



*Laboratoire des Sciences du Climat et de l'Environnement*



# Technical specifications

Supply of an ultra-stable frequency comb for frequency metrology

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## Summary:

This document describes the specifications to be met by a laser frequency measurement device covering a spectral range from 760 nm to 2000 nm. This equipment is dedicated to research, development and training, mainly for the analysis of ice carbonates or atmospheric samples. It will be installed at the Laboratoire des Sciences du Climat et de l'Environnement (LSCE) and placed under the responsibility of the PALEOCEAN team.

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## 1 PROJECT CONTEXT

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The Laboratoire des Sciences du Climat et de l'Environnement, LSCE (CEA-CNRS-UVSQ) is a long-standing player in geochronology and geochemistry. It provides a major contribution to technological developments in these fields and to training in environmental and climate sciences. The PALEOCEAN team's research focuses on understanding the mechanisms of past climate variability in their oceanic components (the last few million years) and their impact on global climatology. This research is based, among other things, on the analysis of oxygen and carbon isotopes in the carbonates produced by marine organisms such as corals and foraminifera (unicellular organisms measuring around 100  $\mu\text{m}$  whose fossil shells are found in the sediments on the ocean floor).

The aim of this call for tenders is to acquire a frequency comb to reference laser measurements from VCOF-CRDS-type instruments developed by LSCE teams over the past 10 years. The aim is to stabilize lasers in a spectral region ranging from the visible (760 nm) to the near infrared (2000 nm) to enable the study of all the molecules targeted by LSCE's research subjects. This equipment will be shared-used and made available via the Panoply platform. It will also be integrated into LSCE's future laser isotope platform, which will be part of REGEF.

<http://panoply-geops.lsce.ipsl.fr/>

<https://www.regef.fr/>

## 2 SCOPE

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This document defines the technical specifications and provisions relating to the purchase of a metrology frequency comb, hereinafter referred to as the equipment. It must enable laser frequency measurement via a beat signal or laser stabilization with a coherence transfer device to be developed later by the LSCE. The service includes:

- Supply and installation of equipment,
- Supply of driver software,
- Supply of a beat detection module,
- Qualification of equipment in terms of performance, quality and quantity through factory or CEA tests,
- Technical documentation for the equipment,
- Training in the use of the equipment (including routine maintenance) and in the use of the operating software during installation,
- Equipment warranty for a minimum of 12 months,
- Hotline support for 3 years.

## 3 DESCRIPTION OF ENVIRONMENT

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### 3.1 Premises-related constraints

The equipment will be installed by the Contractor on LSCE premises:

Laboratoire des Sciences du Climat et de l'Environnement (LSCE)  
Bâtiment 714, Orme des merisiers, P 28  
RD128  
91191 GIF SUR YVETTE CEDEX

In agreement with:

Justin Chaillot,  
Laboratoire des Sciences du Climat et de l'Environnement  
CEA Paris-Saclay,  
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91191 GIF SUR YVETTE CEDEX  
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The room in which it will be installed and used is suitable for this type of equipment: temperature stabilized at  $22^{\circ}\text{C} \pm 2^{\circ}\text{C}$ , accessibility to electrical sources, a 10MHz clock signal (GPSDO) and an optical clock signal (REFIMEV).

It can be adapted according to the recommendations of the Contractor. However, dimensions must not exceed 3m\*2m\*2m.

The Contractor must specify the need for benches or supports for the equipment. He will also specify the optimum conditions of use.

### 3.2 Equipment constraints

The equipment must comply with standard French electrical standards.

The Contractor shall specify in his proposal the requirements and recommendations for the installation and all available information concerning the equipment. The list of information and recommendations shall include:

- Equipment size and weight,
- Connection specifications (power supply, type of connection, ground connection) in compliance with French and European regulations,
- User manuals, including the software user manual.

## 4 EQUIPMENT DESCRIPTION

### 4.1 Equipement details :

The equipment is a system that will enable laser frequency determination or laser source stabilization by coherence transfer.

The equipment must simultaneously measure the frequency of several laser sources by beat signal. The expected specifications are detailed in the table below.

(Table 1) :

**Table 1 – expected details**

Spectral purity transfer :	Sub-Hz tooth width from 650 to 2000nm when locked to an optical signal: the beat signal in the 1550nm and 760nm range must have a bandwidth of less than 1Hz.
Stability on internal frequency	At least 1e-10 to 1s
Stability on external frequency	Better than 1E-15 to 1s

### 4.2 Technical specifications :

Table 2 lists the expected technical specifications.

**Table 2 – Technical specifications**

6 fibered outputs, with an acceptable minimum of 4 outputs and no maximum values
FC/APC fiber outputs
Comb teeth spacing: between 200 MHz and 300 MHz
The spectral range covered must be at least 760 nm to 2060 nm
Optical power at least 100mW, no maximum values
As far as possible, optimize equipment for beat signal at 760nm, 1392nm, 1450nm, 1542nm, 1598nm, 1605nm and 2060nm

The repetition rate must be adjustable by +/- 2MHz with respect to the base value
The beat signal module must be completely fiber-reinforced and easy to use, with no moving parts
Active stabilization and control of the carrier envelope offset frequency (to control the absolute position of the comb lines and their spacing to match defined frequencies)

## 5 EQUIPMENT PERFORMANCE TESTS

Comb performance must be guaranteed by the Contractor in the technical documentation, particularly with regard to stability and accuracy. This performance must be at least:

- ADEV of at least 1e-15 to 1 second in stability
- ADEV of at least 1e-16 to 100 second in accuracy.

The Contractor will be asked to demonstrate that the Equipment does not require significant maintenance and that the Equipment's servo-control, its ability to lock onto an external optical reference, can be maintained without error for a minimum period of one month. This demonstration can be made by the Holder in three different ways:

- By sending scientific publications or test reports demonstrating this,
- By indicating a laboratory where it is possible to see the equipment in operation, which the engineer in charge of future use of the Equipment can contact to visit or contact users.

Once the equipment has been delivered to CEA, this locking capability will be tested at LSCE by CEA.

## 6 DOCUMENTARY DELIVERABLES

The Contractor must include the following detailed documentation with the contract:

- A report of the tests carried out previously in the factory or at the CEA, specifying the qualifications of the Equipment in terms of performance, quality and quantity.
- A maintenance manual for first-order troubleshooting, which may be in English.
- Training materials for users of the equipment, which may be in English.



## 7 WARRANTY AND MAINTENANCE

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### 7.1 Warranty

A 12-month warranty is required on the equipment, including parts, labor and travel.

### 7.2 Maintenance (options)

The Contractor must guarantee hotline, through its after-sales service, for a period of 3 years.

## 8 SERVICE DESCRIPTION

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### 8.1 Packaging and transport

The Contractor will be responsible for:

- Packaging supplies to prevent damage during transport (impact, weather, storage, handling, etc.),
- Protecting the equipment during transport,
- Transport to LSCE, room 28, building 714.

Transport, including customs duties and installation, will be the responsibility of the Contractor. The Contractor shall specify the precautions taken to comply with environmental standards in the performance of this contract, particularly regarding transport and waste management.

### 8.2 Assembly and installation

The Contractor will handle, assemble and commission the equipment on the LSCE site, in compliance with current regulations and French standards. For all operations carried out on the CEA site, the Contractor must first inform the CEA of the procedure to be followed and obtain its agreement.

On site, he will be responsible for handling the equipment until it is fully installed. The CEA will provide the power supply for the equipment as recommended by the Contractor.

The specifications required for the installation and optimal operation of the equipment must be stated by the Contractor in the tender.

## 9 SPARE PARTS

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The Contractor undertakes to market all necessary spare parts for a minimum period of 10 years after signing the acceptance report.

## 10 TECHNICAL SUPPORT

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The Contractor will deliver the equipment with technical documentation of the equipment and operations.

The Contractor will indicate the technical support available and the name(s) of the person(s) to be contacted in case of need.

The Contractor must commit to provide all documents required for first-rate operation, maintenance and trouble-shooting.

## 11 ENVIRONMENTAL CRITERION

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The Contractor must undertake to deliver the Equipment in packaging made from recycled or recyclable materials.

All necessary measures must be taken to integrate corrective maintenance into the environmental cycle: harmlessness of components and consumables and means of recycling the device after use must be envisaged.

## 12 CONDITIONS OF ACCEPTANCE

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The Contractor shall not proceed with the shipment of the Equipment until it has obtained the CEA's prior written agreement on the validity of the above-mentioned test reports. The Contractor and the CEA must jointly agree on the date of delivery of the Equipment to the CEA Saclay site.

The Contractor will not install the equipment until it has obtained written authorization from the CEA for the technician(s) to visit the site.



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Delivery of the equipment to the CEA/LSCE site at Gif-sur-Yvette will give rise to the contradictory signature of a report on the transfer of risks inherent in the equipment, from the Contractor to the CEA.

The final acceptance of the equipment is formalized by the signature of a joint report transferring ownership of the equipment from the Contractor to the CEA, and starting the contractual warranty period.

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