Concept of the Centre for Aerosol In Situ Measurements

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Note: Operation support marked with * in the following sections is mandatory to be organized and provided by this Central Facility.
1 Purpose of the document

This document describes the relevance, mission, requirements and obligations of the ACTRIS Centre for Aerosol In Situ Measurements.

2 Description and role of the Centre for Aerosol In Situ Measurements

2.1 Framework

ACTRIS is the European platform for fostering the use of research data and data analysis tools in the field of atmospheric aerosols, clouds, and reactive trace gases. ACTRIS Central Facilities (CFs) represent the key operative entities of this Research Infrastructure (RI) and have a fundamental role as they provide services to the users according to the ACTRIS access policy as well as operation support to the National Facilities (NFs). CFs are operated at the European level and are part of the governance and decision-making structure of the RI. Each CF may have several operational Units that can be located in the same or different locations, and are operated by research performing organizations (RPOs) or by ACTRIS ERIC. The CFs link the NFs, i.e. the observational and exploratory platforms, which are operated at the national level and produce the majority of the ACTRIS measurement data.

The Centre for Aerosol In Situ Measurements is one of the six ACTRIS Topical Centres (TCs) organized around the main scientific themes of ACTRIS: aerosols, clouds, and reactive trace gases, each with a particular focus on either remote sensing or in situ measurement techniques.

2.2 Scientific relevance

Aerosol particles play an important role in atmospheric physics and chemistry. They contribute not only health effects, but also influence directly radiative climate forcing and indirectly by acting as cloud or ice nuclei. They are thus involved into the hydrological cycle, supply nutrients to oceanic and terrestrial ecosystems, influence heterogeneous atmospheric chemistry, lead to adverse health effects, and reduce visibility. In contrast to trace gases, which have “a” concentration, aerosol particles have multi-dimensional properties. First, aerosol particles cover a size range from 0.001 µm to approximately 100 µm, making them subject to size-dependent aerosol microphysical processes. Aerosol particles of a certain size may also have different shapes, leading to different particle surface areas, which is important, for instance, for heterogeneous chemical processes. Moreover, particles of the same size can have different chemical composition, and compounds in the particle can either be liquid or solid. Not all of these dimensions can be currently accounted for by appropriate measurement techniques, but the most relevant ones with respect to climate forcing and air quality shall be measured at the ACTRIS aerosol in situ NFs. These are currently (2018):
• Particle number size distribution – mobility diameter (0.01 - 0.8 \( \mu \)m)
• Particle light scattering and backscattering coefficient (multi-wavelengths)
• Particle light absorption coefficient and equivalent black carbon concentration
• Mass concentration of particulate organic and elemental carbon
• Particle number size distribution – optical and aerodynamic diameter (0.7 - 10 \( \mu \)m)
• Particle number concentration (> 0.01 \( \mu \)m)
• Mass concentration of particulate elements
• Mass concentration of particulate organic tracers
• Cloud condensation nuclei number concentration (at various supersaturations)
• Mass concentration of non-refractory particulate organics and inorganics
• Nanoparticle number concentration (< 0.01 \( \mu \)m)
• Nanoparticle number size distribution (0.001 - 0.02 \( \mu \)m)

Accordingly, operation support with respect to quality assurance and quality control (QA/QC) is needed for these variables in ACTRIS and this is described in this document.

The ACTRIS aerosol in situ observations already started to be established in the framework of the European projects CREATE (Construction, use and delivery of a European aerosol database, 2003 - 2005) and EUSAAR (European Supersites for Atmospheric Aerosol Research 2006 - 2011). In the ACTRIS-1 (2011 - 2015) and ACTRIS-2 (2015 - 2019) European projects this development was intensified, with a particular focus on harmonization, quality assurance and quality control. Now, in ACTRIS PPP (2017 - 2019) the definition and selection of aerosol in situ NFs and the respective TC shall be organized.

2.3 Mission

The mission of the Centre for Aerosol In Situ Measurements is to offer operation support to ACTRIS NFs operating instruments for the physical or chemical in situ characterization of atmospheric aerosol particles as well as for particle sampling and subsequent laboratory analysis of these particles.

Additionally, the Centre for Aerosol In Situ Measurements should offer specialized services for the above instruments and related ACTRIS variables, to ACTRIS users of various types: academia, business, industry and public services.
3 Operation support provided to ACTRIS National Facilities

The operation support provided by the Centre for Aerosol In Situ Measurements comprises: a) procedures and tools for quality assurance and quality control of ACTRIS measurements and data, b) transfer of knowledge and training to ACTRIS operators, and c) improvements of measurement methodologies for aerosols, clouds, and reactive trace gases. The operation support is offered to the NFs for the measurement techniques described in this concept document, also listed in the Technical concepts and requirements for ACTRIS Observational Platforms.

The Centre for Aerosol In Situ Measurements is obliged to put in place and offer to NFs the specific operation support marked with * in this document. Other operation support described in this document is not mandatory for the TC, but recommended.

The operation support can be scheduled or on request. Participation at the scheduled activities is mandatory for the NFs. Measurements not following the mandatory actions are not considered as ACTRIS-conform and do not yield ACTRIS data.

In addition, NFs may request operation support which is not scheduled, depending on the identified need. Specific operation support offered as scheduled or offered on request is detailed in Annex: Provision of the operation support. This annex shall be updated each time is necessary (e.g. development of new testing or calibration methods and tools).

The Centre for Aerosol In Situ Measurements should operate at the state-of-the-art, fostering the implementation of validated new techniques in ACTRIS. To sustain a high level of performance and to stimulate the advancement of new techniques and methodologies, the Centre for Aerosol In Situ Measurements contributes to expert collaboration networks.

3.1 Measurement techniques covered by the Centre for Aerosol In Situ Measurements, and related ACTRIS variables

3.1.1 Particle number size distribution - mobility diameter

A mobility particle size spectrometer (MPSS) is used to measure the particle number size distribution of the submicrometer size range from approximately 0.01 to 0.8 µm. The technology is well established and is commercially available, but there are also custom designed measurement systems. A MPSS is robust and designed for long-term operations. However, it need regular checks on-site to quality-assure the measurement. The MPSS includes also a Condensation Particle Counter (CPC), which ideally has to undergo frequent on-site checks. This is done by a Round-Robin test with CPCs, which are sent from station to station. Additionally, annual or every second year calibrations of the entire MPSS and the CPC against a reference instruments are required. In case the MPSS instrument performance is not controlled, MPSS might drift with time causing unnoticed biases in both particle sizing and particle number concentration of up to several ten percent.
3.1.2  Particle light scattering and backscattering coefficient
Currently (2018), an integrating nephelometer is used to determine the particle light scattering and backscattering coefficient, usually for the PM\textsubscript{10} size range. The technology is well established and instruments are available from two manufacturers. Integrating nephelometers are robust and designed for long-term operations. Regular on-site gas calibrations are done with a frequency of at least once per three month to quality-assure the measurement. These calibrations are a common standard procedure already. Additionally, annual or every second year calibrations against a reference instrument are required. In case the nephelometer performance is not controlled, nephelometers might drift with time causing an unnoticed bias of up to several ten percent.

3.1.3  Particle light absorption coefficient and equivalent black carbon concentration
Generally, filter-based absorption photometers are used to determine the particle light absorption coefficient. The equivalent black carbon concentration mass concentration can be estimated from this. Usually for regional site, the measurements are done for the PM10 size range, while for urban station also PM1 can be required. The technology is well established and different instruments are available covering different number of wavelengths. Absorption photometer are robust and designed for long-term operations. However, they need regular checks to quality-assure the measurement, especially in terms of cleaning. Additionally, annual or every second year calibrations against a reference instrument are required. In case the absorption photometer performance is not controlled, absorption photometers might drift with time causing an unnoticed bias of up to several ten percent.

3.1.4  Mass concentration of particulate organic and elemental carbon
Particulate organic and elemental carbon concentrations are determined from the thermal-optical analysis on atmospheric particulate matter deposited on filters. Thermal-optical analysers actually determine the mass of total carbon deposited on the filter. Total carbon is split in OC and EC by measuring the aerosol deposit light transmittance during the thermal analytical process. The measurement of OC and EC deposited on filters is described in the European standards EN 16909. It states that OC and EC shall be determined using the thermal protocol EUSAAR-2 (Cavalli et al., 2010), also described in EN16909. This protocol is currently used by most research performing organisations in Europe. However, the 14 inter-laboratory comparisons organised across Europe show that various instruments lead to different determination of total carbon and OC or EC content in the same filter. Support is therefore needed to determine systematic error (bias) or random error (variability) in the determination of the total carbon, OC and EC variables. The errors generally observed are about 10% for total carbon and 25% for EC. Feedback provided to the beneficiaries by the TC can help reduce systematic biases. At least, bias and variability communicated to the beneficiaries can be clearly associated to the final data products.
3.1.5 Particle number size distribution – optical and aerodynamic diameter

For the upper accumulation and coarse more size ranges, optical and aerodynamic particle size spectrometers (OPSS and APSS) are employed. The technology of the APSS is well established and is commercially available from one manufacturer. The APSS is robust and designed for long-term operations. There a different OPSS on the market, from which most could be used for long-term measurements. However, APSS and OPSS need regular checks on-site for sizing to quality-assure the measurement. Additionally, annual or every second year calibrations against a traceable standards and reference instruments are required. In case OPSS or APSS performance is not controlled, OPSS or APSS instruments might drift with time causing an unnoticed bias of up to several ten percent.

3.1.6 Particle number concentration

A condensation particle counter (CPC) is used to measure the particle number concentration for particle greater than 0.01 µm. The technology is well established and is commercially available from different manufacturers. The CPC is robust and designed for long-term operations. However, it need regular checks on-site to quality-assure the measurement, especially in terms of cleaning the saturator and the optics. Additionally, annual calibrations the CPC against a reference instrument are required. In case CPC performance, the counting efficiency, is not controlled, CPCs might drift with time causing an unnoticed bias of up to several ten percent.

3.1.7 Mass concentration of particulate elements

Mass concentration of particulate elements are determined by several analytical techniques

- Particle Induced X-ray Emission (PIXE)
- Energy Dispersive X-Ray Fluorescence (ED-XRF)
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
- Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES)

The quantification of particulate elements by these techniques depends on internal and/or external calibration. Trained practitioners are needed to produce high quality data that have passed various QA/QC measures. Previous inter-laboratory comparisons have shown that the various techniques can lead to different determination of aerosol elemental components in the same filter sample. Thus, feedback provided to the beneficiaries by the TC will reduce systematic biases. Audits in the form of inter-laboratory comparisons and Round-Robin tests with reference samples are needed to evaluate the performance of each single technique and/or experimental set-up.
3.1.8 Mass concentration of particulate organic tracers

Several analytical techniques are used to determine the Mass concentration of particulate organic tracers including:


- **Gas Chromatography Mass spectrometry (GC/MS):** Curie-Point-Pyrolysis Gas Chromatography with Mass Spectrometry (CPP-GCMS), standard GCMS applications with derivatisation procedures

- **Ion Chromatography Pulsed Amperometric Detection (IC/PAD)**

The quantification of organic tracers by these techniques highly depends on internal and external calibration. Thus, well trained operators are needed to produce high quality data that has passed various QA/QC measures. Also audits in the form of inter-laboratory comparisons and Round-Robin test with reference compounds are needed to evaluate the performance of each single system.

3.1.9 Cloud condensation nuclei number concentration

A cloud condensation nuclei counter (CCNC) is used to measure the Cloud condensation nuclei number concentration at different supersaturations and possibly as function of particle size. The technology is established and is commercially available from one manufacturers. The CCNC designed for long-term operations. However, it needs regular calibrations with a standard aerosol (every six month) on-site to quality-assure the measurement. Additionally, annual or every second year calibrations the CCNC against a reference instrument are required. In case CCNC performance is not controlled, CCNC flow might change with time causing an undefined supersaturation in the instrument and a bias in the measured number concentration.

3.1.10 Mass concentration of non-refractory particulate organics and inorganics

An Aerosol Chemical Speciation Monitor is designed for in situ measurement of non-refractory submicron (NR-PM1) aerosol chemical species, on a time-basis of typically 30 min. Measured species include nitrate, sulphate, ammonium, chloride and organic aerosols. Further data treatments are also allowing for source apportionment studies, notably of the organic fraction. It is based on a rather simple and robust technology, and its suitability for continuous monitoring has been demonstrated within ACTRIS in the last 6 years. However, its operation and data production required the involvement of experienced users. Indeed, several calibration steps must be completed regularly and non-trivial raw data correction procedures have to be performed carefully. Moreover, the instrument technology and data treatment tools (e.g., upgrade of key parts of the analyser, detection and adjustments of measurement
artefacts, etc.) are still constantly evolving. It is then necessary to perform intercomparison campaigns and update best practice documents, in order to ensure accurate final data products. The uncertainty of the latter ones will notably depend on the availability of the TC unit to evaluate and harmonize the procedures raw data correction, notably including correction of measurement artefacts.

3.1.11 Nanoparticle number concentration

Atmospheric aerosol number concentration below 0.002 µm in size (Kulmala et al. 2012) is observed with a Particle Size Magnifier, which is a dual stage Condensation Particle Counter (Vanhanen et al. 2011). In the PSM the aerosol is turbulently mixed with air saturated with diethylene glycol, therefore creating a supersaturation high enough to activate even 0.001 µm ions, the nominal cut-off size being about 0.0015 µm. The 50% activation diameter can be varied between 0.001 and 0.0025 µm in mobility diameter by changing the mixing ratio of the saturator and sample flows. The PSM allows us to determine aerosol number concentrations between 0.001 to 0.0025 µm as well as their initial growth rate as a function of particle size (Lehtipalo et al. 2014). This will enable comparison between number concentration measurements with larger cut-off diameters. Similar instruments are now in the market by other manufacturers as well.

3.1.12 Nanoparticle number size distribution

There is a need to extend the size range of ACTRIS MPPS systems (Wiedensohler et al. 2012) below 0.02 µm. Here we utilize a well-established ultra-fine DMPS system of Aalto et al. 2001. However, we will drive towards development by utilizing higher resolution differential mobility analysis in combination with higher flow rate condensation particle counter and minimized particle diffusion losses in the sampling line as illustrated in Kangasluoma et al. 2017 (submitted). This facilitates better counting statistics in low concentrations as well as more detailed size classification in sub-0.01 µm size range.

Neutral Cluster and Air Ion Spectrometer (NAIS) measures electrical mobility distribution of naturally charged and total nanoparticles in high time resolution utilizing two parallel DMA columns. The size range is 0.002 – 0.042 µm and 0.0008 – 0.042 µm for the neutral aerosols and ions, respectively. The NAIS is a robust, field-worthy instrument, which can be operated for extended periods unattended (Manninen et al. 2010).
3.2 **Estimation of the need**

Numbers in the following table are based on QA/QC expert estimates and information by the countries how many NFs they potentially want to contribute to ACTRIS.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of NFs to which the TC is providing operation support</th>
<th>Now</th>
<th>by 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>1. Particle number size distribution – mobility diameter</td>
<td></td>
<td>40</td>
<td>70 110</td>
</tr>
<tr>
<td>2. Particle light scattering and backscattering coefficient</td>
<td></td>
<td>40</td>
<td>70 110</td>
</tr>
<tr>
<td>3. Particle light absorption coefficient and equivalent black carbon concentration</td>
<td></td>
<td>50</td>
<td>70 110</td>
</tr>
<tr>
<td>4. Mass concentration of particulate organic and elemental carbon</td>
<td></td>
<td>20</td>
<td>30 55</td>
</tr>
<tr>
<td>5. Particle number size distribution - optical and aerodynamic diameter</td>
<td></td>
<td>10</td>
<td>60 100</td>
</tr>
<tr>
<td>6. Particle number concentration</td>
<td></td>
<td>20</td>
<td>60 100</td>
</tr>
<tr>
<td>7. Mass concentration of particulate elements</td>
<td></td>
<td>5</td>
<td>20 45</td>
</tr>
<tr>
<td>8. Mass concentration of particulate organic tracers</td>
<td></td>
<td>5</td>
<td>30 60</td>
</tr>
<tr>
<td>9. Cloud condensation nuclei number concentration</td>
<td></td>
<td>10</td>
<td>20 45</td>
</tr>
<tr>
<td>10. Mass concentration of non-refractory particulate organics and inorganics</td>
<td></td>
<td>20</td>
<td>25 50</td>
</tr>
<tr>
<td>11. Nanoparticle number concentration</td>
<td></td>
<td>5</td>
<td>10 30</td>
</tr>
<tr>
<td>12. Nanoparticle number size distribution</td>
<td></td>
<td>10</td>
<td>20 40</td>
</tr>
</tbody>
</table>
3.3 **Operation support for quality assurance and quality control**

3.3.1 **Definition and establishment of standard operation procedures**

3.3.1.1 **Particle number size distribution – mobility diameter**

Measurement guidelines to operate mobility particle size spectrometers for long-term atmospheric observations have been developed during EUSAAR and ACTRIS. These have been published in Wiedensohler et al. (2012) as well as in the WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations (report no 227).


For the existing NFs, the guidelines should be in place.

3.3.1.2 **Particle light scattering and backscattering coefficient**

Measurement guidelines to operate integrating nephelometer for long-term atmospheric observations have been developed during EUSAAR, ACTRIS and within the GAW community. These have been published in the WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations (report no 227).


For the existing NFs, the guidelines should be in place.

3.3.1.3 **Particle light absorption coefficient and equivalent black carbon concentration**

Measurement guidelines to operate absorption photometers for long-term atmospheric observations have been developed during EUSAAR, ACTRIS and within the GAW community. These have been published in the WMO/GAW Aerosol Measurement Procedures, Guidelines and Recommendations, report no 227.


For the existing NFs, the guidelines should be in place.

3.3.1.4 **Mass concentration of particulate organic and elemental carbon**

A European standard (EN 16909) for the measurement of OC and EC in ambient PM samples deposited on filters has been published (2017). It is mainly based and fully consistent with the SOP for the measurement of OC and EC developed under ACTRIS. The objectives of this SOP is that thermal-optical analysers are optimally operated, and above all that the necessary QA/QC operations are carried at the frequency needed to ensure data quality and traceability. The TC shall be responsible to check that the SOPs have been correctly followed before validating OC and EC data. While the SOP for off-line analyses is already in place, a SOP for semi-continuous instrument shall be developed, mainly focusing on the instrument calibration and participation in Round-Robin test. New SOPs shall be developed if new instrumentation types emerge.

3.3.1.5 **Particle number size distribution – optical and aerodynamic diameter**

Measurement guidelines for optical and aerodynamic particle size spectrometers have not been developed for atmospheric observations. This is the task for the preparation phase of ACTRIS, working together with metrology institutes.
3.3.1.6 Particle number concentration

Measurement guideline for condensation particle counters are described in the standard FprCEN/TS 16976 developed in the working group CEN TC 264, WG 32, in which ACTRIS was actively involved.

3.3.1.7 Mass concentration of particulate elements

Firstly SOPs shall be developed tailored to each analytical technique, then these SOPs shall be distributed to the NFs, and discussed and trained within the trainings at the TC. The successful implementation of the SOPs shall be controlled by continuous inter-laboratory comparisons. All SOPs (if not already available at the TC) shall be developed during the implementation phase and shall be fully available with the start of the operational phase. SOPs will address the sample treatment (filter material, sampling procedure, level of purity for solvents and extraction procedures when applicable, sample storage, etc.) and the use of proper calibration standards.

3.3.1.8 Mass concentration of particulate organic tracers

At a first stage SOPs shall be developed focusing on sample preparation, as this strongly affects the results of the analysis. In a second stage SOPs shall be provided recommending certain measurement techniques for each class of compounds to be analysed. These SOPs shall be distributed to the NFs and discussed and trained within the trainings at the TC. The successful implementation of the SOPs shall be controlled by continuous ILCs. If certain users are not able to follow the recommend measurement techniques (e.g. due to money issues) the TC will provide minimum requirements on alternative techniques (calibration, response factors, detection limits etc.).

All SOPs (if not already available at the TC) shall be developed during the implementation phase and shall be fully available with the start of the operational phase. For new classes of compounds or if fundamental new techniques emerge the TC will provide improved SOPs. Besides the recommendation of certain measurement techniques SOPs will address the following points:

- sample treatment: filter material, sampling proceeding, level of purity for solvents, extraction proceeding, derivatisation proceeding (if applicable), sample storage and maximum storage time
- authentic standard compounds: supplier or synthesis proceeding, level of purity, storage, stability

3.3.1.9 Cloud condensation nuclei number concentration

Measurement guidelines to cloud condensation nuclei counter for long-term atmospheric observations have been developed during ACTRIS. They are available at http://actris.nilu.no/Content/SOP. For the existing NFs, the guidelines should be in place.
3.3.1.10 Mass concentration of non-refractory particulate organics and inorganics

Preliminary measurement guidelines have been defined within ACTRIS FP7 and ACTRIS2 H2020 projects. The TC unit shall be responsible for further updating related documents as well as new measurement guidelines for the ACSM calibration and operation. It shall also define rules for the transformation of raw data into level 1.5 validated data. All relevant procedures shall be openly shared and discussed amongst the user community, and will evolve over time based on the improving knowledge of the instrument operation. Likewise, the TC might develop and implement new measurement guidelines for every additional online aerosol chemical monitors being included into the field of the ACTRIS aerosol in situ TC (e.g. note that the TC unit will not be responsible for establishing procedures for the repair or heavy maintenance of the instrument (which is left to the manufacturer), but it can participate in the elaboration and/or the diffusion (e.g., through wiki pages, dedicated website, ...) of relevant material (such as technical videos, e-learning tutorials, etc.).

3.3.1.11 Nanoparticle number concentration

The optimization and harmonization work of the number concentration measurements with the PSM relies on the work presented in Kangasluoma et al. 2016, which describes the inlet configurations. In the next years this is complemented by including a standardized method for performing a PSM cut-off calibration with one organic and one inorganic test aerosol, and a harmonized sample dilution that is a prerequisite in high number concentration environments, such as in China. Further harmonization for the field operation of the PSM shall be provided with regards to the particle composition and sample flow temperature and RH. The PSM data inversion is described in Lehtipalo et al. 2014. The knowledge is collected into a PSM SOP by 2021. The responsibility of the TC is to develop and refine the abovementioned SOPs and distribute them within ACTRIS RI. The process is facilitated by SOP workshops organized at the TC for the NF operators.

3.3.1.12 Nanoparticle number size distribution

The procedures and measurements with the NAIS instrument was harmonized in ACTRIS. The corresponding document is published for the scientific audience in Manninen et al. 2016. This document describes the installation, sampling, operation and data analysis procedures for the NAIS. Within EUCAARI-project (Kulmala et al. 2010), the NAIS data protocols were developed enabling data delivery to EBAS. This shall be reinstated and put into operational phase by 2021 with near real-time data delivery. The sub-0.01 µm size distribution measurements follow the general guidelines and best practices set for sub-micron aerosol number size distribution measurements (Wiedensohler et al. 2012) with the specific focus on minimizing nanoparticle losses by optimizing the sample lines and increasing sample flow rates. A new SOP for the sub-0.01 µm size distribution shall be elaborated during the following years and the use of high resolution Differential Mobility Analysers and higher sample flow rates for the Condensation Particle Counters are explored. The technical target for this activity is to
improve the coherence of sub-0.01 µm size distribution measurements and bring this capacity into a wider use within ACTRIS. The next for the SOPs should be ready by 2025. The responsibility of the TC is to develop and refine the abovementioned SOPs and distribute them within ACTRIS RI. The process is facilitated by SOP workshops organized at the TC for the NF operators.

3.3.2 Definition of measurement quality-assurance criteria and procedures*

3.3.2.1 Particle number size distribution – mobility diameter
The on-site quality assurance are described in detail in the publication of Wiedensohler et al. (2012) and at [http://www.wmo-gaw-wcc-aerosol-physics.org/recommendations.html](http://www.wmo-gaw-wcc-aerosol-physics.org/recommendations.html). Diagnostic data from the MPSS such as temperature, relative humidity and flow rates are the base for data flagging.

3.3.2.2 Particle light scattering and backscattering coefficient
Quality assurance procedures are related to on-site gas calibrations, which have to be done regularly as described at [http://www.wmo-gaw-wcc-aerosol-physics.org/recommendations.html](http://www.wmo-gaw-wcc-aerosol-physics.org/recommendations.html). Diagnostic data such as the relative humidity are the base for data flagging.

3.3.2.3 Particle light absorption coefficient and equivalent black carbon concentration
On-site quality assurance procedures have to be developed during the ATRIS preparation phase. Diagnostic data such as the relative humidity and flow rate are the base for data flagging.

3.3.2.4 Mass concentration of particulate organic and elemental carbon
The quality assurance criteria (bias and variability) defined for the measurement of OC and EC under ACTRIS and already included to the data files submitted to EBAS shall be determined by the specific TC Unit and communicated to beneficiaries. They shall be calculated from statistical analyses of the results of Round-Robin tests. The assigned values for OC and EC shall be determined form the robust average among the participant (ISO 13528). Additionally, synthetic reference samples shall be distributed to beneficiaries so that there measurements can be confronted to true values. The statistical outputs of the Round-Robin tests and the results of the analyses of the synthetic reference materials shall be used by the TC to investigate the reasons and the period for under-performance, if any. The data reported by the beneficiaries shall be flagged accordingly. The procedure for determining the data quality criteria shall be in place from the pre-operational phase. The TC shall adapt the thresholds for determining under-performance according to the evolution of analytical technologies.

3.3.2.5 Particle number size distribution – optical and aerodynamic diameter
Measurement quality assurance criteria and procedures for OPSS and APSS instruments currently only exist concerning particle sizing, using latex particles (Pfeifer at al., 2016). Criteria and calibration procedures for the size resolved particle number concentration are currently not existing, but are under development.
3.3.2.6 Particle number concentration
On-site quality assurance procedures are described in the standard FprCEN/TS 16976 developed in the working group CEN TC 264, WG 32, in which ACTRIS was actively involved.

3.3.2.7 Mass concentration of particulate elements
The TC will provide protocols for each analytical technique that will address the key performance parameters such as external and internal calibration standards, number of blank measurements, number of repetitions, reproducibility, number of control samples. The developed protocols should be applied to each analytical technique. When all minimum parameters are fulfilled data will flagged as QA/QC controlled. If the data do not passed the control they shall be still available but without flagging. The protocols shall be developed during the implementation phase and shall be available in the operational phase. Additionally, synthetic reference samples shall be distributed to beneficiaries so that their measurements can be compared to true values. The statistical outputs of the Round-Robin tests and the results of the analyses of the synthetic reference materials shall be used by the TC to investigate the reasons of under-performances, if any. The data reported by the beneficiaries shall be flagged accordingly. The TC shall adapt the thresholds for determining under-performance according to the evolution of analytical technologies.

3.3.2.8 Mass concentration of particulate organic tracers
The TC will provide protocols for each recommended technique that will address the following key performance parameters (in addition 3.3.1.1):

• external calibration: sequence design, concentration range, minimum number of dilution steps, minimum regression factor, number of blank measurements, storage and stability of standard dilutions
• measurement: column material for separation, number of repetitions, reproducibility, number of control samples
• mass calibration (if applicable): internal standard/calibrant composition

The developed protocol should be applied to each measurement and linked to created data set. Thus for each measurement the protocol is available. If all minimum parameters are fulfilled data can be flagged as QA/QC controlled. If the data do not passed the control they shall be still available but without flagging.

The protocols shall be developed during the implementation phase and are available in the operational phase. As this kind of protocols are not instrument specific they can be transfer to new emerging techniques. Nevertheless, for each emerging technique the TC will prove the applicability of the protocols and will provide updated recommendations (if necessary).

3.3.2.9 Cloud condensation nuclei number concentration
Quality assurance procedures have been developed during ACTRIS. They are available at http://actris.nilu.no/Content/SOP. For the existing NFs, the guidelines should be in place.
3.3.2.10 **Mass concentration of non-refractory particulate organics and inorganics**

Quality assurance for each instrument shall be based on a strict set of criteria for instrument setup at each observational site. Related quality assurance procedures notably include inspection of technical parameters (such as Air Beam value, mass spectrometer tunings, fittings for internal calibrations, ...), check of the ion balance, and PM mass and/or optical closure exercises (by comparison with collocated instruments). These criteria shall be defined and revised as part of the measurement guidelines. They will provide confidence to the NF and the TC, as well as ACTRIS as a whole, ensuring that quality requirements are fulfilled and/or less quality data are accurately flagged.

3.3.2.11 **Nanoparticle number concentration**

The procedures and criteria of the sub-0.01 µm total number concentration data are or shall be described in the developed SOPs (see 3.3.1). The technical target for the measurements is to provide harmonized observations in NRT data delivery. The NRT data stream shall be automatically flagged for preliminary quality checks.

The following instrument maintenance procedures are required with the PSM:

- Yearly cut-off and CPC concentration calibration
- Monthly PSM and CPC inlet flow rate measurements
- CPC pulse width monitoring
- Regular PSM zero measurement using particle free air
- Removing excess diethylene glycol from tubing as needed.

These procedures shall be elaborated in the SOPs for the PSM developed by the TC. In order to reach higher level data, automatic flagging shall be developed based on measured instrument operation parameters followed by manual data quality assurance by an expert, re-inversion if needed, flagging or removal of bad quality data.

The criteria and procedures for the PSM are intended to be in place 2019, co-incident with the development of the SOPs.

3.3.2.12 **Nanoparticle number size distribution**

The procedures and criteria of the sub-0.01 µm size distribution data are or shall be described in the developed SOPs (see 3.3.1). The technical target for the measurements is to provide harmonized observations in NRT data delivery. The NRT data stream shall be automatically flagged for preliminary quality checks.

The following instrument maintenance procedures are required with the NAIS:

- DMA column cleaning as needed,
- Ion and particle concentration and sizing calibration yearly,
- Inlet flow rate measurement monthly,
- Electrometer zero current monitoring.
The NRT data stream shall be automatically flagged for preliminary quality checks. In order to reach higher level data, automatic flagging shall be developed based on measured instrument operation parameters followed by manual data quality assurance by an expert, re-inversion if needed, flagging or removal of bad quality data.

The UF-DMPS data quality assurance requires the same procedures as in ACTRIS documentation for the DMPS systems with the specific focus on sub-0.02 µm size distribution.

The criteria and procedures are intended to be in place 2021 (NAIS) and 2025 (UF-DMPS), co-incident with the development of the SOPs.

### 3.3.3 Development and provision of instrument-specific calibration*

#### 3.3.3.1 Particle number size distribution – mobility diameter

The calibration procedures of MPSS have been described in Wiedensohler et al. (2017) and are already applied during ACTRIS2. For the calibration at the calibration facility reference a MPSS, a CPC and a FCAE are needed. On-site intercomparisons include a MPSS and a CPC. Size calibrations are done with a certified PSL particle standard.

#### 3.3.3.2 Particle light scattering and backscattering coefficient

For the calibration of integrating nephelometers, particle free air and CO₂ is used. Calibration are also done at the calibration facility against a frequently calibrated reference integrating nephelometer.

#### 3.3.3.3 Particle light absorption coefficient and equivalent black carbon concentration

A reference set-up for absorption photometers was developed during ACTRIS2, see deliverable D34. This set-up includes a three extinction monitors for three different wavelengths and a multi-wavelengths integrating nephelometer. Laboratory-generated sulphate aerosol is used to calibrate the reference set-up. The absorption photometers are calibrated against the reference set-up and a reference absorption photometer using an absorbing aerosol.

There is no reference for the equivalent black carbon concentration mass concentration yet. This shall be a task for the preparation phase of ACTRIS.

#### 3.3.3.4 Mass concentration of particulate organic and elemental carbon

The TC will provide remote access to its facilities for calibrating measurements of OC and EC in ambient PM samples deposited on filters. Round-Robin test shall be organised at least once a year from the beginning of the pre-operational phase, in order to cover all requests from beneficiaries. Synthetic certified materials shall be made available to beneficiaries at least from the beginning of the operational phase.


3.3.3.5 Particle number size distribution – optical and aerodynamic diameter

The size calibration of optical and aerodynamic particle size spectrometers are done with certified PSL-particle standards. For the calibration of the size-resolved particle number concentration, a concept was developed in ACTRIS-2, see deliverable D96. The implementation shall be done during the preparation phase of ACTRIS.

3.3.3.6 Particle number concentration

The calibration of CPCs are done, using a calibrated FCAE, which is traceable to an SI-unit. The procedure is described in detail in Wiedensohler et al. (2017).

3.3.3.7 Mass concentration of particulate elements

The TC will provide remote access to its facilities for calibrating measurements of particulate elements and elements in ambient PM samples deposited on different kind of filters, according to the request of the beneficiaries. Round-Robin test shall be organised every second year from the beginning of the pre-operational phase. Synthetic certified standards shall be made available to beneficiaries at least from the beginning of the operational phase.

3.3.3.8 Mass concentration of particulate organic tracers

For each single instrument type, SOPs shall be developed that will also contain requirements about the internal and external calibration. Furthermore, the protocols defined in 3.3.2.1 are part of these SOPs. The SOPs shall be instrument specific as well as analyte specific. In general, for each single analysis the instrument has to be checked in terms of:

- mass calibration, response function, retention time of the standards, and instrument-specific performance indicator (flow rate, pressure etc.).
- Furthermore, the TC unit will offer services in terms of inter-laboratory comparisons (ILCs) with subsequent workshops and Round-Robin tests with reference standards. For the ILC filter samples (from field and laboratory-generated) and reference standards shall be distributed. Each user should participate once per year in one ILC or Round-Robin test to evaluate the performance of the instrument. Besides this, internal and external users can be always in-touch with the TC unit operator for rapid assistance. Each kind of service shall be available from the beginning of the implementation phase and shall be further developed continuously.

3.3.3.9 Cloud condensation nuclei number concentration

The cloud condensation nuclei counter is calibrated with size-resolved ammonium sulphate particles, knowing the theoretical activation behaviour. This was described in detail by Rose et al. (2008) and is also given in the ACTRIS recommendation (http://actris.nilu.no/Content/SOP).
3.3.3.10 Mass concentration of non-refractory particulate organics and inorganics

One of the main roles of the aerosol in situ measurement TC is to provide specific and advanced (state-of-the-art) calibration services to the users. This shall be done through dedicated calibration and intercomparison campaigns. These campaigns shall be performed regularly at the TC unit and involving ACSM reference instrument as well as a large set of co-located online instrument and particle samplers for the comprehensive measurements of aerosol physics and chemistry. A decisive advantage of achieving such calibration campaigns is also to gather an optimum number of users, increasing collaborations between groups as well as identifying the robustness of instrument operation from one system to the next. These intensive campaigns should also provide a unique opportunity for training in terms of instrument operation, and knowledge.

3.3.3.11 Nanoparticle number concentration

The TC will offer workshops for instrument calibrations and operation verification. At the beginning of the workshop, the initial status of the instruments is evaluated followed by required routine maintenance to increase the performance (e.g. cleaning, flow checks). The PSM calibrations include 1) flow calibrations, 2) detection efficiency calibration with different test aerosols of variable chemical composition, 3) detection efficiency as a function of PSM operation parameters (internal flow rates, supersaturation), 4) CPC concentration calibration.

3.3.3.12 Nanoparticle number size distribution

The TC will offer workshops for instrument calibrations and operation verification. At the beginning of the workshop the initial status of the instruments is evaluated followed by required routine maintenance to increase the performance (e.g. cleaning, flow checks). The NAIS calibration procedures are described in Manninen et al. 2016. These include: 1) flow calibration, 2) sizing calibration against high-resolution DMA, 3) concentration calibration against a reference electrometer and 4) side-by-side ambient sampling. The UF-DMPS calibration include 1) flow calibrations, 2) sizing calibration against reference DMA (low resolution and high resolution), 3) loss measurements through the whole instrument, 4) detection efficiency measurements for the detector CPC with different test aerosols with variable chemical composition, 5) concentration calibration of the whole instrument and inversion code against a reference instrument.

3.3.4 Development and provision of in-house check-up tools*

3.3.4.1 Particle number size distribution – mobility diameter

The calibration procedure is described in Wiedensohler et al. (2017). For the size calibration, certified PSL particle size standards are used. To calibrate the condensation particle counter, a calibrated FCAE is employed, which is traced back to a SI unit.
3.3.4.2 Particle light scattering and backscattering coefficient
For the calibration of the integrating nephelometers, particle-free air and CO₂ is used, as described in the WNO-GAW report No 227.

3.3.4.3 Particle light absorption coefficient and equivalent black carbon concentration
The calibration procedure of absorption photometers was developed in ACTRIS. A calibrated reference multi-wavelengths integrating nephelometer and several reference extinction monitor are necessary.

3.3.4.4 Mass concentration of particulate organic and elemental carbon
In between the regular Round-Robin tests, the TC will offer the beneficiaries the possibility to get QC materials, including atmospheric PM deposited on large filters for repeatability and long term stability tests (from the pre-operational phase) and synthetic certified materials (from the beginning of the operational phase).

3.3.4.5 Particle number size distribution – optical and aerodynamic diameter
For the calibration of aerodynamic and optical particle size spectrometers, certified PSL particle size standards are used.

3.3.4.6 Particle number concentration
The calibration of condensation particle counter is based on a calibrated FCAE, which is traced back to a SI unit at a national metrology institute.

3.3.4.7 Mass concentration of particulate elements
The TC will offer the beneficiaries the possibility to get QC materials, such as atmospheric PM deposited on different kind of filters (from the pre-operational phase) and synthetic certified standard (from the beginning of the operational phase).

3.3.4.8 Mass concentration of particulate organic tracers
For each of the measurement technique a check-up tool shall be developed containing the QA/QC parameters defined in 3.3.2.1. This tool provides a quick overview how the data were created and if they meet the defined QA/QC standards. It shall be created as fast check-up protocol and can be made available to all users, in particular to the DC as a quick link for all uploaded data. This tool shall be developed within the implementation phase and has to be ready with the start of the operational phase.

3.3.4.9 Cloud condensation nuclei number concentration
The calibration of cloud condensation particle counter is based on the well-known water take-up of ammonium sulphate.
3.3.4.10 **Mass concentration of non-refractory particulate organics and inorganics**

The TC unit will not provide any physical in-house check-up tools (such as standard reference material, which is not currently defined for the variables measured by the ACSM). Instead, it will provide NFs procedures and tools (software) for the data quality assurance based on validation of the operation parameters, raw data corrections and validation with co-located instruments, as explained above.

3.3.4.11 **Nanoparticle number concentration**

The development of tools required for on-site checking shall be developed by 2025. For the PSM an automatic sample handling system is endorsed (Kangasluoma et al. 2016, Ahonen et al. 2017). This will enable automatic zero measurements, ion and neutral separation, sample dilution in high concentrations and monitoring of the inlet conditions. This shall be put into place by 2018.

Additional tools to be provided to the NF capacity include e.g. an optimization of PSM supersaturation. These tools shall be procured by the NFs, but TC will help to operate them on a routine basis. This shall be put into place by 2020.

The laboratory set-ups for instrument checking and calibration (both hardware and software) shall be re-designed by 2025 to facilitate larger workshop with several instruments.

3.3.4.12 **Nanoparticle number size distribution**

The development of tools required for on-site checking shall be developed by 2025. Additional tools to be provided to the NF capacity include e.g. a cluster ion source to verify the cluster ion measurements with the NAIS. These tools shall be procured by the NFs, but TC will help to operate them on a routine basis. This shall be put into place by 2020.

Although some of PSM and NAIS software will remain proprietary by the instrument manufacturer, the aim is to that the pre-processing of the NAIS, PSM and UF-DMPS data shall be done with open source software developed at TC. The final PSM and UF-DMPS inversion algorithms shall be open source.

The laboratory set-ups for instrument checking and calibration (both hardware and software) shall be re-designed by 2025 to facilitate larger workshop with several instruments.

3.3.5  **Development of data evaluation procedures and plausibility test**

3.3.5.1  **Particle number size distribution – mobility diameter**

The data evaluation program of MPSS is described in Wiedensohler et al. (2012) and is worldwide harmonized. A reference condensation particle counter is used as an independent instrument to determine the total particle number concentration, which is compared to the integral over the particle number size distribution.
3.3.5.2 Particle light scattering and backscattering coefficient
Integrating nephelometer are traced back to SI-units. There are no further tools to perform plausibility tests.

3.3.5.3 Particle light absorption coefficient and equivalent black carbon concentration
The reference method of “particle light extinction minus scattering” is traced back to SI-units. Increasing uncertainties are related to the single scattering albedo. Otherwise, no additional plausibility test is needed.

3.3.5.4 Mass concentration of particulate organic and elemental carbon
The OCEC unit shall apply ISO guides for the evaluation of the instruments’ performance from Round-Robin tests and against certified reference materials. Instruments’ performances shall be determined by comparison of the data they deliver with assigned values. This procedure implies a good knowledge of the statistical procedures for evaluating proficiency tests. Accreditation according to ISO 17043 would be an asset. It is probably not optimal that this procedure be transferred to the DC considering the specificity of the plausibility tests to be applied.

3.3.5.5 Particle number size distribution – optical and aerodynamic diameter
There is no common data plausibility test yet, since the reference for the particle number concentration of particles greater 3 µm is not developed yet. This is planned for the initialization phase of ACTRIS.

3.3.5.6 Particle number concentration
The calibration of condensation particle counters is described in Wiedensohler et al. (2017). No further development of a plausibility test is needed.

3.3.5.7 Mass concentration of particulate elements
Proficiency tests according to ISO guidelines for the evaluation of the performance of the analytical techniques and the associated experimental set-up from Round-Robin tests and against certified reference standards shall be applied.

3.3.5.8 Mass concentration of particulate organic tracers
Data evaluation shall be ensured by
1) The QA/QC parameters defined in 3.3.2.1. These criteria shall be used to flag the data as QA/QC controlled.
2) The check-up tool defined in 3.3.4.1. The output of the tool shall be directly linked to the data uploaded to the DC.
3) Continuous ILCs to prove if all QA/QC standards were meet.

The check-up tool as well as the QA/QC standards shall be available to the NF and also to the DC. The usage of the tool and the accordance to the QA/QC standards shall be permanently controlled. The data evaluation procedure will start with the implementation phase and shall be fully operational at the beginning of the operational phase.
3.3.5.9 Cloud condensation nuclei number concentration

The plausibility of the size-dependent Cloud condensation nuclei number concentration is based on the commonly used calibration procedure with ammonium sulphate as described in Rose et al. (2008). No further plausibility test is needed.

3.3.5.10 Mass concentration of non-refractory particulate organics and inorganics

Data evaluation algorithms to be applied by the user shall be developed under the activities of the TC unit. Checks based on co-located cross-instrumental (e.g., comparison of data provided by chemical monitors with outputs of mass concentration measurements/estimates) shall be proposed to ensure plausibility of the measurements. Furthermore, the TC unit shall develop and apply tools based on cross-station checks to further ensure plausibility of the measurements at the whole RI level. This will include the development (by 2020) of a platform for data screening as well as regular review sessions - in collaboration with data providers - of level 1 datasets.

3.3.5.11 Nanoparticle number concentration

Data evaluation procedures and plausibility tests need to be developed for the PSM hand-in-hand with the measurement quality assurance criteria. The simplest plausibility test is to require that the total concentration of measured particles in the size range of the instrument in ambient air cannot be negative, equal zero or be larger than the total concentration over the full measurement range. More sophisticated tests will need to be instrument specific. These procedures and tests shall be developed in collaboration with TC for sub-micron size distribution measurements.

The main requirements for these procedures and tests are that they ensure that the data quality is sufficient that the data can pass from ACTRIS level 1 (automated inversion and flagging) to level 2 (quality assured data) and enable further analysis and data products (level 3).

The initial tools for plausibility tests shall be put in place alongside the measurement quality assurance criteria and procedures (see 3.3.2) in 2019 (PSM) and be re-defined each time new mature and improved solutions are available.

3.3.5.12 Nanoparticle number size distribution

Data evaluation procedures and plausibility tests need to be developed for the NAIS and the UF-DMPS hand-in-hand with the measurement quality assurance criteria. The simplest plausibility test is to require that the total concentration of measured particles in the size range of the instrument in ambient air cannot be negative, equal zero or be larger than the total concentration over the full measurement range. More sophisticated tests will need to be instrument specific. These procedures and tests shall be developed in collaboration with TC for sub-micron size distribution measurements.

The main requirements for these procedures and tests are that they ensure that the data quality is sufficient that the data can pass from ACTRIS level 1 (automated inversion and flagging) to level 2 (quality assured data) and enable further analysis and data products (level 3).
The initial tools for plausibility tests shall be put in place alongside the measurement quality assurance criteria and procedures (see 3.3.2) in 2021 (NAIS) and 2025 (UF-DMPS) and be re-defined each time new mature and improved solutions are available.

3.3.6 Realization of observational site performance audits with reference samples or mobile systems*

3.3.6.1 Particle number size distribution – mobility diameter
The reference MPSS has to be calibrate at the calibration facility before.

3.3.6.2 Particle light scattering and backscattering coefficient
On-site intercomparisons are not foreseen.

3.3.6.3 Particle light absorption coefficient and equivalent black carbon concentration
On-site intercomparisons are not foreseen.

3.3.6.4 Mass concentration of particulate organic and elemental carbon
On-site performances of OC and EC analysers are determined from the procedures described above. It is not envisaged that the Unit shall audit on-site the analysers showing under-performance to determine its causes.

3.3.6.5 Particle number size distribution – optical and aerodynamic diameter
On-site intercomparisons are not foreseen.

3.3.6.6 Particle number concentration
The reference CPC has to be calibrate at the calibration facility before.

3.3.6.7 Mass concentration of particulate elements
On-site intercomparisons are not foreseen/applicable.

3.3.6.8 Mass concentration of particulate organic tracers
Observational site performance audits shall be done in terms of inter-laboratory comparisons (ILCs) with:

1) Samples collected from the field and from an aerosol chamber. These samples shall be collected under the same conditions and each participant will analyse an aliquot of a filter.

2) Reference standards. This standard will contain a defined mixture of organic aerosol constituents (mainly synthesized). The concentration shall be double-checked at the TC prior dispatch.

Both types of ILC (1 and 2) shall be conducted with the start of the implementation phase. Each observational site should participate (latest with the start of the operational phase) in one audit per year.
3.3.6.9 Cloud condensation nuclei number concentration
On-site intercomparisons are not foreseen.

3.3.6.10 Mass concentration of non-refractory particulate organics and inorganics
On-site intercomparisons are not foreseen.

3.3.6.11 Nanoparticle number concentration
The TC unit will have one reference PSM, which can be used for site performance audits on-site. During the site audit the reference instrument is put to sample next to the tested instrument nanoparticle number concentrations shall be compared. The PSMs shall be audited every year. The audition can be covered also in the calibration workshops taking place every year for the PSM.

3.3.6.12 Nanoparticle number size distribution
The TC will have one reference NAIS and UF-DMPS, which can be used for site performance audits on-site. During the site audit the reference instrument is put to sample next to the tested instrument, and 0.002 - 0.01, 0.002 - 0.04 or 0.01 - 0.0025 µm size resolved particle concentrations, respectively, shall be compared. A mobile calibration system consisting of a high resolution DMA, particle source (wire generator and/or electrospray source) and a reference electrometer can be equally used in the site performance audits, and the system can be used in the field to audit each of the two instruments. With the mobile calibration system known concentration of size selected particles is guided to the tested instrument, and the response of the instrument is compared against the reference electrometer. The mobile calibration platform shall be available 2019. The UF-DMPS and NAIS systems shall be audited with either the reference instrument or the mobile calibration platform once every two years. The audition can be covered also in the calibration workshops taking place every second year for the NAIS and UF-DMPS.

3.3.7 Organization of regular exercises to assess the performances of the NFs, including instrument performance workshops*

3.3.7.1 Particle number size distribution – mobility diameter
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).

3.3.7.2 Particle light scattering and backscattering coefficient
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).

3.3.7.3 Particle light absorption coefficient and equivalent black carbon concentration
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).
3.3.7.4 Mass concentration of particulate organic and elemental carbon
For off-line OC and EC analyses, NFs’ performances would be determined from the procedures described above if beneficiaries apply regularly. No additional exercise would be suitable to such instruments. The procedures described above should also apply to on-line OCEC analysers. If persistent issues occur with the calibration and inter-comparison of on-line analysers during the pre-operational phase, side by side inter-instruments comparisons will have to be organized, at least annually, to cover the needs of the beneficiaries.

3.3.7.5 Particle number size distribution – optical and aerodynamic diameter
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).

3.3.7.6 Particle number concentration
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).

3.3.7.7 Mass concentration of particulate elements
Hands-on trainings for each analytical technique (i.e. PIXE, ED-XRP, ICP) shall be conducted typically every second year. Workshops shall be always conducted after each inter-laboratory comparison exercise, discussing the results, identifying threats and vulnerabilities, and solving open issues.

3.3.7.8 Mass concentration of particulate organic tracers
Workshop shall be organised as scientific trainings and after the ILCs the results shall be discussed, vulnerabilities identified and open issues solved. Hands-on trainings shall be conducted continuously and with a special focus on 1-2 measurement techniques including also sample collection, preparation and quantification. ILCs workshops shall be always conducted after each ILC. Each kind of workshop will start with the implementation phase and shall be fully operational with the start of the operational phase.

3.3.7.9 Cloud condensation nuclei number concentration
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).

3.3.7.10 Mass concentration of non-refractory particulate organics and inorganics
Frequent instrumental calibration workshops shall be organized by the TC (if necessary several per year).

3.3.7.11 Nanoparticle number concentration
As indicated above, PSM systems should be calibrated every year. The TC will organize workshops for these activities. The technical target for the PSM is 15% in concentration.
3.3.7.12 Nanoparticle number size distribution

As indicated above, the NAIS and UF-DMPS calibration scheme should be completed once per two years. The TC will organize workshops for these activities. In the NAIS system the technical target is 20% in concentration at 0.003 µm with a sizing accuracy of 15% at this size. The UF-DMPS system the technical target is 10% in concentration at 0.003 µm with 10 % sizing accuracy.

3.3.8 Contribution to documentation and traceability of level 0 to level 3 data products*

3.3.8.1 Particle number size distribution – mobility diameter

The calibration reports of the TC are linked to the data of the DC. This is realized since 2017. Flagging of the data is a task of the data provider.

3.3.8.2 Particle light scattering and backscattering coefficient

The calibration reports of the TC are linked to the data of the DC. This is realized since 2017. Flagging of the data is a task of the data provider.

3.3.8.3 Particle light absorption coefficient and equivalent black carbon concentration

The calibration reports for the particle light scattering coefficient of the TC are linked to the data of the DC. This is realized since 2017. Flagging of the data is a task of the data provider.

3.3.8.4 Mass concentration of particulate organic and elemental carbon

The calibration reports of the TC are linked to the data of the DC. This is realized since 2017. Flagging of the data is a task of the data provider. The TC will make OC and EC data fully traceable when reported atmospheric data are linked to the measurements of certified reference materials. Such measurements, as well as the results of the Round-Robin tests described above, will allow the TC to calculate biases and variability, which can directly be used for correcting the data, and/or calculate (possibly asymmetric) uncertainties, flag and document the quality of the data. For OC and EC, the TC should address level 2 data only, at the pre-operational stage. It should not be necessary to deal with level 0 and 1 at a later stage.

3.3.8.5 Particle number size distribution – optical and aerodynamic diameter

The calibration reports of the TC shall be linked to the data of the DC. Flagging of the data is a task of the data provider.

3.3.8.6 Particle number concentration

The calibration reports of the TC are linked to the data of the DC. This is realized since 2017. Flagging of the data is a task of the data provider.

3.3.8.7 Mass concentration of particulate elements

The calibration reports of the TC shall be linked to the data of the DC. Flagging of the data is a task of the data provider. For particulate elements, the TC should address level 2 data only.
3.3.8.8 **Mass concentration of particulate organic tracers**
Each observational site participating in an audit will obtain a one-year certificate. If an observational site completely failed the ILC, a TC operator will visit the site or will invite the user to an additional training. Besides this the data created by the NF shall be controlled by the check-up tool defined in 3.3.4.1 and flagged if the QA/QC standards were met. The output of the check-up tool shall be directly linked to the data available in the database. With this, a full traceability of the data creation process can be guaranteed. The calibration reports of the TC shall be provided to the data of the DC.

3.3.8.9 **Cloud condensation nuclei number concentration**
The calibration reports of the TC are linked to the data of the DC. This is realized since 2017. Flagging of the data is a task of the data provider.

3.3.8.10 **Mass concentration of non-refractory particulate organics and inorganics**
After successful participation to an intercomparison/calibration exercise (and QC/QA requirement fulfilled) the data submitted by the concerned NF shall be certified for a period of two years. Calibration reports generated by the TC shall be available at the DC. Ongoing data verification shall be made by the data provider following the QC/QA flagging procedures outlined in section 3.3.3 and 3.3.5.

3.3.8.11 **Nanoparticle number concentration**
If the tested instruments do not agree with the reference instruments within the pre-set uncertainty range during the site audits or workshops, instrument specific maintenance procedures will take place. This is because of the verified concentration accuracy of the reference instruments.

3.3.8.12 **Nanoparticle number size distribution**
If the tested instruments do not agree with the reference instruments within the pre-set uncertainty range during the site audits or workshops, instrument specific maintenance procedures will take place. This is because of the verified sizing and concentration accuracy of the reference instruments. Similar procedure is in place with e.g. MPSS systems. The site audit system shall be operational by 2025.

The NAIS data will include the following steps in order to be traceable and reproducible: level 0: logging of raw data (electrometer currents, operation voltages, flow rates), level 1: inversion of the raw data with documented and identifiable inversion algorithm (at the moment from the manufacturer) that takes into account inlet loss corrections, concentration correction (based on ion calibration in Wagner et al., 2016 and particle calibration in Autumn 2017), conversion to standard pressure and temperature and multiple charging. Automatic flagging based on operational parameters. Level 2: flagging by an expert user.
3.3.9 Contribution to CEN, ISO, or similar standardization activities

3.3.9.1 Particle number size distribution – mobility diameter
The TC contributes to respective ISO and CEN committees and a related EMPIR project for MPSS measurements.

3.3.9.2 Particle light scattering and backscattering coefficient
The TC intends to contribute to related ISO and CEN committees.

3.3.9.3 Particle light absorption coefficient and equivalent black carbon concentration
The TC intends to contribute to respective ISO and CEN committees and already contributes to related EMPIR projects for absorption photometer measurements.

3.3.9.4 Mass concentration of particulate organic and elemental carbon
The H2020 project ACTRIS-2 and its ancestors have had an essential contribution to the development of the CEN standard EN 16909 for the measurement of OC and EC in PM2.5 deposited on filters. It is envisaged that the TC will participate actively in new working items in CEN TC 264 related to the measurements of atmospheric particulate carbonaceous species, including the applicability of EN16909 to the analysis of the PM10 fraction, and on automated measurements of OC and/or EC.

3.3.9.5 Particle number size distribution – optical and aerodynamic diameter
The TC intends to contribute to respective ISO and CEN committees in the future.

3.3.9.6 Particle number concentration
The TC contributed to the existing CEN standardization for condensation particle counters.

3.3.9.7 Mass concentration of particulate elements
Currently (2018) not.

3.3.9.8 Mass concentration of particulate organic tracers
The SOPs defined under 3.3.1 shall be developed following the GLP/GMP guidelines. The TC operator will have a GLC/GMP certificate.

3.3.9.9 Cloud condensation nuclei number concentration
Currently (2018) not.

3.3.9.10 Mass concentration of non-refractory particulate organics and inorganics
The TC unit outputs shall contribute to the works and outcomes of standardization activities, especially the ones within CEN/TC 264 Working groups 34 (water-soluble ions) and 35 (EC-OC).
The TC unit activities will also be presented to the EU association gathering National Reference Laboratories for air quality monitoring (AQUILA).
3.3.9.11 Nanoparticle number concentration

The work contributes to aerosol number concentration standardization (ISO 27891:2015, Aerosol particle number concentration - Calibration of condensation particle counters by extending the size range below 0.005 µm.

3.3.9.12 Nanoparticle number size distribution

Work is intended to contribute to aerosol number concentration standardization (ISO 27891:2015, Aerosol particle number concentration - Calibration of condensation particle counters) by extending the size range below 0.005 µm.

3.4 Operation support for knowledge transfer and training

3.4.1 Training of operators and scientists*

3.4.1.1 Particle number size distribution – mobility diameter

Training of operators and scientist is part of the frequent instrumental calibration workshops at the calibration facility. The training contains teaching of the technical operation procedures, quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants that the training is effective.

3.4.1.2 Particle light scattering and backscattering coefficient

Training of operators and scientist is part of the frequent instrumental calibration workshops at the calibration facility. The training contains teaching of the technical operation procedures, quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants that the training is effective.

3.4.1.3 Particle light absorption coefficient and equivalent black carbon concentration

Training of operators and scientist is part of the frequent instrumental calibration workshops at the calibration facility. The training contains teaching of the technical operation procedures, quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants that the training is effective.

3.4.1.4 Mass concentration of particulate organic and elemental carbon

Since remote access would be the most cost effective way for the OCEC unit to support beneficiaries, knowledge transfer and training is envisaged by means of a tutoring of those who ask for it (e.g. new comers), and those probably need it (as suggested by under-performance during the proficiency tests). A web-based forum would certainly be the best way to help beneficiaries operate their instruments and apply the required QA/QC tests at any time. Advice from the TC shall be made available to the whole RI when they are of general interest, and shall cover all the aspects of the analyses and QA/QC activities required under ACTRIS.

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3.4.1.5  Particle number size distribution – optical and aerodynamic diameter
Training of operators and scientist is part of the frequent instrumental calibration workshops at the calibration facility. The training contains teaching of the technical operation procedures (if available), quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants that the training is effective.

3.4.1.6  Particle number concentration
Training of operators and scientist is part of the frequent instrumental calibration workshops at the calibration facility. The training contains teaching of the technical operation procedures, quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants that the training is effective.

3.4.1.7  Mass concentration of particulate elements
Training of operators and scientists is part of the frequent hands-on training workshops at the calibration facility. The training contains teaching of the technical operation procedures, quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants for the training to be effective.

3.4.1.8  Mass concentration of particulate organic tracers
The training course will address each step from sample collection to analysis of measurement results. Thus each participant will have hands-on experience during instrument- and target-dependent courses. It is planned to organize minimum one training course for each measurement technique per year. The number of participants will depend on the capacity of the TC and the level of experience of the participants. A second focus of the training shall be the instruction into the SOPs and QA/QC parameters defined under 3.3.1 and 3.3.2 as well as the usage of the check-up tool described under 3.3.4. The feedback of the training participants will also be used to improve the check-up tool. Furthermore, the results of the ILC shall be distributed and discussed within the participant group. Vulnerabilities shall be identified and rectified.

3.4.1.9  Cloud condensation nuclei number concentration
Training of operators and scientist is part of the frequent instrumental calibration workshops at the calibration facility. The training contains teaching of the technical operation procedures, quality assurances checks, data evaluation procedures as well as plausibility tests. The workshops are limited to maximum six participants that the training is effective.

3.4.1.10  Mass concentration of non-refractory particulate organics and inorganics
Technical workshops and training sessions shall be organized once a year, along with intercomparison/calibration exercises. These workshops/trainings shall notably include
tutorials for the application of measurement guidelines as well as check-up tools (evaluation procedures and plausibility tests) developed by the TC unit as defined above. Workshops will also be used to further defined and/or revised these quality assurance procedures and standard operating procedures.

3.4.1.11 Nanoparticle number concentration

The objective of the training activity is capacity building of ACTRIS in aerosol in-situ number concentration measurements in the size range below 0.01 µm. The knowledge transfer occurs during the workshops for PSM systems. These can be jointly organized e.g. in ACTRIS-wide summer schools at an ACTRIS observational site. The workshops shall be organized annually or every second year and facilitate the process towards the development of the required SOPs.

3.4.1.12 Nanoparticle number size distribution

The objective of the training activity is capacity building of ACTRIS in aerosol in-situ number size distribution measurements in the size range below 0.01 µm. The knowledge transfer occurs during the workshops for NAIS and UF-DMPS systems. These can be jointly organized e.g. in ACTRIS-wide summer schools at an ACTRIS observational site. The workshops shall be organized annually or every second year and facilitate the process towards the development of the required SOPs.

3.4.2 Consultancy for setting-up new observational or exploratory platforms and new instruments at the NFs*

3.4.2.1 Particle number size distribution – mobility diameter

Consultancy for setting-up new observational or exploratory platforms shall be provided by the TC on request. The existing relevant SOPs and measurement and sampling guidelines shall be provided and explained to the NF operators accordingly.

3.4.2.2 Particle light scattering and backscattering coefficient

Consultancy for setting-up new observational or exploratory platforms shall be provided by the TC on request. The existing relevant SOPs and measurement and sampling guidelines shall be provided and explained to the NF operators accordingly.

3.4.2.3 Particle light absorption coefficient and equivalent black carbon concentration

Consultancy for setting-up new observational or exploratory platforms shall be provided by the TC on request. The existing relevant SOPs and measurement and sampling guidelines shall be provided and explained to the NF operators accordingly.

3.4.2.4 Mass concentration of particulate organic and elemental carbon

Since a European standard for the measurement of OC and EC exists, which has been endorsed by ACTRIS, the consultancy offered to beneficiaries to start with OCEC measurements shall be limited. The TC will not recommend any specific brands of OCEC analysers. In contrast, the TC is expected to advise on the apparatus to be implemented for
sampling atmospheric particulate matter for subsequent OC and EC analyses at the beginning of the implementation phase. This consultancy shall best be provided via a web based forum.

3.4.2.5 **Particle number size distribution – optical and aerodynamic diameter**
Consultancy for setting-up new observational or exploratory platforms shall be provided by the TC on request. Guidelines for appropriate sampling of larger aerosol particles already exist.

3.4.2.6 **Particle number concentration**
Consultancy for setting-up new observational or exploratory platforms shall be provided by the TC on request. The existing relevant SOPs and measurement guidelines shall be provided and explained to the NF operators accordingly.

3.4.2.7 **Mass concentration of particulate elements**
New observational and exploratory platforms shall be directly invited to attend training courses and inter-laboratory comparison exercises, in addition to have the possibility to visit the TC and get a brief instruction. The TC will provide consultancy to NFs planning to buy new instruments. This consultancy will include technical recommendations (minimum technical requirements to the instrument, demands of the instrument etc.) as well as instrument-dependent recommendations (number of operators, operating costs etc.). As the technology develops continuously, the consultancy support shall be developed and improved over the whole period of the project.

3.4.2.8 **Mass concentration of particulate organic tracers**
New observational and exploratory platforms

- shall be directly invited to participate into training courses and ILCs,
- can visit the TC and get a brief instruction.

The TC will provide consultancy if a NF plans to buy new instruments. This consultancy will include technical recommendations (minimum technical requirements to the instrument, demands of the instrument etc.) as well as instrument-dependent recommendations (number of operators, operating costs etc.). As the technology develops continuously, the consultancy support shall be developed and improved over the whole period of the project.

3.4.2.9 **Cloud condensation nuclei number concentration**
Consultancy for setting-up new observational or exploratory platforms shall be provided by the TC on request. The existing relevant SOPs and measurement guidelines shall be provided and explained to the NF operators accordingly.

3.4.2.10 **Mass concentration of non-refractory particulate organics and inorganics**
The TC unit will offer assistance to NF that would like to implement new ACSM device. This shall be done by dissemination of existing SOPs and measurement guidelines, as well as direct exchange during teleconference and workshops, if necessary and on request.
3.4.2.11 Nanoparticle number concentration
The measurement activities by the TC with PSM is by default a capacity building activity for ACTRIS as this fills the observational gap between the trace gases and aerosol particles. In particular a beneficial collaboration with exploratory platforms in relation to e.g. vertical profiling within the boundary layer with drones and aircraft with the PSM instrumentation shall be supported.
The activities with PSM connect to manufacturer organized workshops that facilitate harmonization of the observation methodology.

3.4.2.12 Nanoparticle number size distribution
The measurement activities by the TC with NAIS and UF-DMPS is by default a capacity building activity for ACTRIS as this fills the observational gap between the trace gases and aerosol particles. In particular a beneficial collaboration with exploratory platforms in relation to e.g. vertical profiling within the boundary layer with drones and aircraft with the NAIS instrumentation shall be supported.

3.5 Operation support for improvement of measurement methodologies

3.5.1 Testing of new measurement instruments and procedures*

3.5.1.1 Particle number size distribution – mobility diameter
Operation support for improvements of measurement methodologies shall be provided on request and based on capacity.

3.5.1.2 Particle light scattering and backscattering coefficient
Operation support for improvements of measurement methodologies shall be provided on request and based on capacity.

3.5.1.3 Particle light absorption coefficient and equivalent black carbon concentration
Operation support for improvements of measurement methodologies shall be provided on request and based on capacity.

3.5.1.4 Mass concentration of particulate organic and elemental carbon
It is expected that the TC will test new measurement instruments for the determination of OC and EC deposited on filters, when substantial technological steps are made. Reproducibility tests making use of atmospheric samples shall be available from the beginning of the pre-operational phase. Proficiency tests based on the analysis of certified reference materials should be made possible by the beginning of the operational phase. The European standard EN16909:2017 is expected to be revised by the beginning of the pre-operational phase. Any revision of the analytical procedure should be tested against atmospheric samples for consistency with the procedure endorsed by the RI.
3.5.1.5 Particle number size distribution – optical and aerodynamic diameter
Operation support for improvements of measurement methodologies shall be provided on request and based on capacity.

3.5.1.6 Particle number concentration
Operation support for improvements of measurement methodologies shall be provided on request and based on capacity.

3.5.1.7 Mass concentration of particulate elements
The TC unit will offer benchmarking for novel instrumentation and procedures, by the beginning of the operational phase.

3.5.1.8 Mass concentration of particulate organic tracers
The TC will always follow the on-going development in scientific research and technical evolution. At the methodology side improvements are foreseen with regards to selective derivatisation procedures, enrichment processes and purification steps. Besides this, new methods shall be developed continuously for so-far unidentified classes of compounds. Special efforts shall be spend to develop environmental friendly methods by avoiding or at least reducing the amount of harmful chemicals and decrease the consumption of solvents of the instruments.
New and/or improved methods shall be made available continuously to the ACTRIS community.
On the other hand, the technical evolution will lead to instruments with higher mass resolutions and sensitivity, combined with an enhanced time resolution. This will lead to new requirements to the purity of the solvents, background corrections and data storage. The support with regards to the technical evolution is limited to the instruments available at the TC. Nevertheless, the TC will always work on recommendations and will have a link to manufacturers that can be used by the NF.

3.5.1.9 Cloud condensation nuclei number concentration
Operation support for improvements of measurement methodologies shall be provided on request and based on capacity.

3.5.1.10 Mass concentration of non-refractory particulate organics and inorganics
If new instruments are developed and interest is expressed by NFs, these instruments shall be tested at the TC unit as part of ongoing tests, notably based on comparison with reference instruments at the TC. Through collaboration with the manufacturer, different software analysis tools shall be developed, tested, and distributed to the ACTRIS community.

3.5.1.11 Nanoparticle number concentration
The TC unit will offer benchmarking for novel instrumentation for sub-0.01 μm aerosol measurements. The TC unit offers laboratory calibration services and intercomparison
activities both in the field and in the laboratory. This activity shall be performed in collaboration with NFs. Several SMEs are already taking advantage of this opportunity.

**3.5.1.12 Nanoparticle number size distribution**
The TC unit will offer benchmarking for novel instrumentation for sub-0.01 µm aerosol measurements. The TC unit offers laboratory calibration services and intercomparison activities both in the field and in the laboratory. This activity shall be performed in collaboration with NFs. Several SMEs are already taking advantage of this opportunity.

**3.5.2 Development of strategies to increase the duty cycle of instruments operated at the NFs, to reduce breakdown and maintenance downtime**

**3.5.2.1 Particle number size distribution – mobility diameter**
As there is a large variability among the MPSS instruments operated at ACTRIS NFs and moreover replacement parts are usually not very expensive, it is expected that the NFs will take care that the most common replacement parts for their instruments are at hand at the NFs.

**3.5.2.2 Particle light scattering and backscattering coefficient**
Replacement parts are usually not very expensive, hence it is expected that the NFs will take care that the most common replacement parts for their instruments are at hand at the NFs.

**3.5.2.3 Particle light absorption coefficient and equivalent black carbon concentration**
Replacement parts are usually not very expensive, hence it is expected that the NFs will take care that the most common replacement parts for their instruments are at hand at the NFs.

**3.5.2.4 Mass concentration of particulate organic and elemental carbon**
The TC will maintain / develop optimal relationships with the instruments’ manufacturers and/or representatives in Europe. Based on information verified by both manufactures and the TC, “best practice” for optimising OCEC analysers’ lifetime shall be edited. It is expected that the OCEC unit will seek for an agreement with manufacturers / representatives to have the most “consumable” spare parts of the analysers available within acceptable delays in Europe. NB: this question mainly regards the on-line OCEC analysers, since off-line instrument downtimes can be easily overcome by storing the filter samples for several months.

**3.5.2.5 Particle number size distribution – optical and aerodynamic diameter**
As there is some variability between the OPSS instruments operated at ACTRIS NFs and moreover replacement parts are usually not very expensive, it is expected that the NFs will take care that the most common replacement parts for their instruments are at hand at the NFs.
3.5.2.6 **Particle number concentration**

As there is some variability between the CPCs operated at ACTRIS NFs and moreover replacement parts are usually not very expensive, it is expected that the NFs will take care that the most common replacement parts for their instruments are at hand at the NFs.

3.5.2.7 **Mass concentration of particulate elements**

The SOPs take into consideration the strategies to increase the duty cycle of the covered analytical techniques and provide guidance on the optimal operation procedures and maintenance. The TC expertise can be utilized the NF sites for trouble-shooting instrument problems.

3.5.2.8 **Mass concentration of particulate organic tracers**

Proper handling and careful maintenance can easily increase the lifetime of an instrument, both conducted by the user. The training courses will always include recommendation for cleaning procedures as well as basic instructions for the service. In urgent cases the support can be done remotely. Additionally, the TC can recommend special services offered by manufactures. The weighting between user-conducted service and manufacture-offered service might lead to a decrease of the operational costs of the NFs.

3.5.2.9 **Cloud condensation nuclei number concentration**

Replacement parts are usually not very expensive, hence it is expected that the NFs will take care that the most common replacement parts for their instruments are at hand at the NFs.

3.5.2.10 **Mass concentration of non-refractory particulate organics and inorganics**

By following the recommended operating procedures supplied to the ACTRIS community instrument operation, performance, and lifetime shall be optimised. Training courses run through the TC will provide assistance to new users on optimal instrument operation, as well as providing a place for the distribution of updated SOPs. This continuing work will lead to sets of corrections that can be applied to current and previous datasets.

3.5.2.11 **Nanoparticle number concentration**

The SOPs take into consideration the strategies to increase the duty cycle of the instruments and provide guidance on the optimal operation procedures and maintenance. When within the capacity of the TC, additional instrumentation can be loaned to cover observational gaps. The TC will negotiate with instrument manufacturers to have readily available crucial spare parts. The TC expertise can be utilized the NF sites for trouble-shooting instrument problems.

3.5.2.12 **Nanoparticle number size distribution**

The SOPs take into consideration the strategies to increase the duty cycle of the instruments and provide guidance on the optimal operation procedures and maintenance. When within the capacity of the TC, additional instrumentation can be loaned to cover observational gaps. The TC will negotiate with instrument manufacturers to have readily
available crucial spare parts. The TC expertise can be utilized the NF sites for trouble-shooting instrument problems.

3.5.3 Development of new technological products and methods

New measurement techniques, technological products and methods are developed by the TC in collaboration with the NFs. Depending on the situation, the TC may recommend to the ACTRIS Committee to decide on the implementation of such new techniques at the RI level. The TC has no obligation to develop the full set of operation support for such new techniques, unless they are embraced by ACTRIS and implemented as part of the NFs.

3.5.3.1 Particle number size distribution – mobility diameter

There exist already commercially available MPSS systems from several manufacturers. Hence the focus shall be to convince the manufacturers to follow with their instruments the guidelines set by the TC.

3.5.3.2 Particle light scattering and backscattering coefficient

There exist already commercially available nephelometers from at least two manufacturers. Hence the focus shall be to convince the manufacturers to follow with their instruments the guidelines set by the TC.

3.5.3.3 Particle light absorption coefficient and equivalent black carbon concentration

There exist already commercially available absorption photometers from several manufacturers. Hence the focus shall be to convince the manufacturers to follow with their instruments the guidelines set by the TC.

3.5.3.4 Mass concentration of particulate organic and elemental carbon

It is expected that the TC unit shall communicate the needs of the RI to the manufacturers to enhance the operability, the repeatability, the reproducibility, and the accuracy of the analyses. In the near future, analyser automation is foreseen. More sophisticated heating systems, enhanced control of the sample position in the analyser, additional instrument diagnosis parameters would be useful.

3.5.3.5 Particle number size distribution – optical and aerodynamic diameter

There exist already commercially available OPSS instruments from many manufacturers. For APSS instruments there is currently only one manufacturer. In both cases the focus shall be to convince the manufacturers to follow with their instruments the guidelines set by the TC.

3.5.3.6 Particle number concentration

There exist already commercially available CPCs from many manufacturers. Hence the focus shall be to convince the manufacturers to follow with their instruments the guidelines and data quality criteria set by the TC. Close collaboration with CPC manufacturers exists concerning new CPC types and will continue in the future.
3.5.3.7 Mass concentration of particulate elements

The responsible TC unit shall communicate the needs of the RI to the manufacturers to enhance operability, sensibility and accuracy of the analytical techniques. TC may recommend the implementation of new technological products and developments (for instance, novel detectors) at the RI level.

3.5.3.8 Mass concentration of particulate organic tracers

Please see 3.5.1.

3.5.3.9 Cloud condensation nuclei number concentration

Currently, (2018), there is only one CCNC manufacturers, but their might be more in the near future. Focus shall be to advise the manufacturers and to convince them to follow with their instruments the guidelines set by the TC.

3.5.3.10 Mass concentration of non-refractory particulate organics and inorganics

There shall be regular meetings with the users, during either training schools or intercomparison workshops, which shall help to determine the need for new tools and techniques by the ACTRIS community. It is particularly important to generate harmonized tools for a better correction of sampling and/or measurement artefacts.

3.5.3.11 Nanoparticle number concentration

New measurement techniques, technological products and methods are developed by the TC unit in collaboration with the NFs. Depending on the situation, the TC may recommend to the ACTRIS Committee to decide on the implementation of such new techniques at the RI level. The TC has no obligation to develop the full set of operation support for such new techniques, unless they are embraced by ACTRIS and implemented as part of the NFs.

3.5.3.12 Nanoparticle number size distribution

New measurement techniques, technological products and methods are developed by the TC unit in collaboration with the NFs. Depending on the situation, the TC may recommend to the ACTRIS Committee to decide on the implementation of such new techniques at the RI level. The TC has no obligation to develop the full set of operation support for such new techniques, unless they are embraced by ACTRIS and implemented as part of the NFs.

Improvements in the sub-0.01 µm size distribution measurements are foreseen as suitable medium-to-high resolution DMAs start to be available. Higher flow rate CPCs improve the counting statistics particularly in the size distribution measurements, where single counts can transfer into high apparent number concentrations. These developments need to be considered, when mature enough for a wider application.
3.5.4 Development of retrieval algorithms or tools for producing level 1 to 3 data, including the exploitation of instrument synergies

3.5.4.1 Particle number size distribution – mobility diameter
Tools for producing level 1 to 2 data already exist and shall be improved by the TC in the future.

3.5.4.2 Particle light scattering and backscattering coefficient
Tools for producing level 1 to 2 data already exist and shall be improved by the TC in the future.

3.5.4.3 Particle light absorption coefficient and equivalent black carbon concentration
Tools for producing level 1 to 2 data already exist and shall be improved by the TC in the future.

3.5.4.4 Mass concentration of particulate organic and elemental carbon
The determination of OC and EC does not involve the use of retrieval algorithms. It is expected that up-to-date tools to convert raw data to the level 2 data template are made available by the TC, at least from the pre-operational phase onwards.

3.5.4.5 Particle number size distribution – optical and aerodynamic diameter
Tools for producing level 1 to 2 data are currently (2018) under development and shall be improved by the TC in the future.

3.5.4.6 Particle number concentration
Tools for producing level 1 to 2 data shall be developed and improved by the TC in the future.

3.5.4.7 Mass concentration of particulate elements
The determination of particulate elements in PM samples does not involve the use of retrieval algorithms. It is expected that up-to-date tools to convert raw data to the level 2 data template are made available by the TC, at least from the pre-operational phase onwards.

3.5.4.8 Mass concentration of particulate organic tracers
The TC will cooperate with manufacturers in terms of software and method development. As a permanent user of different kind of instruments the TC can give well-founded feedback to beta-versions of software products.

3.5.4.9 Cloud condensation nuclei number concentration
Tools for producing level 1 to 2 data shall be developed and improved by the TC in the future.
3.5.4.10 Mass concentration of non-refractory particulate organics and inorganics

The TC will participate in the development of software tools to be distributed to the community for data quality assurance prior to submission of level 1/1.5 data. Tools for the generation of new level 3 data products, such as the source apportionment of the organic aerosols, shall be also developed through collaborations with the instrument manufacturers and/or software providers.

3.5.4.11 Nanoparticle number concentration

Level 0: raw data- This is provided by the instruments. The TC facilitates data submission to ACTRIS DC in near-real-time.

Level 1: processed data –party provided by instruments (NAIS inversion software), partly developed during the process (automatic loss corrections, flagging, PSM and UF-DMPS inversion).

Level 2: final data – the algorithms and procedures for data quality assurance and plausibility tests need be developed (see 3.3.5)

Level 3: developed data products – algorithms for integrated size distribution using several instruments, condensation sink, formation and growth rates are foreseen. A combined inversion of the aerosol number size distribution in the full ACTRIS measured size range (0.001 to 10 µm) shall be developed. These data products can be automated as soon as NRT data is available from the relevant ACTRIS parameters.

3.5.4.12 Nanoparticle number size distribution

Level 0: raw data- This is provided by the instruments. The TC facilitates data submission to ACTRIS DC in near-real-time.

Level 1: processed data –party provided by instruments (NAIS inversion software), partly developed during the process (automatic loss corrections, flagging, PSM and UF-DMPS inversion).

Level 2: final data – the algorithms and procedures for data quality assurance and plausibility tests need be developed (see 3.3.5)

Level 3: developed data products – algorithms for integrated size distribution using several instruments, condensation sink, formation and growth rates are foreseen. A combined inversion of the aerosol number size distribution in the full ACTRIS measured size range (0.001 to 10 µm) shall be developed. These data products can be automated as soon as NRT data is available from the relevant ACTRIS parameters.

4 Services provided to ACTRIS users

An ACTRIS user is a person, a team, or an institution using either ACTRIS data or any other ACTRIS service. ACTRIS users originate from academia, business, industry and public services, from ACTRIS member countries as well as from countries, which are not ACTRIS members, inside and outside Europe. The Centre for Aerosol In Situ Measurements will in particular serve
atmospheric, climate, air quality, and aerosol research institutes, aerosol instrument manufacturers, environmental protection agencies, and industry companies.

Access to some ACTRIS services is open and free, most importantly the access to ACTRIS data, data products, and digital tools provided by the DC, which is the point of entry for free ACTRIS data services. Other access to ACTRIS services is considered competitive access based on capacity or excellence and will require a review process that is centrally managed by the HO/SAMU. SAMU is the single point of entry for user access to all TC services and to some specific services and data products provided by the DC. Access is regulated by both the ACTRIS access policy and the ACTRIS data policy, respectively.

4.1 Estimation of the need
Numbers in the following table are based on QA/QC expert estimates and give number of users (individuals) who currently (2018) benefit and might benefit in the future from ACTRIS services.

<table>
<thead>
<tr>
<th>Type of ACTRIS user</th>
<th>Number of users to which ACTRIS can provide services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Now</td>
</tr>
<tr>
<td>Academia</td>
<td>85</td>
</tr>
<tr>
<td>Business &amp; Industry</td>
<td>40</td>
</tr>
<tr>
<td>Public services</td>
<td>80</td>
</tr>
</tbody>
</table>

4.2 Provision of measurement quality assurance and quality control procedures and tools

4.2.1 Particle number size distribution – mobility diameter
The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.2 Particle light scattering and backscattering coefficient
The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.3 Particle light absorption coefficient and equivalent black carbon concentration
The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.4 Mass concentration of particulate organic and elemental carbon
Same as for operation support.
4.2.5 Particle number size distribution – optical and aerodynamic diameter

The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.6 Particle number concentration

The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.7 Mass concentration of particulate elements

The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.8 Mass concentration of particulate organic tracers

The SOPs (3.3.1), the check-up tool (3.3.4) and the QA/QC parameters (3.3.2) shall be made available to the ACTRIS users. The instruction into the procedures and tools shall be made by a clear documentation and during the training courses. If there is a special need, workshops or special sessions during conferences can be organized.

4.2.9 Cloud condensation nuclei number concentration

QA/QC tools as outlined in section 3.3.3 and 3.3.5 shall be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.10 Mass concentration of non-refractory particulate organics and inorganics

The same QA/QC tools as outlined in section 3.3.3 and 3.3.5 can be provided to ACTRIS users, such as the standard operating procedures and software tools.

4.2.11 Nanoparticle number concentration

The TC should provide calibration services for PSM systems. The TC should organize audits and calibration workshops and develop SOPs in collaboration with the NFs. The data streams need to be developed and optimized. The data utilization need to be facilitated by network-wide data workshops.

4.2.12 Nanoparticle number size distribution

The TC should provide calibration services for NAIS and UF-DMPS systems. The TC should organize audits and calibration workshops and develop SOPs in collaboration with the NFs. The data streams need to be developed and optimized. The data utilization need to be facilitated by network-wide data workshops.

4.3 Instrument-specific calibration

4.3.1 Particle number size distribution – mobility diameter

The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.
4.3.2 Particle light scattering and backscattering coefficient
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.

4.3.3 Particle light absorption coefficient and equivalent black carbon concentration
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.

4.3.4 Mass concentration of particulate organic and elemental carbon
Same as for operation support.

4.3.5 Particle number size distribution – optical and aerodynamic diameter
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.

4.3.6 Particle number concentration
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.

4.3.7 Mass concentration of particulate elements
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.

4.3.8 Mass concentration of particulate organic tracers
Instrument dependent calibration proceedings are continuously trained during scientific trainings. These trainings are open to all users. Within these trainings special requests and critical issues can be addressed.

4.3.9 Cloud condensation nuclei number concentration
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.

4.3.10 Mass concentration of non-refractory particulate organics and inorganics
The main role is to provide specific and advanced calibration services and specific hands-on training to NF and ACTRIS users.
Depending on the capacity, competition, and excellence, ACTRIS users can participate in organised instrument specific calibration and intercomparison campaigns. The advantages of participating in such calibration campaigns is to gather an optimum amount of users, increasing collaborations between groups as well as identifying the robustness of instrument operation from one system to the next. These intensive campaigns will provide a unique opportunity for the deployment of new instrument prototypes.
4.3.11 Nanoparticle number concentration
TC offers, limited by its resources, site audits and instrument specific workshops year for the PSMs, which are open to ACTRIS users. Workshop services are as in 3.3.3, and site audits as in 3.3.6.

4.3.12 Nanoparticle number size distribution
TC offers, limited by its resources, site audits and instrument specific workshops every two year for the NAIS and UF-DMPS, which are open to ACTRIS users. Workshop services are as in 3.3.3, and site audits as in 3.3.6.

4.4 Knowledge transfer and operator training

4.4.1 Particle number size distribution – mobility diameter
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for this specific measurements.

4.4.2 Particle light scattering and backscattering coefficient
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for this specific measurements.

4.4.3 Particle light absorption coefficient and equivalent black carbon concentration
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for this specific measurements.

4.4.4 Mass concentration of particulate organic and elemental carbon
Same as for operation support.

4.4.5 Particle number size distribution – optical and aerodynamic diameter
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for this specific measurements.

4.4.6 Particle number concentration
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for this specific measurements.

4.4.7 Mass concentration of particulate elements
In addition to the services applied to ACTRIS users, training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for these specific measurements.
4.4.8 Mass concentration of particulate organic tracers
Knowledge transfer is a key focus of the scientific trainings. The training will cover each single step from sample collection until analysis of measurement results. The TC will spend special effort to offer each participant hands-on experience. With this the TC reaches the highest level of knowledge transfer that shall be afterwards controlled during the ILCs. If vulnerabilities were identified during the ILC, the problems were identified in a 1:1 discussion and if necessary an additional training can take place.

4.4.9 Cloud condensation nuclei number concentration
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for this specific measurements.

4.4.10 Mass concentration of non-refractory particulate organics and inorganics
In addition to the services applied to ACTRIS users; training for new operators and scientists shall be provided on the recommended SOPs and the QA/QC tools developed for these specific measurements.

4.4.11 Nanoparticle number concentration
The capacity building shall be organized in annual workshops that will provide operator training. The training sessions for the data analysis and data procedures occur during summer schools organized by the TC.

4.4.12 Nanoparticle number size distribution
The capacity building shall be organized in annual workshops that will provide operator training. The training sessions for the data analysis and data procedures occur during summer schools organized by the TC.

4.5 Improvement of measurement and retrieval methodologies for aerosols, clouds, and reactive trace gases

4.5.1 Particle number size distribution - submicrometer
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.2 Particle light scattering and backscattering coefficient
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.
4.5.3 Particle light absorption coefficient and equivalent black carbon concentration
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.4 Mass concentration of particulate organic and elemental carbon
Same as for operation support.

4.5.5 Particle number size distribution – optical and aerodynamic diameter
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.6 Particle number concentration
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.7 Mass concentration of particulate elements
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.8 Mass concentration of particulate organic tracers
Customized service of the TC shall be offered as direct support via telephone, email or remote access.

4.5.9 Cloud condensation nuclei number concentration
The TC will provide services of testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.10 Mass concentration of non-refractory particulate organics and inorganics
The TC will propose services for testing new prototypes, in close interactions with manufacturer. Requests for the development of specific software tools shall be considered on a case by case basis depending on the current interest and need within the community.

4.5.11 Nanoparticle number concentration
The TC should perform instrument development at the edge of the current knowledge to facilitate technology transfer from the scientific forefront to operational infrastructure. This will facilitate the TC to react to the needs arising from the user community.
4.5.12 Nanoparticle number size distribution

The TC should perform instrument development at the edge of the current knowledge to facilitate technology transfer from the scientific forefront to operational infrastructure. This will facilitate the TC to react to the needs arising from the user community.

5 Governance and management structure of the Centre for Aerosol In Situ Measurements

The Units of the Centre for Aerosol In Situ Measurements shall be organized according to the specific role of the CF, assuring that the CF complies with the requirements and obligations described in sections 0 and 8 of this document, and considering the general principles described in the Baseline document for the concept of the Central Facilities. The Centre for Aerosol In Situ Measurements shall be organized such that:

- It has a well-defined structure of Units,
- It has a well-defined decision-making process,
- It is coordinated by a CF Director and managed by a CF Management Board, which consists of the CF Director and the CF Unit Heads,
- It has clear and cost-efficient task sharing between the Units,
- It has a risk management strategy,
- It participates in the ACTRIS decision making by sending representative(s) to the ACTRIS legal entity bodies, e.g. to the RI committee.
6 Requirements for the Centre for Aerosol In Situ Measurements

6.1 General requirements

In order to be labelled as the Centre for Aerosol In Situ Measurements, the candidate shall:

- Commit for long-term operation, at least 10 years starting with the next year after the implementation as a CF,
- Set-up an appropriate structure of Units, to ensure an adequate functionality of the CF, cost-effective operation, and scalability with respect to the user demands and advancement of the state-of-the-art technology,
- Demonstrate the capacity (in terms of material and personnel resources), to ensure the provision of the needed services and operation support, as described in section 6.2
- Provide a feasible implementation and operation plan for the first five years, starting with the next year after the selection as CF,
- Commit to provide a minimum amount of user services, as described in section 0
- Commit to provide the mandatory operation support to the ACTRIS NFs, as described in section 3.

6.2 Technical requirements

6.2.1 Facilities

In view of the operation support and service provision, CAIS should have / put in place:

- Appropriate lab space, estimated to be in the order of 250 m² in total for all TC units
- Appropriate office and storage room space, estimated to be in the order of 110 m² in total for all TC units
- Appropriate instrumentation for aerosol particle generation, modification and characterization, detailed for each variable in the following.

6.2.1.1 Particle number size distribution – mobility diameter

Three reference MPSS: two as reference instruments for the intercomparison workshops, and a third one that should be made available for on-site intercomparisons.

Three reference CPC: two as reference instruments for the intercomparison workshops, and a third one that should be made available for on-site intercomparisons.

Sufficient laboratory space to ensure that at least six instruments and users can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.2 Multi-wavelength particle light scattering and backscattering coefficient

One multi-wavelengths reference Integrating nephelometer.

Sufficient laboratory space to ensure that at least six instruments and users can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.
6.2.1.3 Multi-wavelength particle light absorption coefficient and equivalent black carbon concentration

One multi-wavelengths reference Integrating nephelometer, three single wavelengths reference extinction monitors with three different wavelengths, and two reference different reference absorption photometers.

Sufficient laboratory space to ensure that at least six instruments and users can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.4 Mass concentration of particulate organic and elemental carbon

For the OCEC unit, the minimum facilities required include:

- An aerosol collector able to sample aerosol particles on quartz fibre filters big enough to be split in aliquots suitable to fulfil beneficiaries’ and users’ demand in terms of number and size.
- An OCEC analyser with a repeatability sufficient to determine test filters’ homogeneity with the precision required by the RI
- Gravimetric, dilution and deposition laboratory facilities for making artificial certified reference materials.

6.2.1.5 Particle number size distribution – optical and aerodynamic diameter

One reference APSS or OPSS as reference instruments for the intercomparison workshops, and one reference CPC.

Sufficient laboratory space to ensure that at least six instruments and users can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.6 Particle number concentration

One reference FCAE and one as reference CPC for the intercomparison workshops. Additionally, a generator for Nanoparticles is needed, preferably to produce silver particles.

Sufficient laboratory space to ensure that at least six instruments and users can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.7 Mass concentration of particulate elements

For the mass concentration of particulate elements, the minimum facilities required include:

- One particle accelerator in the mega volt range, with a proton source and a dedicated beamline for PIXE measurements
- One ED-XRF spectrometer with secondary anodes or filters
- One ICP-MS instrument
- One ICP-AES instrument
- One aerosol resuspension chamber to produce synthetic aerosols reference standards
• Sufficient laboratory space to ensure that at least six users can participate during each intercomparison workshop and hands-on training
• A room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.8 Mass concentration of particulate organic tracers
Minimum technical requirements are one LC/MS system with high-resolution mass spectrometer and one with a time-of-flight mass spectrometer, one IC/PAD and one GC/MS with a normal inlet system and one with curie-point-pyrolysis. The technical equipment requires 2 laboratories. Additionally one laboratory is needed for sample preparation and one room for operators and users for data analysis and evaluation.

6.2.1.9 Cloud condensation nuclei number concentration
Needed instruments are one reference CCNC, one reference MPSS, and one reference CPC for the intercomparison workshops. Needed is also sufficient laboratory space to ensure that at least six instruments and users can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.10 Mass concentration of non-refractory particulate organics and inorganics
One aerosol mass spectrometer is needed as reference measurements during the intercomparison workshops as well as for new devices and/or methodology testing purposes.
In order to perform calibrations, it is required to make use of nebulizers, DMA and CPC instruments, as well as a centrifugal particle mass analyser (CPMA). Furthermore, devices allowing for the generation of oxidised organic aerosols (e.g., using a Potential Aerosol Mass Oxidation Flow Reactor) is strongly recommended for examination of the accuracy of organics measurements.
Sufficient measurement techniques to provide satisfactory comparison with other techniques during intercomparison exercises, notably with total PM1, inorganic ions (online chromatography), organic carbon measurements (OCEC) are also needed.
Laboratory space large enough to ensure that an adequate 15 instruments can participate during each intercomparison workshop. Additionally, a room for the external operators and scientists should be provided to evaluate their individual data.

6.2.1.11 Nanoparticle concentration
Technical requirements for test particle production are the following:
• Capability to reproducibly generate size-selected organic and inorganic sub-0.01 µm particles of all charging states (+, -, 0), of which composition can be verified.
• For CPC concentration calibration capability to size select 0.01 – 0.3 µm particles.
• For particle concentration reference capability to produce singly charged 0.1 µm particles of known concentration.
Instruments needed to fulfil these procedures include aerosol electrometer, tube furnace generator, atomizer, electrospray ionizing source, wire generator, DMA, high resolution DMA, PSM, NAIS, and UF-DMPS.

6.2.1.12 Nanoparticle number size distribution
Technical requirements for test particle production are following:

- Capability to reproducibly generate size-selected organic and/or inorganic sub-0.01 µm particles of all charging states (+, -, 0), of which composition can be verified.
- For particle size classification capability to size select charged sub-0.01 µm particles with minimum sizing resolution (Z/ΔZ) of 20 and aerosol flow rate of 10 slpm for PSM, UF-DMPS, and NAIS calibration.
- For CPC concentrations calibration capability to size select 0.01 – 0.3 µm particles.
- For particle concentration reference capability to produce singly charged 0.1 µm particles of known concentration.

Instruments needed to fulfil these procedures include aerosol electrometer, tube furnace, atomizer, electrospray ionizing source, wire generator, DMA, high resolution DMA, PSM, NAIS and UF-DMPS.

6.2.2 Human resources

In view of the needed operation support for the NFs and service provision for ACTRIS users, during the operational phase the Centre for Aerosol In Situ Measurements should employ the following staff.

<table>
<thead>
<tr>
<th>Scientific and technical staff</th>
<th>Management and administration staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific expert</td>
<td>Qualified operator</td>
</tr>
<tr>
<td>CAIS</td>
<td>4.0</td>
</tr>
</tbody>
</table>

The estimation of the needed human resource has been performed by QA/QC experts based on the proposed activities and assuming that the whole TC is fully operational. Numbers are expressed in FTE units.

6.2.3 Other requirements

6.2.3.1 Particle number size distribution – mobility diameter
License for handling radioactive sources is needed.

6.2.3.2 Multi-wavelength particle light scattering and backscattering coefficient
Provision for CO₂ gas must exist.
6.2.3.3 **Multi-wavelength particle light absorption coefficient and equivalent black carbon concentration**

None

6.2.3.4 **Mass concentration of particulate organic and elemental carbon**

The RPO responsible for the OCEC TC unit shall be at least accredited for OCEC measurements (ISO 17025), and best for proficiency testing (ISO 17043).

6.2.3.5 **Particle number size distribution – optical and aerodynamic diameter**

None

6.2.3.6 **Particle number concentration**

Laser safety officer is needed. Provision for N$_2$ gas must exist.

6.2.3.7 **Mass concentration of particulate elements**

None

6.2.3.8 **Mass concentration of particulate organic tracers**

At least one of the TC operators should have a GLP/GMP (Good laboratory practice/Good manufacturing practice) certificate to ensure the highest level of QA/QC.

6.2.3.9 **Cloud condensation nuclei number concentration**

None

6.2.3.10 **Mass concentration of non-refractory particulate organics and inorganics**

License for handling radioactive sources is needed.

6.2.3.11 **Nanoparticle concentration**

Provision for N$_2$ gas must exist.

6.2.3.12 **Nanoparticle number size distribution**

License for handling radioactive sources is needed.

7 **Basic criteria for the selection of the Centre for Aerosol In Situ Measurements**

The applications to host the Centre for Aerosol In Situ Measurements are evaluated against a set of criteria covering:

- The **level of commitment** for long-term operation
- The **capacity** to provide the operation support and the services described in sections 3 and 0
  - The availability of the necessary laboratories, instruments, equipment
  - The availability of human resources (no., expertise)
• The **efficiency** in providing the operation support and the services
  o  The feasibility of the implementation plan (costs, resources, timeline)
  o  The feasibility of the operation plan (methodology, costs per service)
• The **level of maturity**
  o  Status of the development of the Units
  o  No. of existing users
  o  Adequacy of the decision-making
  o  Risk management strategy

These criteria shall be detailed in the associated call documents.

8  Obligations of the Centre for Aerosol In Situ Measurements

8.1  **General obligations**

The following general obligations shall apply to the Centre for Aerosol In Situ Measurements while operational:

• To organize its activities in a cost-efficient way, timely, and with high quality,

• To actively participate in the governance and sustainable development of ACTRIS,

• To provide services to users, according to the access procedures, availability of time, and material resources,

• To provide operation support to the NFs, according to the identified needs, agreed schedules, and procedures,

• To implement efficient user interaction activities by:
  o  Organizing workshops, to interact with users,
  o  Collecting user feedbacks,
  o  Maintaining the CF and ACTRIS websites,

• To document its activities, accesses provided, key performance indicators, and finances, and provide this information to the HO,

• To contribute to minimize and assess the uncertainties related to data and data products, according to their role and in collaboration with each other.

8.2  **Technical obligations**

8.2.1  **Technical obligations in relation with the ACTRIS National Facilities**

Technical obligations of the Centre for Aerosol In Situ Measurements in relation with the ACTRIS NFs refer strictly to the measurement techniques described in this concept document and in *Technical concepts and requirements for ACTRIS Observational Platforms*. The operation of other techniques at the NFs does not imply a technical obligation for the Centre for Aerosol In Situ Measurements to provide operation support. New techniques /
instrument types are only accepted as ACTRIS instruments after the approval of the RI Committee and after the development of the associated QA procedures by the CF.

8.2.1.1 Guidelines, quality assurance criteria and procedures

The Centre for Aerosol In Situ Measurements is responsible for the quality assurance procedures and guidelines of the ACTRIS measurements conducted at the NFs operating instruments for the physical or chemical in situ characterization of atmospheric aerosol particles as well as for particle sampling and subsequent laboratory analysis of these particles. For this, the TC should implement the following operation support for each of the measurement technique under its topics:

- Definition and establishment of standard operation procedures (as described in section 3.3.1)
- Definition of measurement quality-assurance criteria and procedures (as described in section 3.3.2)

All the procedures, guidelines, quality assurance criteria, plausibility tests, etc. should be documented and accessible to all related NFs. Specific training sessions with the related NF operators should be organized to ensure a smooth and correct implementation of the above.

8.2.1.2 Tools, tests and consultancy for quality control of the measurements

It is duty of the Centre for Aerosol In Situ Measurements to assist the related NFs in the quality control of their measurements by providing the following operation support for each of the measurement techniques under its topics:

- Development and provision of instrument-specific calibration (as described in section 3.3.3)
- Development and provision of in-house check-up tools (as described in section 3.3.4)
- Development of data evaluation procedures and plausibility test (as described in section 3.3.5)
- Consultancy for setting-up new observational or exploratory platforms and new instruments at the NFs (as described in section 3.4.3.4.1.12)
- Testing of new measurement instruments and procedures (as described in section 3.5.1)

This operation support should be offered to the related NFs whenever there is a need, or a significant progress in the development of these tools, and accompanied by the appropriate training.

8.2.1.3 Assessment of performances, measurement flagging

The Centre for Aerosol In Situ Measurements is mandated to assist the DC and the related NFs in the quality control of the measurements and data, by:

- Realization of observational site performance audits with reference samples or mobile systems (as described in section 3.3.6)
• Organizing regular exercises to assess the performances of the NFs, including instrument performance workshops (as described in section 3.3.7)
• Contributing to documentation and traceability of level 0 to level 3 data products (as described in section 3.3.8)

The activities involving directly the NFs operating instruments for the physical or chemical in situ characterization of atmospheric aerosol particles as well as for particle sampling should be scheduled by the TC and provided regularly. The corresponding NFs should participate in these activities according to the plan proposed by the Centre for Aerosol In Situ Measurements and agreed together with the ACTRIS Scientific Advisory Board (SAB).

8.2.1.4 Transfer of knowledge and training

In addition to the training organized for the implementation of guidelines, procedures, and tools developed in support of the quality control of the measurements, the Centre for Aerosol In Situ Measurements should organize training sessions with the NFs operating instruments for the physical or chemical in situ characterization of atmospheric aerosol particles as well as for particle sampling and subsequent laboratory analysis of these particles as needed (see section 3.4.1).

8.2.1.5 Improvement of measurement methodologies for Centre for Aerosol In Situ Measurements

Although it is not an obligation, the Centre for Aerosol In Situ Measurements should work to sustain a high level of performance and to stimulate the advancement of new techniques and methodologies in the in situ aerosol measurement field by:

• Development of strategies to increase the duty cycle of instruments operated at the NFs, to reduce breakdown and maintenance downtime (as described in section 3.5.2)
• Development of new technological products and methods (as described in section 3.5.3)
• Development of retrieval algorithms or tools for producing level 1 to 3 data, including the exploitation of instrument synergies (as described in section 3.5.4)
• Organizing regular events (at least once at 2 years) and other forums, in order to exchange knowledge with the NFs and other scientists
• Contributing to CEN, ISO, or similar standardization activities (as described in section 3.3.9)

8.2.2 Technical obligations in relation with the ACTRIS Data Centre

8.2.2.1 Data production and data products

The final in situ aerosol ACTRIS data products (ACTRIS data Level 1 and Level 2) consist of various aerosol particle properties together with the respective precision and accuracy, metadata and time dependent flags as specified by the DC and in the standard operating procedures.

For the online measurements, raw data (Level 0) at temperature and pressure conditions as provided by the instrument has to be stored together with the relevant standard and
calibration measurements and all information and meta data, which is needed to calculate the higher-level data products. Details for the data production are given in the ACTRIS Data Management Plan (D4.2) and the associated data production descriptions and documents provided by the DC and the Centre for Aerosol In Situ Measurements. All data products, pre-products and software tools are version controlled and identified by the associated DC unit.

ACTRIS aerosol in situ data production follows one of two main workflows, online or offline. For the online workflow, data production is based on Level 0 data, i.e. all raw data and signals provided by an instrument in its native time resolution and native conditions of temperature and pressure, brought to a harmonized format, and annotated with all metadata and remarks needed in the further data production process. Level 0 data are to be submitted and archived at the DC unless the ACTRIS Data Management Plan (D4.2), with the associated data production descriptions, defines an exception caused by, e.g., large raw data volumes, e.g. aerosol mass spectra. In this case, an alternative storage procedure has to be agreed between the Centre for Aerosol In Situ Measurements and the DC, which meets long-term archive criteria. The Level 0 data submission includes relevant calibration measurements and measurements of traceable standards needed for data quality control, which are flagged as such. From Level 0 data, Level 1 and Level 2 data are produced. Level 1 data are quality-controlled, calibrations are applied, final variable calculated, native time resolution, invalid and quality control measurements removed, and transferred to standard conditions of temperature and pressure where applicable. Level 2 data is averaged Level 1 data to typically hourly averages, with measure of atmospheric variability included. The Level 1 and Level 2 data can be produced either by the NF or the associated DC unit, depending on variable. The distribution of work is included in the associated data production descriptions available from the DC. The quality control step between Levels 0 and 1 can be automatic (real-real time data production) or manual, performed by the NF. Data level identifiers distinguish between data having received automatic or manual QC. The details of the steps producing Level 1 from Level 0, and Level 2 from Level 1, are specified in the associated data production descriptions and the standard operating procedures.

For the offline workflow, the steps of sample medium pre-exposure treatment, exposure, preparation, sampling, and analysis are documented with standard operating procedures and protocols including metadata and remarks in machine-readable form. Items to be included are specified in the associated data production descriptions and the standard operating procedures. The archive for the protocols is located at the NF, its operating protocols coordinated with and approved by the DC and the Centre for Aerosol In Situ Measurements. From these protocols, the Level 2 data products are produced in the temporal resolution determined by the sampling schedule, and transferred to the DC using the tools provided for data submission to ensure required documentation, flagging and
metadata. The details of the procedure are specified in the associated data production descriptions.

**8.2.2.2 Data delivery and quality control**

It is compulsory for the NF to produce at least Level 1 (online measurements) and Level 2 (online and offline measurements) data for archiving at the associated DC unit. Archiving of Level 0 data will depend on specific variables. For the submission of aerosol in situ data, required procedures are described in the ACTRIS Data Management Plan (D4.2) and the associated data production descriptions. Manually quality controlled data has to be submitted on a regular, scheduled frequency, at least yearly to the ACTRIS DC following the scheme in the ACTRIS Data Management Plan (D4.2), and associated documents. Submission to the DC has to be done before 31 May, using the submission tools and automatic quality control software available within the DC. Data originators at the NF are responsible for checking the data using the procedures in the associated data production descriptions. Data is then reviewed by the Centre for Aerosol In Situ Measurements and shall be discussed at the annual data quality meeting, in collaboration with the DC. An issue tracker is operated in the process of data evaluation to ensure full documentation and traceability of the data production and quality control process. This comes into place yearly following the initial data submission by stations to the ACTRIS DC. Upon errors, the data has to be re-submitted and shall be reviewed again for compliance with suggested changes. Whenever possible by measurement principle and connectivity to the station, Level 0 data must be transmitted to the DC in real-time (RRT), i.e., latest within 3 hours of measurement, for delivery of an RRT data product for operational services.

**8.2.3 Technical obligations in relation with the Centre for Cloud In Situ Measurements and the Centre for Reactive Trace Gases In Situ Measurements**

Currently (2018), there are no technical obligations the Centre for Aerosol In Situ Measurements has to fulfil for other TCs. However, as the six scientific ACTRIS themes partly overlap, there is sometimes the need to agree among two TCs which of the two TCs is responsible for specific operation support or services. For the Centre for Aerosol In Situ Measurements this overlap exists with the Centre for Cloud In Situ Measurements concerning the cloud droplet or ice crystal activation properties of aerosol particles, as well as with the Centre for Reactive Trace Gases In Situ Measurements concerning the transition from gas molecule clusters to aerosol particles.

**8.2.4 Technical obligations in relation with the ACTRIS users**

The Centre for Aerosol In Situ Measurements should commit to provide a minimum amount of user services as described in section 0.

**8.3 Evaluation of the activity of the Centre for Aerosol In Situ Measurements**

Once established and operational, the Centre for Aerosol In Situ Measurements shall be evaluated for its performances, using the following Key Performance Indicators (KPIs):
<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Indicators</th>
<th>Score</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Usefulness for ACTRIS NFs</td>
<td>No. of operation support units provided to ACTRIS NFs for quality assurance and quality control</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of operation support units provided to ACTRIS NFs for knowledge transfer and training</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of operation support units provided to ACTRIS NFs for Improvement of measurement and data processing methodologies</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average score of satisfaction received from NFs</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Average of Usefulness for ACTRIS</strong></td>
<td></td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>Usefulness for ACTRIS users</td>
<td>No. of service units provided to ACTRIS users for quality assurance and quality control</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of service units provided to ACTRIS users for knowledge transfer and training</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of service units provided to ACTRIS users for Improvement of measurement and data processing methodologies</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average score of satisfaction received from ACTRIS users</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Average of Usefulness for external users</strong></td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>3</td>
<td>Impact on science and technology</td>
<td>No. of new technological products, methods and algorithms developed/improved</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of peer-review CF-related papers published</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of CF-related communications at scientific conferences/workshops</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of CF-related patents promoted</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Average of S&amp;T Impact</strong></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>4</td>
<td>Integration into ACTRIS-RI</td>
<td>No. of participations to ACTRIS committees and boards</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. of activities performed in collaboration with other TCs (joint SOPs, joint workshops, etc.)</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average score of satisfaction received from ACTRIS DC for the contribution to documentation and traceability of data products</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average score of satisfaction received from ACTRIS HO for the quality and readiness of the reports</td>
<td>1 ... 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Average of Integration into ACTRIS-RI</strong></td>
<td></td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td><strong>Total score</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Glossary

General ACTRIS terminology

Can be found at: https://www.actris.eu/About/ACTRIS/ACTRISglossary.aspx

Specific ACTRIS terminology

ACTRIS Topical Centres (TCs) – a Central Facility offering services and operation support for QA/QC of measurements and data (including training, calibration, QA/QC tools, and development of standard operation and evaluation procedures)

ACTRIS variables - the measured atmospheric variables as described in the ACTRIS Data Management Plan1.

Central Facility (CF) - a European level ACTRIS component that offers ACTRIS data or other ACTRIS services to users as well as operation support to ACTRIS National Facilities.

Central Facility Unit – part of a Central Facility located at, and operated by a research performing organization (RPO) or by ACTRIS ERIC.

CF Director – the person responsible for the coordination and representation of a Central Facility.

CF Unit Head – the person responsible for the coordination and representation of a Central Facility unit.

CF Management Board – consists of the CF Unit Heads and the CF Director; this board manages the Central Facility.

Measurement traceability - an unbroken chain of comparisons relating an instrument's measurements to a known standard, in the ideal case SI units.

National Facility (NF) - an observational or exploratory platform providing data and/or physical access to the platform within ACTRIS.

Quality assurance and control: Quality assurance is process oriented and focuses on defect prevention; quality control is product oriented and focuses on defect identification:

- Quality Assurance (QA): The process or set of processes used to ensure the quality of a product (e.g. data series, instrument, sample, measured value of a variable, etc.),
- Quality Control (QC): The process and activities of ensuring products and services meet the expectations.

Remote sensing - measured air and instrument are not at the same location and not in physical contact. In the context of ACTRIS, active and passive atmospheric remote-sensing techniques for the observation of aerosols, clouds, and trace gases are applied at observational sites and on mobile surface-based or airborne platforms.

1The ACTRIS data management plan and list of variables were approved by ACTRIS-2 scientific steering committee, October 2015. These documents are expected to be refined during ACTRIS-PPP (WPS).
**User** - a person, a team, or an institution making use of ACTRIS data or other ACTRIS services, including access to ACTRIS facilities.

**References**

**Background documents**

ACTRIS-PPP proposal

ACTRIS Data Management Plan, approved by ACTRIS-2 SSC 23 October 2015

ACTRIS Concept Documents

ISO 10012:2003: Measurement management systems — Requirements for measurement processes and measuring equipment

ISO 9000:2015: Quality management systems—Fundamentals and vocabulary

Baseline document for the Concepts of ACTRIS Central Facilities

Technical concepts and requirements for ACTRIS Observational Platforms

Technical concepts and requirements for ACTRIS Exploratory Platforms

ISO 10012:2003: Measurement management systems — Requirements for measurement processes and measuring equipment

ISO 9000:2015: Quality management systems—Fundamentals and vocabulary

**Scientific and technical references**


### Annex: Provision of the operation support

#### 9.1 Scheduled support

<table>
<thead>
<tr>
<th>Mode</th>
<th>Type of support</th>
<th>Specific support</th>
<th>Frequency</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>In situ measurements</td>
<td>Instrument-specific calibration workshop at TC facility</td>
<td>Comparison with fixed reference instruments, intercomparison measurements, support for beneficiaries whose instrument under-performed</td>
<td>Once every 1-3 years, after major upgrades, or after replacement</td>
<td>TC distributes a schedule one year in advance and agrees with the NFs on potential adjustments of the schedule</td>
</tr>
<tr>
<td>In situ sampling</td>
<td>Site performance test with reference instruments operated at NFs</td>
<td>Round-Robin reference instrument, support for beneficiaries whose instrument under-performed</td>
<td>Once every 1-2 years, after major upgrades, or after replacement</td>
<td>TC distributes a schedule one year in advance and agrees with the NFs on potential adjustments of the schedule</td>
</tr>
<tr>
<td>In situ sampling</td>
<td>Laboratory intercomparison at NFs</td>
<td>Round-Robin reference samples, support for beneficiaries whose instrument under-performed</td>
<td>Once every 1-2 years, after major upgrades, or after replacement</td>
<td>TC distributes a schedule one year in advance and agrees with the NFs on potential adjustments of the schedule</td>
</tr>
<tr>
<td>In situ measurements or sampling</td>
<td>Training of operators and scientists</td>
<td>Training on particle measurement and sampling, exercises to access the performance of NFs, training on data evaluation</td>
<td>Once every 1-2 years</td>
<td>Mostly co-located with instrument calibration workshops, otherwise specific schools announced on the TC web page and with online registration</td>
</tr>
</tbody>
</table>
### 9.2 Operation support on request

<table>
<thead>
<tr>
<th>Mode</th>
<th>Type of support</th>
<th>Specific support</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>In situ measurements or sampling</td>
<td>Measurement guidelines</td>
<td>Definition and establishment of measurement guidelines and standard operation procedures</td>
<td>For new instruments and/or new ACTRIS variables, depending on capacity and time schedule, on request by the National Facilities Assembly and the RI Committee</td>
</tr>
<tr>
<td></td>
<td>Quality-assurance criteria and procedures</td>
<td>Definition of measurement quality-assurance criteria and procedures</td>
<td>For new instruments and/or new ACTRIS variables, depending on capacity and time schedule, on request by the National Facilities Assembly and the RI Committee</td>
</tr>
<tr>
<td></td>
<td>Instrument calibration</td>
<td>Development and provision of instrument-specific calibration</td>
<td>Unscheduled calibration, either at TC or at NF, depending on capacity and time schedule, on request by NFs via SAMU</td>
</tr>
<tr>
<td></td>
<td>Measurement and data tools</td>
<td>Development and provision of in-house check-up tools</td>
<td>Depending on capacity and time schedule, on request by the NFs, the DC, the National Facilities Assembly, or the RI Committee</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Development of data evaluation procedures and plausibility tests</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Site performance tests</td>
<td>Round-Robin test with either reference samples or reference instruments, analysis of samples collected by the NFs</td>
<td>Unscheduled site performance tests, e.g. after major site upgrades, depending on capacity and time schedule, on request by NFs via SAMU</td>
</tr>
<tr>
<td></td>
<td>Training of operators and scientists</td>
<td>Training on particle measurement and sampling, exercises to access the performance of NFs, training on data evaluation</td>
<td>Unscheduled training, depending on capacity and time schedule, on request by NFs or RI Committee</td>
</tr>
<tr>
<td>In situ measurements or sampling</td>
<td>New RI components</td>
<td>Consultancy for setting-up new observational or exploratory platforms and new instruments at NFs</td>
<td>Depending on capacity and time schedule, on request by NFs via SAMU</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Testing of new measurement instruments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data production</td>
<td>Development of tools for producing level 1 to 3 data, including tools for producing NRT data</td>
<td></td>
<td>Depending on capacity and time schedule, on request by the DC, the National Facilities Assembly, or the RI Committee</td>
</tr>
</tbody>
</table>