



## D4.9.1: Testing report of the updated version of the ChAMBRe DAQ and data storage system [B8]



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## LIST OF ACRONYMS

**ACTRIS:** Aerosols, Clouds, and Trace gas Research InfraStructure

**ACTRIS-IT:** Italian component of the distributed research infrastructure ACTRIS

**DAQ:** Data and Acquisition System

**FAIR:** Findable, Accessible, Interoperable and Reusable

**OU:** Operative Unit

**RI:** Research Infrastructure

**TNA:** Trans-National Access

**WP:** Work Package

## 1. INTRODUCTION

This deliverable is prepared in the context of the ITINERIS project, within the Work Package 4 that deals with the integration of Research infrastructures working in the atmospheric domain through synergistic approaches and cross boundaries developments. This deliverable reports the implementation plan of the Task 4.9.1 linked to the FAIR activity i.e. testing the updated version of the ChAMBRé DAQ and data storage system [B8]. The main objective of this task is the two-fold implementation of the FAIR principle for data management: i) the development of a spare data acquisition system to avoid possible data losses during the unique experiments performed at the facility; ii) the empowerment of data processing and storage capability.

The document is structured in five different chapters. Annexes and references are reported at the end of the document.

## 2. ChAMBRé

The atmospheric simulation chambers are small to large-scale facilities where atmospheric conditions can be produced and monitored in real-time to reproduce realistic atmospheric environments and to study interactions among their constituents. Up to now, they have been used mainly to study chemical and photochemical processes that occur in the atmosphere, but the high versatility of these facilities allows for a wider application covering all fields of atmospheric aerosol science.

ChAMBRé (Chamber for Aerosol Modelling and Bio-aerosol Research) is stainless steel atmospheric simulation chamber (volume:  $\approx 2 \text{ m}^3$ ) installed at the National Institute of Nuclear Physics in Genoa (INFN-Genova, [www.ge.infn.it](http://www.ge.infn.it)) and developed in collaboration with the Environmental Physics Laboratory at the Physics Department of Genoa University ([www.labfisa.ge.infn.it](http://www.labfisa.ge.infn.it)). ChAMBRé is a node of the European network of atmospheric simulation chambers and has been partner of the H2020 EUROCHAMP2020 project, funded by UE for the period December 2016 - August 2021.

ChAMBRé is one of the two INFN facilities of ACTRIS. INFN-ChAMBRé is a member of ACTRIS-IT, a Joint Research Unit composed by several Italian Institutions ([www.actris.it](http://www.actris.it)).

Starting from fall 2021, ChAMBRé offers physical and remote Trans-National Access (TNA) in the frame of the 4-year ATMO-ACCESS EU project: the chamber is one of the selected 60 European facilities forming a distributed/integrated research infrastructure. In this frame, the participation to PNRR-ITINERIS gives to ChAMBRé the possibility to significantly improve the data management and conservation of unique and valuable data produced by different types of experiments on atmospheric aerosols.

## 3. SCIENTIFIC OBJECTIVES

The atmospheric simulation chamber ChAMBRé is a national facility of the ACTRIS RI. ChAMBRé has the scientific mission to make possible a large spectrum of studies on phenomena related to atmospheric aerosols, with an approach complementary to in situ observatory stations and platforms. The facility does not perform continuous observations on the atmospheric medium, but instead offers to the scientific community the opportunity to perform targeted and unique experiments to disentangle single parts of complex phenomena. The integration and harmonization activity foresees the purchase of laboratory instrumentation to complete the present equipment. The goal is a comprehensive characterization of aerosol samples produced inside ChAMBRé, with a focus on the elemental composition and the classification of carbonaceous species. The deployment of equipment

to improve the aerosol injection and extraction into/from ChAMBRe completes the instrumental upgrade. Part of the ITINERIS budget is devoted to the renewal of some technological plants to guarantee a flexible and reliable distribution of several technical gases, easily accessible and controllable to/by ChAMBRe external users.

#### 4. UPDATED DAQ SYSTEM AT ChAMBRe

The data acquisition and control of the instruments connected to ChAMBRe is handled by a National-Instruments™-based system consisting of a main controller (NI cRIO-9057) and several modules (C Series) that allow communication with the peripheral devices via analogue, serial, and Ethernet data transfer protocols. The operator interacts with the sensor network using customized NI LabVIEW™ SCADA (supervisory control and data acquisition) application, which provides the user with a global data overview and a full real-time control of all parameters via an easy-to-use graphical human-machine interface (HMI). A screenshot of the graphical HMI of the ChAMBRe SCADA application is reported in **Error! Reference source not found.**

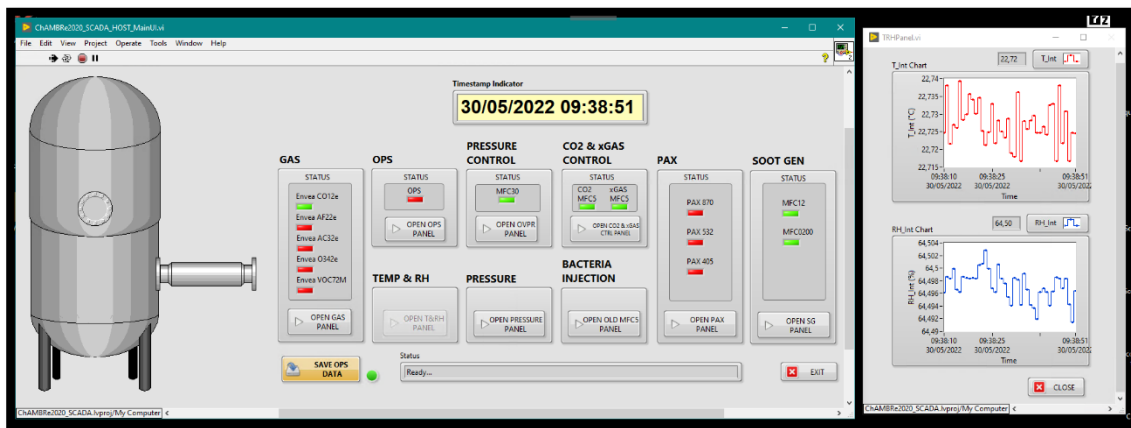


Figure 1: screenshot of the graphical user interface of ChAMBRe SCADA application (LabView language)

Considering the large number of experiments scheduled at ChAMBRe within the bioaerosol research line and the involvement of ChAMBRe as a member of the international network of atmospheric research facilities (ATMO-ACCESS), which makes the facility available to researchers who request the use of the atmospheric chamber (TNA - trans-national-access), the annual experimental agenda at ChAMBRe is particularly busy. This makes the development and testing phase of the software quite difficult. In this context, the financial support by ITINERIS has been used to duplicate the complete DAQ setup of the ChAMBRe facility to meet the needs of developing and testing new features of the main software application (LabView language) in parallel with running experiments. In addition, the exact replication of the DAQ system guarantees a ready-to-use setup in case of unattended hardware failures, thus avoiding periods of facility downtime.

The control station consists of a powerful desktop PC and a main controller (NI-cRIO 9057) connected via Ethernet, as well as several DAQ modules (NI C-Series) that communicate with the sensors embedded in the atmospheric simulation chamber. A picture of the purchased control station is shown in

Figure 2: Picture of the control station. This is an exact duplicate of the DAQ system connected to the ChAMBRe atmospheric simulation chamber.

**Error! Reference source not found.**, shows the hardware core of the ChAMBRe data acquisition and control system: the NI cRIO-9057.

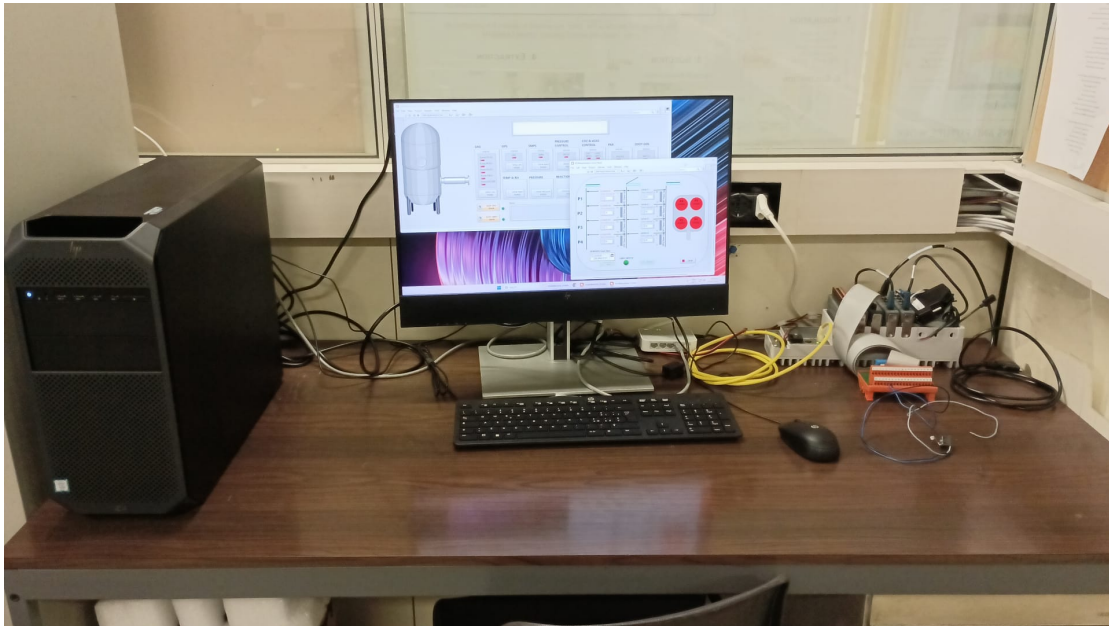


Figure 2: Picture of the control station. This is an exact duplicate of the DAQ system connected to the ChAMBRé atmospheric simulation chamber.

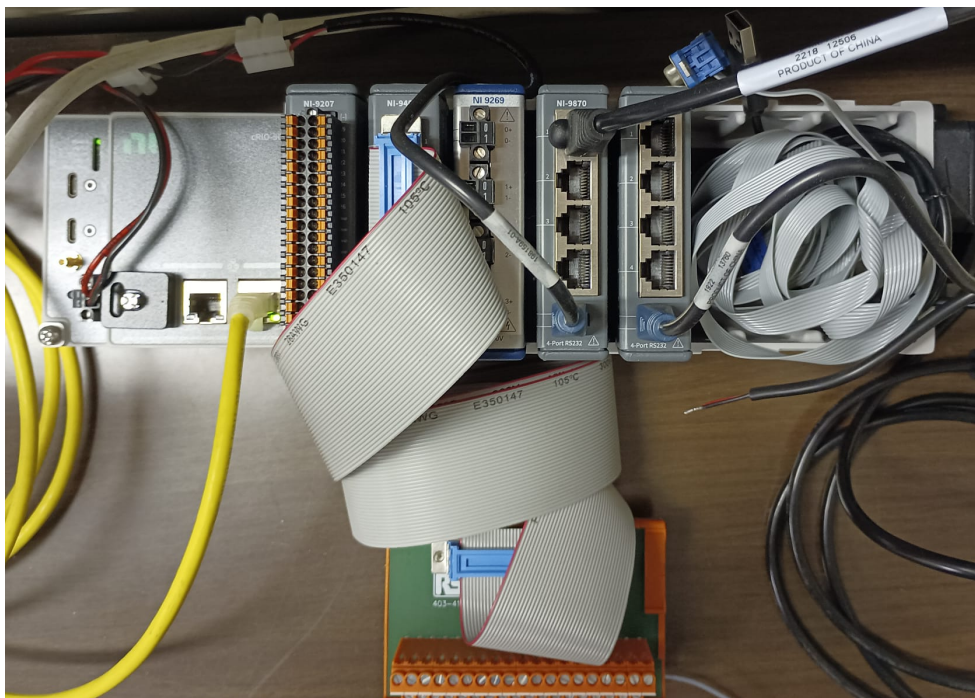


Figure 3: Picture of the NI-cRIO 9057 and of the C-Series module. This is the hardware core of the ChAMBRé DAQ system.

A powerful workstation was also purchased to host the central LabView-based database (Citadel 5) where real-time data recorded during the experiments are deployed and stored. A protocol was locally defined to associate a dataset to a specific experiment using a unique alphanumeric identifier. The database can be accessed by operators to retrieve historical time series of any measured variables and to compare different data sets in an easy-to-use graphical interface.

**Error! Reference source not found.** shows an example of time series retrieved from the central database and visualized by a graphical user interface. Following the FAIR principles, each data set is associated with rich metadata describing the specific conditions of the individual experiment. Data and metadata can be retrieved from the central database using this unique identifier, visualized as a graphical time series, or accessed from a shared folder as a simple text file. Data and metadata are also made available to external users on demand following the standard and the policy adopted in the former EU-EUROCHAMP2020 project.

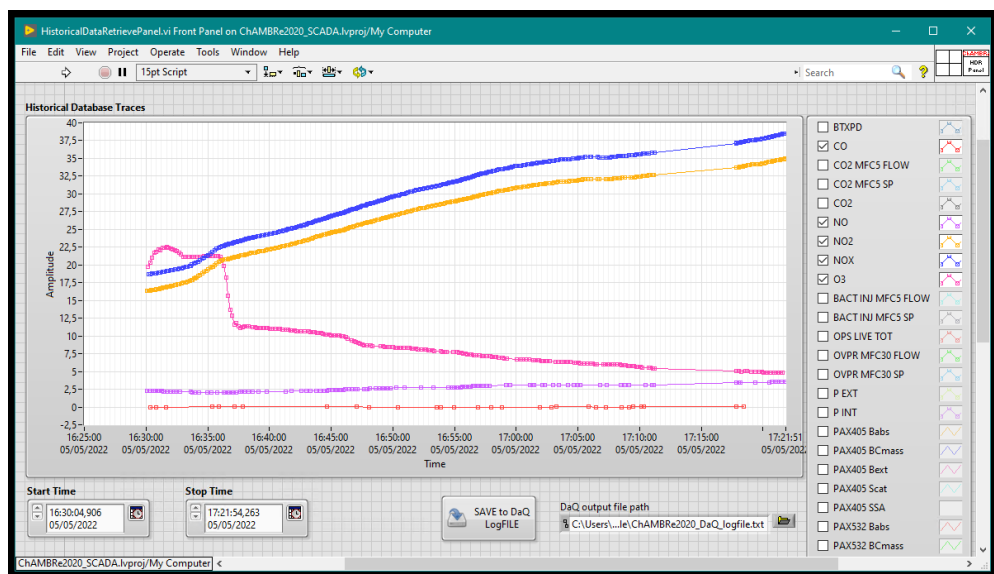


Figure 4: plot of historical time series retrieved from the central database.

## 5. TESTS AND RESULTS

To test the operability of the control station, a hardware failure event was simulated by connecting the cRIO controller and the acquisition modules to the ChAMBRé sensor network in parallel with the main DAQ system. The test was successful, demonstrating that the facility's downtime in case of hardware or software issues can be reduced to about 30 minutes.

In addition, a test was performed on the data acquisition performance of the control station and on the storage capability of the workstation hosting the database. The acquisition system can handle up to 12 serial communication channels (RS232), 4 analog output channels, 32 digital I/O channels, and 16 analog input channels in parallel. In addition, the system can handle parallel communication with a large number of instruments residing on the same LAN (local area network) and equipped for Ethernet communication through different standard protocols (MODBUS, TCP/IP, TELNET). Since the output data is recorded in text format, both on the main database and within the shared files, the data storage capacity is nearly unlimited: the SSD disks of the PCs have capacities of 2.5 TByte each. The powerful chipset of the PC (octal core 4.10 GHz CPU; 32 GByte RAM) allows the graphical display of the output coming from each instrument connected to ChAMBRé in parallel, giving the operator a general overview of the acquisition status.