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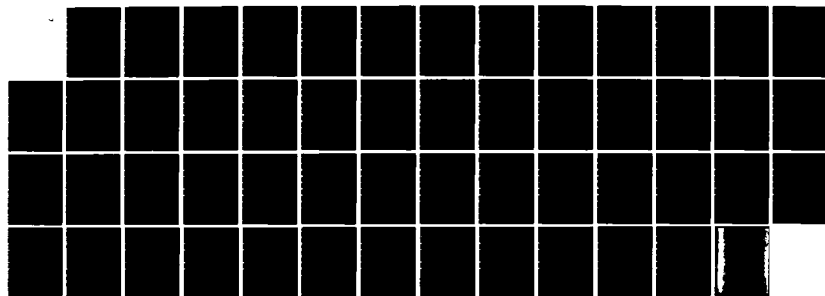
STANDARDIZATION PLAN FOR FIBER OPTICS OPTIONAL PHASE
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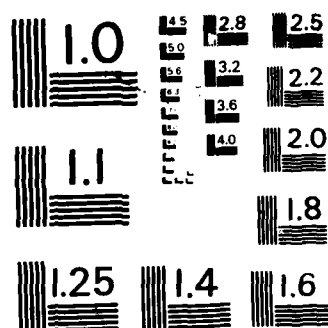
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FINAL REPORT

Standardization Plan for Fiber Optics
Optional Phase

VOLUME I

submitted under Air Force Contract F04606-82-C-1505

to

Sacramento ALC/PM
McClellan Air Force Base

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INTRODUCTION

The second phase of the program to develop a "Standardization Plan for Fiber Optics" as per SM/ALC statement of work MMIRE 82-45 dated June 24, 1984 was to implement the recommendations of the first phase (see first phase final report). Despite the complexity of the task which was unforeseen at the start of the program, the contractor applied a greater amount of effort than was required. However, due to the rapid changing fiber optic technology and the ever increasing number of systems, the complete needs of SM/ALC many not be met for at least several years. In order for SM/ALC to effectively carry out its stocklisting activities without the threat of proliferation, fiber optic technology must stabilize. This is not to say that interim standards for fiber optics should not be pursued or that fiber optics components should not be inventoried. Rather, it does mean that extreme caution must be exercised in the development of such documents and selection of components for the inventory. < 1

Specifically, the optional phase of the statement of work required:

1. Gathering of technical data necessary to prepare limited coordination (USAF) standards in accordance with the Defense Standardization manual DOD 4120.3-M, Chapter III, Section 6.
2. Selection of Fiber Optics items for Air Force Inventory.
3. The preparation of the limited coordination standardization documents.

The majority of this study was spent on Items 1 and 2. Item 1 formed the basis for the selection of the fiber optics items in Item 2 and was by far the most difficult to accomplish. Efforts in



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DATA COLLECTION MODEL

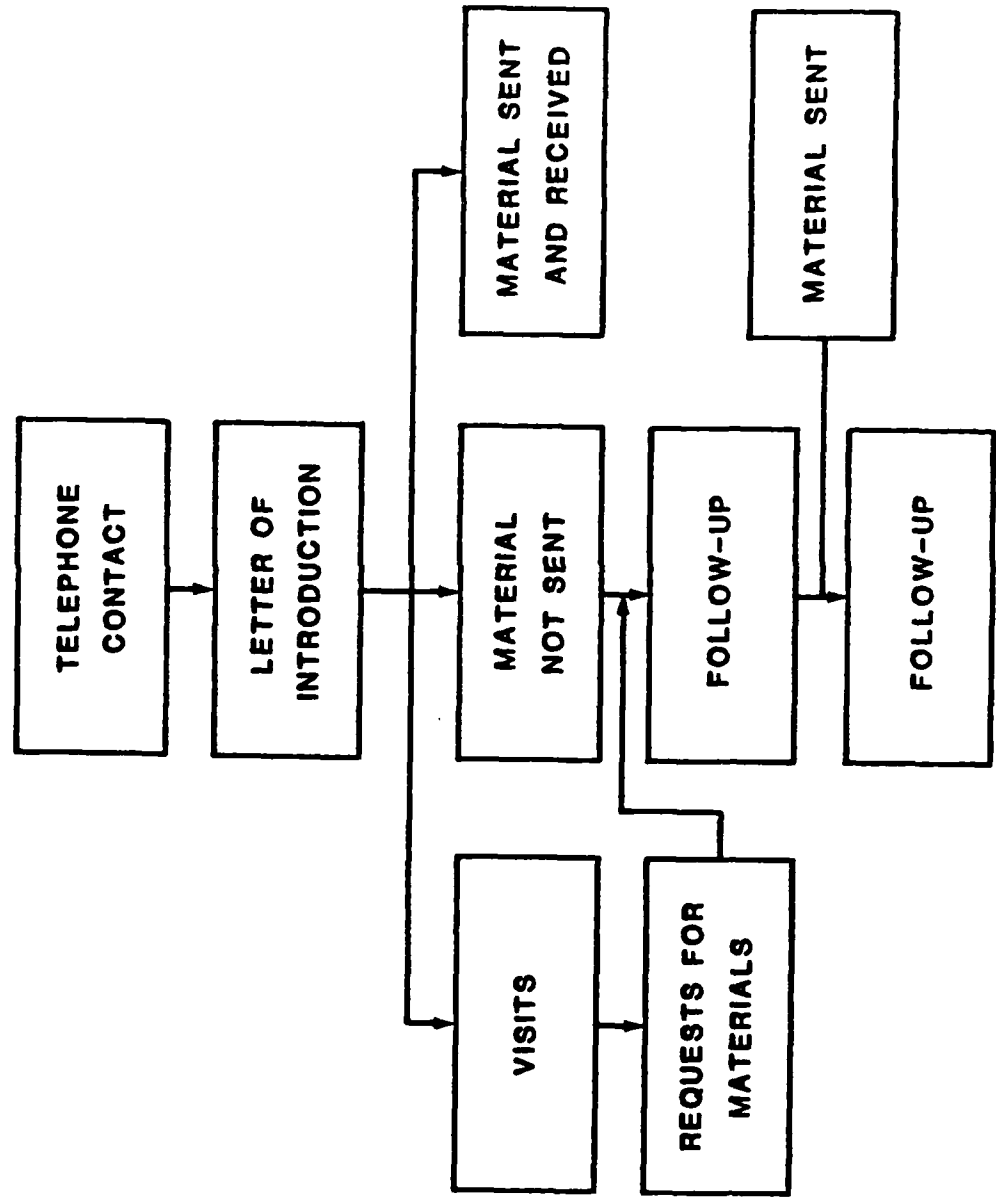


FIGURE 1

Item 1 also showed the need for limited coordination standards. It has been shown in this study that the data base will take several years to complete and hence only limited recommendation on items for the inventory can be made until more in depth data is available. Similarly, limited coordination documents are being prepared by organizations such as DESC and EIA. It is recommended on an interim basis that the DESC documents be used.

Results of this phase were originally to be delivered in hard copy form. However, a decision was made to deliver the resultant data base in machine readable form as specified by SM/ALC. As per this requirement, tapes were delivered to SM/ALC containing the following data bases: Fiber Optic Systems, Standards and Specifications, Commercially Available Fiber Optic Components and Fiber Optic Components Presently Used in Military Systems. Examples of these data bases are included as appendices to this report.

Although this hard copy report is not required, it has been presented as a vehicle to describe the data bases, and to review our summary and conclusions, recommendations, and potential future directions of work that is still needed.

APPROACH

Since the data collection was the most important part of this portion of the study, considerable time and effort was spent on developing a methodology that could obtain the maximum results. Figure 1 shows the model used. Even before initial telephone contacts could be made, a base of contacts was developed for systems, standards, and commercially available components. On the average, several iterations of contacts were required before usable data was obtained. Even though a systematic approach was taken, the results turned out not to be as complete as wished for. Nevertheless, the experience has shown the difficulty in obtaining this type of information.

FIBER OPTIC SYSTEMS DATABASE

Our data collection and analysis activities to date have identified 172 systems that utilize fiber optic components in some capacity. A complete listing of these systems has already been provided in a machine readable form per SM/ALCs specifications. Sample pages of this database have been repeated in Appendix 1 for your reference. This database identifies the responsible management organization, the current status, and the existing or planned amount of systems. Also identified as part of this database is the appropriate military and contractor system contacts. These individuals names should prove most helpful should SM/ALC wish to do further research on a particular system. During the data gathering, the majority of these contacts reacted favorably to the initial collection of this data and to the potential of periodic updates. As was explained in the final oral briefing, a major portion of the listed systems are development or experimental in nature and should not play an important role in SM/ALC's initial stocklisting efforts. However, these should continue to be tracked because of their potential long term effects. A complete alphabetical listing of the 172 systems identified thus far is included in Appendix 2. In addition to these systems, Appendix 3 lists most of the major Air Force and DOD fiber optic research and development programs. Collectively the infiltration of nonstandard components entering the Air Force fiber optic parts inventory from these systems could be overwhelming. It is this potential of uncontrolled proliferation that further emphasizes the need for immediate action to hold this process in check.

The immediate needs of SM/ALC are concentrated on identifying major components thrusts and development trends that will have significant impact on selecting the components to be stocklisted and eventually stock piled by the USAF. An initial step in this process was to identify present and future Air Force programs that will use a significant amount of fiber optic components. The analyses were concentrated on these

programs because of their immediate impact on stocklisting and procurement efforts. In addition, were examined fiber optic systems used and being developed by other services and government agencies in order to identify similar applications. For each of the systems analyzed, the operation and performance specifications of the fiber optic components were reviewed to determine how they might apply to the SM/ALC effort. References to these Tri service and government programs were kept to a minimum and were based on their importance to the stocklisting, stockpiling and procurement needs of SM/ALC. Typically these were limited to major programs that have undergone extensive development efforts.

The conclusions and recommendations as summarized later in this written report are drawn from the entire data collection and analysis efforts. However, as mentioned above, our focus has been narrowed to those systems which will represent the most immediate impact. This list is shown in Figure 2. These systems are representative of the current major application categories. Most of the major trends that will effect SM/ALC have been identified by examining this list.

AIR FORCE

GROUND TACTICAL

AN/GRC-206
TACTICAL GENERAL CABLE
TACS
MFOX
FLEXIBLE INTERCONNECT
ASOC
BETA
AN/MPN-XX
AN/TPS-43
TAOC-85 (MCE)

FIXED BASE COMMUNICATIONS SYSTEMS

AN/TPN-19
AN/GYQ-21 (4)
OASIS
VANDENBURG FIBER OPTIC TRANSMISSION
SYSTEM

AIRBORNE

ARMY

GROUND TACTICAL

FOTS (LH)

FIXED BASE COMMUNICATIONS SYSTEMS

AIRBORNE

NAVY

GROUND TACTICAL

AN/FAC-2A

FIXED BASE COMMUNICATIONS SYSTEMS

AIRBORNE

AV8-B

JOINT SERVICE PROGRAMS

GROUND TACTICAL

GLCM
AN/TTC-39
LDFOCS

FIXED BASE COMMUNICATIONS SYSTEMS

AIRBORNE

FIGURE 2

Research and Development Data Base

Data has been collected from a number of different sources on research and development activities throughout DOD. This data is difficult to characterize so that it cannot be put easily into electronic form. The difficulty arises from the fact that it is interrelated both from a program and time standpoint. In this report is included a large amount of data both in tabular and graphical form. A determination must be made by SM/ALC as to the best format required.

The conclusions to be drawn and the relationship of the Research and Design programs to inventory decisions are not clear at this time except to show major trends that the logistician needs to keep in mind. As the data base is refined, the relationship between Research and Design and actual systems in the inventory will become more clear.

The data collected is included in Appendix 3.

FIBER OPTIC SPECIFICATIONS AND STANDARDS DATABASE

Insight to the type of components that are used, where and in what quantity are not enough for SM/ALC to complete its task of identifying those components to be stocklisted by the United States Air Force. Understanding and knowledge of what specifications have been prepared, and what standards (military and commercial) have been developed is also of prime consideration. In order to prevent the proliferation of components, the Air Force must utilize a common set of standard or specification documents when procuring these items. Ideally, these documents should be adopted from those that currently exist. As identified in our interim report, our standard and specification document data collection was concentrated on providing SM/ALC with documents that may apply to various fiber optic components. Optimally, each should completely identify the desired components design and performance characteristics. Parameters for each of the following characteristics should be identified:

- Optical
- Mechanical
- Environmental
- Electrical (if applicable)

In the pursuit of attaining these optimal specification documents, both military and industrial sources were searched. A list of some of the organizations contacted is shown in Figures 3A & 3B. A machine readable tape (per SM/ALC's specifications) summarizing these efforts has been delivered prior to this report. (A hard copy also has been included for reference in Appendix 4.) Overall system specification documents containing various fiber optic component data have also been reviewed. This process has identified those components being used for particular operational and environmental applications. Additionally reviewed were

STANDARD ORGANIZATIONS CONTACTED

<u>AGENCY</u>	<u>NAME OF CONTACT</u>	<u>WORKING GROUP OR SUBCOMMITTEE</u>	<u>STATUS</u>
DESC	Steven Searcy DESC/EMD	Fiber Optics	Completed specifications on multi- port couplers, splices, sources, detectors, bulkhead penetrator, cable/harness assembly expected during first quarter of 1984. Mil-C-1200 is under revision in order to incorporate connector packaging. Draft specifications on SMA style connectors, multipin connectors (Hughes), repeater devices and various tools expected during first quarter of 1985.
EIA	Joseph R. Neigh AMP, Inc.	EIA-P6	Listing of existing and under development specifications has been presented in standards database. P6 group most active in standards development. EIA is currently writing specifications according to the International Electrotechnical Commission (IEC).
	H. N. Dorris (Chairman) AT&T Information Systems	EIA TR-44	Optical Communications Systems Committee. Deals with technical considerations of lightwave communications systems.
	O.M.M. Mitchel AT&T Information	EIA-TR-44.1	Optical fiber telecommunications systems subcommittee. "General Specification for Digital Optical Fiber Telecommunications Systems" draft 6/83. Single mode systems work is being initiated.
	H. N. Dorris	EIA-TR-44.2	Fiber optic Local Area Network subcommittee considering fiber optic architectures and component uses. Interface and interchange circuit parameters have assigned to a task group. A LAN bibliography of inter- face standards for on premise fiber optic and hybrid networks will be developed. These specifications will deal specifically with fiber optic issues.
	W. L. Schumacher AMP, Inc.	EIA-TR-44.4	Fiber optic system terms and docu- mentation control subcommittee. No progress as yet.

FIGURE 3A

STANDARD ORGANIZATIONS CONTACTED

<u>AGENCY</u>	<u>NAME OF CONTACT</u>	<u>WORKING GROUP OR SUBCOMMITTEE</u>	<u>STATUS</u>
R. F. Hazel ITT		EIA-TR-44.5	Industrial liaison for military optical fiber systems.
EIA JEDC	Walker Sperry Corp	JC-13	Government liaison group for solid state products. Basic related documents are Mil-Std-38510; micro circuits.
ANSI	Russel Bodoff Dir. of Develop. American National Standards Institute	ANSI/ECSB	Meeting held December 14, 1983 to decide on areas in which to concentrate. In order to eliminate a duplication of effort ANSI has proposed that a fiber optic coordinating committee established under the IEEE Electrical and Electronics Standards Board (EESB).
SAE	Charles Husbands Mitre Corp	SAE-AE9C	Has proposed adopting Mil-Std-1773. Document being discussed with Tri Service multiplex committee.
	Victor Saucedo	SAE-AE-8D	Currently working on test requirements for fiber optic wiring installation techniques. It is expected that wire installation of military vehicles will be addressed soon.
IEEE	C. Kleecamp Mitre Corp	802.8	Fiber optics technical advisory group is investigating ways that the various 802 working group efforts can be transferred to the use of fiber optics.
CCITT	L. C. Baehler AT&T Communications	Study Group VI	Current responsibilities are for: conductor insulation requirements, sheaths, protective coverings, placing and installation techniques, corrosion protection. Handbooks are in process of being published on various subjects.
NATO			Fiber optic working group AC301/SGI/STG7 preparing allied standards publications
CCITT	G. Bonaventura	Study Group XV	Transmission systems, digital systems working party. Several reports being prepared at working party and special rapporteur group level. Specific questions and issues regarding fiber optics are being addressed.

FIGURE 3B

fully developed and in progress Department of Defense specifications, military standards, system statements of work and procurement documents in an effort to form a consensus of specifications used. Those pertinent to a specific Federal stock class or a fiber optic system have been included in the database.

In following our earlier discussed methodology, the specifications were reviewed for their direct application to each of the Federal Stock Classes. As was the case with Air Force fiber optic systems, efforts were concentrated on those available specifications that addressed the immediate needs of SM/ALC. Dividing these by their application to each of the federal stock classes enabled developing technology and purchasing trends to be identified. The resultant list created by this review is included in Appendix 5. It is our recommendation that SM/ALC obtain copies of the identified documents for future reference. The results of the analysis of this list will be discussed later in the recommendations section of this Report.

FIBER OPTIC COMPONENTS CURRENTLY BEING USED IN MILITARY SYSTEMS

An area of considerable importance to SM/ALC's efforts was the identification of fiber optic components presently being specified and used. The non existence of a central depository of component information hampered data collection in this area. As presented to SM/ALC orally, the efforts entailed several telephone conversations, and written correspondence followed up by one, and in some cases, two visits with key individuals. Organizations that represent the major sources of data are listed in Figure 4. A large portion of the difficulty in gathering this data was locating the correct individuals. These most often were the SPO or the project manager who held the largest depository of information regarding any one system. In some cases it was necessary to locate additionally a specific engineering group that could provide the component data required. As a result, a quick reference military fiber optic contact list was organized. A copy of this list has been included in Appendix 6.

The existing stocklists of the Defense Electronics Supply Center (DESC) were researched for applicable fiber optic component data. This list, admitted by DESC, represents only a portion of what fiber optic components are actually used in the military. Therefore, this was used as a starting point and acted as a complementary source to the personal visits and questionnaire distribution. A completed list of these fiber optic components has been assembled and forwarded to SM/ALC in a machine readable format (per SM/ALC's specification). The completed overall list and a sample of what components are used in a specific system is included in Appendices 7A & B. Where available, and possible, each component's commercial and military part number has been listed. Also identified in this component listing is the manufacturer and specifications currently met.

In following the theme of identifying acceptable components and applicable specification documentation, the listing submitted to SM/ALC

AGENCIES FROM WHICH DATA WAS COLLECTED

AIR FORCE

AFCC
HQ AFLC
AFWL
ASD
EGLIN, AFB
ESD
AF FLIGHT DYNAMICS LAB

MITRE
HQ USAF
AF AVIONICS LAB
RADC
SM-ALC
SAC
WR-ALC

ARMY

CECOM
ARMY COMM. COMMAND

AVARADCOM
DARCOM

TRI-TAC

U. S. MARINES

C³ DIVISION DEVELOPMENT CENTER

NAVY

NAC

NAVELEX
NOSC
NRL
NAVAIR
NAVAL ELECTRONICS SYSTEMS DIVISION

NAVAL ELECTRONICS SYSTEMS
SYSTEMS CENTER
NAVAL ELECTRONICS SYSTEMS COMMAND
NAVSEA
NAVAL SURFACE WEAPONS CENTER
NAVAL SHIP R&D CENTER

DOD AGENCIES

DCA
DESC

OTHER GOVERNMENT AGENCIES

FAA
NBS

NASA
INSTITUTE FOR TELECOMMUNICATION
SCIENCE

SYSTEM VENDORS AND CONTRACTORS

FIGURE 4

(Appendix 7) was categorized by federal stock class. The resultant stock class lists contain only those components used in Air Force systems. These lists have been organized as performance charts (Appendix 8) so that adoption and usage criteria can be drawn for certain families of components. These charts indicate the stated performance specifications of the various commercially available products currently being used in military systems. (Data on specifically developed military programs that are confidential was not available.) This data has been drawn both from available product data sheets and manufacturer interviews.

Commercially Available Products

Data obtained on commercially available products was received from manufacturers principally by mail. A detailed questionnaire was generated and mailed by Information Gatekeepers, Inc. to various fiber optics manufacturers. It was requested that they provide information on their products, and to make special note of any components used in military systems or to meet military specifications. The majority of manufacturers do not produce for the military market, so a select number of products was sent to the SM/ALC. These included those respondents claiming to have developed military qualified fiber optics products and those firms having components already in use in military systems. An example of the type of data in the SM/ALC data base on commercially available components is shown in Appendix 10.

DATA ANALYSIS METHODOLOGY

The standardization and stocklisting plan developed during the first phase of this contract outlined the methodology to be used in making fiber optic item and specification recommendations. A flow graph depicting the data collection and analysis methodology used has been repeated in Figure 5. As pointed out in previous reports, technical data concerning various fiber optic systems would be used to complement established recommendation procedures. Several other key factors concerning the fiber optic industry have also been taken into consideration.

- a. Developments in fiber optic technology are occurring on the average of every six months. What is considered state of the art today may well be obsolete tomorrow.
- b. Procedures for maintenance and repair of fiber optic items will change as the technology develops.
- c. Decisions concerning the volume and types of components to stock list will require careful scrutiny because of the rapidly advancing technology.

ITEM DATA COLLECTION

CURRENTLY AVAILABLE

IN DEVELOPMENT

INDUSTRY FORECASTS
& BACKGROUND

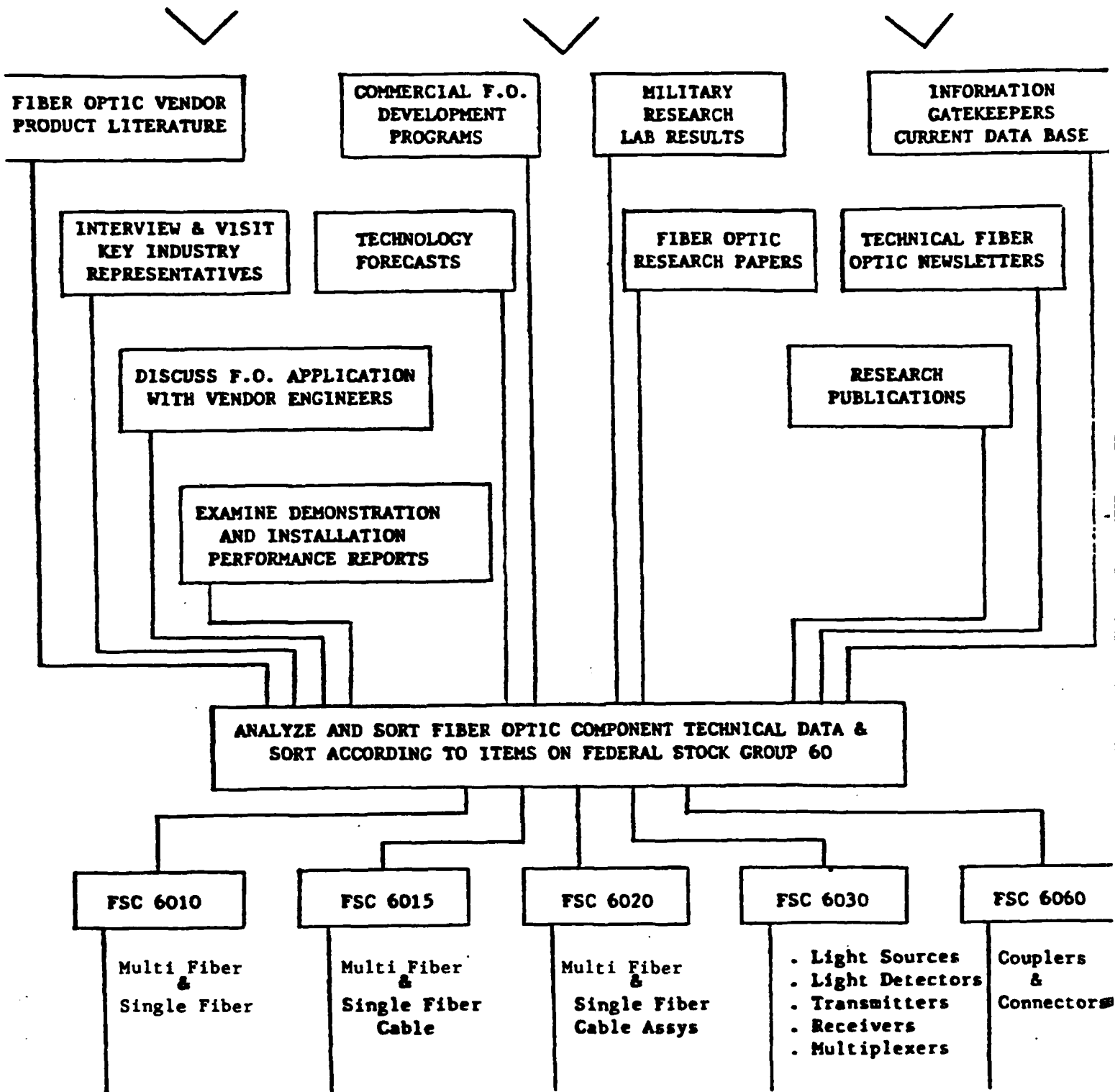


FIGURE 5

- d. Preparation of component evaluation data will be required to perform qualification testing, since standard test and measurement techniques have not been formalized.

Analysis of the currently used item list in Appendix 7, has provided insight to the specific applications of several different components. Further research has resulted in the component performance specification charts (Appendix 8) described earlier. Identified are some of the operational characteristics of these components. Also noted are whether those components were specially manufactured or are no longer available. The information was obtained from applicable manufacturers' data sheets and through interviews with manufacturers' representatives. Categorizing these charts by Federal stock class, has enabled frequently used types of components to be identified. The Hughes Connector family has obvious widespread usage in many tactical and base communication systems. Due to its construction it seems well qualified for ruggedized applications. Many of the systems listed as using the Hughes Connector had originally specified a connector with such qualities. Another frequently used item that can be easily identified is the widespread usage of 50/125 fiber in communications cable and the tendency of procuring transmitter and receiver packages rather than single source and detector devices. Although some of these devices are currently used in Air Force systems the question of whether these items should be stocklisted and/or stockpiled remains.

STOCKLISTING AND STANDARDIZATION RECOMMENDATIONS

The potential growth of fiber optic applications in Air Force systems is overwhelming. The advantages of fiber optics are beginning to be applied in new areas almost daily; hence the initiation of SM/ALC's efforts to limit the potential proliferation of fiber optic items was well timed. Several large research and development programs are beginning to mature into the production stage and many more are expected to follow. However, because the technology is advancing so rapidly, the selection of which components to stocklist must be done so cautiously. SM/ALC should also be aware that those fiber optic systems that are already installed were designed over a period of years and hence may be using out of date components. Our recommendations for the actual stocklisting of components in each of the federal stock classes take these and other factors into consideration.

In addition to identifying what fiber optic components should be stocklisted, SM/ALC requires appropriate standardization or specification documentation. It has been generally agreed that this documentation, necessary for the proper stocklisting and procurement of fiber optic items, be adopted rather than newly generated. Therefore, as discussed, various industry and military standardization documents, program statements of work and system specifications were reviewed for applicable fiber optic specifications. Results of how these apply to the Federal Stock Classes are included in Appendix 9. This investigation was helpful in identifying component trends as well as the trends in what documentation is used to support these components.

In addition to the list of component stocklist recommendations, specification or standards documents that should be adopted in support of these components have been identified.

6010-Fibers

Investigations to date have been unable to identify widespread uses of bare fiber, or production programs where large amounts will be used. Although analysis of the component data base reveals a collection of bare fiber, further research has shown that these specific fibers were cabled by the manufacturer prior to procurement by various Air Force agencies. Our analysis has revealed that the same cable configuration using slightly different fiber is used in various applications. It is more often the case that the specific fiber used in these cables tends to vary more than the cable itself, since engineering groups specify components that meet exact requirements for their system. In any case, it is anticipated that the majority of fiber optic system applications will require cabled not bare fiber. Solutions for which 6010 items should be stocklisted may best be handled by cross referencing which of the 6015 or 6020, cable and cable assemblies house the appropriate 6010 fibers.

Therefore, stockpiling large quantities of bare fiber may not be presently practical since the Air Force is not equipped to cable it. However, this may be a consideration in the future when fiber designs and manufacturing techniques have stabilized. In the interim, limited uses of bare fiber are foreseen with research and design efforts constituting the majority of applications. However, SM/ALC should continue to track these activities so that potential large uses can be identified early. Two such potential major users of bare fiber are laser gyros and missile payout systems. The missile payout programs should particularly be tracked because of their rapid development and widely stated need.

6010 Fiber Specifications

As previously discussed, bare fiber applications are minimal at this time. Most current systems are specifying and using fiber cable rather than bare fiber. The majority of those applications that are using bare fiber are development programs such as the Missile Payout Program.

Adopting specifications for fiber alone, therefore, is also not practical at this time since most current applications call for cabled fiber, and, those programs that could use bare fiber (i.e. Missile Payout) will use a special type not readily applicable to other uses. Therefore it is recommended that fiber specifications be covered under a 6015 cable specification for now; with plans to adopt specifications written for special applications on an ad hoc basis. The operational and physical properties of fiber used in cable is most often specified in those cable documents. Industry trends for commercially available fiber indicate a widespread use of 125um core fiber. In order to reduce proliferation of other diameter fiber and to eliminate stocklisting and system support problems, it is recommended that the Air Force adopt this as an interim fiber standard.

6015 - Cables

Due to the varying degree of operational and environmental Air Force fiber optic applications, it is understandable that a wide assortment of fiber optic cables are currently being used. The introduction of fiber optic cable to new system applications if allowed to increase uncontrolled at its present rate, will surely result in proliferation. However, as mentioned earlier, caution must be used in narrowing the list of currently used components while also planning to meet future systems requirements. Review of current and potential uses of fiber optic cable has revealed certain similarities. These similarities became noticable after an analysis of various system performance and specification documents.

SM/ALC's stocklist strategies should include stocklisting cables for the present and projected tactical, fixed base and airborne applications. Present applications are foreseen to be in tactical and fixed base systems. Airborne applications are non existent and therefore should not be currently considered in stocklist strategies. Several production and development programs have or soon will specify replacements for tactical coaxial cable technologies. The Tactical Generic Cable Replacement (TGCR) program is specifically developing a fiber optic replacement for the 26 pair cable currently used by the Air Force. The FOTS (LH) program is developing a replacement for the coax cable currently used in Army and Tri Service applications. Keeping these future requirements in mind, SM/ALC must also support several present system applications.

The majority of most immediate applications for the Air Force are in the ground tactical area. (AN/TPS-43, AN/GRC-206, TACS, 407L, etc.) All these applications have specified the use of field ruggedized cable. Cables now or planned to be used are:

AN/GRC-206	Valtec	C03-50002-02	2 fiber, 50/125, 400MHZ, 1km & 50'
	Valtec	C03-55018-02	2 fiber, 50/125, 400MHZ, 1km & 50'
AN/TPS-43	ITT EOPD	T-2501-04-1262A	4 fiber, 50/125, 200MHZ, 1km
TACS 407L			
	(AN/TSQ-91)	ITT EOPD T-2501-04-1224	4 fiber, 50/125, 200MHZ, 1km
	(AN/TSQ-61)	ITT EOPD T-2501-04-1224	4 fiber, 50/125, 200MHZ, 1km

Currently used cables in the fixed base applications are:

AN/TPN-19	ITT EOPD	T-2501-02-1224	4 fiber, 50/125, 200MHZ, 1.5km
AN/FAC-2A	ITT EOPD	T-3500-04-1202	4 fiber, 50/125, 200MHZ, 1km
		T-3500-07-1201	7 fiber, 50/125, 100MHZ, 1km
		T-3500-08-1201	8 fiber, 50/125, 100MHZ, 1km

Other systems and preliminary uses of cable that will soon have an impact on stocklist strategies are:

ASOC	Valtec	C03-50002-02	2 fiber, 50/125, 400MHZ, 1km
(AN/TSC-60)			
(AN/TSQ-93)			

TGCR	Siecor		2 fiber, 50/125
TAOC-85	ITT EOPD	T-2501-04-1222C	4 fiber, 50/125, 200MHZ, 2km
(MCE)			

AN/MPN-XX *Cable not yet identified.

Flexible Interconnect *Cable not yet identified.

Consideration should also be given to other service and Joint Service Ground Tactical programs that may have an impact on the cables the Air Force chooses to stocklist. Some of these programs are:

FOTS(LH)	ITT EOPD		2 fiber, 1km
GLCM	SIECOR	6578T1001	6 fiber, 100/140, 20MHZ, 300m
AN/TVC-39	ITT EOPD	T-2501-06-1221	6 fiber, 50/125, 100MHZ
TRI TAC			
LDFOCS			

Prior to reaching a decision on which of the above cables should be stocklisted, the terminations and applications should be considered. Part of this consideration is the present level of skill required to mate a connector to a fiber cable in the field. Although the expertise required to perform this function has decreased, it has not yet reached the level where it can be performed by field personnel. The equipment necessary to expect general levels of acceptable connector cable mating in the field will be available in acceptable size (portable) and price in about two years. Until this time it is recommended that the Air Force stocklist the appropriate cables; however, only minimal amounts of unconnectorized cable should be stockpiled.

In support of this recommendation, all of the sample programs listed above have specified these cables be preconnected assemblies. Therefore, field ready spares should be preconnected. The specific assemblies will be addressed in the 6020 section of recommendations, although cable to support a number of programs may be purchased unconnected with the purpose of depot level connector installation. Therefore, it is recommended that a combination of cable and cable assemblies be stocklisted with the strategy that the Air Force develop the expertise of cable termination.

The specific volumes of fiber optic cable that should be stockpiled are difficult to pinpoint at this time due to a lack of system planning data. It is, however, recommended that the types of cable selected for stocklisting closely match those specified by current production systems (i.e., AN/GRC-206, AN/TPS-43). It is also suggested that these types of cables be purchased in varying configurations (i.e., 2, 4, 6, 8 fibers) so that a number of planned systems can be supported.

6015 Cable Specifications

Adopting a fiber optic cable specification that would meet all cable requirements of Air Force applications is not recommended. This is due to the many current systems that fiber optics currently applies. In addition to the many operational variations, environmental considerations of where these cables are used must also play a part in the final selection of the specified cable. Cables that are used in airborne applications may not be practical in a ground tactical system and vice versa. It is because of these operational and environmental differences that it is recommended that SM/ALC adopt a specification for each application category.

As an example, three major application areas have been identified: Ground Tactical, Airborne and Fixed Base Communication Systems. Within these environmental areas there exists several levels of desired operational performance. Initial recommendations are that an overall application category specification be adopted and used in combination with the systems specific operational criteria until more formal specifications are developed. An additional consideration is the issue of terminated vs unterminated cable. As discussed earlier, SM/ALC must concern itself with this issue for stocklisting efforts, it is recommended that this also be considered when selecting specification documents.

The specifications for cables themselves will vary slightly from those of cable assemblies. The specifications chosen for cables will concern themselves with the cable itself and not with the method of packaging, termination and lengths. Both current and in process cable specifications deal with general cable characteristics. The more specific operational characteristics are included in the individual system specifications.

Therefore, it is we recommended that SM/ALC adopt the following general specifications until the completion of more formal documents:

DOD-C-85045	Military Specification Cables; Fiber Optic General Specification for Metric
DOD-C-85045/1	Military Specification Cables; Fiber Optics, Single Fiber
DOD-C-85045/2	Military Specification Cables; Fiber Optics, Heavy Duty
Mil-Std-1678	Military Standard Fiber Optics Test Methods and Instrumentation

The majority of fiber optic cable applications can utilize these documents to form a basis for future specifications. Further detail is needed since the most current systems (AN/GRC-206, AN/TPS-43, TACS 407L, AN/TPN-19, AN/FAC-2A, etc.), and those that are anticipated (TAOC-85, TGCR, etc.), all specify very similar cable. (See Appendix 9.) Because the TGCR Program is expected to have multiple applications, and meets operation criteria of the other programs, it is recommended that cable specifications developed from this program be adopted for SM/ALC's activities. It is also recommended that SM/ALC continue to review the progress of this program to insure that the results meet the needs of SM/ALC prior to the document's global adoption. Also, SM/ALC can prepare for any modifications that may be required. The majority of systems will be able to immediately use the TGCR cable specified even though in some cases the cable will be much better than was originally required.

6020 Cable Assemblies

As discussed in the 6015 recommendations, there are a wide number of applications for cable assemblies. The majority of systems that are in production or are currently installed specify the use of fiber optic cable assemblies rather than unterminated cable. Moreover, most of the system development programs also specify the use of preconnected assemblies. This is surprising since a review of the component performance tables does not indicate a significantly large number of cable assemblies. Investigations of component information sources (i.e., system specifications, statements of work, interviews) reveal that cables and connectors have been separated so that each can be specified to precise criteria. No effort, until now, has been made to identify these as an assembly.

As explained in the 6015 recommendation section, the reason that most of these systems specify cable assemblies rather than unterminated cable, is the level of expertise currently required to mate a connector to a fiber and maintain an acceptable loss factor in a field installation. Decisions regarding stocklisting of particular cable assemblies should be made with an eye toward future system applications and the efforts of some development programs. Cable assemblies, unlike cables themselves, will not have as wide an application base because of the different required terminations. Therefore, a large volume of assemblies not dedicated to specific system applications should not be immediately stockpiled. Recommended stocklisting and stockpiling strategies in this regard however are structured toward supporting the common applications, as well as specific program needs. Support for systems with an immediate need include cable assemblies for the AN/GRC-206, AN/TPS-43, TACS 407L, AN/TPN-19, AN/FAC-2A Air Force systems. (Although AN/FAC is a Navy system, it has Air Force applications.) The cables used in these assemblies were identified in the 6015 section. The connectors used for each are:

AN/GRC-206	Hughes, 2 contact, hermaphroditic
AN/TPS-43	Hughes, 4 contact, hermaphroditic

AN/TSQ-91	Hughes, 4 contact, Hermaphroditic
(TACS 407L)	
AN/TSQ-61	Hughes, 4 contact, Hermaphroditic
(TACS 407L)	
AN/TPN-19	Amphenol, SMA
AN/FAC-2A	ITT Supplied

Therefore combining the cables identified in 6015 with these terminations, immediate 6020 stocklist recommendations are:

1) <u>CABLE</u>	Valtec	C03-50002-02	2 fiber, 50/125, 400MHZ, 1km
<u>CONNECTOR</u>	Hughes		2 contact, Hermaphroditic
2) <u>CABLE</u>	ITT EOPD	T-2501-04-1262A	4 fiber, 50/125, 200MHZ, 1km
<u>CONNECTOR</u>	Hughes		4 contact, Hermaphroditic
3) <u>CABLE</u>	ITT EOPD	T-2501-04-1224	4 fiber, 50/125, 200MHZ, 1km
<u>CONNECTOR</u>	Hughes		4 contact, Hermaphroditic
4) <u>CABLE</u>	ITT EOPD	T-2501-02-1224	4 fiber, 50/125, 200MHZ, 1&5km
<u>CONNECTOR</u>	Hughes		4 contact, Hermaphroditic
5) <u>ITT CABLE ASSEMBLY</u>			
<u>CABLE</u>	ITT EOPD	T-3500-04-1202	4 fiber, 50/125, 200MHZ, 1km
		T-3500-07-1201	7 fiber, 50/125, 100MHZ, 1km
		T-3500-08-1201	8 fiber, 50/125, 100MHZ, 1km
<u>CONNECTOR</u>	ITT Supplied		

However, as with Cable (6015), development programs will have to be

tracked so that SM/ALC can anticipate a requirement to stocklist additional cable assemblies. Analysis of these programs has also revealed the specification of cable assemblies in the following programs:

ASOC	<u>CABLE</u>	Valtec	C03-50002-02	2 fiber, 50/125, 400MHZ, 1km
(AN/TSC-60)	<u>CONNECTOR</u>	Hughes		2 contact, Hermaphroditic
(AN/TSFQ-90				
TGCR	<u>CABLE</u>	Siecor		2 fiber, 50/125
	<u>CONNECTOR</u>	Hughes		2 contact, Hermaphroditic
FOTS(LH)	<u>CABLE</u>	ITT EOPD		2 fiber, 1km
	<u>CONNECTOR</u>	Hughes		2 contact, Hermaphroditic
AN/TYC-39	<u>CABLE</u>	ITT EOPD T-2501-06-1221	6 fiber, 50/125, 100 MHZ	
	<u>CONNECTOR</u>	Hughes		Hermaphroditic
GLCM	<u>CABLE</u>	Siecor	6578T1001	6 fiber, 100/140, 20MHZ, 300m
	<u>CONNECTOR</u>	Amphenol		
TAOC-85	<u>CABLE</u>	ITT EOPD T-2501-04-1222C	4 fiber, 50/125, 200MHZ, 2km	
	<u>CONNECTOR</u>	Hughes		4 contact Hermaphroditic
AN/MPN-XX				

6020 CABLE ASSEMBLY SPECIFICATIONS

Cable assemblies in essence are finished products, comprised of items of other Federal Stock Classes. Each of these individual items should, of course, meet their own established specifications prior to being considered for the finished assembly. However, fiber optic system development efforts until recently were more system specific. Systems have been developed to meet the needs of a certain application with no effort made to reference similar prior applications for the cable assembly construction. Most of the systems reviewed to date acknowledge the use of preconnected cable assemblies rather than unterminated cable.

As discussed, most of the immediate applications for fiber optic cable assemblies are in the ground tactical area. The purpose of the TGCR program is to replace the Air Force's current 26 pair coaxial cable systems and, as recommended in the 6015 section, future ground tactical applications of fiber optic cable should utilize the specifications developed by this program. It is recommended that SM/ALC track the progress of this program and be prepared to adopt the specifications that result. Preliminary specifications have been developed by the contractor (GTE Communications Products Corporation).

Additional specifications that should be adopted and reviewed by SM/ALC are:

Cable/Harness Assembly Specification - Prepared by: DESC

Contact: Dick Shade

Fiber Optic Transmission [FOTS(LH)] CR-CS-0051-001

Prepared by: Army Tactical Communications Systems

(ATACS) Contact: Alex Mondrick

Airborne systems using fiber optic components have been minimal. However, this may have been due to the lack of acceptable standards. In light of the soon to be completed Mil-Std-1773, Avionics Fiber Optic Databus, it is recommended that SM/ALC adopt this document for avionics cable assembly applications.

6030 - Light Sources, Light Detectors

Fiber optic sources and detectors very much like fiber cable have been specified exactly to the performance characteristics of particular systems. The optical portion of communication links have been designed to meet the needs of individual systems. The individual devices used are often then integrated into larger subassembly, transmitter and receiver devices. Such is the case with light sources and detectors.

A trend is that most systems employ the use of transmitter and receiver packages that contain the respective light sources and detectors rather than the devices themselves. Fiber optic transmission systems are currently used as replacements for coaxial and microwave systems. The optical transmitters and receivers have, therefore, been kept to a minimal level of complexity and size. This is due to the modular nature of most applications. However, specifications detail which particular light source and detector should be used in the respective transmitter and receiver packages. It is recommended that the Air Force decide on which specifications will be used for these devices so that they can be stocklisted; but these should not be stockpiled at this time. The stockpiling of items, if at all, should be concentrated in the transmitter and receiver area.

The current uses of the individual devices are mainly in support of research and design efforts. Therefore, as with cable/cable assemblies, an introduction strategy should be formed. As SM/ALC becomes more familiar with fiber optic technology and the rate of new product introduction slows, the Air Force may wish to consider stockpiling light source and detector devices. This familiarity with fiber optics may encourage depot repair and replacement of such devices. However, it is not recommended that SM/ALC initiate this effort immediately because of

the current level of expertise necessary. Developments are expected that would increase the modularity of these devices, making simple plug in replacement LED and Laser packages. Moreover, the technological thrust of the Air Force in fiber optics is expected to continue; therefore, it is also recommended that the continued use and development of the devices be monitored. And, as these developments are completed, SM/ALC should reevaluate the stocklist and stockpiling situation for these devices.

6030 LIGHT SOURCE, LIGHT DETECTORS SPECIFICATIONS

Even though it is recommended that the Air Force not stockpile these devices, the review and adoption of acceptable specifications should proceed. Recognizing this need, DESC is proceeding with developing general specifications for sources and detectors. However, the bulk of source and detector specification work is being done through the transmitter and receiver development efforts as described earlier. It is recommended that SM/ALC adopt the documents now being developed by DESC and closely monitor the progress of programs where common use transmitter/receiver devices are being developed. As these programs mature, SM/ALC should adopt or modify the source and detector documents because of the potential large effect these would have on SM/ALC's stocklisting efforts. Some of the programs SM/ALC should monitor are:

TGCR
FOTS(LH)
MFOX

Current GTE Specs Available
CR-CS-0051-001
Preliminary Report Available
RADC

6030 - Transmitters, Receivers

Due to the complexity of working with light sources and detectors that has been described, it is recommended that the Air Force begin stocklisting transmitter and receiver modules that apply to various systems. A major trend taking place in the Air Force is the replacement of tactical cable transmission systems. Several development programs already have or will soon identify transmitter and receiver modules that meet these requirements. These development programs are aimed at solving the need of many ground based tactical applications. The thrust of those systems that are installed are aimed more at addressing specific program needs. Immediate stocklist strategies should therefore be directed toward meeting the needs of current applications as well as planning to support future system applications. Recognizing that the application base of these more specific current transmitter and receiver devices is limited, SM/ALC should closely monitor the activities of several development programs since the potential of engineering overlap is quite likely.

Taking the existing USAF programs into consideration, it is recommended that the United States Air Force stocklist and stockpile transmitter and receiver packages to support the needs of installed or in production systems. Therefore, recommendations for stocklisting include:

AN/GRC-206 (Transmitter)	Spectronics	812099-801
(Receiver)	Spectronics	
AN/TPS-43E (Digital	Honeywell Optoelectronics	HFM 2010-224
Transmitter)		
(Digital	Honeywell Optoelectronics	HFM 4002-223
Transmitter)		

(Digital Receiver)	Honeywell Optoelectronics	HFM 1510-222
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(Digital Receiver)	Honeywell Optoelectronics	HFM 3502-222
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AN/TPN-19	(Transmitter)	ITT EOPD	T6011
	(Transmitter)	Honeywell Optoelectronics	SPX-4140
	(Receiver)	ITT EOPD	T6086
	(Receiver)	Honeywell Optoelectronics	SPX-4141
AN/FAC-2A	(Transmitter)	ITT EOPD	T-601C
	(Receiver)	ITT EOPD	T-6078

Fiber optic transmitters/receivers that should also be stocklisted are the product results of the fiber optic Analog and Digital modem programs. These devices are anticipated to address common problems in a number of applications. The contractor for these is Codenoll Technology.

It is also recommended that SM/ALC follow the various development programs that may have an impact on their stocklist and stockpiling strategies. Several Air Force programs now in development are structured to provide a common solution to many specific system needs and requirements. Fiber optic transmitters and receivers being developed in these programs, when available, should be stocklisted by SM/ALC. Some of these development systems that should be tracked are:

- Tactical Generic Cable Replacement (TGCR)
- FOTS (LH)
- TRI-TAC
- AN/TYC-39
- MFOX

The MFOX (Multi Purpose Transceiver) Program should be given special attention because of the number of potential system applications on which it will have impact.

6030 TRANSMITTERS AND RECEIVERS SPECIFICATIONS

As described in the transmitter and receiver component recommendations, current uses of transceivers are very system specific. Adopting one component to be used in all applications at this time is not recommended. However, the replacement of cable technologies through programs such as the TGCR, will play a role in potentially introducing common components and specifications to a number of programs. Current system applications unfortunately may have to continue being supported by their individual program specifications. However, future applications should adhere to the specifications being developed under the following programs:

MFOX
FOTS(LH)
TGCR
TRI-TAC
DIGITAL F.O. MODEMS
ANALOG F.O. MODEMS

These programs promise to have the most impact on SM/ALC's transceiver stocklisting efforts and therefore specifications documents should be adopted for other similar programs. Recommendations for the documents that SM/ALC should review for possible adoption are:

EQUIPMENT PERFORMANCE SPECIFICATIONS FOR DIGITAL F.O. MODEMS

Number: EPS-82-0016

Organization: 1842 EEG/EEICS

Scott AFB, Illinois 62225

Individual: Ken Becker

Phone: 618-256-4591

EQUIPMENT PERFORMANCE SPECIFICATIONS FOR ANALOG F.O. MODEMS

Number: EPS-82-016B

Organization: 1842 EEG/EEICS

Scott AFB, Illinois 62225

Individual: Ken Becker

Phone: 618-256-4591

EQUIPMENT PERFORMANCE SPEC FOR T1 MULTIPLEXER TERMINAL EQUIPMENT (draft)

Number: EPS-82-006

Organization: 1842 EEG/EEICS

Scott AFB, Illinois 62225

Individual: Ken Becker

Phone: 618-256-4591

EQUIPMENT PERFORMANCE SPEC FOR T3 MULTIPLEXER TERMINAL EQUIPMENT (draft)

Number: EPS-83-006

Organization: 1842 EEG/EEICS

Scott AFB, Illinois 62225

Individual: Ken Becker

EQUIPMENT PERFORMANCE SPEC FOR T1 CARRIER SPAN LINE EQUIPMENT (draft)

Number: EPS-82-00&

Organization: 1842 EEG/EEICS

Scott AFB, Illinois 62225

Individual: Ken Becker

FIBER OPTIC TRANSCEIVER SPEC.

Number:

Organization: RADC

Individual: Frank Chiffy

SPECIFICATIONS FOR REPEATER DEVICES

Number:

Organization: Air Force 85; WP AFBRADC

Individual: Dick Shade

DESC-EMD

Dayton, Ohio 45444

6060 - Interconnectors

Interconnection devices used by the USAF vary from simple splices to multipin connectors. The data collection and analysis have identified the Hughes multipin connector as the most widely used and therefore it should be stocklisted by the USAF. In addition to being the most popular connector currently used, the Hughes connector has been identified by DESC as a standard for multipin applications. Although other applications of multipin connectors are being tested, it is recommended that the USAF consider stockpiling the Hughes connector in sufficient quantities to meet the forecasted demand of current and planned system applications. Current system applications have been identified for use in the AN/TPS-43, AN/GRC 206, TACS 407L and other systems. Other connectors that are also specified for use in Air Force fiber optic systems are the ITT Cannon multipin connector, the Amphenol 905 and 906 series connectors. The Air Force should also stocklist and stockpile several quantities of the ITT Cannon multipin connector because of the number of systems now using it and for evaluation and comparison purposes. However, it may be in the best interest of the Air Force to stocklist both connectors to insure their availability. The Amphenol connectors are widely used for single fiber applications and also have a specification currently being written for it by DESC. Similarly, because of its widespread use, the Amphenol connector should be considered for stocklisting by the USAF. The list below depicts the connectors recommended to be stocklisted by the USAF at the present time. However, because of the logistics issues of cable/cable assemblies discussed in the 6015, 6020 section, SM/ALC may wish to consider stocklisting only those connectors that would be used as spares in support of systems. As with cable/cable assemblies, a combination of connectors and assemblies is suggested.

RECOMMENDATIONS FOR STOCKLISTING:

Hughes multipin Hermaphroditic (2, 4, 6, 8 contacts)

ITT Cannon multipin (2, 4, 6, 8 contacts)

Amphenol 906 Series (Single contact)

 905 Series (Single contact)

The following list of systems have immediate applications and hence the respective connectors should be stocklisted and stockpiled in quantities:

AN/GRC-206 Hughes 2 Contact Hermaphroditic

AN/TPS-43E Hughes 4 Contact Hermaphroditic

TACS 407L

 (AN/TSQ-91) Hughes 4 Contact Hermaphroditic

 (AN/TSQ-61) Hughes 4 Contact Hermaphroditic

AN/TPN-19 Amphenol SMA906

The following development programs, whose activities should be tracked, currently specify these connectors:

FOTS(LH) Hughes Hermaphroditic

TRI-TAC Hughes Hermaphroditic

ASOC Hughes Hermaphroditic

TGCR Hughes Hermaphroditic

AN/TYC-39 Hughes Hermaphroditic

TAOC-85 (MCE) Hughes Hermaphroditic

GLCM Amphenol

6060 CONNECTOR SPECIFICATIONS

As shown, a number of interconnector devices are currently used by the USAF. The stocklist recommendations specify the Hughes, Hermaphroditic, ITT Cannon multipin and Amphenol 905 and 906 series connectors as preferred choices for stocklisting. Connectors have not experienced the wide variation problem that has confronted the cable, cable assembly and transceiver component groups. Thus, a significant amount of study has been done in the specification area for interconnection devices. Several military and DOD specs have been or are in process of being completed. Some of these documents are preliminary in nature; however, SM/ALC may wish to adopt these upon their approval. Documents that should be adopted are:

Mil-C-85044	Military Spec Connectors (Fiber Optic) Prepared by: Naval Air Engineering Center
RS-440	Fiber Optic Conector Terminology Prepared by: EIA
Draft Only Final Issue 1/84	Specifications for a Bulkhead Penetrator Prepared by: Defense Electronics Supply Center
Draft Only Final Issue 1/84	Specifications for a Hull Penetration Device Prepared by: Defense Electronics Supply Center
Draft Only Final Issue 1/85	Specification for SMA Style Fiber Optic Connectors Prepared by: Defense Electronics Supply Center
Draft Only Final Issue 1/85	Specification for Hughes Multichannel Connectors Prepared by: Defense Electronics Supply Center

6060 - Couplers

During the information gathering stage and the follow up research, no major uses of fiber optic couplers were identified. This is obviously due to the instability and cost of these items during their development cycle. Until recently these items were very expensive and not readily used because of non standard operating characteristics. However, due to recent developments, these devices have decreased in cost and increased in operationality. Moreover, several military research and development programs have been initiated to study potential system applications of passive and active couplers. These programs are not expected to have an impact on the stocklist for some time, hence the recommendation is to not stocklist these devices now. Also recommended is to track these development efforts to keep abreast of developing funds in this area because of the large potential of these devices in a number of current and planned Air Force systems.

6060 COUPLER SPECIFICATIONS

Since there is no system with widespread coupler use, no specific thrust has been made in developing a specification for these devices. Therefore, adopting or developing a specification for coupler components may be premature at this point. The progress of research and development groups in the coupler area should be tracked, however, for component progress and emerging specifications. Also, the efforts of the DESC fiber optic group should be periodically reviewed for their progress in coupler specifications.

STOCKLIST AND STANDARDIZATION RELATED RECOMMENDATIONS

Fiber optic transmission systems are made up of many components. The linking together of these components (connecting cable, splicing fiber cable and pigtails), is decreasing in complexity. However, it has still not reached the level where these functions can be readily performed in the field. Therefore, stocklist strategies must be developed around the types of field installation that can be effectively accomplished. Also, the location and level of repair of these items must be identified by SM/ALC since the Air Force is beginning to use more fiber optic components. Our recommendation is that SM/ALC develop a certain maintenance expertise in fiber optics. This expertise should be in direct support of fiber optic stockpiled components and assemblies.

Some systems reviewed were recognized as using discontinued fiber optic devices. So that the SM/ALC can continue to support these applications with minimal effort, without proliferating the stocklist with many similar components, a list of currently available commercial fiber optic components was created. This list was described earlier and has been presented to SM/ALC in a machine readable format. To stop the proliferation of items, this list or a similar one, should be used by SM/ALC whenever possible for procurement purposes in support of systems using discontinued components. Upon the identification of an adequate replacement, this device should be stocklisted and stockpiled in the appropriate quantities.

Additional Recommendations

In addition to the recommendations made under each of the stock classifications, the following additional recommendations are made to provide the Air Force with Planning guidance.

1. With the fiber optics technology still three to four years away from stabilizing, it is recommended that additional contract efforts be planned to:

- (a) Collect and refine data on systems applications.
- (b) Collect and refine data on Research and Development activities.
- (c) Collect and refine data on commercially available components that meet military specifications or are used in military systems.
- (d) Collect and categorize reports on fiber optics component tests and evaluation.
- (e) Continue to update contact lists.

2. SM/ALC should develop a capability to test commercially available products, and develop lists of qualified suppliers by product.

3. SM/ALC should develop with its contractor a set of decision rules for determining what and how many fiber optics components to stocklist.

4. SM/ALC should develop a Directory for Fiber Optics systems that can be used for promoting the use of fiber optics and educating system program officers.

5. SM/ALC should investigate ways that data from industry IRAD programs can be entered into the data base.

6. SM/ALC should investigate the establishment of a Federal Stock Classification for fiber optics test equipment and splicing equipment and accessories.

7. SM/ALC should fund the development of test and measurement techniques for use both at the depot level and for use in the field.

8. SM/ALC should initiate a program to train its engineers on fiber optics design, and techniques on connecting, splicing, and test and measurement techniques.

9. SM/ALC should attempt to set up a system whereby industry IRAD fiber optics programs can be included in the R & D data base. This is due to the importance of industry IRAD programs.

FUTURE WORK

Specific work activity that should be pursued by the Air Force is summarized here:

- a. Continue data collections to update the existing data base. This should be continued for another three to four years until the technology matures.
- b. Develop, under a separate contract, a systems directory for fiber optics which would include a system description, cross reference to other systems and acronyms, how fiber optics is used, pictorial diagrams, block diagrams, technical parameters, economics, advantages, etc.
- c. A model should be developed for microcomputer systems that systems designers or analysts can use to determine the effectiveness of using fiber optics, and assist in specifying fiber optics.
- d. Develop an in house consultant group that can assist program managers in the design and specification of fiber optics systems and also "how to" access the data base.
- e. Because of the complexity of acquiring data on Industry IRAD programs, a separate program should be initiated to obtain this data on a non disclosure basis for use in the ALC data base.
- f. Develop a manual of test and maintenance techniques that can be used at various levels.
- g. Develop training programs aimed at various levels of technical and management personnel. These programs should be initiated as soon as possible.

SUMMARY AND CONCLUSIONS

Technology

1. Fiber optic technology is advancing so rapidly that it is difficult to standardize on any one component, group of components and corresponding specifications at this time.
2. A developing trend for fiber optic components is that prices are dropping and components capabilities are increasing. A component selected for use in existing systems today will have a greater technical performance at a cheaper price tomorrow. This does not say that it is impossible to stock fiber optic items; however, it does say that specifications must be written to assume these increased performances.
3. Due to the facts discussed in #2 above, minimal quantities of items should be inventoried at this time.
4. With the rapid changes in technology, commercial product part numbers are constantly changing. A tracking system is needed that can trace products throughout their development cycle in order to support older fiber optic systems already in the field.

Data Collection

The collection of data on fiber optics applications in the Air Force is a difficult and time consuming task. For a number of reasons, this task was underestimated in the past study phase. The data is available but is dispersed and often is buried in a larger system context. Some of the problems encountered in collecting data include:

- a. Lack of any single depository of information.

- b. Lack of an updated data base of contacts, phone numbers, addresses, etc., of persons or organizations responsible for fiber optics implementation.
- c. Delay in locating the right person.
- d. Multiple contacts required.
- e. Lack of priority to provide the information.
- f. Need to know.
- g. Proprietary data.
- h. Delays in shipment of materials requested.
- i. Identifying the types and form of information available and needed.
- j. Lack of suitable system description which contains a block diagram indicating where the fiber optic components are used.
- k. Confusion over names, acronyms, and other designations of systems and subsystems.
- l. Bureaucracies in both government and industry.

As a result of these problems in collecting information and data, a mechanism is needed for continuously reviewing existing data, collecting new data, etc., either in the Air Force or by contract. Based on our understanding of the limitations placed on government organizations with regards to travel and communications, this task is perhaps better performed by an outside contractor.

The data collected to date has also allowed us to focus our questions for further information.

Systems

- 1. There is a lack of readily accessible data on number of systems that may enter the Air Force inventory requiring logistics support. The location of this data was very unclear and was not made available.

2. Due to the increasing familiarity and understanding of fiber optic technology, systems managers, integrators and designers, are considering fiber optics in more systems because of its advantageous properties. In this study alone, over 170 systems throughout the DOD were identified and this number is growing rapidly. Many of these applications are singular or experimental in nature. It is expected that only about ten percent will actually enter the inventory.

Logistics and Support

1. It is difficult to ascertain the criteria that the Air Force presently uses for stockpiling components. That is, if "x" number of systems are planned which use "Yn" fiber optics components, where n is the number of fiber optic components (i.e., source, detectors, cables, etc.), then what number will go into service, inventory, how many spares will be required and over what time period? These decision criteria cannot be made by a contractor and must be made jointly based on the data collected by the contractor.

2. SM/ALC must move quickly to head off the proliferation of non standard components that are now entering the inventory. A set of qualified products and suppliers would be a major first step in stopping this proliferation.

Education

Considerable education of systems program managers is needed to get them to utilize fiber optics at the earliest convenient date. Many are still unfamiliar with the technology and feel it is still too new, unreliable, and hence too much of a risk. This is a prevalent perception of those not intimately familiar with the fiber optics business.

A well developed data base can help in marketing fiber optics to program managers. In particular, the following could be useful:

- a. Series of success stories.

- b. Readily available test data.
- c. Systems descriptions showing how fiber optics has been used.
- d. Data base that can be accessed by program offices to determine availability of military qualified components, manufacturers, and documentation that can be used to specify or procure such components.
- e. In house consultant to advise end users on technical details and access to the data base.

The data included in the data base can be analyzed and presented in a number of different ways. It is essential that the Air Force determine the most useful ways to collect and present this data. In this report, a number of different formats have been used.

Research and Development

1. Data is readily available on research and development activities. Many of the programs are overlapping either whole or in part. Much of the data for SM/ALC's Research and Design and Systems Needs data bases can be obtained from those studies. For example, the MFOX program has two contractors competing for the manufacture of one program. Both contractors have surveyed a number of systems users, collected and analyzed the results. SM/ALC can benefit from their efforts as well as provide aid to the contractors involved in these programs. The data collection can be used to update, validate and complete SM/ALC's Systems Needs data base. With a readily available data base on systems needs, many of the research surveys made by contractors can be eliminated.

2. A large amount of data is available on industry Independent Research and Development Programs (IRAD). Unfortunately, this data is only available to military organizations and hence was not available to this contractor.

Test Equipment

There does not exist a category in the Federal Stock classification for fiber optics test equipment. Such a classification should be developed. MIL-STD-1678 and various EIA standards presently encompass the thrust of standard test and measurement techniques available. SM/ALC should seek funds to develop a fiber optic test and measurement technique manual using the MIL-STD-1678 and the EIA efforts as a basis. From this, various levels of test and maintenance can be determined.

Accessories

No Federal Stock classification exists for fiber optic splices and accessories such as cleavers, tools, and splice enclosures.

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