Draft Functional Requirements

for a

Potential New Generation Standard UNOLS

Small Diameter

Electro-Mechanical (EM)

or

Electro-Optical-Mechanical (EOM) Cable

Report prepared by

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UNOLS Office

February 16, 2004

Purpose and Executive Summary

Why are we doing this?

Oceanographic wires and cables are a component of the scientific infrastructure on board research vessels that are often taken for granted, until they fail or prove to be inadequate. They are absolutely essential to a variety of scientific operations. Many factors go into defining the capabilities of these wires and cables and once defined, the resulting characteristics affect many other components of a research vessel, such as winch size and power, A-frame structure and strength, deck and internal space utilization, and the structural components of the vessel itself. Most importantly the vessel's capacity to accommodate the developing needs of science is determined by the availability of appropriate wires /cables and their matched handling components. The cost of a spool of wire or cable can exceed $250,000 and the cost of developing new wires and adapting (or building new) winches to handle those wires are not insignificant.

For these reasons it is absolutely imperative that the development of new “standard” wires and cables to be used in the UNOLS fleet be accomplished based on well-defined scientific requirements resulting from broad community input. The community also needs to examine ways to use new technology and engineering advancements to better utilize existing wires and cables whenever possible. The Standard UNOLS cables that we have all used over the past twenty plus years have served the community well and any changes to that suite of wires and cables should be designed to further improve the overall capabilities of the Academic Research Fleet. These changes cannot be made lightly.

What do we want to accomplish?

The purpose of these functional requirements is to define the capabilities and characteristics to be used in designing or evaluating designs for a possible new UNOLS standard smaller diameter electro-mechanical (EM) or electro-optical-mechanical (EOM) cable. This new cable should meet the needs of the oceanographic community for the next two or three decades and provide improved performance relative to the existing UNOLS standard small diameter EM cable (0.322 CTD cable). This cable would not replace the capability of the 0.680 coax or 0.681 EOM cable, which support the requirements for larger packages. These functional requirements will provide direction and goals to be used by cable designers and manufacturers in developing a cable design to meet the science community needs. The desired improvements relative to the existing “CTD cable” include increased payload and/or safety margin for deep casts using WOCE size CTD packages; a desire for higher bi-directional data telemetry and the continued need for comparable power transmission to instrument packages. Additionally other instrument packages have been introduced into the fleet and are currently being developed that involve continuous towing, either at fixed depths or in an undulating depth mode. Ideally, one new cable would meet all of these requirements, however it may be necessary to consider more than one design in order to achieve the desired results.

What should be done next, using this report?

The functional requirements contained in this report should become the starting point for a focused design, testing and acceptance process for designating a new UNOLS standard oceanographic cable. This can probably be accomplished in several ways, but in all cases it will be necessary for a focused and properly funded effort that verifies the community requirements, sets specifications to be met and provides for a testing program that verifies the suitability of any proposed cable. This report and the incorporated functional requirements should be used in any call for proposals or for evaluating any unsolicited proposals to develop a new cable. Additionally, this report can be used as a starting point for developing functional requirements for other existing or new wires or cables.

Goals, Objectives and Considerations for developing a new cable

- Greater payload
    - At full depth
    - With reasonable safety factor
- Higher data bandwidth
- Comparable power telemetry
- Design Considerations
    - Above goals are relative to current CTD cable
    - Torque Balanced
    - Support full ocean depth WOCE style CTD casts
    - Support new towed undulating profilers
    - Consider impact on winches and over-the-side handling systems.
    - Might mean more than one cable design

Recommendations for future steps

- This report should be used by agencies, science community and manufacturers for use in soliciting and proposing solutions/designs.
- A small working group should be funded to carry out the development of a new cable.
- Verify and refine these functional requirements and develop acceptance specifications and testing requirements.
- Solicit proposals to design and/or test cables meeting these requirements.
- Obtain and test a new cable in a professional test facility, then test in the field.
- Determine if new cable will be added to the inventory or replace .322 as a standard UNOLS Cable.
- Review the requirements and the capability to meet those requirements for other Standard UNOLS cables and wires.
- Conduct a similar design and acceptance process if necessary for other cables.

Background and process

Standard UNOLS Cables and Wires

During the 1980's the UNOLS community moved from a situation where each individual operating institution purchased the wires or cables they thought they needed to the current system where wires and cables are purchased through a group wire pool with standard cable and wire specifications. According to a survey of operators in 1982, Bob Dinsmore reported they found eleven different CTD cables across 13 laboratories. In 1982 the wire pool was formed and oceanographic cables and wires for the UNOLS fleet were bulk purchased with an initial savings of 54%. In addition this standardization allowed scientists to move from one ship to another with much better assurance of finding a cable that would work with their instrumentation. A similar effect on winch design and construction allowed savings and compatibility from one ship to another. Specifications were set for standard 3x19 torque balanced wire rope, for 0.680 coax cable and for 0.322 CTD cable during the 1980's and these cables have served us well over the past two decades. A design for 0.681 fiber-optic cable was also adapted for use with ROV's other systems requiring the additional data bandwidth. A table of current UNOLS standard wires and cables is included in appendix II.

1999 Winch and Wire Workshop

During the 1990's it became clear that the capabilities of some cables were being stretched to the limits by new instrumentation, such as the large CTD systems being used for the WOCE and JGOFS programs. Also, sophisticated instrumentation such as the JASON ROV and others required much higher bandwidth than what was available using copper conductors. The same could be said for smaller instrumentation packages that needed the data capabilities provided by fiber. Along with concerns about oceanographic winches, cranes and over-boarding equipment these issues provided the motivation for a winch and wire symposium held in New Orleans in December 1999. The report is available from the UNOLS web page and it contains a number of recommendations that led to this effort at defining potentially new standard cables.

- ❖ UNOLS (RVOC/RVTEC) should be tasked to establish a safe working load (SWL) criteria for .322 cable.
    - *Committee formed (Capt. Tom Althouse/SIO is the chair). They looked at methods developed by others and considered engineering support to develop a standard method for determining safe working loads. This item is still pending funding for testing and engineering support. In the meantime the issue has been moved to the RVOC/RVTEC Safety Committee in order to incorporate recommendations in future editions of the RV Safety Standards.*
- ❖ NSF entertain proposals to develop specifications for a new wire to replace .322 EM cable that is stronger and provides a broader band width.
- ❖ NSF entertain proposals to develop specifications for a stronger cable to replace the .680 cable.

- NSF entertain proposals to develop specifications for a lighter .680 cable with the same breaking strength.
    - *A committee was formed and several attempts were made to bring broad community input to bear on the process of defining new wire and cable specifications. The goal was to make recommendations to develop and procure new standard cables if required. These three "requirements" were identified at the New Orleans December 1999 Winch &Wire Symposium. By seeking community input it was hoped to verify the need for cables with these specifications and to identify other "requirements" such as a smaller diameter fiber optic cable that will work with towed undulating profilers. Community input was pretty much limited to those people involved in directing the effort. The process was never funded for a focused specification, design and testing effort and no proposals were submitted other than those submitted as part of the UNOLS office support proposal. Agency direction was to create the functional requirements contained in this document, after which proposals for developing actual cables would be considered.*
- UNOLS be tasked to increase and standardize operator training for winch operations, wire care and maintenance.
    - *This effort will grow out of developing standards for safe working load and as part of the process of implementing ISM in the fleet. The Winch and Wire Handbook has been updated and the Third Edition published to support this effort. In addition, NSF has implemented a program to provide winch inspection and maintenance training by the winch manufacturers, which is ongoing.*
- UNOLS operators to be encouraged to maintain a complete set of records on winches and wires and NSF include a requirement in the NSF Inspection to review these records.
    - *These records are encouraged by the UNOLS Research Vessel Safety Standards and this section will be reviewed with the possibility of strengthening it. The Handbook of Oceanographic Winch, Wire and Cable Technology also contains a full chapter on the subject. These issues have been discussed at the past few RVOC meetings as well. The NSF Inspection program has examined these records in the past and should do so under the new contract.*
- UNOLS operators are encouraged to investigate new innovations in winch and wire handling systems such as motion compensation.
    - *Some individual efforts have been made in this regard. The subject was on the agenda for the combined RVOC/RVTEC meeting in 2001. A study of innovative handling systems is currently underway, led by Matt Hawkins of the University of Delaware.*
- NSF should fund a winch and wire symposium every five years to bring scientists, operators, technicians and manufacturers together for information exchange.
    - *UNOLS will explore the need for a symposium in the next year or two.*

Attempts at getting community input

Two attempts have been made by the current UNOLS Office with help from interested scientists, ship operators and technicians to get broad community input regarding their requirements for wires and cables. The two web based requests for review and comment are attached as appendices to this report. The response was virtually zero. Input to this process has been almost entirely from review and involvement by a small group of interested and knowledgeable individuals. They are listed in the appendices. The reasons for this lack of input are many, including a lack of time to review and input on something that seems a bit esoteric, a perception that there is no real need for new cables, the format of the information was not conducive to effective review and comment. No matter what the reason, it appears evident that in order to get meaningful review and attention to this issue, it will be necessary to get a reasonable sized group of knowledgeable and experienced people together to work out a valid set of functional requirements and specifications. These can again be circulated for comment, but would probably reflect the real requirements for the majority of sea-going scientists if compiled by the appropriate group in the first place. This document could and should be a good starting place for this type of effort.

Narrowed the focus

Because the greatest need appeared to be with finding a small diameter cable with greater payload and greater data bandwidth the current effort and focus of this report was narrowed to defining the functional requirements for such a cable. This effort also represents only a first draft to be used as a seed for follow on efforts that may be funded or undertaken by industry groups or others.

Drafting and posting functional requirements

The functional requirements in this report were drafted by Mike Prince of the UNOLS Office with assistance from Walter Paul/WHOI, Jon Alberts/WHOI, Dale Chayes/LDEO, Rich Findley/RSMAS, Tim McGinnis/UW-APL, Jon Erickson/MBARI, Frank Bahr/WHOI and Craig Marquette/WHOI. Helpful comments were provided through the online review form by Joe Ustach/Duke, Theo Moniz/WHOI, Capt. Larry Bearse/WHOI, Mike Webb/NOAA, Stewart Lamerdin/MLML, Tim McGovern/Hawaii, Steve Poulos/Hawaii and George Batten/SOC-UK.

Final Draft of Functional Requirements

The following section contains the draft functional requirements for a potential new UNOLS Standard electro-mechanical or electro-optical-mechanical cable. These requirements do not dictate the use of fiber or the use of steel over synthetic fibers. The idea is that we try to state the need (requirements) and then cable design engineers can attempt to create a solution that meets all (or most) of those requirements. This draft has been reviewed by several people knowledgeable about scientific requirements and with cable design. However, further review by cable manufacturers, designers and users is necessary to verify the actual need in some areas, such as electrical and optical requirements. Also, tradeoffs between competing requirements will need to be made. Lastly, this process needs to consider the big picture, which includes the entire suite of available standard cables, impact on winch, over-boarding equipment and vessel design as well as the design of current and future instrumentation.

New UNOLS Standard Small Diameter EM or EOM Cable(s)

Functional Requirements

(Revised 2/16/04)

The purpose of these functional requirements is to define the capabilities and characteristics to be used in designing or evaluating designs for a possible new UNOLS standard smaller diameter electro-mechanical (EM) or electro-optical-mechanical (EOM) cable. This new cable should meet the needs of the oceanographic community for the next two or three decades and provide improved performance relative to the existing UNOLS standard small diameter EM cable (0.322 CTD cable). This cable would not replace the capability of the 0.680 coax or 0.681 EOM cable, which support the requirements for larger packages. These functional requirements will provide direction and goals to be used by cable designers and manufacturers in developing a cable design to meet the science community needs. The desired improvements relative to the existing "CTD cable" include increased payload and/or safety margin for deep casts using WOCE size CTD packages, a desire for higher bi-directional data telemetry, and the continued need for comparable power transmission to instrument packages.

Additionally other instrument packages have been introduced into the fleet and are currently being developed that involved continuously towing, either at fixed depths or in an undulating depth mode. Ideally, one new cable would meet all of these requirements, however it may be necessary to consider more than one design in order to achieve the desired results.

A. Purpose and General Operating Requirements	
Functional Requirement	**New UNOLS EM or EOM cable**
Purpose	Long cable with improved safety margin for desired payload at maximum depth, a reliable and significantly higher rate data transmission capability than current CTD cable. Power transmission and data telemetry over copper at least comparable to current CTD cable.
Primary use	Vertical lowering of instrumented packages to depths up to 6,000 meters. Longer scope of wire will be necessary to achieve this depth in many cases.
Other uses	Towed packages with continuous tension and length cycling over extended periods of time. (Deep towed or large instrumentation will use existing larger diameter cables)

B. Design Priorities	
Cable Design Priorities	
	1. Increased payload and/or safety margin at maximum depth compared to existing CTD cable.
	2. Survive periodic peak loading.
	3. High degree of rotational stability (i.e. nominally torque balanced).
	4. Copper conductors should support at least the current power and telemetry requirements of existing CTD systems (e.g. Seabird 911).
	5. Significantly higher bi-directional data telemetry capability than available with current CTD cable.
	6. Service life ≥ 3 years based on nominal use by Global Class research vessel.
	7. Designed for storage under tension and with size characteristics to allow maximum use of existing winches.
Design Assumptions	
	Strength criteria based on one end free to rotate
	Cable will operate over sheave and drum diameters that are 40 times cable diameter (40:1)
	Safety factor of 2.5:1 or greater for maximum allowable working load.

C. Environmental Factors	
Operating environment	Dynamic ocean environment
	Continuous operation
	Use newer existing or newly purchased winches
Operating depth	≤ 6000 meters
Maximum lowering & recovery rates. **(To be considered as a factor in dynamic loading)**	≥ 60 m/min
D. Mechanical Requirements	
Size	
Diameter	0.250" to 0.50" and as close to existing 0.322" as possible. Useable on as many existing winches as possible while at the same time not compromising on any significant gains in capability. Design so that diameter fits a precise number of turns on drums designed for .322 cable.
Length	7,000 to 10,000 meter lengths. Maximum length required will be 10,000 meters w/o splices and we may want to specify a shorter length if this will save cost, weight and space. Length must support operations to at least 6,000 meters, which may require deployments of 7,000 to 8,000 meters of cable.

D. Mechanical Requirements (cont.)	
Strength	
Payload weight = (working load minus weight in water) - no allowance for dynamic loading	2000 lb (907 kg.) at 6000m 2,000 lb exceeds the payload for 0.322 at 6,000 m or deeper at any safety factor greater than 2:1, not taking into account any dynamic loading. Either a much stronger or much lighter in water cable would be required to achieve this goal.
Strength	RBS > 10,000 lbf w/one-end-free to rotate
Weight	
Air	This is a factor that affects winch design, ship stability and the ability to handle the cable spools. This value should be kept a small as practical to allow for use with existing newer winches.
Water	Need lighter or much stronger cable without increasing the outside diameter too much. Weight to strength ratio should provide greater payload than .322 cable at full depth. The weight of the cable plus the desired payload should not exceed the SWL.
Weight to Strength ratio (%) **(Weight of cable in water/RBS)**	Need weight to strength ratio that provides the specified payload at full operating depth. Using a SWL of 40% RBS (2.5:1 safety factor) a weight to strength ratio of 20% at 6,000 meters would be needed for RBS of 10,000 lbs (4,500 kg) and 26% for RBS of 15,000 lb (6,800 kg) in order to achieve a payload of 2,000 lb (907 kg)

Dynamic characteristics	
Rotation	< 1° /ft (3.3° /m) (this is the 0.681 FO cable spec) Other specifications seem to allow a little more than this, but the 20°/ft specified for current CTD cable is excessive. We should specify the smallest amount of rotation possible. The spec for 0.680 coax is 5°/ft (16°/m) @ 40 % RBS
Flexure	50,000 to 1,000,000 cycles. (If the cable is held at one position on a sheave while towing for extended periods of time, this number of bending cycles could be achieved very quickly.)
Tension cycling	Average tension of 25% RBS ± 15% RBS over the lifetime of 50,000 to 1,000,000 cycles over a 40:1 sheave diameter.
Min. Sheave size	40 to1 Sheave diameter to cable diameter ratio 40 to 1 is a good standard, but a smaller allowable bending diameter without sacrificing the working life or safe working load would be desirable.
Armor	
Strength	Specifications as needed to achieve cable strength/weight characteristics. Should not be any less than XIPS (extra improved plow steel).
Ductility	Specify as needed to achieve required yield strength. Should not be any less than XIPS.
Min. outer wire diameter	Large enough to give adequate protection against abrasion.
Galvanized	Yes if steel construction.
Lubrication	Pre-lubed as necessary for achieving life cycle.

E. Electrical Requirements	
Objectives	Provide for power transmission capabilities at least comparable to the current “CTD” cable. Capable of supporting WOCE type CTD at full depth and towed undulating profilers (with shorter lengths if necessary)
# conductors	One to three conductors if armor available for return path. Primary goal for multiple conductors is reliability and survival of the conductor. Tow cables may need more conductors if fiber can't be used. Color code conductors with different, easily distinguishable colors, for ease of termination and troubleshooting.
Type	Consider other conductors as part of design in order to add strength or to achieve other characteristics.
Size	Design to meet electrical specs
DC resistance	15.4 Ω /km (4.7 Ω /kFt) Conductor 7.9 Ω /km (2.4 Ω /kFt) Armor
Capacitance (cdr-armor)	< 40 pF/ft (131 pF/m)
Voltage	> 600 VDC (comparable to the .322 rating of 1000 V) at amperage necessary for common equipment.
Insulation resistance	3,000 MΩ • km
Primary circuit	One conductor to armor, unless synthetic material is used.
Telemetry	Optimum frequency < 20 kHz
Copper yield	> 65% RBS of cable

F. Optical Requirements	
Comments on Optical Requirements	These specs are taken from a couple of different Rochester Fiber-Optic cables, some were at 850 & 1310 nm and the other was at 1310 & 1550 nm. We really need help on how to define the optical characteristics and construction.
Type of optical fibers	Single mode
Allowable stretch on Optical Fibers	< 0.5% maximum allowable stretch applied to optical fibers
Optical Fiber Proof Test	Sufficient to prevent failure at the strain levels that will be encountered at safe working load with shock loads
Attenuation	
@ 850 nm	≤0.45 dB/km (0.14 dB/kft)
@ 1310 nm	≤0.35 dB/km (0.11 dB/kft)
@ 1550 nm	
Bandwidth	
@ 850 nm	≥ 160 MHz • km
@ 1310 nm	≥ 500 MHz • km
@ 1550 nm	
G. Requirements for synthetic cables	
Stretch	Design so that higher percent stretch does not have an adverse affect on copper or fiber-optic conductors or on any attached equipment.
Electrical	Provide for return conductor in electrical design.
Termination	Provide for termination at rated strength of cable that can be repaired or made in the field.
Protective jacket	Provide outer jacket or other method for ensuring abrasion resistance and appropriate level of cable stiffness

Appendix I

Contributors to the development of these Functional Requirements

- Dr. Walter Paul, Woods Hole Oceanographic Institution
- Jon Alberts, Woods Hole Oceanographic Institution
- Richard Findley, University of Miami
- Dale Chayes, Lamont Doherty Earth Observatory
- Tim McGinnis, Applied Physics Laboratory, Univ. of Washington
- Jon Erickson, Monterey Bay Aquarium Research Institute
- Frank Bahr, Woods Hole Oceanographic Institution
- Craig Marquette, Woods Hole Oceanographic Institution
- Mike Prince, UNOLS Office

Helpful comments were provided through the online review form by:

- Joe Ustach, Duke University
- Theo Moniz, Woods Hole Oceanographic Institution
- Capt. Larry Bearse, Woods Hole Oceanographic Institution
- Mike Webb, NOAA
- Tim McGovern, University of Hawaii
- Steve Poulos, University of Hawaii
- George Batten, SOC-UK.
- Stewart Lamerdin, Moss Landing Marine Laboratories

Meetings held

- December 1999 Winch and Wire symposium, New Orleans
- October 2001 Joint RVOC/RVTEC meeting at URI
- January 2002 on board R/V THOMPSON at UW
- January 2002 at Woods Hole Oceanographic Institution
- November 2002 RVTEC meeting at Honolulu, Hawaii
- October 2003 RVOC meeting at Duluth, Minnesota
- November 2003 RVTEC meeting at Seattle, Washington

Appendix II

Table of Standard UNOLS Wires and Cables

UNOLS Standard Wire Rope – 3x19 (Seale)				
Diameter (inches)	**2% yield (lbs)**	**Breaking load**	**SWL at 2.5:1 safety factor**	**Weight in water, lb/kft**
3/16	3,500	4,000	1,600	50.9
1/4	5,900	6,750	2,700	86.7
3/8	13,000	14,800	5,920	191
1/2	22,600	25,700	10,280	341
9/16	28,600	32,500	13,000	428

UNOLS Standard EM & EOM Cables					
Diameter (inches)	**Conductors & fibers (#)**	**Load at 0.4% strain**	**Breaking load**	**SWL at 2.5:1 safety factor**	**Weight in water, lb/kft**
.225 EM	1 & none	1,100	4,400	1,760	67
.322 EM	3 & none	2,500	10,000	4,000	144
.680 coax	Coax	10,000	37,000	14,800	553
.681 F-O	3 & 3	14,000*	46,000	18,400	608

* 0.5% strain spec for .681 cable

Appendix III

Community input request website – 2002

http://www.unols.org/publications/reports/wire/wirespec.html

http://www.unols.org/publications/reports/wire/wireform.html

UNOLS STANDARD WIRES AND CABLES

SCIENCE MISSION REQUIREMENTS FOR THE NEXT GENERATION

Oceanographic wires and cables are a component of the scientific infrastructure on board research vessels that are often taken for granted, until they fail or prove to be inadequate. They are absolutely essential to a variety of scientific operations. Many factors go into defining the capabilities of these wires and cables and once defined, the resulting characteristics affect many other components of a research vessel, such as winch size and power, A-frame structure and strength, deck and internal space utilization, and the structural components of the vessel itself. Most importantly the vessel's capacity to accommodate the developing needs of science is determined by the availability of appropriate wires /cables and their matched handling components.The cost of a spool of wire can approach $250,000 and the cost of developing new wires and adapting (or building new) winches to handle those wires are not insignificant. For these reasons it is absolutely imperative that the development of any new Standard wires and cables to be used in the UNOLS fleet be accomplished based on well defined scientific requirements resulting from broad community input. We will also need to examine ways to use new technology and engineering advancements to better utilize existing wires and cables whenever possible. The Standard UNOLS cables that we have all used over the past twenty plus years have served the community well and any changes to that suite of wires and cables should be designed to further improve the overall capabilities of the Academic Research Fleet. These changes can not be made lightly. As a result we are asking for your help in this endeavor.

Steering Committee for Wire and Cable Science Mission Requirements:
Fred Spiess/SIO, Albert J. (Sandy) Williams/WHOI , Andy Bowen/WHOI, Dan Fornari/WHOI, James Broda/WHOI, Peter Weibe/WHO, Roy WIlkens/UH, Craig Lee/UW, Stewart Lamerdin/MLML, Steve Rabalais/LUMCON, Dale Chayes/LDEO, Jon Alberts/WHOI, Tom Althouse/SIO, Mark Willis/OSU, Rich Findley/RSMAS, Theo Moniz/WHOI & Mike Prince/UNOLS

WE NEED YOUR INPUT

January 29, 2002 Wire Meeting Agenda

Goals

- Identify the scientific uses for current & future UNOLS wire/cables and develop Science Mission Requirements for a new generation of wire & cables.
- Create specifications for UNOLS Standard wires and cables to meet these requirements.
- Develop recommendations for introducing new standard wires and cables into the UNOLS fleet.

Objectives

- Continue work toward development of safe working load standards and procedures that are compatible with typical operations on UNOLS vessels.
- Define, based on broad community input, the types of activities and equipment that will be used in the future and in particular those that will stress the capabilities of existing wires and cables
- Quantify the resulting physical loads, dynamic stresses, power transmission requirements and data transmission requirements.
- Identify those requirements that are met or could be met by current Standard UNOLS wires and cables with the goal of justifying the retention of those Standard wires and cables that will continue to be useful for the foreseeable future.
- Identify capabilities that cannot be met by current Standard UNOLS wires and cables and recommend which of those capabilities should be met by new Standard wires or cable designs if possible.
- Determine if some capabilities can be met by engineering changes to the sampling or survey equipment or by changing procedures given the high cost of providing new Standard Wires.
- Determine what information wire manufacturers will need in order to specify and/or design the appropriate wires and cables.
- Provide the necessary information to define future wire specifications and obtain vendor proposals for wires to meet new requirements.
- Agree on and choose specifications for any new Standard UNOLS wires or cables.

Background

- NSF sponsors and oversees a wire pool of Standard Wires and Cables that are purchased in bulk for use on UNOLS vessels.
- Current Standard Wires and Cables include:

3 x 19 Torque Balance Wire Rope				
Size (inches)	Breaking Strength (lbs)*	SWL 5:1	SWL 3:1	SWL 2:1
3/16	4,000	800□	1,333	2,000
1/4	6,750	1,350	2,250	3,375
3/8	14,800	2,960	4,933	7,400
1/2	25,700	5,140	8,567	12,850
9/16	32,500	6,500	10,833	16,250

Conducting and Fiber Optic Cables ≠ Strength info				
Size (inches)	Breaking Strength (lbs)*	SWL 5:1	SWL 3:1	SWL 2:1
.252	5,600	1,120	1,867	2,800
.322	11,600	2,320	3,867	5,800
.680	37,000	7,400	12,333	18,500
.680	46,000	9,200	15,333	23,000

* Breaking Strength gives the relative strength of these wires and cables Actual working loads are determined by applying a safety factor that may vary according to type of operation, equipment and ship operator. Typically the safety factors range from 2:1 to 5:1 which would result in working loads for the .680 FO cable from 23,000 lbs to 9,000 lbs. A separate committee is working on standardizing safety factors based on engineering input and regulatory considerations.

Graphs that show SWL's at 5:1, 3:1, and 2:1 along with the weight of the wire in water with depth. This should be able to give people an idea of how much weight could be hung fromt he end of the wire depending on how deep it is going and what safety factors to use.

Conducting & Fiber Optic Cables ≠ conductor/fiber info			
Size (inches)	Breaking Strength (lbs)*	Conductors	Fibers
.252	5,600	1	0
.322	11,600	3	0
.680	37,000	Coax	0
.680	46,000	3	3

- Most standard winches on UNOLS vessels are designed around one or more of these Standard wires or cables.
- A-Frames and other overboard system components are designed to be at least 1.5 times stronger than wires or cables deployed by them.
- Even using safety factors approaching 2 to 1, many cables are reaching the limit of their capabilities, especially when working at depth.
- Data and Power requirements continue to move beyond the capabilities of existing cables.
- Manufacturer's and developers of many new sampling equipment are requiring cables (& winches) with capabilities beyond current standard cables.

At the Winch and Wire Symposium held in New Orleans (Dec 1999), there were several recommendations including three related to developing new cables.

Recommendations and action taken to date (10/1/2001):

- UNOLS (RVOC/RVTEC) be tasked to establish a safe working load (SWL) criteria for .322 cable.

  Committee formed (Capt. Tom Althouse/SIO is the chair). They plan to use methods developed by others and engineering support to develop a standard method for determining safe working loads.

- NSF entertain proposals to develop specifications for a new wire to replace .322 EM cable that is stronger and provides a broader band width.
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- NSF entertain proposals to develop specifications for a lighter .680 cable with the same breaking strength.

  Committee formed and this effort is designed to bring broad community input to bear on the process of defining new wire and cable specifications. The end product will be recommendations to develop and procure new Standard cables if required. These three ≥requirements≤ were identified at the winch & wire symposium. A goal for the current effort is to verify the need for cables with these specifications and to identify other ≥requirements≤ such as a smaller diameter fiber optic cable that will work with towed undulating profilers.

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  This effort will grow out of developing standards for safe working load and as part of the process of implementing ISM in the fleet. The Winch and Wire Handbook has been updated and the Third Edition published to support this effort.

- UNOLS operators be encouraged to maintain a complete set of records on winches and wires and NSF include a requirement in the NSF Inspection to review these records.

  These records are encouraged by the UNOLS Research Vessel Safety Standards and this section will be reviewed with the possibility of strengthening it. The NSF Inspection program has examined these records in the past and will do so under the new contract.

- UNOLS operators be encouraged to investigate new innovations in winch and wire handling systems such as motion compensation.

  Some individual efforts have been made in this regard. The subject is on the agenda for the combined RVOC/RVTEC meeting in 2001.

- NSF fund a winch and wire symposium every five years to bring scientists, operators, technicians and manufacturers together for information exchange.

  UNOLS will recommend an appropriate forum at that time.

- This report, including the attached panel comments, be made available to the community at large through direct email and posting on the UNOLS web site.

Science Mission Requirements for UNOLS Wires & Cables

What kind of wire or cable do you need?

Please help us define the science mission requirements for the

UNOLS Standard Wires and Cables of the future.

Goals and Objectives for this effort are listed on the following page:

http://www.unols.org/wire/wirespec.html

IDENTIFICATION

First Name:	Last Name:
Institution:	Phone:
Email:	Fax:
May we contact you to follow up? (•) Yes ( ) No	

Provide a summary of your wire and/or cable requirements now and in the future that should be considered during the process of defining specifications for standard wires and cables. Especially important are operations where you are limited by existing wires or new operations, sampling methods and survey methods that would not be possible with existing wires. Tell us about things you would like to be able to do that cannot be done now using standard UNOLS wires and cables. Please fill out at least this part of the form to help define the wire and cables of the future. The second part of this form allows you to submit more detailed information if you prefer.

CLICK HERE TO SUBMIT YOUR SUMMARY OR CONTINUE BELOW IF YOU WOULD LIKE TO ADD MORE DETAIL. THANK YOU.

Submit Summary only

IF YOU WOULD LIKE TO PROVIDE MORE DETAILED INPUT

PLEASE CONTINUE BELOW.

Please complete the following form for each piece of sampling, survey or other project equipment that you currently use or plan to use in the future. Especially important is information on equipment that may stress the

capabilities of existing UNOLS wires and cables or that may not be possible to deploy with existing standard wires and cables. Are there tasks that you can visualize that are not now being attacked because of a lack of appropriate wire capabilities? Information regarding work done with standard packages usually provided by UNOLS ship operators is not necessary, however if you are not sure, we would welcome any input. If you have more than one system, you can skip some of the repetitive information in the identification section and just fill in your name and email address on subsequent submissions so we can correlate all of your responses.

OUR PRIMARY GOAL IS TO CLEARLY IDENTIFY OPERATIONS (CURRENT AND FUTURE) THAT WOULD BE LIMITED BY OR NOT POSSIBLE WITH EXISTING WIRES AND CABLES.

RESEARCH

Science Discipline: Select **Funding Sources:** ☐ **NSF** ☐ **ONR/Navy** ☐ **NOAA** ☐ **Other Federal** ☐ **State** ☐ **Private**

Brief Description of Research Interests:

Comments regarding your operations:

Contact for Technical, Engineering or Manufacturer information on sampling or profiling equipment

Complete if you know of someone that can provide useful technical or engineering input

Name:	Institution/Company
Phone:	Email

Area of expertise

Sampling or Profiling Equipment

Brief Description of Sampling/Profiling/Survey Equipment.

Size and Weight of Equipment

Engineers would use this information to estimate loads on the wire.

Height (feet)	**Width or Diameter (feet)**	**Length (feet) (enter D if round)**
Estimate of Surface area	in square feet.	
Weight at deployment:	lbs in air	lbs in water
Does equipment gain or lose weight during deployment and how much?	Gain Lose	Amount in lbs: :

Parameters of the Deployment

Depth of deployment in meters:	Average	Maximum
Wire speed in meters/min:	Payout	Recovery

Type of deployment (Check all that apply):			
midwater only	drag on sea floor	drive on sea floor	penetrate sea floor
towed	vertical deployment	deployed - released	maneuvered (ROV)
cycled in and out during deployment			
	Avg # of cycles per deployment		
	Range of cycles (in Meters)		
	Duration of deployment for any of the above activities (hours)		

Wire Tension and Tension Factors

Estimate of maximum tension on wire during deployment:	lbs
Maximum weight of any samples collected:	lbs
Estimate of maximum pullout for cores:	lbs
Maximum penetration of sea floor by cores:	meters
Tension needed to break weak link on dragged devices:	lbs

Other Physical Factors effecting your deployments we didn't think of: (Also use this to elaborate on any of the above items)

Electrical/Power (through the wire) Requirements

Number of conductors needed:	
Size of conductors:	awg
Voltage:	

Amps:	Max

Describe power or electrical requirements:

Data Transmission Requirements

Data Rate:	Bytes/Second
Number of discrete data paths needed:	

Other data transmission requirements:

Do you already use or have you already identified a wire/cable that meets your requirements?

Existing UNOLS Standard:

3 x 19 wire rope: ☐ 3/16" ☐1/4" ☐3/8" ☐1/2" ☐9/16" ☐ 7/8"

EM Cable: ☐.252 single cond. ☐.322 three cond. ☐.680 coax ☐.680 fiber optic

Other non - standard wire or cable:

☐Wire Rope ☐ Copper conductors ☐ Fiber Optic ☐Synthetic ☐Other (describe below)

Manufacturer:

Model Number or Name of wire/cable:

Description of wire or cable or source for specs. Describe how the wire or cable you are currently using limits your science or if it makes it possible to do your work what factors are most important:

ANY OTHER THOUGHTS OR COMMENTS THAT WILL HELP US ACHIEVE OUR GOALS:

Thank you for helping with this project. If you would like to receive emails regarding our progress check this box

Submit your input to our Wire & Cable SMR database: Submit

Appendix IV

Community review and comment page for Functional Requirements – 2003

http://www.unols.org/wire/Cable_Functional_req.html

New UNOLS Cable(s) - Draft Functional Requirements

(revised 11/6/03)

Please review and provide your feedback using the text blocks below each section

The purpose of these functional requirements is to define the capabilities and characteristics to be used in designing or evaluating designs for a possible new UNOLS standard smaller diameter electro-mechanical (EM) or electro-optical-mechanical (EOM) cable. This new cable should meet the needs of the oceanographic community for the next two or three decades and provide improved performance relative to the existing UNOLS standard small diameter EM cable (0.322 CTD cable). This cable would not replace the capability of the 0.680 coax or 0.681 EOM cable which support the requirements for larger packages. Your input to these functional requirements will help define the parameters for desired capabilities and characteristics that will direct cable designers and manufacturers in developing a cable design to meet your needs. Among the improvements that are driving the need for a new cable are a desire for increased payload and/or safety margin for deep casts using WOCE size CTD packages; a desire for higher bi-directional data telemetry and the continued need for power transmission to instrument packages.

Additionally other instrument packages have been introduced into the fleet and are currently being developed that involved continuously towing, either at fixed depths or in an undulating depth mode.

Functional Requirement	UNOLS "CTD" cable: 0.322" diameter - three conductors. (Rochester A301592)	Rochester A305382 cable - 0.393" diameter, 4 conductors, 2 SM fibers (This cable is currently being used for SeaSoar or Triaxus deployments) It is an example of an alternate cable	New UNOLS EM or EOM cable
A. Purpose and General Operating Requirements			
Purpose	Long cable with data and power transmission capability used to lower varied instrumentation from Research Vessels on the high seas.	Medium length (3000M) with fiber optic and copper telemetry capabilities and slightly higher strength characteristics.	Long cable with improved safety margin for desired payload at maximum depth, a reliable and significantly higher rate data transmission capability than current CTD cable. Power transmission and data telemetry over copper at least comparable to current CTD cable.
Primary use	CTD's to 6000 meters	Towed undulating bodies to 400 meters.	Vertical lowering of instrumented packages to depths up to 6,000 meters. Longer scope of wire will be necessary to achieve this depth in many cases.
Other uses	Instrumented packages, primarily lowered vertically, some towing applications such as smaller MOCNESS nets and Optical Plankton Counters (OPC).		Towed packages with continuous tension and length cycling over extended periods of time. (Deep towed or lowered large instrumentation will use existing larger diameter cables)
Reviewer Comments:			

B. Design Priorities

Cable Design Priorities			
	Best weight/strength ratio		1. Increased payload and/or safety margin at maximum depth compared to existing CTD cable.
	Survive periodic loading > 50% RBS		2. Survive periodic peak loading.
	Function @ > 40%RBS for 70% life		3. High degree of rotational stability (i.e. nominally torque balanced).
	Service life >3 years		4. Copper conductors should support at least the current power and telemetry requirements of existing CTD systems (e.g. Seabird 911).
	Highest elastic limit		5. Significantly higher bi-directional data telemetry capability than available with current CTD cable.
	Best abrasion resistance		6. Service life ! 3 years based on nominal use by Global Class research vessel.
	Best corrosion resistance		7. Designed for storage under tension and with size characteristics to allow maximum use of existing winches.
	High degree of rotational stability		
	Withstand cyclic loading		
	low powered telemetry		
	minimal power capacity (see power spec below to see how this impacted design)		
Design Assumptions			
	"well logging" design		Strength criteria based on one end free to rotate
	Operate over sheaves 40 x O.D.		Cable will operate over sheave and drum diameters that are 40 times cable diameter (40:1)
	Preformed (resist unlaying)		Safety factor of 2.5:1 or greater for maximum allowable working load.
	Armor stress balance		
	multiple conductors		
	Galvanized		
	Storage under tension to 40 layers		
	Lubricated		
Reviewer Comments:			

C. Environmental Factors

Operating environment	Dynamic environment		Dynamic ocean environment
	Continuous operation		Continuous operation
	Intermediate winch size		Use newer existing or newly purchased winches
Operating depth	" 5,460 meters	" 4,800 meters	" 6000 meters
Maximum lowering & recovery rates. (to be considered as a factor in dynamic loading)	> 60 m/min		! 60 m/min
Reviewer Comments:			

D. Mechanical Requirements

Size			
Diameter	0.322" (± 0.003") at 15% RBS & < 2% at 50% RBS. Uniform over entire length.	0.393"	0.250" to 0.50" and as close to existing 0.322" as possible. Useable on as many existing winches as possible while at the same time not compromising on any significant gains in capability. Design so that diameter fits a precise number of turns on drums designed for .322 cable.
Length	10,000 meters w/o splices	! 10,000 meters w/o splices	7,000 to 10,000 meter lengths. Maximum length required will be 10,000 meters w/o splices and we may want to specify a shorter length if this will save cost, weight and space. Length must support operations to at least 6,000 meters, which may require deployments of 7,000 to 8,000 meters of cable.

Strength			
Payload weight = (working load minus weight in water) - no allowance for dynamic loading	> 1000 lb (454 kg.)	Using the spec sheets working load of 3,400 lbf (1542 kgf) you can lower 2000 lbs (907 kg) to 1,966 meters. At 4,776 meters you have zero payload. At a 2:1 Safety factor you have a payload at 6,000 meters of 2,600 lb (1,183 kg). At a 2:5 Safety factor you have a payload at 6,000 meters of 1,232 lb (559 kg).	2000 lb (907 kg.) at 6000m 2,000 lb exceeds the payload for 0.322 at 6,000 m or deeper at any safety factor greater than 2:1, not taking into account any dynamic loading. Either a much stronger or much lighter in water cable would be required to achieve this goal.
Strength	RBS > 10,000 lbf w/one-end-free to rotate. Spec Sheet shows: 10,000 lbf (45 kN) with one end free to rotate 11,600 lbf (52 kN) with fixed end	Breaking strength: 13,760 lbf with one end free to rotate (estimated) 16,000 lbf with both ends fixed.	RBS > 10,000 lbf w/one-end-free to rotate
Weight			
Air	175 lb/kft 260 kg/km	261 lb/kft 389 kg/km	This is a factor that affects winch design, ship stability and the ability to handle the cable spools.
Water	144 lb/kft 214kg/km	217 lb/kft 322 kg/km	Need lighter or much stronger cable without increasing the outside diameter too much. Weight to strength ratio should provide greater payload than .322 cable at full depth.
Weight to Strength ratio (%) **(Weight of cable in water/RBS)**	Using weight at max depth of 6,000 m 1286kg/4082kg = 34%	At 6,000 m 1938kg/7257kg = 27%	Need weight to strength ratio that provides the specified payload at full operating depth. Using a SWL of 40% RBS (2.5:1 safety factor) a weight to strength ratio of 20% at 6,000 meters would be needed for RBS of 10,000 lbs (4,500 kg) and 26% for RBS of 15,000 lb (6,800 kg) in order to achieve a payload of 2,000 lb (907 kg)

Dynamic characteristics			
Rotation	< 20°/ft at 40% RBS(spec @ 2500 lb is 15°/ft or 49°/m)	Reported to be better than 322 cable	< 1° /ft (3.3° /m) (this is the 0.681 FO cable spec) Other specifications seem to allow a little more than this, but the 20°/ft specified for current CTD cable is excessive. We should specify the smallest amount of rotation possible. The spec for 0.680 coax is 5°/ft (16°/m) @ 40 % RBS
Flexure	> 50,000 cycles, sheave 40 x O.D. at 40% RBS without failure		50,000 to 1,000,000 cycles. (If the cable is held at one position on a sheave while towing for extended periods of time, this number of bending cycles could be achieved very quickly.)
Tension cycling	> 50,000 cycles, sheave 40 x O.D. at 10% to 40% RBS		Average tension of 25% RBS ± 15% RBS over the lifetime of 50,000 to 1,000,000 cycles over a 40:1 sheave diameter.
Min. Sheave size	" 15 " tread diameter (spec = 12")		40:1 Sheave Diameter to cable diameter ratio 40 to 1 is a good standard, but a smaller allowable bending diameter without sacrificing the working life or safe working load would be desirable.
Armor:			
Strength	! XIPS (extra improved plow steel)		Specifications as needed to achieve cable strength/weight characteristics. Should not be any less than XIPS (extra improved plow steel).
Ductility	" XIPS		Specify as needed to achieve required yield strength. Should not be any less than XIPS.
Min. outer wire dia.	0.032" (0.81mm) (Spec 22/0.0375")	0.042" (1.07mm)	Large enough to give adequate protection against abrasion.
Galvanized	Yes	Yes	Yes if steel construction
Lubrication	Low viscosity, water displacing to be applied during armoring		Pre-lubed as necessary for achieving life cycle.
Reviewer Comments:			

E. Electrical Requirements

# conductors	Three	Four	One to three conductors if armor available for return path. Primary goal for multiple conductors is reliability and survival of the conductor.
			Tow cables may need more conductors if fiber can't be used.
			Color code conductors with different, easily distinguishable colors, for ease of termination and troubleshooting.
Type	Stranded copper wire	#18 - stranded copper wire with embedded SM fiber	Consider other conductors as part of design in order to add strength or to achieve other characteristics.
		(Electro-Light®)	
		#24 - stranded copper wire	
Size	> #20 AWG	2 x #18 AWG	design to meet electrical specs
		2 x #24 AWG	
DC resistance	< 10#/1000 feet (spec is 9.4 #/kFt for the cond. & 2.4#/kFt for armor)	6.5 #/kft (#18) 25.0 #/kft (#24)	15.4 #/km (4.7 #kFt) Conductor 7.9 #/km (2.4 #/kFt) Armor
Capacitance (cdr-armor)	> 40 pf/ft @ 1kHz (spec is 35pF/ft or 115 pF/m)		< 40 pF/ft (131 pF/m)
Voltage	Rated > 600 VDC (spec 1000 V)	1200V (#18) 500V (#24)	> 600 VDC (should it be at least as high as the .322 rating of 1000 V?)
Insulation resistance	3,000 M# • km	3,000 M# • km	3,000 M# • km
Primary circuit	1 conductor to armor		One conductor to armor, unless synthetic material is used.
Telemetry	Optimum frequency < 20 kHz (5 kHz + 10 kHz)		Optimum frequency < 20 kHz
Copper yield	> 65% RBS of cable		> 65% RBS of cable
Reviewer Comments:			

F. Optical Requirements

Comments on Optical Requirements		The actual property of the fiber that limits the bandwidth-distance product is dispersion. It could be specified either way but bandwidth is the one that the user cares about.	These specs are taken from a couple of different Rochester Fiber-Optic cables, some were at 850 & 1310 nm and the other was at 1310 & 1550 nm. We really need help on how to define the optical characteristics and construction.
Type of optical fibers			Single mode
Allowable stretch on Optical Fibers			< 0.5% maximum allowable stretch applied to optical fibers
Optical Fiber Proof Test			Sufficent to prevent failure at the strain levels that will be encountered at safe working load with shock loads
Attenuation			
@ 850 nm			" 0.45 dB/km (0.14 dB/kft)
@ 1310 nm		" 0.45 dB/km (0.14 dB/kft)	" 0.35 dB/km (0.11 dB/kft)
@ 1550 nm		" 0.35 dB/km (0.11 dB/kft)	
Bandwidth			
@ 850 nm			! 160 MHz • km
@ 1310 nm			! 500 MHz • km
@ 1550 nm			
Reviewer Comments:			

G. Requirements for synthetic cables

Stretch			Design so that higher percent stretch does not have an adverse affect on copper or fiber-optic conductors or on any attached equipment.
Electrical			Provide for return conductor in electrical design.
Termination			Provide for termination at rated strength of cable that can be repaired or made in the field.
Protective jacket			Provide outer jacket or other method for ensuring abrasion resistance and appropriate level of cable stiffness
Reviewer Comments:			