Laboratori Nazionali del Sud

INFN

PROPOSAL for NEMO ELECTRICAL POWER SYSTEM

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AGENDA

We will talk about the following topics:

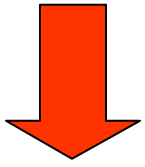
- ***NEMO POSSIBLE ELECTRICAL POWER SYSTEMS COMPARISONS***
- ***NEMO ELECTRICAL POWER SYSTEM PROPOSAL***
- ***NEMO PHASE 1 ELECTRICAL POWER SYSTEM***
- ***NEMO PHASE 1 POWER CONTROL SYSTEM PROPOSAL***

ELECTRICAL POWER SYSTEMS COMPARISON

With "*Energy Transmission System*" we define the portion of NEMO electrical power system that connects the shore station to the NEMO laboratory submarine site

Should this subsystem be designed to work in alternating or direct current ?

As all the loads to feed are dc loads



why do not use a dc power delivery system?

We have analyzed the possible solutions…

ELECTRICAL POWER SYSTEMS COMPARISON

The possible solutions evaluated for the Electrical Power System are:

- ***AC SYSTEMS***
  - Mono phase
    - bipolar
    - monopolar
  - Three phase
- ***DC SYSTEMS***
  - bipolar
  - monopolar

ELECTRICAL POWER SYSTEMS COMPARISON

The *MONOPOLAR SYSTEMS* have been rejected because:

- **a single-line-to-ground fault causes the complete isolation of the system (low reliability)**
- **corrosion and seawater pollution problems:**
  - **Electrodes should be rightly dimensioned, designed**
  - **metal structures nearby the electrode should be rightly protected**
- **electrodes presence cause system higher complexity**
- **periodic maintenance inspections should be done, this means very long delays and high cost due to undersea campaigns**
- **from a Nexans preliminary study came out that monopolar line + electrodes cost is 20% higher**

ELECTRICAL POWER SYSTEMS COMPARISON

Several comparison have been carried out among dc bilopar,ac monophase and threephase systems. These comparisons have been done with different values of voltage and kinds of cables. The most significant is the following:

Evaluation of ***VOLTAGE DROPS*** and ***POWER JOULE LOSSES***

fixed values

- P power delivered: 35 kW
- V end-line nominal voltage: 10 kV
- S cable conductors total section 75 mm^2
- L cable length 100 km
- power factor equal to 0.9 (expected value)

dc voltage drop are 20% higher than three phase ones

dc power losses are 7% higher

ELECTRICAL POWER SYSTEMS COMPARISON

Other *disadvantages* of dc system are:

- on shore conversion station presents major complexity and costs
- higher conversion power losses than electrical transformers one
- **lower *RELIABILITY* due the presence of electronic devices**

CONCLUSIONS

For all the previous mentioned reasons we have agreed upon the use of the ac three phase solution.

This can be used not only for the energy transmission system but also for the distribution one.

In this way an improvement in reliability can be obtained by installing electrical transformers in critical points (such as the primary JB) and electronics devices (such as dc/dc or ac/dc converters) near each load; as a results, a fault that occur to an electronic power supply will cause only a localized loss of power.

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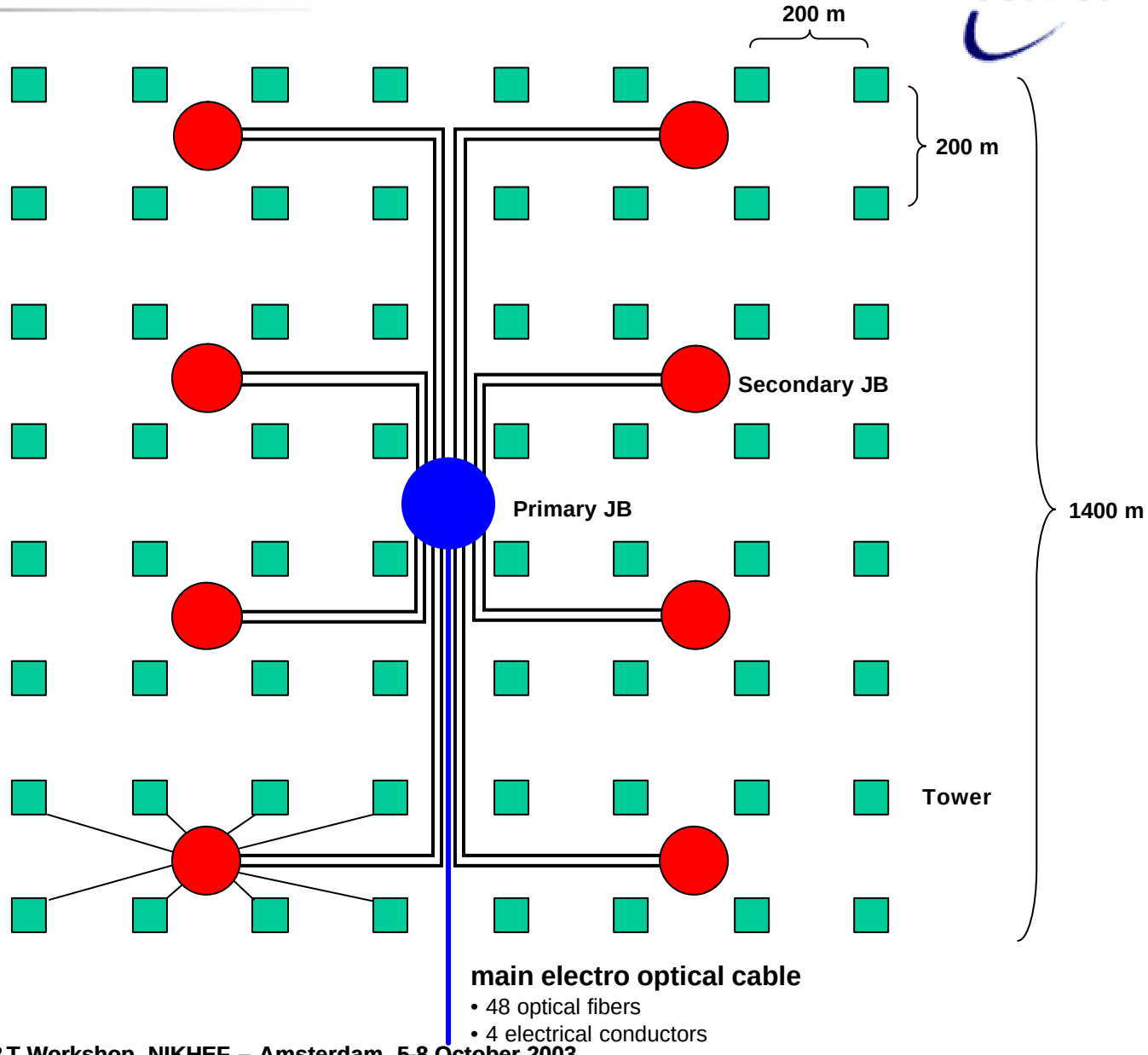
NEMO ELECTRICAL POWER SYSTEM

NEMO ELEMENTS:

- Shore station
- n. 1 Primary Junction Box
- n. 8 Secondary Junction Box
- n. 64 Towers
- 16 storeys for each tower
- 64 PMT for each tower
- 4096 PMT

CHARACTERISTIC DISTANCES :

- Shore- Primary JB: 100 km
- Primary JB - Secondary JB: 450-600m
- Secondary JB-Tower: 150-300m
- Base tower-1st storey:150m
- Storey-storey: 40m



NEMO ELECTRICAL POWER SYSTEM

ELECTRICAL LOADS

considered in the preliminary design study

Tower storey
- 4 PMT
- data transmission module
- physic parameters measuring systems
- position control system, acoustic transponder

→ 18 W - 48 Vdc

Tower box
- data concentrator module
- control electronics
- sensors to measure physic parameters

→ 100 W - 48 Vdc

Secondary JB and Primary JB
- data concentrator module
- control electronics
- sensors to measure physic parameters

→ 200 W - 48 Vdc

TOT 27 kW

NEMO ELECTRICAL POWER SYSTEM

The electrical power system has been divided in the following subsystems:

- ***ENERGY TRASMISSION SYSTEM*** **:**

  from the shore to the submarine site - AC THREE-PHASE 4 wires

- ***PRIMARY DISTRIBUTION SYSTEM*** **:**

  from the Primary JB to the Secondary JB, redundancy included - AC THREE-PHASE 4 wires

- ***SECONDARY DISTRIBUTION SYSTEM*** **:**

  from the Secondary JB to the storey box- AC THREE-PHASE 4 Wires + MONOPHASE

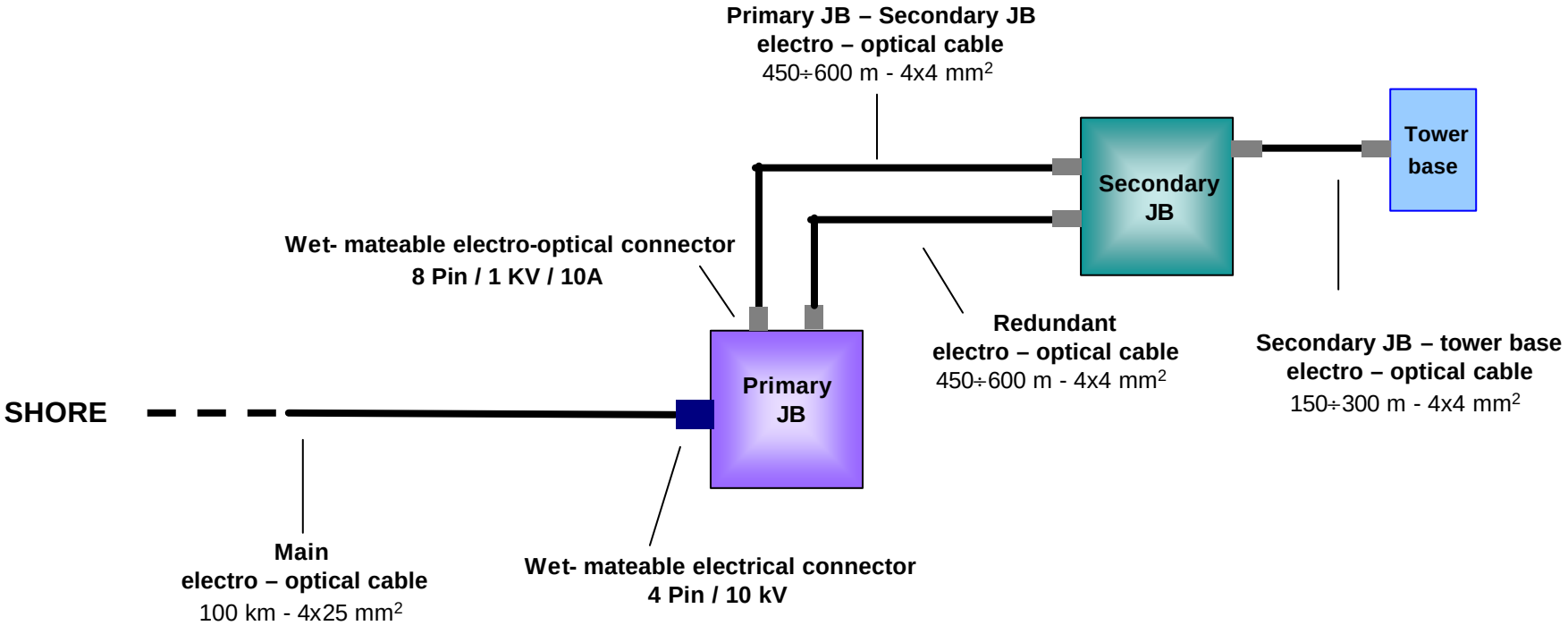
- ***STOREY DISTRIBUTION SYSTEM*** **:**

  from the storey box to the storey electrical loads - DC

NEMO ELECTRICAL POWER SYSTEM

NEMO POWER SUBSYSTEMS

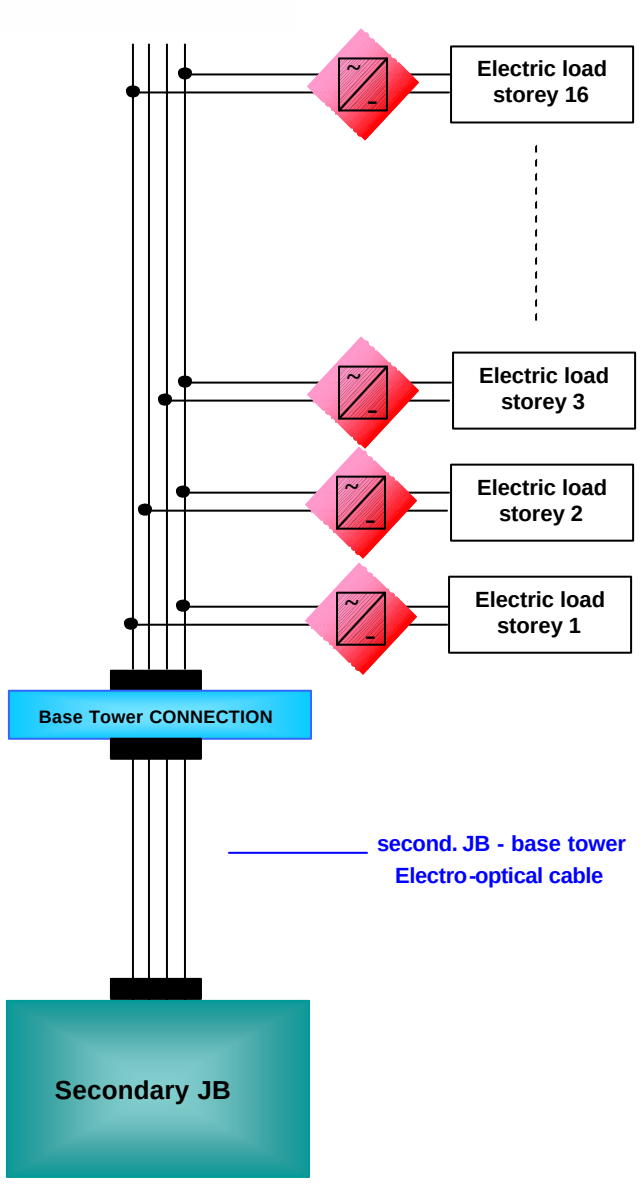
Energy Transmission → Primary Distribution ↔ Secondary Distribution….



NEMO ELECTRICAL POWER SYSTEM

The SECONDARY DISTRIBUTION SYSTEM can be realized:

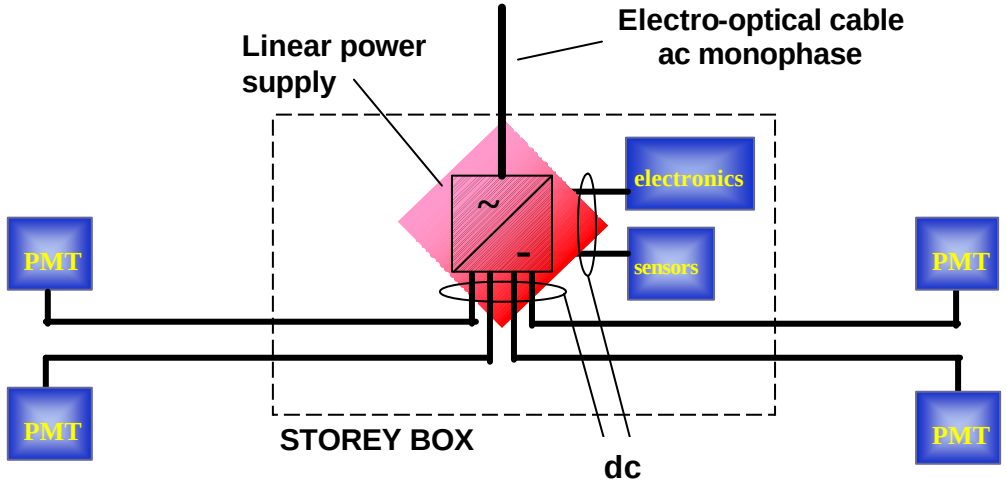
- from the Secondary JB to top of the tower by ac three phase
- From the tower backbone to each storey box by ac monophase
- all the storey loads should be distributed to the three phases to realize a balanced load
- In each storey is present a linear power supply



SECONDARY DISTRIBUTION SYSTEM

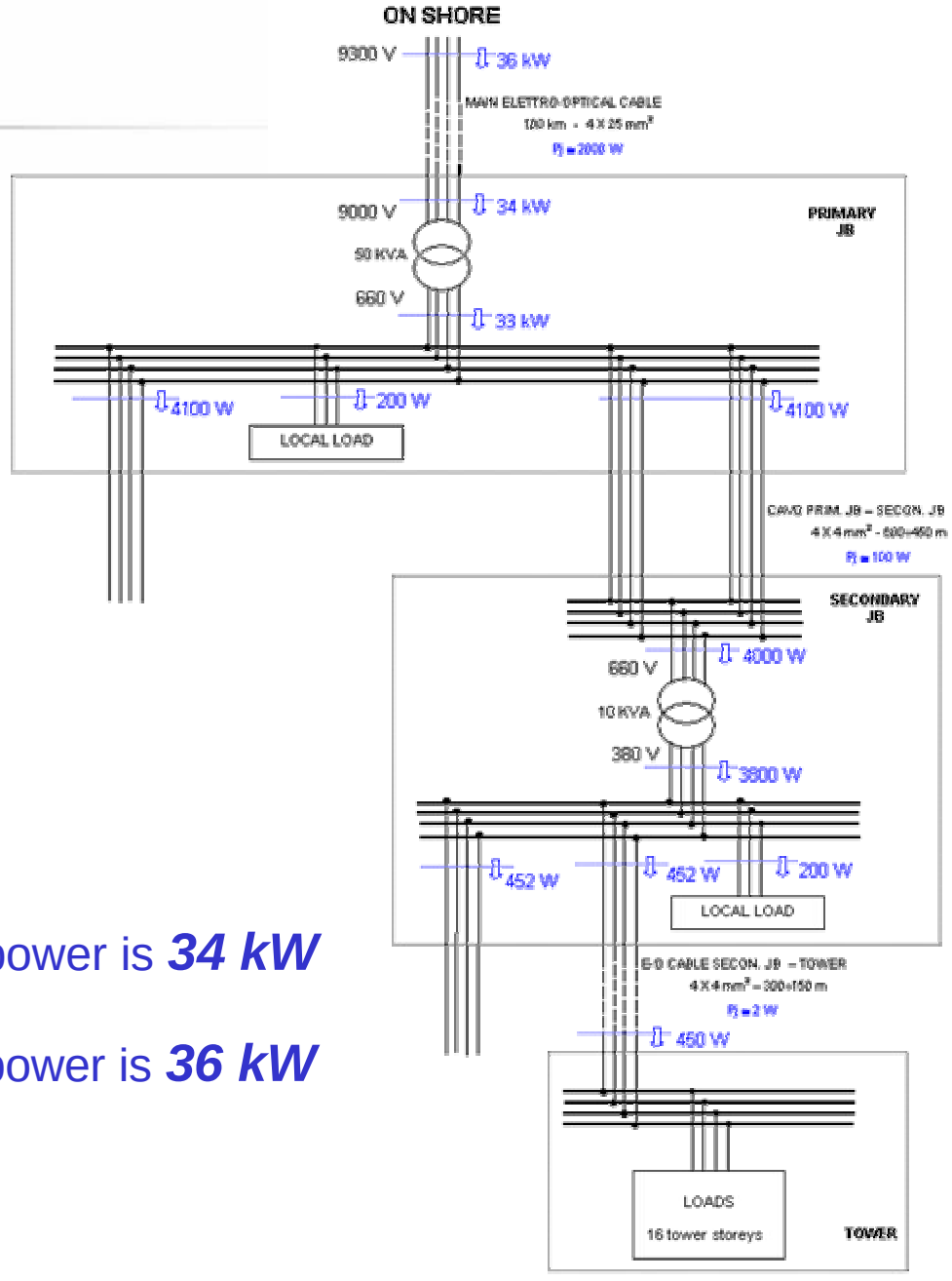
NEMO ELECTRICAL POWER SYSTEM

NEMO POWER SUBSYSTEMS



STOREY DISTRIBUTION SYSTEM

NEMO ELECTRICAL POWER SYSTEM



In this drawing are represented:

- Voltage levels
- Power delivered
- Power losses

- The ***offshore*** total amount of power is ***34 kW***
- The ***onshore*** total amount of power is ***36 kW***

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- ***NEMO PHASE 1 POWER CONTROL SYSTEM PROPOSAL***

NEMO PHASE 1 POWER SYSTEMS

The *aim* of NEMO PHASE 1 project

is to test all the elements that compose NEMO such as:

- **The electrical power system**
- **The data transmission system**
- **The control and diagnostics system**

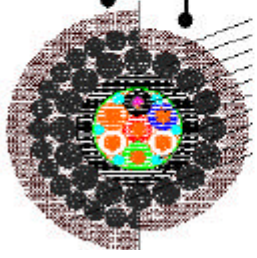
<u>in NEMO PHASE 1 are taken the same design choices proposed</u>

<u>for NEMO with the appropriate changes</u>

NEMO PHASE 1 POWER SYSTEMS

NEMO PHASE 1 ELEMENTS

SHORE STATION



MAIN ELETTRO- OPTICAL CABLE

- 10 optical fibres
- 6 electrical conductors 4mm²

MAIN ELETTRO-OPTICAL CABLE

20 km

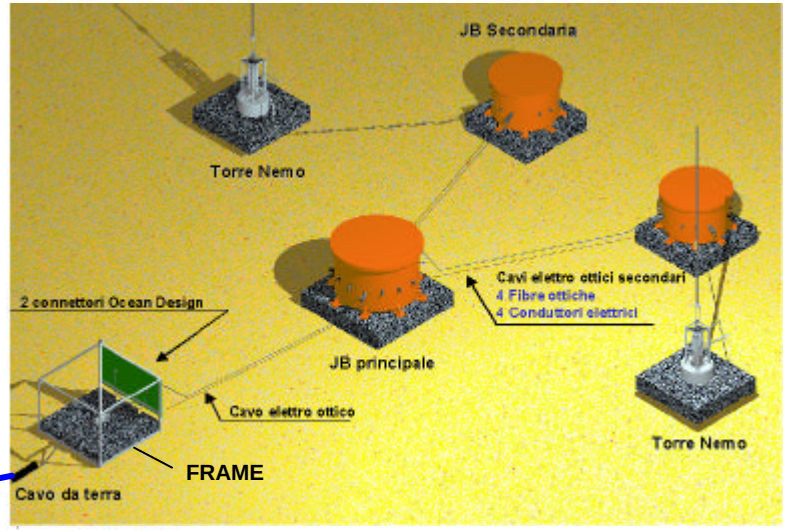
BU

E- O CABLE for NEMO PHASE 1

5000 m

E- O CABLE for GEOSTAR

5220 m

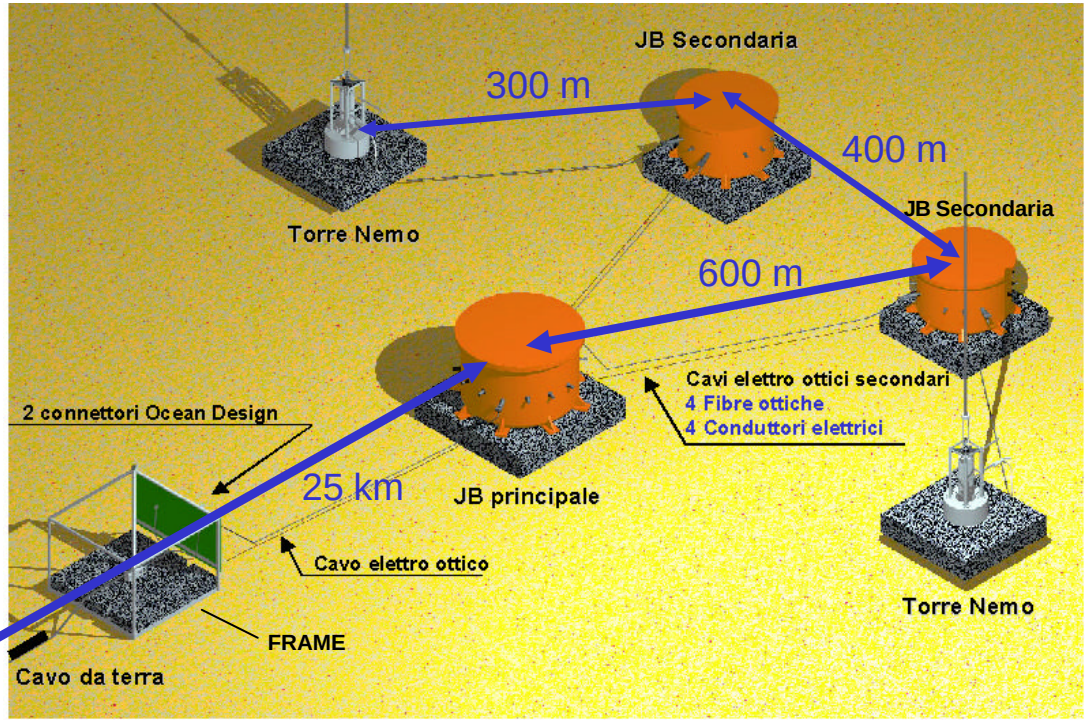


NEMO PHASE 1

GEOSTAR

- Shore station
- Electro-optical cable
- Branching Unit - BU
- Frame
- Primary JB
- Secondary JB
- Tower

NEMO PHASE 1 POWER SYSTEMS



Distances :

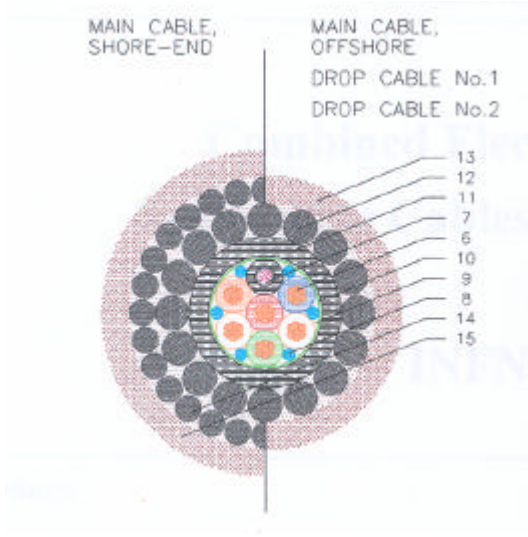
- JB Primary – shore: 25 km
- JB Primary – JB Secondary: 600m
- JB Secondary – JB Secondary: 400m
- JB Secondary – Tower: 300m

NEMO PHASE 1 POWER SYSTEMS

ELECTRICAL DESIGN CONSTRAINTS

MAIN ELECTRO-OPTICAL CABLE

- 6 electrical conductors
- Conductor section: 4 mm^2
- 10 optical fibres
- <u>Maximum allowable voltage: 1200V</u>



WET – MATEABLE ELECTRO-OPTICAL CONNECTORS

- 8 optical fibers and/or electrical circuits
- Maximum allowable current 10 A
- <u>Maximum allowable voltage : 1000V</u>

NEMO PHASE 1 POWER SYSTEMS

ELECTRICAL LOADS

considered in the preliminary design study

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- 4 PMT
- data transmission module
- physic parameters measuring systems
- position control system, acoustic transponder

→ 18 W - 48 Vdc

Tower box
- data concentrator module (passive)
- control electronics
- sensors to measure physic parameters

→ 100 W - 48 Vdc

Secondary JB and Primary JB
- control electronics
- sensors to measure physic parameters

→ 200 W - 48 Vdc

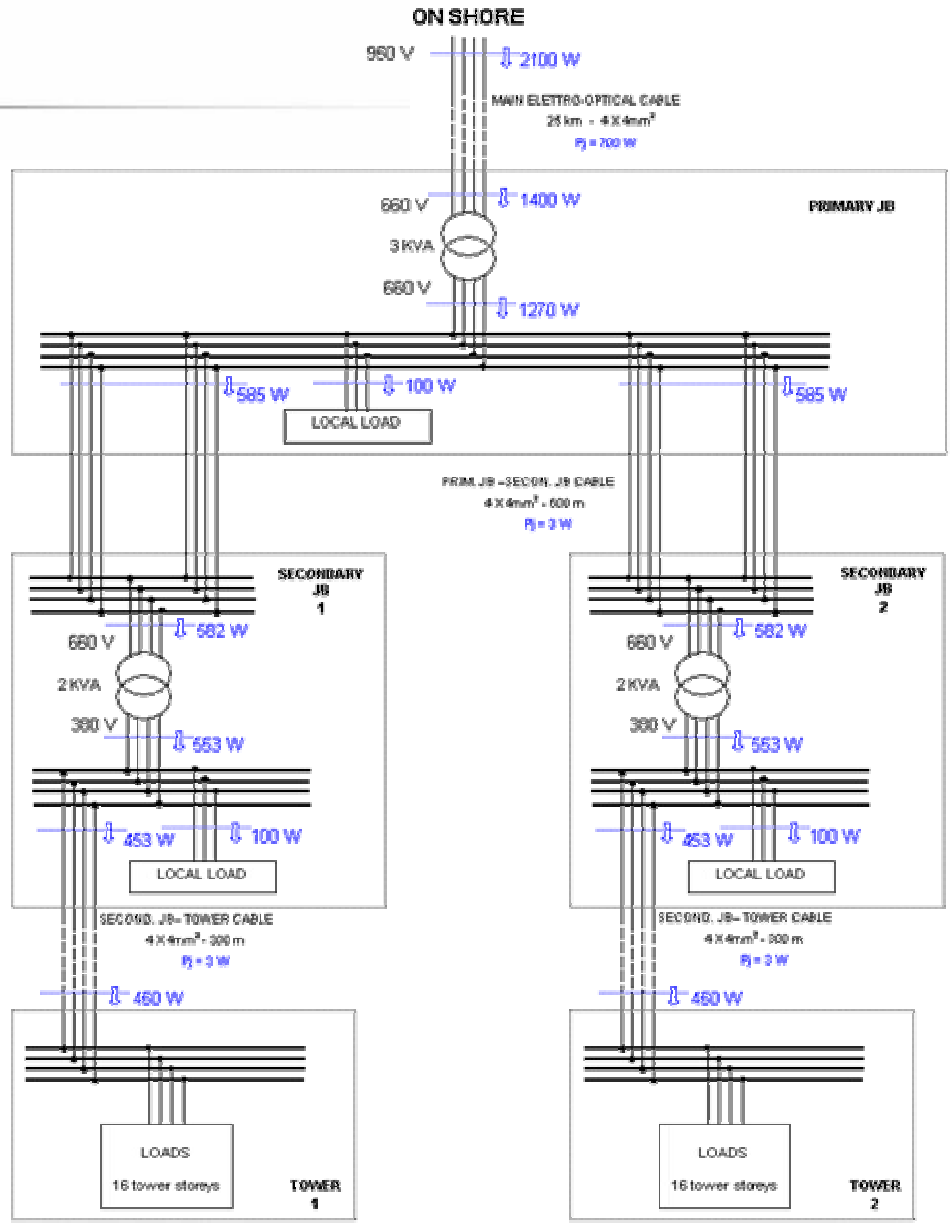
TOT 1.4 kW

NEMO PHASE 1 ELECTRICAL POWER SYSTEM

In this drawing are represented:

- Voltage levels
- Power delivered
- Power losses

The on shore total amount of power is 2 kW



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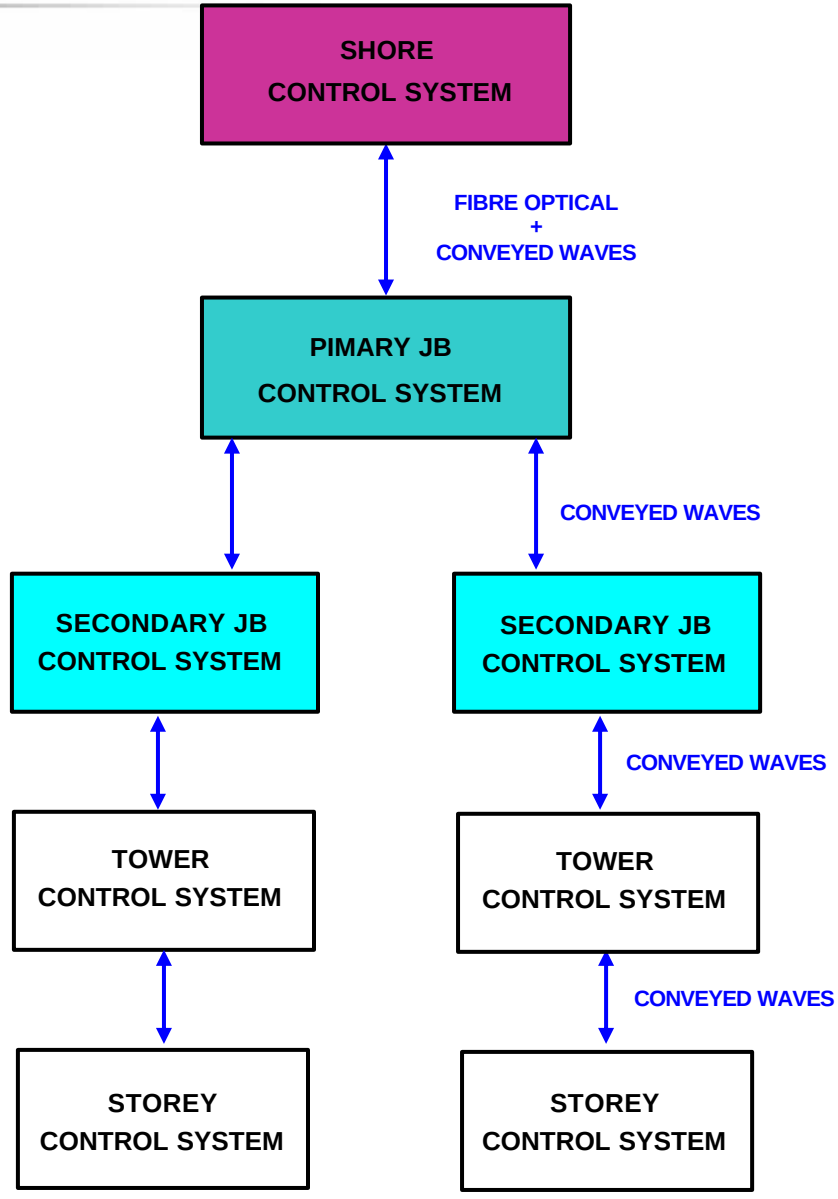
NEMO PHASE 1 POWER CONTROL SYSTEMS

CONTROL LEVELS

- The communication between the field control system and the shore can be realized by **fiber optic**
- The communication among the field control levels can be realized with a conveyed waves system (the transmission means is represented by the **electrical wires**) fiber optical are not available



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NEMO PHASE 1

POWER

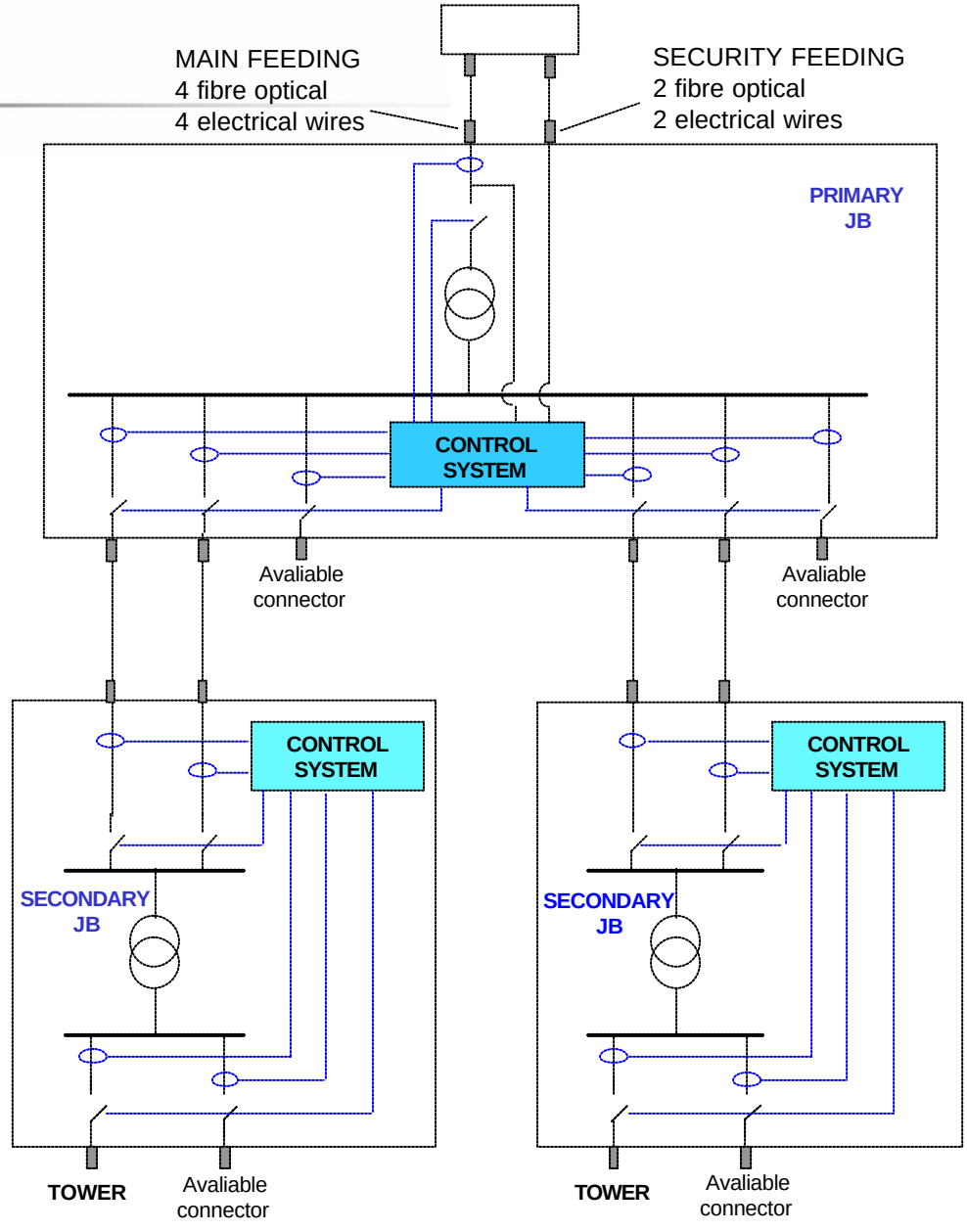
CONTROL SYSTEM

The power control system should be able to:

• acquire physics parameters (temperature, humidity, current, voltage, etc.) inside the boxes

• switch the power on and off to each feeding line, both under ordinary and fault conditions,

• reveal the electric fault and remotely control the breakers in order to continue feeding the JB interested by the fault.



During design will be important:

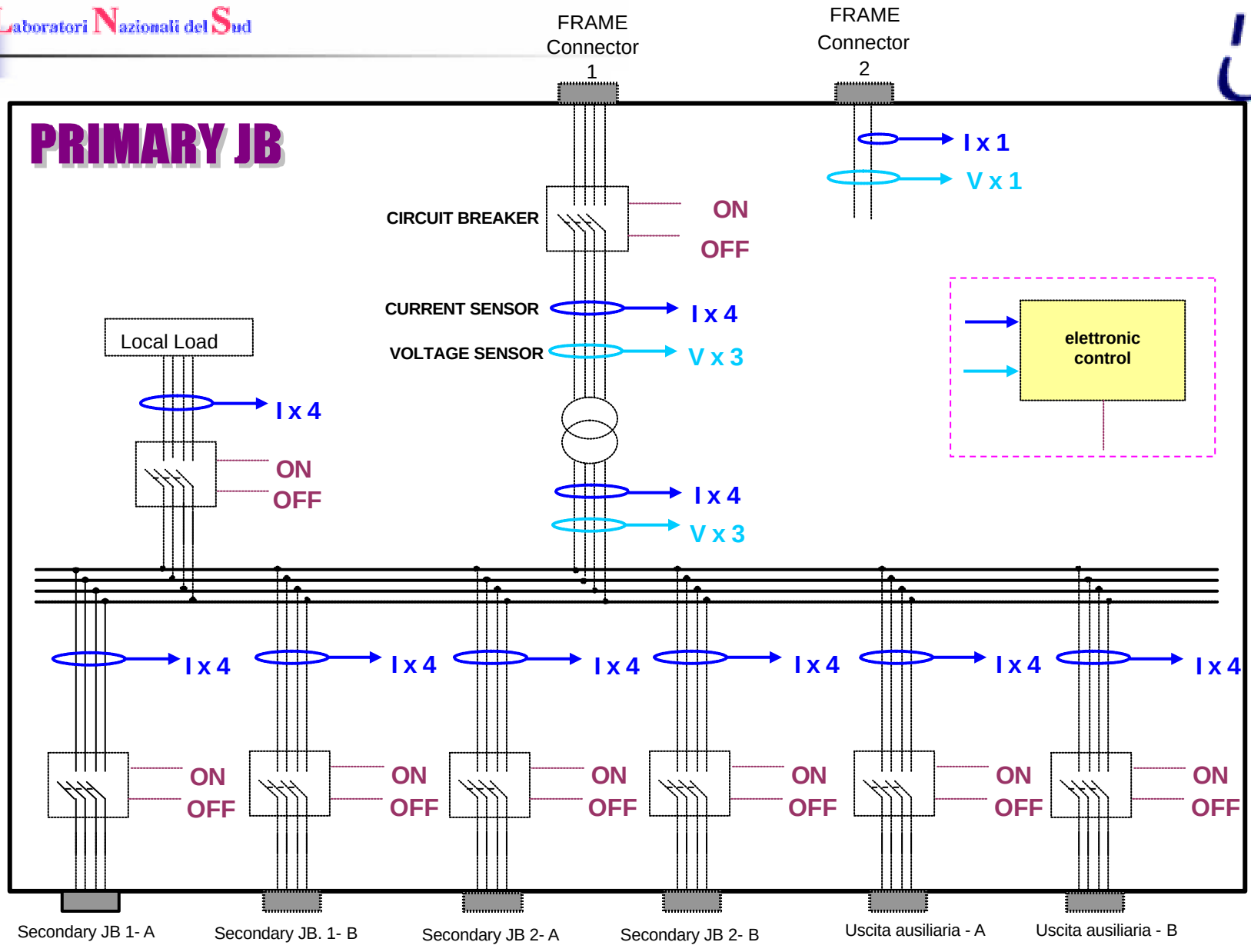
• foresee the storage of as much as possible device inside the fiberglass box (in which there is oil and high pressure environment), to reduce the steel box dimensions.

• use, where it is possible, commercial devices already tested and used,

• minimize the failure points to maximize reliability,

• foresee the right redundancies.

POWER CONTROL SYSTEMS



POWER CONTROL SYSTEMS