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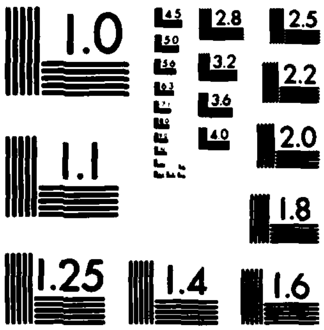

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FEASIBILITY STUDY FOR AN AFGL FIBER OPTIC DATA LINK AT WSMR SOUNDING ROCKET LAUNCH AREA

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Scientific Report No. 2

1 October 1984

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AIR FORCE GEOPHYSICS LABORATORY
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"This technical report has been reviewed and is approved for publication"

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Chief, Sounding Rocket Branch

FOR THE COMMANDER

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C. NEALON STARK

Director

Aerospace Instrumentation Division

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR- 84-0292	2. GOVT ACCESSION NO. AD-A150852	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FEASIBILITY STUDY FOR AN AFGL FIBER OPTIC DATA LINK AT WSMR SOUNDING ROCKET LAUNCH AREA		5. TYPE OF REPORT & PERIOD COVERED Scientific Report No. 2 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Harold L. Shaw Donald F. Terwilliger		8. CONTRACT OR GRANT NUMBER(s) F19628-82-C-0111
9. PERFORMING ORGANIZATION NAME AND ADDRESS Physical Science Laboratory Instrumentation Division - Box 3548 Las Cruces, New Mexico 88003-3548		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 765904BF
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory Hanscom AFB, Massachusetts 01731 Monitor/Kenneth R. Walker/LCR		12. REPORT DATE 1 October 1984 13. NUMBER OF PAGES 22
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fiber Optics Telemetry Link
Fiber Optics Data Link
Fiber Optics Data Link for Sounding Rocket Facility

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

After determining that a fiber optic data link was feasible for the sounding rocket launch facility at the White Sands Missile Range (WSMR), fiber optic cable and hardware were purchased for testing a simulated data link. A survey was conducted to compare the advantages, disadvantages and costs of various fiber optic data link installations at the sounding rocket launch area on WSMR with either a simplex or duplex microwave link installation. Approximate installation costs for three possible fiber optic cable routings are presented along with comparative cost estimates for microwave links.

SUMMARY

A study was performed to determine the feasibility of installing a fiber optic data link at the White Sands Missile Range (WSMR) to enhance support of sounding rocket launches for the Air Force Geophysics Laboratory. Fiber optic cable and associated hardware were purchased and tested with sample video and telemetry signals. Cost estimates were prepared for the installation of a six-fiber optical cable along various routes between three buildings in the WSMR Sounding Rocket Launch Area. Advantages of the various alternatives are described in sufficient detail so that the most cost-effective alternative can be selected in terms of available funds and mission requirements. The estimated costs for the installation of either a simplex or duplex microwave data link are also provided for comparison with the cost of installing fiber optic links.

Additional keywords: launching sites.

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1.0 INTRODUCTION

Three PSL-operated telemetry stations and one range-operated station are presently used to support most of the sounding rockets launched from the White Sands Missile Range (WSMR) in New Mexico. These stations are located at Parker Station, Building N-200, the NASA Vehicle Assembly Building (VAB), and Site JIG-67 on Alamo Peak. Site JIG-67 is located approximately 40 miles northeast of the sounding rocket launch area on WSMR. Two permanent microwave data links currently exist to transmit video and PCM telemetry data from Parker Station and from the VAB to Building N-200 at Launch Complex LC-35 (see Figure 1). A mobile range-operated microwave system is parked adjacent to N-200 for receiving the telemetry data from JIG-67 as required during operations. Therefore, Building N-200 serves as a hub for collecting the data from these various sources. The data from JIG-67 is usually primary due to the strong signal from the large-diameter tracking antenna on site.

The network described above is adequate for supporting the launch of the smaller AFGL rockets at LC-35. However, there is no data link between Parker Station, N-200 or the VAB and LC-36 where the larger rockets are launched. The only RF capability at LC-36 is a four-foot diameter dish antenna located on top of the 350 Blockhouse (350 BH) that is used to manually track various sounding rockets during flight. Normally, however, this antenna will not be manned until approximately 60 seconds after lift off for safety reasons. Also, the low gain of this antenna renders it insufficiently sensitive to ensure reliable acquisition of wideband video and telemetry data throughout the flight. Therefore, a data link is needed between the 350 BH and one of the other ground stations to provide more reliable real-time data to the experimenters located in the 350 BH during rocket flights. Since data from Parker Station, the VAB and JIG-67 (as well as from the station located at N-200) are available at the N-200 ground station, the addition of a data link between N-200 and the 350 BH would ensure that data from any of these sources could be forwarded from N-200 directly to the 350 BH.

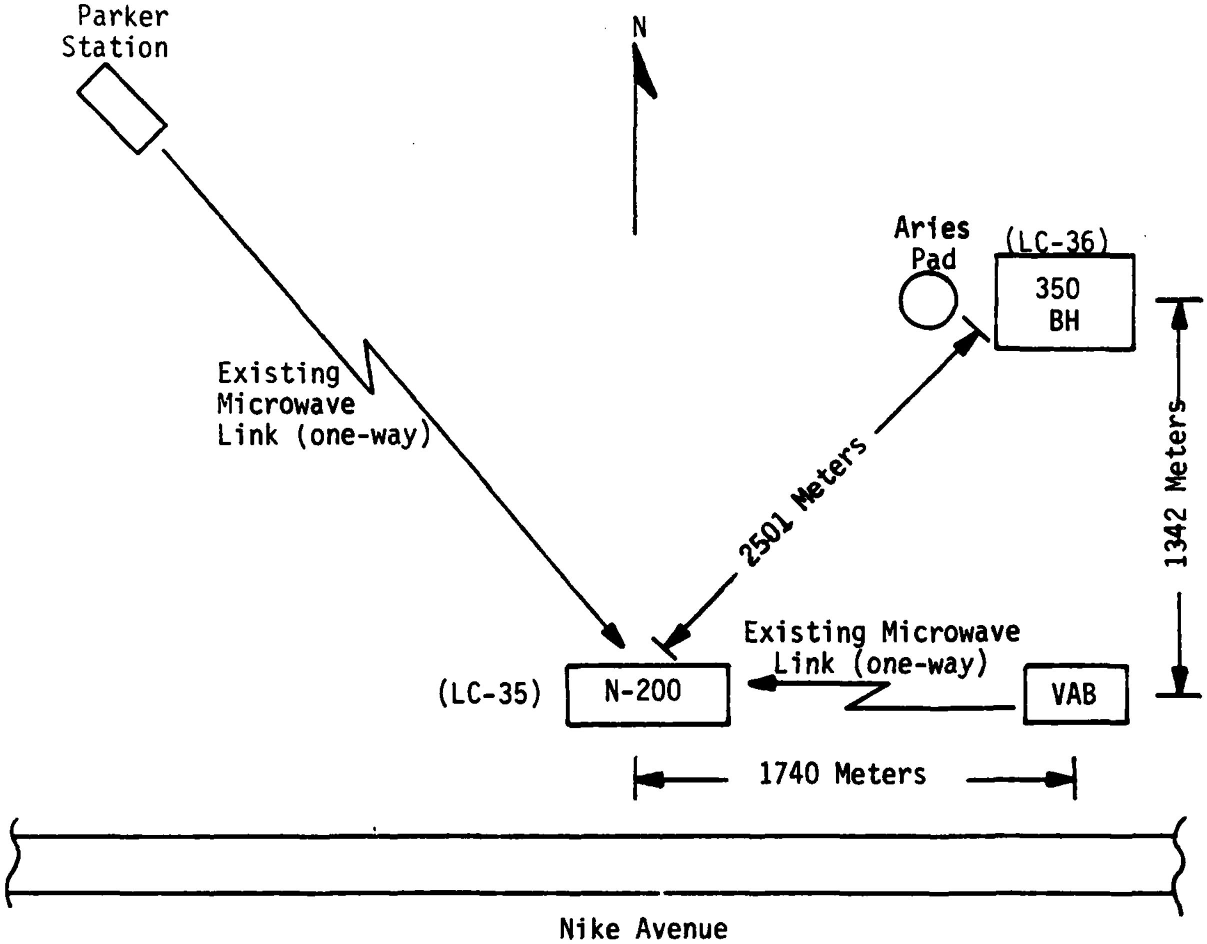


Figure 1

Plan View of WSMR Sounding Rocket Launch Site

This study was undertaken to determine the feasibility of adding a fiber optic telemetry data link between N-200 and the 350 BH, and to prepare a cost/benefit comparison between the installation of a conventional microwave link and a fiber optic data link.

2.0 FIBER OPTIC SYSTEM

A survey was initiated to determine what type of fiber optic equipment was available that could fulfill the requirements of this data link. At the time this survey was initiated, the only company that could be found to provide rack-mountable equipment along with fiber optic cable was Fiberlink, a division of Math Associates, Inc. Therefore, a Fiberlink Model XV/RV-1200 Video System consisting of a pair of receiver/transmitter modules was ordered. This system has a video bandwidth covering the range of 10 Hz to 10 MHz and an audio bandwidth from 10 Hz to 10 KHz. A Fiberlink Model XR-1100 was ordered to serve as the data link for the RS-232 interface for handling up to 100 Kb/s of computer data. The Model XR-1100 requires two fibers for full duplex asynchronous data transmission and reception, and can accommodate data rates up to 100 Kbits/sec. Asynchronous time division multiplexers are available from Fiberlink and other vendors that would allow from 8 to 64 full duplex asynchronous channels to be operated over the same two fibers. Two Fiberlink Model MCR-1000 rack enclosures, each capable of housing up to ten fiber optic modules, were also ordered. Specifications for the purchased Fiberlink hardware are included in Appendix A.

The cost of fiber optic cable increases approximately linearly with the number of fibers as well as length. The cost of installing fiber optic cable ranges from about one- to two-dollars per lineal foot depending on whether the cable is buried or pulled through existing conduit, and how crowded the conduit is with other cables. Therefore, there is a tradeoff consideration between the number of optical fibers per cable and total cost. Fiber optic cables are available with one, two, four, six, twelve and eighteen optical fibers. PSL selected a cable with six fibers as being the most practical in terms of enough channels for present and envisioned future needs, and the best value in terms of capability versus overall cost (including installation cost).

A 100-meter length of Fiberlink AOF-100 series of fiber optic cable containing six fibers was ordered so that testing of a typical telemetry link could be performed. The maximum allowable attenuation for either the computerized data or the video links is 30dB. For the RS-232 link, the 30dB maximum optical attenuation is for a bit-error-rate (BER) of 10^{-8}. In the proposed application, PSL believes this to be an acceptable BER. The attenuation of fiber optic cable is typically on the order of 6dB/km. Allowing 4dB (maximum) for the insertion loss of the connectors on each end of the cable, this leaves 26dB of tolerable cable loss, or approximately 4Km of cable length. This is well beyond the longest cable length being considered for this application.

The fiber optic equipment was set up in the laboratory at PSL to simulate a video/audio/data link between the 350 BH and Building N-200. Transmission and reception from either site of 5 MHz closed-circuit television (CCTV) plus 2 Mbit NRZ PCM telemetry data (or 500 KHz video) should be adequate to support most data requirements anticipated between these sites. Figure 2 contains a block diagram of the laboratory set up for the simulation. One video link was successfully tested using an 875-line television video signal with a bandwidth of approximately 10MHz. The RS-232 link operated successfully at 9600 baud. The remaining video link was tested successfully with a 2 Mbit PCM Biphase-L signal from a PCM simulator to a PCM computerized ground station.

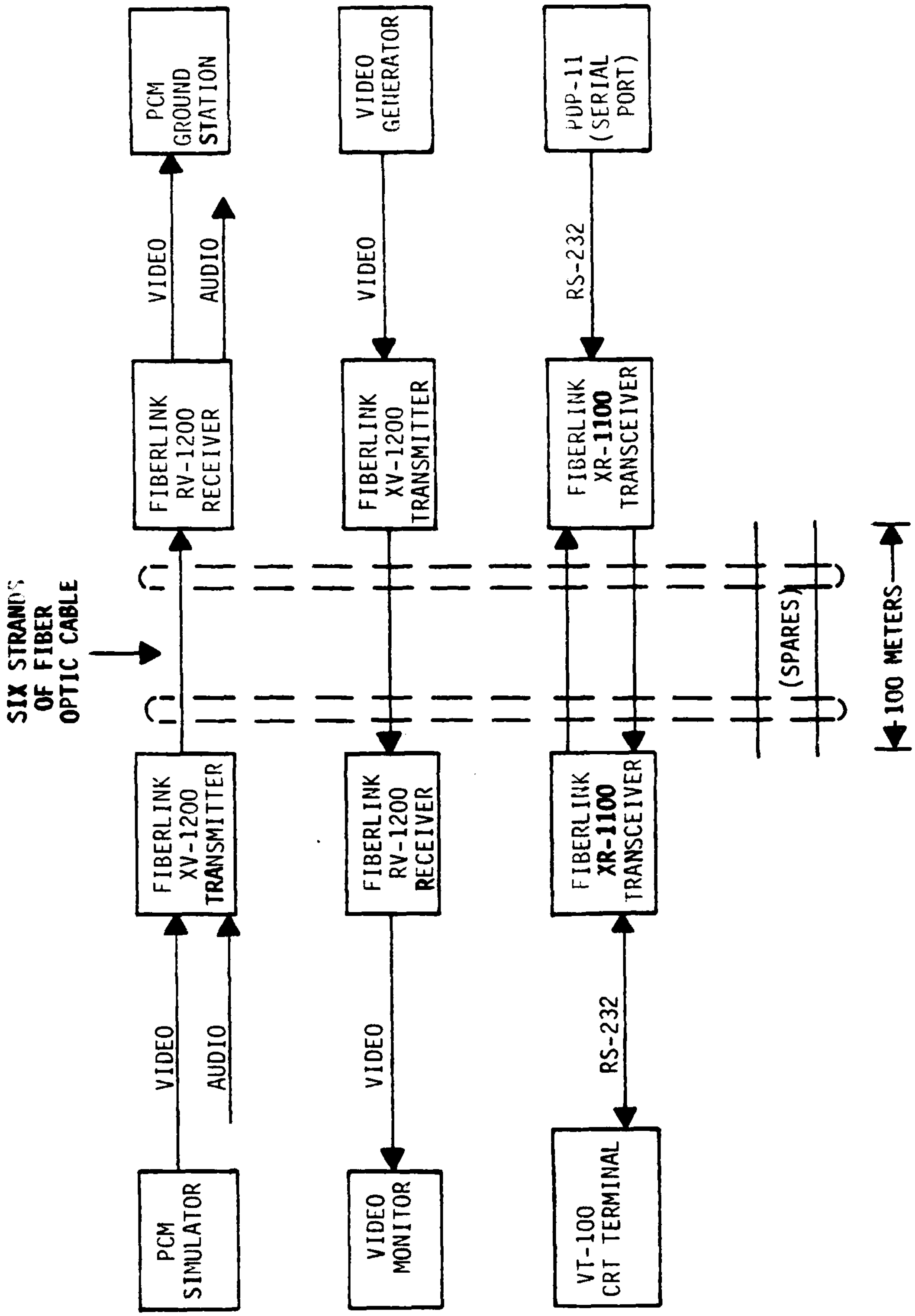


Figure 2

Simulation of Video/PCM/Data Link

The purchase of a variable optical attenuator was considered for simulating the path length of the optical cable. However, the longest path of fiber optic cable for the proposed application would be approximately 2500 meters plus ten percent for terminations, road crossings, routing around obstacles, etc. Therefore, the maximum path length being considered (2750 meters) would have a path loss of approximately 6dB/km x 2.75km = 16.5dB + 4dB (2 connectors) = 20.5dB. Therefore, the $2,000 cost of the attenuator was not justified since the signal attenuation would be approximately 20dB, and the bit-error-rate (BER) for a full 30dB of optical attenuation is believed by PSL to be acceptable for this application.

3.0 SITE CONSIDERATIONS

Since data from Parker Station, the VAB and Site JIG-67 are presently telemetered via microwave to Building N-200, it would be desirable to add a fiber optic data link between the 350 BH and Building N-200 directly. Thus, data received from Parker Station, the VAB, JIG-67 or Building N-200 could be routed to the 350 BH over the new data link. A more advantageous routing of the fiber optic link between the 350 BH and Building N-200 would be by way of the VAB. This routing would require a little more cable and one extra set of transceivers (which are very inexpensive relative to the cost of the fiber optic cable), but would have the advantage of providing video, computer and PCM telemetry data at the 350 BH, the VAB and at N-200. Thus, up to three full-duplex channels would be available over this new fiber optic data link. This capability would be useful, for example, if the portable AFGL Enhanced PCM Telemetry Receiving System were set up in the 350 BH and computer data from the portable station were to be transfered to both the VAB and N-200. Thus, observers at either the VAB or N-200 could view the computer data from the 350 BH on local CRT terminals.

The Physical Science Laboratory recommends the inclusion of the VAB in the fiber optic data link between N-200 and the 350 BH; therefore, this approach is discussed as Option 1. Option 2 is the cable routing that links N-200 directly with the 350 BH. A relatively inexpensive alternative to either Option 1 or Option 2 would be the installation of a fiber optic link between the 350 BH and the VAB directly. Since this is not considered by PSL to be a primary recommendation, this will be presented only as an alternative.

These two primary fiber optic cable routings are shown in Figure 3 and are identified as Option 1 and Option 2. This particular order is established in terms of total improvement or additional capability for the sounding rocket launch area on WSMR, and also in terms of cost. That is, Option 1 is the most expensive, but provides the greatest additional capability. Likewise, the alternative installation mentioned above is the least expensive and also provides the least additional capability. Moreover, the alternative does not meet the fundamental requirement for a link between N-200 and the 350 BH. In spite of this drawback, PSL felt this alternative should be presented for consideration by AFGL.

In order to estimate the total costs associated with each of these possible fiber optic installations, it was necessary to obtain approximate installation costs for the cable. Estimates were obtained from the Operations Division of the U.S. Army Communications Command at WSMR through the Naval Ordinance Missile Test Facility, the organization on WSMR responsible for LC-35 and LC-36. Communications conduit exists between the 350 BH and VAB, and also exists along Nike Avenue between the VAB and N-200. To install a fiber optic cable in the conduit over the entire route (350 BH/VAB/N-200) would require approximately 15,000 feet of cable and would cost approximately $2.00 per foot, or about $30,000 for installation labor costs. Direct burial cable installed over the same (but more direct) routing would require approximately 11,000 feet of cable and would cost about $1.00 per foot, or approximately $11,000 for installation labor. The reason the conduit installation costs more than

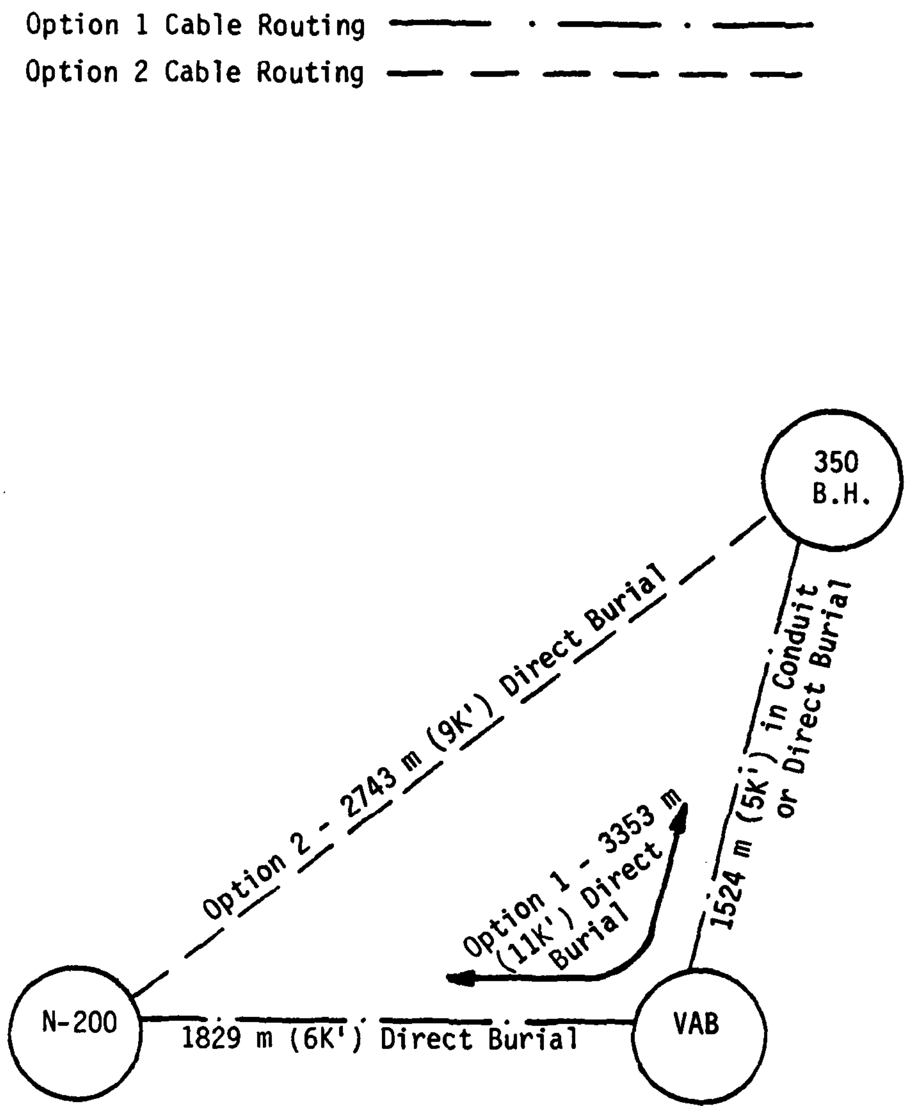


Figure 3

Possible Fiber Optic Cable Routings
at WSMR Sounding Rocket Range

the direct burial installation is because the conduit routed along Nike Avenue is full and some unused cables would have to be removed before a new installation could be made. Due to the expense, routing of fiber optic cable in the conduit along Nike Avenue between the VAB and N-200 is not recommended by PSL and, therefore, is not considered as a viable alternative for this study. Direct burial is considered for all installations, except the routing between the VAB and the 350 BH can be either routed through existing (uncrowded) conduit or directly buried for about the same cost.

4.0 COST/BENEFIT COMPARISON

Data were gathered to provide a comparison of cost versus benefit for the installation of either a microwave data link or one of two optional (plus one alternative) fiber optic links at the WSMR sounding rocket launch area. The minimum known requirement could be met with the installation of a one-way microwave link between N-200 and the 350 BH. This would allow the transmission of video and PCM telemetry data on baseband and one subcarrier from N-200 to the 350 BH. Moreover, the data source (JIG-67, Parker, VAB, N-200) can be selected for transmission over this microwave link to the 350 BH. This would also be the least expensive means of meeting the minimum requirement.

A disadvantage of a fiber optic link compared to a microwave link is that the fiber optic interconnecting cable must be installed. However, if a duplex (two-way) link would be useful, especially if more than two channels (e.g., video and PCM telemetry) of information are desired to be transferred back and forth between N-200 and the 350 BH, then a fiber optic link has both capability and cost advantages over a microwave link. Table 1 was prepared to provide a cost comparison for the various options. It was assumed that a microwave link would be installed only between N-200 and the 350 BH. The $60,000 cost estimate is for a two-way microwave link, while $30,000 is the approximate cost for a one-way microwave link between N-200 and the 350 BH.

	OPTION 1 ROUTING (N-200/VAB/350 BH)	OPTION 2 ROUTING (N-200/350 BH)	ALTERNATE ROUTING (VAB/350 BH)
Total Installation & Checkout of Fiber Optic System	$55,000	$45,000	$23,000
One Duplex Microwave Link		$60,000	
One Simplex (one-way) Microwave Link		$30,000	

Table 1
Cost Estimate for Fiber Optic/Microwave Link Installations

The cost estimates for the fiber optic installations considered for this report are presented for ease of comparison with the costs for the installation of either a single or a duplex microwave link. These estimates include the cost of rodent-proof fiber optic cable with six fibers, the cost of installing the cable, engineering support for checkout after the cable is installed, and loading. The fiber optic sending and receiving equipment has already been purchased. Therefore, the only additional costs for fiber optic hardware (other than cable) would be those required for the primary routing (Option 1) recommended by PSL which includes the VAB in the link. This additional hardware cost (slightly over $2,000) is included in the cost estimate for Option 1. PSL feels that these cost estimates are accurate to within 10% at 1984 prices.

In order to adequately compare the proposed fiber optic links with microwave links, it must be remembered that each fiber optic link includes six fibers or enough for three full duplex or six single (one-way) data channels. If future expansion or the availability of spare channels is important, then the fiber optics method has a decided advantage. In fact, if three full duplex microwave links were to be installed between N-200 and the 350 BH, the cost would be approximately $180,000; thus, the fiber optics package with comparable capability would cost considerably less ($180,00 - $45,000 = $135,000 less; refer to Table 1) than three duplex microwave links installed over the same route.

In examining the case for installing a fiber optic cable over the Option 1 routing (which includes the VAB in the link), it can be seen that three full duplex channels can be installed between <u>three</u> points (N-200, VAB, 350 BH) for approximately the same cost as two channels (baseband and one subcarrier) over a duplex microwave link between only <u>two</u> points (i.e., N-200 and 350 BH). Data security is also an advantage of fiber optics over microwave. A disadvantage of microwave links compared to fiber optics at WSMR is the requirement for range coordination prior to use.

The Physical Science Laboratory recommends the installation of a fiber optic data link over either the Option 1 routing (N-200/VAB/350 BH) or the Option 2 routing (N-200/350 BH). Moreover, PSL believes that the extra cost of including the VAB in the recommended primary link is justifiable in terms of capability and flexibility for future mission support. But, only the customer can assess which of these options provides the most return on the investment in terms of anticipated mission requirements versus availability of funds for support of those missions. The value of being able to send video, PCM or computer-generated data bi-directionally over one of these routes can be best assessed by AFGL personnel. The data provided should make it easier for the customer to make a choice from among these options presented. If funds are scarce, the fiber optic link between the VAB and the 350 BH may be attractive to the customer. This alternative provides considerable benefit for the cost.

A fourth option was considered but not presented because it would involve the relocation of the existing microwave link between the VAB and N-200 in order to provide a data link from N-200 to the 350 BH. Moreover, this microwave link is owned by NASA. But, for approximately the same cost as the installation of a one-way microwave link ($30,000), a fiber optic link could be installed between the VAB and N-200 (via direct burial), and the microwave link between the VAB and N-200 could be relocated to provide a dual-channel, one-way microwave link from N-200 to the 350 BH. This would provide for three two-way fiber optic links between the VAB and N-200, and one dual-channel (baseband and subcarrier) microwave link from N-200 to the 350 BH. This alternative could benefit both AFGL and NASA, but would require interagency cooperation.

Interagency cooperation on the funding of a fiber optic link installation at the WSMR Sounding Rocket Range may also be worth considering. Thus, each customer could reap a large return on their respective investment.

One other factor that could influence a decision on a fiber optic installation at the sounding rocket launch area needs to be mentioned. There is a possibility that fiber optic communications links may be installed throughout WSMR in the future. However, the current discussions being held at WSMR on this topic--although serious--are very preliminary. It could be years before these fiber optic links are actually installed.

5.0 CONCLUSION AND RECOMMENDATION

The conclusion of this study is that the addition of a fiber optic data link at the sounding rocket launch area on White Sands Missile Range is feasible. Also, considering the advantages of data security and of additional channel capacity (or redundant channels) over a fiber optic link with six fibers, the cost of a fiber optic installation compares favorably with the installation of a microwave link. The Physical Science Laboratory recommends that a fiber optic data link be installed between Building N-200 and the 350 BH at the sounding rocket launch area on WSMR. Moreover, PSL believes that extending the fiber optic link to include the Vehicle Assembly Building in the link provides the greatest return on the dollar investment in terms of enhanced capability for support of future sounding rocket launches.

APPENDIX A

Specifications for Purchased Fiberlink Equipment

XV/RV-1200 AUDIO/VIDEO TRANSMISSION SYSTEM

FOR SIMULTANEOUS TRANSMISSION OF VIDEO AND AUDIO OVER A SINGLE FIBER

The MATH ASSOCIATES, INC. XV/RV-1200 is a complete, ready-to-operate optical fiber transmission system designed to transmit audio and video signals on a single fiber via modulated light over distances of 3000 meters or more.

TECHNICAL SPECIFICATIONS

The XV/RV-1200 system consists of the XV-1200 transmitter and RV-1200 receiver. Both units utilize linear modulation and wideband, low noise circuitry throughout, to assure excellent transmission of composite video signals of all sorts. A channel is provided for high fidelity audio transmissions of all kinds and operates completely independently of the video channel. Sync pulse "droop" and low frequency distortion is virtually non-existant. In addition, built-in AC or DC power supplies allow operation from batteries, unregulated DC sources, or simple AC voltages, thereby providing unparalleled versatility in an optical fiber transmission system. The small size of the individual modules also allow convenient mounting directly to TV cameras or monitors and, in most cases, all operating power can be derived from those units.

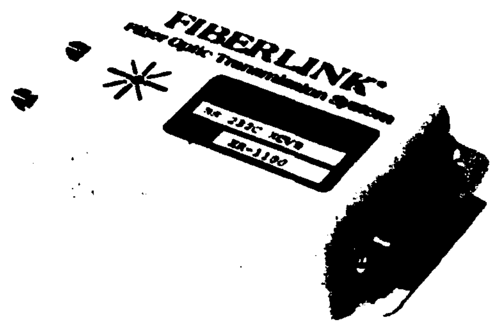
COMPLETE VIDEO BANDWIDTH (+1,-3dB)	*10Hz to 10MHz*
COMPLETE AUDIO BANDWIDTH (+1,-3dB)	10Hz to 10KHz
TRANSMITTER INPUT IMPEDANCE (VIDEO)	75 ohms
TRANSMITTER INPUT IMPEDANCE (AUDIO)	600 ohms
NORMAL INPUT VOLTAGE (AUDIO and/or VIDEO)	1 to 3Vpp
DYNAMIC RANGE	60dB typ.
LINEARITY	1 percent or better
DIFFERENTIAL GAIN	1 percent typ.
DIFFERENTIAL PHASE	1^{o} typ.
OUTPUT LOAD IMPEDANCE (VIDEO)	75 ohms
OUTPUT LOAD IMPEDANCE (AUDIO)	600 ohms
ALLOWABLE OPTICAL ATTENUATION	-30dB
OPERATING WAVELENGTH	820 nmeter
OPTICAL CONNECTORS	SMA type (AMP type available)
POWER REQUIREMENTS[1] (trans. and/or rec.)	+15 to +25 volts or 14 to 18 volts AC 50/60Hz
PHYSICAL SIZE (per module)	10.6 x 11.8 x 4.4cm
OPERATING TEMPERATURE	0 to 50^{o}C

1. This system can operate from 115V 50/60Hz with an XP-1000 plug-in transformer (2 required).

NOTE: THIS UNIT IS INTENDED FOR CCTV WORK AND WILL OPERATE WITH COLOR OR MONOCHROME SIGNALS.

FIBERLINK
A DIVISION OF MATH ASSOCIATES, INC.
2200 Shames Drive,
Westbury, New York 11590 (USA)
516-334-6800

XR-1100 RS-232C TRANSMISSION SYSTEM



FOR LOW COST DATA TRANSMISSIONS ONLY

The MATH ASSOCIATES, INC. XR-1100 is a complete, ready-to-operate optical fiber transmission system designed to transmit digital data via modulated light over distances of 2000 meters or more.

TECHNICAL SPECIFICATIONS

The XR-1100 system consists of an optical transmitter, receiver, and signal conversion circuitry that is fully compatible with EIA standard RS-232C. The system is suitable for simplex or full duplex asynchronous data transmission at up to 100 Kb/s.

The small size of the unit, along with the integral 25 pin EIA connector, allows the system to be quickly "plugged in" to existing equipment with no more effort than a normal jumper. Removable optical connectors also allow various lengths of optical fiber cable to be used, thereby providing unparalleled versatility in an optical fiber transmission system. The XR-1100 obtains its operating power either directly through the DB25 connector from the equipment it is used with, or by means of an optional XP-1005 plug-in adapter. Normal RS-232C "handshaking" signals are not provided for in this unit. If these signals are required, please refer to the MATH ASSOCIATES' model XR-1000.

DATA TRANSMISSION RATE	DC to 100Kbits/sec
OPERATING MODE	Simplex, Full Duplex, Asynchronous
LOGICAL "1" INPUT	+3.75 to +15VDC
LOGICAL "0" INPUT	-3.75 to -15VDC
LOGICAL "1" OUTPUT	+3.75 to +12VDC
LOGICAL "0" OUTPUT	-3.75 to -12VDC
ALLOWABLE OPTICAL ATTENUATION (10^{-8} B.E.R.)	-30dB
OPERATING WAVELENGTH	820 nmeter
OPTICAL CONNECTORS	SMA type (AMP type available)
ELECTRICAL CONNECTOR	EIA compatible DB-25P
POWER REQUIREMENTS	$\pm$12 to $\pm$25 volts unregulated or 12 to 18VAC 50/60Hz
PHYSICAL SIZE (per unit)	6.4 x 12 x 3.2cm
OPERATING TEMPERATURE	0 to 50°C

PIN CONNECTIONS

1	Chassis Ground	(AA)	7	Signal Ground	(AB)
2	Transmitted Data	(BA)	11	*See Note	
3	Received Data	(BB)	18	+12 to +25VDC	(Vcc)
6	Data Set Ready	(CC)	25	-12 to -25VDC	(Vee)

*NOTE: 1. For AC operation, apply 6.3 to 18VAC rms between pin 7 and 11.
2. This system can operate from 115VAC 50/60Hz with our optional XP-1000 adaptor.

SPECIAL MODIFICATIONS, PIN CONNECTIONS, AND PARTIAL "HANDSHAKING" SIGNAL VERSIONS ARE AVAILABLE.

FIBERLINK
A DIVISION OF MATH ASSOCIATES, INC
2200 Shames Drive,
Westbury, New York 11590 (USA)
516-334-6800

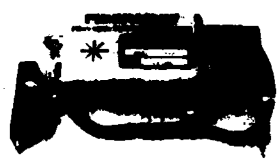
OPTIONAL FIBERLINK ENCLOSURES 7

MATH ASSOCIATES, INC. offers various special purpose enclosures as indicated below, for use with all FIBERLINK data transmission modules. In addition, many other mechanical, as well as electrical modifications, are available to meet most needs.

MCR-1000 MULTIPLE CHANNEL RACK ENCLOSURE

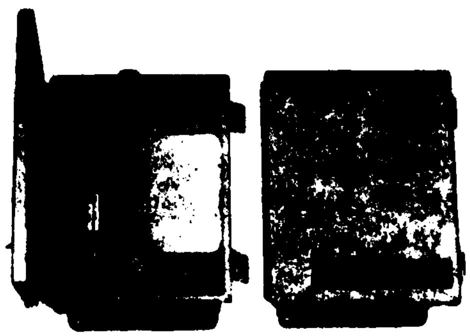
The MCR-1000 consists of a standard E.I.A. 5¼" x 19" card frame cabinet with provision for up to ten FIBERLINK modules. Any combination of analog or digital modules may be employed and the unit contains a common 115VAC power supply, line cord, pilot lamp, power switch, and BNC signal connectors.

Modules mount on an AP-1000 adaptor (available separately) and simply "plug-into" the rack. Electrical signal connectors are normally provided on the rear of the enclosure, but can be supplied on the front panel if so desired.



BPM-1000 BATTERY POWERED MODULE ENCLOSURE

The BPM-1000 consists of a rugged J.I.C. type weatherproof cabinet, 8" x 10" x 4", that will accept any single FIBERLINK module. Full operating power is provided by an internal 12 volt rechargeable battery. The enclosure also contains a power switch, battery status indicator and a strain relief for the fiber optic cable. The BPM-1000 is suitable for outdoor use.



SPECIAL MODIFICATIONS, CUSTOM PACKAGES, OR UNUSUAL CONFIGURATIONS ARE AVAILABLE. PLEASE CONTACT FACTORY FOR DETAILS.

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2200 Shames Drive,
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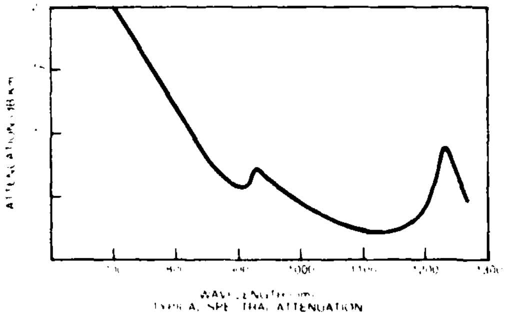
516-334-6800

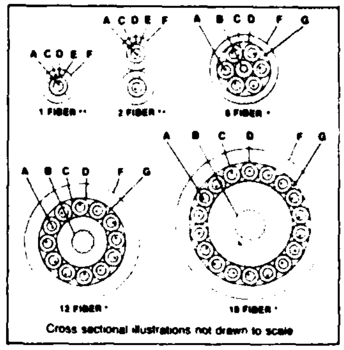
AOF-100 SERIES FIBER OPTIC CABLE

The AOF-100 series of fiber optic cable consists of all glass, low-loss graded index fiber, enclosed in fully ruggedized, protected outer jackets. Designed for a variety of applications including data transmission, process control and instrumentation, these fibers are suitable for most installations including conduit, cable trays, plenums, hooks, etc. The cables are engineered for impact/crush resistance, as well as high tensile strength to protect against mechanical damage when being installed. The AOF-100 series can be used with all FIBERLINK systems at distances of up to 1000 meters.

ATTENUATION CURVE

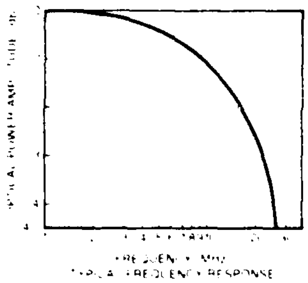


CABLE CONFIGURATION



A Optical fiber
B Jacketed Kevlar strength member
C Engineering plastic tubes
D Plastic separator tape
E Braided Kevlar strength member
F PVC jacket
G Rip cord

BANDWIDTH CURVE



TECHNICAL SPECIFICATIONS

FIBER CORE DIAMETER	100 microns
CLADDING DIAMETER	140 microns
COATED DIAMETER	250 microns
NUMERICAL APERTURE	0.3 (nominal)
ATTENUATION	6dB/Km @850nm (typ.)
BANDWIDTH	20MHz/Km

CATALOG NO.	NO. of FIBERS	OVERALL DIA.mm	WEIGHT KG/KM	MAX. LBS. PULLING STRENGTH	MAX. BEND RADIUSmm
AOF-100-1	1	3.8	13.5	260	50
AOF-100-2	2	3.8 x 7.6	27	520	50
AOF-100-6	6	8	40	480	100
AOF-100-12	12	14	155	800	150
AOF-100-18	18	18	260	800	200

RECOMMENDED CONNECTORS		RECOMMENDED TERMINATING SETS
Amphenol SMA	906-110-5009	T-1200
Math Assoc. SMA	SMA 140G	T-1200
AMP Optimate	227285-4	TC-1000
AMP Optimate SMA	227992-2	T-1100

NOTE: While the above fiber cables are ideal for use with all FIBERLINK systems, they are only representative of the wide range of cables, bundles and other fibers that may also be employed with excellent results. Please contact MATH ASSOCIATES to check compatibility with any other fiber that may be desired.

FIBERLINK
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END

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