}		ns	①
	T_{D3}	One Zero Overlap			T_{DC} -10	ns	①
	T_{D4}	Short Data Transition Span		6T_{DC}		ns	①
	T_{D5}	Long Data Transition Span		12T_{DC}		ns	①
	T_{D6}	Sync Delay (ON)			110	ns	
	T_{D7}	Take Data Delay (ON)			110	ns	
	T_{D8}	Serial Data Out Delay			80	ns	
	T_{D9}	Sync Delay (OFF)			110	ns	
	T_{D10}	Take Data Delay (OFF)			110	ns	
	T_{D11}	Valid Word Delay			110	ns	
	T_{D12}	Synchronous Clock To Shift Clock Delay			75	ns	
	T_{D13}	Synchronous Data Setup	30			ns	

NOTE ① 15T_{DC} +10 = [15 (Decoder Clock Period)] +10ns T_{DC} = Decoder Clock Period = $\frac{1}{F_{DC}}$
These parameters are guaranteed but not 100% tested.

— Courtesy Harris Corp.

Table 29-6. RTU CHARACTERISTICS

CHARACTERISTICS FOR CT1553-1

Data Bus Input/Output	Completely compatible with 1553B Configurations
Power	+ 5VDC ± 5%, 200 mA
	+ 12 to + 15VDC ± 2%, 50 mA (standby) and 185 mA (transmitting) *
	− 12 to − 15VDC ± 2%, 40 mA (standby) and 175 mA (transmitting) *
	*Note: Current increases linearly from standby to 100% duty cycle at a level of 13.5 mA for each additional 10% duty cycle
User Control Interface	Standard low-power Schottky
Temperature Range	− 55°C to See chart below
CMRR	> 40 DB
Input Level	Up to 40V p-p differential
Threshold Level	Internally set to minimize word error rate
Optional Threshold Adjustment	Factory adjustable upon request
Input Impedance	> 2200 ohms — Direct-coupled Mode
	> 1100 ohms — Stub-coupled Mode
Low-Power Schottky Levels	16 Bits Parallel "IN DATA" and "OUT DATA"
Transmitter Override Control	TTL "1" inhibits transmission. Driver logic must sink 1.6 mA max
Output Level	7.5 ± 1.5V p-p differential at the bus (35-ohm load, Direct-coupled)
	22.5V ± 4.5V p-p differential at the stub (70-ohm load, Stub-coupled)

MAXIMUM AMBIENT TEMP.**	ALLOWABLE % TRANSMIT TIME*	
	± 15V SUPPLIES	± 12V SUPPLIES
70°C	60%	90%
85°C	45%	70%
105°C	25%	45%

CONTACT FACTORY FOR HIGH DUTY CYCLE AT HIGH TEMPERATURE REQUIREMENTS.

$$\text{*\% TRANSMIT TIME} = \frac{\text{TRANSMIT TIME}}{\text{TRANSMIT + RECEIVE TIME}} \times 100$$

**ASSUMES NATURAL CONVECTION COOLING

— Courtesy Circuit Technology, Inc

Code: 29.1 – CD, CE, CH

Title: Interconnection Technology for Electrical Connector Wiring Systems

Author: Leuba, E.R.
Burndy Corp., Norwalk, Conn

Date: September 1979

Source: SPE, Reg Tech Conf, Conn Sect: Adv. in Wire and Cable/Electron Packaging Technology, Greenwich, Conn, pages 30-32

Code: 29.2 – CB, CD

Title: USAF Thrust in Aircraft Electrical Power Technology

Author: Fox, D.G.
APL, Wright-Patterson, OH

Date August 1979

Source: IEEE American Chemical Society Proceedings of the 14th Intersociety Energy Conversion Engineering Conference

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Code: 29.3 – CB, CD, CH

Title: MIL-C-26500 Series Connector

Author: Anon
Pyle-National Company

Date June 1980

Source: Pyle-National Company, 38 pages

Code: 29.4 – CD, CE

Title: A Polled Contention Multiplex System Using MIL-STD-1553 Protocol

Author: Wilson, Dayton, H.; Kee, Edward G.
Vought Corporation; Naval Air Development Center

Date 1980

Source: NAECON, 8 pages

DATA BUS

Code: 29.5 – CB, CD, CE, CH

Title: French Unit Gains in U.S. – Low Insertion Force Plug Said to Offer High Performance

Author: Anon

Date: October 6, 1980

Source: Electronic News, 2 pages

Code: 29.6 – CB, CD, CE, CH

Title: Connectors That Need no Insertion Force

Author: Taylor, James D.
AMP, Inc.

Date January 24, 1980

Source: Machine Design, 4 pages

Code: 29.7 – CB, CD, CE, CH

Title: Focus on Cylindrical Connectors: Tough Environments Bring Out Best

Author: Hall, Edwin
Field Editor

Date December 20, 1980

Source: Electronic Design, 4 pages

Code: 29.8 – CB, CD, CE, CH

Title: Makers Seek to Contain Gold Costs

Author: Anon

Date October 6, 1980

Source: Electronic News, 4 pages

Code: 29.9 – CG

Title: High Voltage Specifications and Tests (Airborne Equipment)

Author: Dunbar, W.G.
Boeing Aerospace Company

Date: April 1979

Source: Air Force Aero-Propulsion Laboratory, 4 pages

Code: 29.10 – CE, CI

Title: Self-Organizing Bus Control

Author: Wise, Carl D.; Gibler, Robert A.
Westinghouse – USAF ASD/AEWE Wright Patterson

Date 1979

Source: NAECON, 4 pages

Code: 29.11 – CB, CD, CE

Title: Tin, Nickel Not Making Converts

Author: Anon

Date October 6, 1980

Source: Electronic News, 2 pages

Code: 29.12 – CE

Title: ZBI: A System Bus for the Z8000

Author: Bender, Linda
Zilog, Inc.

Date June 1980

Source: Mini-Micro Systems, 5 pages

Code: 29.13 – CE

Title: Integrating the IEEE-488 Bus

Author: O'Loughlin, Joseph
Dylon Corporation

Date: June 1980

Source: Mini-Micro Systems, 1 page

Code: 29.14 – CD, CE

Title: Impact of Aircraft Electrical Power Quality on Utilization Equipment

Author: Schmidt, A.W.; Reiquam, E.T.

Date May 16-18, 1978

Source: IEEE (Cat. No. 78CH1336-7), 4 pages

Code: 29.15 – CD, CE

Title: Stores Management and Data Bus Systems

Author: Sternberg, William J.
GM

Date May 17-19, 1977

Source: IEEE (77CH1203-9 NAECON), pages 907-193

Code: 29.16 – CB, CD, CE

Title: Microprocessor Realization of the Bus Interface Unit for a Distributed Avionic Computer System

Author: Simpson, Robert C.; Peterson, James B.
AF Institute of Technology, Wright-Patterson AFB

Date May 17-19, 1977

Source: IEEE (77CH1203-9 NAECON), pages 914-919

Code: 29.17 – CE, CI

Title: Inside MIL-STD-1553: Interface Format Guidelines

Author: Edwards, J.A.
General Dynamics

Date: May 15-17, 1979

Source: IEEE (Cat. #79CH1449-8 NAECON), pages 419-425

Code: 29.18 – CE, CI

Title: Compatibility Testing and Integration of DAIS Multiplex Bus Equipments

Author: Barber, G.W.; Rich, B.A.
TRW Defense and Space Systems Group

Date May 17-19, 1977

Source: IEEE (77CH1203-9 NAECON), pages 743-748

Code: 29.19 – CB, CD, CE, CG

Title: Standard Programmable I/O for the Advanced Aircraft Electrical System Power Control Set

Author: Perkins, J.R.; Tunage, W.T.; Brown, H.; Davidson, J.
Vought Corporation

Date May 16-18, 1978

Source: IEEE (Cat. #78CH1336-7), Volume 2, pages 765-771

Code: 29.20 – CG

Title: Impact of Aircraft Electrical Power Quality on Utilization Equipment

Author: Schmidt, A.W.; Reiquam, E.T.
Boeing Commercial Airplane Company

Date May 16-18, 1978

Source: IEEE (Cat. #78CH1336-7), Volume 3, pages 1010-1014

Code 30

ELECTRICAL TECHNOLOGY

This technology brief provides information on hybrid microcircuits, including A/D and D/A converters, operational amplifiers, solid-state power supplies, and regulators; as well as on connectors. Whereas Code 34, LSI Technology, describes monolithic circuits at a general level, this brief discusses the state of the art for specific devices and circuits.

Potential AAAS Applications

- Power conditioning equipment for conversion and interfacing with aircraft power systems
- Stores station interfaces
- SMS interconnections

Advantages

- Hybrid devices provide higher reliability, greater density, lower cost, and smaller size and weight than the discrete counterparts. Further details are provided in Table 30-1.
- Hybrid circuits can withstand extreme combinations of electrical, mechanical, thermal, and environmental stresses such as are expected to be encountered by the AAAS.

Disadvantages

- Lack of device standardization due to relatively new types on the marketplace.

Risk

Premised on the fact that hybrid microcircuits are successfully implemented in airborne military programs, the risk in using these devices (when Mil-qualified) for the AAAS is considered low.

Trends and State of the Art

– Power Conditioners. Hybrid microcircuits are experiencing greater use in power conditioning applications for advanced aircraft armament systems. Typical state-of-the-art devices include hybrid linear series regulators having output voltages ranging from +5V at 3.5A to +36V at 20A. Complementary negative voltage regulators have outputs ranging from -5V at 2A to -12V at 8A. These regulators are available in single or dual form, or as multiple types contained in the same package, with overvoltage and overcurrent protection incorporated into their design.

– Switching Power Supplies. These devices operate from 115V, 3-phase, 400-Hz prime power sources to provide ranges of characteristics from +5.3V at 114A to +15V at 0.2A. Negative voltage systems are available to complement these components.

— SEM Devices. The Standard Electronic Module (SEM) devices are available for advanced armament systems. SEM devices are discussed under Code 37, Packaging Technology.

— Relay Devices. Numerous types of high-power, solid-state relay devices (e.g., 75A steady and 1000A for one-cycle surges) incorporate transistors and/or silicon controlled rectifiers. The trend in this area is toward increased current and voltage capability. New materials and manufacturing techniques are supporting these developments, with high-reliability products resulting for applications of armament systems.

— Converters. D/A and A/D converters are available as hybrid circuits, and are beginning to emerge as monolithic types. Hybrids still provide the best performance, however, and a large number of hybrid types are fully qualified to MIL-STD-883, Method 5008. Available are high-speed D/A converters (25 and 50 ns maximum settling times) having capacities of 8, 10, 12 and 16 bits, and high-speed A/D converters (600 ns maximum conversion time) of 12-bit capacity.

— Operational Amplifiers. In addition to converters, operational amplifiers having very high slew rates (e.g., 1,000 V/us) are available in production quantities.

— Connectors. Major advances in connector state of the art are of interest to the stores station interfaces and internal electronics of the AAAS. Several manufacturers are producing Mil-qualified connectors having improved RFI/EMI shielding characteristics (see Code 31) and better moisture-sealing capabilities than previously available (see Code 4).

Connectors of the above type are designed to permit replacement of individual wires, or to accept wires of varying sizes, with no penalty in reliability. Individual wire sealing is by gaskets or grommets and crimping procedures. Plastic inserts provide structural as well as dielectric benefits for Mil connectors. Contacts are gold-plated copper alloys, but the high cost of gold has resulted in numerous R&D efforts to reduce or replace the gold plating.

Connectors are available that can accommodate up to 104 contacts per insert. Subminiature types handle as many as 85 No. 22 contacts in a size-18 shell.

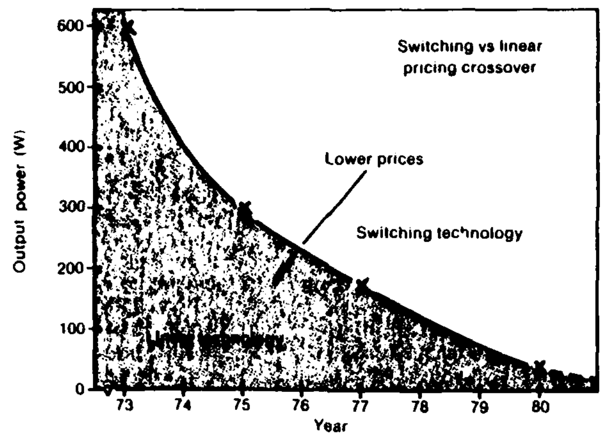
A series of connectors is now available for high-reliability military avionics applications. These connectors incorporate quick-coupling threads and an antidecoupling device to prevent vibration problems.

Connectors for use with flat cables are state of the art for stores management systems that do not require rigid environmental protection, such as needed for SS1 connectors. These flat-cable devices are available for connecting up to 50 strands of wire. A recent development in flat-cable interconnections is a high-density connector for SMS applications that accommodates two 40-conductor flat cables, resulting in significant weight and volume reduction.

Cost Direction

The life-cycle cost of hybrid power circuitry is projected to be less than that of discrete-device power circuits since hybrids operate at a lower temperature and have a higher reliability. Costs of Mil-connectors are going up because of the increase in the price of fabrication materials (gold plating and other precious metals). However, large quantity procurements and elimination of failure and corrosion problems should produce lower life-cycle costs for the systems in which these connectors are implemented.

The cost direction for switching power supplies is illustrated in Figure 30-1. It can be seen that the cost of switching supplies is decreasing and becomes almost equal to that of linear supplies during the 1980 time period. Linear supplies were lower in cost up to that time.



– Courtesy Electronic Design Magazine (© 1981, Hayden Publ. Co.)

Figure 30-1. COMPARISON OF COSTS

Table 30-1. COMPARISON OF PRODUCTION AND HYBRID REGULATORS

Version	Outside Dimensions (inches)	Watts/in^3	W/lb	Volume		Weight	
				in^3	Relative	lb	Relative
Production Switching Regulator	23.4 x 7.06 x 2.16	1.70	46.8	356.8	100%	13.01	100%
Switching Regulator with Power Hybrid Packages	12.58 x 7.06 x 2.16	3.18	67.3	191.8	53.8%	9.05	69.6%

– Courtesy IEEE (© 1979)

Code: 30.1 – CB, CD, CG

Title: Solid State Power Controllers

Author: Coyle, P.J.; Whitman, C.L.
RCA, Camden, NJ

Date: November 1979

Source: NTIS AD A080 482/3; MF A01

Code: 30.2 – CB, CD

Title: Star Flight Control System

Author: Carlock, Gaylord W.; Gatlin, Charles M.; Guinn, Kenneth F.; Borgeson, Roger D.
Bell Helicopter Texton, Fort Worth, TX

Date: July 1979

Source: Journal of American Helicopter Society, Vol. 24, No. 4, July 1979, pages 20-28

Code: 30.3 – CG

Title: Solid State Power Controller Verification Studies

Author: Linder, Carl O.

Date: January 1979

Source: NTIS - AD-A078238; 196 pages

Code: 30.4 – CG

Title: High Voltage Power Supplies

Author: Hawkins, C.,
Wallis Electron Ltd.

Date: June 1979

Source: New Electronics, Vol. 12, No. 12, pages 72-75

ELECTRICAL

Code: 30.5 – CD, CG

Title: Factors Affecting the Application-Reliability of Schottky

Author: Blatt, Fred M.
Unitrode Corp., Watertown, Mass.

Date: May 1979

Source: Proceedings of Power Conference 6; National Solid State Power Conversion Conference 6th

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Code: 30.6 – CB, CD, CE

Title: Membrane Switches; Low Cost Companion for Electric Logic

Author: Haggerty, J.K.; Centralab, Inc., Milwaukee, WI

Date: April 1980

Source: Machine Design, Vol. 52, No. 7, pages 90-95, April 1980

Code: 30.7 – CB, CD

Title: Solid State Relay Design, a Hybrid and Monolithic Approach

Author: Skok, J.A.
LMSC, Sunnyvale, CA

Date: May 1979

Source: IEEE Proceedings of the 29th Electronic Components Conference, May 1979, pages 388-92

Code: 30.8 – CB, CD, CG

Title: Advanced Electronics and Digital Sensor Technology, Volume I: Management Summary

Author: Anon
Martin Marietta Aerospace

Date: Feb. 1980

Source: NTIS AD-B044 803L, 20 pages

Code: 30.9 – CB, CD, CG

Title: Advanced Electronics and Digital Sensor Technology, Volume II: Generic Autopilot

Author: Anon
Martin Marietta Aerospace

Date: February 1980

Source: NTIS AD-B044 804L, 336 pages

Code: 30.10 – CB, CD, CE, CG

Title: Integrated Circuit Characteristics for Future Military Avionics

Author: Preston, Glenn W.
Institute for Defense Analyses

Date: January 1980

Source: NTIS AD-B049 084L, 87 pages

Code: 30.11 – CG

Title: Power Hybridization – Key to Reducing Avionics Power Supply Weight and Volume

Author: Newton, Robert C., Jr.; Frey, Donald G.
Westinghouse Electric Corporation

Date: 1979

Source: NAECON, 6 pages

Code: 30.12 – CG

Title: Materials & Process Considerations for Reliable High Wattage Hybrids

Author: Konsowski, S.G.; Pearson, R.C.; Lucas, M.R.
Westinghouse

Date: 1980

Source: NAECON, 5 pages

Code: 30.13 – CB, CD, CE

Title: Sensor Processing System

Author: Bondurant, David W.
Sperry-Univac

Date: 1980

Source: NAECON, 5 pages

Code: 30.14 – CE, CI

Title: Analysis and Evaluation of Current MIL-STD-1553 Digital Avionics Architecture as the Basis for Advanced Architectures Using MIL-STD-1553B

Author: Turner, C. Ray; McCall, Mack B.
Boeing Aerospace Co.

Date 1979

Source: NAECON, 7 pages

Code: 30.15 – CG

Title: Fundamental Limitations and Design Considerations for Compensated Pulsed Alternators

Author: Weldon, W.F.; Bird, W.L.; Driga, M.D.; Tolk, K.M.; Rylander, H.G.; Woodson, H.H.
Center for Electromechanics, University of Texas at Austin

Date June 1979

Source: NAECON, pages 76-82

Code: 30.16 – CG

Title: IC Voltage Regulators

Author: Coon, Art
National Semiconductor

Date December 1980

Source: *Electronic Products Magazine, 2 pages*

Code: 30.17 - CB, CG

Title: An Overview of Avionics Technologies for the Improvement of All Weather Attack Avionics System (AWAAS) - Operational Readiness in the 1980-1990 Time Frame

Author: Cicak, John J.
Naval Avionics Center

Date: September 1978

Source: NTIS AD-A062 812/3ST, 93 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code:
Title:
Author:
Date
Source:

Code 31

ELECTROMAGNETIC ENVIRONMENT TECHNOLOGY

This brief addresses electromagnetic technology relative to its application to the AAAS. The information provided concerns electromagnetic compatibility (EMC), electromagnetic interference (EMI), and electromagnetic pulse (EMP) characteristics and components associated with advanced aircraft systems.

Potential AAAS Applications

- All AAAS subsystems employing electronic and/or electrical circuits.

Advantages

Judiciously applied electromagnetic technology yields:

- Decreased susceptibility of sensitive digital devices and circuits to the effects of conducted and/or radiated EMI through proper shielding, grounding, bonding, and filtering technologies.
- Increased reliability of weapon separation and control guidance through the specification of appropriate EMC requirements and tests of MIL-E-6051 and MIL-STD-461.
- Enhanced system protection from conducted transients associated with currently used discrete/relay technology, through the application of fiber optics and multiplexed digital data bus technologies.
- Increased system protection from circuit transients when conventional high-current relays, solenoids, contactors, etc., are replaced with the solid-state power control devices associated with an EMUX system.
- Ready availability of mathematical models to help analyze and resolve problems of inter- and intra-system compatibility.
- Increased nuclear hardening through application of proven design techniques and components that can withstand the effects of EMP.

Disadvantages

- Increased system cost and weight due to tendency to overspecify EMC and EMP requirements.
- Reduced technical innovation and/or use of state-of-the-art components because of requirements to meet specified levels of nuclear hardness (see Tables 31-1 and 31-2).

Risk

The primary risk in applying electromagnetics technology to the AAAS involves possible cost and schedule impacts to the development and testing of the hardware, particularly in the area of nuclear hardness. A tradeoff between system safety/survivability and cost has to be made to determine the level of nuclear hardness desired. Very little risk is involved in applying sound EMC requirements appropriately.

Trends and State of the Art

— Connectors. The latest series (III) OF MIL-C-38999 connectors incorporates expanded EMI shielding protection compared to earlier series. A minimum shielding capability of -65 dB at 10 GHz is possible with the new metal-to-metal coupling finger design.

A new development for advanced armament systems is the Radio Frequency Attenuating Connector (RFAC) used to connect electrically initiated explosive devices to fire control systems. This connector provides RF and electrostatic hazards (RADHAZ) protection. The RFAC operates on an inductive coupling principle. In addition, several RFAC versions using fiber optics technology have emerged for armament systems.

— Fiber Optics. Many advances have been made recently in fiber optics applications in aircraft. The technology brief for Code 32 presents more information on this subject.

— Solid State Power Controllers. Recent developments in the area of solid state power controllers for controlling aircraft power (and thus reducing EMI problems) have resulted in the development of a specification, MIL-P-81653, for potential advanced armament systems.

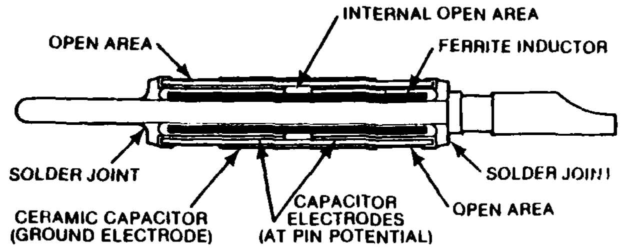
— Filters. Signal line filters are available that can be incorporated into connector pins, as illustrated in Figure 31-1. Most connector manufacturers can supply this type of pin filter. Ferrite beads are also available for in-circuit filtering of critical signal lines.

— Shielding. As wire shielding technology advances, additional standard shielded cables are added to the military system through MIL-C-17. An example is the RG-108 cable, used for MIL-STD-1553 data bus interfaces. Figure 31-2 shows an acceptable method of terminating such shielded cable. Table 31-3 lists techniques for shielding against the effects of EMP.

— Radiation Hardening. More types and quantities of radiation-resistant semiconductor devices are becoming available (see Table 31-1). A major trend in semiconductor design is the use of dielectric isolation to obtain radiation hardening.

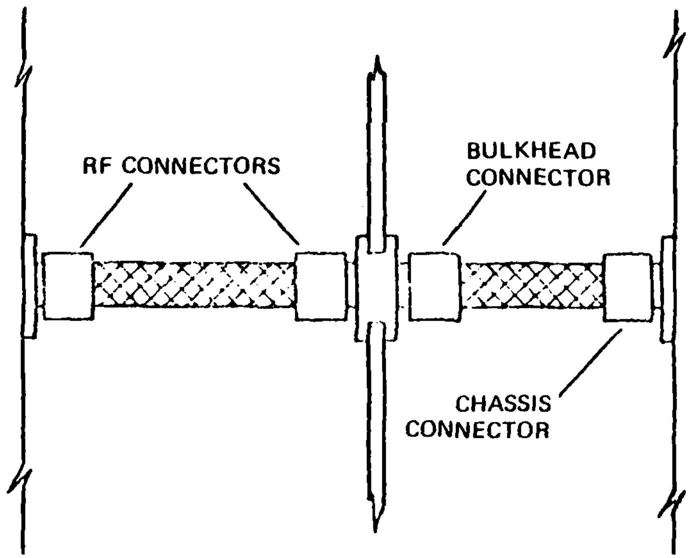
Cost

Overall system life cycle cost should be reduced through the judicious application of electromagnetics technology to the AAAS. Cost savings should be achieved through increased system safety, enhanced mission survivability, and reduced system downtime due to intermittent EMI problems.



– Courtesy EDN Magazine
(© 1979, Cahners Publ. Co.)

Figure 31-1. CONSTRUCTION OF MINIATURE EMI FILTERS



– Courtesy Design Handbooks Branch, ASD

Figure 31-2. TERMINATION OF COAXIAL CABLE SHIELDS

Table 31-1. SPECTRUM OF RADIATION EFFECTS ON SEMICONDUCTOR COMPONENTS AND ESTIMATED SUSCEPTIBILITY RANGES

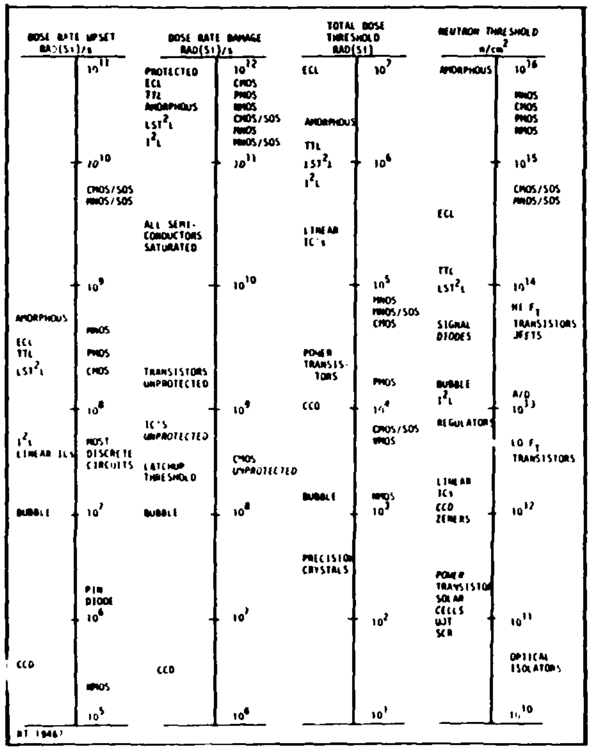


Table 31-2. EFFECTS OF EMP-INDUCED CURRENTS ON ELECTRONIC COMPONENTS

Energy (joules)	Damage Possible
10^{-7}	Microwave mixer diodes burn-out
10^{-6}	Linear IC's suffer upset and burnout
10^{-5}	Low power transistors and bipolar IC's upset and burnout
10^{-4}	CMOS logic, medium power transistors and diodes, and capacitors suffer permanent damage
10^{-3}	Zeners, SCR, JFET's, high power transistors, and thin film resistors damaged

Table 31-3. HARDENING TECHNIQUES AGAINST EFFECTS OF EMP-GENERATED CURRENTS

SHIELDING

- Acceptably thick metal walls
- All joints lapped and gasketed
- Cooling ports closed with screen and/or honeycomb sections
- Penetrating screws, bolts, shafts, etc., grounded with conductive mating surfaces

CABLE SHIELDS

- Good shielding effectiveness of overall shield
- Additional shielding from internal shields and cable layout
- 360 degrees shield continuity at connectors required

MINIMIZATION OF EMP PICKUP

- Fiber optic link as isolator

GROUNDING

- Equipotential single point ground - satisfactory for localized regions
- Floating grounds - only for use between line replaceable units

TRANSIENT SUPPRESSION

- Filtering
- Limiting

– All tables courtesy IRT Corp. (© 1979)

Code: 31.1 – CB, CH

Title: An Investigation of the Relationship Between EMP Grounding Practices and MIL-STD-188-124

Author: Woody, J.A.; Denny, H.W.
Geo. Tech.

Date: April 1979

Source: NTIS AD-A082 315/3
Geo. Tech. Report for Defense Nuclear Agency

Code: 31.2 – CB, CH

Title: User's Manual for SCWAR Shielded Wire Cable Code for EMP

Author: Vrabel, Michael J.
Harry Diamond Labs, Adelphi, MD

Date: May 1979

Source: NTIS AD A070 884/2ST

Code: 31.3 – CB, CH

Title: High Voltage Specification and Tests (Airborne Equip)

Author: Dunbar, W.G.; Koenig, W.P.
Boeing, Seattle, WA

Date: April 1979

Source: NTIS A069 473/75T
Boeing Aerospace for AFAPL

Code: 31.4 – CB, CD, CE, CH

Title: YAV-8B Harrier Electromagnetic Immunity and Flight Test Program

Author: Greenwell, R.A.
Naval Ocean Systems Center

Date: 22 October 1979

Source: Naval Ocean Systems Center Technical Report 476, 60 pages

ELECTROMAGNETIC ENVIRONMENT

Code: 31.5 – CB, CD, CH

Title: EMP Hardening of Airborne Systems Through Electro-Optical Techniques: Design Guidelines

Author: Greenwell, R.A.
Naval Ocean Systems Center

Date: December 15, 1979

Source: Naval Ocean Systems Center Technical Report 469, 53 pages

---

Code: 31.6 – CB

Title: Protection of Systems Avionics Against Atmospheric Electricity Hazards – Lightning and Static Electricity

Author: Corbin, John C. Jr.
Air Force Flight Dynamics Lab

Date May 17-19, 1977

Source: IEEE (77CH1203-9 NAECON), pages 842-849

Code: 31.7 – CB

Title: Electromagnetic Compatibility Considerations in System Integration

Author: Wick, E.E.
Wright-Patterson AFB

Date May 13-15, 1974

Source: IEEE, pages 317-324

Code: 31.8 – CB, CD, CE, CH

Title: EMI Shielding: What You Need to Know – and Why

Author: Regan, James J.
Int Technol, Inc.

Date January 1980

Source: Plast Technol, Vol. 26, #1, pages 71-74

Code:	31.9 – CB, CD, CE, CH
Title:	EMC Requirements for Airborne Digital Data Transmission Systems
Author:	Audone, B.; Bolla, L. Aeritalia Gruppo S.A.S. (Italy)
Date:	May 20-22, 1975
Source:	IEEE (Cat #75CH1012-4 MONT), pages 1-6

Code:	31.10 – CB, CD, CE, CH
Title:	RAE Research and Development Programme on EMC for Aircraft and Flight Weapons Systems
Author:	Thomason, J.M. R. Aircraft Establ (England)
Date	October 9-11, 1979
Source:	IEEE (Cat #79CH1383-9 EMC), pages 118-123

Code:	31.11 – CB, CD, CE, CH
Title:	Intersheaths Between Cable Braids
Author:	Blackband, W.T. Royal Aircraft Establishment (England)
Date	September 1972
Source:	Technical Report #RAE-TR-72151, 14 pages

Code:	31.12 – CD, CG
Title:	MAU-12 C/A Electromagnetic Impulse Emission Test
Author:	Colyer, William H. Air Force Special Weapons Center
Date	January 1972
Source:	NTIS AD-891 809/6ST, 13 pages

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Code:	31.13 – CB
Title:	Advanced Composites: Electromagnetic Properties, Vulnerabilities, and Protective Measures
Author:	Hiebert, A.L. Rand Corporation
Date:	May 1977
Source:	Rand Corporation Report #R-1979-AF, 54 pages

Code:	31.14 – CD, CE, CG, CH
Title:	Simulated Lightning Test on the Navy Airborne Light Optical Fiber Technology (ALOFT) A-7 Aircraft
Author:	Dijak, Jerome T. Air Force Flight Dynamics Lab
Date	June 1977
Source:	NTIS AD-A046 370/3ST, 99 pages

Code:	31.15 – CB, CH
Title:	Electromagnetic Environment Effects. Summary Report to the Chief of Naval Material
Author:	Anon Naval Material
Date	September 30, 1977
Source:	NTIS AD-A060 314/2ST, 57 pages

Code:	31.16 – CB, CD, CE, CG, CH
Title:	AFWL Technical Objective Number 1. Nuclear Weapons Technology, AFWL Technical Objective Number 3. Advanced Weapons Technology. Fiscal Year 1980.
Author:	Collier, William D. AF Weapons Lab
Date	December 1978
Source:	NTIS AD-A062 142/5ST, 31 pages

Code: 31.17 - CB, CD, CE, CH

Title: The Multiwire Shielded Array - Theory and Code

Author: Vrable, Michael J.
Harry Diamond Labs

Date: October 1978

Source: NTIS AD-A063 585/4ST, 58 pages

Code: 31.18 - CB, CD, CE, CH

Title: Dead-Faced Electrical Connector with Electromagnetic Vulnerability Protection

Author: Erbe, Alfred R.
Department of the Navy

Date June 18, 1980

Source: NTIS AD-D007 298/3, 16 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 32

FIBER OPTICS TECHNOLOGY

This technology brief focuses on fiber optics cables, light sources, detectors, connectors, and transmitter/receiver modules.

Potential AAAS Applications

- Standard stores interface
- Data transfer equipment

Advantages

- Wide bandwidths (100 MHz or more) and high data rate capacity (300 Mb/s presently, with up to 1 Gb/s projected).
- Elimination of electromagnetic compatibility problems in armament systems.
- Immunity to electromagnetic pulse effects, thus providing a radiation-hardened environment for nuclear stores.
- Absence of radiated fields, for greater communication security.
- Elimination of ground loops and the need for shielding.
- Absence of such hazards as sparking, fire, and explosion normally associated with conventional electrical systems.
- Significant weight reduction through use of a lighter (nonmetallic) conductor medium instead of copper wiring, and the elimination of shielding.
- Direct usability with optical sensors without the need for amplifying circuitry.

Disadvantages

- No fiber optics components are military-qualified. However, investigations and tests show that for an advanced armament application of a MIL-STD-1553B 1-Mb/s data bus, a compatible set of components exists that can be qualified to MIL-E-5400.
- Signal losses due to fiber attenuation and mechanical mismatching of fiber cables to connectors can create problems if not properly controlled. However, recent advances in technology have significantly reduced — and in some instances eliminated — mechanical mismatching.
- The fiber optics industry is geared toward mass production of components for telecommunication systems, and has not begun to pursue the potentially large volume of military applications, such as that of the AAAS Program. This situation has led to nonstandardization of components.

Risk

The risk in applying fiber optics technology to aircraft armament programs is considered low-to-medium because of the many successful applications reported. For example, in the ALOFT program for A-7 aircraft, development of a fiber optics interconnection system for a data bus application was considered of low risk.

Trends and State of the Art

— Fiber Optics Cables. The number of suppliers of fiber optics cables suitable for use in military SMS applications is increasing. New materials have low attenuation losses (see Table 32-1), and are available for single-mode and multimode propagation. Losses as low as 1 to 3 dB/km are reported for single-mode fiber optics, making them suitable for use as a data bus (MIL-STD-1553B) for advanced armament systems.

— Light Sources. Light sources consist of GaAs or GaAlAs, and emit infrared wavelengths of from 750 to 950 micrometers. Technology advances are increasing the spectral range from 1.0 to 1.6 micrometers to overcome attenuation losses (see Table 32-2). The number of suppliers of these light sources is steadily increasing. Problems of coupling losses and lack of external optical enhancement are being eliminated, in the former case through hermetic sealing of emitters.

— Detectors. Detectors consist mainly of PN, PIN, and avalanche photodiode structures. Significant advances are occurring in the detector field to overcome problems of losses, with one approach being the development of integrated amplifiers on the same chip as the diode (see Table 32-3).

— Optical Connectors. Connectors for fiber cables are now available that optimize transmitter and receiver alignment (see Table 32-4). Another major connection available for fiber optics is patterned after the Standard Military Approved (SMA) RF coaxial connector. Of further interest is a hybrid connector that accommodates a mixture of electrical and optical signals. Connectors are also being developed containing combined light-emitting sources and detectors.

— Transmitter and Receiver Modules. Several companies have successfully developed fiber optics transmitter/receiver modules for advanced armament MIL-STD-1553B applications. Table 32-5 provides further details.

Cost Direction

For at least one application, the A-7 aircraft, fiber optics provide a significant reduction in total life cycle cost relative to the use of wire alternatives. The economic advantages are due to the lower cost of fiber optics connectors, cables, and circuitry versus the cost of conventional elements (see Figures 32-1 through 32-5). Other data are given in Table 32-6.

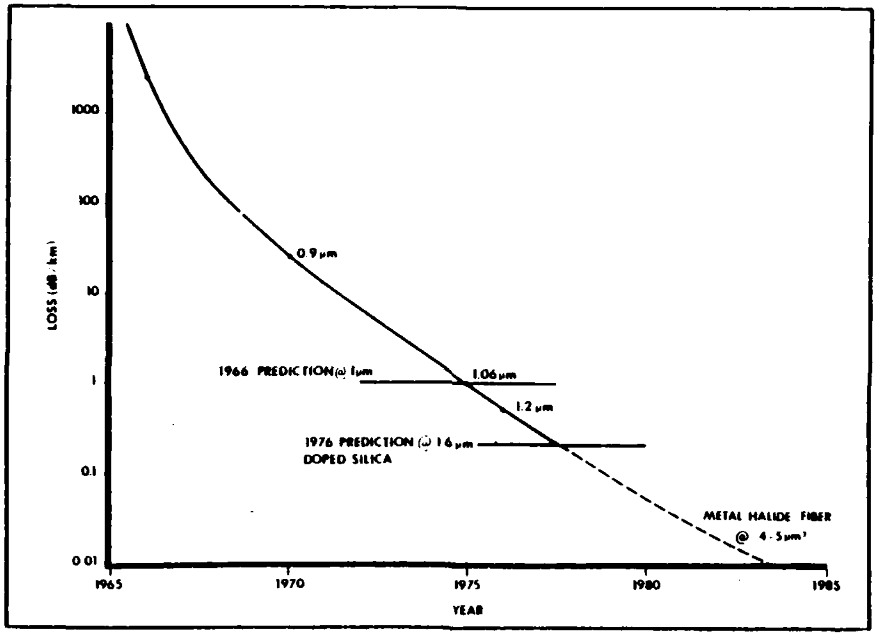

Figure 32-1. PROJECTION OF ATTENUATION LOSS IMPROVEMENT

– *Courtesy Sea Technology Magazine*
(© 1980, Compass Publications, Inc.)

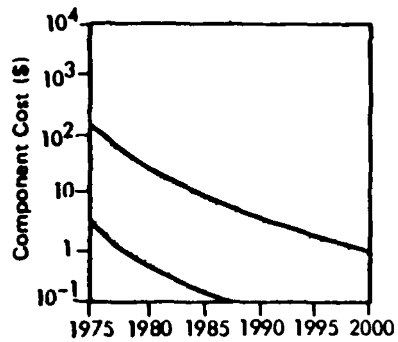

Figure 32-2. SINGLE-FIBER AND BUNDLE CABLES

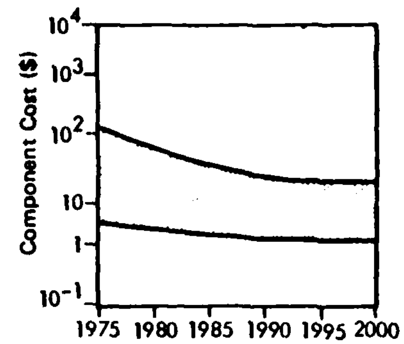

Figure 32-3. MULTI- AND SINGLE-FIBER OPTIC CONNECTIONS

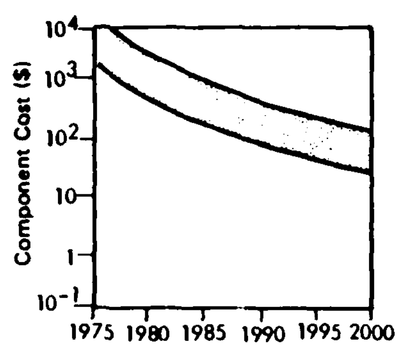

Figure 32-4. ANALOG FIBER OPTIC TRANSMITTER-RECEIVER MODULES

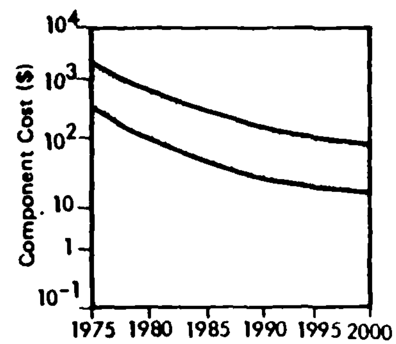

Figure 32.5. DIGITAL FIBER OPTIC TRANSMITTER-RECEIVER MODULES

– All figures courtesy U.S. Navy, Naval Ocean Systems Center

Table 32-1. FIBER-OPTIC CABLE SAMPLINGS

Manu-facturer	Type number	Core* type (core/clad)	Dimensions (core/over-all) (μm)	Attenuation (dB/km) wavelength (nm)	Bandwidth dispersion (per km)	Numerical aperture	Refractive index	Jacket Diameter (single fiber)	Material
Belden	225000	GG	63/125	10@820	200 MHz	0.21	—	3.8 mm	PVC
	220000	SG	200/400	10@850	25 MHz	0.22	—	3.8	"
	221000	SG	300/440	10@850	20 MHz	0.22	—	3.8	"
Corning (fibers only)	Corguide								
	5040/41	GG	63/125	5@820/900	400 MHz	0.24		138 μm	lacquer
	10020/21	GG	63/125	10@820/900	200 MHz	0.24		138 μm	lacquer
Du Pont	PFX-S120	SP	200/600	40@775	—	0.04	1.46	2.4 mm	Hytrel
	PFX-P140	plastic/plastic	400/435	385@650	—	0.53	1.49	1.25	↓
	PFX-PIR	plastic/plastic	385/400	320@690	—	0.53	—	1.9	↓
Galileo	3000 D					0.48	1.61	2.23 mm	PVC
	-LC	SG	204/245	50@850	—	↓	↓	↓	Tefzel
	-7	↓	110/88	100@850	—	↓	↓	↓	PVC/Kelvar
	-19	↓	68/85	100@850	—	↓	↓	↓	Tefzel/Kovar
ITT (fibers only)	T-200	GG	55/125	5-12@850	3.5 ns	0.25	1.48	500 μm	Hytrel
	T-320	SP	200/350	10-35@800	30 ns	0.30	1.46	↓	↓
	T-300	SP	125/300	10-35@800	30 ns	0.30	1.46	↓	↓
	T-100	SG	55/125	3-8@1060	15 ns	0.25	1.48	↓	↓
Quartz Products	QSF-A-200	SG	200/400	5@850	25 MHz	0.22	—	600 μm	Tefzel
	QSF-A-600	SG	600/750	5@850	9 MHz	0.22	—	1060	"
Siecor	standard	GG	63/125	10@820	200MHz	0.24	—	5 mm	PVC
	premium	GG	63/125	6@820	400 MHz	0.24	—	5 mm	PVC
Times Fiber	S-7-50	SP	90/200	7@800	—	0.16	—	—	—
	G-250	GG	90/250	5-10@800	—	0.16	—	—	—
	G-600	GG	90/600	6-8@800	—	0.16	—	—	—
Valtec	XD-MG05-06	GG	63/125	5@820	400 MHz	0.20	—	15 mm	Telephone grade
	HD-PC10-02	SP	250/430	15@820	10 MHz	—	—	6x9	—
	LD-SG04-01	SG	50/100	10@820	1 ns	0.20	—	2	—

*SG step index, glass clad glass (or silica)
GG graded index, glass clad glass
SP step index, plastic clad glass (or silica)

– Courtesy Electronic Design Magazine (© 1980, Hayden Publ. Co.)

Table 32-2. COMPARISON OF EMITTER PERFORMANCE

Emitter	Type	Delay time (T_d, ns)	Rise time (T_r, ns)	Fall time (T_f, ns)	f_{max} (MHz)
Laser	diffused junction single heterojunction double heterojunction	<2	<2	≤10	—
	large optical cavity	<3	<5	≤10	—
LED	diffused junction single heterojunction double heterojunction surface	<10	≈40	≤15	10-15
LED	double heterojunction, edge mesa	<10	≈15	≈15	25
LED	double heterojunction limited junction stripe circle	<5	≤10	<10	40

– Courtesy Electronic Design Magazine (© 1980, Hayden Publ. Co.)

Table 32-3. TYPICAL DETECTOR CHARACTERISTICS

Diode	Wavelength (μm)	Quantum efficiency (%)	Switching time 50-Ω load (ns)	Capacity (pF)	Dark current (A)	Surface area (mm^2)
Si p-i-n	0.5—0.07	> 90	0.1	1	10^{9}	0.002
Si p-i-n	0.4—1.1	≈ 90	3	3	5×10^{9}	2
Au-Si-In	0.38—0.8	≈ 75	5	4	10^{10}	0.2
Si pn (lateral)	0.4—1.1	≈ 90	0.5	1.8	10^{9}	0.03
Ge (n·p)	0.6—1.65	≈ 50	0.12	0.8	10^{9}	0.002

– Courtesy Electronic Design Magazine (© 1980, Hayden Publ. Co.0

Table 32-4. SINGLE-FIBER OPTICAL CONNECTORS

Manufacturer	Designation	Fiber size (μm)	Insertion loss (dB)	Remarks
Amphenol	906 Series	125	2	fits size common to many fiber makers
	905 Series	600	3	for PFX-S120 (Du Pont) or bundles
AMP	OSC 22658	400	2	for PFX-P140 (Du Pont) or bundles
	Multimate	400-600	—	fits size 16 cavity of Multimate housing together with standard electrical contacts
ITT Cannon	Unilux/FOS	100-325	2	fits outdoor cables
ITT Electro-Optical	Multiway	50-200	2	for factory assembly
T&B/Ansley	998-100	125	1.5	assembly tools and strain relief available
	998-500	400	4	for PFX-P140 (Du Pont) or bundle

– Courtesy Electronic Design Magazine (© 1980, Hayden Publ. Co.)

Table 32-5. TYPICAL CHARACTERISTICS OF OPTICAL COMPONENTS

SYSTEM	NOMINAL
NRZ bit rate	DC to 5 Mb/s
Temperature range	−20°C to +35°C
T-6006 TRANSMITTER	NOMINAL
Input load	1 TTL load
Maximum input signal level	5V (TTL)
Optical wavelength	840 nm
Average optical power*	
55 μm graded-index fiber pigtail	30 μW (−15 2 dBm) (TTL "Low")
55 μm step-index fiber pigtail 100 μm step-index fiber pigtail	40 μW (−14 0 dBm) (TTL "Low")
Power supply	+5 vdc @ +250 mA max

*Higher output powers are available by special request

T-6056 RECEIVER	NOMINAL
Output drive capability	4 TTL loads
Optical sensitivity at 10^{-8} BER**	500 nW (−33 0 dBm) (TTL "Low")
Optical dynamic range	20 dB
Rising-edge jitter	10 ns, p-p
Falling-edge jitter	40 ns, p-p
Power supply	+5 vdc @ +75 mA −5vdc @ −50 mA

**Measured from cable termination with no connector installed at receiver, assuming negligible fiber dispersion

– Courtesy ITT Corp. (© 1980)

Table 32-6. TYPICAL FIBER-OPTIC COMMUNICATIONS LINKS

Manu-facturer	Model	Cable type	Length	Signal capicity	Remarks
Burr-Brown	3712	plastic	20 ft.	2 Mbits/s	TTL compatible, $167.
Harris	ESD-3121	low-loss single fiber	1 km	45 Mbits/s	two duplex channels
	ESD-4364	"	2.3 km	90 MHz	two analog channels
HP	HFBR	glass-clad single-fiber	10-100m	10 Mbits/s	TTL compatible, $570.
ITT	2D-AS	low-loss single-fiber	2 km	20 Mbits/s	with p-i-n receiver for short length
	2A-AS 2V-PS	↓	↓	20 MHz 4.5 MHz	two-analog 8-kHz channels frequency mixed above 4.5 MHz
3M	3M-Brand	Plastic-clad silica	30 m	10 Mbits/s	duplex channels, biphase code, plugs into PC board, TTL compatible, $695.
RCA	C86003E	PFX-S120R	1 km	20 Mbits/s	TTL compatible, $850.
Spec-tronics	SPX-2672/2674	fiber bundle	30/50 m	0.1/10 Mbits/s	
	SPX-2673	"	30 m	5 MHz	
TI	TXES475/476 (sources)	PFX-PIR140 or	50 m	35-to-60 ns rise time (tens of kHz/s)	GaAlAs source, 790 nm, 20-ns rise time
	TXED 453 (detector) TXEF 402 (cable)	0.4-mm bundle			AMP connectors, $121.
Valtec	RSK/RSH	PC-10 250-μm fiber	1 km/100m	50-μs (min) pulse width 20 kbits/s (NZR)	RS-232C compatible, duplex channels, $600/$500, 815 nm
	TTK/TTH	↓	↓	100-ns (min) pulse width 10/3 Mbits/s	TTL compatible, duplex channels, $650/$600 815/660 nm

– Courtesy *Electronic Design Magazine*
(© 1980, Hayden Publ. Co.)

Code: 32.1 – CB, CD, CE

Title: Multi-Processor Bus Architecture

Author: Taylor, Henry F.
Rockwell International, Thousand Oaks, CA

Date: June 1980

Source: NTIS AD A086 146/8
Rockwell Report for Electronics Research Center

Code: 32.2 – CB, CD, CE, CH

Title: Fiber Optic Technology Review

Author: Lyons, P.B.
Los Alamos Scientific Lab., NM

Date: March 1980

Source: NTIS LA UR-80-667
Confidential Los Alamos Report for Dept. of Energy

Code: 32.3 – CD, CE

Title: Fiber Optic Sensors

Author: Mongeon, P.; Buczek, C.
Department of the Navy, Washington, DC

Date: April 1980

Source: NTIS AD-D007 165

Code: 32.4 – CB, CD, CE

Title: Fiber Optic Couplers

Author: Bickel, G.W.; Foltzer, L.E.; Rines, G.A.; Nelson, A.R.
ITT Electro-Optical Div., Roanoke, VA

Date: July 1980

Source: NTIS AD-A082-360, Air Force Avionics Lab
ITT Report for A/F Avionics Lab.

FIBER OPTICS

Code: 32.5 – CB, CD, CE, CH

Title: Study of the Effects of Bending and Microbending on Glass Fibers

Author: Akers, F.I.; Mahurin, S.L.
ITT Electro-Optical Div.; Roanoke, VA

Date: November 1979

Source: NTIS AD-A081 239/6

Code: 32.6 – CB, CD

Title: Cyrogenic Sensor Model Description

Author: Sharma, M.M.;
TRW, Redondo Beach, CA

Date: November 1979

Source: NTIS N80-17848/6

Code: 32.7 – CB

Title: Optical Sensors for Aeronautics and Space

Author: Baumbick, R.J.; Alexander, J.; Katz, R.; Terry, J.
NASA, Cleveland, OH

Date: January 1980

Source: NTIS N80-17423/8

Code: 32.8 – CB, CD, CE, CH

Title: High NA Single Mode Fiber

Author: Akers, Frank I.
ITT Electro-Optical, Roanoke, VA

Date: June 1979

Source: NTIS AD-A080 526/7

Code: 32.9 – CB, CD, CE

Title: Application of Passive Couplers in Fiber Optic Systems

Author: Duck, Gary S.
Bell-North Res. Corp., Ottawa, Canada

Date: February 1980

Source: Electronics Packaging Prod., Vol. 20, No. 2, Feb 1980, pages 111-112, 114, 116

Code: 32.10 – CE, CH

Title: Noise Phenomena in High-Bit Rate Fiber-Optic Systems

Author: Miskovic, E.J.; Casper, P.W.
Harris Corp., Melbourne, FL

Date: May 1980

Source: Electro-Optical System Design, Vol. 12, No. 5, pages 27-33, May 1980

Code: 32.11 – CD, CE, CH

Title: Packaging Hybrid Circuit Fiber Optics Transmitters and Receivers

Author: Dassele, M.A.; Kush, S.
Sperry, Phoenix, AZ

Date: January 1980

Source: Electronic Packaging and Production, Vol. 20, No. 1, pages 135-8, 140-1

Code: 32.12 – CH

Title: Completely Integrated Fiber-Optic Link

Author: Redmond, R.J.
IBM Corp., Armonk, N.Y.

Date: February 1980

Source: IBM Technical Disclosure Bulletin, Vol. 22, No. 9, pages 3975-6 - IEEE

FIBER OPTICS

Code: 32.13 – CB, CD, CE

Title: Fiber Optics Connector Prices Drop, Performance Rises

Author: Kessler, J.N.
Kessler Marketing Intelligence, Newport, RI

Date: October 1979

Source: Electro-Optical System Design, Vol. 11, No. 10, pages 29-33

Code: 32.14 – CB, CD, CE

Title: Fiber Optic/Power Switch System for Multiplexed Automotive and Aircraft Wiring

Author: Ming, Joe D.; Samsen, Gearld R.; Smith, Rosemary
Texas Instruments, Dallas, TX

Date: February 1980

Source: SAE Paper No. 800504, Meeting Feb. 25-29, 1980, 5 pages

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Code: 32.15 – CB, CD, CE

Title: Comparison of Wire and Fiber Optics Data Transfer System for Large Military Aircraft

Author: Trumble, Kenneth; Zelon, Charlotte C.
A/F Avionics Lab., Dayton, OH

Date: 1979

Source: Fiber Integrated Optics, Vol. 2, No. 3-4, 1979, pages 315-338

Code: 32.16 – CB, CD, CE

Title: Fiber Optics Technology Program

Author: Anon.

Date: November 11, 1980

Source: Naval Ocean Systems Center, San Diego; Technical Reports

Code: 32.17 - CB, CD, CE

Title: Aircraft Monitor and Control (AMAC) Airborne Weapon Control and Release Equipment (AWCRE)

Author: Anon.

Date: 11 November 1980

Source: Naval Avionics Center, Indianapolis, Indiana; Technical Reports

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Code: 32.18 - CD, CE, CH

Title: Fiber Optics Interconnection System for Airborne Electronics

Author: Wittmann, J.E.
Hughes Aircraft

Date:

Source: Hughes Aircraft, 12 pages

Code: 32.19 - CD, CE

Title: FORUM on Fiber Optics

Author: Mendelshon, Alex
Associate Editor

Date: November 1980

Source: Electronic Products, pages 35 through 42

Code: 32.20 - CD, CE

Title: ITT Fiber Optic Systems and Components

Author: Anon.
ITT Electro-Optical Products Division

Date: Various

Source: ITT, 5 technical notes (R-1, R-4, R-5, R-6, R-8), 12 single information sheets, 3 multiple information sheets

FIBER OPTICS

Code: 32.21 - CD, CE, CH

Title: Aircraft Fiber-Optic Interconnect Systems Project

Author: Harder, R.D.
IBM Federal Systems Division

Date: August 15, 1980

Source: Naval Ocean Systems Center Technical Report 576, 228 pages

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Code: 32.22 - CD, CE

Title: Fiber Optics Transmitter Integrated Circuit Development

Author: Elmer, Ben R.
Honeywell, Inc.

Date July 1978

Source: NTIS AD-A071 437/8ST, 130 pages

Code: 32.23 - CC, CD, CE

Title: LEDs or DLs: Which Light Source Shines Brightest in Fiber-Optic Telecomm Systems?

Author: Lauer, R.B.; Schlafer, J.
GTE

Date April 12, 1980

Source: Electron Design, Vol. 28 #8, pages 131-135

Code: 32.24 - CD, CE, CH

Title: Optimize Optical Modem Cost/Performance Through Emitter, Detector and Fiber Selection

Author: Randall, Eric; Lavelle, Ron
Galite, Inc.

Date April 12, 1980

Source: Electron Design, Vol. 28, #8, pages 125-127

FIBER OPTICS

Code: 32.25 – CC, CD

Title: Fiber-Optic Semis Carve Out Wider Infrared Territory

Author: Ohr, Stephan

Date: January 18, 1980

Source: Electron Des., Vol. 28, #2, pages 52-54

Code: 32.26 – CD

Title: Fiber-Optics Links Work Better When Matched with the Right Emitters

Author: Fellinger, David V.; Matare, Herbert F.
IAV Incorporated

Date October 25, 1978

Source: Electron Design, Vol. 26, #22, pages 112-115

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 33

COMPUTER PROGRAMMING LANGUAGE TECHNOLOGY

This technology brief addresses representative programming languages widely used in military systems having applicability to the AAAS.

Potential AAAS Applications

- Stores management software (operational and executive)
- Stores system management and control
- Weapon delivery control
- Signal processing

Advantages

- Pascal, FORTRAN 77, JOVIAL, Ada, and CMS-2 all provide for structured programming.
- Pascal permits a smooth transition to Ada.
- JOVIAL and Ada, as compared to CMS-2M and FORTRAN 77, are projected to offer better reliability and maintainability.
- CMS-2M can specify packed tables for interfacing with hardware-defined data structures.
- CMS-2 is widely used for Navy computers.
- Ada permits multidimensional structuring of programs to meet the parallel processing domain of embedded computers. Ada also allows for plug-in use of software components, regardless of the source language in which they are written.

Further advantages are listed in Table 33-1.

Disadvantages

- HOL execution time is slow, but this disadvantage is negated by the use of faster microprocessors.
- HOL programs generally use more memory.

Further disadvantages are listed in Table 33-1.

Risks

The primary risks of slower processing speeds and inefficient use of memory associated with HOLs in the past are disappearing. Current versions of the HOLs discussed above will satisfy most requirements for AAAS applications. Ada represents the highest risk of the HOLs discussed here, since it is a new language and therefore not proven. However, its design has been an ongoing international effort since 1975, and further is fashioned very closely to that of the widely implemented Pascal. The primary risk associated with Ada is the shortage of personnel experienced in its use. Systems currently in development or about to begin development can avoid this risk by utilizing other HOLs, such as Pascal or J73, for initial development and implementation. After successful implementation at some future time, the operational software could be transitioned to Ada, the planned DoD standard HOL.

Trends and State of the Art

SMS software is being implemented to an increasing extent in HOL rather than assembly language. Assembly language will still be used for some time for situations where timing and/or memory space are critical. To accommodate the trend toward HOL, a great quantity of HOL software development tools are available, including program design language, debugging aids, and system hardware and environment simulators.

Extensions of Pascal, such as Concurrent Pascal and UCSD Pascal, go far in meeting specific programming requirements. Another example of an extended Pascal is OMSI Pascal, which can be implemented for real-time applications.

In 1976, a 10-year program was adopted for the JOVIAL language by the Air Force Systems Command. The purpose of this program is to reduce the current inventory of "JOVIAL-like" languages to two standard versions (J3 and J73), with the intent of reducing the number of JOVIAL compilers that must be maintained and simplifying training requirements for Air Force computer programmers.

Firmware is being developed by private industry targeted to specific HOLs, such as Ada and Pascal. This would enable software development directly on the target computer rather than on a software development computer that merely emulates the target computer. Such an advancement would decrease software development costs while increasing efficiency.

Costs

The increased use of HOL and off-the-shelf software not only reduces development costs because of higher programmer productivity, but also improves system reliability/maintainability and thus decreases software maintenance costs. Software design aids are gaining in practicality and usefulness. These aid in quality control of software, which in the future may account for up to 50 percent of the total development budget. This expenditure is justifiable because of the potentially great cost of removing a "bug" in the field.

Table 33-1. ADVANTAGES AND DISADVANTAGES OF VARIOUS COMPUTER LANGUAGES

ADVANTAGES	
FORTRAN	Has no real advantage over the other HOLs, with the possible exception of having been in existence the longest.
JOVIAL	Includes constructs for exception handling and strong data typing.
CMS-2	Allows insertion of assembly language code directly between CMS-2 HOL statements.
Pascal	Programmer oriented — easy to write and read.
Ada	Includes all the advantages of other HOLs. Real-time processing and a high degree of exception handling constructs are built into the design. Allows separate compilation of individual modules. Program units can be compiled separately and easily linked, regardless of their source language, HOL, or assembly language.
DISADVANTAGES	
FORTRAN	Lacks low-level I/O, bit and partial word data manipulation, and tightly packed data records.
JOVIAL	The J73 version has no real strong disadvantages with the possible exception of its complexity.
CMS-2	Lacks strong data typing. It is the most complex language of this group, and difficult to implement and maintain.
Pascal	Originally handled sequential files only; exception processing was not available; common code must be duplicated and is inadequate for time-critical operations.
Ada	Because this language is new, it is not proven and there is a lack of experienced personnel. Ada includes several new features not familiar to a large segment of programmers.

Code: 33.1 – CI

Title: Digital Avionics Information System (DAIS)

Author: Stanten, S.F.; Williams, P.Y.; Flanders, D.A.; Stein, S.Z.; Adams, S.E.
Intermetrics Inc., Dayton, OH

Date: February 1980

Source: NTIS AD-A085 136/0

Code: 33.2 – CI

Title: Trends in Digital Data Processing and System Architecture

Author: Callaway, A.A.
R. Aircraft Establishment, Farnborough, Hamps, England

Date: May 1979

Source: AGARD Conference Proceedings, N272, 3 pages 1-3, 5

Code: 33.3 – CB, CI

Title: Progress on the FTMP Program

Author: Smith, T. Basil, III; Hopkins, Albert L., Jr.
C.S. Draper Lab., Cambridge, Mass.

Date: June 1979

Source: Proceedings of the Annual International Conference on Fault Tolerance Computer, 9th. IEEE Cat N79CH1396-IC 1979, 168 pages

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Code: 33.4 – CI

Title: Software Standard

Author: Walters, Steven A.; Trainor, W. Lynn
Systran Corp., Dayton, OH

Date: May 1979

Source: NAECON 1979 Proceedings

LANGUAGES

Code: 33.5 – CB, CD

Title: Radar Detection System; A Real Time Application Using ADA

Author: Holschbach, J.M.; Kamrad, J.M. II
Honeywell Avionics, Minneapolis, MN

Date: May 1980

Source: NAECON 1980

Code: 33.6 – CB, CI

Title: HOL for Signal Processors

Author: Matysek, T.E.; Novaco, A.C.
Westinghouse Electric Corp., Baltimore, MD

Date: May 1980

Source: NAECON

Code: 33.7 – CI

Title: TASK Force Distributed Software for Solving Problems of Substantial Size

Author: Anon.

Date: September 1979

Source: IEEE Proceedings of the 4th International Conference on Software Engineering, 17-19 Sept 1979

Code: 33.8 – CI

Title: ADA Exception: Specification and Proof Techniques

Author: Anon
Honeywell, Inc.

Date: February 1980

Source: NTIS AD-A086 577/4

Code: 33.9 – CI

Title: Rationale for the Design of the ADA Programming Language

Author: Anon
Honeywell, Inc.

Date: June 1979

Source: NTIS AD-A073 854

Code: 33.10 – CI

Title: High Level Language Oriented Aerospace Computer

Author: Vahey, Michael; Mosteller, George

Date: 1979

Source: NAECON, 7 pages

Code: 33.11 – CI

Title: High Order Language Architectures for DoD Tactical Systems

Author: Ligler, George T.

Date: 1979

Source: NAECON, 3 pages

Code: 33.12 – CI

Title: DOD's ADA Compared to Present Military Standard HOLS – A Look at New Capabilities

Author: Scheer, Linda S.; McClimens, Michael G.
Systems Consultants, Inc.

Date: 1980

Source: NAECON, 9 pages

LANGUAGES

Code: 33.13 – CI

Title: Ada – The DoD Common High Order Language

Author: Whitaker, Lt. Col. William A.
USAF

Date: 1979

Source: NAECON, 4 pages

Code: 33.14 – CI

Title: JOVIAL Language Control

Author: Slavinski, Richard T.
Rome Air Development Center

Date 1979

Source: NAECON, 6 pages

Code: 33.15 – CI

Title: Pascal Programming Language Easy to Write and Troubleshoot

Author: Richerson, M.E.

Date August 7, 1980

Source: Machine Design, Vol. 52, #18, pages 112-118

Code: 33.16 – CI

Title: POPSS, A System for Modelling and Analyzing Operating System Resource Allocation Strategies

Author: Hughes, Charles E.; Walker, Justin C.
National Bureau of Standards, Tennessee University

Date 1974

Source: NTIS PB-255 814/6ST, 9 pages

Code: 33.17 - CI

Title: PASCAL - Survey of Existing Implementations

Author: \non
Old Dominion Systems, Inc., Lister Hill National Center for Biomedical Communications

Date: April 1979

Source: NTIS PB80-217177, 47 pages

Code: 33.18 - CI

Title: Computer Language Evaluation for MFTF SCDS

Author: Anderson, R.E.; McGoldrick, P.R.; Wyman, R.H.
California University - Lawrence Livermore Lab - Department of Energy

Date April 11, 1979

Source: NTIS UCID-18089, 14 pages

Code: 33.19 - CI

Title: Pascal 1100: An Implementation of the Pascal Language for Univac 1100 Series Computers

Author: Ball, M.S.
Naval Ocean Systems Center

Date July 1, 1978

Source: NTIS AD-A059 861/5ST, 26 pages

Code: 33.20 - CI

Title: *Concurrent Pascal with Backward Error Recovery: Language Features and Examples*

Author: Shrivastava, S.K.
University of Newcastle

Date December 1979

Source: *Software Pract. Exper., Vol. 9, #12, pages 1001-1020*

LANGUAGES

Code: 33.21 - CI

Title: With a Real-Time Operating System, a Pascal Program Can Run Your Test Set

Author: Krouse, Tim
Electro Sci Ind., Inc.

Date: December 1978

Source: Electron Des., Vol. 26, #26, pages 78-81

Code: 33.22 - CI

Title: Structured Specification of a Hierarchical Operating System

Author: Saxena, Ashok R.; Bredt, Thomas H.
Stanford University Digital System Lab

Date April 21-23, 1975

Source: IEEE (Cat #75CH0940-7 CSR), pages 310-318

Code: 33.23 - CI

Title: Programming Language Pascal

Author: Wakerly, John

Date November 1979

Source: Microprocessors Microsyst, Vol. 3, #9, pages 405-412

Code: 33.24 - CI

Title: Subprograms and Types Boost Ada Versatility

Author: Loveman, David
The Institute for Advanced Professional Studies Massachusetts Computer Associates, Inc.

Date October 25, 1980

Source: Electronic Design, pages 153 through 158

Code: 33.25 - CI

Title: Ada Knack for Multitasking Benefits Process Control

Author: Loveman, David
The Institute for Advanced professional Studies Massachusetts
Computer ASSOCIATES, Inc.

Date: December 6, 1980

Source: Electronic Design, 3 pages

Code: 33.26 - CI

Title: The Many Choices in Development Languages

Author: Ogdin, Carol Anne
Software Technique, Inc.

Date August 1980

Source: Mini-Micro Systems, 2 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 34

LARGE-SCALE INTEGRATION TECHNOLOGY

Large-scale integration (LSI) and the emerging very-large-scale integration (VLSI) represent state-of-the-art integrated circuits of particular interest to the AAAS Program. A future technology (late 1980s), very-high-speed integrated circuits (VHSIC) is considered beyond the present state of the art, and is not discussed herein.

Potential AAAS Applications

- Stores station equipment for analog, digital, and power interfaces
- Stores management integration, including the aircraft system interface unit
- Program controllers and distributed processing systems.

Advantages

- LSI (1,000 to 50,000 components per chip) has already proven to be a reliable, economic technology for implementing military circuitry. Numerous devices of LSI design are available for use in advanced armament systems.
- VLSI (greater than 50,000 components per chip) systems should be more reliable than LSI assemblies since they will contain fewer sources of failure, such as power chips and external connections (see Figure 34-1). As particular examples, VLSI would provide increased reliability of fault-tolerant computing and on-chip BITE for functional and diagnostic testing.
- Emerging, smaller VLSI devices provide increased clock speeds in the range of 100 MHz or more.
- Bipolar bit slice components of LSI design increase commonality and standardization between military and commercial markets.
- Because of the increased number of gates per chip, LSI and VLSI circuitry offer reduced power consumption, weight, volume, and cost (see Figure 34-2).

Disadvantages

- No major disadvantages are associated with the use of LSI, except for potential problems of improper device selection by designers.
- The smaller geometry sizes, and hence increased current density, of VLSI makes that technology somewhat potentially less reliable than LSI.
- VLSI technology requires more complex manufacturing techniques, such as multilevels of interconnections on the same chip. Problems of increased contact resistance and instability are the most serious technical issues to be overcome.
- Parasitic effects of current design may be unforeseen and unrecognized in VLSI circuits.

Risk

The risk in using LSI technology for the AAAS is considered low because of the numerous successful applications of LSI in DoD systems. For example, microprocessors of LSI design are being used in avionics computers, radar signal processors, displays, and fire control systems of F-16 and F-18 aircraft.

VLSI technology is considered of medium risk since it is an emerging technology. VLSI is being extensively applied in high-density memory devices. A limited number of 32-bit microprocessors of VLSI design have been marketed. Projections are that VLSI will be available for DoD systems within the next few years (see Figure 34-3).

Trends and State of the Art

– LSI. The speed and power capabilities of available LSI circuits are demonstrated in Figure 34-4. Emerging GaAs devices offer significant improvements in speed over the conventional silicon types. LSI designs are shifting from the once-predominant NMOS to CMOS because of the lower power requirements of the latter type. For digital or analog processing, the following circuits are available:

- Microprocessors of 4- through 16-bit architecture containing arithmetic units, I/O functions, and programmable memories. These circuits are capable of processing real-time analog signals and are suitable for distributed processing.
- Single-chip circuits that combine D/A and A/D converters with microprocessors. These circuits are also available without microprocessor elements.
- Multiplier circuits for use in the fabrication of complex digital filters.
- Bipolar, 8-bit-slice based assemblies

– VLSI. VLSI circuits are becoming available as 32-bit microprocessors. Other, more readily available, types include:

- NMOS microprocessor chips having a 32-bit CPU, I/O processor, memory controller, 528-kb ROM, and 128-kb RAM
- Multipliers for advanced filtering applications
- D/A and A/D converters employing an erasable and programmable memory.

Future VLSI capabilities are summarized in Table 34-1.

Cost

The cost benefits of using LSI and larger integrated circuits are well known. Typical benefits are summarized in Figure 34-5.

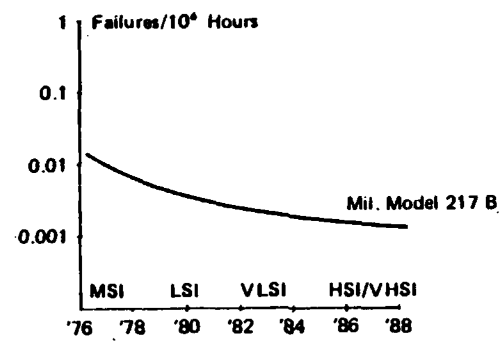


Figure 34-1. FAILURE RATES/GATE PROJECTIONS

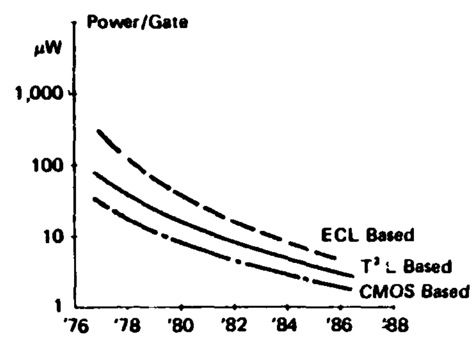


Figure 34-2. POWER/GATE PROJECTIONS

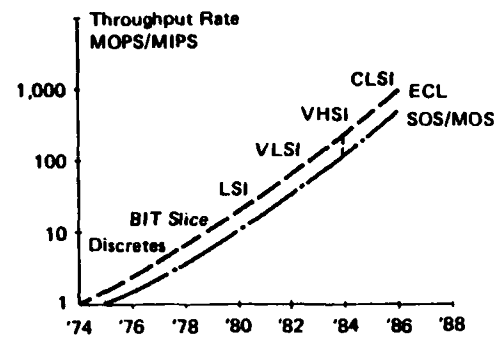
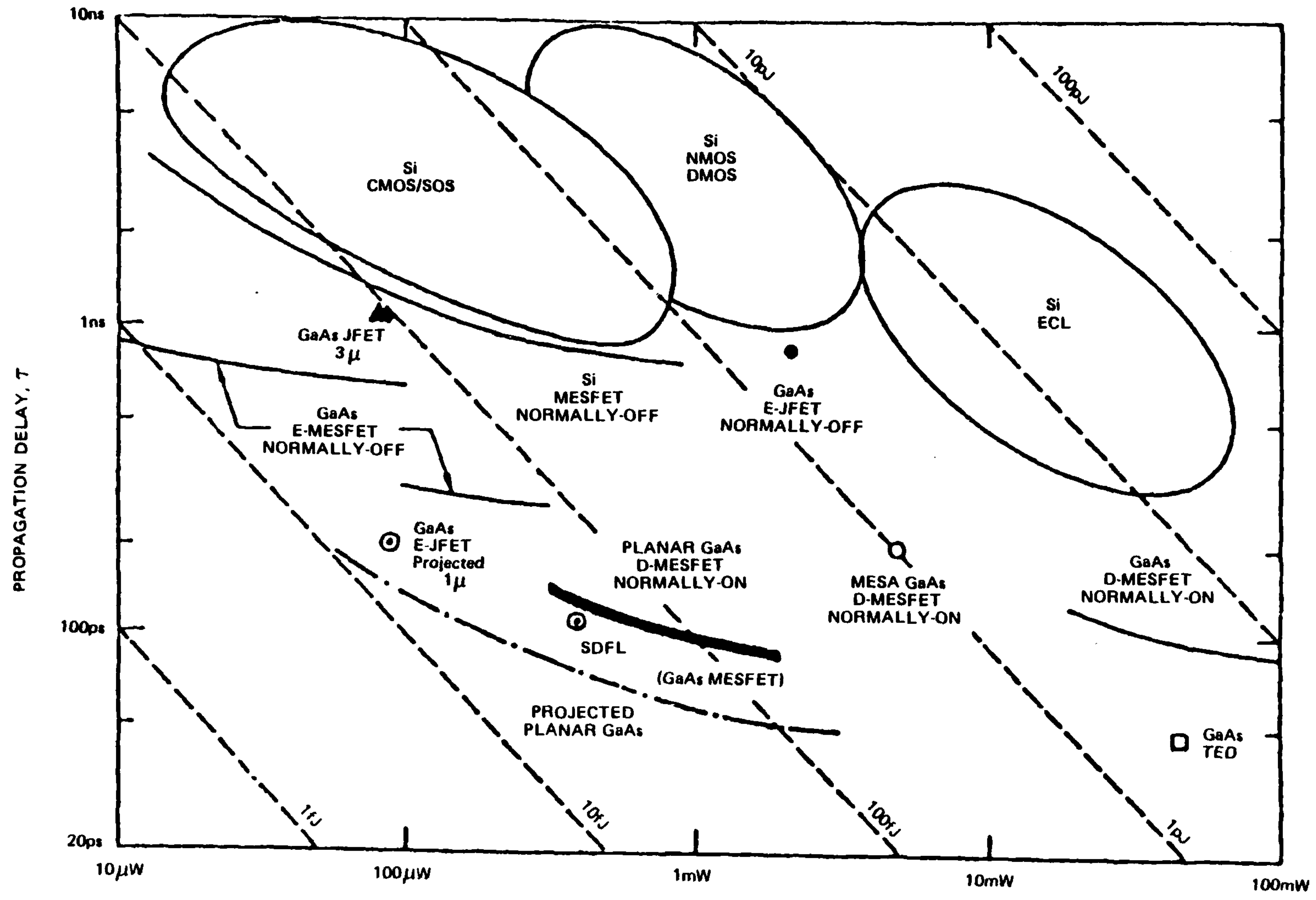


Figure 34-3. COMPONENT TRENDS

– *All figures courtesy Electronics Test Magazine (© 1980, Benwill Publishing Corp.)*



NOTE: f_j = femto joules
p_j = picojoules
μ = micro
τ = speed

Figure 34-4. POWER/SPEED RATINGS FOR LSI TECHNOLOGIES

– Courtesy Astronautics and Aeronautics (© 1980, AIAA)

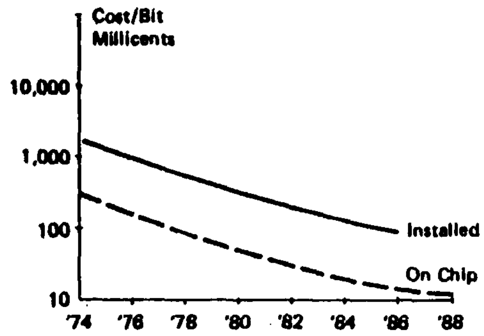


Figure 34-5. COST/BIT PROJECTIONS

– Courtesy Electronics Test Magazine (© 1980)

Table 34-1. FUTURE VLSI FUNCTIONS

Function	Maximum Capacity	
	1981	1985
RAM	256 K Bits	1 M Bits
ROM	1 M Bits	4 M Bits
MICROPROCESSOR	16 Bit	32 Bit
CUSTOM LOGIC		
MOS	80 K Gates	130 K Gates
BIPOLAR	40 K Gates	90 K Gates

– Courtesy IEEE (© 1979)

[illegible] Keeps the Extra Functions Coming

[illegible] 1980

[illegible] Design, 2 pages

[illegible] CD, CG

[illegible] and CMOS A/D LSI Performance/Cost Tradeoffs

[illegible] Haque, Y.; Nedbal, R.; Nicholson, B.; Gregorian, R.
AM Microsystems, Santa Clara, CA

September 1979

[illegible] Technical Paper V23, 16/3, Western Electronic Show and Conference, 6 pages

---

Code:	34.3 - CB, CD, CG
Title:	Bipolar VLSI for High-Performance Digital Signal Processing
Author:	Koral, William TRW, El Segundo, CA
Date:	March 1979
Source:	IEEE National Telecommunications Conference, March 27-29, 1979, Vol. 2, p. 25.

Code:	34.4 - CD, CE
Title:	LSI Chips Ease Standard 488 Bus Interfacing
Author:	Williams, Ronald M. Intel Corp., Santa Clara, CA
Date:	October 1979
Source:	Computer Design, Vol. 18, No. 10, Oct. 1979, pages 123-131

Code:	34.5 - CB, CD
Title:	One-Chip Data-Encryption Unit Accesses Memory Directly
Author:	Beaston, John Intel. Corp., Santa Clara, CA
Date:	August 1979
Source:	Electronics, Vol. 52, No. 16, Aug. 2, 1979, pages 126-129

Code:	34.6 - CB
Title:	V-MOS Chip Joins Microprocessor to Handle Signals for Real Time
Author:	Biasco, Richard W. AM Microsystems, Santa Clara, CA
Date:	August 1979
Source:	Electronics, Vol. 52, No. 18, Aug. 1979, pages 131-138

Code:	34.7 - CB, CD
Title:	Programmable Logic Approach for VLarge Scale Integration
Author:	Patil, Suhas S.; Welch, Terry A. University of Utah, Salt Lake City
Date:	September 1979
Source:	IEEE Transaction Computors, Vol. C-28, No. 9, Sept. 1979, pages 594-601

Code:	34.8 - CB, CD, CE
Title:	Integrated Injection Logic (IIL) Gate Arrays Make Custom ICS Economically Feasible
Author:	O'Neil, William D. Exar Integr Syst., Sunnyvale, CA
Date:	September 1979
Source:	Computer Design, Vol. 18, No. 9, Sept. 1979, 4 pages between p. 168-174

Code: 34.9 – CD, CE

Title: Separating Data from Addresses on the 488 Bus

Author: Nguyen, Trung
Systron-Donner Corporation

Date: August 2, 1979

Source: Electronic, 4 pages

Code: 34.10 – CC, CE

Title: D-A Converter's Low-Glitch Design Lowers Parts Count in Graphic Displays

Author: Yuen, Michael
Hybrid Systems Corporation

Date August 2, 1979

Source: Electronics, 5 pages

Code: 34.11 – CB, CD, CE, CG

Title: Large VLSI Module Multipliers

Author: Taylor, Fred J.
University of Cincinnati

Date 1980

Source: NAECON, 5 pages

Code: 34.12 – CD, CE

Title: *Interface Bus Transceivers*

Author: Anon
Texas Instruments

Date

Source: Machine Design, 1 page

LARGE SCALE INTEGRATION

Code: 34.13 – CB, CI

Title: Built-In Test and VHSIC/VLSI Technology

Author: Heines, J.M.H.
Raytheon Company

Date: October 1980

Source: *Electronics Test, pages 60 through 74*

Code: 34.14 – CB, CD, CE, CG

Title: *Microfunctions Distribute VLSI Advantages*

Author: Hughes, John; Conrad, Marvin
Microprocessor System Engineering, Texas Instruments
Semiconductor Group

Date December 20, 1980

Source: Electronic Design, pages 81 through 88

Code: 34.15 – CB, CD, CE, CG

Title: Applications of LSI to Digital Systems: An Overview of Expectations and Reality

Author: Giles, Dean M.; Nash, Jeffrey M.
TRW, Inc. - VERAC, Inc.

Date 1979

Source: NAECON, pages 26 through 31

Code: 34.16 – CB, CD, CE, CG

Title: VLSI With a Vengence

Author: Sumney, Larry W.
U.S. Dept. of Defense

Date April 1980

Source: *IEEE Spectrum; pages 24-27*

Code: 34.17 - CB, CD, CE, CG

Title: Very High Speed Large Scale Integration

Author: Keyes, Robert W.
IBM

Date:

Source: 12 pages

Code: 34.18 - CB, CD, CE

Title: Bit-Slide Microprocessor Emulation of an Aerospace Processor

Author: Mersten, Gerald S.; Oh, Se Jeung
Bendix Corporation

Date May 16-18, 1978

Source: NAECON, IEEE Cat. #78CH1336-7, pages 594-601

Code: 34.19 - CB, CD, CE

Title: Choosing a MUP by its Capabilities is a Growing 'Family Affair'

Author: Bursky, D.; Barnes, C.

Date July 5, 1977

Source: Electron. Design, Vol. 25, #14, 7 pages

Code: 34.20 - CB, CD, CE

Title: Microprocessor as an Intelligent Interface Between Flight Data Acquisition Equipment and a Minicomputer

Author: Kruisbrink, J.
The National Aerospace Laboratory NLR, Amsterdam

Date March 15, 1978

Source: NTIS N79-32861, 2 pages

LARGE SCALE INTEGRATION

Code: 34.21 - CB, CD, CE

Title: An NMOS Micorprocessor for Analog Signal Processing

Author: Townsend, Matt; Hoff, Marcian E. Jr.; Holm, Robert E.
Intel Corp.

Date: 1980

Source: NAECON, 6 pages

Code: 34.22 - CB, CD, CE

Title: Microprocessors: Optimizing Microprocessor Performance

Author: Bal, Subhash; Lavi, Yoav; Kaminker, Asher; Menachem, Avram
National Semiconductor Corp.

Date June 1980

Source: Mini-Micro Systems, 3 pages

Code: 34.23 - CB, CD, CE

Title: Microprocessors - 4 to 32-Bit - Push Back Performance Limits

Author: Bursky, Dave
Semiconductors Editor

Date November 22, 1980

Source: Electronic Design, pages 109 through 140

Code: 34.24 - CB, CD, CE

Title: Microprocessors: Evaluating the 16-Bit Chips

Author: Grappel, Robert; Hemenway, Jack
Hemenway Associates, Inc.

Date December 1980

Source: Mini-Micro Systems, pages 154 through 162

LARGE SCALE INTEGRATION

Code: 34.25 – CB, CD, CE

Title: Development Systems Support 16-Bit Microprocessors

Author: Weitzner, Steve
Executive Editor

Date: December 1980

Source: Electronics Products Magazine, 2 pages

Code: 34.26 – CB, CD, CE

Title: A Processor Family with the Flexibility You Need to "Design for Your System Requirements." Control Data 480

Author: Anon
Data Control Corporation

Date

Source: Data Control Corporation G-12712-0977, 4 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 36

MEMORY TECHNOLOGY

This technology brief presents information on semiconductor memories, magnetic bubble memories, and charge-coupled devices.

Potential AAAS Applications

- Data storage and retrieval in the computer and controller areas of process control equipment, stores station equipment, and data transfer equipment
- Refer to Table 36-1 for functional applications.

Advantages

- Semiconductor memories offer high storage density and fast speed, and have a good reliability history.
- Some memory devices can be programmed and erased either electrically or with ultraviolet light.
- Nonvolatile memory devices are available for airborne applications.
- Static RAM devices have an inherent speed advantage over dynamic devices.
- Bubble devices offer megabit mass storage capability in a small, rugged form suitable for military airborne applications.

Disadvantages

- Standardization efforts for certain devices have proven inadequate to date.
- Systems designed with memory devices require complex tradeoffs among performance, technology, cell structure, and packaging. The numerous circuits and variables associated with memory technology necessitate very creative designing to prevent improper system designs and applications.
- Bubble devices are an emerging technology, with limited risk information available.
- Charge-coupled device technology is no longer being pursued by manufacturers as a prime candidate for memory application because of the slow speed and volatility of these devices.

Risk

Since the semiconductor memory is an established technology, having been successfully applied in numerous aircraft and space applications, such devices represent a low technical risk. Care should be taken, however, when considering devices at the leading edge of development. Historically, development goals have usually been met but the projected schedules for these developments have been substantially exceeded in many cases.

The risk in using bubble memories is considered medium. Although no major reliability problems have been experienced in commercial applications, military airborne applications have been insufficient to provide confidence in the utilization of bubble memories for the AAAS. However, several high-reliability space programs are considering the use of bubble devices in onboard processing systems.

Trends and State of the Art

— Static RAMs. The most prevalent static RAM applications are the 4-kb HMOS and CMOS structures, which have access times ranging from 35 to 75 ns. Bipolar devices, although faster (e.g., 6.5 ns) are limited in availability at these speed levels.

Bit-wide static RAMs of 16Kx1 organization, fabricated using HMOS, bipolar, or CMOS structures, will be in production in 1981, along with byte-wide static RAMs of 2Kx8 organization. These latter devices, although slower in access time and of higher power dissipation than bit-wide devices, find numerous applications in microprocessor systems.

— Dynamic RAMs. Dynamic RAMs of 64Kx1 organization have power dissipation levels from 200 to 400 mW and access times from 100 to 500 ns. RAMs having 8Kx8 organization are expected to be available in the near future (1981-1982), while growth will increase to 256 kb in 1984 and 1 Mb in 1987.

— Pseudostatic RAMs. Some dynamic memory devices have on-chip automatic or semiautomatic refresh circuitry and are available in various organizations.

— ROM Memories. NMOS mask-programmed ROMs of 64-kb capacity are available, along with a 256-kb NMOS device having an 80-ns access time.

In development are 128-kb CMOS ROMs having access times of 2 to 20 us and a standby current of 200 uA. International companies have produced 1- to 4-Mb ROMs of wafer size, as well as a 512-kb ROM chip.

Bipolar ROMs have bit densities of up to 8 kb. No new developments are in progress in this area.

— PROM Memories. Fuse-link PROM devices have bit densities of from 8 to 16 kb. Most PROMs are implemented in Schottky TTL, and achieve access speeds in the 30- to 90-ns range. State-of-the-art 16-kb devices are available in 2Kx8 format, emerging in the 4Kx4 format. In the more distant future, 32-kb devices will be marketed.

— UVEPROMs. UVEPROMs have bit densities up to 16 kb, with 32- and 64-kb devices beginning to emerge and 256-kb versions expected to be available within 5 years.

— EEPROMs and EAPROMs. These devices have bit densities of up to 8 kb, with at least one type employing NMOS memory cells and CMOS peripheral circuits.

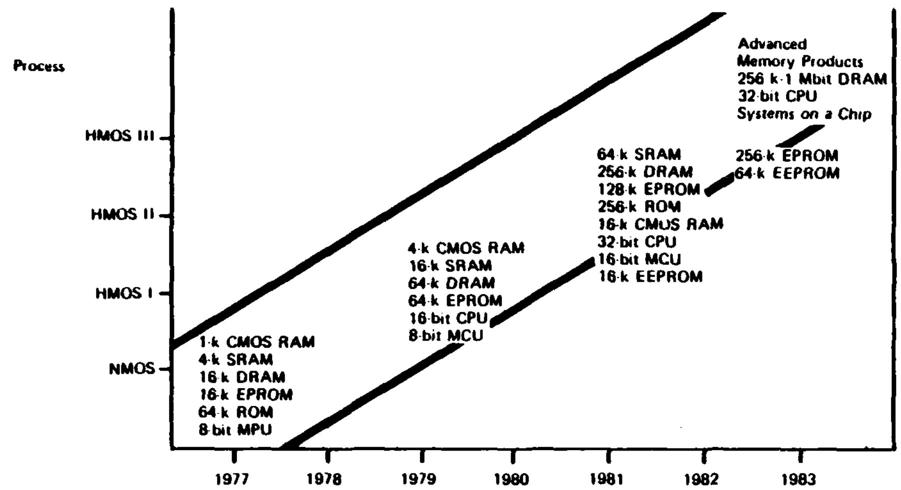
— CCD Memories. Other technologies appear to have nullified the requirement to develop CCD technology. Although some experts take exception to this prognosis, the future of CCD memories is uncertain.

— Magnetic Bubble Memories. Magnetic bubble memories are available with bit densities of up to 1 Mb. Near-term developments will increase the sources of 256-kb and 1-Mb devices.

Projected capabilities of various memory devices are depicted in Figure 36-1.

Cost

The cost direction of semiconductor, CCD, and magnetic bubble memory devices is illustrated in Figures 36-2 and 36-3.



Geometry	4-6 um	2-4 um	1-2 um	Submicrometer
Density	10k	100-300k	750k	1-million
Area factor	1	0.48	0.26	0.15
Lithography	Optical proj. print chrome masks mixed wet/dry etch	Optical proj. print chrome masters dry etch	Optical direct-step adv etch lower resist inter	E-Beam X-ray Direct step
Approx gate delay	10 ns	4 to 5 ns	2 to 3 ns	1 ns

Motorola

– *Courtesy Electronic Design Magazine*
(© 1981, Hayden Publ. Co.)

Figure 36-1. PROJECTIONS OF MEMORY CAPABILITIES

– *Courtesy Computer Design Magazine*
(© 1979, Computer Design Publishing Corp.)

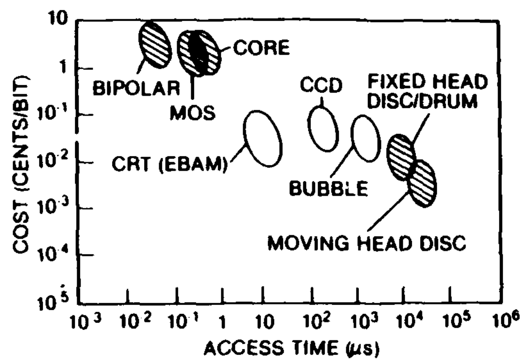


Figure 36-2. MEMORY TYPE AND COST PER BIT VERSUS ACCESS TIME

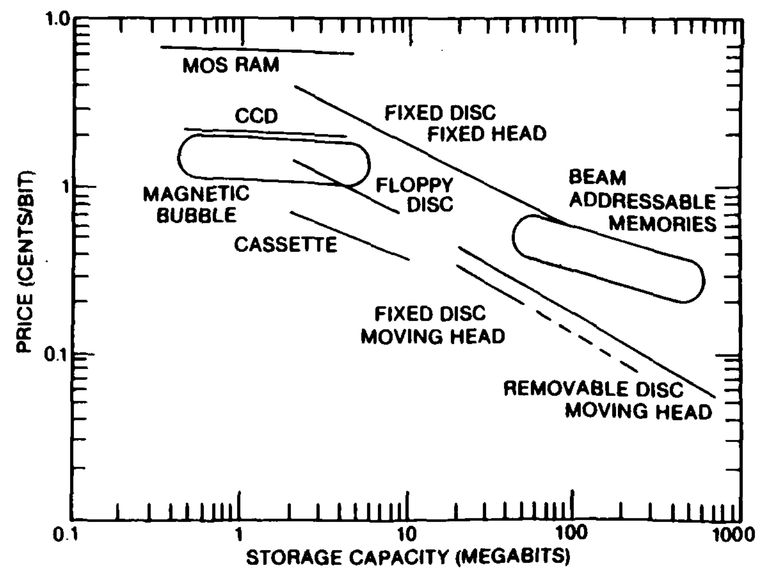


Figure 36-3. MEMORY STORAGE CAPABILITY VERSUS COST

– *Courtesy Computer Design Magazine*
(© 1979, Computer Design Publishing Corp.)

Table 36-1. SEMICONDUCTOR MEMORY TYPES AND APPLICATIONS

Application	Memory Technology
High Density Bulk Storage	64k NMOS.dynamic RAM, magnetic bubble, MOS ROM
Microprogram Writable Control Stores	Magnetic bubble, static NMOS, ECL, and TTL RAM
Disc Replacement (Fixed and Floppy)	16k/64k dynamic RAM, magnetic bubble
High Speed	Bipolar (TTL/ECL), static NMOS RAM
Byte Organization (Microprocessor Support)	Static NMOS/CMOS RAM, bipolar P/ROM, CMOS/NMOS EPROM, programmable array logic
EPROM Compatible	Static NMOS RAM, MOS ROM
Low Power	CMOS P/ROM-RAM, static and power shutdown NMOS RAM
Nonvolatility	Bipolar P/ROM, magnetic bubble, bipolar/MOS ROM, EAROM
Intelligent Terminals	Magnetic bubble, static NMOS RAM
Peripherals	Magnetic bubble, bipolar P/ROM-ROM, MOS EPROM, EAROM, static RAM

– Courtesy Computer Design Magazine

Code:	36.1 – CD
Title:	Developments and Trends in Memory Technology
Author:	Paratt, D. Texas Instruments Ltd., Bedford, England
Date:	June 1980
Source:	Automation (GB), Vol. 15, No. 6, pages 39-42

Code:	36.2 – CB
Title:	CRT Controller Adds System Compatibility
Author:	Boisvert, C.J. Synertek Inc., Santa Clara, CA
Date:	April 1980
Source:	Computer Design, Vol. 19, No. 4, pages 154-156, 159-160, April 1980

Code:	36.3 – CD
Title:	A Two Transistor SIMOS EAROM Cell
Author:	Anon
Date:	June 1980
Source:	IEEE Journal of Solid State Circuits, Vol. SC-15, No. 3

Code:	36.4 – CB, CD
Title:	Bubble Memories are Bursting Out with Huge Densities in Small Packages
Author:	Bursky, D.
Date:	May 1979
Source:	Electron Design, Vol. 27, No. 10, p. 54-55, 10 May 1979

MEMORY

Code:	36.5 – CB
Title:	High Speed Data Acquisition and Hardware Signal Processors for the TM990/101 Microcomputer
Author:	Ford, J.; Sarkady, A.A. Dept. of Electrical Engineering, U.S. Naval Academy, Annapolis, MD
Date:	March 1980
Source:	IEEE Cat. No. N80CH1551-1, pages 313-318; IECI Annual Conference Proceedings, 6th

Code:	36.6 – CB, CD
Title:	Design of a Programmable Protocol for IEEE 488 Interface Bus
Author:	Vaidya, A.K. University of Wisconsin, Madison, WI
Date:	March 1980
Source:	IECI Annual Conference Proceedings IEEE Cat. N80CH1551-1, pages 325-329

Code:	36.7 – CB, CD
Title:	NMOS Microprocessors for Analog Signal Processing
Author:	Townsend, Matt; Hoff, Marcian F., Jr.; Holm, Robert E. Intel. Corp., Santa Clara, CA
Date:	February 1980
Source:	IEEE, Journal of Solid State Circuits, Vol. SC-15, No. 1, Feb 1980, pages 33-38

Code:	36.8 – CB
Title:	Status and Future of VMOS Memory Technology
Author:	Rodgers, T.J.
Date:	October 1979
Source:	Electrochemical Society Extended Abstract, Vol. 79-2, October 14-19, 1979, pages 825-829

Code: 36.9 – CB

Title: Megabit Bubble Memory for Non-Volatile Storage

Author: Siegel, P.
Intel. Magnetic, Santa Clara, CA

Date: February 1980

Source: Electronic Engineering (London), Vol. 52, No. 634, Feb 1980, pages 51-59

Code: 36.10 – CB

Title: Solid State Look to VLSI

Author: Bernhard, Robert

Date: January 1980

Source: IEEE Spectrum, Vol. 17, No. 1, Jan. 1980, pages 44-49.

Code: 36.11 – CB

Title: Overview of Programmable Logic and Memory Devices

Author: Bursky, Dave
Electron DES MAG, Sunnyvale, CA

Date: September 1979

Source: Wescon Tech papers, Vol. 23

Code: 36.12 – CB

Title: UV EPROM as a Circuit Element

Author: Greene, Bob
Intel. Corp., Santa Clara, CA

Date: September 1979

Source: Wescon Tech papers, Vol. 23

MEMORY

Code: 36.13 – CD

Title: MNOS BORAM Manufacturing - Project and Technology Project

Author: Brewer, J.E.
Westinghouse DESC, Baltimore, MD

Date: February 1980

Source: NTIS AD-A081 662/9

Code: 36.14 – CB

Title: Advanced Bubble Memories

Author: Anon.

Date: April 1980

Source: International Defense Review, Vol. 13, No. 4

Code: 36.15 – CB

Title: Magnetic Bubble Memory

Author: Anon.

Date: November 1979

Source: Midcon 1979 Conference Records, Nov. 6-8, pages 14, 26 and Volume 3

Code: 36.16 – CB

Title: Byte-Erase/Write-Ability Speeds Memory Change

Author: Anon.

Date: November 1980

Source: Electronic Products Magazine, 1 page

MEMORY

Code: 36.17 – CB

Title: Bubble Memory Pricing

Author: Anon

Date: October 9, 1980

Source: Machine Design, 2 pages

Code: 36.18 – CB, CD

Title: EEPROM Eclipses Other Reprogrammable Memories

Author: DesRochers, Gary
Hughes Aircraft Company

Date November 22, 1980

Source: Electronic Design, pages 247 through 250

Code: 36.19 – CB, CD

Title: Bubble Memories Hold a Lot in Store for uCs

Author: Swanson, Paul
Rockwell International

Date November 22, 1980

Source: Electronic Design, pages 263 through 268

Code: 36.20 – CB

Title: UVEPROMs and EEPROMs Crash Speed and Density Limits

Author: Bursky, Dave
Semiconductors Editor

Date November 22, 1980

Source: Electronic Design, pages 55 through 66

Code 37

PACKAGING TECHNOLOGY

Advanced packaging approaches for utilization in the SMS are described in this technology brief, together with current trends in production for solving interconnection problems. Packaging approaches of particular interest include the Standard Avionics Module (SAM), Standard Electronic Module (SEM), Improved SEM (I-SEM), Tape Automatic Bonding (TAB), and chip carriers.

Potential AAAS Applications

- Process control equipment
- SMS interface to data bus
- Control and display equipment
- Power conditioning equipment

Advantages

- SAM should provide optimum packaging techniques for advanced armament electronic systems and modular avionics
- I-SEM offers improved cooling characteristics and thermal properties for advanced armament systems (see Figure 37-1), and increased "pinout" capability.
- Chip carrier technology reduces (relative to the standard DIP) the surface area required for attachment of components to boards or substrates (see Table 37-1). Chip carriers are more compatible with LSI and VLSI devices than other packaging technologies.
- CAD/CAM technology allows the use of hardwired electronics at a cost and time reduction over conventional PCB approaches.

Disadvantages

- Need for industry acceptance of such changes as eventual replacement of DIPs by chip carriers, and the standardization of pinouts for LSI and VLSI. This situation causes apprehension concerning future availability and cost of components for implementing advanced modular packaging.
- The Modular Avionics Packaging (MAP) Program is not compatible with USAF architectural concepts due to the use of the I-SEM 2A as the building block. MAP also fixes rack size and allows no installation flexibility for the airframe manufacturer.

Risk

The risk in using the above technologies for advanced armament systems is considered low to medium. One reason is that certain approaches such as the SAM will require more involved testing and qualification before full confidence can be gained. However, SEM has exhibited a very successful operational history.

Trends and State of the Art

— Standard Electronic Module. The state of the art for SEM is established, with more than 4.5 million modules committed to Navy electronic systems. The trend is toward greater use of I-SEMs due to their improved qualities and direct interchangeability with SEM. A development effort is underway to prepare an I-SEM with a microprocessor module based on carrier technology. The resulting circuitry will provide a fully buffered microprocessor function with 2Kx16 bits of PROM and 1Kx16 bits of static RAM.

To obtain more efficient packaging with a higher density of circuits per area, the SAM technology is evolving. SAM uses an approach similar to the SEM, but concentrates on mechanical, electrical, and thermal interfaces for airborne environments. SAM modules are projected to occupy approximately 3 x 6 inches of board area (1/2 ATR).

The Modular Avionics Packaging program has generated considerable interest. This program anticipates using the SEM and SAM technologies, along with an integrated rack concept. The latter concept allows for combining groups of standard modules into multiple subsystems packaged in a rack assembly that provides cooling, mechanical, and environmental protection as well as signal and power capabilities. The MAP Program schedule calls for flight testing in FY82. Tables 37-3 and 37-4 provide SEM information.

— Chip Carriers. Chip carriers are projected as a replacement for DIPs, and offer good potential for implementing SEM and SAM designs. Chip carriers consist of chips within leadless, hermetically sealed packages soldered to PCBs. They provide high density and permit higher functional capability with fewer "pinouts" and interconnections. Chip carriers are being investigated for application to Air Force and Navy systems.

— Tape Automatic Bonding. TAB packaging is emerging as a candidate for very-high-density circuit applications (see Figure 37-2). This method involves the mass bonding of integrated circuits to copper microinterconnections on insulated film, and is projected to eventually replace the common bare-chip mounting approach. With TAB, it is possible to mount 100 or more components on a single substrate.

— CAD/CAM. This design and manufacturing technology has been used for numerous high-reliability DoD programs having hardwired PCB systems. It is now being considered for complex interconnections to allow the use of welded-wire boards with chip carriers and TABs instead of multilayer PCBs. Hardwire welding of circuits permits fast turnaround time for electronic systems without sacrificing cost or reliability.

— Interconnection Technology. The trend toward LSI and VLSI, with their very-high-packaging densities, is producing new technology for interconnections. The advent of chip carriers and the TAB packages has aided these trends. High-density multilayer substrates for direct mounting of integrated circuit chips are emerging for use in attachment to the larger PCB (see Figure 37-3).

Cost

Cost directions for the packaging technologies discussed in this section are demonstrated in Figure 37-4 and Table 37-2.

– Courtesy IEEE (© 1979)

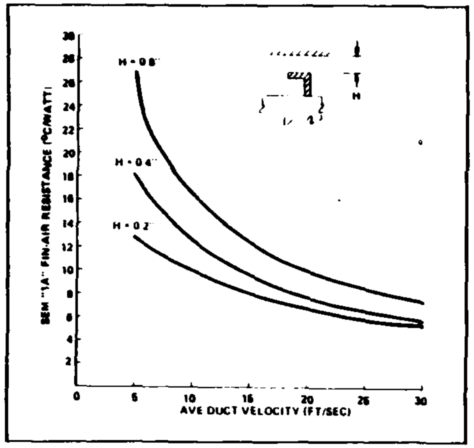


Figure 37-1. TYPICAL COOLING CHARACTERISTICS OF I-SEM

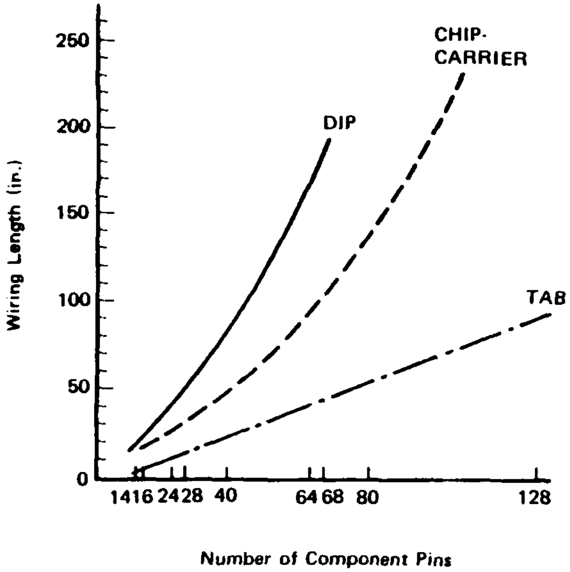


Figure 37-2. INTERCONNECTION REQUIREMENTS BY PACKAGE TYPE

– Courtesy Electronics Magazine (© 1980)

– Courtesy Electronics Magazine (© 1980)

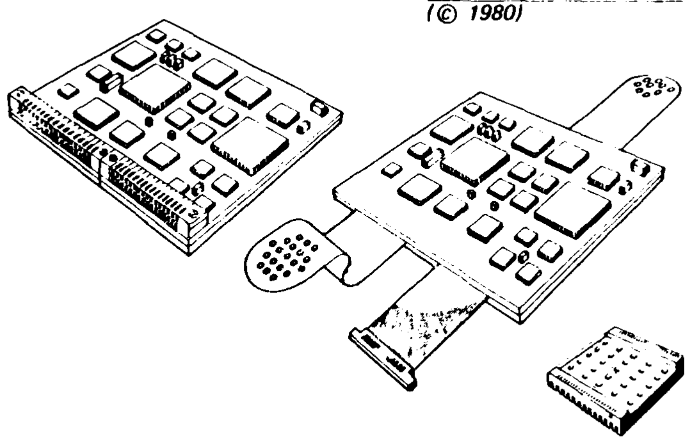


Figure 37-3. DESIGN CONFIGURATION FOR MULTISUBSTRATES

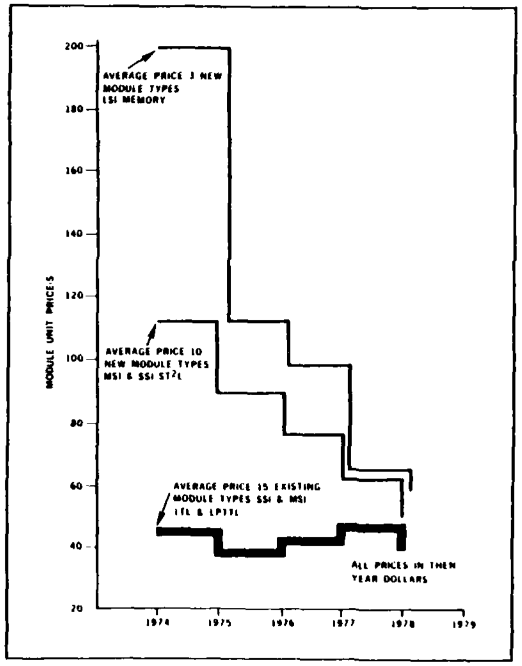


Figure 37-4. SEM COST DIRECTIONS

– Courtesy IEEE (© 1979)

AD-A107 680 ARINC RESEARCH CORP SANTA ANA CA F/G 1/3
TECHNOLOGY OVERVIEW FOR ADVANCED AIRCRAFT ARMAMENT SYSTEM PROGR--ETC(U)
MAY 81 H ROSENBERG, K BRAMAN, R BROOKS N60530-80-C-0270
UNCLASSIFIED 1789-01-1-2406 NL

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Table 37-1. COMPARISON BETWEEN CHIP CARRIER PACKAGE AND DUAL-IN-LINE PACKAGE

I/O count	1 Chip carrier area	2 DIP area	3 Ratio 2/1
16	0.0324	0.2400	7.4
18	0.0625	0.2700	4.3
24	0.1122	0.7200	6.4
28	0.1600	0.8400	5.3
40	0.2116	1.2000	5.7
48	0.2500	2.1600	8.6
64	0.5184	2.8000	5.4

Mean of column 3 = 6.16

Table 37-2 COMPARATIVE SYSTEM COST ANALYSIS FOR A CENTRAL PROCESSOR UNIT IMPLEMENTED IN SEVERAL PACKAGING DESIGNS

Packaging Type	IC	Board	Cabinet Cable, Assembly & Test	Total, Without Power or Cooling
DIP Assemblies 300 Boards	$3,000	$2,000	$3,000	$8,000
LSI and DIPs 7 Boards	$1,050	$1,050	$1,500	$3,600
LSI and 14 Chip Hybrids 1 Board	$1,920 ($1,050)*	$ 500 ($1,370)*	$ 750	$3,170
LSI and 4 Chip Hybrids 1 Board	$1,300 ($1,050)*	$ 400 ($600)*	$ 750	$2,450
Partial Hybrid Conversion to LSI	$1,000	$ 400	$ 750	$2,150

*Restated costs if hybrid substrates counted as "boards".

Table 37-3. MAXIMUM DEVICE POPULATIONS

Flatpacks	SEM 2A	ISEM 2A	ISEM/SEM
14 pin	40	60	1.5
16 pin	40	60	1.5
24 pin	14	28	2.0
40 pin	8	12	1.5
Dual-in-lines	**SEM 2A**	**ISEM 2A**	**ISEM/SEM**
16 pin	12	18	1.5
18 pin	8	12	1.5
24 pin	4	4*	1.0*
40 pin	2	2*	1.0*

*Can accommodate an additional horizontal row of 0.3 in. center DIPs

Table 37-4. MODULE LEVEL POWER CAPABILITIES

Configuration	Power (W) ISEM	SEM	ISEM/SEM
"1A" DIP frame	6.78	4.53	1.50
"1A" center frame	16.40	12.10	1.35
"2A" DIP frame	7.11	4.74	1.50
"2A" center frame	13.30	9.80	1.35

- Alloy 6101 aluminum frame
- 60°C guide rib
- 105°C max junction
- Chip carriers on center frames
- Junction–case resistance
  - –25°C/W for DIPs
  - –30°C/W for chip carriers

– All tables courtesy IEEE (© 1979)

Code: 37.1 – CB

Title: Circuit Board Packaging Considerations for Optimum Utilization of Chip Carriers

Author: Amey, Daniel I.; Balde, John W.
Sperry Univac, Blue Bell, PA

Date: March 1980

Source: IEEE Trans Components Hybrids Manufac. Technol., Vol. CHMT-3, No. 1, pages 105-110

Code: 37.2 – CE, CG

Title: CAD/CAM in Packaging Aerospace Electronics

Author: Gargione, Frank
RCA

Date: April 1980

Source: Astronautic Aeronautics, Vol. 18, No. 4, pages 56-59

Code: 37.3 – CB, CD

Title: Large VLSI Moduli Multipliers

Author: Taylor, F.J.
University of Cincinnati, OH

Date: April 1980

Source: Proceedings of the 1980 IEEE International Symposium on Circuits and Systems, pages 379-383

Code: 37.4 – CB

Title: Capability of the 300 *MIL CERDIP* with *Large Chip*

Author: Otsuka, K.; Komaru, T.; Tsueno, H.; Yamamoto, H.
Hitachi Ltd, Tokyo, Japan

Date: April 1980

Source: IEEE Proceedings of the 30th Electronic Components Conference, 28-30 April 1980, pages 67-73

PACKAGING

Code: 37.5 – CB

Title: IC Packaging Panels

Author: Anon.

Date: March 1980

Source: Electronic Packaging and Production, Vol. 20, No. 3, pages 51-52, 54, and 56-57

Code: 37.6 – CB, CE

Title: The Silicon Detector-Amplified Combination

Author: Anon.

Date December 1980

Source: Optical Spectra, 2 pages

Code: 37.7 – CB, CD, CG

Title: The Standard Electronic Modules Program

Author: Reece, D.M.; Huss, R.H.
Naval Weapons Support Center

Date December 1979

Source: IEEE Trans. Components, Hybrids and Manuf. Technol. Vol. CHMT-2 #4, pages 491-499

Code: 37.8 – CB, CD, CG

Title: The Impact of Standard Electronic Modules on Future Navy Electronic Systems Development

Author: Hugo, James W.
Defense Systems Management College

Date November 1977

Source: NTIS AD-A052 382/9ST, 46 pages

Code:	37.9 – CB, CD, CG
Title:	Modular Avionics Packaging (MAP)
Author:	Anon General Electric Company
Date:	November 30, 1977
Source:	NTIS AD-A059 637/9ST, 341 pages

Code:	37.10 – CE, CG
Title:	Standard Avionic Module Study
Author:	McBrayer. D.B.; Courtney, G.R.; Tomme, A.R. Vought Corp.
Date	March 1978
Source:	NTIS AD-A061 349/7ST, 183 pages

Code:	37.11 – CB, CD
Title:	Packaging for the Military Environment
Author:	Markstein, H.W.
Date	September 1977
Source:	Electron. Prod., Vol. 6, #8, 5 pages

Code:	37.12 – CE, CG
Title:	New Family of Microelectronic Packages for Avionics
Author:	Settle, Roger E. Jr. AF Avionics Lab, Wright-Patterson AFB
Date	June 1978
Source:	Solid State Technology, Vol. 21, #6, pages 54-58

PACKAGING

Code:	37.13 – CB, CD, CE, CG
Title:	Cost Effectiveness of Pluggable Wire-Wrappable IC Circuit Boards
Author:	Schwartz, William B. Garry Manufacturing Co.
Date:	October 17-18, 1979
Source:	Electron Connect. Study Group Inc., pages 339-347

Code:	37.14 – CB, CD, CG
Title:	Economics of Standard Electronic Packaging
Author:	Leskin, Robert; Smithhisler, William L. Hughes Aircraft Co.
Date	January 23-25, 1979
Source:	IEEE (79CH1429-OR), pages 67-72

Code:	37.15 – CB, CD, CG
Title:	Standard Avionics Packaging, Mounting, and Cooling Baseline Study
Author:	Baily, S.; Jackson, A.; Russell, J.; Smith, C.N.D.; Sullivan, N. ARINC Research Corp.
Date	January 31, 1980
Source:	NTIS AD-A082 166/0, 218 pages

Code:	37.16 – CB, CD, CG
Title:	Efficient Sources of Cooling for Avionics
Author:	Giles, G.R.; Stevenson, G.F. Normalair-Garrett Ltd. (England)
Date	June 10-11, 1976
Source:	AGARD Conf Proc #196, Paper #13, 19 pages

Code: 37.17 - CB, CD, CE

Title: Wanted: A New Interconnection Technology

Author: Lassen, C.L.
Exacta Circuits Ltd. (Scotland)

Date: September 27, 1979

Source: Electronics, Vol. 52, #20, pages 113-121

Code: 37.18 - CB, CD, CE

Title: Electronics Hardware Review

Author: McCormick, M.

Date March 1980

Source: Electron. Packaging and Prod., Vol. 20, #3, 9 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 38

RELIABILITY TECHNOLOGY

This technical brief addresses reliability technology in two areas: recent advances that have the potential of contributing to the reliability of SMS, and the latest publications and techniques for supporting reliability programs.

Trend Information

There is increasing reliance on software for organizing and speeding the use of reliability-oriented procedures originally developed for manual manipulation and for such prosaic purposes as the storage and retrieval of data files. Software reliability technical references have experienced significant refinements in recent years. Finally, the reliability of software itself continues as a research and development concern. A listing of areas in which advances have been made are:

- Application of graph theoretic methods of network reliability analyses
- Application of Fourier series to Bayesian techniques
- Application of Boolean/switching algebra to the reliability analysis of complex networks
- Continued development and availability of computer programs for performing system reliability predictions
- Continued development of computer programs for performing exhaustive tie-set and cut-set enumerations for complex systems
- Application of data management systems to searching and scoring FMEA and other tabular analyses.

Many of the programs mentioned above require failure rate estimates as an output. These estimates can be obtained as computer products. Many companies have automated the procedures for performing reliability predictions in accordance with MIL-HDBK-217. In addition, Defense contractors can obtain access to a government-owned prediction program (RADC-ORACLE), which is resident on the Rome Air Development Center computer.

Other examples of automated reliability analysis support are the Microcircuit Reliability Analysis Program (MRAP) and Semiconductor Reliability Analysis Program (SRAP). These programs compare an inputted parts list to a data base and, for each part, lists whether or not: a military specification is available, a QPL source exists, an alternate military specified part is recommended, the device is recommended for new designs, and if a standardization activity is planned. Besides their use in evaluating proposed program parts lists, the programs are used to generate listings to aid designers in selecting parts. One listing provides a functional description, specification and slash-sheet designator. It also provides a recommended substitute if a particular device is not recommended for use in new designs. A second listing provides cross-references to the data by commercial or generic part number. A third listing cross-references the military specification/slash sheet designator and generic number by DESC drawing number.

Another example of reliability computer software is a program for optimizing burn-in procedures originally published in 1978 in RADC-TR-78-55, Electronic Equipment Screening and Debugging Techniques. The program has been used by the Navy to design a screening program for the Mk 47 torpedo and by various industrial firms, one of whom estimated that its use could result in a cost avoidance of $900,000 a month.

Screening remains an area of high interest, with the Institute of Environmental Sciences leading a team to develop a recommended standard. A survey of current burn-in knowledge was made in 1980 and will be published in 1981 as an RADC Technical Report entitled, "Burn-in; Which Environmental Stress Screens Should be Used?" Among other findings, the report questions the adequacy of ten thermal cycles cited as sufficient in previous documents including NAVMAT P-942, Navy Manufacturing Screening Program, the only government screening standard now available.

Documents and Standards

Of primary significance is the release of DoD directive 5000.40, Reliability and Maintainability, 1980. The directive provides DoD standard R&M terms and mandates R&M accounting using terms related to operational effectiveness and ownership costs. These terms were anticipated by the Air Force and already implemented in AFR 80-5 and AFSC Supplement 1, both released in 1979.

MIL-HDBK-217C, Reliability Prediction of Electronic Equipment, Notice 1, was published in May 1980 with major changes in the monolithic integrated circuit and microwave solid state device models. In December 1980, the proposed MIL-HDBK-217D was released for coordination review, in accordance with the preparing activity (RADC) policy of annual revisions to the handbook. The proposed revision will add CCD, bubble memory, and GAAsFET models and change the environment factors, except for avionics environmental factors that will be changed in the 1982 revision.

MIL-STD-785B, Reliability Program for System and Equipment Development and Production, was published in 1980 by the Air Force Avionic Systems Division. That standard provides reliability program elements in a form amenable to tailoring for specific procurements.

Soon to be available is MIL-HDBK-189, Reliability Growth Management, prepared by the U.S. Army Communications Research and Development Command.

The International Electrotechnical Commission (IEC) is currently developing and publishing a standard (IEC publication 605) that gives procedures for equipment reliability compliance and determination testing.

Code: 38.1 – CI

Title: Redundancy in Data Structures: Improving Software Fault Tolerance

Author: Taylor, David J.; Morgan, David E.; Black, James P.
NAECON

Date: November 1980

Source: NAECON, pages 585 through 594

Code: 38.2 – CB, CI

Title: BIT & ATE Central to Military VLSI

Author: Beines, J. Matt
Raytheon

Date August 1980

Source: Military Electronics, pages 25 through 30

Code: 38.3 – CI

Title: A-7 Experiment Moving Toward F/O Validation

Author: Anon

Date August 1980

Source: Military Electronics, 2 pages

Code: 38.4 – CB, CD, CI

Title: Reliable Error Recovery in Distributed Computer Control Systems

Author: Schoeffler, J.D.
Cleveland State University

Date May 15-18, 1979

Source: IEEE - 1979 Power Industry Computer Applications Conference
PICA-79, pages 245-249

RELIABILITY

Code: 38.5 – CB, CD, CG

Title: Nonoperating Failure Rates for Avionics Study

Author: Kern, George A.; Tung, Steve S.; Quart, Irving; Wong, Kam L.
Hughes Aircraft Company

Date: April 1980

Source: NTIS AD-A-087 048/5, 154 pages

Code: 38.6 – CC

Title: Reliability and Maintainability Improvement Program for the AV-8A Harrier Head-Up Display Set. Vol. I. Modifications to Digital Display Indicator, IP-1351/AVQ-30(V)

Author: Lowrie, Richard W.
Smiths Industries Inc.

Date May 1, 1980

Source: NTIS AD-A085 309/3, 17 pages

Code: 38.7 – CI

Title: Memory Finds and Fixes Errors to Review Reliability of Microcomputer

Author: Anon.

Date January 1980

Source: Electronics, Vol. 53, No. 1, pages 168-72, 3 Jan. 1980

Code: 38.8 – CB, CI

Title: Validation Methods Research for Fault Tolerant Avionics and Control System

Author: Gault, J.W.; Trivedi, K.S.; Clary, J.B.
NASA, Hampton, VA

Date October 1979

Source: NTIS N80-23008/9

Code: 38.9 – CI

Title: An Error-Correcting System for Mobile Radio Data Transmission

Author: En, J.
Cubic Corp., San Diego, CA

Date: May 1980

Source: IEEE Transaction of Vehicle Technology, Vol. VT-29, No. 2, pages 278-80

Code: 38.10 – CB, CD, CI

Title: Status of the Reliability Technology 1980

Author: Coppola, A.

Date April 1981

Source: Reliability Society Newsletter, Vol. 27, No. 2, April 1981

Code: 38.11 – CI

Title: An Approach for Determining Optimum RAM Requirements

Author: Cox, T.D.; Morrison, B.L.
U.S. Army Logistics Center, Fort Lee, VA

Date January 1977

Source: 1977 Proceedings of Annual Reliability and Maintainability Symposium

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Code: 38.12 – CB, CI

Title: CARE 3, Phase 1, Volume 1

Author: Stiffler, J.J.; Bryant, L.A.; Guccione, L.
Raytheon Co., Sudbury, MA

Date November 1979

Source: NTIS N80-15423/0

RELIABILITY

Code: 38.13 – CI

Title: Pragmatic Software Reliability Prediction

Author: Wall, J.K.; Ferguson, P.A.
McDonnell

Date: January 1977

Source: 1977 Proceedings of Annual Reliability and Maintainability Symposium

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Code: 38.14 – CB, CI

Title: An Automated Program Testing Methodology and Its Implementation

Author: Benson, J.P.; Andrews, D.M.
General Research Corp., Santa Barbara, CA

Date 1980

Source: NTIS AD-A085-404/2; 23 pages

Code:

Title:

Author:

Date

Source:

Code:

Title:

Author:

Date

Source:

Code 39

SOFTWARE TECHNOLOGY

Software applications and trends, as relevant to the AAAS, are discussed in this technology brief.

Potential AAAS Applications

- Operating systems that provide top-level control
- Applications programs that perform the major SMS functions.

Advantages

- A single processor can accomplish multiple functions with software modules that would otherwise require more and bulkier hardware elements.
- Software technology provides the capability of accomplishing/monitoring routine navigational functions, thus allowing the flight crew more time for non-routine armament tasks.
- Fault-tolerant software architectures will increase the probability of mission success through increased advanced armament system reliability.
- Distributed software architectures lend themselves to adding or modifying functions.

Disadvantages

- The use of software instead of hardware for advanced armament system functions increases the cost of software development and maintenance. The cost is even greater for centralized architectures.
- Distributed architectures require more exhaustive testing of software modules at an earlier stage of development, thus necessitating earlier availability of test facilities and simulation techniques.

Risk

Utilizing software instead of hardware to accomplish aircraft armament functions is considered of medium risk. As they become increasingly complex, advanced aircraft armament systems will also become less understandable and manageable unless discipline is applied early in their design. Concepts of software modularity will help alleviate this problem. Other techniques that will reduce the risks associated with increasing complexity are the use of design management aids, e.g., requirement statement languages, high-order languages, and structured programming.

Trends and State of the Art

The refinement of current design aids and techniques will provide more reliable/ maintainable software and will also help to offset the increasing costs of software development. The current emphasis on software modularity and structured programming will continue. Modularity and structured programming both improve the maintainability of software.

The use of program design languages, such as PDL, are also gaining popularity. This tool provides a more thorough overall design early in the development of the software system. The "chief programmer" approach, top-down design philosophy, and peer design walkthrough are also software development techniques required of many projects, which result in a more orderly design.

The advent of software configuration control has helped to control and monitor the progress of software projects. Future enhancements of software configuration control will be methodologies for accessing the impact of proposed changes/enhancements on software that is already operational.

Advances in the hardware/software architectures have not kept pace with individual hardware/software techniques. However, microprocessor manufacturers are beginning to pay more attention to this area, as is evidenced by the hosting of HOL interpreters on the microprocessor itself. One manufacturer has built a Basic computer Language interpreter into a chip. Another manufacturer has developed a chip that has type checking and multitasking on the chip in preparation for direct translation of high-order languages.

The software resident in the AAAS should be coded in HOL for easier access, and will be modular in nature to facilitate changes and validation.

Other software trends include component software such as file management and protocol procedures that can be easily tailored to a user's particular requirements. Standard interface rules (the "software bus") will ensure compatibility between software components.

Cost

The overall cost of avionics software/hardware architectures will rise, but with the refinement of software development tools (see Figure 39-1) not necessarily in the same proportion as functionality. The increased use in AAAS of multifunction displays and controls will drive up software costs. The reduced workload benefits to the flight crews need to be weighed against the costs of implementing this custom-designed software. The improvement of software development tools and development methodologies will help keep development costs at a manageable level. More aggressive quality control procedures are being achieved during the software development phase, which improves reliability and maintainability, both of which will help to minimize software maintenance costs. Automatic programming (i.e., automated software code generation directly from user specified requirements) will reduce system development time and cost.

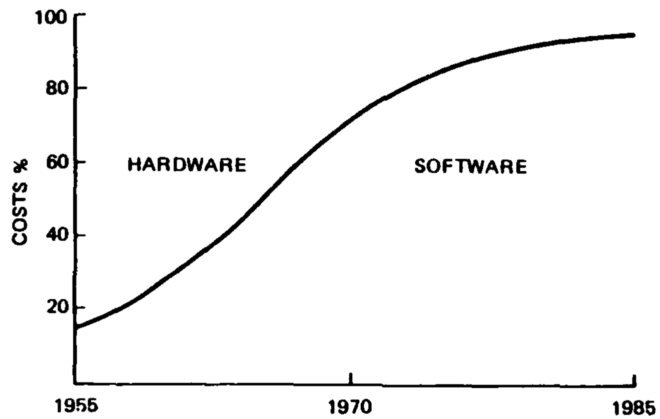

Figure 39-1. PREDICTED HARDWARE-SOFTWARE COST TREND

– Courtesy IEEE (© 1980)

Code: 39.1 – CB, CI

Title: Software Links A/D's to Computers

Author: Taylor, R.D.
Brooks Res. & Manuf. Inc.

Date: January 1976

Source: Electronic Design; Vol. 24, No. 1; pages 102-105

Code: 39.2 – CI

Title: Assessing Operator Task Loading: A Function Analytic Approach

Author: Helm, Wade R.
Naval Air Test Center

Date: July 11-16, 1976

Source: Human Factors Society, pages 243-244

Code: 39.3 – CB, CI

Title: Exception Handling in CLU

Author: Lisko, B.H.; Snyder, A.
MIT, Cambridge, Mass.

Date: November 1979

Source: IEEE Transaction Software Engineering Vol. SE-5, No. 6, Nov. 1979, pages 546-558

Code: 39.4 – CI

Title: Software Strategy for Multiprocessors

Author: Dawson, M.; Collins, B.; McBride, B.
Scicon Consultants International, Ltd., London, England

Date: August 1979

Source: Microprocessors Microsystems, Vol. 3, No. 6, pages 263-266

SOFTWARE

Code: 39.5 – CI

Title: ADA Exception, Specification and Proof Techniques

Author: Luckham, D.C.; Polak, W.

Date: February 1980

Source: Technical Report, Stanford University, CA, NTIS AD-A086 577/4, 21 pages

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Code: 39.6 – CI

Title: Rationale for the Design of the ADA Programming Language

Author: Ichbiah, J., et al

Date: June 1979

Source: Final Report by Honeywell System, Minneapolis, MN, NTIS AD-A073854, 267 pages

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Code: 39.7 – CI

Title: Human Factors in Interactive Computer Graphics

Author: Simanis, A.
National Defense Headquarters (Ontario)

Date: May 26-27, 1975

Source: National Res. Council of Canada, paper #4, 12 pages

Code: 39.8 – CI

Title: Evaluation of Software Life Cycle Data from the PAVE PAWS Project

Author: Anon

Date: March 1980

Source: NTIS AD A085-323

Code: 39.9 – CB, CI

Title: Fault Tolerance and Digital Systems

Author: Anon.

Date: October 1979

Source: Microprocessors Microsystems, Vol. 3, No. 8, Oct 1979, pages 365-373

Code: 39.10 – CB, CI

Title: Built-in Test of A/D Converters – Present Approach and Recommendations for Improved BIT Effectiveness

Author: Anon.

Date: May 1979

Source: NAECON

Code: 39.11 – CI

Title: On the Specifications and Testing of Software Reliability

Author: Anon.

Date: January 1980

Source: *Annual Reliability and Maintainability Symposium, IEEE*, 1980

Code: 39.12 – CI

Title: Reliability Measurement for Operational Avionics Software

Author: Thacker, J.; Ovadia, F.
Aerospace Corp.

Date: September 1979

Source: NTIS; N80-22000/7; 40 pages

SOFTWARE

Code: 39.13 – CB, CI

Title: Fault Tolerant Computer Network Study

Author: Comfort, Webb T.; Anthony, T.L.; Battle, T.R.; Kaufman, J.E.; Kogge, P.M.; et al
IBM Federal Systems Division

Date: April 1980

Source: NTIS AD-A088 066, 182 pages

Code: 39.14 – CB, CI

Title: Fault Tolerance Applications to Future Military Systems Avionics

Author: Harris, Robert L.; Jones, Lt. Col. Eugene E.
AF Wright Aeronautical Labs.

Date: 1979

Source: NAECON, 3 pages

Code: 39.15 – CB, CI

Title: F-15 Software Support

Author: Howard, Major John E.
Engineering Division (MMEC), Warner Robins ALC

Date:

Source: NAECON, 2 pages

Code: 39.16 – CI

Title: Software Standards

Author: Walters, Steven A.; Trainor, W. Lynn
SYSTRAN Corp.

Date: 1979

Source: NAECON, 6 pages

Code:	39.17 – CI
Title:	The Effect of Standardization on Avionics Software Quality Assurance
Author:	Rubey, Raymond J. SofTech, Inc.
Date:	1979
Source:	NAECON, 7 pages

Code:	39.18 – CC, CI
Title:	Tailoring Software Logic to the Needs of the Pilot: A Software Designer's Nightmare?
Author:	Murray, John; Reising, John Systems Consultants, Inc., and Air Force Wright Aeronautical Labs.
Date:	1979
Source:	NAECON, 5 pages

Code:	39.19 – CI
Title:	Logistics Support of Avionic Software Stored on Erasable Programmable Read Only Memory
Author:	Day, Douglas B. Support Systems Associates, Inc.
Date:	1980
Source:	NAECON, 6 pages

Code:	39.20 – CD, CE, CI
Title:	A Bus Oriented Modular Avionic Architecture
Author:	Moran, John F. General Electric Co.
Date:	1980
Source:	NARCON, 5 pages

SOFTWARE

Code:	39.21 – CI
Title:	Common Modular Multimode Radar (CMMR) Software Acquisition Study
Author:	Baily, S.; Gilbertson, R.; Straub, E. ARINC Research Corporation
Date:	September 1980
Source:	ARINC Publication 2302-01-1-2291

Code:	39.22 – CI
Title:	Automatic Test Software for Calibration Strapdown Systems
Author:	Stave, Lloyd P.; Andrews, Angus P. Rockwell International
Date	May 15-17, 1979
Source:	IEEE (Cat #79CH1449-8 NAECON), Vol. 3, pages 1111-1116

Code:	39.23 – CI
Title:	Digital Avionics Information System (DAIS) Mission Software
Author:	Stanten, S.P.; Williams, P.Y.; Stein, S.E.; et al Intermetrics, Inc.
Date	February 1980
Source:	Avionics Laboratory, Wright-Patterson AFB, 3 pages; #AFWAL-TR-80-1003

Code:	39.24 – CB, CI
Title:	A Microprocessor-Based Synchronous Communications Subsystem for Minicomputers
Author:	Schlesinger, H.M.; Rosenbaum, R.H. Distributed Systems Software Engng. - Digital Equipment Corporation
Date	September 26-29, 1978
Source:	Publ: North-Holland, Amsterdam, pages 77-81

SOFTWARE

Code:	39.25 - CI
Title:	Collins Adaptive Processing System (CAPS) Architecture Overview
Author:	Anon Rockwell International
Date:	
Source:	Rockwell International, 5 pages

Code:	39.26 - CI
Title:	A Hierarchy of Network Systems
Author:	Levy, Walter A. Edgewood Computer Associates, Inc.
Date	June 1980
Source:	Mini-Micro Systems, pages 79 through 100

Code:	39.27 - CI
Title:	Advanced Avionic Architectures for the 1980's: A Software View
Author:	Morgan, L. Frank Lockheed-California Company
Date	1979
Source:	NAECON, pages 13 through 18

Code:	39.28 - CI
Title:	Component Software Slashes System - Development Costs
Author:	Conrad, Marvin Texas Instruments
Date	22 January 1981
Source:	Electronic Design; pages 95-101

Code 40

SWITCHING TECHNOLOGY

This technology brief provides a state-of-the-art review of high power switching technology, with particular attention to solid state devices.

Potential AAAS Application

- Power conditioning equipment for advanced armament systems

Advantages (Bipolar vs. MOSFET Devices)

- Bipolar transistors provide higher current and voltage, are current-controlled, have lower forward voltage drops, cost less, and have an established reliability history.
- MOSFET devices have faster switching speeds, are less susceptible to secondary breakdown failure (see Figure 40-1), require less drive power, are voltage controlled, and are compatible with CMOS and TTL because of their higher input impedance.
- The use of MOSFETs in switching power supplies reduces power dissipation.

Risk

The risk in using the power semiconductor switches described herein for SMS is low due to extensive successful military applications.

Trends and State of the Art

. Solid-State Components

— Bipolar Power Semiconductor Switches. Typical devices are capable of operating in the 50-100 kHz frequency range, and can carry 40A of current at up to 600V. Some devices can carry 8A at voltages of 900, 1,200, and 1,500; and Darlington bipolar devices (see Figure 40-2) can carry up to 20A at 850V and 60A at 250V. One company has announced a 100A Darlington rated at 900V.

Trends in bipolar development are toward increasing speed to make them competitive with FETs. One such device in development has been demonstrated to operate at 0.5 MHz, and has current ratings varying up to 30A for voltages from 40 to 450. For power applications where speed is not critical, bipolars exist that are rated at 200A peak at 450V. One foreign supplier claims to have a transistor in limited quantity that is rated 300A continuous (450V peak).

— MOSFET Power Switches. Fast-switching MOSFET devices (Figure 40-3) are typically rated at 28A at 60V, or 11A at 400V. New manufacturing techniques and material improvements are beginning to yield MOSFETs having higher currents and voltage.

The earlier VMOS structures are competing with newer DMOS and TMOS types that provide current ratings (pulsed) of 16A at 400V. These devices exhibit forward voltage drops comparable to those of bipolar types.

Numerous lower power FETs are available with typical characteristics of 40 ns switching speed at currents (continuous) of 4A from 40 to 80 volts. These devices are emerging in production quantities, with trends toward higher voltage and current without sacrificing speed.

– Thyristors. These high power devices, also referred to as SCRs, have capabilities up to 2 kV (standoff) and up to 10 kA peak current capacity. A unique aspect of SCRs is the ability to be triggered by a laser light source.

– Hot Carrier Diodes. These devices, also known as Schottky diodes, operate at very high frequencies, although limited to 75A at 45V (breakdown). They have a forward voltage drop half that of a PN junction diode.

– Standard Diodes. Fast-recovery diodes are emerging having speeds of 50 to 70 ns, with capability of 30 to 70 amperes at high voltages. Variations of these devices have voltages up to 600V, and current ratings up to 100A.

Cost Direction

Bipolar devices are less expensive than MOSFETs. A rule of thumb for pricing is that off-the-shelf power transistors rated at 100A and up cost between $1 and $2.50 per ampere. It is anticipated that solid-state switches will become less expensive than their electromechanical counterparts.

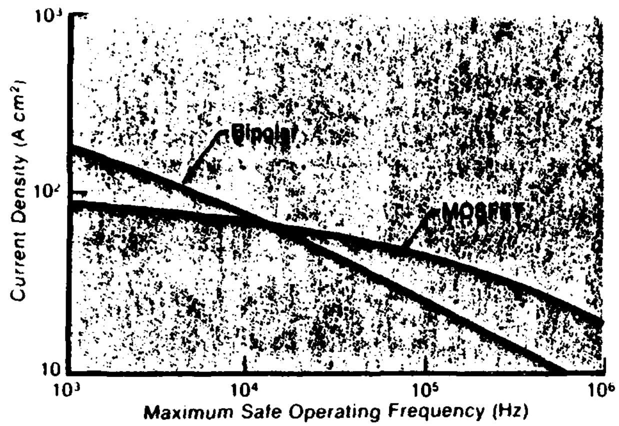

Figure 40-1. MAXIMUM SAFE OPERATING FREQUENCY (Hz)

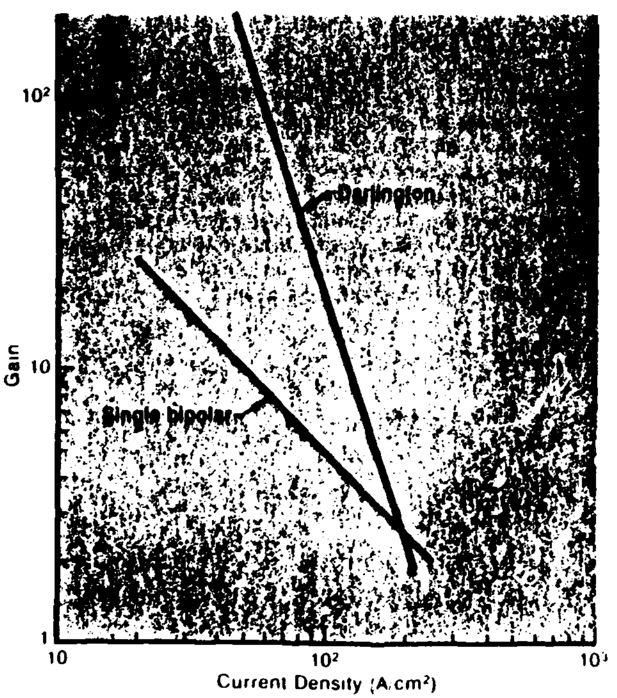

Figure 40-2. HIGH GAIN OF DARLINGTON COMPARED TO A SINGLE BIPOLAR TRANSISTOR

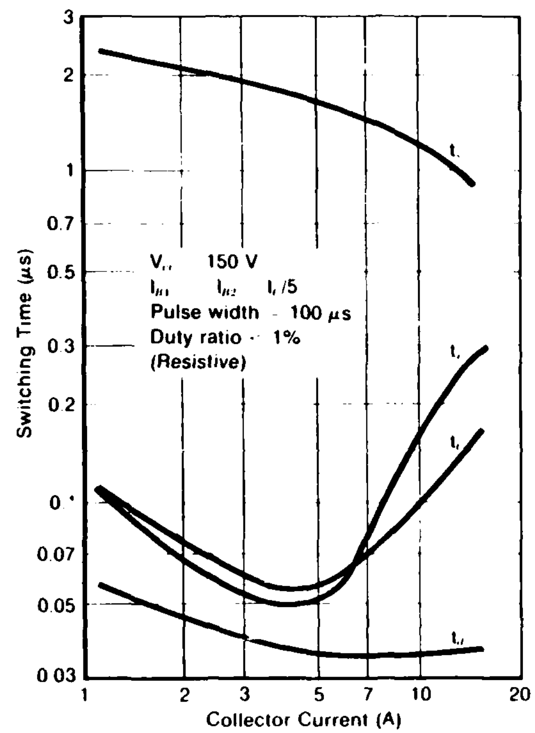

Figure 40-3. TYPICAL SWITCHING CHARACTERISTICS OF POWER MOS TRANSISTORS

– *All figures courtesy* *Machine Design Magazine* (*© 1980, Eaton Corp.*)

Code: 40.1 – CB, CD

Title: PIN Diode Trade-Off Study for Broadband High Power Fast Switching Speed Microwave Switches

Author: Moran, John
Microwave Associates Inc., Burlington, MA

Date: January 1979

Source: NTIS AD-A071/9ST, 109 pages

Code: 40.2 – CD, CG

Title: High Voltage Low Current Solid State Switch

Author: Cordingley, B.V.

Date: February 1980

Source: New Electronic, Vol. 13, No. 3, Feb. 1980, page 38

Code: 40.3 – CB, CC, CD, CG

Title: Fiber Optic/Solid State Switch Systems for Switching 20 Amp Inductive and Resistive Loads

Author: Mings, Joe D.; Bremmer, Joseph P.
Texas Instruments, Inc., Dallas, TX

Date: March 1979

Source: IEEE Vehicle Technology Conference, 29th, March 27-30, 1979; pages 217-221.

Code: 40.4 – CB, CC, CD, CG

Title: 1980 Electrical and Electronics Reference Issue

Author: Teschler, L.E.; Carlisle, B.H.

Date: May 1980

Source: Machine Design, Vol. 52, No. 11, 366 pages, 15 May 1980

SWITCHING

Code: 40.5 – CB, CC, CD

Title: Membrane Switches, *Low-Cost* Companion for Electronic Logic

Author: Haggerty, J. Kenneth
Centralab, Inc.

Date: April 10, 1980

Source: Machine Design, pages 90 through 95

Code: 40.6 – CB, CD, CG

Title: Bipolars Fight Back

Author: Carlisle, Ben H.
Staff Editor

Date September 25, 1980

Source: Machine Design, 5 pages

Code: 40.7 – CB, CE, CG

Title: Crossing the Analog/Digital Interface

Author: Anon

Date October 9, 1980

Source: Machine Design, pages 209 through 215

Code: 40.8 – CG

Title: Darlingtons Will Thrive on High Voltage, Currents

Author: Anon

Date December 6, 1980

Source: Electronic Design, 1 page

Code:	40.9 – CB, CG
Title:	6-Bit A-D Converter Pulls Only 200 mW at 15 MHz
Author:	Wolfson, Craig RCA
Date:	December 6, 1980
Source:	Electronic Design, 1 page

Code:	40.10 – CG
Title:	Nanosecond Pulsers for MM Wave Tubes
Author:	Stover, J.; Komatsu, N.; Nieto, A. Hughes
Date	February 1980
Source:	USA Electronics Technology and Devices Lab, 18 pages

Code:	40.11 – CB, CD, CG
Title:	Bipolar Power Transistors Feature High Switching Speed and High SOA
Author:	Takesuye, Jack Motorola Semiconductor
Date	1980
Source:	Electronics Products Magazine, 1 page

Code:	40.12 – CG
Title:	Microwave Transistors Handle High Power
Author:	Franklin, Gary California Eastern Labs
Date	November 1980
Source:	Electronic Products Magazine, 1 page

SWITCHING

Code:	40.13 – CB, CD, CG
Title:	Getting Reliable Signals from Position Sensors
Author:	Reick, P. *Eaton Corporation*
Date:	January 15, 1980
Source:	Machine Design Special Supplement, pages 42-43

Code:	40.14 – CG
Title:	A Review of High-Power Switch Technology
Author:	Burkes, I.R.; Craig, J.P.; Hagler, M.D.; Kristiansen, M.; Portnoy, W.M. Texas Tech University
Date	October 1979
Source:	IEEE Trans. Electron Devices, Vol. ED-26, #10, pages 1401-1411

Code:	
Title:	
Author:	
Date	
Source:	

Code:	
Title:	
Author:	
Date	
Source:	

Code 41

LASER TECHNOLOGY

This technology brief addresses laser emitting sources for application to fiber optics data links, as described under Code 32.

Potential AAAS Applications

Laser technology as it pertains to fiber optics is potentially applicable to data transfer equipment of the AAAS.

Advantages

- Laser emitters have a higher degree of waveguiding than is available from current LEDs, and thus offer better coupling efficiency.
- Because of the ability of laser emitters to produce higher output levels than LEDs, using comparable input power, attenuation losses are overcome and overall system efficiency is improved.
- Lasers have faster rise and fall times and greater bandwidth performance characteristics than LEDs.

Disadvantages

- Laser outputs degrade with time and vary with temperature (see Figure 41-1).

Risk

The risk in using laser devices rather than LEDs for advanced armament systems is considered medium because laser technology is still evolving (see projections, Figure 41-2). No reliability information is available for military applications, nor has the ability to meet Mil-qualification requirements been demonstrated. However, at least one supplier claims the capability of producing a reliable laser transmitter having an output power of 5 mw cw and an operational life of 100,000 hr. Because the telecommunications market for fiber optics is so universal, use of lasers is expected to become a successful, standardized alternative to LEDs, which should benefit the AAAS Program.

Trends and State of the Art

- New materials of indium-gallium-arsenide-phosphide (InGaAsP) and GaAsP are being used to produce laser emitters. Most LEDs use GaAlAs.
- Lasers are being incorporated into complete package assemblies that include cooling elements, thermistors, detectors, and signal interface devices. The packages are coupled to a fiber optics pigtail for direct connections to other optical components.
- Developmental devices are available having 1,300-um wavelengths, CW operated. These lasers incorporate a stripe-contact that confines the active lasing region of the junction to a narrow section of the emitting facet.

Cost

The cost of implementing laser emitters for fiber optics applications is high compared to that of LEDs. However, as the technology evolves and is suitable for mass production, the cost is likely to decrease, as has been observed for fiber optic semiconductor devices; see Code 32 discussion.

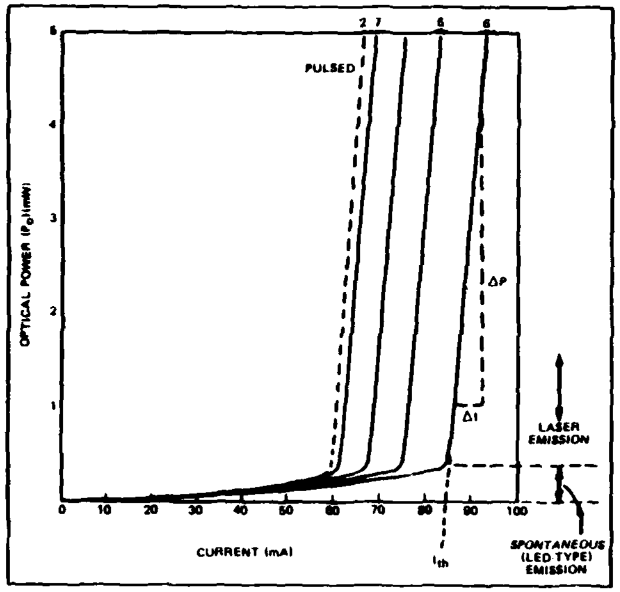

Figure 41-1. TECHNOLOGY FORECAST FOR LASERS

– Courtesy Sea Technology Magazine (© 1980)

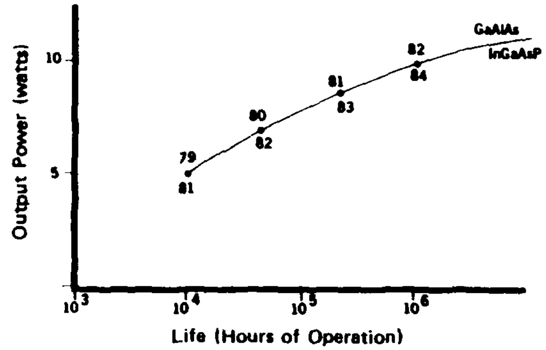

Figure 41-2. POWER VERSUS CURRENT CHARACTERISTICS OF A LASER DIODE AT DIFFERENT AMBIENT TEMPERATURE

– Courtesy Electronic Design Magazine (© 1981, Hayden Publ. Co.)

Code: 41.1 - CG

Title: Fundamental Limitations and Design Considerations for Compensated Pulse Alternators

Author: Weldon, W.F.; Bird, W.L.; Driga, M.D.; Tolk, M.D.; Rylander, H.G.; Woodson, H.H.
University of Texas, Austin, TX

Date: June 1979

Source: IEEE International Pulsed Power Conference, 2nd Digest of Technical Papers

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Code: 41.2 - CG

Title: Ignition of Composite Propellant at Subatmospheric Pressures by Means of Carbon Dioxide Laser

Author: Sofue, T.; Iwama, A.
Japan National Space Dev. Agency, Tokyo

Date: October 1979

Source: Propellants Explosives, Vol. 4, No. 5, October 1979, pages 98-106

Code: 41.3 - CD, CG

Title: Laser Technology, Fundamentals/Applications

Author: Anon

Date: December 18-19, 1980

Source: New York University, School of Continuing Education, 2 pages

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Code: 41.4 - CD, CG

Title: Multi-Dimensional Information Services for the Optical Radiation, Laser and Electro-Optics Community

Author: Anon
Rockwell Associates, Inc.

Date: Fall 1980 Catalog

Source: Rockwell Associates, Inc., Seminar Management, 34 pages

Code: 41.5 - CD, CG

Title: Fiber-Optics Semis Carve Out Wider Infrared Territory

Author: Stephan Ohr
Components Editor

Date: January 18, 1980

Source: Electronic Design #2, pages 52-54

Code: 41.6 - CD, CG

Title: Optimize Optical Model Cost/Performance Through Emitter, Detector and Fiber Selection

Author: Eric Randall; Ron Lavelle
Galileo Electro-Optics Corp., Sturbridge, Mass.

Date: April 12, 1980

Source: Electric Design #8, pages 125-127

Code: 41.7 - CB, CD, CE, CH

Title: Fiber Optic Links Work Better When Matched with the Right Emitters

Author: David F. Fellinger; Herbert F. Matare
Science Advisor, IAV, Inc., Van Nuys

Date: October 25, 1978

Source: Electronic Design #22, pages 112-115

Code: 41.8 - CB, CD, CG

Title: Semiconductor Light Sources for Fiber Optic Applications

Author: T.E. Stockton, R.B. Gill
Laser Diode Labs., New Brunswick, NJ

Date: October 1980

Source: Microwave Journal, pages 48-56

APPENDIX A

TECHNOLOGY MATRICES

Table A-1. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT

WBS Element		Technology Spectra															
		Aerodynamics		Controls	Corrosion		Fluidics	Pneumatics	Hydraulics		Manufacturing	Materials		Pyrotechnics	Reliability		Safety
BB	Primary Station	X		X	X		X	X	X		X	X		X	X		X
BC	Missile Launcher	X		X	X		X	X	X		X	X		X	X		X
BD	Special Station	X		X	X		X	X	X		X	X		X	X		X
BE	Multistore Adapter	X		X	X		X	X	X		X	X		X	X		X
BF	Aircraft Hardpoint	X			X		X	X	X		X	X					
BG	Integration Equipment	X		X	X			X	X		X	X		X	X		X

Table A-1a. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT, PRIMARY STATION PROFILE

WBS Element	Aerodynamics	Controls	Corrosion	Fluidics	Pneumatics	Hydraulics	Manufacturing	Materials	Pyrotechnics	Reliability	Safety
	Technology Spectra										
BB Primary Station	X	X	X	X	X	X	X	X	X	X	X
Ejector Rack	X	X	X		X	X	X	X		X	X
Power Source			X	X	X	X	X	X	X		X
Safe/Arm Unit		X					X				X
Connector			X	X	X	X	X				
Pylon	X		X				X	X		X	
*SSI Interface		X		X	X	X					

Table A-1b. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT, MISSILE LAUNCHER PROFILE

WBS Element	Aerodynamics	Controls	Corrosion	Fluidics	Pneumatics	Hydraulics	Manufacturing	Materials	Pyrotechnics	Reliability	Safety
BC Missile Launchers	X	X	X	X	X	X	X	X	X	X	X
Rail Launcher	X	X	X		X	X	X	X		X	
Ejector Rack (Programmable)	X	X	X		X	X	X	X		X	
Arm/Safe Unit (Digital Coded)		X					X				X
Connector			X	X	X	X	X				
Pylon	X		X					X		X	
Power Source			X	X	X	X	X		X		X
Interface				X							

Table A-1c. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT, SPECIAL STATION PROFILE

WBS Element	Aerodynamics	Controls	Corrosion	Fluidics	Pneumatics	Hydraulics	Manufacturing	Materials	Pyrotechnics	Reliability	Safety
	Technology Spectra										
BD Special Stations	X	X	X	X	X	X	X	X	X	X	X
Ejector Rack	X	X	X	X	X	X	X	X		X	
Dispenser	X	X	X		X	X	X	X		X	
Connector			X	X	X	X	X				
Arm/Safe Unit		X					X				X
Pylon	X		X					X		X	
Interface			X	X							
Power Source		X	X		X	X	X		X	X	

Table A-1d. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT, MULTIPLE STORES ADAPTER PROFILE

WBS Element	Aerodynamics	Controls	Corrosion	Fluidics	Pneumatics	Hydraulics	Manufacturing	Materials	Pyrotechnics	Reliability	Safety
	Technology Spectra										
BE Multiple Stores Adapter	X	X	X	X	X	X	X	X	X	X	X
Power Source		X	X		X	X	X	X	X		
Connector			X	X	X	X	X				
Ejector Rack	X	X	X		X	X	X	X		X	
Safe/Arm Unit		X					X				X

Table A-1e. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT, AIRCRAFT HARDPOINT PROFILE

WBS Element	Aerodynamics		Controls	Corrosion		Fluidics	Pneumatics	Hydraulics		Manufacturing	Materials		Pyrotechnics	Reliability		Safety
BF Aircraft Hardpoint	X			X		X	X	X		X	X					
Connector/Coupler			X	X		X	X	X		X	X					
Fastener	X			X						X	X					

Table A-1f. TECHNOLOGY MATRIX, SUSPENSION AND RELEASE EQUIPMENT, INTEGRATION EQUIPMENT PROFILE

	Technology Spectra															
WBS Element	Aerodynamics		Controls	Corrosion		Fluidics	Pneumatics	Hydraulics		Manufacturing	Materials		Pyrotechnics	Reliability		Safety
BG Integration Equipment	X		X	X			X	X		X	X		X	X		X
Power Source			X	X		X	X	X					X			X
Pylon	X			X							X					
Tray	X			X							X			X		
Rail Launcher	X		X	X			X	X		X	X			X		
Shroud	X			X							X			X		

Table A-2. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM

WBS Element	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CB Process Control Equipment	X		X	X	X	X	X	X	X		X	X	X	X	X	
CC Control Display Equipment	X		X				X		X			X				
CD Stores Station Equipment	X			X	X		X	X	X		X	X	X	X	X	X
CE Data Transfer Equipment	X			X	X		X		X			X				X
CF Structural Mounts (SRE)																
CG Power Conditioning Equipment				X	X	X			X			X	X		X	
CH SSI Configuration				X	X	X	X		X							
CI Stores Management Software	X							X					X	X		
CJ Stores Management Integration (all of above)																

Table A-2a. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM,. PROCESS CONTROL EQUIPMENT PROFILE

WBS Element	Technology Spectra															
	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CB Process Control Equipment	X			X	X	X	X	X	X		X	X	X	X		
Microprocessor/Minicomputer/ Microcomputer	X				X			X	X		X	X	X	X		
Input Device/Data	X			X	X							X				
Cable				X		X	X									
Connector				X		X	X						X			
BIT	X				X				X		X			X		

Table A-2b. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, CONTROL/DISPLAY EQUIPMENT PROFILE

WBS Element	Technology Spectra															
	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CC Control/Display Equipment			X				X		X			X			X	
Controls			X						X			X			X	
Display			X				X					X				

Table A-2c. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, STORES STATION EQUIPMENT PROFILE

	Technology Spectra															
WBS Element	Computers		Controls/Display	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CD Stores Station Equipment	X			X	X		X	X	X		X	X	X	X	X	X
Power/Mux. Terminal					X				X			X			X	
Power/Signal Conditioner					X				X			X			X	
Programmed Controller	X				X				X		X	X		X	X	
Interface Module	X				X		X	X	X		X	X		X		
Fiber Optics Term.	X				X		X					X				X
Connector				X	X	X	X						X			
Cable				X			X									

Table A-2d. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, DATA TRANSFER EQUIPMENT PROFILE

WBS Element	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CE Data Transfer Equipment	X			X	X		X		X			X				
Cable - Discrete Wire				X	X		X									
Connector				X	X		X									
Amplifier/Driver					X		X		X			X				X
Data Bus	X			X			X					X				

Table A-2e. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, STRUCTURAL MOUNTS PROFILE

WBS Element	Computers	Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.	Memory	Packaging	Reliability	Software	Switching	Laser
CF Structural Mounts														
Isolator (Shock, Vibration) (considered for S&RE)														

Technology Spectra: column group heading over Computers through Laser.

Table A-2f. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, POWER CONDITIONING EQUIPMENT PROFILE

WBS Element	Computers	Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.	Memory	Packaging	Reliability	Software	Switching	Laser
	Technology Spectra													
CG Power Conditioning Equipment				X				X		X	X		X	X
Converters				X									X	X
Rectifier				X										
Power Supply				X	X					X			X	
Protection Circuit				X	X									
Regulator				X										
Filter				X				X		X			X	
Solid State Switch				X							X		X	

Table A-2g. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, SSI CONFIGURATION PROFILE

	Technology Spectra															
WBS Element	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CH SSI Configuration (MIL-STD-1760)				X		X	X									
Connector Series (Hybrid)				X	X	X	X					X				X
Cable				X	X	X	X									X

Table A-2h. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, STORES MANAGEMENT SOFTWARE PROFILE

WBS Element	Computers	Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.	Memory	Packaging	Reliability	Software	Switching	Laser
	Technology Spectra													
CI Stores Management Software	X					X				X	X			
Operational/Executive Package	X					X					X			
Control/Display Package	X					X					X			
Stores Station Package	X					X					X			
BIT	X					X					X			
Digital Code										X	X			
Distributed/Central	X									X	X			

Table A-2i. TECHNOLOGY MATRIX, STORES MANAGEMENT SYSTEM, STORES MANAGEMENT INTEGRATION PROFILE

WBS Element	Technology Spectra															
	Computers		Controls/Displays	Data Bus	Electrical	Electromag Envrnmt	Fiber Optics	Language	Large Scale Integ.		Memory	Packaging	Reliability	Software	Switching	Laser
CJ Stores Management Integration																
System Architecture and Partitioning																
SEM/SAM Utilization																
Stores Separation Sensing																
Weapon Fuzing Control																
Store Identification																
BIT																
Nuclear Stores Ramification																
Aircraft Interface																

APPENDIX B

KEY WORD/PHRASE LISTING

B.1 SUSPENSION AND RELEASE EQUIPMENT

1. AERODYNAMICS

   Airborne, Aircraft, Aircraft Carriage Compatibility, Aircraft Weapon Carriage, Airplane, Analytical Technique, Captive Load, Carriage Drag, Dispenser, Flutter, Installed Load, Launch Disturbance, Launch Dynamics, Launcher, Models, Pylon, Rack, Rail, Release Envelope, Skin, Stores Carriage, Stores Separation, Tip Off, Trajectory Analysis, Weapon Ballistics, Wind Tunnel

2. BACTERIA

3. CONTROLS

   Aero, Airborne, Aircraft, Armament, Arms, Automatic, Bomb Rack, Digital, Electrical, Electromechanical, Fluid, Fluidic, Load, Mechanical, Missile Launcher, Override, Pressure, PSI, Remote, Sensors, Stores Temperature, System Device, Valve, Weapons

4. CORROSION

   Airborne, Anodic, Cathodic, Cationic, Coating, Connector, Control, Fatigue Loading, Galvanic, Inhibition, Maintenance, Mechanical, Ocean, Painting, Plating, Prevention, Protection, Replacement Material, Resistance, Sacrificial Material, Salt, Sea, Stress, Stress Cracking, Wear

5. ENVIRONMENT

6. FLUIDICS

Airborne, Aircraft, Characteristics, Cold Temperature, Control, Cryogenic, Dynamics, Flow, High Temperature, High Viscosity, Launcher Support, Liquid Phase, Low Viscosity, Mechanics, Property, Sensor

7. PNEUMATICS

Actuator, Container, Control, Device, Flow Rate, High Pressure, Low Pressure, Power Source/Supply (Hydraulic, Fluid, Pneumatic, Laser), Pressure Generation, Servomechanism, System, Vacuum, Valve, Vessel

8. HYDRAULICS

Airborne, Aircraft, Accumulator, Control, Coupling, Cylinder, Fluid, Jets, Pressure Pump, Seal, Sensor, Servomechanism, Valves

9. LASERS

10. MANUFACTURING

Airborne, Aircraft, Airplane, Automation, Bonding, Casting, Connector, Dispenser, Forging, Launcher, Process, Pylon, Rack, Rail, Skin, Welding

11. MATERIALS

Adhesives, Airplane/Airborne Structure, Alloys, Composite, Metals, Polymers, Synthetic

12. PACKAGING

Hydraulic, Pneumatic

13. PYROTECHNICS

Airborne, Aircraft, Booster, Cartridge, Delay Equipment, Detonator, Gas Generator, Igniter, Jet, Power Source, Primer, Propellant, Safety, Weapon

14. RELIABILITY

Airborne, Aircraft, Availability, Avionics, Derating Parameters, Mean Time Between Failure, Mechanical Structure, MTBF, Readiness, Weapon

15. STRUCTURES

16. SAFETY

Arms, Handling, Loading, Stores, Weapons

B.2 STORES MANAGEMENT SYSTEM

26. COMPUTERS

Airborne, Aircraft, Architecture, Armament, Avionics, Cost, Distributed Process, Electrical, Failure Mechanism, General Purpose, Input Devices, Integration, Interface, Keyboard, Manufacturing, Mechanical, Memory, Microprocessor, Minicomputer, Missile Launch, Mission, Multifunction, Network, Programmable, Reliable, Reliability, Safety, Shared, Signal Processing, Weapon Release

27. (Not used)

28. CONTROLS/DISPLAYS

Calligraphic, Computer, Group, Heads-Up, Indicator Lights, Matrix Displays, Moving Target Indicators, Multifunction, Screens, Television

29. DATA BUS

Airborne, Aircraft, Avionics, Cable, Circuit Protection, Connector, Communications Network, ICD, Integration, Power Supply, Signal Synthesis

30. ELECTRICAL

Amplifier/Driver, Avionics Regulators, Avionics Relays, Avionics Switches, Avionics Transformers, Converter, Cost, Fuzing, Multiplex Terminal, Power Supply, Reliability, Safe/Arming, Signal Conditioner

31. ELECTROMAGNETIC ENVIRONMENT

Aircraft, Armament, Cables/Shielding, Compatibility, Electromagnetic Radiation, Hazard, Nuclear Electro Pulse, Ordnance, R&D, Safety, Specification/Standard, Vulnerability, Weapon

32. FIBER OPTICS

Amplifier/Driver, Amplification, Attenuation, Bus Architecture, Coupler, Emitter, Laser Driver, MIL-STD-1553B, Multiplex Digital Data Bus, Power, Repeater, Sensor, Signal Splitting

33. LANGUAGES

AN/AYK-14, Avionics, CMS-2, Fortran, High Order, OMSI (Oregon Museum of Science Institute), Operation System, Pascal, Programming, SDEX

34. LARGE SCALE INTEGRATION

Airborne Qualified, Cost, Digital Data Bus, Manufacturing Technologies, MIL-STD-1760, Reliability, Research and Development, Voltage Protection, Voltage Standardization

35. (Not used)

36. MEMORY

Airborne Digital, Bubble, Erasable, Non-Volatile, Programmable, Reliability

37. PACKAGING

Airborne, Aircraft, Circuit Board, Electronics, LSI Module, Microprocessor, Minicomputer, SEM (Standard Electronic Module), Standards

38. RELIABILITY

Computer Coding, Digital Code, Encoding, Error Correction, Error Detection, Signal Coding

39. SOFTWARE

ADA, Bit, DEC Computer, Direct Memory Access, Distributed Data Process, Documentation (MIL-STD-1679), High Order Language, Human Factor, Modularity, Pilot Interaction, Standards/Spec, Structured Programming, Univac Computer

40. SWITCHING

Airborne, Aircraft, Avionic, Digital-Analog, Electronics, Solid State

41. LASERS

Detonator, Driver, Fuse, Fuze, Laser Fusing, Optical, Packaged Laser Weapon, Podded Laser Weapon, Power Generator, Power Source, Power Supply, Self-Contained

APPENDIX C

DATA SOURCES

C.1 GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM

The Government-Industry Data Exchange Program (GIDEP) is a cooperative data exchange among government and industry participants seeking to reduce or eliminate expenditures of time and money by making maximum use of existing knowledge. The program provides a means of automatically exchanging certain types of data essential in the research, design, development, production, and operational life cycle of systems and equipment.

C.1.1 GIDEP Data Banks

Participants in GIDEP are provided access to four major data banks:

a. Engineering

b. Metrology

c. Failure Experience

d. Reliability-Maintainability

A member organization may participate in any or all data banks by agreeing to abide by the requirements for participation defined in Section 2 of the GIDEP Policies and Procedures Manual.

The Engineering Data Bank (EDB) contains engineering evaluation and qualification test reports, nonstandard parts justification data, parts and materials specifications, manufacturing process information, failure analysis data, and other related engineering data. The bank also includes a section of reports on specific engineering methodologies and techniques, air and water pollution reports, alternate energy sources, and other subjects. The Engineering Data Bank is available on 16-mm microfilm. The data bank is supplemented with computerized hard-copy index, abstracts, and hard-copy summary sheets.

The Metrology Data Bank (MDB) contains related metrology engineering data on test systems, calibration systems, and measurement-technology and test-equipment calibration procedures. The Metrology Data Bank is available on 16-mm microfilm. The data bank is supplemented with a computerized hard-copy index.

The Failure Experience Data Bank (FEDB) contains objective failure information generated when significant problems are identified concerning parts, components, processes, fluids, materials, or safety. The Failure Experience Data Bank is computerized to provide source data collected into selected indexes and summaries. Source documents are contained on 16-mm microfilm in the Engineering Data Bank as a permanent record.

The Reliability-Maintainability Data Bank (RMDB) contains failure rate/mode and replacement rate data on parts and components based on field performance information and/or reliability demonstration tests of equipment, subsystems, and systems. The Reliability-Maintainability Data are abstracted for computer retrieval and also distributed as hard-copy summaries. Reports and source data are contained on 16-mm microfilm.

C.1.2 Data Retrieval

GIDEP has developed a data retrieval system which makes the microfilmed information in the data banks rapidly accessible, either through hard copy indexes or by access to the Operations Center's computer data system through a remote computer terminal.

C.2 DIALOG INFORMATION RETRIEVAL SERVICE

The DIALOG Information Retrieval Service is a computerized service of the Lockheed Missiles and Space Company, Inc. Following is a listing of specific files within DIALOG that were accessed in this study. More detailed descriptions of these files appear after page C-6 (reprinted courtesy of LMSC, Inc.).

File Name and Description	File No.
NTIS (National Technical Information Service)	6
COMPENDEX (Engineering developments)	8
INSPEC (Physics, electrical engineering, electronics, computers, and control engineering	12, 13
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C.3 PARTICIPATING FIELD ACTIVITIES

Participating Field Activities (PFAs for this study are listed below, together with areas of expertise and the prime individual responding to requests for information.

PFA	Areas of Expertise	Contact
Naval Air Development Center (NADC), Warminster, PA	S&RE gravity rack design and engineering, SMS/avionics system integration, advanced power systems, displays/controls, store attachment, and MSER mods	Tom Milhous
Naval Ocean System Center (NOSC), San Diego, CA	Fiber optics	R. D. Harder
Naval Surface Weapons Center (NSWC), Dahlgren, VA	Weapon system fuzing, aircraft armament safety, ballistic data	Ken Brown
Pacific Missile Test Center (PMTC/PM), Point Mugu, CA	Aircraft stores interface manuals, air-to-air flight testing, SM integration	
Naval Weapons Evaluation Facility (NWEF), Albuquerque, NM	Aircraft stores compatibility and interface, aircraft monitor and control	
Naval Ordnance Station (NOS/IH), Indian Head, MD	Ejection cartridges (S&RE power source)	Marty Henderson
Naval Avionics Center (NAC/I), Indianapolis, IN	Aircraft monitor and control, airborne weapon control and release equipment	
Naval Air Test Center (NATC), Patuxent River, MD	Ground support equipment, aircraft stores compatibility, separation flight testing	Norman Davis
Naval Air Engineering Center (NAEC), Lakehurst, NJ	Ground support equipment, engineering specifications and standards	
DTNSRDC	Conformal carriage	
Naval Safety Center (NSC), Norfolk, VA	Safety	Mr. Vose

C.4 INDUSTRY CONTACTS

Industrial sources providing information for this study are listed below.

Alkan Corporation
235 Loop 820 N.E.
Hurst, TX 76053
Kent Goldsmith
(817) 589-2451

Control Data Corp.
5630 Arbor Vitae
Los Angeles, CA 90045
Wally Jones
(213) 642-2439

Crouzet Aeronautics and Systems
5535 Balboa Blvd.,
Encino, CA 91316
John Lent
(213) 995-3655

Deutsch Optical
Waveguide Systems
Banning, CA 92220
(714) 849-7822

EDO Corporation
13-10 111th St.,
College Point, NY 11356
Walter Glover
(213) 542-5524

Fairchild Industries
Stratos Div.
1800 Rosecrans Ave.,
Manhattan Beach, CA 90266
C. Ballard

G&H Technology, Inc.
1649 17th St.,
Santa Monica, CA 90404
(213) 450-0561

Hughes Aircraft
17156 Von Karman Ave.,
Irvine, CA 92705
T. Jarnigan
(714) 549-5701

ITT Cannon
666 E. Dyer Road
Santa Ana, CA 92702
L. Fields
(714) 972-2061

ITT Electro-Optical Division
7635 Plantation Road
Roanoke, VA 24019
J. Smiley
(703) 563-03781

Northrop Corporation
3901 W. Broadway
Hawthorne, CA 90250
Ron Blakhurst
(213) 970-4027

Perkin Elmer Corp.
2 Crescent Place
Ocean Port, NJ 07757
(201) 870-4712

Pyle National Co.
1334 N. Koster Ave.,
Chicago, ILL 60651
(312) 342-6300

Rockwell International
Collins Government
Avionics Division
2201 Seal Beach Blvd.,
Seal Beach, CA 90740
Edward Martin
(213) 594-2552

Sanders Associates
Information, Products Division
Daniel Webster Highway, South
Nashua, NH 03061
(603) 885-5280

Scot Incorporated
1126 El Camino Drive
Costa Mesa, CA 92626
Ben E. Paul
(714) 549-2405

Teledyne Philbrick
30941 Agoura Road
Westlake Village, CA 91361
(213) 889-3827

TRW Cinch Connectors
1501 Morse Ave.
Elk Grove Village, ILL 60007
(312) 921-6151

Western Gear Corp.
P.O. Box 629
Jamestown, ND 58401
George Demos
(701) 252-6250

Zilog, Inc.
10460 Bubb Road
Cupertino, CA 95014
(408) 446-4666

C.4 BIBLIOGRAPHY

Title

Hydraulic Systems, Aircraft, Types I and II, Design and Installation Requirements for, 14 September 1979

Coupling, Quick Disconnect, Automatic Shut Off, General Specification for, 16 May 1973

Airborne Stores, Associated Suspension Lugs, and Aircraft-Store Interface (Carriage Phase); General Design Criteria for, 30 January 1979 with Amendment 1, 10 August 1979

NATOPS Flight Manual, Navy Models A-7A, A-7B Aircraft, 15 March 1977

Airborne Weapons/Stores Loading Manual, Navy Model A-7E Aircraft, 2 June 1972

Flight Manual, A-7D Aircraft, 15 February 1979

Maintenance Instructions, Organizational, Armament Systems A-7D, 15 August 1973

Aircraft Internal Time Division Command/Response Multiplex Bus, 21 September 1978 with Notice 1 (USAF), 12 February 1980

Standard Store Interface, Aircraft/Stores Electrical Interface Definition, May 1980

Standard Avionics Packaging, Mounting, and Cooling Baseline Study, January 1980

Common Multimode Modular Radar (CMMR) Software Acquisition Study, September 1980

An Overview of Avionics Technologies for the Improvement of All Weather Attack Avonics Systems (AWAAS), Naval Avionics Center, NAC-TR-2180, September 1978

AN/AYK-14(V), Navy Standard Airborne Computer, Technical Description, Control Data Corporation, Aerospace Division, Minneapolis, MI, January 1980

Title

MIL-STD-1760 Open Forum Proceedings, Eglin AFB, FL, 28-30 October 1980

Second AFSC Multiplex Data Bus Conference, ASD-TR-78-34, 10-12 October 1978

Stores Management Systems Architectural Tradeoff Studies, Fairchild Space and Electronics Co., Germantown, MD, 687-TR-3000, 3 November 1980

Airborne Weapons/Stores Loading Manual, Navy Model F/TF-18A, 15 September 1980

Advanced Aircraft Armament System (AAAS) Program Master Plan, October 1979

Contract Development Specification for Advanced Development Model (ADM) Stores Management System, 24 July 1980

Aircraft Armament Interoperability Interface Program (A^2I^2), Joint Program Management Plan, April 1979

Technical Description of the Advanced Aircraft Armament System Aircraft Hardpoint, undated

Technical Description of the Advanced Aircraft Armament System Pylons, undated

Technical Description of the Advanced Aircraft Armament System Standard Armament System Interface, undated

Technical Description of the Advanced Aircraft Armament System Standard Store Interface, undated

A-7 ALOFT (Avionic Light Optical Fiber Technology) Economic Analysis Development Concept, NELC/TD 435, 7 July 1975

DIALOG* INFORMATION RETRIEVAL SERVICE

NTIS

FILE DESCRIPTION

The NTIS database consists of government-sponsored research, development, and engineering reports plus analyses, journal articles, and translations prepared by federal agencies, their contractors or grantees. NTIS also covers federally generated machine-readable files and software as well as U.S. Government inventions available for liscensing. It is the means through which unclassified, unlimited distribution reports are made available to the public. (¶ 6.1)

SUBJECT COVERAGE

The NTIS database includes material from both the "hard" and "soft" sciences, including topics of immediate, broad interest, such as environmental pollution and control, energy conservation, technology transfer, health planning, societal problems, and urban and regional development and planning. An outline of the subject coverage of this file is shown below: (¶ 6.2)

- Administration
- Aeronautics and Aerodynamics
- Agriculture and Food
- Astronomy and Astrophysics
- Atmospheric Sciences
- Behavior and Society
- Biomedical Technology and Engineering
- Building Technology
- Business and Economics
- Chemistry
- Civil Engineering
- Communication
- Computers, Control and Information Theory
- Electrotechnology
- Energy
- Environmental Pollution and Control
- Health Planning
- Industrial and Mechanical Engineering
- Library and Information Sciences
- Materials Sciences
- Mathematical Sciences
- Medicine and Biology
- Military Sciences
- Natural Resources and Earth Sciences
- Navigation, Guidance and Control
- Nuclear Science and Technology
- Ocean Technology and Engineering
- Physics
- Space Technology
- Transportation
- Urban and Regional Technology

SOURCES

Since 1964 more and more federal agencies have been announcing and selling reports through NTIS so that as of 1977, the NTIS database represents the reports of over 300 federal government agencies. (¶ 6.3)

DIALOG FILE DATA

(¶ 6.4)

Inclusive Dates:	1964 to the present
Update frequency:	Biweekly (approximately 5,000 a month)
File Size:	560,000 citations, as of March 1977

ORIGIN

(¶ 6.5)

National Technical Information Service (NTIS) Telephone: 703/557-4642
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22151

*Trademark Reg. U.S. Pat & Trademark Office.

DIALOG* INFORMATION RETRIEVAL SERVICE
COMPENDEX

FILE DESCRIPTION

The COMPENDEX database is the machine-readable version of *The Engineering Index**, which provides the engineering and information communities with abstracted information from the world's significant engineering and technological literature. COMPENDEX provides worldwide coverage of the journal literature, publications of engineering societies and organizations, papers from the proceedings of conferences, and selected government reports and books.

(¶ 8.1)

SUBJECT COVERAGE

COMPENDEX is an interdisciplinary index to the world's engineering developments, including the following subject areas:

(¶ 8.2)

- Civil, Environmental, Geological and Biological Engineering
- Electrical, Electronics and Control Engineering
- Chemical, Agricultural and Food Engineering
- Mining, Metals and Fuel Engineering
- Mechanical, Automotive, Nuclear and Aerospace Engineering
- Industrial and Management Applications

SOURCES

Publications from around the world are indexed, among which are the following types:

(¶ 8.3)

- Approximately 1800 journals
- Publications of engineering societies and organizations
- Approximately 1000 works from conferences, symposia, etc.
- Selected government reports and books

DIALOG FILE DATA

(¶ 8.4)

Inclusive Dates:	January 1970 to the present
Update Frequency:	Monthly (about 7,000 citations per month)
File Size:	Over 550,000 records, as of April 1977

ORIGIN

COMPENDEX is produced by Ei and questions concerning file content should be directed to:

(¶ 8.5)

Mr. John W. Carrigy, Manager — Telephone: 212/644-7600
Magnetic Tape Sales
Engineering Index, Inc. (Ei)
345 East 47th Street
New York, NY 10017

*Trademark Reg. U.S. Pat. & Trademark Office.

DIALOG* INFORMATION RETRIEVAL SERVICE

INSPEC

FILE DESCRIPTION

The Science Abstracts family of abstract journals, indexes, and title bulletins commenced publication in 1898. Today it forms the largest English-language database in the fields of physics, electrical engineering, electronics, computers, and control engineering. Foreign-language source material is also included, but abstracted and indexed in English. File 12 includes *Physics Abstracts*. File 13 is the companion file, including *Electrical and Electronics Abstracts* and *Computer and Control Abstracts*. (¶ 12.1)

SUBJECT COVERAGE

The principal subject areas are indicated by major headings below, used with the INSPEC database (File 12 and File 13): (¶ 12.2)

- Atomic and Molecular Physics
- Computer Programming and Applications
- Computer Systems and Equipment
- Condensed Matter: Electrical, Magnetic, and Optical Properties
- Condensed Matter: Structure, Thermal, and Mechanical Properties
- Control Technology
- Electrical and Magnetic Devices
- Electromagnetics, Optics, and Circuits
- Gases, Fluid Dynamics, and Plasmas
- General Topics
- Elementary Particle Physics
- Instruments and Measurement
- Interdisciplinary Subjects
- Information/Communication Science and Engineering
- Mathematics and Mathematical Physics
- Nuclear Physics
- Power Systems and Applications

SOURCES

Journal papers, conference proceedings, technical reports, books, patents, and university theses are abstracted and indexed for inclusion in the INSPEC database. The number of journals scanned regularly is approximately 2,100; over 340 of these are abstracted completely. (¶ 12.3)

DIALOG FILE DATA (¶ 12.4)

Inclusive Dates:	1969 to present
Update Frequency:	Monthly (approximately 12,500 citations per month)
File Size:	About 500,000 records in each file, as of May 1977

ORIGIN

INSPEC is produced by IEE and questions concerning file content should be directed to either of the following offices: (¶ 12.5)

INSPEC Market Administrator
IEEE
445 Hoes Lane
Piscataway, NJ 08854
USA
Telephone: 201/981-0060

INSPEC Magnetic Tape Services
IEE
Station House, Nightingale Road
Hitchin Herts SG5 1RJ
England
Telephone: 0462 53331

*Trademark Reg. U.S. Pat. & Trademark Office.

DIALOG* INFORMATION RETRIEVAL SERVICE

ISMEC

FILE DESCRIPTION and SOURCES

The ISMEC (Information Service in Mechanical Engineering) database corresponds to the biweekly printed *ISMEC Bulletin*. ISMEC indexes significant articles in all aspects of mechanical engineering, production engineering, and engineering management from approximately 250 journals published throughout the world. In addition, books, reports and conference proceedings are indexed. These sources are further supplemented by relevant material from more than 2,000 periodicals in physics and engineering that are received by INSPEC. The primary emphasis is on comprehensive coverage of leading international journals and conferences on mechanical engineering subjects. (* 14.1)

SUBJECT COVERAGE

The principal subject areas are indicated by the hierarchical classification scheme developed by ISMEC. A representative, but not exhaustive, listing of the sections comprising each division is given below: (* 14.2)

- Management and Production
  - Management Studies
  - Production
- Measurement and Control
  - Measurement Science
  - Measurement and Control of Specific Variables
  - Measurement and Control Equipment
  - Fluidic Devices and Systems
- Mechanics, Materials, and Devices
  - Analytical Mechanics
  - Mechanical Properties and Effects
  - Physical and Chemical Properties and Effects
  - Materials Testing
  - Fluid Mechancis
  - Tribology
  - Mechanical Components
  - Acoustic Devices and Equipment
- Production Processes, Tools, and Equipment
  - Hardening
  - Forming Processes and Equipment
  - Machining and Machine Tools
  - Joining Processes and Equipment
  - Finishing Processes and Equipment
  - Hand Tools
- Energy and Power
  - Thermodynamics
  - Heating, Cooling, and Ventilating
  - Fuel Technology
  - Engines
  - Mechanical and Fluid Power Transmission
- Transport and Handling
  - Motor Vehicle Engineering
  - Motorless Vehicle Engineering
  - Railway Engineering
  - Marine Engineering
  - Aerospace Engineering
  - Mechanical Handling
- Mechanical Engineering and Natural Resources
  - Agricultural Engineering
  - Mining
  - Oil and Natural Gas
  - Ecology
- Mechanical Engineering in Science and Industry
  - Nuclear Engineering
  - Electrical Engineering
  - Electronic Engineering
  - Civil Engineering
  - Optical Engineering
  - Medical Engineering
  - Industrial Process Engineering
- Other Applications of Mechanical Engineering
  - Military Engineering
  - Business Equipment
  - Domestic Equipment
  - Other Special Applications

DIALOG FILE DATA

(* 14.3)

Inclusive Dates	1973 to the present
Update Frequency	Monthly (approximately 15,000 citations a year)
File Size	58,000 citations, as of March 1977

ORIGIN

(* 14.4)

Data Courier, Inc.
620 South 5th Street
Louisville, KY 40202

Telephone: 502/582-4111

* Trademark Reg. U.S. Pat. & Trademark Office.

METADEX

DIALOG INFORMATION RETRIEVAL SERVICE

FILE DESCRIPTION

The METADEX (Metal Abstracts/Alloys Index) database, produced by the American Society for Metals (ASM) and The Metals Society (London), provides comprehensive coverage of international metals literature. The database corresponds to the printed publications: *Review of Metal Literature* (1966-67), *Metals Abstracts* (1968 to the present), and *Alloys Index* (1974 to the present). The *Metals Abstracts* portion of the file includes references to about 1,200 primary journal sources. *Alloys Index* supplements *Metals Abstracts* by providing access to the records through commercial, numerical, and compositional alloy designations; specific metallic systems; and intermetallic compounds found within these systems.

Informative abstracts are included for most records since 1979.

SUBJECT COVERAGE

In addition to specialized topics (including specific alloy designations, intermetallic compounds, and metallurgical systems), six basic categories of metallurgy are covered:

- Materials
- Processes
- Properties
- Products
- Forms
- Influencing Factors

SOURCES

Each month about 3,000 new documents from a variety of international sources are scanned and abstracted for the ASM database, with intensive coverage of appropriate journals, conference papers, reviews, technical reports, and books. Dissertations, U.S. patents, and government reports have been included since 1979.

DIALOG FILE DATA

Inclusive Dates:	1966 to the present; *Alloys Index*, 1974 to the present
Update Frequency:	Monthly (approximately 3,000 records per month)
File Size:	405,000 records as of October 1980

ORIGIN

METADEX is produced by Metals Information, a joint service of the American Society for Metals and The Metals Society. Questions concerning file content should be directed to:

Ed Kaminski
Manager, Information Services
American Society for Metals
Metals Park, OH 44073

Telephone: 216/338-5151
TELEX: 980-619 METALEX-MTPK

DIALOG* INFORMATION RETRIEVAL SERVICE

SCISEARCH

FILE DESCRIPTION

SCISEARCH is a multidisciplinary index to the literature of science and technology prepared by the Institute for Scientific Information (ISI*). It contains all the records published in *Science Citation Index* (SCI*) and additional records from the Current Contents series of publications that are not included in the printed version of SCI. SCISEARCH is distinguished by two important and unique characteristics. First, journals indexed are carefully selected on the basis of several criteria, including citation analysis, resulting in the inclusion of 90 percent of the world's significant scientific and technical literature. Second, citation indexing is provided, which allows retrieval of newly published articles through the subject relationships established by an author's reference to prior articles. (¶ 34.1)

SUBJECT COVERAGE

Subjects include the following areas: (¶ 34.2)

- Acoustics
- Aeronautics
- Agriculture
- Astrophysics
- Behavioral Sciences
- Biochemistry
- Biology
- Biophysics
- Botany
- Cardiology
- Chemistry
- Dermatology
- Electronics
- Engineering
- Environmental Science
- Geology
- Mathematics
- Medicine
- Microbiology
- Pharmacology
- Physics
- Physiology
- Psychiatry
- Psychology
- Surgery
- Virology
- Zoology

SOURCES

The ISI staff indexes all significant items (articles, reports of meetings, letters, editorials, correction notices, etc.) from about 2,600 major scientific and technical journals. In addition, the SCISEARCH file for 1974-75 includes approximately 38,000 items from *Current Contents — Clinical Practice*. Beginning January 1, 1976, all items from *Current Contents — Engineering, Technology, and Applied Sciences* and *Current Contents — Agriculture, Biology, and Environmental Sciences* that are not presently covered in the printed SCI will be included each month. This expanded coverage will add approximately 58,000 items per year to the SCISEARCH file. (¶ 34.3)

DIALOG FILE DATA (¶ 34.4)

Inclusive Dates:	January 1974 to the present
Update Frequency:	Monthly (about 42,000 items per month)
File Size:	More than 1,500,000 citations, as of June 1977

ORIGIN

SCISEARCH is produced by ISI and questions concerning the file content should be directed to: (¶ 34.5)

Mr. Richard Sweet, Manager
Data Base Marketing
Institute for Scientific Information
325 Chestnut Street
Philadelphia, PA 19106

Telephone: 800/523-1850 toll free; in Penn. call 215/923-3300, Ext. 357, collect.

*Trademark Reg. U.S. Pat. & Trademark Office.

DIALOG* INFORMATION RETRIEVAL SERVICE
MAGAZINE INDEX™

FILE DESCRIPTION

MAGAZINE INDEX provides cover-to-cover indexing of over 370 popular American magazines. All articles, news reports, editorials on major issues, product evaluations, biographical pieces, short stories, poetry, recipes, and reviews are included. The only items not included are minor personnel notes, brief bulletins and other ephemera. MAGAZINE INDEX is particularly useful for answering general reference questions; because it includes information not available in any other online database, it provides a valuable adjunct in such areas as market research, public relations, government relations, journalism, food and nutrition, and the social sciences.

SUBJECT COVERAGE

The subject coverage of the magazines included in MAGAZINE INDEX can be broken down by the following major groupings:

- General/News
- Man and His Society
- Life and Living
- Leisure Time Activities
- Home Centered Arts
- Sports, Recreation, Travel
- The Performing Arts, Literature
- Business
- Science and Technology, Agriculture
- Consumer Product Evaluation
- Regional
- Environment

SOURCES

MAGAZINE INDEX provides coverage of the 371 most popular magazines in America and includes coverage of all 173 magazines covered by *Reader's Guide*.

DIALOG FILE DATA

Inclusive Dates:	1976 to the present
Update Frequency:	Monthly (approximately 5,000 citations per month)
File Size:	58,000 records, as of April 1978

DOCUMENT RETRIEVAL

MAGAZINE INDEX provides a document copy and delivery service for articles from magazines not available in a local library. The service is provided in compliance with the Copyright Act of 1978 and in cooperating with the Copyright Clearance Center. There is a processing fee and per-page copy charge. For further information contact MAGAZINE INDEX below.

ORIGIN

MAGAZINE INDEX is produced by The Magazine Index, a division of IAC, and questions concerning file content should be directed to:

Mr. Dick Kollin
Vice President
The Magazine Index
Information Access Corp.
885 North San Antonio Rd.
Los Altos, CA 94022

Telephone: 800/227-8431 toll free or in Calif. 415/941-1100

*Trademark Reg. U.S. Pat. & Trademark Office

DIALOG* INFORMATION RETRIEVAL SERVICE

PIRA

FILE DESCRIPTION

PIRA is a machine-readable version of *Paper and Board Abstracts, Printing Abstracts, Packaging Abstracts,* and *Management and Marketing Abstracts.* The first three provide abstracts of industry-specific scientific, technical, marketing, and management literature; the last-named covers the general literature and is not slanted to any particular industry.

SUBJECT COVERAGE

The database is divided into four principal subject areas: paper and board, printing, packaging, and management and marketing. A representative, but not exhaustive, listing of subjects covered is given below:

- Adhesives
- Binding
- Composition
- Education and Training
- Finishing
- Food Packaging
- Forecasting
- Graphic Arts
- Industrial Relations
- Inks
- Materials
- Machinery
- Occupational Safety
- Plastics Packaging
- Pollution
- Production
- Pulps
- Recycling
- Reprography
- Retailing
- Testing

SOURCES

Material in PIRA is gathered from literature published throughout the world and includes over 600 periodicals as well as books, pamphlets, standards, specifications, legislation, translations, conference papers, research reports, trade literature, and other information.

DIALOG FILE DATA

Inclusive Dates:	1975 to the present
Update Frequency:	Monthly (approximately 10,000 citations a year)
File Size:	31,000 records, as of May 1978

ORIGIN

PIRA is produced by Pira, and questions concerning file content should be directed to:

Pira
The Research Association for
the Paper and Board,
Printing and Packaging Industries
Randalls Road, Leatherhead
Surrey KT22 7RU, U.K.

Telephone: Leatherhead 76161

Telex: 929810

*Trademark Reg. U.S. Pat. & Trademark Office.

DIALOG* INFORMATION RETRIEVAL SERVICE
CONFERENCE PAPERS INDEX

FILE DESCRIPTION

CONFERENCE PAPERS INDEX (CPI) covers about 100,000 papers of approximately 1,000 scientific and technical meetings worldwide each year. Because of the inherently strong interdisciplinary orientation of scientific meetings, CONFERENCE PAPERS INDEX is extremely useful because it provides a single index to meetings in all scientific and technical fields. The corresponding printed publication is the monthly Conference Papers Index.

SUBJECT COVERAGE

CONFERENCE PAPERS INDEX covers meeting and papers in the following areas:

Life Sciences:

- Clinical Medicine
- Experimental Biology and Medicine
- Animal and Plant Science
- Biochemistry
- Pharmacology

Engineering:

- Aerospace
- Mechanical
- Civil
- Electronic
- Chemical
- Nuclear
- Power

Physical Sciences:

- Chemistry
- Geosciences
- Physics
- Mathematics
- Operational Research
- Materials Science and Technology

SOURCES

The information included in CONFERENCE PAPERS INDEX is taken from the final program or abstract publication of conferences, supplemented by responses to questionnaires sent by CONFERENCE PAPERS INDEX staff. Each entry includes the title of the paper; name(s) of author(s); conference publications issued or planned for issuance; preprints, reprints, abstract booklets, and proceedings volumes available; dates of availability; costs; and ordering procedures.

CONFERENCE PAPERS INDEX may also include both references to papers presented at conferences but not yet published, and to some not intended for publication. Entries include the location of the author for further information.

DIALOG FILE DATA

Inclusive Dates:	January 1973 to the present
Update Frequency:	Monthly (approximately 10,000 records per month)
File Size:	530,000 records as of August 1978

ORIGIN

CONFERENCE PAPERS INDEX is produced by Data Courier, Inc., 620 South Fifth Street, Louisville, Kentucky 40202.

Questions concerning file content should be directed to:

Information Services Dept.
Data Courier, Inc.
620 South Fifth Street
Louisville, Kentucky 40202

Telephone: 502/582-4111

*Trademark Reg. U.S. Pat. & Trademark Office.

BHRA FLUID ENGINEERING ABSTRACTS (FLUIDEX)

DIALOG INFORMATION RETRIEVAL SERVICE

FILE DESCRIPTION

BHRA FLUID ENGINEERING ABSTRACTS (FLUIDEX) is a specialized database produced by the British Hydromechanics Research Association (BHRA). It provides a comprehensive source of information on all aspects of fluid engineering and behavior and applications of fluids. The file contains records from the ten BHRA-produced abstract journals and other sources.

An informative abstract is included for most records.

SUBJECT COVERAGE

Coverage includes all aspects of fluid engineering:

- Aerodynamics; Meteorology; Wind Energy
- Noise
- Coastal and Inland Fluid Engineering Works; Offshore Technology
- Multiphase Flow
- Mixing
- Measurement and Instrumentation
- Oilhydraulics (Fluid Power)
- Fluidics
- High Pressure Technology - Jet Cutting
- Computational Fluid Mechanics; Mathematical Modelling
- Fluid Sealing
- Materials - Properties, Corrosion
- Process Engineering (except Mixing)
- Heat Exchange
- Dredging, Mining
- Oceanography
- Pumps, Compressors, Hydraulic Turbines; Pipelines, Pipes and Fittings; Storage Vessels
- Fluid Mechanics in General
- Tribology
- Rheology
- Energy Extraction, Storage and Conversion

SOURCES

BHRA FLUID ENGINEERING ABSTRACTS contains references to articles from 550 international scientific and technical journals. Reports, conference proceedings, theses, books, standards, and British patents are also included.

DIALOG FILE DATA

Inclusive Dates:	1974-1976; 1978 to the present (1977 to be added in 1981)
Update Frequency:	Quarterly (approximately 3,000 records per update)
File Size:	58,000 records as of December 1980

ORIGIN

BHRA FLUID ENGINEERING ABSTRACTS (FLUIDEX) is produced by the British Hydromechanics Research Association. Questions concerning file content should be directed to:

FLUIDEX Database Support Team
BHRA Fluid Engineering
Cranfield
Bedford, MK43 OAJ
United Kingdom

Telephone: (0234) 750422
TELEX: 825059

No special terms or conditions.

DIALOG INFORMATION RETRIEVAL SERVICE
WELDASEARCH

FILE DESCRIPTION

WELDASEARCH, the database of The Welding Institute, is a comprehensive database covering all aspects of the joining of metals and plastics. Welded design, welding metallurgy, fatigue, and fracture mechanics are included, as well as related areas such as metals spraying and thermal cutting. The database provides international coverage of journals, books, patents, theses, conferences, etc. The file is indexed using the International Welding Thesaurus. There is no corresponding paper index or abstract journal.

SUBJECT COVERAGE

All aspects of the welding and joining of metals and plastics are included; in particular, the following topics:

- Welding
- Brazing
- Soldering
- Thermal cutting
- Metal spraying
- Design of welded structures
- Fatigue of welds
- Brittle fracture
- Welding and joining equipment
- Corrosion
- Welded construction
- Quality control
- Nondestructive testing
- Pipelines
- Pressure vessels
- Offshore structures

SOURCES

WELDASEARCH is international in scope covering several thousand journals as well as research reports, books, and monographs, new standards, patents (mostly U.K.), theses, and special publications.

DIALOG FILE DATA

Inclusive Dates:	1967 to present
Update Frequency:	Monthly (approximately 4,500 citations per year)
File Size:	45,000 records to March 1979

ORIGIN

WELDASEARCH is produced by The Welding Institute and questions concerning file content should be directed to:

Mr. R. T. Bryant
Head of Information Processing
The Welding Institute
Abington, Cambridge CB1 6AL
ENGLAND

Telephone: Cambridge 0223 891162
Telex: 81183

No special terms or conditions.

*Trademark Reg. U.S. Pat & Trademark Office

DIALOG* INFORMATION RETRIEVAL SERVICE

SURFACE COATINGS ABSTRACTS

FILE DESCRIPTION

SURFACE COATINGS ABSTRACTS is derived from the publication *World Surface Coatings Abstracts* (WSCA), founded in 1928. It provides worldwide coverage of the significant literature on all aspects of coatings applied to materials. SURFACE COATINGS ABSTRACTS is produced by the Paint Research Association.

SUBJECT COVERAGE

Subject areas encompass all aspects of surface coatings including the following:

- Paints
- Varnishes
- Lacquers
- Component Polymers and Pigments
- Printing Inks and Recording Materials
- Adhesives
- Dyestuffs
- Fire Retardants
- Resins
- Solvents
- Plasticizers
- Industrial Hazards
- Pollution
- Testing
- Technoeconomics

SOURCES

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C.6 FIGURE/TABLE SOURCE INFORMATION

C.6.1 Figures

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