Design and Testing of Equipment for Deep Sea Research

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Saclant Undersea Research Centre

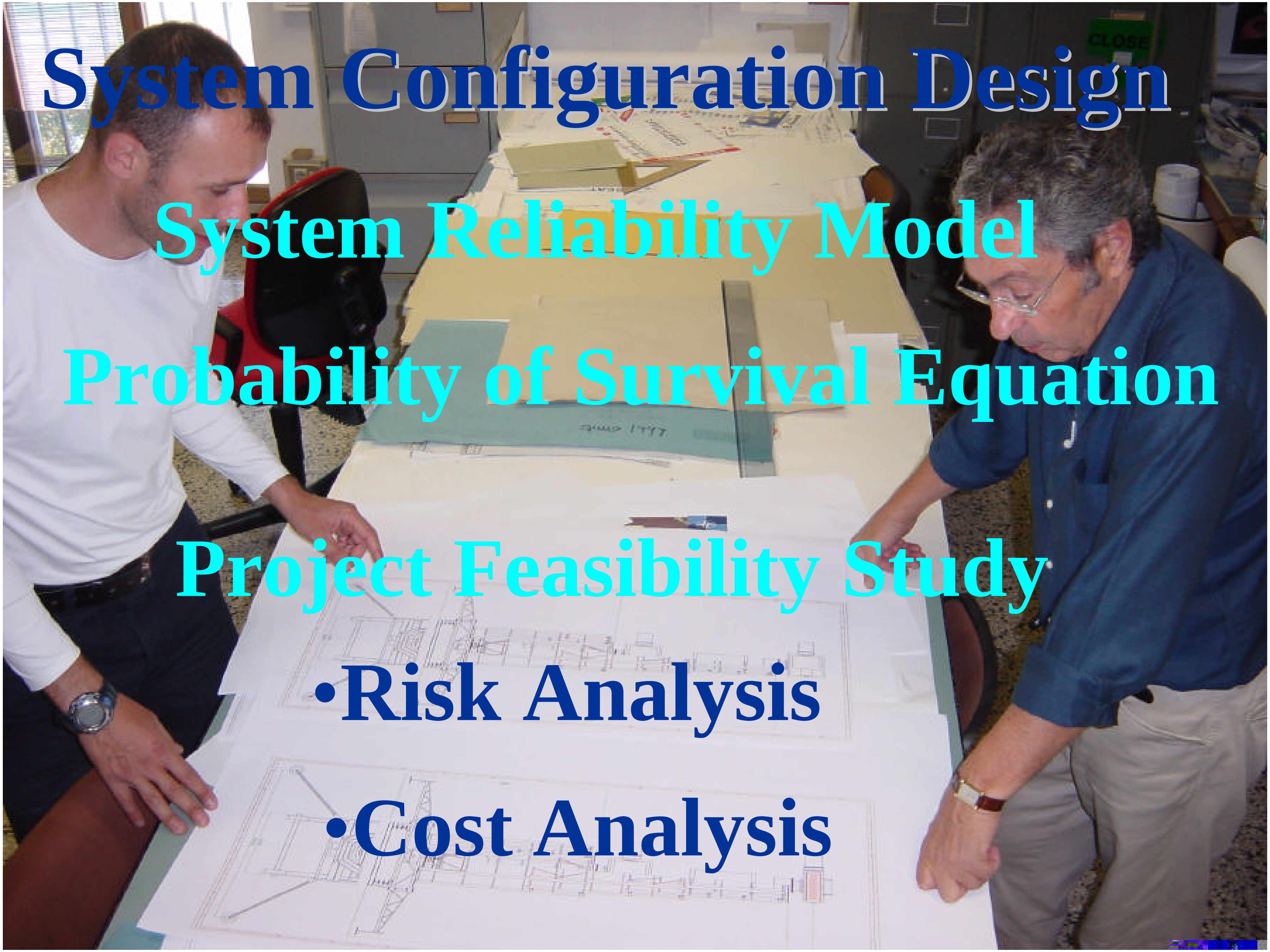
La Spezia

A working team since 1959

- **Synergy created by changing influx of scientists, engineers and naval officers**
- **On the leading edge in underwater acoustics, oceanography, signal processing and ocean engineering**
- **Charter for applying science to NATO maritime operational requirements since 1959**

Design and Feasibility Phase

- **Mission Definition**
- **Mitigate the complexity of a system by dividing it into component problems more susceptible to a ready in house solution**
- **Mission Environment**
  - **Vessel sea-keeping**
  - **Vessel’s deployment and recovery facilities**
  - **Working area characteristics**



System Configuration Design

System Reliability Model

Probability of Survival Equation

Project Feasibility Study

- **Risk Analysis**
- **Cost Analysis**

Typical Design Procedure

- **Input Constraints:**

logistics, budget, deadline, space, weight

- **Component's Data Base:**

-feed-back type (operational performance):
failure rate

-analysis type (quality control check list)
figure of merit

- **Evaluation Software:**

quality assurance, operations, reliability, maintenance, availability, cost analysis

Component Status

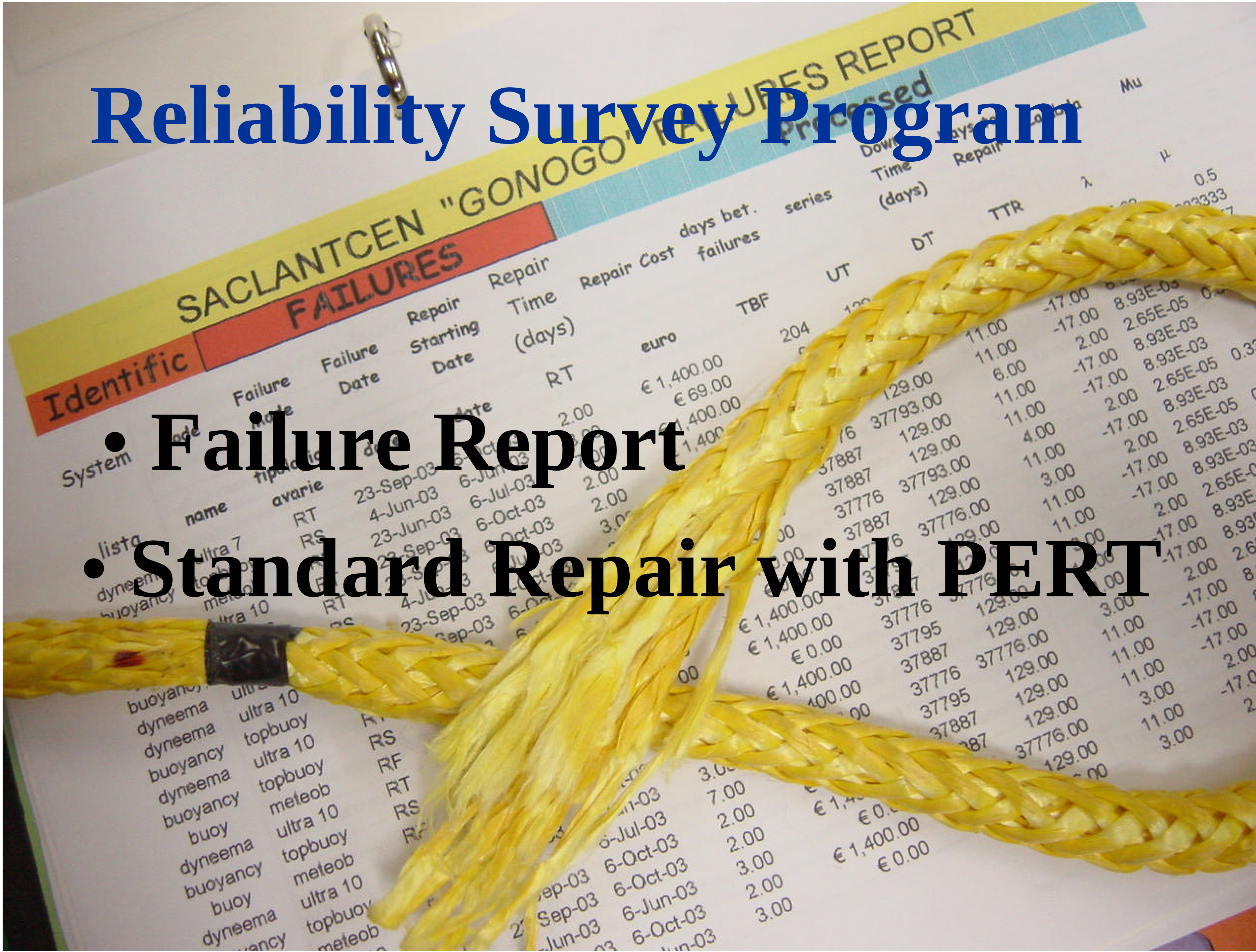
QA Status
Reliability Trend
Maintenance Status
Logistic Needs
Cost Evaluation

Quality Assurance

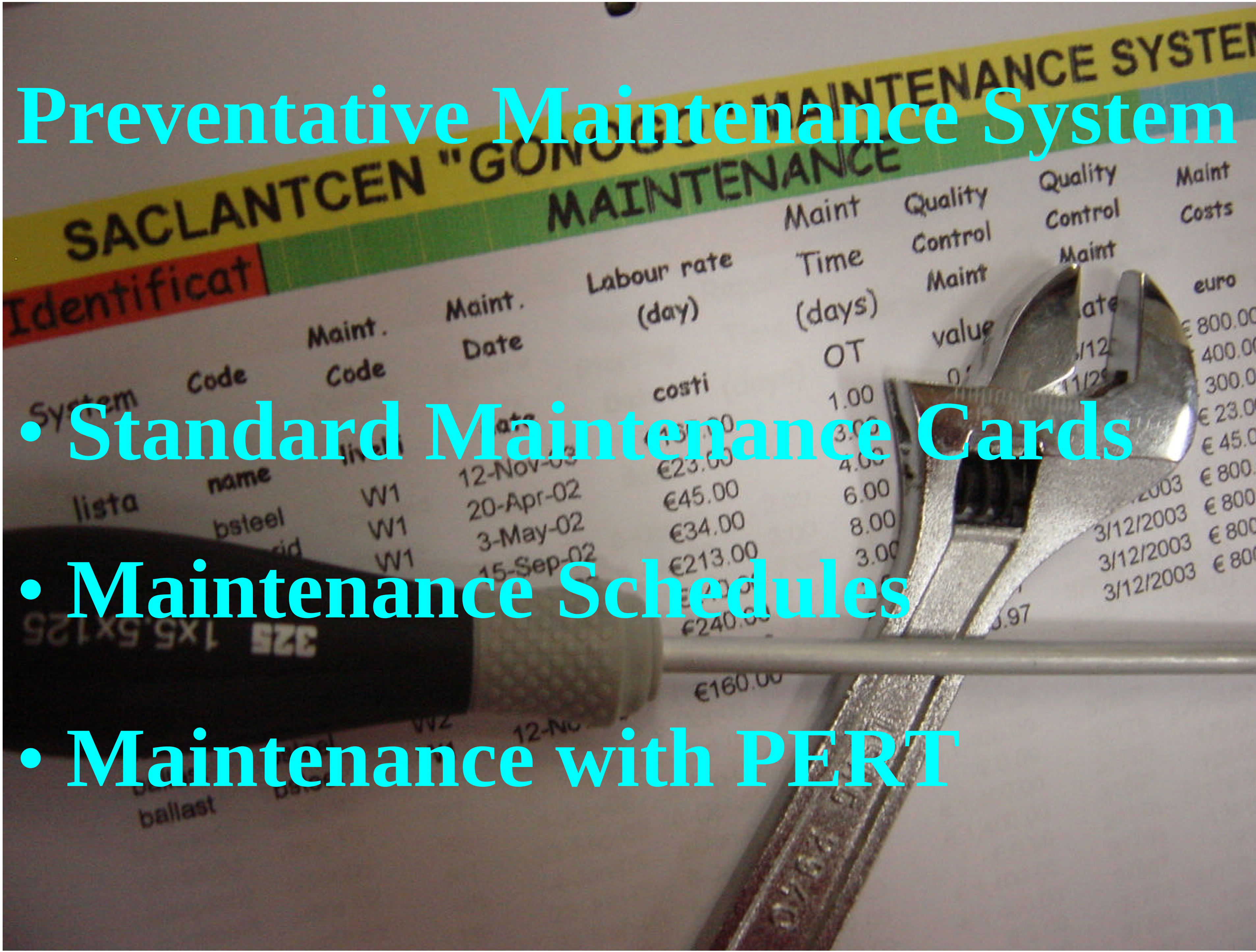
- Standard Check-List
- Figure of Merit
- Periodical Survey
- Systems Reliability Calculations

Reliability Survey Program

- Failure Report
- Standard Repair with PERT



Preventative Maintenance System

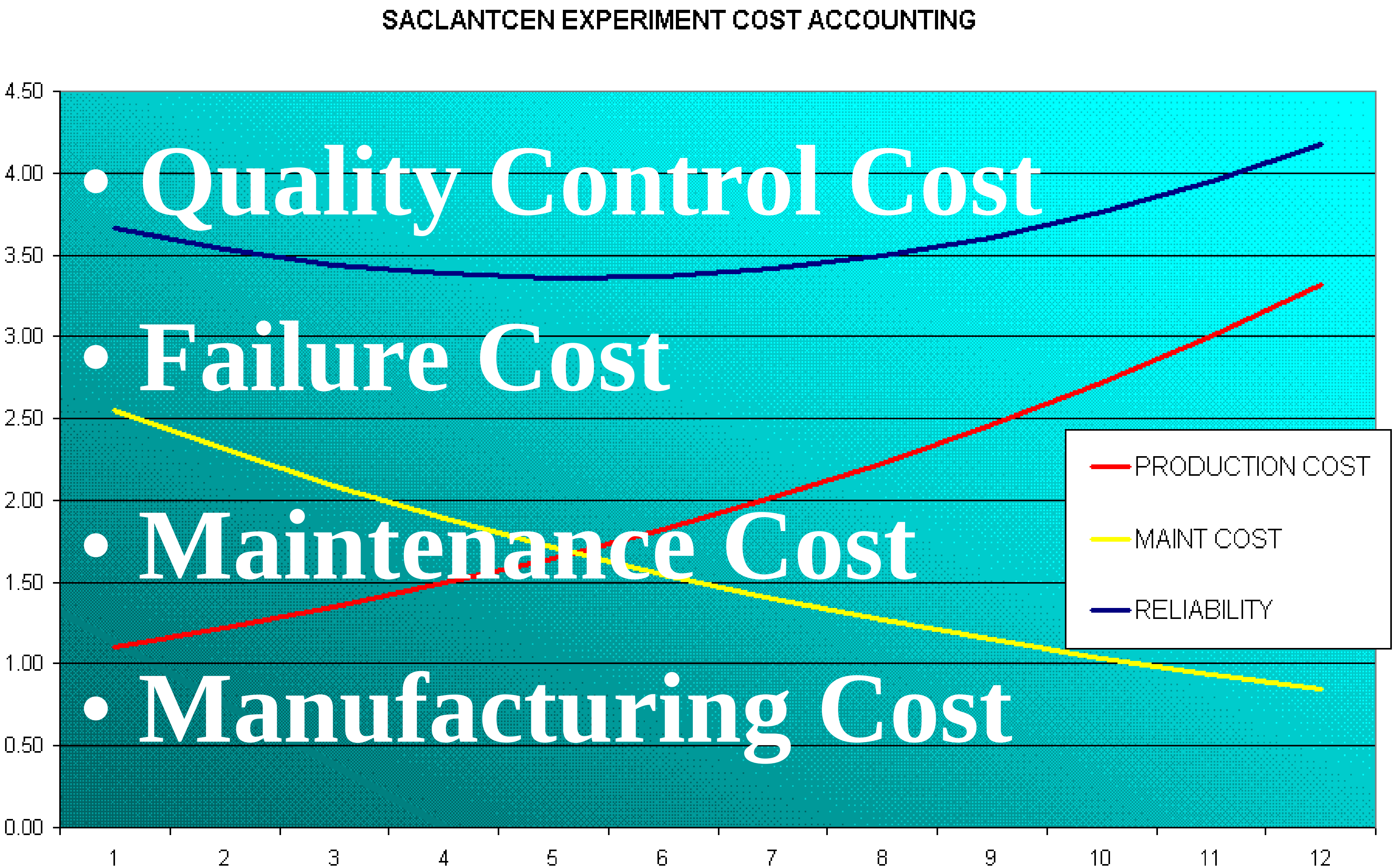


- Standard Maintenance Cards
- Maintenance Schedules
- Maintenance with PERT

Availability and Logistic Cycle

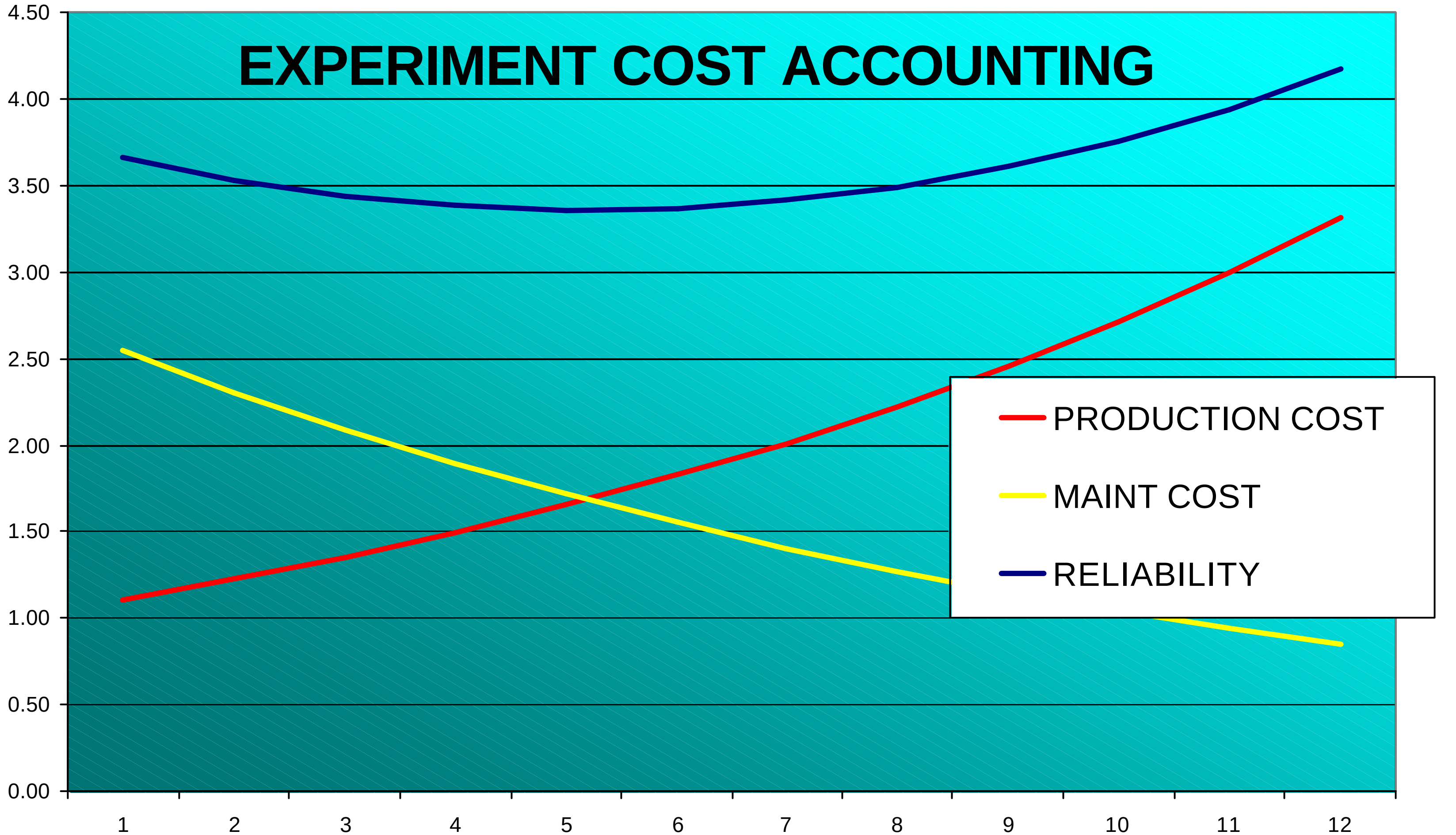
- **Optimum Redundancies Under Various Constraints**
- **Optimum Spare Parts Policy**
- **Standard Repair and Maintenance Kits**

System’s Cost Survey



- Quality Control Cost
- Failure Cost
- Maintenance Cost
- Manufacturing Cost

Reliability vs. Cost



Simulation Models

- **Quantitative prediction of performances**
- **Analysis of survival in extreme working conditions**
- **Analysis of congruence in any operational phase (deployment and retrieval)**
- **costs associated to a failure in deep mooring operations are much higher than the ones in shallow waters**

Lab Facilities

- Pressure Tanks
- Cable Test Machine
- Climatic chamber for accelerated life test
- CTD calibration tank
- Acoustic Calibration lab
- Resin lab for cable and boards molding
- Towing Tank (Trieste University)

Pressure Test Chamber

Inner Diam. 400 mm

Height   1800 mm

Max. Depth 6000 m

External connectors:

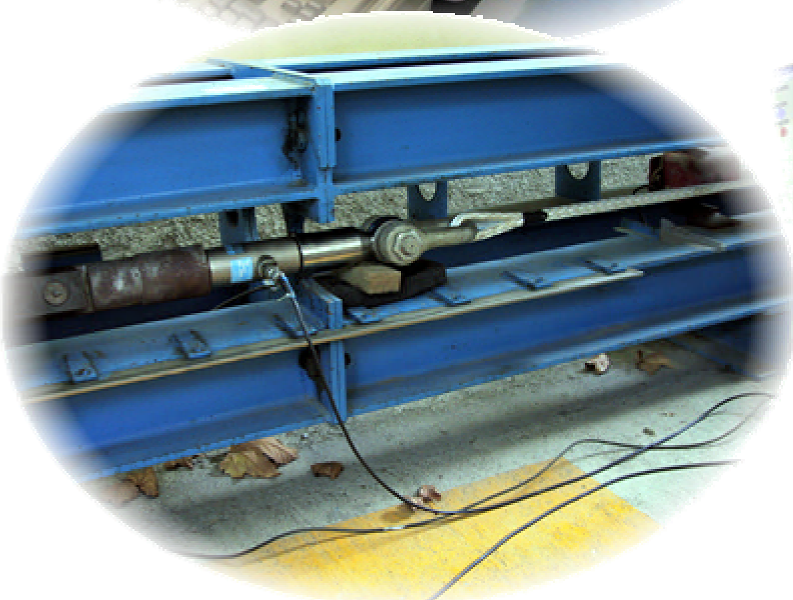
Sourieau 6 pins

Sourieau 12 pins

A set of connectors allows dynamic test inside the chamber:
u/w winch rotating at the working depth
deep water switch operated 1000 times at its working depth

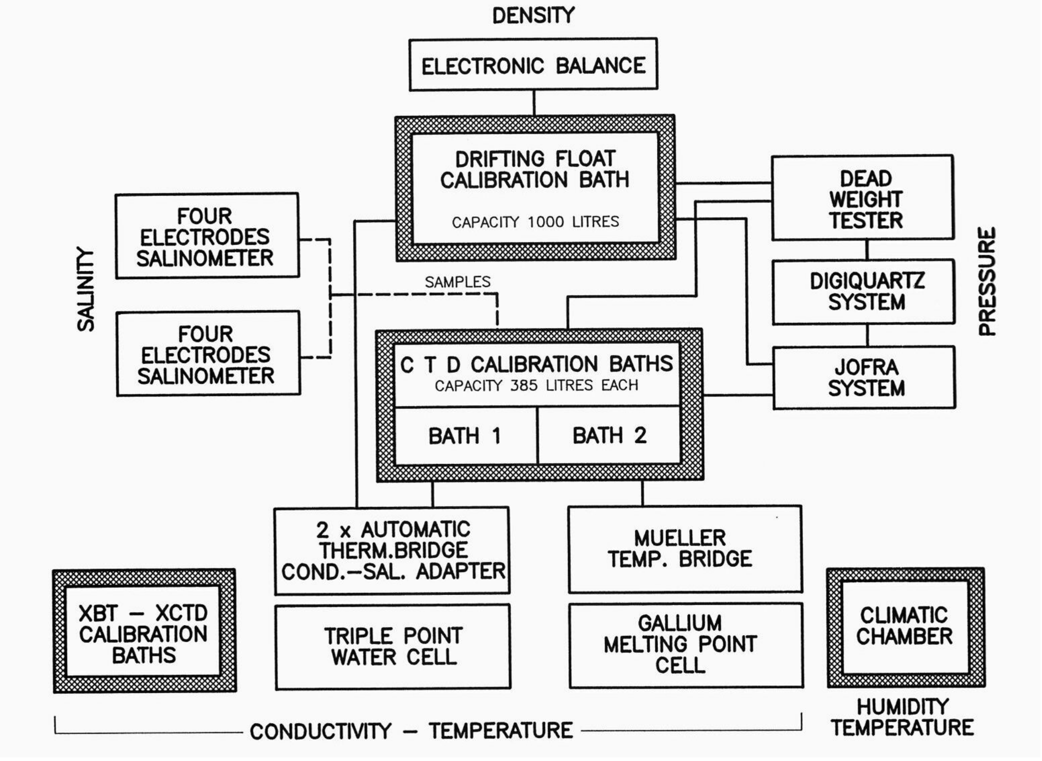
Cable Test Machine

20 m. sample @ 50 T
Tensile test
Elongation test
Fatigue Test



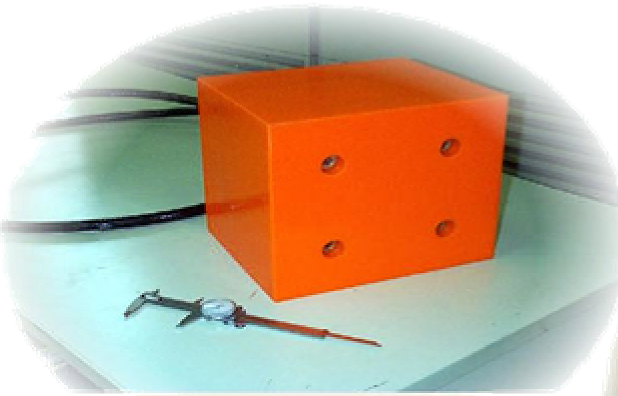
Oceanographic Calibration Facilities
WOCE Standard

- » Thermally controlled salt water baths
- » Fully automated data acquisition
- » Evaluation of secondary effects on sensors

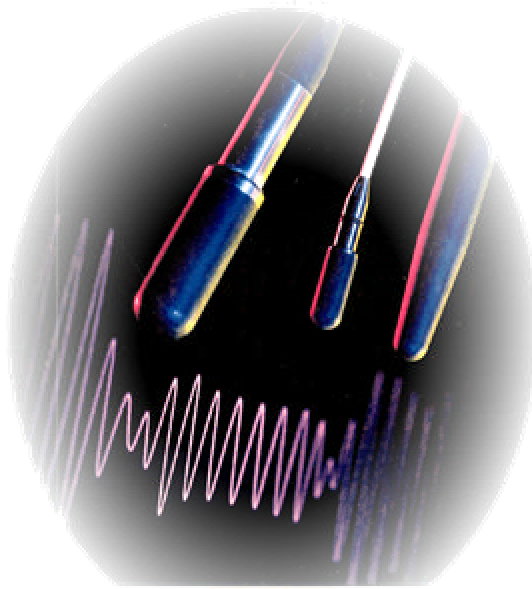


- » Service to Saclantcen
- » NATO Nation Navies&Research Communities
- » “Partnership for peace” Countries

Acoustic Calibration Tanks



MRAD 15 kHz, 4-stave



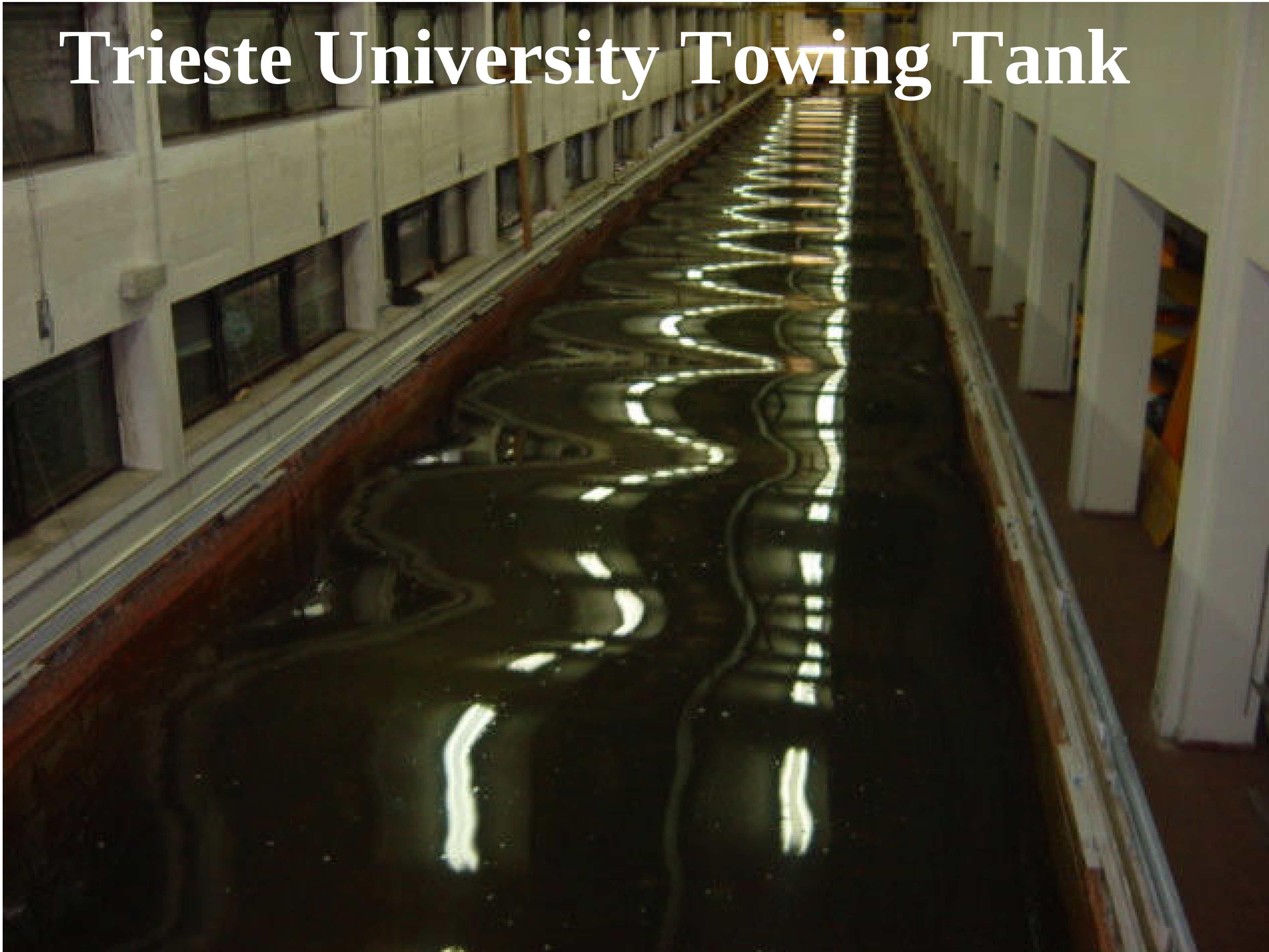
hone types (from left

Figure 1 The acoustic calibration tank

Connectors Molding Lab

Customized Molded Parts

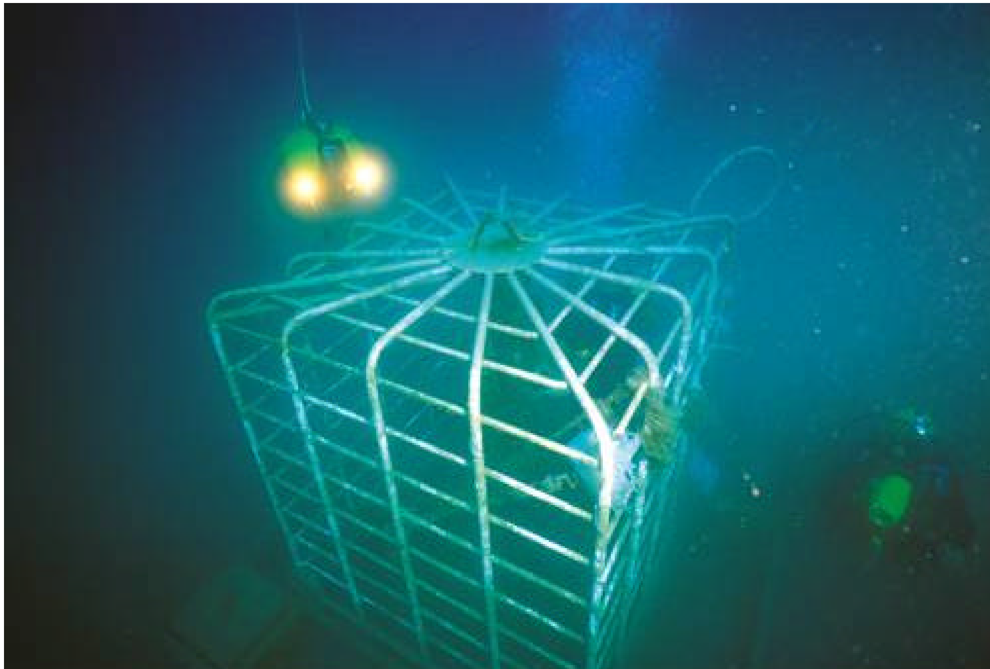
Trieste University Towing Tank



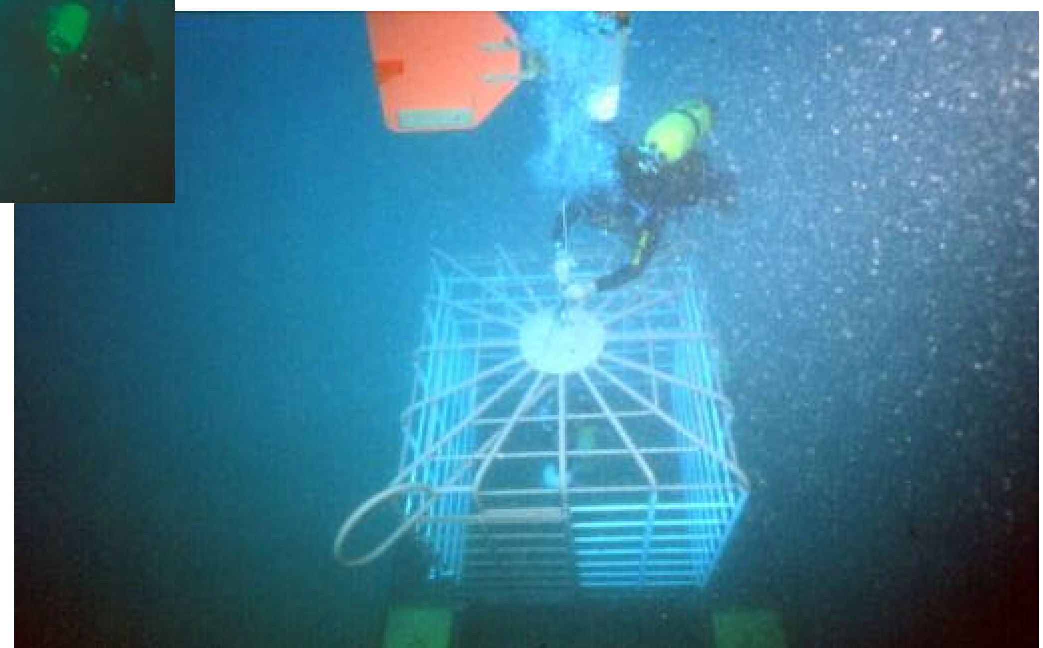
Test Sites

- **Elba Marciana Marina**
- **Monesteroli Corrosion Test (Cinque Terre)**

Monesteroli Corrosion Test (Cinque Terre)



Underwater Site for direct endurance testing of alloys



Components of various alloys compatibility test

Elba Island

Marciana Marina

A shore lab for engineering test of underwater scientific instrumentation and real time data collection

BARNY Sentinel
Launch procedure

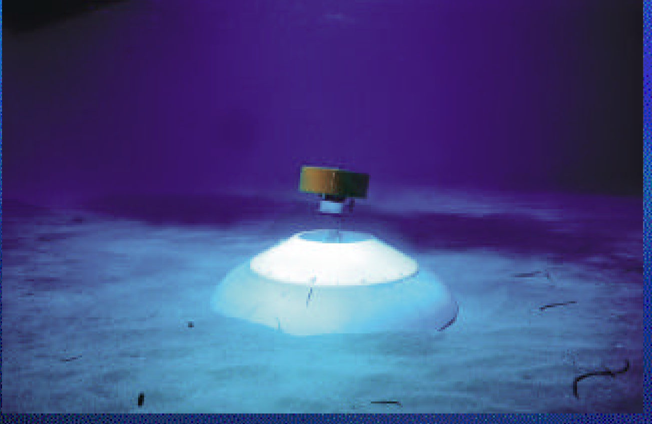
The unit is lowered by electromechanical cable. Through the cable, real-time information regarding instrument pitch, roll, and depth is passed from the sending unit (white cylinder near the ADCP transducers) to a PC-based display on the ship. Once satisfactory placement on the bottom is confirmed, the external release is activated and is retrieved together with the sending unit.

Barny Sentinel

Depth
Inclination
monitored

Positioned
on
the bottom

Instrument
pop-up
with
recovery
rope



Emergency
recovery

ballast
release

Barny Sentinel

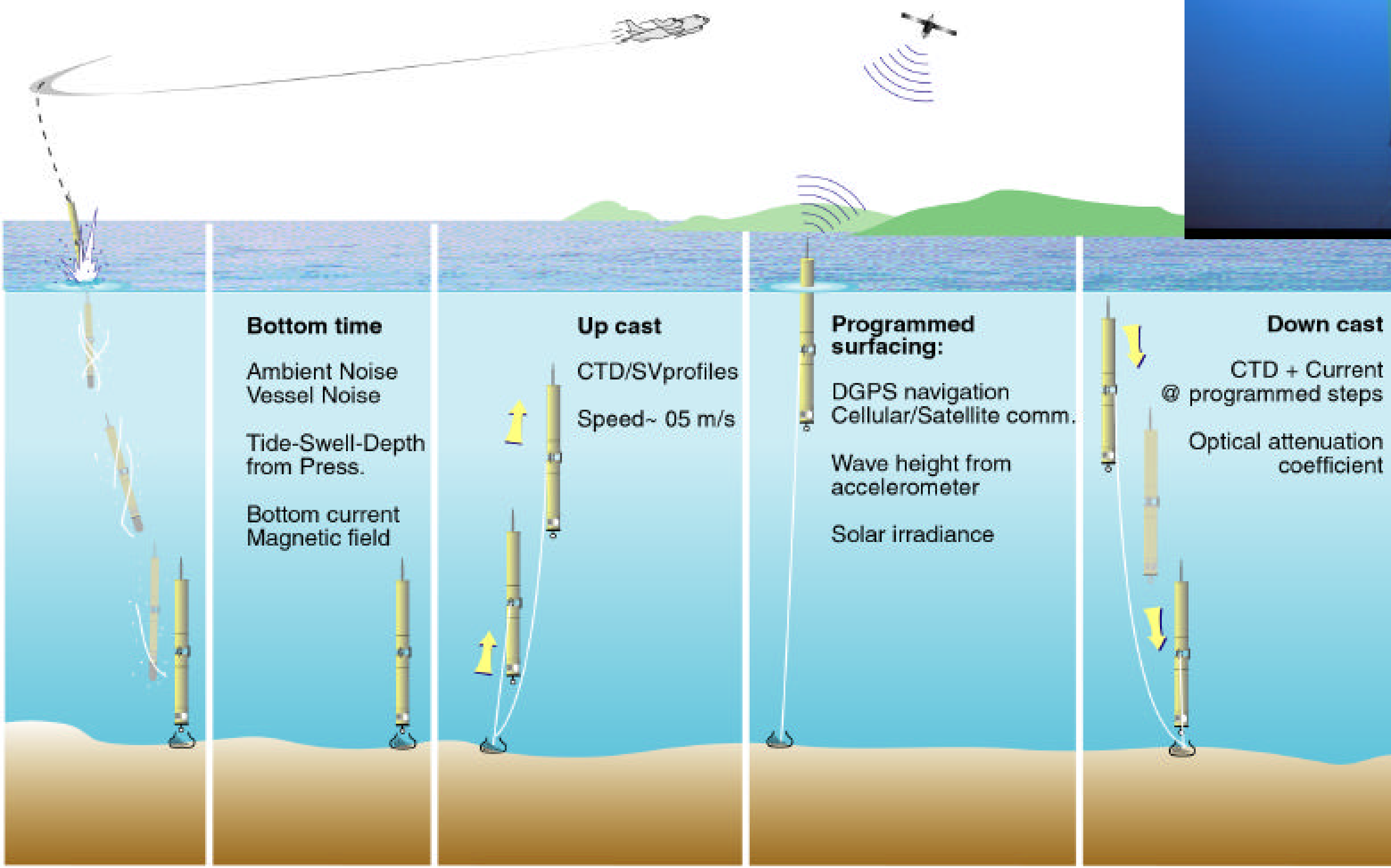
Platform overturned

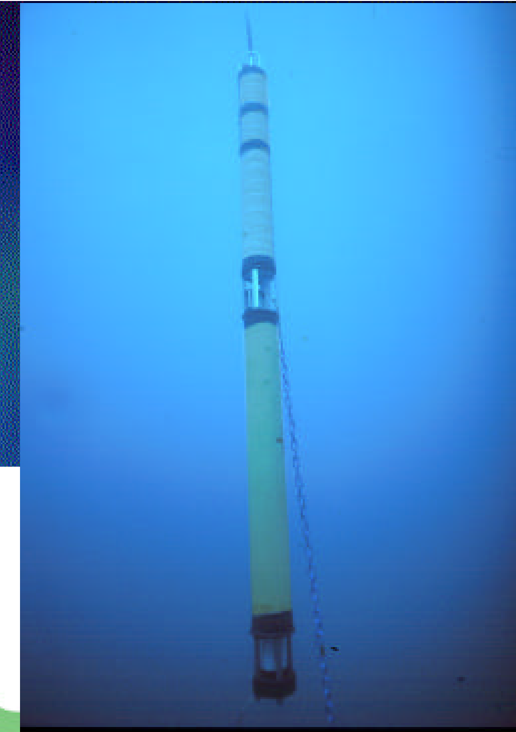
Recovery allowed

Lesson Learned from Barny Sentinel

- Bottom lay-out monitoring system proved to be a vital tool for deployment
- A life time for individual components was assessed and new investments oriented
- Redundancy for overturned unit recovery was a successful design criteria
- Anti-collision design was a vital feature

SWEEP

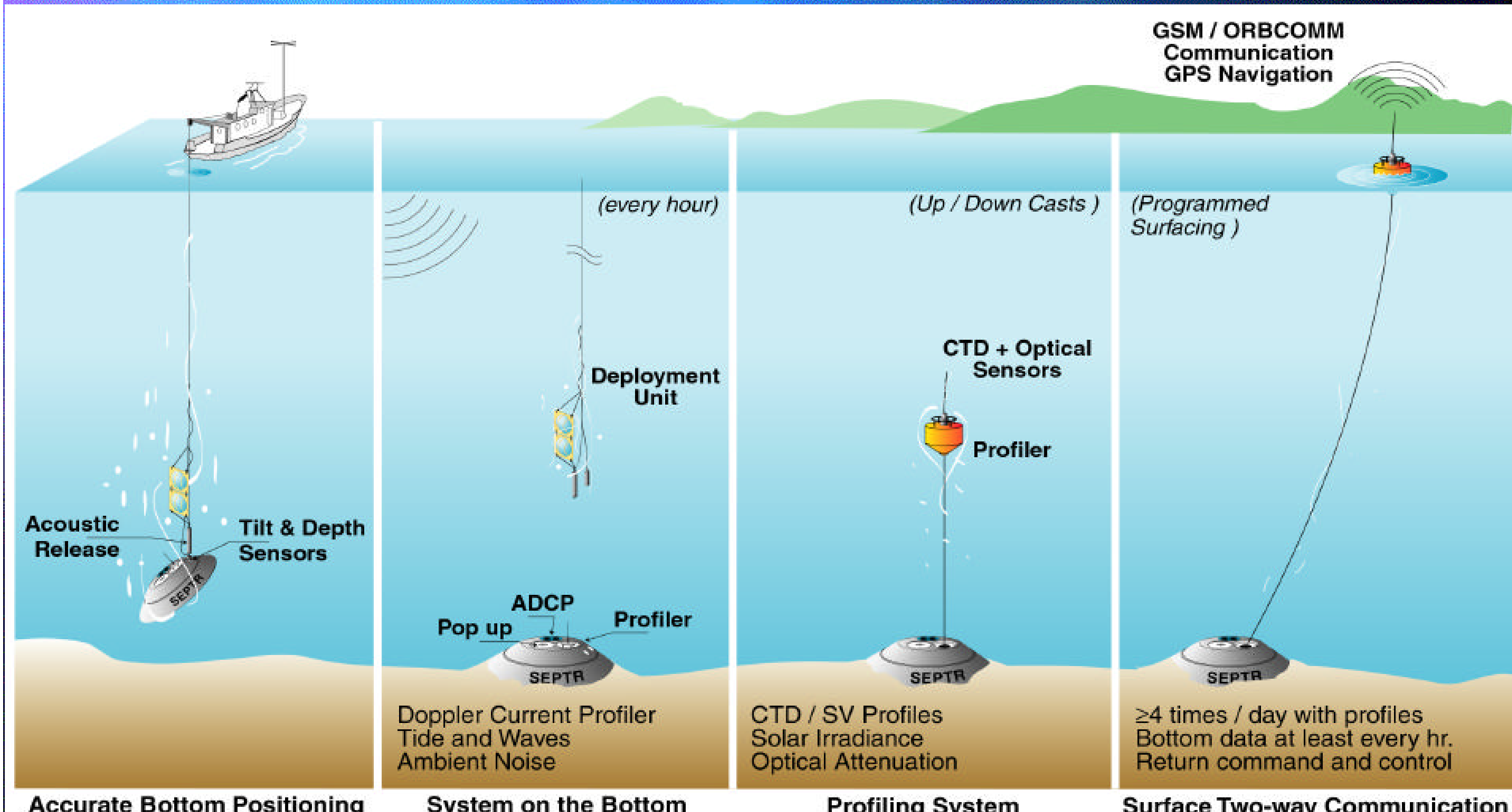

Bottom time
Ambient Noise
Vessel Noise
Tide-Swell-Depth
from Press.
Bottom current
Magnetic field
Up cast
CTD/SVprofiles
Speed~ 05 m/s
Programmed
surfacing:
DGPS navigation
Cellular/Satellite comm.
Wave height from
accelerometer
Solar irradiance
Down cast
CTD + Current
@ programmed steps
Optical attenuation
coefficient



Lesson learned from SWEEP

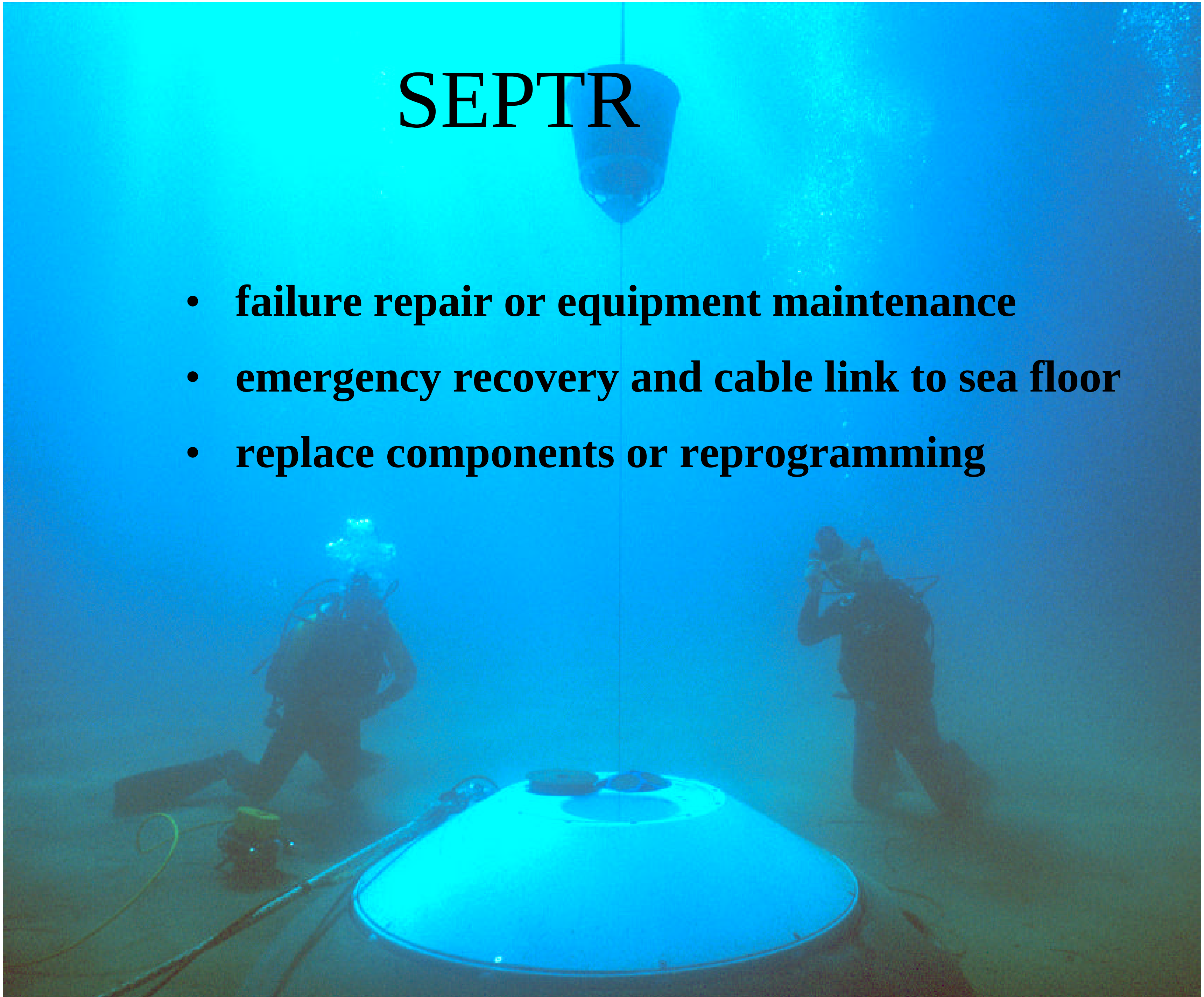
- Winch on board the vehicle fitted with a good spooling gear represents a viable technique
- Spar buoy shape of the vehicle is very stable in waves ensuring a reliable data link to satellite
- SWEEP has a very high performance investment ratio

SEPTR

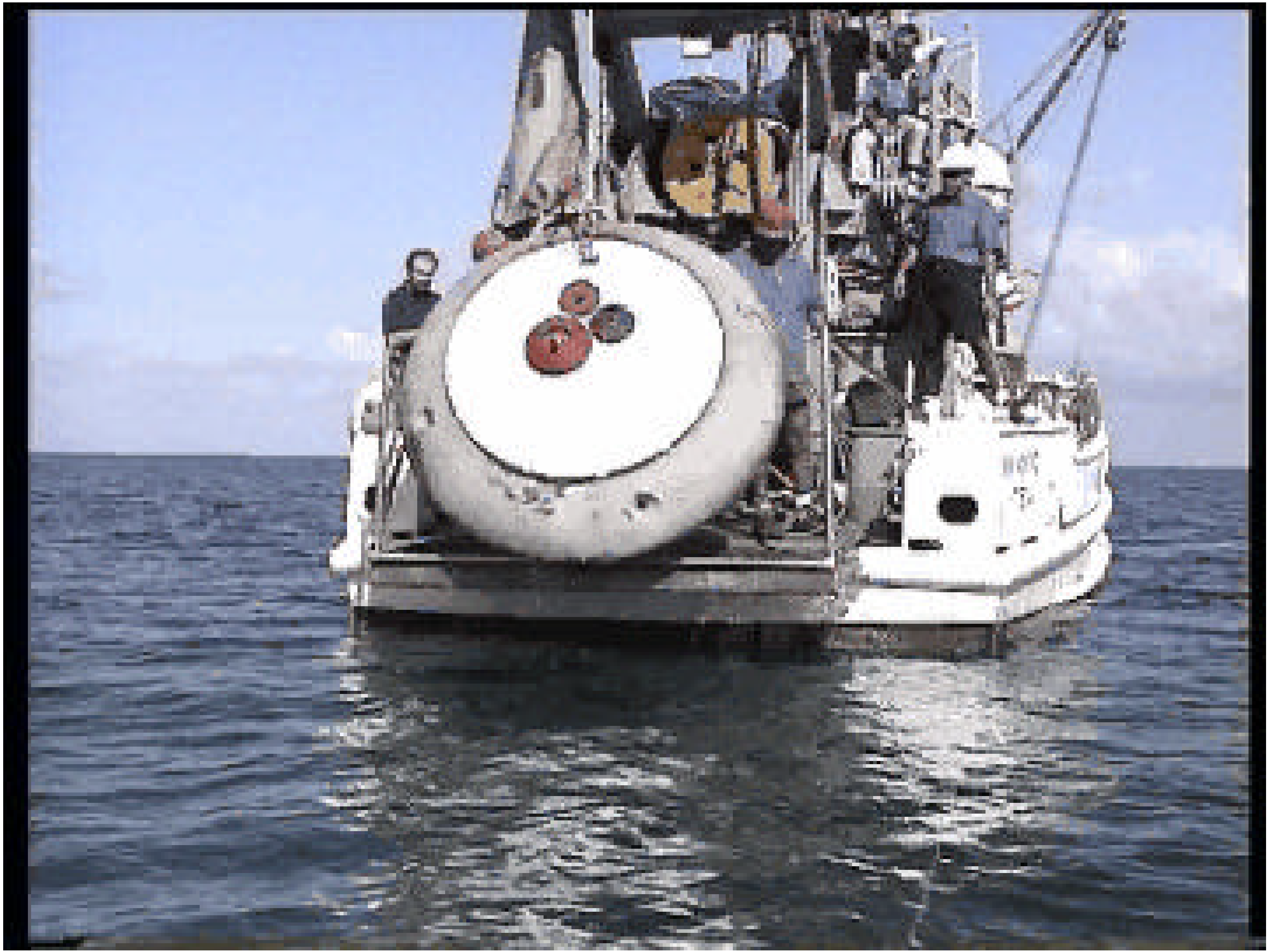

GSM / ORBCOMM
Communication
GPS Navigation
(every hour)
(Up / Down Casts)
(Programmed
Surfacing)
CTD + Optical
Sensors
Deployment
Unit
Profiler
Acoustic
Release
Tilt & Depth
Sensors
ADCP
Pop up
Profiler
Doppler Current Profiler
Tide and Waves
Ambient Noise
CTD / SV Profiles
Solar Irradiance
Optical Attenuation
≥4 times / day with profiles
Bottom data at least every hr.
Return command and control
Accurate Bottom Positioning
System on the Bottom
Profiling System
Surface Two-way Communication

SEPTR

- **failure repair or equipment maintenance**
- **emergency recovery and cable link to sea floor**
- **replace components or reprogramming**



SEPTR in Operation



Lesson Learned from SEPTR

- Also a bottom unit mounted winch demonstrated good performances
- HDPE profiler's rope had no failures
- Pop-Up recovery technique is reliable
- ROV emergency recovery was successfully tested
- Aluminum alloy must be abandoned when endurance is required

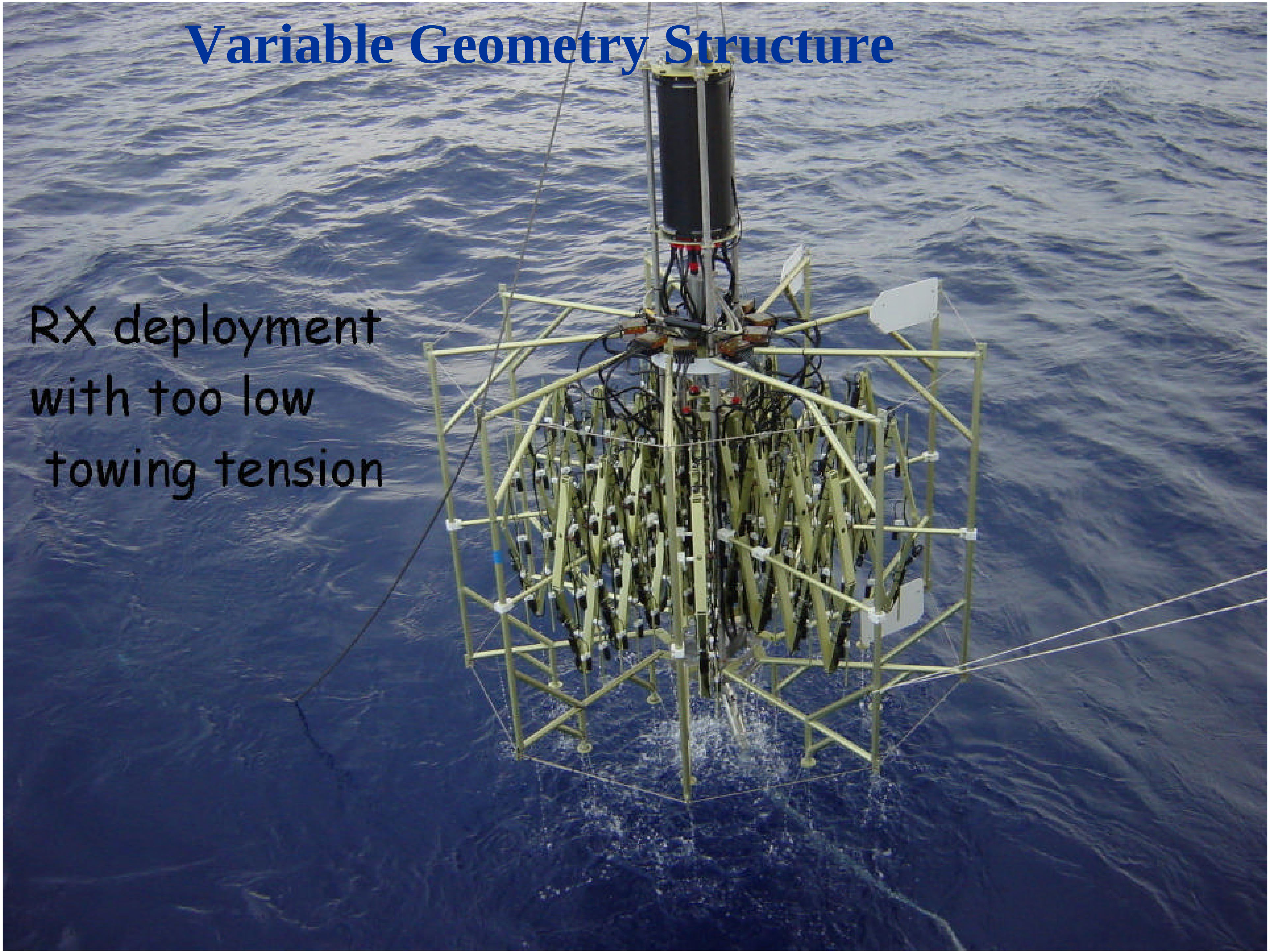
Underwater Rail
Underwater lab for in-situ acoustic calibration

using rail screwed to the bottom as opposed to traditional steel ballast offers the following advantages:

- very precise positioning on the seafloor
- keeps mutual distances between close moorings very precise
- it can be used to obtain an easier underwater connection

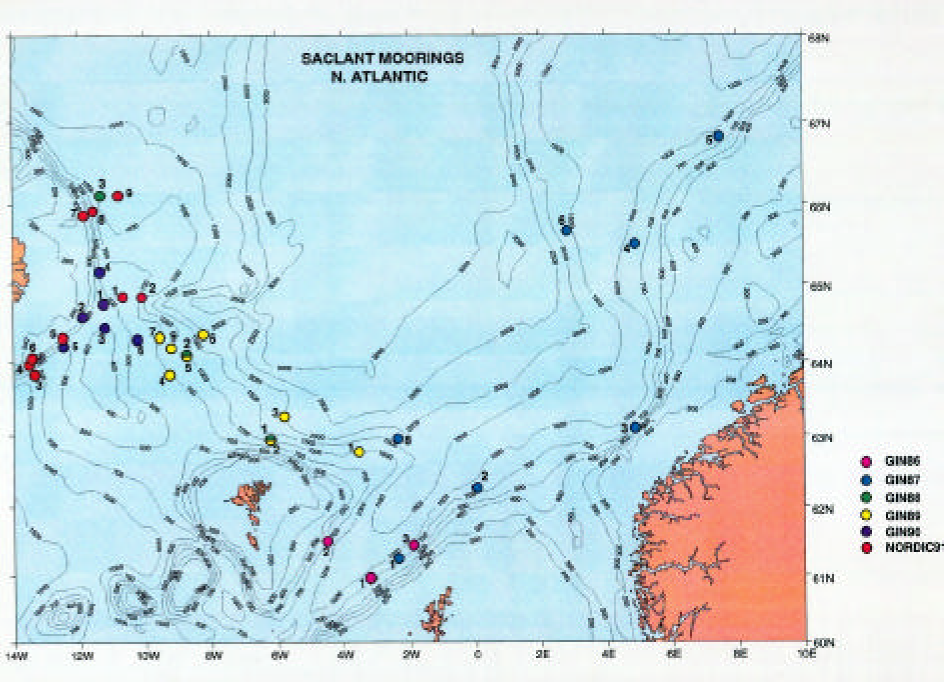
Underwater Rail for in-situ acoustic calibration

- **Although made with the help of divers in shallow waters, the rail-tower assembly is designed for an easy and quick procedure**

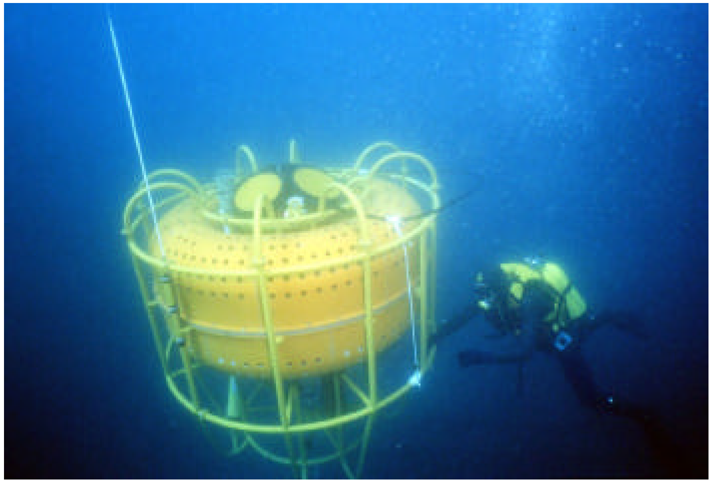

Variable Geometry Structure
RX deployment
with too low
towing tension

The GIN sea period: 86-91

Development of buoy & mooring technology for long -term sea deployments in severe weather conditions

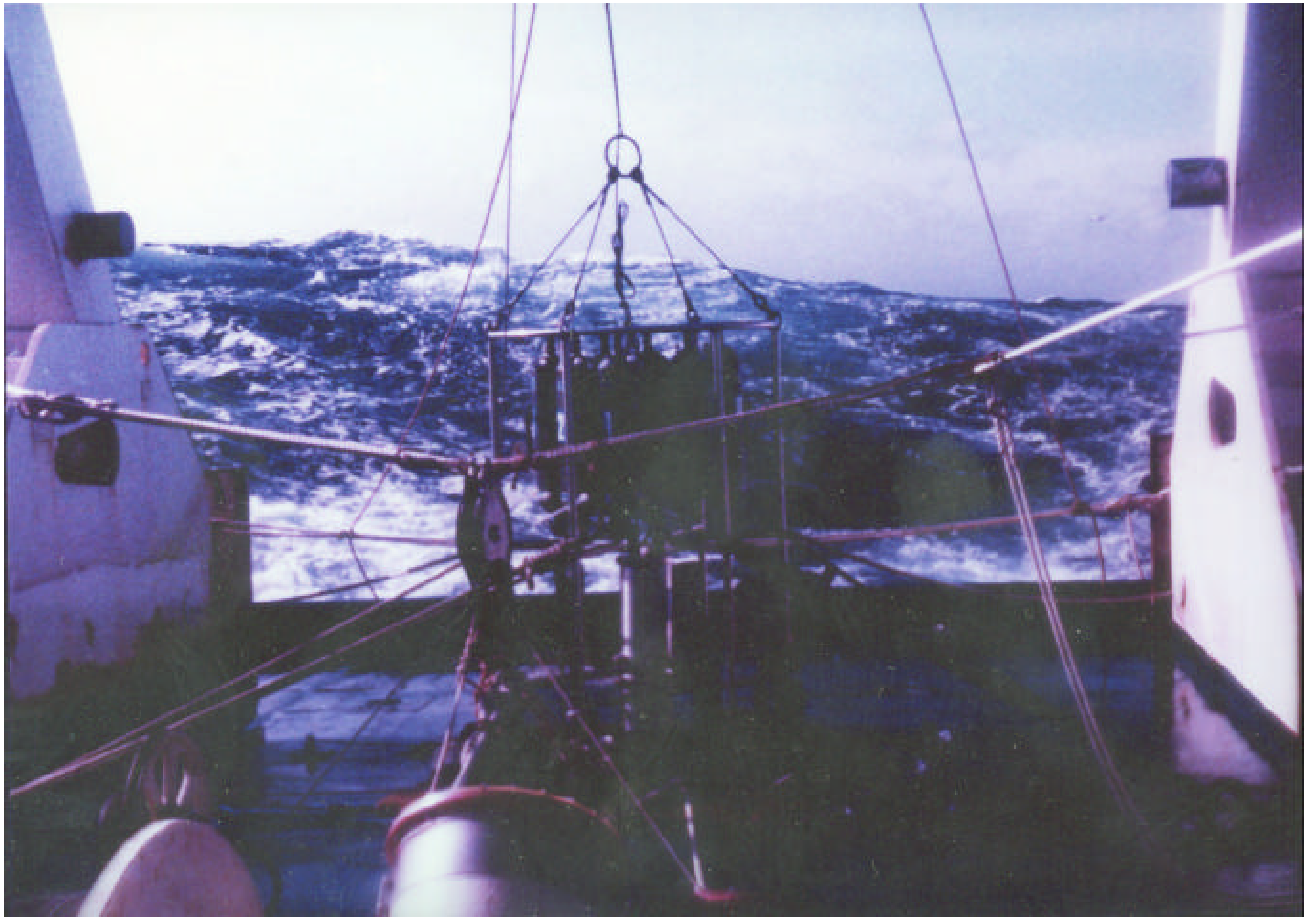


31buoys, 118 instruments
up to one year of deployment
less than 5% of loss



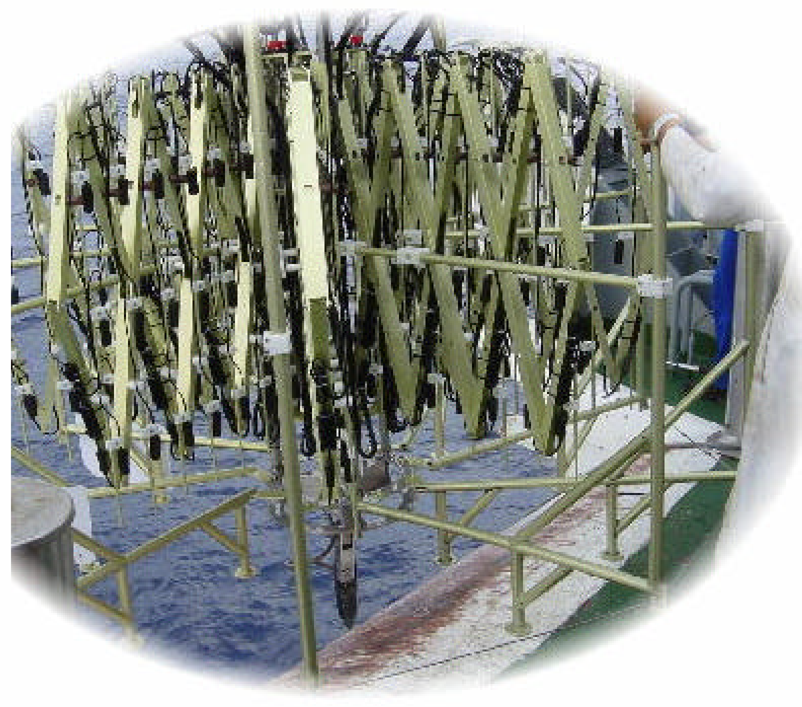
Saclantcen designed ADCP flotation package

Operations in Very Hostile Environment

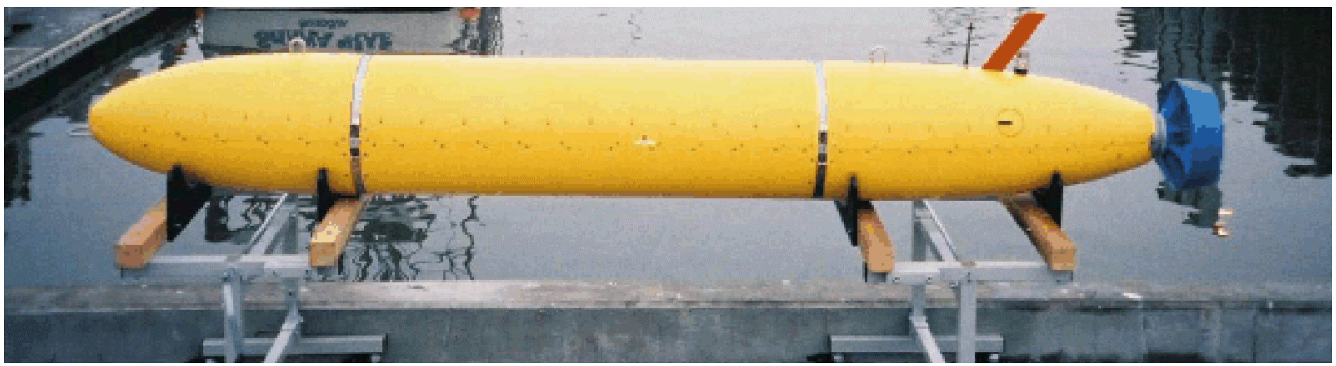


Mooring Operations



AUV Program at SACLANTCEN



Research Vessel Alliance