

Statement of Work for FRM4SOC phase2

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1 INTRODUCTION

This Statement of Work (SoW) describes activities and requirements for an EU Copernicus Programme study on Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC). This FRM4SOC phase-2 study develops upon ESA's FRM4SOC contract (FRM4SOC phase-1) [AD-1]. The goal of this phase-2 is to build on the achievements of the first FRM4SOC study and to further expand the Copernicus FRM capabilities and ensure the adoption of FRM principles across the ocean colour community.

1.1 Scope

FRM are a suite of independent, fully characterized, and traceable ground measurements that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO). These FRM provide the maximum Return On Investment for Copernicus satellite missions by delivering, to users, the required confidence in data products, in the form of independent validation results and satellite measurement uncertainty estimation, over the entire duration of a mission.

The main goal of this FRM4SOC phase-2 study is to ensure the adoption of FRM principles across the ocean colour community. This will be done through establishment of a network of radiometric measurements with the FRM certification. The phase-2 aim is to complete the required laboratory and field activities, which were started in phase-1, and to develop the tools, protocols, procedures and datasets needed to set up the network and demonstrate its operation. The network will start with the most common hand-deployed or stationary field radiometers, as identified in the FRM4SOC phase-1 study. The network will be based on the developed laboratory calibrations and characterizations (cal/char) and measurement protocols for these radiometers. The radiometers and their operators will have an FRM-certified cal/char status and a maintained history of calibrations and measurement deployments. The measurement protocols will be finalized, including initiation of protocols for complex waters. A community processor will be developed to process the radiometer data in a standardized way and to include detailed FRM uncertainty propagation and SI traceability. The study will also define a process for new radiometer and measurement certification as an FRM.

Following from the first FRM4SOC study, the FRM measurements must a) have documented SI traceability (e.g. via round-robin inter-calibration of instruments) using measurement standards; b) be independent from the satellite geophysical retrieval process (noting the exception of L2 product vicarious adjustment that fundamentally depends on FRM ground based measurements); c) have an uncertainty budget for all FRM instruments and derived measurements available and maintained; d) have defined and openly published measurement protocols and community-wide management practices (measurement, processing, archive, documents etc.); e) be openly and freely available for independent scrutiny.

1.2 Terminology

In the following sections, “shall”, “should” and “desirable” or “optional” are used to define the priority of the requirements / activities, with the meaning that requirements / activities described by:

- “shall” are mandatory;
- “should” are strongly recommended, but may be replaced by a different technical solution with equivalent or better functionality or deleted for well justified reasons;

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- “desirable” or “optional” are not mandatory (nice to have) and improve the quality of the Technical proposal and of the final system. “Should” and “desirable” / “optional” requirements or activities remaining in the Technical proposal shall be, in agreement with the EUMETSAT Technical Representative, converted to “shall” requirements or activities or deleted during the negotiation phase or after the necessary investigations have been performed.

1.3 Acronyms and Abbreviations

AD	Applicable Document
ADUM	Architecture Design and User Manual document
API	Application Program Interface
BRDF	Bidirectional reflectance distribution function
Cal	Calibration
CEOS	Committee on Earth Observation Satellites
Char	Characterization
CLI	Command-Line interface
DP	Data Package
EO	Earth Observation
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FRM	Fiducial Reference Measurements
FRM4SOC	Fiducial Reference Measurements for Satellite Ocean Colour
GEO	Group on Earth Observations
HQ	Headquarters
IOCCG	International Ocean-Colour Coordinating Group
IPR	Intellectual Property Rights
KO	Kick Off meeting
NMI	National Metrology Institute
OCDB	Ocean Colour Database
OCR	Ocean Colour Radiometer
PDF	Portable Document Format
QA4EO	Quality Assurance framework for Earth Observation
RSP	Remote Sensing and Products Division
RD	Reference Document
TR	Technical Report

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SI	International System of Units
S3VT-OC	Sentinel-3 Validation Team – Ocean Colour group
SoW	Statement of Work

1.4 Applicable Documents

- [AD-1] ESA's contract no 4000117454/16/I-SBo (<https://frm4soc.org>)
- [AD-2] D-70: Technical Report TR-2 "A Review of Commonly used Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) used for Satellite OCR Validation" (available at <https://frm4soc.org/index.php/documents/deliverables/>)
- [AD-3] 'Statement of Work for Database of Ocean Colour In Situ Fiducial Reference Measurement Collections for Calibration and Validation', EUM/OPS-COPER/SOW/17/956607. (<https://frm4soc.org/index.php/documents/statement-of-work/>)
- [AD-4] IOCCG Protocol Series (2019). "Protocols for Satellite Ocean Colour Data Validation: In Situ Optical Radiometry". Zibordi, G., Voss, K. J., Johnson, B. C. and Mueller, J. L. IOCCG Ocean Optics and Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation, Volume 3.0, IOCCG, Dartmouth, NS, Canada. (Available at <https://ioccg.org/what-we-do/ioccg-publications/ocean-optics-protocols-satellite-ocean-colour-sensor-validation/>)
- [AD-5] K. Ruddick et. al., "A Review of Protocols for Fiducial Reference Measurements of Water-Leaving Radiance for Validation of Satellite Remote-Sensing Data over Water", Remote Sens. 2019, 11(19), 2198; <https://doi.org/10.3390/rs11192198>
- [AD-6] K. Ruddick et. al., "A Review of Protocols for Fiducial Reference Measurements of Downwelling Irradiance for the Validation of Satellite Remote Sensing Data over Water", Remote Sens. 2019, 11(15), 1742; <https://doi.org/10.3390/rs11151742>
- [AD-7] International Network for Sensor Inter-comparison and Uncertainty assessment for Ocean Color Radiometry (INSITU-OCR), <http://ioccg.org/wp-content/uploads/2016/02/INSITU-OCR-white-paper.pdf>.
- [AD-8] D-80a: Technical Report TR-3a "Protocols and Procedures to Verify the Performance of Reference Irradiance Sources used by Fiducial Reference Measurement Ocean Colour Radiometers for Satellite Validation" (available at <https://frm4soc.org/index.php/documents/deliverables/>)
- [AD-9] D-80b Technical Report TR-3b "Protocols and Procedures to Verify the Performance of Reference Radiance Sources used by Fiducial Reference Measurement Ocean Colour Radiometers for Satellite Validation" (available at <https://frm4soc.org/index.php/documents/deliverables/>)
- [AD-10] Białek, A.; Douglas, S.; Kuusk, J.; Ansko, I.; Vabson, V.; Vendt, R.; Casal, A.T. Example of Monte Carlo Method Uncertainty Evaluation for Above-Water Ocean Colour Radiometry. Remote Sens. 2020, 12, 780. <https://doi.org/10.3390/rs12050780>

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- [AD-11] TR-9 Technical Report “Results from the First FRM4SOC Field Inter-Comparison Experiment (FICE) of Ocean Colour Radiometers” (available at <https://frm4soc.org/index.php/documents/deliverables/>)
- [AD-12] IOCCG Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation (<https://ioccg.org/what-we-do/ioccg-publications/ocean-optics-protocols-satellite-ocean-colour-sensor-validation/>)

1.5 Reference documents

- [RD-1] FRM4SOC Scientific and Operational Roadmap (https://frm4soc.org/wp-content/uploads/filebase/D-280-FRM4SOC-SOR_-signed_UT_ESA.pdf)

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2 ORGANISATION OF THE STUDY AND TASK REQUIREMENTS

The study has a duration of 24 months, with two options of 12 months for further extension.

The FRM4SOC project is organised as twelve mandatory tasks plus four optional requirements mandatory in case of any of the extensions is granted, all described in this document. The diagram in (Figure 1) shows work logic for main activities, showing dependencies among different tasks. The Contractor, while planning task activities shall take these logic dependencies into account.

Req. 1. This study is intended as a continuation of FRM4SOC project, founded by ESA [AD-1], referred as FRM4SOC phase-1 in this SoW. Therefore, the outcome from phase-1 shall be a starting point for FRM4SOC phase-2 study. Technical reports shall be used and eventually updated if needed; lessons learned from phase-1 shall also be implemented in this phase-2 and data and results, when available, from practical experiments shall be included into the developments and analyses.

Req. 2. The Contractor shall take into account outcomes from other European/Copernicus projects related to in situ data collection or to which in situ data are fundamental for algorithm development/validation. The Contractor shall consider engagement with the entities running those projects to develop cooperation on instrument cal/char and measurement protocols, tools, and knowhow to achieve the FRM suitable for OC satellite product validation.

A non-comprehensive list of such projects is here reported as an example. Contractor shall complete and discuss this list with EUMETSAT at KO.

This list could be updated during the study to include more recently kicked-off projects.

Project	Project reference	Project website
HYPERNET	H2020 research and innovation program - grant agreement No 775983	http://www.hypernets.eu/from_cms/summary
GLOBOLAKES	NE/J024279/1	http://www.globolakes.ac.uk
FRM4SOC	4000117454/16/I-SBo	https://frm4soc.org/
CMEMS In-Situ TAC	77-CMEMS-TAC-OC	http://www.marineinsitu.eu/
MONOCLE	H2020 research and innovation programme - grant agreement No 776480	https://www.monocle-h2020.eu/Home

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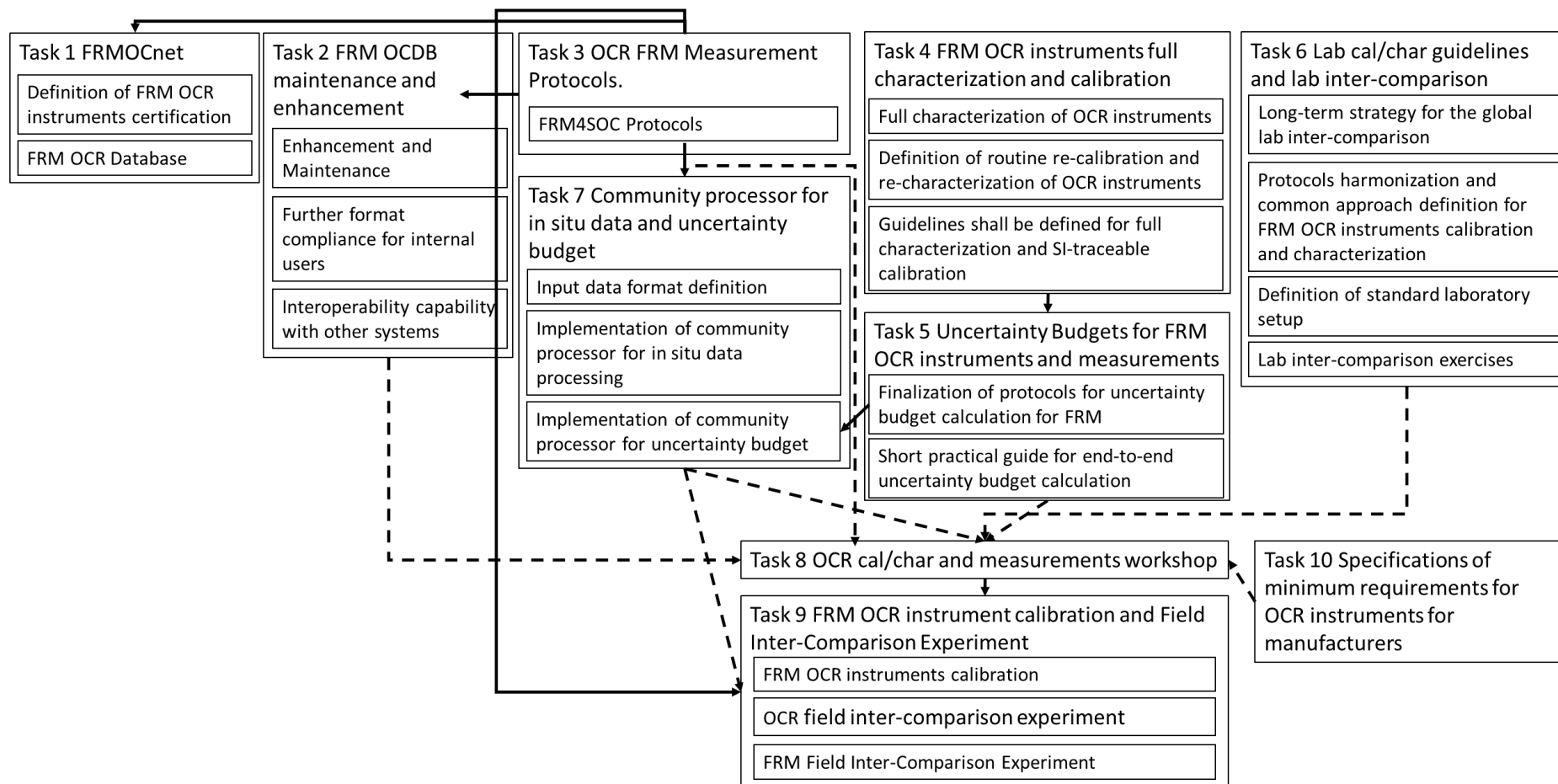


Figure 1 Study activities workflow. Arrows indicate input needed by task from previous tasks in the direction of the arrow. Dashed arrows indicates iteration between the 2 tasks is needed.

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2.1 Task 1 Copernicus FRM-certified OC instrument network (FRMOCnet) and Database

The aim of this task is to define requirements for qualification of OCR instruments as FRM and to put the basis for the establishment of the network of FRM-certified instruments and measurements (FRMOCnet). The goal is also the establishment of this network. FRMOCnet will document the FRM-certified instrument models and their cal/char specifications and measurement protocols. FRMOCnet will also record the corresponding individual instruments, owned by investigators, with their cal/char and deployment protocol status and history. FRMOCnet will start from the creation of a Database in support to FRMOCnet and its population with characterization and calibration information of initial FRM-certified instruments.

Req. 3. FRMOCnet shall be initiated with OCR models, which were characterized during FRM4SOC phase-1 (i.e. TriOS-Ramses and Satlantic-HyperOCR). These radiometer models were found to be the most commonly used by the community [AD-2].

Req. 4. The Contractor shall identify which specifications and tools are still missing for these OCR models to form the initial basis for the FRM certification and FRMOCnet definition. As a starting point, the existing characterizations, calibration, lab protocols, measurement protocols, data processing and uncertainty budget shall be used, developed for these radiometer types in FRM4SOC phase-1.. The missing specifications will be addressed by activities in the following Tasks.

Req. 5. Specifications of minimum requirements for the FRM certification of single individual OCR instruments shall be defined. The single OCR instruments shall initially come from the two OCR models. The minimum requirements shall include:

- baseline instrument calibration, characterization and SI traceability
- re-calibration/re-characterization record
- deployment record and measurement protocols followed at each deployment

These specifications are required to evaluate the inclusion of any new individual instrument in FRMOCnet (Req. 7). The specifications shall be delivered to EUMETSAT as the technical report D-2 and, as a first draft (v.1), shall be accessible by broader community for further review and acquiescence (when agreed by the review board experts). The final version shall be then delivered to EUMETSAT after the inclusion of contributions from the following Tasks and after the review process.

Req. 6. The process for inclusion of any new OCR models in FRMOCnet shall be defined. The process for bio-optical instrumentation shall also be initiated.

Req. 7. A Database (D-3) shall be set up to host all FRM specifications for each OCR model, including their characterization, calibration and measurement protocols, as well as single instrument specifications and characterization, calibration and protocol history.

- The Database shall be expandable to new OCR models and new single OCR instruments.
- The possibility for a future extension to other types of instruments than OCR (e.g. spectrophotometers, fluorimeters) shall be enabled.

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- The Database shall serve data and information in a suitable format to be directly propagated to the community processor in Task 7.
 - The Database shall grant two levels of access to individual Collections:
 - open access
 - restricted access, only possible for certain users who are granted specific privileges
 - The Database shall be hosted at EUMETSAT and once populated shall be accessible by general public.
- Req. 8. First version of D-3 shall be available before Task 9 takes place, and shall grant the access to Task 9 participants. A second version shall be delivered, populated with data gathered during characterization and calibration activities in Tasks 4 and 9.
- Req. 9. Any source code related to D-3 and D-5 shall be delivered to EUMETSAT through GITLab. EUMETSAT recommendations on the coding practices are listed in Appendix A.
- Req. 10. The Contractor shall train EUMETSAT staff in order to maintain the Database independently at the end of the contract .
- Req. 11. FRMOCnet Database Architecture Design and User Manual document (ADUM) shall be delivered as D-4.
- Req. 12. The Contractor shall maintain the Database until the end of the contract, and the optional extensions implemented. Contractor shall fix any anomaly or issue identified before the end of the project (including any optional extension granted) in v.2 of D-3, released before the end of the project.

Task deliverables
D-2 TR: <i>Specifications of minimum requirements for qualification of individual OCRs as FRM instruments and process for inclusion of any new instrument models in the FRMOCnet</i>
D-3 Database to host FRMOCnet specifications, data and documentation for the OCR models as well as for individual instruments and their deployment history.
D-4 FRMOCnet Database <i>Architecture Design and User Manual document (ADUM)</i>

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2.2 Task 2 Copernicus Database of Ocean Colour In Situ FRM maintenance and enhancement

A Copernicus Database for in situ Ocean Colour measurement has been established to easily distribute FRM data to general community ([AD-5]), later called OCDB. A first version was made available in November 2019 for testing by S3VT-OC community.

This Database needs maintenance and enhancement in order to guarantee continuous updates and access to the newest best quality data, as listed in the following requirements.

Enhancements described in the following requirements shall be included in a new release of the Database WebUI and related CLI and Python API. Additionally, planning of EUMETSAT's support in verification, testing and anomaly reporting (E-VER) shall be included and update of Architecture Design and User Manual document (ADUM), as the deliverable D-5 (v.1).

The roadmap presented at the end of the OCDB-dedicated Copernicus study identified some limitations of the functionality of this Database and its tools.

In the current version, querying the Database, users can get the files containing the data and not the data themselves.

For internal use only, tables of parameters derived from raw data (e.g. surface values, radiometric measurements resampled to OLCI bands, etc.) are stored in the Database as well, not accessible by public. Currently these tables cannot be distinguished from the raw data themselves by the Database.

Req. 13. Users shall be able to get data directly instead of files.

Req. 14. To provide data directly, the Contractor shall select a unique data file format for same product types among ones currently admitted by the system. The choice shall be carried out through consultation with users and in the context of a more general debate, to align with other international/national agency systems (e.g. SeaBASS) to enable interoperability.

Req. 15. A plotting tool shall be available for submitter users (i.e. users providing data to the Database), to check data quality during the submission.

Req. 16. A data editing tool to support users' submission shall be provided (helping solving data format errors, and reformatting)

Req. 17. A new status needs to be added, named: 'TABLE' among the possible *stati* to which a submission could be classified, to make these data queryable separately by the other data. Current available *stati*, as well as their meaning and functionality are fully described at <https://ocdb.readthedocs.io/en/latest/>.

Req. 18. OCDB shall be able to ingest and query, for internal use only, MOBY buoy, AERONET-OC as well as Biogeochemical-Argo data format.

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- Req. 19. OCDB service (webUI and python/API included) shall be maintained to ensure service continuity. Maintenance shall also solve issues identified through users' feedback, collected and evaluated by EUMETSAT.
- Req. 20. Interoperability with other international/national agency systems (e.g. SeaBASS) shall be granted. In particular, specification of CLI and python API shall be provided to SeaBASS's team. The Database shall be also ready to query directly SeaBASS as soon as this capability is in place on SeaBASS side as well. Interoperability with NOAA future capabilities shall also be investigated.
- Req. 21. Maintenance shall be ensured until the end of the contract, including any optional extension, if granted. A final version of D-5 (v.2) shall include any necessary modification identified during the maintenance period.
- Req. 22. Any source code related to D-5 shall be delivered to EUMETSAT through GITLab. EUMETSAT recommendations on the coding practices are listed in Appendix A.

Task deliverables

D-5 OCDB Database WebUI, CLI, Python API, and Architecture Design and User Manual document, updated following requirements from Req. 13 to Req. 22.

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2.3 Task 3 OCR FRM Measurement Protocols

In project phase 1, the review of protocols for FRM of Water-Leaving Radiance and Downwelling Irradiance was carried out. In this second phase, the Contractor shall clearly define the minimum requirements, which will allow classifying a measurement as FRM, including measurement protocols to operate OCR instruments and quality assurance schemes for in situ data. Quality assurance processes and data processing methods shall be defined to guarantee in situ data FRM-quality.

Req. 23. Requirements and Protocols used when operating OCRs shall be defined, harmonising with, and eventually contributing to, existing certified protocols documented by IOCCG ([AD-4]) for OCR above- and in-water measurements, which shall be the starting point, together with the protocol reviews published at the end of FRM4SOC phase-1 ([AD-5], [AD-6]).

Req. 24. The protocols shall also include the list of complementary measurements and calculations needed for a complete processing of the in situ measurements of FRM-quality in order for these measurements to be suitable for satellite ocean colour validation (e.g. BRDF correction).

Req. 25. The protocol shall include dedicated sections for operating measurements in complex waters, where standard protocols may not apply.

Req. 26. The protocols shall be the input for Task 1 FRMOCnet and its Database, Task 7 community processor, Task 8 workshop and Task 9 field inter-comparison exercise.

Req. 27. The first version of the protocols described in TR D-6 shall be available to be implemented in the first version of the community processor (Req. 46) and to be discussed during OCR workshop (Task 8).

After discussion and review process, v.2 shall be delivered, and protocols shall be applied in the field inter-comparison exercise in Task 9, for implementation and verification. V.3 shall include any necessary modification identified during the field exercise.

Task deliverables

<i>D-6 TR: Measurement requirements and protocols when operating Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) and processing data deriving Remote Sensing Reflectance for Satellite Validation – phase 2</i>

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2.4 Task 4 Full characterization and calibration of the FRM OCR instrument models

In FRM4SOC phase-1 some uncertainty sources in the two most common OCR models were not fully investigated, as stated in [AD-2]. The goal of this task is to achieve the complete characterization and SI-traceable calibration of these OCR models and their resulting uncertainty budgets.

Req. 28. The Contractor shall identify remaining uncertainty sources and their full characterization shall be carried out, for the OCR instrument models selected already in phase-1. The coordination and possible co-occurrence with the targeted lab inter-comparison exercise of Task 6 shall be included. Outcome shall be delivered as a TR to EUMETSAT as v.1 to be available for discussion during OCR workshop (Task 8). After the discussion and review process and after feedback from Task 6 and 9, v.2 shall be delivered to EUMETSAT as the TR D-7.

Req. 29. OCR Instrument model full characterization results (D-9) shall be made available through Task-1 FRMOCnet Database before Task 9 takes place.

Req. 30. A routine for periodic re-characterization and re-calibration shall be defined and established for the OCR models.

Req. 31. Guidelines shall be defined for full characterization and SI-traceable calibration of single instruments from the OCR models, to be followed by laboratories different than the pilot one.

Task deliverables
D-7 TR: <i>Complete characterization and calibration results for FRMOCnet OCR models and re-characterization routine: an update</i>
D-8TR: Guidelines for individual OCR full characterization and calibration
D-9 DP: FRMOCnet OCR models full characterization and calibration results

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2.5 Task 5 Uncertainty Budget for FRM OCR instruments and measurements

The goal of Task-5 is to finalize the uncertainty budget calculation from FRM4SOC phase-1 since, as stated in [AD-10], ‘some of the environmental contributors were not fully evaluated’.

- Req. 32. Protocols for uncertainty budget calculation shall be finalized and include additional uncertainty components to compose the full uncertainty budget for the instrument and the measurement. Starting point for this activity shall be phase 1 protocols ([AD-10]). The protocols shall also incorporate the outcome of measurement protocols from Task 3 and instrument characterizations from Task 4. An optimal calibration protocol shall be established that will enable to provide robust absolute calibration coefficients.
- Req. 33. The protocols shall provide uncertainty budget calculation for in situ data processing leading to remote sensing reflectance and fully normalised water-leaving radiance.
- Req. 34. The deliverable shall include a short practical guide for OCR measurement end-to-end uncertainty budget calculation, allowing to reproduce the same routines in other laboratories different than the pilot one, selected by the Contractor.
- Req. 35. The protocols shall be delivered to EUMETSAT as a first version v.1 of D-10, and shall be made accessible by broader community for further review and acquiescence (when agreed by the review board experts). Protocols shall be presented and discussed during the OCR workshop (Task 8). V.2 shall include updates suggested during the workshop and review process and shall be made available for the implementation in the processor for end-to-end Uncertainty Budget calculation. Version 3 shall be then delivered to EUMETSAT, including any necessary modification eventually suggested during field experiment (Task 9).

Task deliverables

<i>D-10 TR: Protocols for uncertainty budget calculation of FRMOCnet OCR and practical guide for OCR measurement end-to-end uncertainty budget calculation</i>
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2.6 Task 6 Laboratory cal/char guidelines and laboratory inter-comparison

In FRM4SOC phase-1 project, laboratory comparison of the irradiance/radiance sources was run during LCE-1 experiment ([AD-8], [AD-9]). The experiment was carried out at a reference National Metrology Laboratory (at the National Physical Laboratory, NPL), which was responsible for primary SI calibration sources and for strict adherence to standards and processes, and which performed the calibration of the reference lamps and the processing of results. Participants involved came from the ‘secondary cal/char laboratories’ which on a regular basis calibrate and characterize OCR instrumentation. The participants had the possibility to ‘fully understand irradiance source calibration results and uncertainties in order to appropriately apply them at the next stage in their own laboratories’ ([AD-8]).

Starting from these lessons learned, the Contractor shall define cal/char guidelines for secondary laboratories, and shall run a cal/char inter-comparison exercise of hyperspectral instruments for those labs in order to:

- verify the performance of secondary standards transferred from reference NMI SI-traceable radiance sources and of lab protocol application, used by labs to perform the calibration of their FRM OCR instruments,
- establish common processes to be followed in cal/char laboratories, vet them and gather consensus, if possible involving multiple actors, including international coordination, either through the review process or direct participation.

The main aim is to develop guidelines, under the direction of an NMI, for secondary cal/char laboratories to ensure full adoption of radiance/irradiance source calibration traceability, lab set-up, results and uncertainties and to establish a shared and common standard, to be applied at the cal/char laboratory level.

Req. 36. A strategy for the inter-comparison and harmonization of secondary cal/char labs shall be defined by the Contractor as deliverable D-11 and it shall include a targeted lab inter-comparison exercise. A major part of the strategy shall address the lab cal/char harmonization guidelines for the most common OCR instruments in use in FRMOCnet. If feasible, in order to conserve time and resources, the strategy shall plan to combine the lab inter-comparison exercise with the full cal/char of the FRMOCnet OCR models from Task 4, .

Req. 37. Engagement of multiple laboratories and/or national metrology institutes shall be sought in order to develop consensus on cal/char lab guidelines, including harmonized protocols and methodologies aimed at hyperspectral OCR. The list of labs and possible international agencies/institutes shall be discussed and agreed with EUMETSAT.

Req. 38. Harmonized cal/char lab guidelines shall be delivered as TR D-12 v.1 to EUMETSAT. V.1 shall identify the specific points where there is a lack of clarity on cal/char standards or methods and these points shall be tested during the targeted lab inter-comparison exercise. The guidelines shall be reviewed (v.2) after being discussed and evaluated during the lab inter-comparison exercise and shall be ready for the OCR workshop (Task 8). They shall be again updated (v.3), if needed, after the inter-

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comparison exercises have been run and after calibrations have been carried out in Task 9.

- Req. 39. The report shall contain also guidelines for standard laboratory measurement setup for FRMOCnet OCR cal/char. V.2 shall include updates suggested during the lab inter-comparison exercise and shall be available for the workshop in Task 8 and the instrument calibrations before the field exercise (Req. 70).
- Req. 40. Inter-comparison laboratory exercise shall be run following the strategy agreed with EUMETSAT in Req. 36 with engaged laboratories and results shall be provided as a deliverable (D-13) to EUMETSAT. Data may be subjected to an embargo of two years from the date the exercise has been carried out, after which they shall be made available to broader community through the FRMOCnet Database (Req. 7).

Task deliverables
D-11 Strategy plan for the secondary laboratory cal/char inter-comparison exercise and the definition and harmonization of laboratory guidelines
D-12 TR: Harmonized cal/char lab guidelines, including lab protocols for FRMOCnet OCR models

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This Document is Public**2.7 Task 7 Community processor for in situ data processing and uncertainty budget calculation**

As outlined by the broader community and stated in [AD-7] and [AD-4], the application of different processing codes and subjective decisions limit the standardization of in situ FRM data. A community processor for in situ data is thus strongly needed.

In order to design and implement it, several steps are required to define proper protocols, input/output data format, and measurement uncertainty budgets.

2.7.1 Input

Req. 41. Input of the community processor shall be underwater/above water radiometric measurements and related ancillary information needed for Rrs/Normalized water-leaving Radiance estimation

Req. 42. The community processor shall be able to ingest input data in the most common formats that are adopted by instrument manufacturers, at least including the formats used by the two instrument models identified for FRMOCnet and characterised since phase 1. Contractor shall identify most common raw data format adopted and shall define a standard data format to be proposed as a guideline to manufacturers.

Req. 43. Community processor input data format options and description shall be provided as deliverable D-14. D-14 v.1 shall be delivered before Task 8 takes place, to be there discussed and refined.

2.7.2 Output

Req. 44. Output of the community processor shall be Rrs/Normalized water-leaving Radiance along the measured spectrum and the corresponding end-to-end Uncertainty Budget.

Req. 45. NASA Ocean Biology Processing Group's SeaBASS Database Data file format (https://seabass.gsfc.nasa.gov/wiki/Data_Submission#Data%20Format) shall be adopted as output data format, being required for submission to SeaBASS Database and Copernicus Ocean Colour In Situ Fiducial Reference Measurement Database (OCDB). Required metadata list shall be discussed with EUMETSAT and, if applicable, with review board experts.

2.7.3 In situ data handling processor

Req. 46. Output from Req. 23 - Req. 24, and Req. 41 - Req. 45, shall be then followed implementing a common processor for OCR above and in-water measurements data processing, which together with Community processor for uncertainty evaluation from Req. 50, shall produce standardized in situ FRM best quality data, and data uncertainty budget.

Req. 47. The processor shall be flexible enough to allow handling measurements gathered in complex waters, where standard protocols may not apply, and to be compliant with any protocol update.

Req. 48. The processor shall be open source and easily accessible by users. Python language should be preferred.

Req. 49. The coding shall be modular, clearly readable, commented, portable, as much generic as possible, and following EUMETSAT programming guidelines in Appendix A; any

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use of libraries with background IPRs and/or under commercial licence shall be submitted to prior EUMETSAT written approval.

2.7.4 Uncertainty budget calculation implementation

Req. 50. Following Req. 29 and Req. 32 outcomes, a community processor for end-to-end Uncertainty Budget shall be implemented. The processor shall be flexible enough to allow for differences between ideal and non-ideal instrument performance and to allow uncertainty budget calculation for measurements operated in complex waters, where standard protocols may not apply.

2.7.5 Community processor verification and validation, maintenance and versioning control

Req. 51. Processor ATBD (D-17 v.1), shall be preliminary delivered to EUMETSAT for approval.

Req. 52. Community processor software verification plan (D-20) shall be delivered by the contractor.

Req. 53. The software verification plan shall include test case suit, to be defined by the contractor, to test software functionality for any new release.

Req. 54. Software output validation shall be planned, including test cases to verify software output is correct and coherent with protocols defined in D-6, D-9 and D-10 for any new release.

Req. 55. The first verified and stable version of the community processor software (D-15) as well as its Architectural Design and User Manual (D-18D-18) shall be used and eventually refined during activities in Task 9.

Req. 56. The community processor software shall be released to EUMETSAT GITLab (Annex B) following milestone and version content in Table 1.

Req. 57. Any major change shall be discussed with and approved by EUMETSAT and, if applicable, review board experts.

Req. 58. Any new release shall be accompanied by updated deliverables from D-16 to D-19 and verification and validation reports.

Req. 59. Any anomaly and issue identified or enhancement proposed by EUMETSAT and by activity participants during Task 9, shall be collected by the contractor and shall be recorded and tracked through *Issue Tracker* tool in the dedicated GITLab Repository. Also anomaly and issue identified by EUMETSAT will be tracked through the same tool.

Table 1. Community processor version release milestones

Version	Content	Deadline
v.1	It shall include the implementation for any calculation as defined in Req. 46 to process row data to obtain Rrs/Normalized water-leaving Radiance estimation.	KO + 15

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v.2	It shall include Uncertainty Budget calculation implementation as in Req. 50 and fixes to any issue identified by EUMETSAT after v.1 release.	KO + 18 and before Task 9
v.3	It shall include any refinements and modifications identified during its usage in Task 9 and any issue identified by EUMETSAT after v.2 release. It shall also include any updates in applicable protocols/data in deliverables from D-6 to D-10	KO + 24
v.4*	It shall include the implementation for any modifications introduced following Req. 106 and Req. 107	KO + 33
v.5*	It shall include any refinements and modifications identified during its usage in Req. 100 and any issue identified by EUMETSAT after v.4 release.	KO + 36

(*) if first optional extension is granted.

Req. 60. Short training session (half a day) on the use of the community processor software (in person or remotely) shall be planned for EUMETSAT.

Req. 61. A maintenance manual shall be provided for future updates and development as deliverable D-19.

Task deliverables
D-14 Definition of standard raw data format for OCR measurements
D-15 Open source community processor for OCR above and in-water measurements data handling and uncertainty budget calculation
D-16 Community processor software release note
D-17 Community processor <i>Algorithm Theoretical Basis Documents (ATBD)</i>
D-18 Community processor <i>Architecture Design and User Manual document (ADUM)</i>
D-19 Community Processor software Maintenance Manual
D-20 Community processor Verification Plan and report
D-21 Community processor Validation Plan and report

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2.8 Task 8 OCR cal/char and measurements workshop

The goal of the OCR cal/char and measurement workshop is to discuss in detail the lessons learned from the developed FRMOCnet foundations and to ensure the new protocols and tools are reviewed and taken up by the community. The workshop shall advertise and encourage community uptake of the FRM principles.

Req. 62. A 3 days workshop on FRM OCR cal/char and measurements shall be planned by the Contractor (D-22) and organised at EUMETSAT premises to collect community and expert reviews and comments.

Req. 63. Deliverables linked to workshop themes shall be made available at least a month in advance of the workshop to its participants and shall be presented during the workshop and then refined, following workshop outcome.

Req. 64. Workshop agenda shall cover at least the following points:

- lessons learned from previous phase during inter-comparison laboratory and field activities
- Minimum requirements for instruments qualifications as FRM; possible steps and strategy towards instruments certification. Deliverable D-2 shall be here presented and refined. Specifications of minimum requirements for manufacturers (D-27) should also be addressed
- protocols and guidelines for operating OCR measurements (D-6) to be presented and refined
- guidelines for standard cal/char laboratory setup (D-12) and characterizations results (D-9) to be presented and refined
- long-term strategy plan for lab inter-comparison at a global level, across agencies and metrological institutions (D-11, D-13) to be presented and refined
- open source community processor ATBD and functionalities (D-15, D-17D-17). A practical demonstration of the use of the Community Processor shall be organised.

Req. 65. The workshop shall be announced in due time, at least five months in advance.

Req. 66. A list of experts to be invited shall be presented and discussed with EUMETSAT in advance.

Req. 67. The workshop can be opened to broader community. In this case, among interested users, the final list of participants shall be defined by the organizer and agreed with EUMETSAT.

Req. 68. Workshop recommendation shall be itemized and protocols, methodologies and tools shall be updated according to workshop outcomes.

Req. 69. Professional Workshop proceedings shall be published

Task deliverables
D-22OCR Workshop planning, logistics, agenda
D-23 OCR Workshop proceedings

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2.9 Task 9 FRM OCR instrument calibration and Field Inter-Comparison Experiment

The goal of the FRM instrument calibration and field experiment is to facilitate exchange of experience and understanding and acceptance of the FRM principles developed in this study. User training is also a major goal in practical in-the-field application of the FRM protocols for calibration and measurements and in using the community processor. Further primary aim is the practical and critical review of the developed protocols and tools and their update, as required.

For example, in FRM4SOC phase-1 a field Inter-Comparison Experiment was carried out ([AD-11]) at the Acqua Alta Oceanographic Tower (AAOT) and on the Atlantic Meridional Transect (AMT). The principal inter-comparison for above-water measurements was carried using TRIOS-RAMSES and SeaBird HyperOCR models, including several instruments belonging to different institutions and laboratories in Europe. In-water measurements, were also included.

Important points have been suggested by FRM4SOC Scientific and Operational Roadmap ([RD-1]):

- Inclusion of other radiometric systems, for both above water measurements and in water measurements and new technological developments plus autonomous sun tracker systems
- Extension of the activity to a wider global participation and a broader international range of participants

2.9.1 FRM OCR instruments calibration

Req. 70. OCR instruments calibration and characterization shall be performed in preparation for the field inter-comparison experiment following the protocols previously defined in Task 5 and 6.

Req. 71. Calibration should be done at one calibration facility and chronology and results shall be delivered to EUMETSAT through FRMOCnet Database (Req. 7) as deliverable D-24, in order to ensure that, for each radiometer, history can be gathered for long time calibration.

Req. 72. Calibration results shall be accessible and shall be comparable across different instruments/models.

Req. 73. Feedback for potential protocol updates following this activity shall be provided back to the Task 5 and Task 6 deliverables.

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2.9.2 FRM Field Inter-Comparison Experiment

In this second phase, it is also important to share lessons learned with the broader community, which needs to be trained on the use of protocols while operating FRM measurements and of the new Community processor while handling in situ data.

- Req. 74. The Contractor shall thus grant the participation of teams (at least one) others than the teams who joined the activity in FRM4SOC phase-1 field activities
- Req. 75. The Contractor shall present the list of possible invited teams and relative instruments. This list could be eventually refined before field activity takes place, in accordance with EUMETSAT.
- Req. 76. Phase-2 field inter-comparison experiment shall be carried out starting from lessons learned in phase 1 activity [AD-11].
- Req. 77. The two initial FRMOCnet OCR models shall be a part of the experiment. Additionally, other radiometric systems that are commonly used internationally can also be included, for both above and in-water methods, provided that calibration as in Req. 70 is for them implemented before field activity takes place.
- Req. 78. The activity shall be carried out in a location and in a period of the year which environmental conditions would not hinder the application of OCR measurement protocols, which may not apply to complex waters.
- Req. 79. Ancillary and complementary measurements (e.g. Inherent Optical Properties, pigments etc.) leading to remote sensing reflectance or fully normalised water-leaving radiance calculation shall be collected.
- Req. 80. FRM Protocols for operating in situ OCR measurements (Req. 23) shall be applied during inter-comparison experiment.

2.9.3 In situ data processing and uncertainty budget calculation

- Req. 81. Protocols and Community processor for data processing and uncertainty budget calculation shall be applied for in situ data processing, by the teams joining the activity, guided by the Contractor. Both protocols and processor shall be updated according to feedback coming from this activity.
- Req. 82. Evaluation and compilation of end-to-end uncertainty budgets for in situ measurements shall be carried out. This activity shall be done with the cooperation of all the teams owning the instruments, in order to train them. Results shall be delivered, as part of deliverable D-25.
- Req. 83. Data collected and processed during this task (including ancillary and complementary measurements) shall be made available to EUMETSAT as the deliverable D-25, through Copernicus FRM in situ Database facility (OCDB). An embargo of 2 years

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after data collection date could apply, after which data will be published to all users of the OCDB Database, and made available to the broader community for further reanalysis and independent scrutiny. The same applies to ancillary and complementary measurements (e.g. Inherent Optical Properties, pigments etc.) leading to remote sensing reflectance or fully normalised water-leaving radiance calculation.

Req. 84. Data shall be provided in the format required by OCDB Database and fully documented, by describing or referring to any measurement protocols adopted and Calibration/Instrument Reports, or providing reference to Calibration reports in FRMOCnet Database.

Req. 85. Uncertainty budget shall be associated with every measurement provided to OCDB Database.

2.9.4 Inter-comparison results

Req. 86. Results obtained from the inter-comparison analysis shall be delivered to EUMETSAT as D-26 v.1. A final version (v.2) shall be delivered at the end of the project after EUMETSAT review.

Task deliverables
D-24 DP: Chronology and results from instrument calibration
D-25 DP: Measurements collected in field experiment (both raw and QCed processed data), including ancillary and complementary measurements and end-to-end uncertainty budget calculation results
D-26 TR: <i>OCR field inter-comparison analysis results</i>

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2.10 Task 10 Specifications of minimum requirements for OCR instruments for manufacturers

This task, that could be done in collaboration with the OCR manufacturers, aims at identifying the minimum requirements which allow to classify an OCR instrument as FRM.

Req. 87. Specifications of minimum requirements for manufacturers that qualifies an OCR as FRM shall be defined.

Req. 88. A list of standard set of information needed for FRM classification of OCR to be provided by manufacturers shall be also defined.

Req. 89. Both, specifications and information identified in Req. 87 and Req. 88 shall be addressed also during OCR workshop in Task 8, which outreach shall be taken into account in the final version of deliverable D-27.

Task deliverables

D-27 TR: <i>Specifications of minimum requirements for qualification of OCR instrument as FRM instruments for manufacturers</i>

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2.11 Task 11 Outreach, communication and review process

In order to ensure new protocols and tools are taken up by the broader community, project outreach publications are strongly encouraged, in particular about OCR community processor, and FRMOCnet concept and protocols.

In addition,

Req. 90. A monthly report (D-28) shall be delivered to EUMETSAT by email, describing on going activities status, planned activity, findings, delays or issues (both technical and managerial).

Req. 91. At least one web story presenting new scientific results from this activity shall be prepared in cooperation and agreement with the EUMETSAT Technical Officer. The web story shall be provided to EUMETSAT (D-29) for publication on its web site.

Req. 92. The Contractor shall propose a design of the web pages from the study including user-friendly presentation of FRMOCnet and links to OCDB. The contractor shall contribute content for the study web pages containing information about the project, results and reports and shall maintain the web pages for the duration of this study.

Req. 93. The web site layout and content shall comply with the EUMETSAT webpage guidelines.

Req. 94. In addition to the OCR workshop (Req. 62) and laboratory/field exercises (Req. 76), where FRMOCnet outcomes shall be discussed and refined, the contractor of this study shall propose an independent review process.

Req. 95. Study reviews shall be conducted by a separate expert review team. The membership of the review team and the schedule of the reviews shall be proposed by the contractor and agreed with EUMETSAT (). Some of the reviews can be conducted during Ocean Colour community workshops and at other opportunities, if convenient and agreed with EUMETSAT.

Task deliverables
D-28 Monthly activity report
D-29 Web story

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2.12 Optional extensions requirements

Any of the 12-months optional extensions, if granted, shall be spent on

Req. 96. Maintenance of Copernicus OCDB Database. A new version of D-5 shall be delivered before the end of each granted option, including any changes or enhancement, identified during maintenance period.

Req. 97. Maintenance of FRMOCnet and related Database. A new version of D-3 (and relative D-4) shall be delivered before the end of each granted option, including any changes or enhancement, identified during the maintenance period.

Req. 98. Maintenance of the Community processor software.

Req. 99. Continuation of international cooperation

Req. 100. Repetition of inter-comparison exercises and analysis (1 for each year of extension).

Req. 101. Instruments calibration before the field experiment shall be carried out and results shall be delivered as a new version of D-9 in FRMOCnet Database.

Req. 102. At least one new team shall be involved in each field experiment different from the teams involved in the previous field experiment events.

Req. 103. After protocols for operating measurements in complex waters have been drafted (Req. 106), at least one field experiment shall be carried out in complex waters, to apply and verify them.

Req. 104. Data collected shall be processed and made available to EUMETSAT as in Req. 83 as a new version of D-25.

Req. 105. Results from the inter-comparison analysis shall be delivered as a new version of D-26.

If at least one of the optional extensions is granted,

Req. 106. Requirements and Protocols used when operating OCRs in complex waters shall be addressed and included in a new version of D-6.

Req. 107. Protocols and guidelines in D-10 shall be updated (v.4) to include a section describing a first approach for uncertainty budget calculation when deriving Ocean Colour parameters in complex waters, where standard protocols may not apply. An updated version shall be delivered (v.5) after feedback from experts following the field exercise has been addressed.

Req. 108. The Community processor (D-15 and relative deliverables, from D-16 to D-21) shall be updated accordingly to Req. 106-Req. 107. The first version shall be

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delivered in time to be used for in situ experiment data processing, and the final version at the final presentation, after feedback from experts following the field exercise has been addressed.

Req. 109. A plan for the definition of uncertainty budget compilation for bio-optical measurements shall be drafted as deliverable D-31.

If a second extension is granted:

Req. 110. The definition of the process and specifications of minimum requirements for bio-optical instrumentation to be included in FRMOCnet shall be carried out and delivered to EUMETSAT as deliverable D-32.

Req. 111. FRMOCnet (D-3, and relative D-4) shall be adapted in order to be able to host, if not possible yet, bio-optical instrumentation, identified through specification is D-32.

Req. 112. Protocols and guidelines in D-10 shall be updated (v.6) to include a section describing the first approach for uncertainty budget calculation when deriving bio-optical parameters, following the plan defined in D-31. An updated version shall be delivered (v.7) after feedback from experts following the field exercise has been addressed.

Req. 113. The Community processor (D-15 and relative deliverables, from D-16 to D-21) shall be updated accordingly to Req. 112. A first version shall be delivered in time to be used for in situ experiment data processing, and a final version at the final presentation, after feedback from experts following the field exercise has been addressed.

Req. 114. During yearly in situ experiment (Req. 100), bio-optical measurements shall be operated following biogeochemistry IOCCG protocol [AD-12]. Bio-optical parameters and relative uncertainty budget shall be derived using latest version of D-10 and D-15 from Req. 112 and Req. 113.

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3 SKILLS OF THE CONTRACTOR

Req. 115. The Contractor shall cover a broad range of skills associated with Ocean Colour product science and Ocean Colour algorithms.

Req. 116. Very good knowledge is required of Ocean Colour product validation with in situ measurements.

Req. 117. Very good knowledge and demonstrated hands-on experience are required of in situ radiometric measurements and protocols, as well as bio-optic measurements.

Req. 118. Very good knowledge and demonstrated hands-on experience are required of complete calibration and characterization of in situ radiometers, with SI traceability. Capability to develop SI-traceable processes for cal/char and complete uncertainty budget of in situ instruments is also required.

Req. 119. Very good knowledge and demonstrated hands-on experience are required to develop in situ radiometric protocols and a complete uncertainty budget of in situ measurements, accounting for all instrumental and environmental factors.

Req. 120. Good knowledge and demonstrated experience are required for processing of in situ radiometric measurements and propagating the uncertainty estimates.

Req. 121. Demonstrated experience is required with development of modular, clearly readable and adaptable scientific open source software, as well as in situ measurement databases.

Req. 122. Proven record of amicable collaboration across the Ocean Colour community is required, including the ability to establish cooperative networks and to achieve community leadership roles.

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4 GENERIC REQUIREMENTS

4.1 Scientific Review and Requirements Consolidation

The following requirements apply to all project tasks.

Req. 123. The Contractor shall start with an analysis of EUMETSAT requirements, and derive a consolidated and elaborated requirement set in a Requirements Baseline Document (RBD D-33).

Req. 124. A critical review of the state-of-the-art in the scientific field related each task involving the delivery of protocols and guidelines shall be prepared and presented in the Requirements Baseline Document.

Req. 125. The critical review shall be based on peer-reviewed scientific and technical publications.

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5 PROJECT ORGANISATION

5.1 Project Schedule

The study has a duration of 24 months, with two options of 12 months for further extension.

Following the KO (at EUMETSAT HQ), a trimestral progress meeting shall be organised in person at EUMETSAT HQ or via Teleconference. If needed, any additional progress meeting may be organised to discuss specific topics. A final presentation of the study shall take place at EUMETSAT HQ at KO + 21.

Some tasks require input from other tasks or iteration as shown in Figure 1. On the other hand, it is strongly recommended to bring forward some activities, when applicable (e.g. community processor may be ready to ingest instrument characterization and calibration results before characterization is completed or protocols are reviewed).

Req. 126. The project schedule shall follow the table below:

Project Milestone	Location	Timeframe (nominal***)
Kick-off (KO) <ul style="list-style-type: none"> • D-1 • D-30 • D-33 	EUMETSAT HQ	KO
Progress Meeting 1 <ul style="list-style-type: none"> • D-11 v.1 	Teleconference	KO + 3 months
Progress Meeting 2 <ul style="list-style-type: none"> • D-2 v.1 • D-5 v.1 	EUMETSAT HQ	KO + 6 months
Progress Meeting 3 <ul style="list-style-type: none"> • D-14 v.1 	Teleconference	KO + 9 months
Progress Meeting 4 <ul style="list-style-type: none"> • OCDB enhancement • D-6 v.1 • D-7 v.1 • D-8 v.1 • D-10 v.1 • D-12 v.1 • D-17 v.1 • D-20 • D-21 	EUMETSAT HQ	KO + 12 months
Progress Meeting 5 <ul style="list-style-type: none"> • D-3 v.1 • D-4 v.1 • D-6 v.2 	Teleconference	KO + 15 months

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<ul style="list-style-type: none"> • D-7 v.2 • D-8 v.2 • D-9 v.1 • D-10 v.2 • D-12 v.2 • D-14 v.2 • D-15 v.1 • D-16 v.1 • D-18 v.1 • D-19 v.1 		
Progress Meeting 5 <ul style="list-style-type: none"> • D-15 v.2 	Teleconference	KO + 18 months
Final Presentation <ul style="list-style-type: none"> • One hour seminar open to EUMETSAT's general audience • D-2 v.2 • D-5 v.2 • D-6 v.3 • D-10 v.3 • D-12 v.3 • D-26 v.1 	EUMETSAT HQ	KO + 21 months
Progress Meeting 7 <ul style="list-style-type: none"> • All deliverables final version 	Teleconference	KO + 24
Progress Meeting 8*	EUMETSAT HQ	KO + 27 months
Progress Meeting 9* <ul style="list-style-type: none"> • D-5 v.3 • D-6 v.4 • D-31 v.1 	Teleconference	KO + 30 months
Progress Meeting 10* <ul style="list-style-type: none"> • D-10 v.4 • D-15 v.4 	Teleconference	KO + 33 months
Final Presentation option 1* <ul style="list-style-type: none"> • D-3 v.3 • D-4 v.3 • D-10 v.5 • D-15 v.5 • D-26 v.3 • D-31 v.2 	EUMETSAT HQ	KO + 36 months
Progress Meeting 11**	Teleconference	KO + 39 months
Progress Meeting 12**	EUMETSAT HQ	KO + 42 months

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<ul style="list-style-type: none"> • D-5 v.5 • D-32 v.1 		
Progress Meeting 13** <ul style="list-style-type: none"> • D-10 v.6 • D-15 v.6 	Teleconference	KO + 45 months
Final Presentation option 2** <ul style="list-style-type: none"> • D-3 v.4 • D-4 v.4 • D-10 v.7 • D-26 v.4 • D-32 v.2 • D-15 v.7 	EUMETSAT HQ	KO + 48 months
* if first optional extension is granted ** if second optional extensions is granted ***Nominal timeframe may deviate and is specified in the Specific Requirements Document.		

EUMETSAT may contact the contractor regarding the progress of the study and/or for potential difficulties during the execution of the tasks defined in the present Statement of Work. Those interactions would be by teleconference or Webex.

5.2 Project Management

Req. 127. A Project Management Plan (PMP) shall permit to define, organise, monitor and control all the activities within the project, including the identification and mitigation of possible risks. The PMP shall be the controlling document for the project. It shall be prepared by the Contractor and submitted with the proposal. An update shall be reissued at every major change with EUMETSAT's approval.

Req. 128. The PMP shall provide a feasible and effective breakdown of the activities and shall include the following items (described below):

- Staffing Plan
- Key Personnel
- Work Breakdown Structure
- Work Packages
- Deliverables
- Facilities and Resources
- Project schedule monitoring and progress reporting
- Quality Plan
- Project History Document

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Req. 129. The management necessary for completion of all the tasks shall be the responsibility of the Contractor. This includes the management of any sub-contractors as well as the control of the Contractor's own resources.

5.3 Deliverables

Req. 130. The Contractor shall produce a detailed list of deliverables. The deliverables extracted from the requirements in the SoW shall include at a minimum:

Deliverable and description	Periodicity (nominal*)	Requirement(s)
D-1 <i>Project Management Plan (PMP)</i>	At KO	Req. 127
D-2 TR: <i>Specifications of minimum requirements for qualification of individual OCRs as FRM instruments and process for inclusion of any new instrument models in the FRMOCnet</i>	v.1: KO + 6 v.2: KO + 21	Req. 3
D-3 Database to host FRMOCnet specifications, data and documentation for the OCR models as well as for individual instruments and their deployment history.	v.1: KO + 15 v.2: KO + 24 v.3*: KO + 36 v.4**: KO + 48	Req. 7, Req. 8, Req. 12, Req. 97*, Req. 111**
D-4 FRMOCnet Database <i>Architecture Design and User Manual document (ADUM)</i>	v.1: KO + 15 Updated with any new release of Error! eference source not found.	Req. 11, Req. 97*, Req. 111**
D-5 OCDB Database WebUI, CLI, Python API, and Architecture Design and User Manual document, updated following requirements from Req. 13 to Req. 22.	v.1: KO + 6 v.2: KO + 21 v.3*: KO + 30 v.4**: KO + 42	Req. 13-Req. 22, Req. 96**
D-6 TR: <i>Measurement requirements and protocols when operating Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) and processing data deriving Remote Sensing Reflectance for Satellite Validation – phase 2</i>	v.1: KO + 12 v.2: KO + 15 v.3: KO + 21 v.4*: KO + 30	Req. 23-Req. 27, Req. 106*

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D-7 TR: <i>Complete characterization and calibration results for FRMOCnet OCR models and re-characterization routine: an update</i>	v.1: KO + 12 v.2: KO + 15	Req. 28
D-8 TR: Guidelines for individual OCR full characterization and calibration	v.1: KO + 12 v.2: KO + 15	Req. 31
D-9 DP: FRMOCnet OCR models full characterization and calibration results	At least once at KO + 15 Updated according to established routine in Req. 30 and after any calibration done during optional extensions	Req. 29, Req. 101*
D-10 TR: <i>Protocols for uncertainty budget calculation of FRMOCnet OCR and practical guide for OCR measurement end-to-end uncertainty budget calculation</i>	v.1: KO + 12 v.2: KO + 15 v.3: KO + 21 v.4*: KO + 33 v.5*: KO + 36 v.6**: KO + 45 v.7**: KO + 48	Req. 32-Req. 35, Req. 107*, Req. 112**
D-11 Strategy plan for the secondary laboratory cal/char inter-comparison exercise and the definition and harmonization of laboratory guidelines	v.1: KO + 3	Req. 36
D-12 TR: Harmonized cal/char lab guidelines, including lab protocols for FRMOCnet OCR models	v.1: KO + 12 v.2: KO + 15 v.3: KO + 21	Req. 37-Req. 39
D-13 <i>Lab cal/char inter-comparison exercise</i>	v.1: KO + 21	Req. 40
D-14 Definition of standard raw data format for OCR measurements	v.1: KO + 9 v.2: KO + 15	Req. 42-Req. 43
D-15 Open source community processor for OCR above and in-water measurements data handling and uncertainty budget calculation	v.1: KO + 15 v.2: KO + 18 v.3: KO + 24	Req. 41-Req. 51, Req. 55-Req. 59, Req.

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	v.4*: KO + 33 v.5*: KO + 36 v.6**: KO + 45 v.7**: KO + 48	108*, Req. 113**
D-16 Community processor software release note	v.1: KO + 15 Updated with any new release of D-15	Req. 58
D-17 Community processor <i>Algorithm Theoretical Basis Documents (ATBD)</i>	v.1: KO + 12 Updated with any new release of D-15	Req. 51
D-18 Community processor <i>Architecture Design and User Manual document (ADUM)</i>	v.1: KO + 15 Updated with any new release of D-15	Req. 55
D-19 Community Processor software Maintenance Manual	v.1: KO + 15 Updated with any new release of D-15	Req. 61
D-20 Community processor Verification Plan and report	KO + 12 For reports, after any new release of D-15	Req. 52
D-21 Community processor Validation Plan and report	KO + 12 For reports, after any new release of D-15	Req. 54
D-22 OCR Workshop planning, logistics, agenda	KO + 4 and up to WS	Req. 62
D-23 OCR Workshop proceedings	KO + 24	Req. 69
D-24 DP: Chronology and results from instrument calibration	After any instrument calibration activity	Req. 70, Req. 105*

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D-25 DP: Measurements collected in field experiment (both raw and QCed processed data), including ancillary and complementary measurements and end-to-end uncertainty budget calculation results	A new DP shall be delivered any field experiment activity Eventual updates for each DP can be submitted by data PIs through OCDB	Req. 82-Req. 85, Req. 104*
D-26 TR: <i>OCR field inter-comparison analysis results</i>	v.1: KO + 21 v.2: KO + 24 v3*: KO + 36 v4**: KO + 48	Req. 86, Req. 100*
D-27 TR: <i>Specifications of minimum requirements for qualification of OCR instrument as FRM instruments for manufacturers</i>	v.1: KO + 21	Req. 87- Req. 89
D-28 Monthly activity report	Monthly	Req. 90
D-29 Web story	v.1: KO + 21	Req. 91
D-30 Establishment of expert review board	v.1: KO	Req. 95
D-31 Plan for uncertainty budget compilation for bio-optical measurements	v.1*: KO + 30 v.2*: KO + 36	Req. 109*
D-32 TR: <i>Specifications of minimum requirements for qualification of bio-optical instruments as FRM instruments and process for inclusion of any new instrument in the FRMOCnet**</i>	v.1: KO + 42 v.2: KO + 48	Req. 110**
D-33 Requirements Baseline Document (RBD)	v.1: KO	Req. 123-Req. 125

(*) if first optional extension is granted

(**) if second optional extensions is granted

Req. 131. The last version indicated for any deliverable, shall be revised by EUMETSAT and eventually updated by Contractor, following EUMETSAT reviews. A final version shall be delivered to EUMETSAT before the closure of the project.

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5.3.1 Documents

Req. 132. All documents shall be in English and shall be delivered in Portable Document Format (PDF) and Microsoft Word.

Req. 133. At least 5 working days shall be available for each document's review by EUMETSAT.

Req. 134. The contents of ATBD documents shall be as follows:

- Algorithm Description
 - Processing Outline
 - Algorithm Input
 - Theoretical Description
 - Physical Description
 - Mathematical Description
 - Algorithm Output
 - Practical Considerations
 - High-Level Description of the Prototyped Software
 - Numerical Computation Considerations
 - Programming and Procedural Considerations
 - Quality Assessment and Diagnostics
 - Exception Handling
- Assumptions and Limitations
 - Performance Assumptions
 - Potential Improvements

Req. 135. The contents of the installation and software user manual shall be as follows:

- Purpose of the software
- Contents of the software delivery
- Operational environment
 - Hardware configuration
 - Software configuration
 - Operational constraints
 - External dependencies
- Installation
 - Setup and initialisation
 - Verification
- Operations manual
 - Getting started
 - Normal operations
 - Error conditions

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5.4 Customer Furnished Items

- [R- 1] EUMETSAT shall provide existing OCDB Database user manual, python API and CLI code, as well as users' feedback from testing phase and access to VM where OCDB is deployed
- [R- 2] For the deployment of FRMOCnet Database, access to VM by the Contractor shall be granted by EUMETSAT if needed
- [R- 3] EUMETSAT shall provide access to dedicated GITLab repositories to the Contractor

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5.5 QUALITY ASSURANCE REQUIREMENTS

EUMETSAT shall have the right in any activity during the contract duration, to call and perform Quality Assurance audits and to call Quality Assurance reviews and perform test witnessing of the premises of the contractor and its sub-contractors.

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APPENDIX A EUMETSAT REQUIREMENTS ON THE CODING PRACTICES

EUMETSAT requirements on the coding practices are listed below:

- The coding of all application prototype software shall be in accordance with generally accepted standards and software quality metrics, which shall be agreed with EUMETSAT.
- The coding of all application prototype shall be in a language that is portable between different computer platforms i.e. using a Write Once Run Anyway (WORA) or Write Once Compile Anyway (WOCA) language. This supports the flexibility of choosing the platform for hosting the operational implementation. The software code shall follow industry standards and software quality metrics, which shall be agreed with EUMETSAT before implementation.
- The programming language(s) for all software developments shall be approved by EUMETSAT.
- Each major module of the software developed as part of the contract, shall start with a comment section, which shall identify its functionality.
- All the comments in the software code shall be written in English.
- The Contractor shall use a software configuration management tool. The use of GITLab is mandatory.
- The software provided will ultimately be shared publicly through a repository on the EUMETSAT GITLab platform. For this, the (software/code) will be submitted to a quality assurance process at EUMETSAT. The requirements for this process are outlined below:
 - Software must be committed to a private Git repository within the EUMETSAT GITLab for review and development by EUMETSAT staff and the contractors.
 - Software shall be supplied with auxiliary files (authors, license, and readme), for which templates will be provided.
 - EUMETSAT will select an appropriate license taking into account all intellectual property considerations.
 - IPR conflicts from the contractor side (if software has dependencies) must be declared and discussed with EUMETSAT.
 - Use of software standards, where relevant, is encouraged. For example, PEP8 (<https://pep8.org/EXT>) could be considered for Python based software.
 - Software shall be extracted (if not already written as such) to a plain text format for ingestion into quality assurance software.
 - EUMETSAT will provide a report with regards to identified plagiarism and IPR issues. Contractors are required to support revisions of the software to resolve issues identified during the review process.
- The Contractor shall obtain EUMETSAT's written approval prior to using any Commercial Off-The-Shelf (COTS), open source or other third party-licensed software that may become, or may become required to use, a deliverable under this Contract. Such request for approval shall be made for each COTS, open source and third party-licensed software as early as possible and shall include a description of its benefits, the complete associated licence terms and conditions and the proposed maintenance approach. EUMETSAT's approval shall not relieve the Contractor from his obligations towards EUMETSAT.