Topic	H2020 – INFRAIA-2018-2020
Short Title	Eurofleets+
Title	An alliance of European marine research infrastructures to meet the evolving requirements of the research and industrial communities
Project Number	824077
Delivery Date	31 January 2023
Deliverable No	D3.20
Lead Beneficiary	CSIC
Dissemination Level	Public

Viability Study of design of interchangeable drum winches

Document information	
Document Name	D3.20 Viability Study of design of interchangeable drum winches
Document ID	EurofleetsPlus_WP3_D3-20_20012023_V2
Revision	V2.0
Revision Date	20 January 2023
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Security	Public

Approvals			
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History			
Revision	**Date**	**Modification**	**Author**
V1.0	09 December 2022	First draft	Arturo Castellón Masalles
V2.0	16th January 2023	Second Draft	

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1. Introduction

Currently it is estimated that only 5% of the oceans have been explored. In order to discover that remaining 95%, oceanographic vessels play a special role by sampling at all depths and especially the deep sea that occupies two thirds of the total oceans. Specialised gear and equipment are installed on board ships to enable sampling at all depths along the water column. Depending on the size of a ship's deck, these rigs can take up considerable space, more so if it is a medium-sized ('regional') ship. Studying and sampling the deep sea can be limited when using regional vessels due to their size. Increasing the capacity of Regional Vessels to enable deep sea sampling is a priority to increase capacity across the European Research Vessel fleet, to allow greater geographic coverage and also for the potential cost savings.

The use of deck space is one of the objectives in ship design, especially in medium and small size ships. Designing a 90-meter ship is easier than designing a 50-meter ship. One of the objectives of JRA 3.2 is the design and study of opportunities to take advantage of the space on the work deck, design mobile, interchangeable and versatile equipment, the use of gear in several operations and design new deep sea sampling systems that allow to take advantage of time and space on the ship.

Rigs and gears are usually fixed on the vessel deck with some, such as winches housed below deck. Cranes, frames, davits and winches are all used to deploy equipment at sea and obtain samples from both the water column and the seabed.

Some efforts have been made in optimizing the use of the equipment. A trend towards the standardization of some elements is observed as some of the equipment to be deployed is also standard such as CTDs, Side Scan Sonar, plankton nets, coring, etc. This fact makes a certain convergence appear in the characteristics of the cables used, the winches, even the blocks and sheaves.

The attitude of the vessel during operations also seems more common, so certain characteristics of the rigs, such as frames, spoolers and their placement on the deck as well as the path of the cables (and reeving) on their way out to sea (outboard block) are also similar in different vessels. Usually RV (Research Vessels) use two types of manoeuvres: *on station* and *towing* (trawling). And for this they need two configurations of winches and davits or frames that serve these operations. For this deliverable we will consider a frame on the starboard side (at least) and another located aft *[1. Guidelines and recommendations for ship design on work deck installation and operations for scientific equipment. EUROFLEETS2-WP11-D11.2. V3. S. Duduyer , Arturo Castellon, Juan J. Dañobeitia , Aodhan Fitzgerald, Marc. Nokin, Anna Vetrano ,Andreé Cattrijsse , E. Özsu.]*

Continuing with our observation we will see that the blocks located in these frames are used to guide a cable from winches located on the winch-deck although in some cases the winches can be located below deck guiding the cable by reeving (fairleader). Other operations require use of cranes like mooring lines or special LARS (Launch And Recovery System) for Remotely Operated Vehicles (ROV) and Automatous Under Vehicles (AUV) which are usually portable.

Currently the trend in regional ships is versatility, multipurpose, so that they can have a wide range of operating scenarios to make them more profitable. Within these operations, of these gears, the winches are fundamental elements. With the exception of autonomous moorings and AUVs, all equipment needs a link that joins them to the ship: the wire cable or rope.

Obviously different types of cables with different performance or characteristics are used. Firstly, we can distinguish between traction cables and cables with conductors. We use the latter when it is necessary to acquire sensor data or use actuators (power) at the depth of the deployed equipment. In addition to this, the size, diameter of the wire/rope will be adequate for the operation depending on the depth to which we lower the equipment and its total load (SWL) of equipment plus wire/rope. Finally, in the case of wires with conductors, the number of these and their characteristics (F.O., coaxial...) will also be decisive for the operation, the handling, the winch and the blocks used. These aspects will determine the design and characteristics of the winches to be used. Depending on the type of cable, the winch will be adapted to operate safely and efficiently.

The pre-ranurated drum Lebus, the pitch of the level-wind, the slip-ring, the cable fleet angles towards the snatch block, the pull and recovery speeds, the maximum tension, are some of the characteristics to take into account. So is the weight, the total load of the winch with its cable. The type of cable or rope is very important both for the characteristics of the manoeuvre and for the design of the winch and its accessories. Some fiber ropes can be terminated like steel wire (Hampidjan Fiber Winch Warps) *[2. EUROFLEET+. WP3. Deliverable D3.6 Guidelines on use and limitations of drum winches vs. captive winches using Fiber Ropes* Arturo Castellón Masalles, Niamh Flavin, Aodhan Fitzgerald, David Waage, Lars Jørgensen.*]*

It is also important to highlight the technological evolution of the winches and, within it, the evolution of the spoolers or level-wind with an electronic control that allows highly precise stowage of the cable. This allows that, when exchanging a reel with cable of different characteristics, the spooler can be adjusted to the diameter of the cable. Another important issue in this evolution are captive winches. In these winches, the spooler is replaced by a 90º sheave at the cable entry/exit.

The objective of this study is to determine the viability of designing or developing a winch in which the drum with its cable can be interchanged. In this way, maintaining the base of the winch, its drive inputs (electric, hydraulic) and the level-wind (spooler), a different drum can be placed with the appropriate cable for the necessary deployment. In EUROFLEETS+ MacArtney presented a task (deliverable) on the design of a new deep sea winch, portable and with interchangeable drum. [3. Eurofleets+_WP3.2_D3.15_120321_V2.0. D3.15 Outline of Electric Winch. Lars Jørgensen].

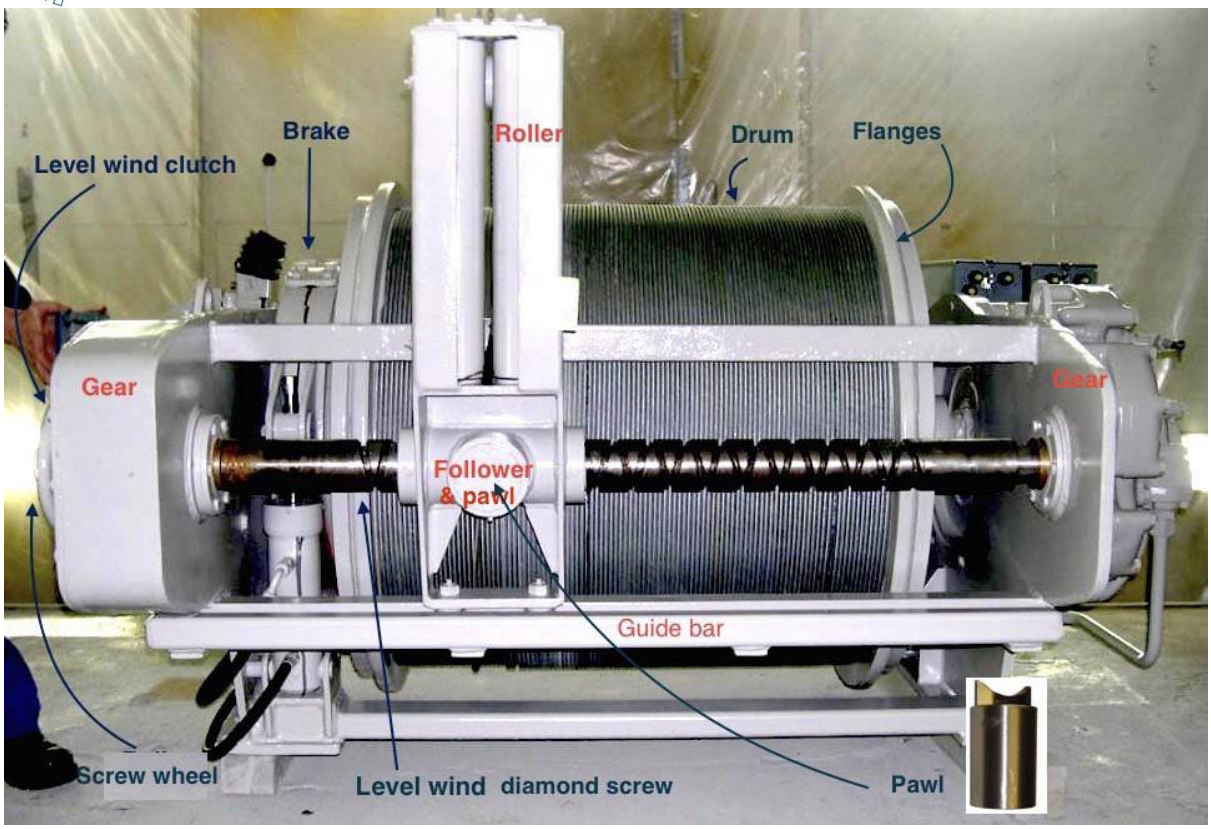


Figure 1 Parts of a hydraulic winch (Rapp-Hydema winch). (Photo UTM)

2. Objectives: Why?

The reasons for having a winch with an interchangeable drum, among many others, could be the following:

2.1. Reduce the number of elements on the deck

On ships, space is usually a very precious element. In this case the area we will study is the deck. Oceanographic ships have a wide range or diversity of equipment for different scientific purposes like CTD casts, plankton net hauls, coring sampling, etc. For sampling operations numerous moving elements are involved (blocks, cables, winches, frames). The working scenario changes depending on what operations are taking place. The path of the cable through the deck is determined by the position and posture of the winch (the exit/entrance of its cable through the spooler and the relative position of the drum) and the situation/position of the outboard block and, in turn, the position of the frame that supports it. When different winches are used, they should be placed on deck in a position and angle relative to the outboard block. Often some of the winches installed on the working deck or on the winch deck are not used on all cruises. There is usually a set of winches with different cables such as traction and conductors, steel or fiber ropes, pointing aft or to the starboard side. In some RVs, winches are installed that can rotate on themselves by means of a toothed crown or similar to point it aft or to the side.

In the case of interchangeable drum winches (IDW) the solution would be to change the drum and therefore the cable of winch already positioned. This solution can complement the other. With less

equipment on deck (a winch with an interchangeable drum instead of two with different cable diameters) the workplace is clearer, this will result in greater safety for personnel and equipment during scientific manoeuvres.

2.2. Avoiding the transport of the complete winch.

Another reason for having a winch with an interchangeable drum is not having to disassemble the of the ships equipment. Sometimes this equipment is quite heavy, so a sufficiently powerful crane must be available to carry out the operation. On the other hand, the disassembly operation will be more laborious and will take much longer due to the fact that it must be disassembled from its base and electrically or hydraulically disconnected, an operation that in the case of having a winch with a well-designed interchangeable drum can changed over by removing the minimum number of elements.

2.3. Interoperability between different ships

Another reason would be interchangeability. Currently the fleet, or at least part of the existing oceanographic research vessels that carry out similar research cruises, may need the appropriate cable and drum and can be easily shipped since the weight is less than with the complete winch.

2.4. Easy to replace a winch/cable in time and costs

With the optimized design of the winch and its drum, its installation on board will be as simple as removing bolts and sensors. The use of a specialized technician would not be necessary, the existing electrical/hydraulic installation of the equipment would be used, all this would avoid:

- Construction costs of new equipment for similar operations for each ship.
- Cost reduction in shipping heavy and bulky equipment
- Reduction of assembly and disassembly times
- Reduction of waiting times for ships and their crews
- Costs of technicians specialized in the equipment

Also and depending of the size, it could be possible to transport an additional drum with it cable preconfigured for other types of operation. This *spare drum* can be used and set at sea during cruise time using on board cranes. This will avoid harbour entries and time consumption.

3. Winches

3.1. Description and parts of an oceanographic winch

An oceanographic winch is designed for deploying instruments and devices into the sea using cables made from steel wires, fiber ropes or other type of cables. It basically consists of a drive (hydraulic or

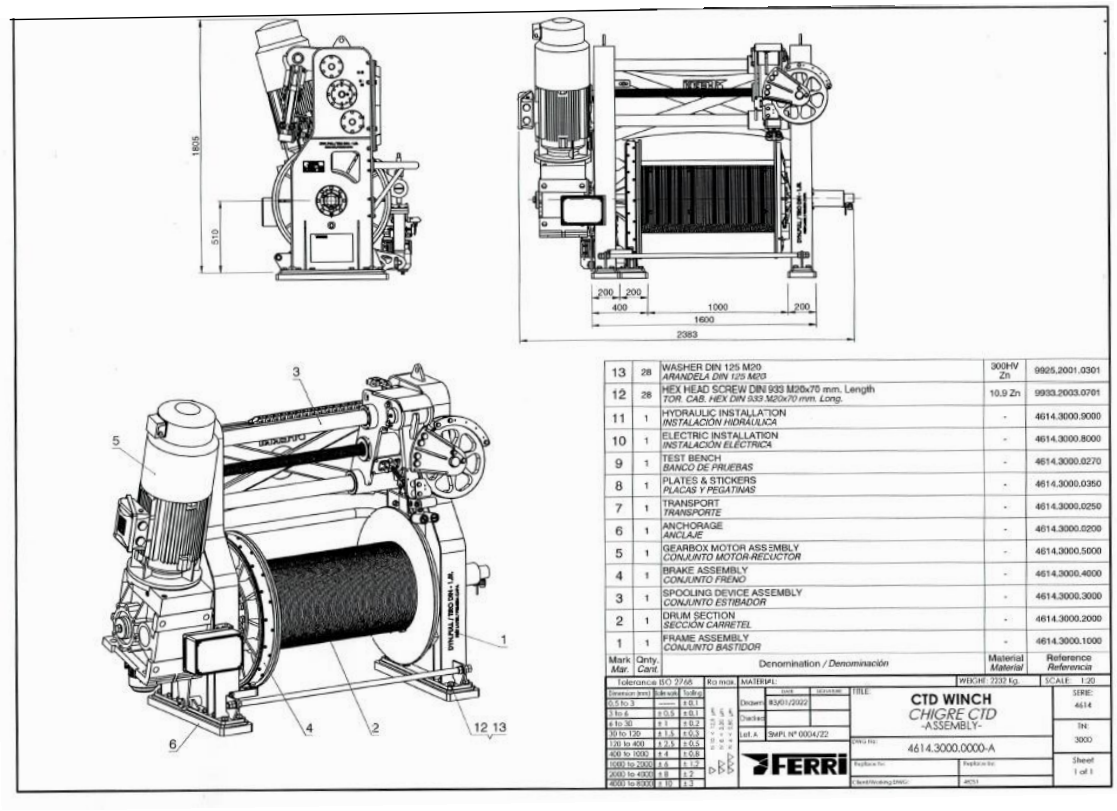
electric) with plugs and connections, gears, brake (usually pneumatic), level wind and spooler and a drum with the cable. (see Figure. 1)

The equipment is installed on vessels and research platforms facilitating different manoeuvres. These manoeuvres vary and can include dragging or towing, trawling and vertical descent in the water column and to the seabed. The cable used can be steel cable or fiber rope and with some equipment conductor cable is needed.

The type of winch required will depend on the operation being carried out and the associated power requirements. Variables include the depth, data collection and towing requirements which also informs the use of the appropriate type of steel cable/fiber. Its drive can be electric, hydraulic or a combination of both systems, although currently with the evolution of electrical components in the marine environment and their tightness and durability, this type of equipment tends to work with electricity, since this improves its efficiency and energy consumption is lower.
Figure 2 shows some of the parts of a winch, in this case a cable will operate for a CTD equipment, drawing provided by Industrias FERRI:

- **Frame:** structural element that supports the entire assembly.
- **Reel:** will be the element in charge of storing the cable, sometimes to improve the stowage of the steel cable, this type of reel is usually grooved or with Lebus casings.
- **Level-wind**: will be in charge of the good stowage of the cable in the drum, as the cable is collected or released, the spooler moves in tune with the cable from one end of the drum to the other.
- **Flanges:** are the lateral “wings” of the drum.
- **Electric motor/reducer**: in charge of providing energy for the hoisting or launching of the equipment.
- **Slip ring:** (for data/power conducting scenarios)

Sometimes in combination with the winch, more external elements intervene during hoisting or equipment release manoeuvres, such as return pulleys, davits, LARS equipment release and recovery equipment.



Mark Mar.	Qnty. Cant.	Denomination / Denominación	Material Material	Reference Referencia
13	28	WASHER DIN 125 M20 ARANDELA DIN 125 M20	300HV Zn	9926.2001.0301
12	28	HEX HEAD SCREW DIN 933 M20x70 mm. Length TOR. CAB. HEX DIN 933 M20x70 mm. Long.	10.9 Zn	9933.2003.0701
11	1	HYDRAULIC INSTALLATION INSTALACIÓN HIDRAÚLICA	-	4614.3000.9000
10	1	ELECTRIC INSTALLATION INSTALACIÓN ELÉCTRICA	-	4614.3000.8000
9	1	TEST BENCH BANCO DE PRUEBAS	-	4614.3000.0270
8	1	PLATES & STICKERS PLACAS Y PEGATINAS	-	4614.3000.0350
7	1	TRANSPORT TRANSPORTE	-	4614.3000.0250
6	1	ANCHORAGE ANCLAJE	-	4614.3000.0200
5	1	GEARBOX MOTOR ASSEMBLY CONJUNTO MOTOR-REDUCTOR	-	4614.3000.5000
4	1	BRAKE ASSEMBLY CONJUNTO FRENO	-	4614.3000.4000
3	1	SPOOLING DEVICE ASSEMBLY CONJUNTO ESTIBADOR	-	4614.3000.3000
2	1	DRUM SECTION SECCIÓN CARRETEL	-	4614.3000.2000
1	1	FRAME ASSEMBLY CONJUNTO BASTIDOR	-	4614.3000.1000

Tolerance ISO 2768 | Ra max. | MATERIAL: | WEIGHT: 2232 kg. | SCALE: 1:20

Dimension (mm)	Side wall	Toe/Brg.
0,5 to 3	----	± 0,1
3 to 6	± 0,5	± 0,1
6 to 30	± 1	± 0,2
30 to 120	± 1,5	± 0,3
120 to 400	± 2,5	± 0,5
400 to 1000	± 4	± 0,8
1000 to 2000	± 6	± 1,2
2000 to 4000	± 8	± 2
4000 to 8000	± 10	± 3

Drawn: RSG1/2022 | Checked: | Lot A | SMPL N° 0004/22

FERRI

TITLE: CTD WINCH CHIGRE CTD -ASSEMBLY-

DWG NO: 4614.3000.0000-A

SERIE: 4614 | IN: 3000 | Sheet 1 of 1

Figure 2 Parts of an Electrically driven winch (From Industrias Ferri S. A.)

3.2. Types of winches

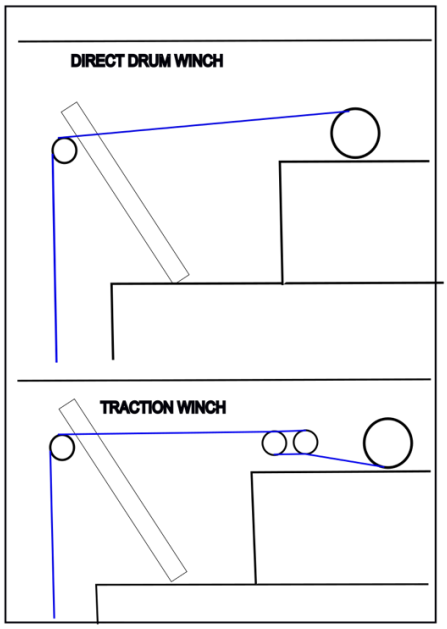


Figure 3 Direct drum (up) and traction winch (down).

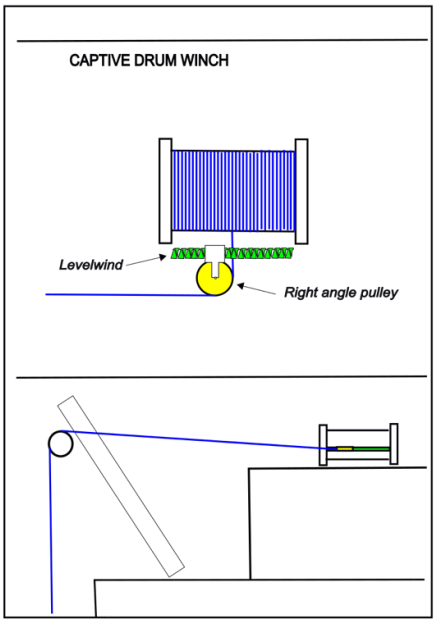


Figure 4 Captive winch.

a) Direct drum winches

In direct pull winches, (Figure. 1 and Figure. 3) the winding of the cable with tension is carried out directly with the drum itself.
These types of winches are the most common on research vessels and also on fishing boats, for carrying out the different operations of launching and hoisting CTD equipment, ROV, trawl nets..., sometimes with the help of davits, sheaves, etc.
This equipment has a number of advantages over traction winches such as:

- They are simple
- Less space on deck
- They tend to be less heavy
- They are cheaper.

Contrastingly, one of the biggest problems in this type of equipment is the stowing, which must be done very carefully to avoid the *twisting effect*[1], ensuring that the stowage angle between the drum and the last reference point before entering the drum do not exceed 1.25 º (fleet angle, Figure. 6), this will ensure that each of the layers of the cable sits correctly.

Another factor to take into account for the positioning of this type of winch is the presence of blocks, fairleads and other elements that lead the cable to the drum, these increase the slack (Figure. 5) in the cable making it difficult to wind it properly, so the closer to the sea is the winch the more efficient lifting and launching manoeuvres will be.

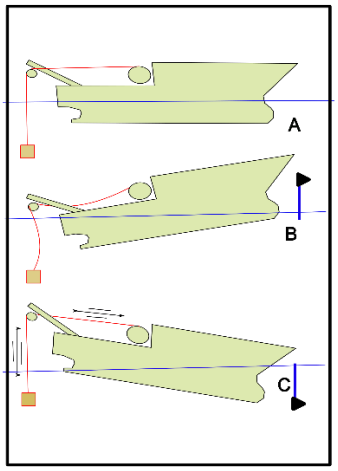


Figure 5 Slack problem

b) Traction winches.

[1] When applying a load to a wire, it will twist or unlay. This will affect wire rope with block twisting or rope distortion.

In traction winches, the tension of the cable to be wound on the drum is carried out by a series of grooved pulleys or traction heads that apply a certain tension to the cable to ensure its correct winding on the drum. (Figure. 7). They work on the same principle of increasing force due to winding friction.

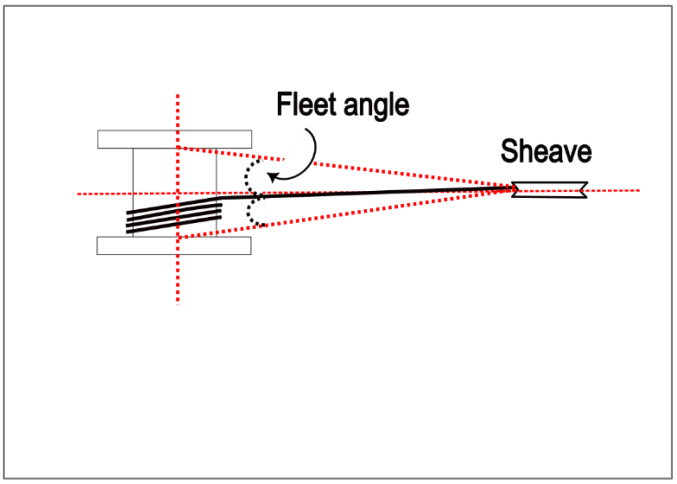


Figure 6 Fleet Angles

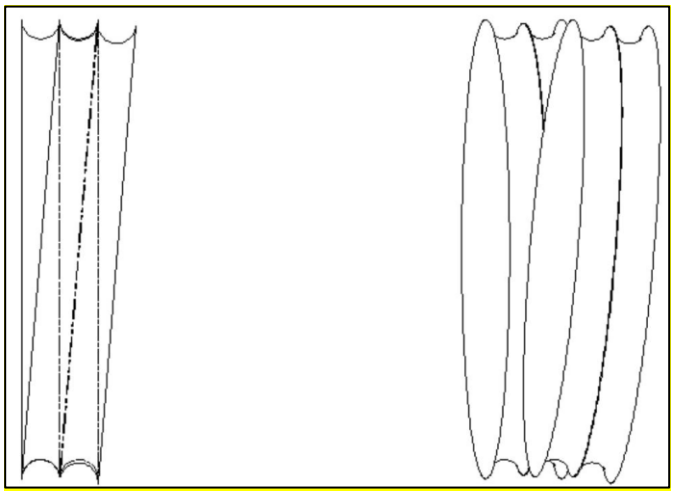


Figure 7 Traction Winch Traction Head

The pulley diameter is determined by the minimum bend diameter of the rope, which increases as the resulting loads approach 100% of the rope's breaking strength.

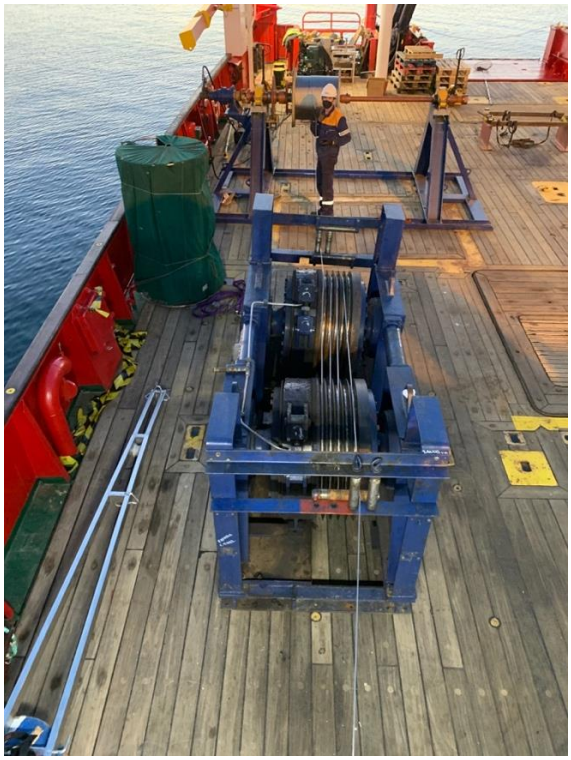


Figure 8 Traction winch

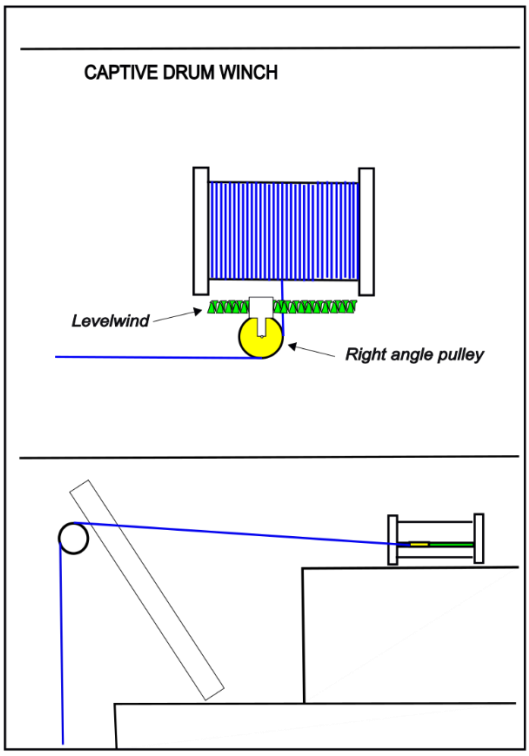


Figure 9 Scheme of captive drum winch

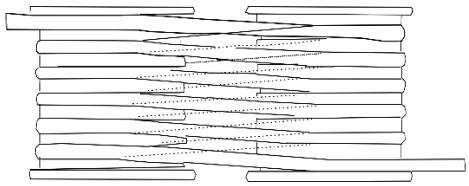


Figure 10 Traction head

Nowadays, cables used in marine research are sophisticated and expensive. Winches used for pulling these cables must be efficient avoiding cable damage. As an example, fiber optics cable 17 mm 30 $USD per meter to 130 $USD for 6 umbilicals plus Kevlar 38 mm cable.

When using tractor heads we must highlight the following advantages:

- The principal function of traction winch is to stow the cable with a constant tension. This is achieved by guiding the cable through a series of grooved pulleys that apply tension to said cable, ensuring its correct winding on the drum and protecting and increasing the useful life of the cable. Load of the cable is done by these pulleys (friction) and drum is used for storage with low tension. In some oceanographic operations maintain a constant tension is very important.
- Knife effect is avoided. Cable is stored in the drum with a constant low tension avoiding the risk of the cable entering between the previous stowed layers specially when using braided fiber ropes.
- Traction system sheaves absorb high tensile loads allowing the rope to work in a groove formed with the required minimum bend diameter. Tension in the storage drum is 10-15 % of the operating load of the cable.
- The traction pulleys must be operated independently providing the same surface speed for the cable
- They allow the cable to be stored in larger drums, thus reducing the heating of the cable during hoisting and launching manoeuvres.
- Performance is the same regardless of how much cable is moved

When deciding whether the winch should have tractor heads, these are conditioned by several factors:

- Economic factor, having the tractor heads supposes a higher cost in the equipment.
- These new items will make the winch more sophisticated and require more maintenance.
- The complete equipment will be heavier and bulkier, so more space will be needed on the boat.
- The cost of the cables and the frequency of work with which the winch will work should be assessed. In the long term, if the cables used are expensive, the tractor head will pay off in a short period of time and it will be worth incorporating it into the team.

- If the cable with which you are working is fiber (specially braided fiber), the tractor head is the recommended solution.
- The coefficient of friction is another important point to take into account when using tractor heads that will come into play when designing the winch.

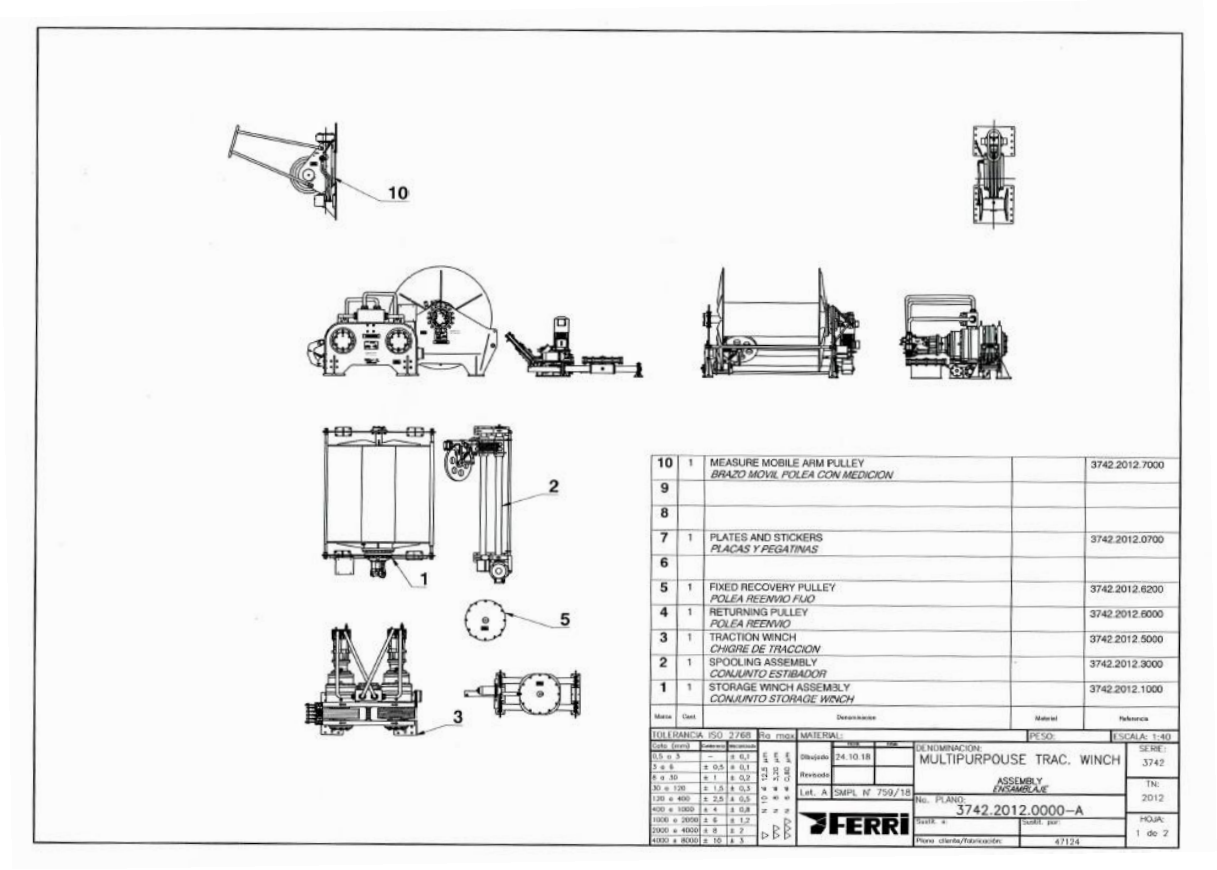


Figure 11 Multipurpose traction winch (From Industrias Ferri S.A.)

In general, to define a traction system, the following parameters must be taken into account:

- Operation/manoeuvre to perform.
- Released and hoisted speed.
- Working depth/Maximum cable length.
- Type of cable to be used: steel cable / fiber cable (braided or twisted).
- Maximum cable diameter.
- Drag coefficient.
- Maximum shot.
- Bending diameters
- Variation of dynamic loads due to the movement of the ship.

The use of tractor unit's/traction winches are an economically viable option when the operating pull approaches 25-50% of the breaking strength of the rope or when braking demands exceed the breaking load of the rope.

It is considerably easier to utilise exchangeable drums with traction winches as the drum is solely used to store the cable and the traction head is utilised to apply the required working load to the cable, this simplifies the exchange of the drums if required.

c) Captive winches

See deliverable D3.6 *Guidelines on use and limitations of drum winches vs captive winches USING Synthetic Fibre Ropes.*

We consider in this document that a captive winch is a drum winch which uses a 90º angled pulley at the cable entry/exit so that there are no fleet angles (or these are fixed) since the cable always exits from the same place without swaying/ angle change.

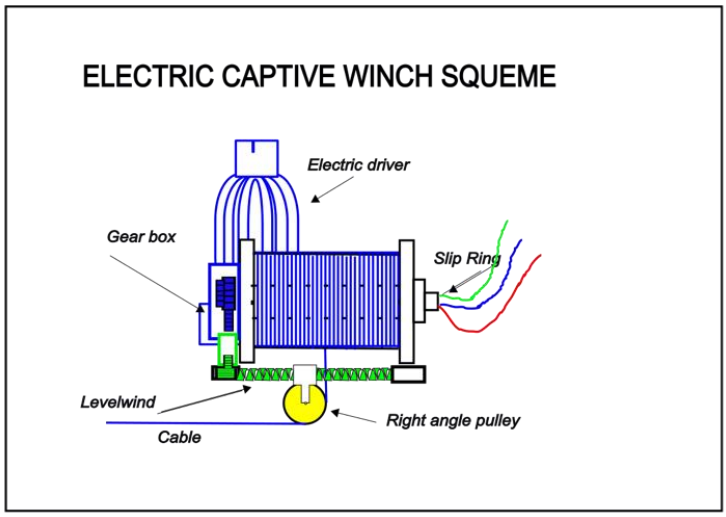


Figure 12 Captive winch: No fleet angles in the cable path

3.3. What type of winch (direct drum, traction or captive) is best suited for an interchangeable drum?

Essentially, all rope, wire or umbilical winches can be made with an interchangeable drum, the design must allow for free lifting of the drum, or temporary moving the level wind construction.

A captive winch with a Right-Angle level wind place under the drum, will allow for a free lift, however, can be slightly more complicated to route the cable. Where a straight or a Right-Angle level wind place over the drum, can require the temporary moving of the Level Wind, but typically allows for a simpler cable routing.

4. Solutions: How?

In the MacArtney design shown in this deliverable, the design is based on a top-installed Right Angle level wind. This is to allow for all operations to be carried out with the same crane and allow for the simpler cable routing when replacing the drum.

Having the electrically driven RA level wind, also allows for quick re-programming of the cable diameter. The RA level wind also allows for the winch to be installed closer to any kind of LARS, thereby taking up less deck-real estate.

As previously mentioned, there is an important diversity in the types of winches, the characteristics of the cables and the operation they carry out. It is impossible to design an IDW that encompasses all that diversity. Therefore, the starting point would be to identify which sets of winches can be integrated into an IDW while maintaining that diversity in the type of stowed cable. Another important feature must be the simplicity of the drum change manoeuvre.

The winches work by means of hydraulic or electric drives. These drives will be fixed on the ship together with the gears and reduction boxes. Only the drum will be removable and the coupling of the drum with the gears must be designed. In the case of conductor cables, the slip ring must also be coupled between the drum and winch shafts. Another important issue is the type of cable, steel or fiber rope or fiber optic conductor cables (F.O.) with only the steel core.

Maximum and minimum diameters of the cables also will affect level-wind pitch design. Spooler is a key issue; electronic control spooler will be needed.
The sizing of the equipment would be conditioned by several aspects:

- Working depth/length. Depending on the wire/rope type used, the weight of all the drum plus cable could be a limiting factor.
- Type of cable to be used, steel cable or fiber rope or both and diameter (spooler design).
- Conductor cable or traction cable or both. (Slip-ring design).
- Traction winch? (constant tension winch or not)
- Maximum payload, maximum weight of all the system: equipment-cable.
- Maximum tension.
- Drive (hydraulic, electric).
- Maximum winch speed.

a) Storage winch

Some winches have what we call storage drum. We have seen previously that, in traction winches, the drum stows the cable with low tension since its function is to store the cable. In this type of winches it is relatively easy to have an interchangeable drum and this is the case in some ships such as the example below in the R/V Siquliak of the University of Alaska. This allows other drums to be stored as a spare or with another type of cable.

b) Is it worth making a winch with an interchangeable drum?

When it comes to economically analysing whether it is profitable to manufacture an interchangeable winch, it would be necessary to study different conditions such as:

- Study of the number of oceanographic ships that carry out similar cruises with the equipment/drum + cable that they will use.
- Type of cable to be used: steel cable/fiber cable.
- Cable characteristics: diameter/length.
- Type of existing installation on board the study vessels for driving the winch: electric/hydraulic…
- Sizing of the winch to be able to easily remove the drum with its cable by the ship's crane.
- Space on the boat deck to carry out the dismantling manoeuvre safely, quickly and easily.
- Frequency of cable change during the different oceanographic cruises.

c) Fiber ropes and steel cables (and others)

One of the design goals of an IDW has to be the ability to interchange drums with different types of wire: steel wire and fiber rope (and hybrid cable).

Fiber ropes and steel cables (and others)

Currently in the naval sector there is an evolution towards fiber ropes with respect to steel cables. In the past, steel cables were used in practically all fishing manoeuvres, especially in bottom and pelagic trawling. In the research vessels field this type of cable was used for equipment deployment. Currently, due to advances and improvements in fiber ropes, the latter are being chosen due to the numerous advantages they present, among which are:

- Lower weight per linear meter, which in turn affects various aspects.
- Easier to handle.
- Buoyancy in water.
- Lighter winches.
- Less fuel consumption in the ship making it more efficient.
- Cruises of longer duration and further.
- Greater cargo capacity on the ship.
- Greater depth of work with less powerful equipment that consumes less energy.
- It is not necessary to have grooved drums and the drum can have a smooth surface without any problem. The stowage of the first layer must be carried out with great care.
- They do not tend to corrode easily, if they have a cover and, as Hampidjan developed, the manufacture of the cover and the resistance member in a single unit increases the properties of the cable, facilitating the stowage maneuver, reducing corrosion problems derived from the presence of dirt, saltpeter, sand…etc., thus increasing the useful life of the cable.
- Some of the fiber cables have properties superior to steel cables, with high axial stiffness and very good transverse stability.
- In terms of tensile and flexural fatigue performance, some outperform steel cables.
- When it comes to splicing or shortening fiber cables, this is done relatively easily on board the ship.
- They require less maintenance than wire ropes that must be regularly greased.

Regarding the disadvantages presented by fiber cables compared to steel cables, we will highlight the following:

- One of the biggest disadvantages compared to steel cables is the economic one, the price per linear meter is significantly higher than for steel cables, but with the passage of time and the increase in demand these prices will equalize, a factor that at the time it will no longer be decisive
- Sensitivity to sharp edges, any sharp edge would sever the cable relatively easily.
- During winding, it must be done at least 2% of the maximum traction load WLL, so we must have tractor heads.
- They are cables more sensitive to heat, it is recommended not to exceed 60ºC during storage, nor direct exposure to sunlight.
- On the reel during storage it is not recommended to wind it with high tension.

As for its inspection, it is a little more complicated when it comes to assessing the internal fibers.

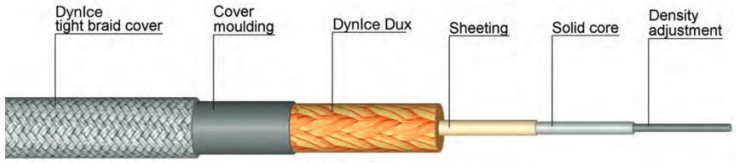


Figure 13 Hampidjan Dynice Warp

d) An example

Here is an example on the R/V Sikuliaq, which is fitted with Rapp Marine winches. It has a storage drum for interchangeable drums including steel wire rope, Rochester cable and synthetic rope options 10,000 meters. Another interchangeable drum hydrographic winch can load Rochester A302351, synthetic rope and synthetic hybrid cable rope (Steel + fiber rope cable).

Oceanographic Winch System of R/V Sikuliaq. (Rapp Marine) [ ]
• Traction/Tow Winch System indoors/below main deck
• Nominal traction winch performance: 15 metric tons at 60 meters per minute, or 9 metric tons at 100 meters per minute
• **Storage Drum** designed for **interchangeable drums** that holds the following:
  • 10,000 meters of 9/16" Wireco Steel Wire Rope
  • Up to 10,000 meters of Rochester A310114 .681" EOM Cable
  • Up to 10,000 meters 5/8" synthetic rope
• **Electric level wind** for independent spooling control
• Slack Wire Compensator included
• Oceanographic tension member fed to either Stern A-Frame or Main Crane

Hydrographic Winch System
• Hydrographic Winch installed on 01 deck
• Nominal winch performance: 8 metric tons at 60 meters per minute first layer, or 5.4 metric tons at 90 meters per minute
• Hydrographic winch designed **for interchangeable drums that holds the following:**
  • 10,000 meters of Rochester A302351 .393" EOM Cable
  • 10,000 meters 3/8" synthetic rope
  • ~7,000 meters 13 mm synthetic hybrid cable rope
• **Electric, 90 degree top angle level wind for independent spooling control**
• Hydrographic tension member fed to Starboard CTD Davit (Overboard Handling Apparatus)
• Extra sheave on top of frame for routing portable winch wire to CTD davit

e) EF+ MERMAC RCRA AHC Winch (MacArtney) [3]

As we referenced, MacArtney has designed, within the Joint Research Activities of Eurofleets Plus, a Deep sea winch. We highlight here three important points of this design:

- Right-angled level wind ensures the required fleet angle for the drum
- Automatic cable spooler with electronic control that allows adapting the speed of the level-wind to the diameter of the cable in real time. The drive of the level-wind depends on an electronic motor-reducer activated independently by an electronic control system.

- MacArtney replaceable drum winch.

This winch can be transported in a 20' container and the drum is removed for this transport.

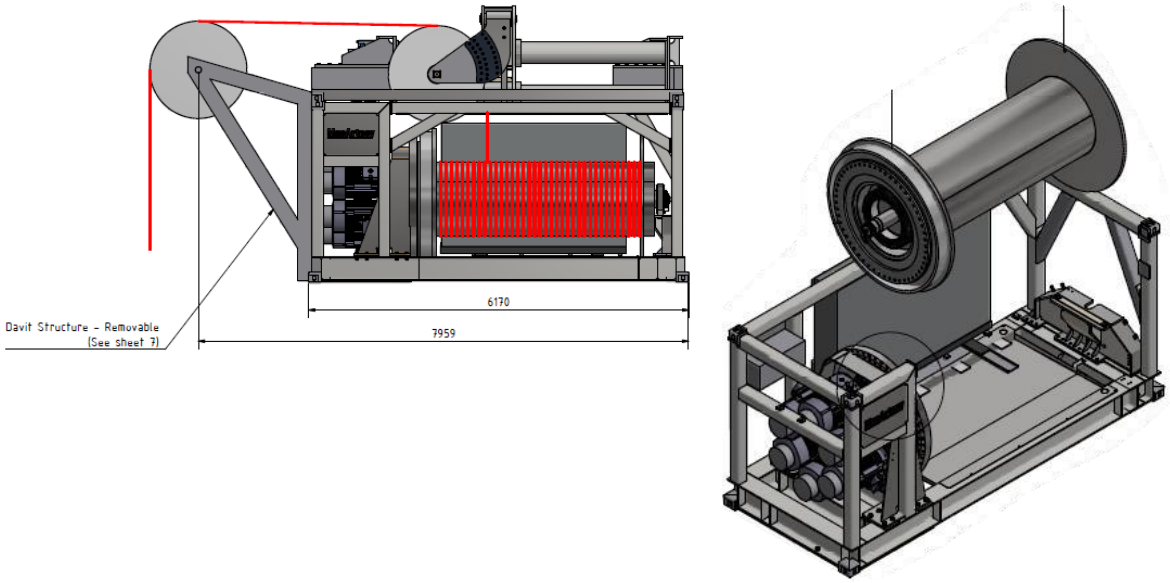


Figure 14MacArtney winch design for Eurofleets+. Interchangeable drum

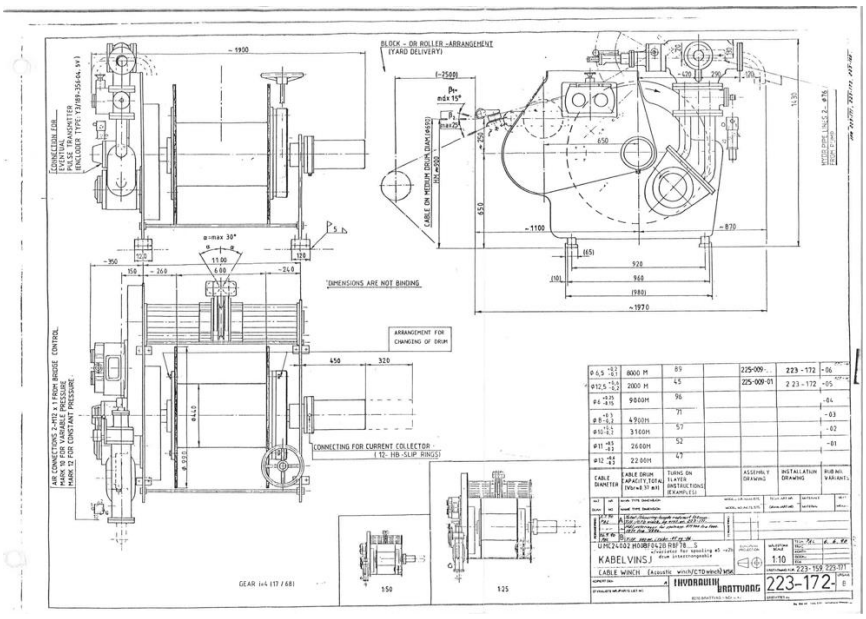


Figure 15 Drawing of NIWA interchangeable drum winch. (Courtesy of NIWA

4.1. Slip ring solutions

A slip ring is an electrical collector that carries a current from a stationary wire to a rotating device. Slip rings consist of a stationary contact brush of graphite or metal that rubs the outside diameter of

a rotating metal ring. As the metal ring rotates, electrical current passes through the stationary brush to the metal ring making the connection.
Slip rings typically work with multiple rings, providing a smooth flow of current to various parts of a device.

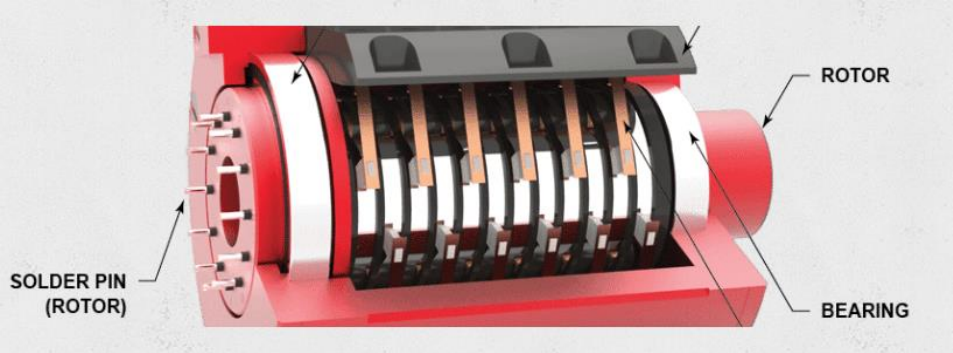


Figure 16 From https://rotarysystems.com/support/faqs/slip-ring-definition/

The cables of the stationary structure are wound around the module that houses the electrically conductive rings. The slip ring is energized when the brush block lead contacts the slip ring connecting leads. This electricity is transferred from the wire brushes to the metal rings, and from there it transfers the electricity out of the slip ring to the device.

In research vessels winches, slip rings are used for the transmission of data and power through the umbilical cable from the sampling equipment to the ship itself.
There are several types of slip ring:

- *Mercury-wetted slip rings*
- *Pancake slip rings*
- *Wireless slip rings*
- *Gold-plated rings*

***Gold-plated rings**, with brushes are the most common type of sliprings, and can easily be integrated with a Fibre Optic rotary joint.*
https://en.wikipedia.org/wiki/Slip_ring

Two possibilities when connecting it to the drum are the following:
• Embed the slip-ring in the drum itself.
• Fabricate an external support to the drum and remove the cable through a housing made in the drum's bucket.

What can be the slip ring solution for a winch with an interchangeable drum?
The MacArtney design keeps the slipring mounted in the drum, as these would always match the umbilical.

The commonly available Gold-plated rings/brushes type of sliprings are a very good type for the exchangeable drum. As these very easy to install in a junction box base configuration, allowing the operator to quickly hook up the electrical lead and fibre optics upon replacing the drum.

4.2. Level wind and spooler solutions

An Electronically controlled level-wind permit fiber rope and steel wire drums to be interchangeable, as changes in cable diameter easily can be changed, and likewise the end-stops matching individual drum, can be programmed and stored within the control system.

4.3. Shaft coupling and gear box solutions

The MacArtney design is based on a solution where the motors are mounted with pinion wheels, all placed on the lower half of the ring-gear attached to the drum, allowing crane operations to lift out the drum. The opposite drum end is a standard bearing, kept locked in place by a removable bracket, the drum-end, also contains the slipring installation.

5. Conclusions

The first winches to adopt interchangeable drums are traction winches which, due to their characteristics (low tension on cable storage) make them more affordable. In addition, these winches are usually used with a traction cable (non-conductive). However, we can develop IDW on direct pull winches and captive winches. The latter have the advantage that the spooling system has a fixed fleet angle, unlike the traditional spooler where the fleet angles are a very determining factor in the location on deck and in the operation of the winch.

We have seen that we can design winches with the interchangeable drum. There are already some such as MacArtney, Rapp, Ibercisa, etc. In the case of traction winches, this is easier and they are usually used as storage winches. However, we can also do it with direct pull winch and captive winches. The choice will depend on some factors such as total load, cable length, cable diameter and others.

A general planning of the set of winches is necessary to decide which ones will be IDW and in which position on the deck. In this way we can reduce the number of winches on board.
To share drums with other vessels requires coordination. The MacArtney EF+ winch is an example of a standardization that could be adopted especially on regional or medium-sized vessels. The use of these drums for mooring cables is also a possible use.

We see that slip ring can be embedded into the drum with a good solution. Also electronically controlled level wind permits to change spooling steps adaptation to different diameter and type cable.

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