



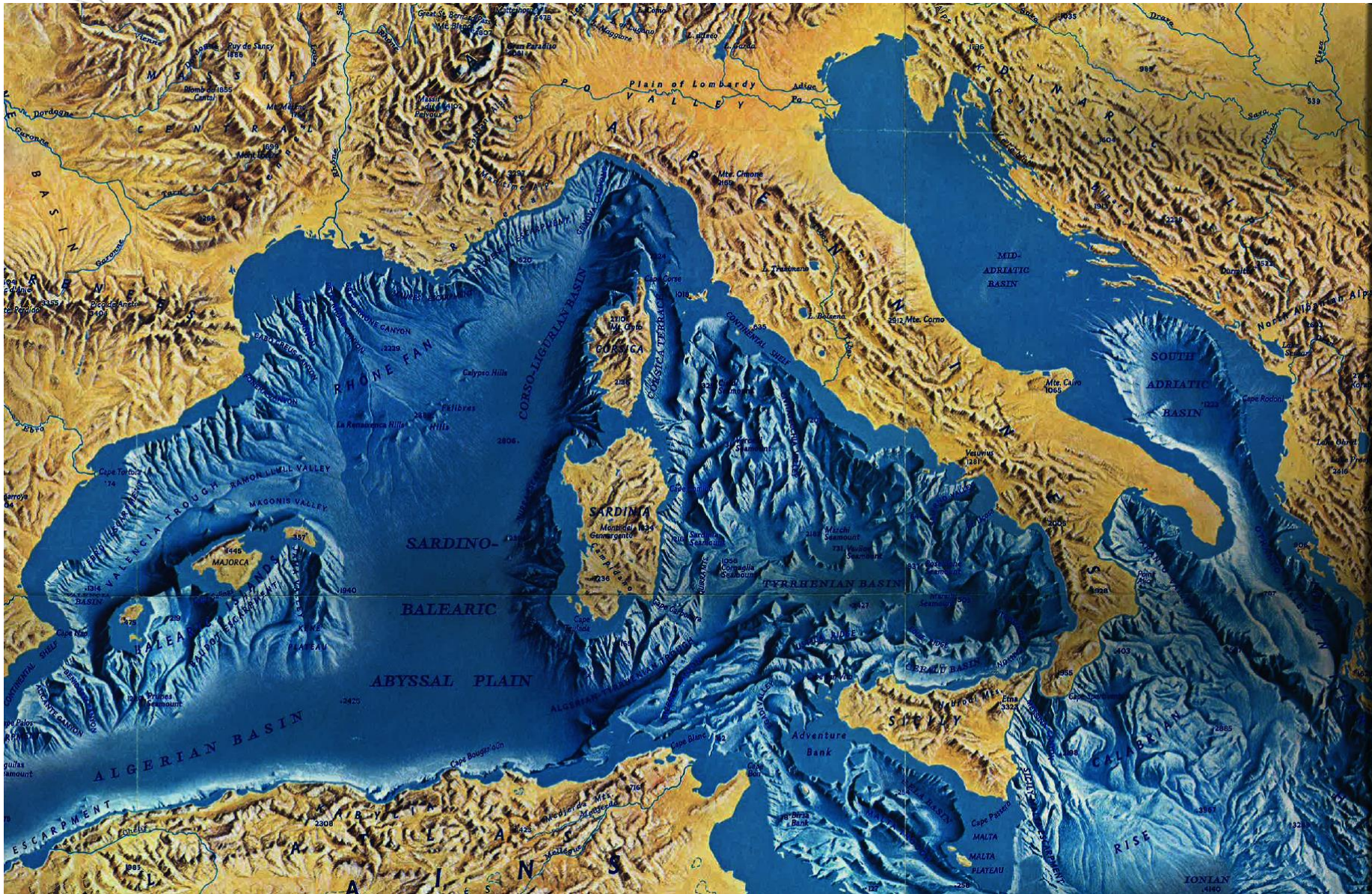
First South East European Regional CIGRÉ Conference, Portoroz 2016

SEERC

**Submarine cables HV DC&AC in the
Mediterranean sea
Terna experience**

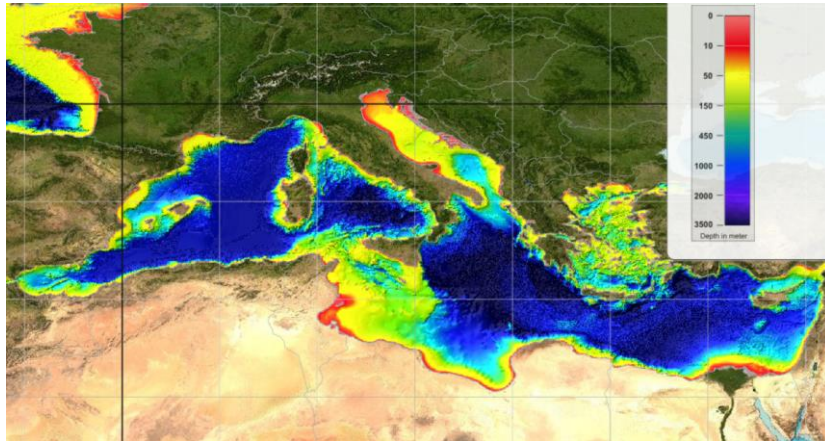
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Perda
Terna Rete Italia S.p.A
ITALY**

Mediterranean seabed



Mediterranean vs. North Sea

High average depth :
Few corridors North-South below 2000 m.



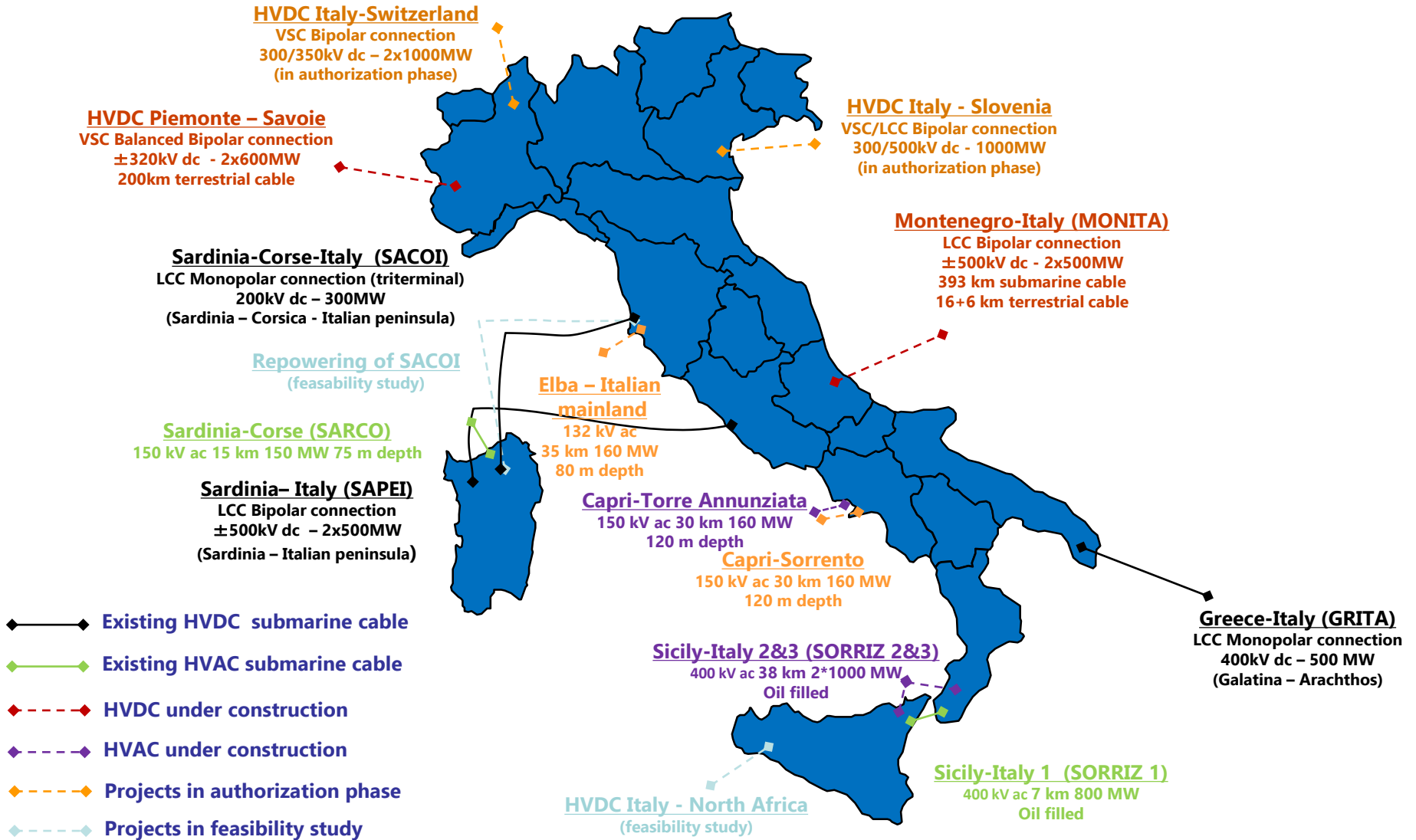
North Sea
Shallow water (Skagerrak -700m)

Without difficulties as Mediterranean
presents (geology, volcanism, earthquake)

Mediterranean AC & DC Projects (existing & under construction)

Link	Nominal Voltage	Length (only sea cable)	Nominal Power	Year	Note
Sardinia-Corse-Italy (SACOI)	200 kV dc	105 km +15 km	300 MW	1967 (ref. 1992)	HVDC triterminal – two cables in parallel
Sicily-Italy 1 (SORRIZ 1)	400 kV ac	7 km	800 MW	1985	Oil Filled Cable
Greece-Italy (GRITA)	400 kV dc	160 km	500 MW	2001	1000 m depth
Sardinia-Corse (SARCO)	150 kV ac	15 km	150 MW	2005	75 m depth
Morocco-Spain	400 kV ac	26 km	2 × 700MW	2006	615 m depth
Maiorca-Spain	±250 kV dc	244 km	2 × 200 MW	2011	1480 m depth
Sardinia– Italy (SAPEI)	±500 kV dc	420 km	2 × 500 MW	2011	1640 m depth
Sicily-Italy 2&3 (SORRIZ 2&3)	400 kV ac	38 km	2 × 1000 MW	Under construction	375 m depth
Montenegro-Italy (MONITA)	±500 kV dc	393 km	2 × 600 MW	Under construction	1200 m depth
Turkey-Europe	400 kV ac	4 km	2 × 1000 MW	Under Construction	-
Maiorca-Ibiza	132 kV ac	115 km	2 × 100 MW	2014	750 m depth
Malta-Sicily	230 kV ac	100 km	2 × 225 MW	2014	180 m depth
Capri-Torre Annunziata	150 kV ac	30 km	160 MW	Under Construction	120 m depth
Capri-Sorrento	150 kV ac	xx km	160 MW	Authorization phase	120 m depth
Ischia - Cuma	150 kV ac	23 km	90 MW	1987	Oil Filled Cable
Elba – Italian mainland	132 kV ac	35 km	160 MW	Authorization phase	80 m depth
Lavrio – Syros (Grece)	150 kV ac	108 km	200 MW	Under Construction	300 m depth

Terna AC & DC Projects (existing & under construction)



TERNA sea cables experiences & approach

All equipment installed in Terna electrical network shall be submitted to a qualification approach by (1) operating experience (2) testing process or (3) analysis . The main drivers are:

➤ Safety

of the people;
of the environment;
of other equipment.



➤ Reliability and quality

A good and continuous service shall be guaranteed



➤ Duration

verification by operating experience and by ageing test means:
- better investments;
- evaluation of next refurbishment



➤ Improvement

Tests, prior to the experience on site can highlight weak points and lead to innovation in terms of material, design, construction...

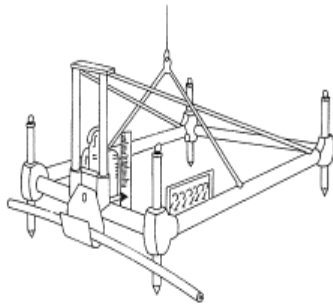
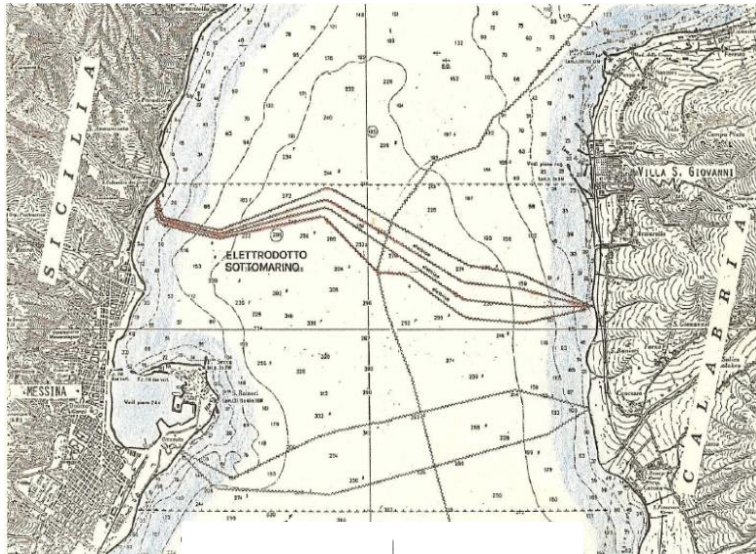




Previous projects operational experience

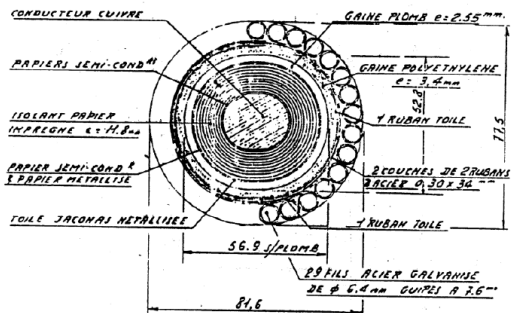
1. Sicily – Calabria HVAC 380 kV

The first marine HV ac link Strait of Messina was put into service in 1985. The single-core cables are laid in flat formation forming a three phase circuit 380 kVca with 1 spare cable. The figure shows the route followed for a total of 6.85 km with a maximum depth of 300 m. The connection also includes short landside 0,450 m in Calabria side and 1900 m in Sicily. The nominal transport capacity is 1000 MVA.



Difficulties arose from the simultaneous presence of bottom irregularities and strong tidal currents. Irregularities create danger of having the cable suspended and excessively bent. The currents add the danger of cable movements with possible failure for abrasion or fatigue phenomena. Theoretical studies were necessary to define the behaviour of the cables in such severe conditions and special provisions had to be taken before, during and after laying special supports were installed to cut the most critical free spans) in order to avoid mechanical failure

TERNA Operational Experience



Manufacturers

Pirelli /Alcatel

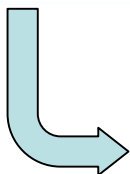
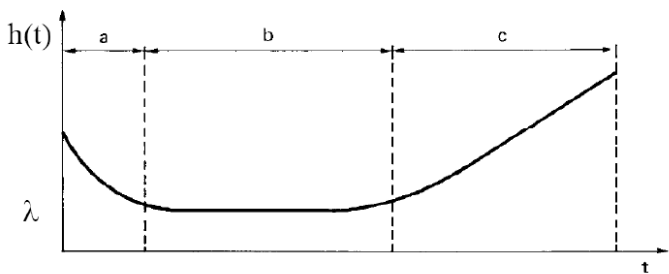
Number of cables

2

Nominal Current each cable

750 A

Marine cable insulation and cross section MI - Cu 420 mmq



Experience : Several mechanical damages in the first period of operation 1967- 1974 due to fishing activities and anchoring ; Protection methods developed



Experience : Failures due to aging of cables in final period of cables life cycle (2004-2012) , 40 years

1967

Biterminal connection SA.CO.I 200 MW, 200 kV between Codrongianus (Sardinia) and San Dalmazio (Tuscany), converter bridges equipped with mercury arc valves.

1987

A third terminal, 50 MW, in Corsica was connected to the link, so SACOI became a multiterminal HVDC connection (first in the world).

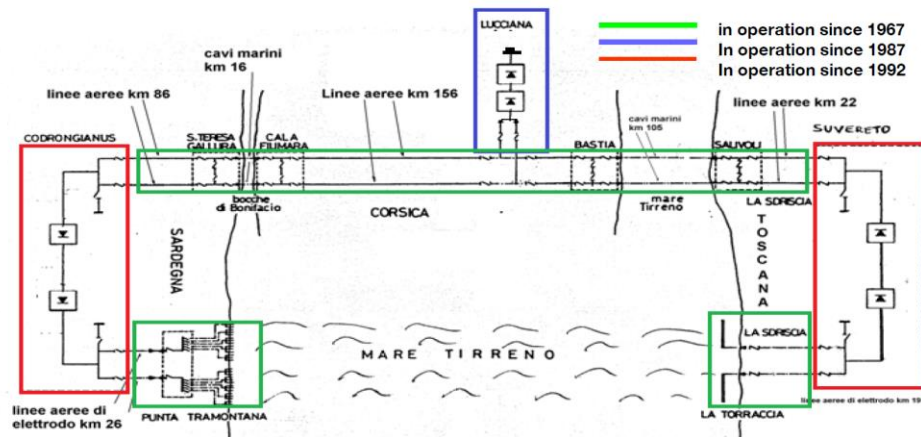
1992

Commissioning of new connection 200 kVdc - 300 MW called SACOI 2 obtained through the renovation of the two principal converter stations adopting the new technology of thyristor

2001

2009 2010

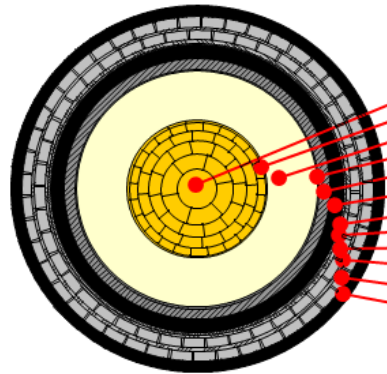
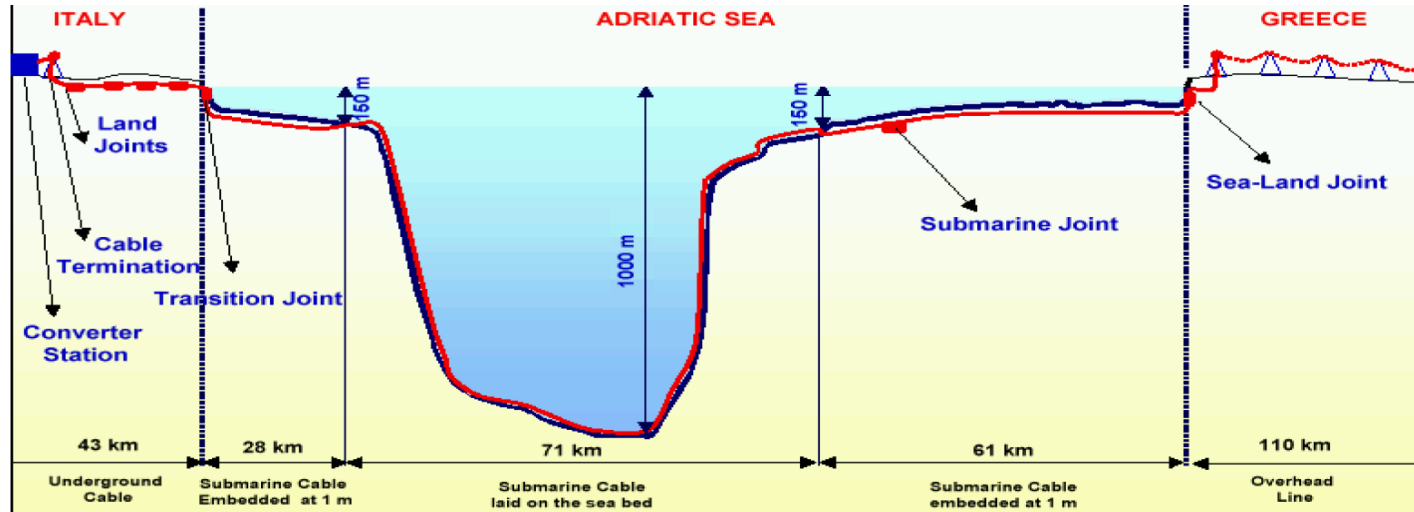
SACOI



- Monopolar triterminal (3 Converter Station)
- Rated Power 300 MW
- Dc Voltage ± 200 kVcc
- Rated Current 1500 A
- Total length of the link 385 km (121 km marine cable + 264 km OHL)

TERNA Operational Experience

GRITA



1. Conduttore in rame
2. Strato semiconduttivo
3. Isolamento
4. Schermo
5. Guaina in lega di piombo
6. Guaina in PE
7. Nastro in acciaio di rinforzo
8. Copertura in poliestere
9. Prima armatura (fili acciaio)
10. Copertura in polipropilene
11. Seconda armatura (fili acciaio)
12. Guaina in polipropilene

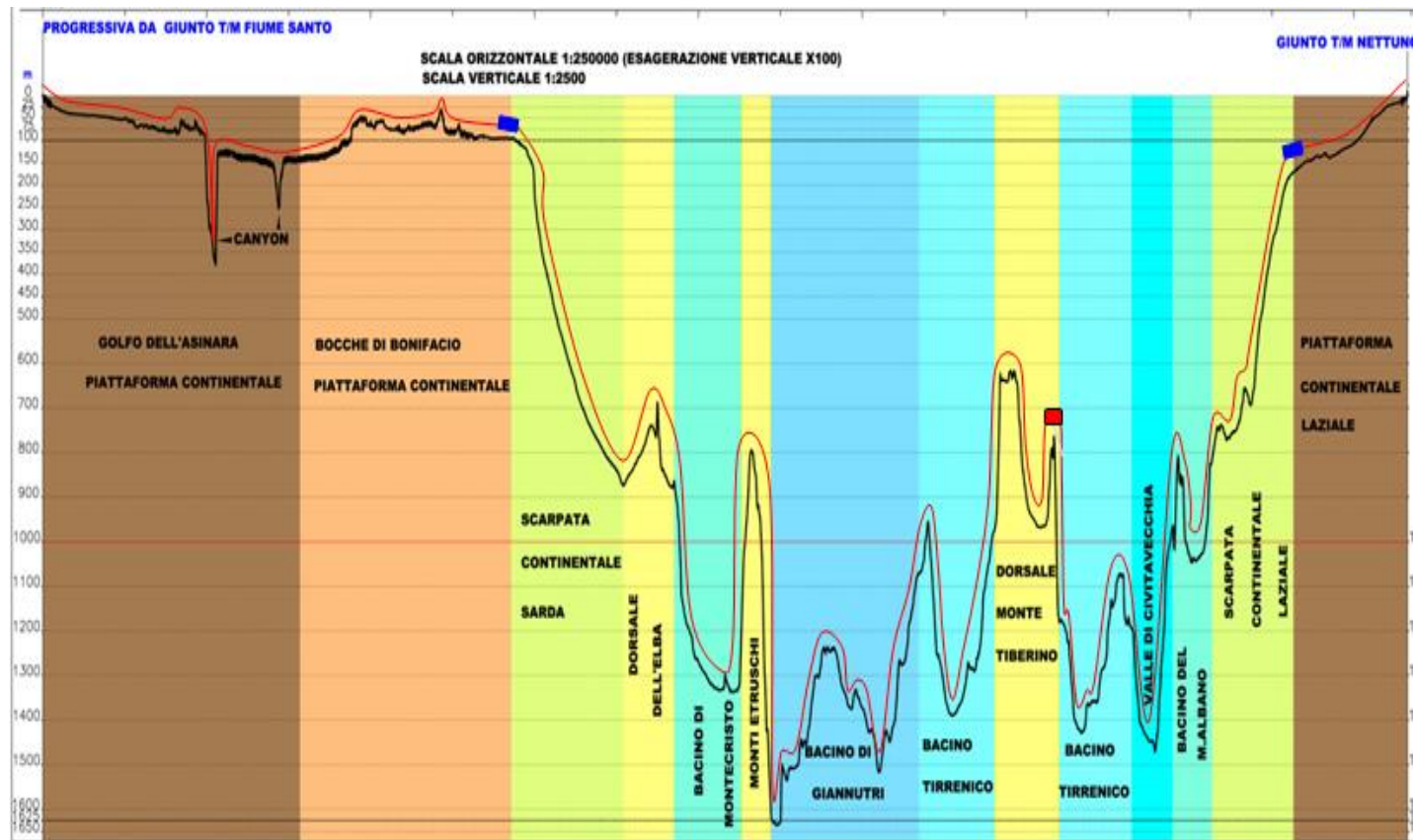
	MARINE
Nominal Voltage [kV]	400
Nominal Current [A]	1250
Maximum depth [m]	1000
Insulation Type	MIND
Cable Section [mm ²]	Cu 1250

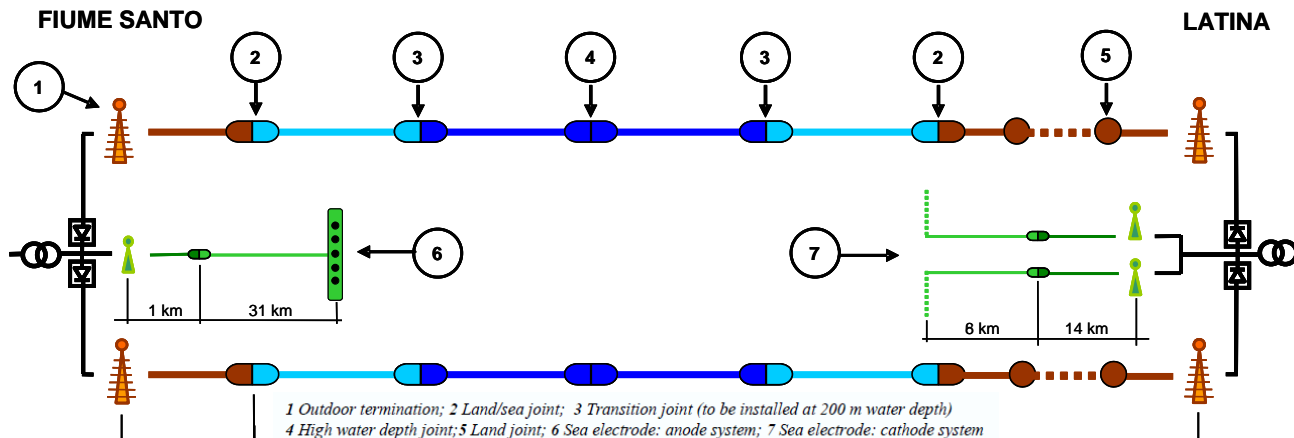
Manufacturer: Pirelli (Italy)

[Return of experience on sea cables :](#)
At now good experience on sea cables

TERNA Experience

N. Poles: 2 @ ± 500 kV DC
Rated Current: 1000 A
Rated Power: 1000 MW





1 Outdoor termination; 2 Land/sea joint; 3 Transition joint (to be installed at 200 m water depth)
4 High water depth joint; 5 Land joint; 6 Sea electrode: anode system; 7 Sea electrode: cathode system

	Terrestrial cable	Cable for Medium-shallow water	Cable for deep water		Cable for Medium-shallow water	Terrestrial cable
Conductor	Copper	Copper	Aluminum	Aluminum	Copper	Copper
Section (mm) ²	1400	1000	1150	1150	1000	1400
Length (km)	~ 1	~ 150	~150	~85	~40	~14
Max depth (m)	---	400	1620	1400	200	---

Return of experience on sea cables : only 1 minor failure experimented due to not correct installation

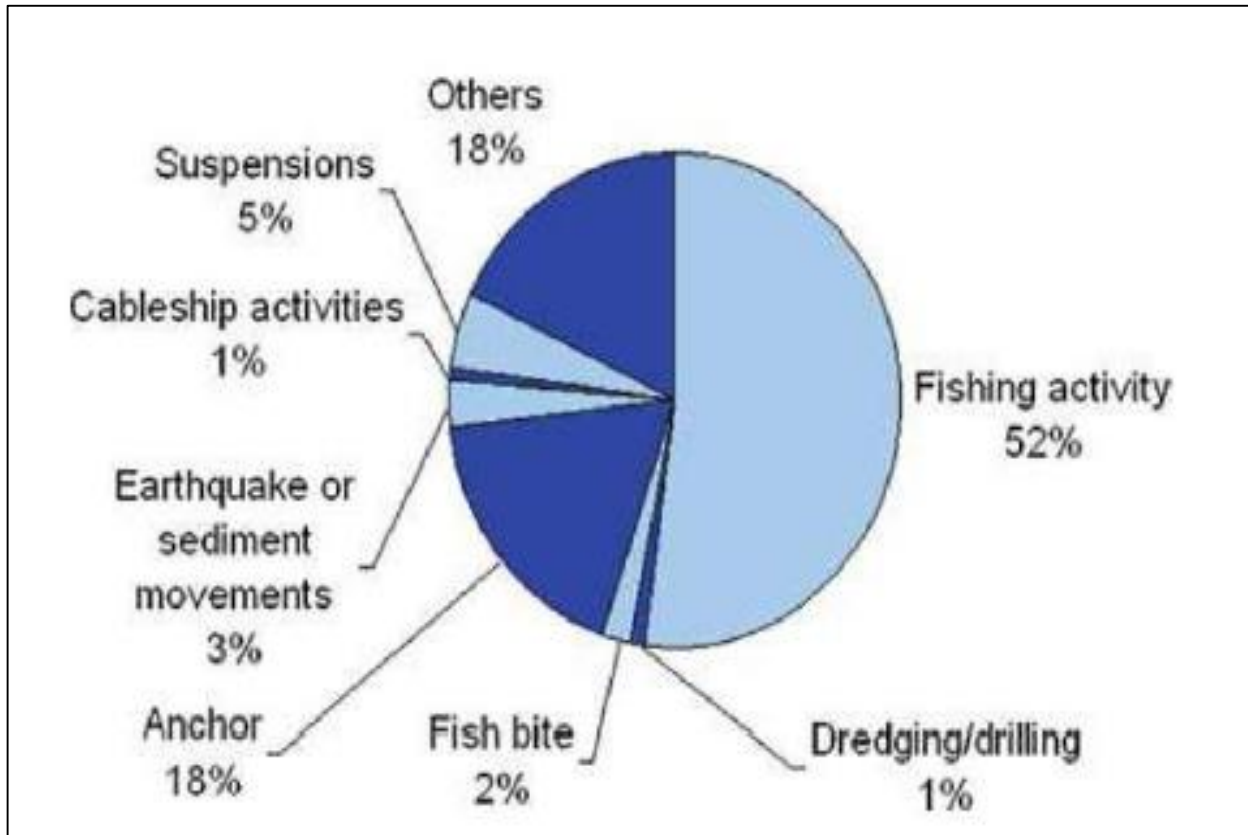
At now good experience on sea cables

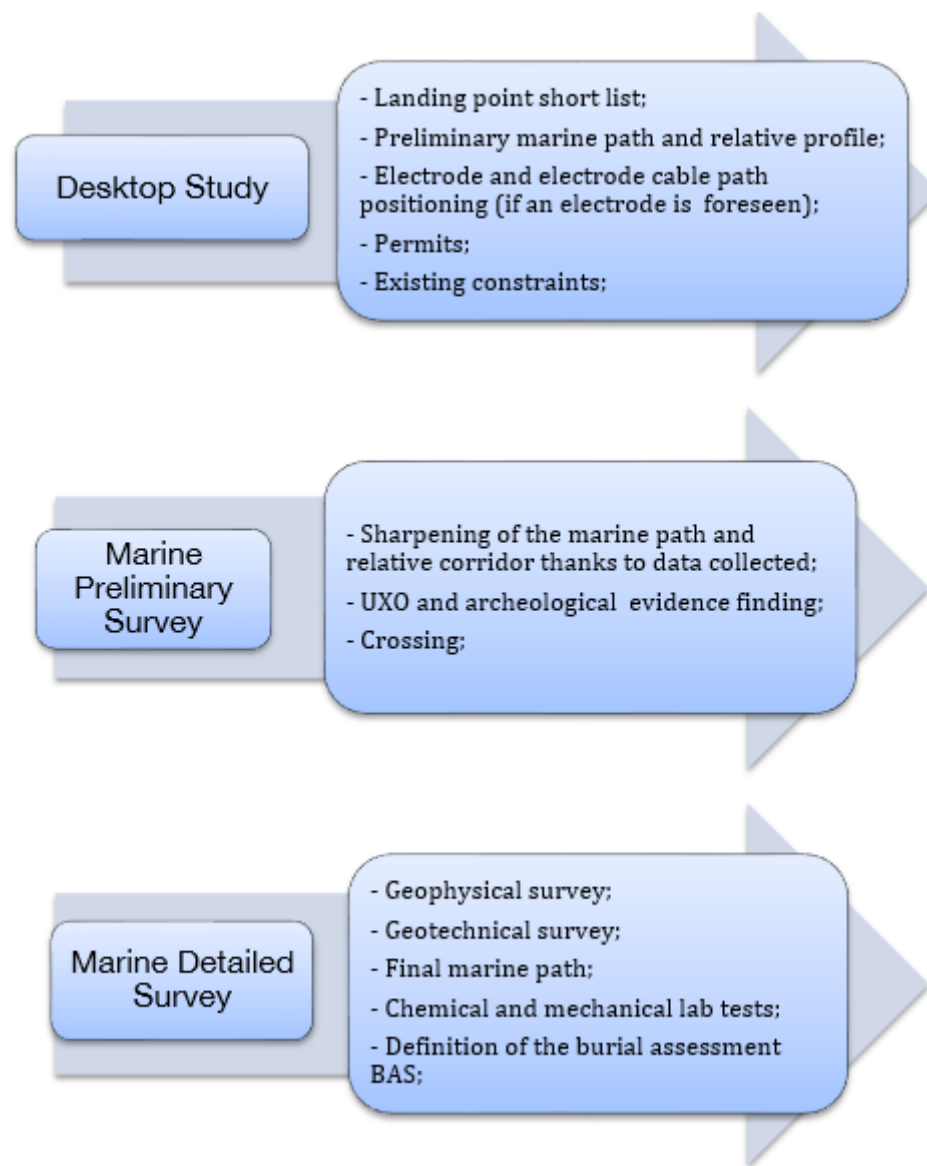


Cable for medium-shallow water
Manufacturers Prysmian, Nexans



Cable for deep water – Manufacturer Prysmian





Cable Vessels

The cable vessels today can transport up to 7,500 t of cable in a single campaign pose and have a pulling lay capacity up to 70 ton. Up to now a few cable ships are able to install HV cables at high depth: reason that influences the market and is a critical factor in logistics projects submarine links.

Giulio Verne (Prysmian)

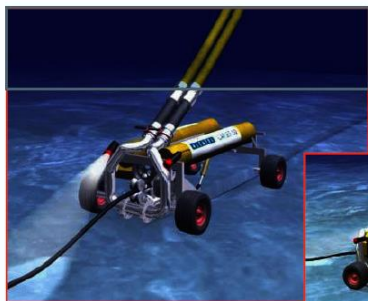
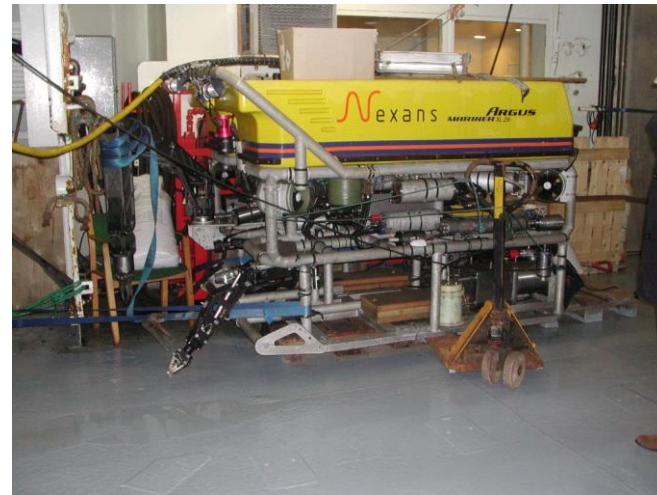


Skagerrak (Nexans)



Lewek Connector (EMAS)

Not only on surface but also in the deep ROV : Remotely Operated Vehicle



Qualification Test on marine cables TERNA Experiences

TESTING EXPERIENCES ON MARINE CABLES

Tests on submarine cable system

Submarine cable system is usually part of special projects:

- special tests procedures need to be followed;
- taking into account the peculiarities (different cross sections, different water depths etc.), the test shall be performed for each project (i.e. SAPEI, MONITA, CaprITA etc.);

Test procedures:

- **Mechanical tests** (Electra 171(y1997):
e.g. Tensile bending test;
- **Electrical test**
e.g. on MIND Cable
Electra 189 test + Terna Test
- **Additional test**
e.g. Short circuit withstand test
on earthing connection
- **Sea Trial Test**
- **After installation test**
e.g. on MIND Cable
Voltage test (Electra 189 - 1,4U_o
DC negative polarity for 15 min);



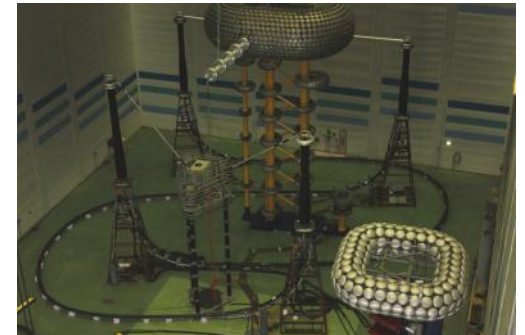
Sea trial test of protection facilities



Sea trial test of laying facilities



Tensile bending test configuration



Type test circuit