COMPONENT PART NOTICE

THIS PAPER IS A COMPONENT PART OF THE FOLLOWING COMPILATION REPORT:

TITLE: Proceedings of the International Wire and Cable Symposium (35th) Held in Reno, Nevada on 18-20 November 1986

TO ORDER THE COMPLETE COMPILATION REPORT, USE AD-A180 828.

THE COMPONENT PART IS PROVIDED HERE TO ALLOW USERS ACCESS TO INDIVIDUALLY AUTHORED SECTIONS OF PROCEEDING, ANNALS, SYMPOSIA, ETC. HOWEVER, THE COMPONENT SHOULD BE CONSIDERED WITHIN THE CONTEXT OF THE OVERALL COMPILATION REPORT AND NOT AS A STAND-ALONE TECHNICAL REPORT.

THE FOLLOWING COMPONENT PART NUMBERS COMPRISE THE COMPILATION REPORT:

AD#: P005 203 through P005 290 AD#: ______

AD#: ______ AD#: ______

AD#: ______ AD#: ______

Accession For		
NTIS GRA&I	X	
DTIC TAB	☐	
Unannounced	☐	
Justification		
By		
Distribution/		
Availability Codes		
Dist	Avail and/or Special	
A-1		

RAPID PAYOUT AND RETRIEVAL OF TACTICAL FIBER-OPTIC CABLES

F. T. Mikolajewski, R. Coon, R. W. Hickson*, and J. Wright**

ITT Electro-Optical Products Division, Roanoke, VA; *Weber & Scher Mfg. Co. Inc., Newark, NJ; and **U.S. Army CECOM, Fort Monmouth, NJ

Abstract

A key element in a highly mobile military communications system is the speed with which the system can become operational in rapidly changing areas of battle. The advent of optical fiber based cable has radically changed the nature of military voice and data transmission by greatly increasing information capacity and permitting longer distance between repeaters or end users. Reduced cable size and weight permit multi-kilometer lengths of cable to be transported to battle areas. However, a major limitation to voice or data transmission operational status is the slow process of deploying tactical cable assemblies in the field. This paper discusses two methods for rapid payout of a lightweight, single optical fiber cable assembly for use in point to point voice communications. This paper also discusses a rewinding method capable of recovering cable assemblies in the field for subsequent redeployment.

Introduction

Fiber-optic cable assemblies (FOCA) were payed out successfully from a helicopter at speeds up to 192 km/hr (120 mph) under the "Air Layable, Expendable Fiber-Optic Cable Assembly Package"[1] program contracted by the U.S. Army CECOM in January 1979. The air layable concept was further expanded with the award of the "Rapidly Deployable Fiber-Optic Cable" (RDFOC) contract by the U.S. Army CECOM in November 1985. An important feature of the RDFOC program is the requirement for retrieval of previously deployed cable assemblies. Combined with the requirements for radiation hardened optical fiber, flame retardant cable, and high retention strength field rugged connectors, the retrieval of cable assemblies results in increased cable assembly versatility and cost effectiveness when compared to expendable cable assemblies.

The payout speed for optical fibers and optical fiber cables can vary from 1.3 km/hr (0.8 mph), for two persons carrying a cable reel, up to 360 km/hr (225 mph), for a fiber-optic guided missile. The mechanical forces on the cable assembly during deployment depend on the velocity of deployment, which determines the upper limit for optical fiber tensile strength and connector-cable retention capabilities. The cable assembly must survive in tactical environments that can include extremes in temperature and severe mechanical forces. A multimode single optical fiber cable, similar in construction to the cable used in the Air Layable Program, was selected as a low risk component for the cable assembly. This cable has a high modulus polyester buffer coating giving additional mechanical protection to the optical fiber, Kevlar[R] strength members, and a flame retardant outer jacket. The connector selected was an Amphenol 906, which provides the low optical loss and good repeatability needed to meet the optical link budget. Careful attention to the Kevlar[R] strength member termination and a special "overmolded" bend limiter results in high cable to connector retention strength. A streamlined mated connector to connector profile prevents snagging during deployment and ensures survivability of the cable assembly for repeated payout.

Practical optical fiber cable deployment from a helicopter, vehicle, or backpack requires consideration of several factors:

a. Reduced inertial forces on the cable assembly during payout to ensure cable survival after repeated deployment.

b. Easy installation of cable handling equipment on backpacks, trucks, or helicopters with a minimum number of parts.

c. Capability of interconnecting up to four 2 km cable assemblies for serial deployment from a helicopter at speeds up to 145 km/hr (90 mph).

Several payout methods were evaluated for the RDFOC program. This paper presents the method selected and preliminary field performance data. A retrieval method compatible with the payout technique completes the rapid use cable assembly development program.

High Speed Deployment Requirements

The deployment of fiber-optic cable in air assault operations is performed at high speed using nap of the earth (NOE) maneuvers to avoid detection of positions such as command posts. Higher altitude deployment may be satisfactory in positions well back from the forward edge of the battle area (FEBA). The preferred method of paying out cable in a tactical air operation at high speed uses a helicopter that need not land during the procedure, thereby not revealing the position of the terminal equipment. First, the helicopter drops a weight attached to the cable, and the cable pays out while the helicopter maintains altitude and speed. Meanwhile, ground personnel connect the cable assembly to the equipment. The cable is deployed and at the far end terminal equipment, the helicopter releases any remaining cable "on the run."

Previous Experience

The design of a fiber-optic cable assembly suitable for high speed deployment from a helicopter was successfully verified during the "Air Layable, Expendable Fiber-Optic Cable Assembly Package" program.[2] The initial phase of the program consisted of fiber, cable, and connector evaluations. These evaluations verified the payout dynamic math models[3] used to characterize the forces that the cable assembly experiences during deployment. The cable winding method selected for the air layable program uses a self-supporting coil package (Figure 1) wound orthonormally on a precision grooved mandrel. A moderately weak adhesive applied to each layer of cable during winding keeps the coil pack from unwinding due to handling during transport or vibration during helicopter flight. The adhesive must not cause severe bending at the peel point during deployment, and it must be stable over the cable assembly's operating temperature range. The adhesive must apply easily and cure rapidly.

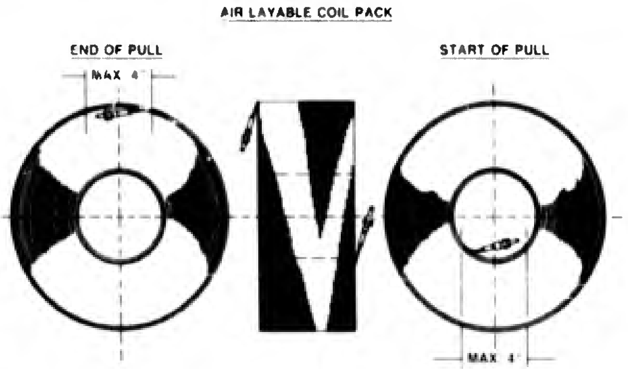

Figure 1. Self-Supporting Coil Pack.

After the cable has been wound on the grooved mandrel and the adhesive has cured, the mandrel is removed. Then the coil pack is inserted into an aluminum canister (Figure 2). A special adhesive foam holds the coil pack inside the aluminum canister and permits multiple canister deployments in which cable assemblies pass through empty canisters of previously deployed cable assemblies. Also the foam protects the cable from abrasion against by the aluminum canister. Up to four canisters can be installed in a special helicopter mounting frame for serial deployment. The coil packs are joined by Amphenol 906 connectors so that after deployment, a communications link up to 8 km in length can be set up by connecting the appropriate end terminal equipment for bidirectional transmission over the single optical fiber.

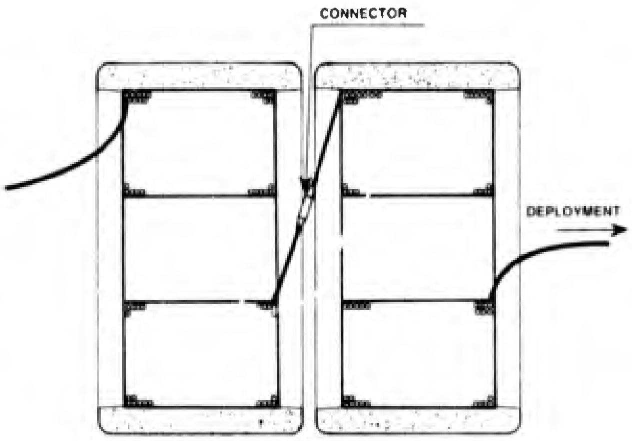

Figure 2. Serial Canister Configuration.

Helicopter payout tests performed at Fort Campbell, Kentucky, verified the performance of the air layable, fiber-optic cable assembly and precision winding technique. The canister configuration, helicopter mounting, and cable assembly form a single optical fiber system capable of being deployed at high speeds over terrain obstacles, such as mountains, rivers, swamps, and jungles, that are impassable by conventional deployment methods.

Deployment and Retrieval System Compatibility

The RDFOC requirements incorporated the advanced development of a fiber-optic cable assembly capable of being rapidly deployed from a backpack, military vehicle, or helicopter and a technique for retrieval and field repackaging.

The wound cable assembly and canister configuration used in the Air Layable Program are not adaptable to the requirement for field retrieval of cable assemblies for several reasons. Winding cable assembly packs on precision grooved mandrels requires careful attention to the assembly of the various parts used in the mandrels, the control of the cable's turn to turn spacing, and placement of the cable against the mandrel flanges. During cable retrieval and rewinding in the field, mud and ice accumulating on the cable will cause loss of precision winding, resulting in an unstable cable pack geometry. The problems of using collapsible machined mandrels and precision winding techniques are best handled by skilled operators in a factory environment. The binder adhesive used during cable winding to provide coil pack stability usually requires mixing two part adhesives to obtain rapid curing. An additional problem with the adhesive occurs during retrieval. The residual adhesive must be cleaned from previously deployed cables or it eventually builds up on the cable. This operation also is best handled by skilled operators in a factory environment. Based on these limitations, the air layable winding technique was not selected for the RDFOC program.

The most practical method of handling cable assemblies in the field is to incorporate a cable reel for both payout and retrieval. A second major consideration is the rotation of the cable reel, particularly during payout. Due to the large inertial forces required to rotate a cable reel to obtain a cable payout velocity of 145 km/hr (90 mph), it was not considered practical to use the conventional rotation cable reel for payout.

Payout Unit

In a final report titled "Study of R Deployment and Retrieval Techniques for Fiber-Optic Cables,"[4] Armament Systems indicates that a spinning reel payout and retrieval system is practical for repeated deployment of small diameter (approximately 2.54 mm) cables. This technique uses a stationary reel with the cable deployed over the reel flange (as compared to deploying cable tangentially to the reel drum for rotating reels). A survey of wire and cable equipment manufacturers was conducted to determine if a scaled up version of the conventional "fly casting" fishing reel could be built. Similar equipment existed for high speed payoff of textile fibers, and it appeared practical to expand the concept to produce equipment capable of deploying fiber-optic cables.

The repeated payout of cable can be accomplished by reducing the dynamic forces to a level below the cable's damage point. The free payout of cable without binder adhesives produces minimal dynamic forces and a reliable, tangle free deployment. Centrifugal force due to the cable mass pays off the cable at high speed.

A rotating disc is used to assist the cable over the reel flange and guide the cable toward the payout direction when the cable is near the flange during slow speed deployment. For helicopter, vehicle, and backpack deployment, a housing reduces the cable helix formed during high speed payout, keeping the cable in line with the reel axis, and assisting in the proper functioning of the rotating disc at slow speeds (Figure 3).

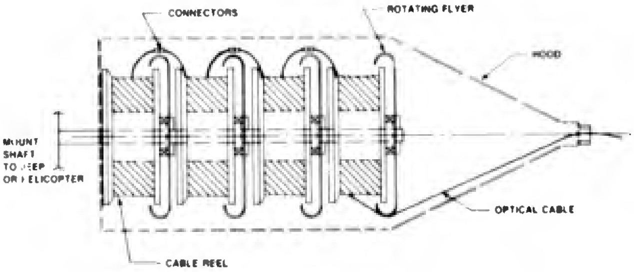

Figure 3. Multiple Coil Pack Payout Arrangement.

The payout unit for helicopter deployment consists of a self-supporting housing with a mounting shaft capable of holding up to four 2 km cable assemblies on reels. The reels can be loaded into the housing and then strapped to a special helicopter mounting frame. This mounting technique permits quick installation and release of cable assemblies from helicopters during deployment operations. A single cable assembly on a reel can be deployed from a vehicle or backpack with a shorter housing and mounting shaft. Vehicle mounting is accomplished by angle brackets located on a mounting plate supporting the housing flyer, cable assembly, and reel. The angle bracket slides on the tailgate of a jeep or truck with cable paying out cantilevered from the vehicle. Clamps hold the mounting plate to the tailgate, eliminating predrilled mounting holes in the vehicle frame and also conserving space in the rear of the vehicle. The backpack unit uses the same mounting plate, housing, flyer, cable assembly, and reel with a quick snap-in bracket designed to accept the All-purpose Lightweight Individual Carrying Equipment (ALICE) backpack unit. The payout units have a minimum of moving parts, and made from lightweight materials and are easy to install and operate.

Retrieval Unit

The selection of a nonrotating cable reel for payout requires unwinding cable from the reel over the flange. A twist is imparted to the cable for each revolution that is unwound from the reel. This twist in the cable becomes additive with repeated retrieval deployment cycles. Eventually the twist causes the cable to hockle resulting in damage to the optical fiber due to the small bending radii when the cable is tensioned. The retrieval unit (Figure 4) is designed to rapidly retrieve cable onto a stationary reel and at the same time impart a counter or back twist that effectively counteracts the twist resulting from payout, eliminating cable hockle.

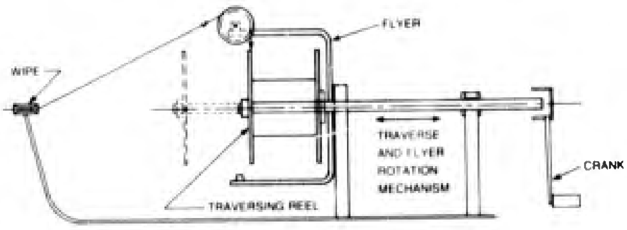

Figure 4. Retrieval System.

The retrieval unit is designed to be easy to operate and to quickly rewind cable from a truck without excessive force on the cable. The weight of the unit depends upon the choice of pulleys, belts, structural support steel, and spinning reel take-up mechanism. Use of commercially available components increases reliability and reduces cost.

To rewind cable, an empty cable reel is mounted on the support shaft. This shaft moves the reel in a horizontal direction, causing the cable to traverse the reel. A spinning reel flyer arm rotates around the reel, winding the cable with a back twist onto the reel drum. A crank handle is used to rotate the flyer arm and traverse the reel to obtain a uniform layer to layer wind. The turn to turn cable spacing is slightly gapped so dust, mud, and sand contamination will not affect the cable pack geometry during winding. The unit is geared so that one revolution per second of the crank will retrieve 2 km of cable in approximately 15 minutes. A torque limiting coupling is used to restrict the force the cable can experience to approximately 50 lb.

The weight of the unit is estimated to be 300 lb; therefore, retrieval from a jeep is feasible. Helicopter retrieval can be accomplished by mounting the unit on a sled or support structure and motorizing the hand crank to permit control of the rewinder from inside the helicopter.

Preliminary Tests

Preliminary field tests to verify the equipment design of the vehicle and backpack deployment units were conducted near Roanoke, Virginia, on August 12-13, 1986. A total of 11 deployment tests was performed using cable and cable assemblies. One test deployed cable from a backpack at walking speed and the remaining tests deployed cable from a truck traveling at speeds up to 130 km/hr (80 mph). The general results of the tests show that deployment of cable from a backpack and a vehicle is feasible when a housing contains the payed out cable's helical path and if the cable is uniformly wound with a back twist onto a cable reel.

The rotating flyer disc is critical to slow speed deployment up to approximately 10 km/hr (6 mph). Above this speed the cable inertia causes the cable to ride on the inner surface of the housing. The retrieval unit was not finished in time for the deployment tests; therefore, the cable was retrieved without neutralizing the cable twist. It became apparent after a few deployments that the cable was hockling severely. A final test was done to deploy a connector to connector pair that subsequently payed out without a problem and maintained optical continuity after test.

The next phase of the RDFOC program is the serial deployment of up to four 2 km cable assemblies from a helicopter at a speed of 90 mph. The field retrieval of a cable and its subsequent redeployment will complete the program requirements for the development of a fiber-optic cable assembly that can be deployed from a helicopter, jeep, or backpack in a battlefield.

References

1. Glavas, X. "Air Layable Expendable Fiber Optic Cable Assembly Program," Final Report. CECOM-79-0803-F (July 1981).

2. Hoffman, A. "Fiber Optic Cable Coil Packs for Air Deployment." IW&CS (1981) pp 378-385.

3. Moon, Francis C. "Dynamics of Fiber Optic Cable Payout," Appendix A of "Air Layable Expendable Fiber Optic Cable Assembly Program," Final Report. 41H-HSING PAO.

4. Armament Systems Inc. "Study of Rapid Deployment and Retrieval Techniques for Fiber Optic Cables and Human Engineering Analysis of FOTS (LD), Advanced Development Program," Vol. I. Contract DAAD05-84-C-0164.

James Wright received his B.S. degree in electrical engineering from Lafayette College in 1975 and his M.S. degree in electrical engineering from Fairleigh Dickinson University in 1980. From 1976 to the present he has been associated with the Center for Communications/ Automatic Data Processing at Fort Monmouth, NJ. He is involved in the development of both local distribution and long haul tactical fiber optic communication systems. Mr. Wright is currently project engineer for the Rapid Deployment Fiber Optic Cable program.

Robert W. Hickson, Weber & Scher Mfg. Co., Inc., Newark, NJ. Mr. Hickson holds a degree in engineering from Newark College of Engineering. He has been involved in the cable industry since 1959, first with the Hatfield Wire and Cable Co. as a design draftsperson and then as plant engineer. In 1981 he joined Weber and Scher as general manager. He is a member of the Wire Association.

Robert L. Coon, ITT-EOPD, Roanoke, VA. Mr. Coon holds a B.S. degree in physics from Michigan State University and a M.S. degree in physics from Stevens Institute of Technology. His experience prior to joining ITT includes the Hellfire missile system and laser locator designator, work with the Department of Defense on countermeasure testing of laser guided weapons and program management for the Military Systems Division of International Laser Systems, Inc. for development of laser rangefinder/ designator for the Advanced Attack Helicopter. At ITT-EOPD, Mr. Coon is Manager of Fiber Optic programs responsible for providing program direction and preparing cost and schedule plans.

Thomas Mikolajewski, ITT-EOPD, Roanoke, VA. Mr. Mikolajewski holds a B.S. degree in electrical engineering from Pennsylvania State University. Prior to joining ITT, he was responsible for electrical systems and process equipment for Simplex Wire and Cable Co. including commissioning of equipment used in the manufacture of the first transatlantic cable (TAT-8). As a member of the Technical Staff at ITT, he is involved with military fiber optic projects including RDFOC, AN/TAC and bobbin winding for the FOG-M program and several technology transfer programs outside the U.S.A.