MISSIONE 4
ISTRUZIONE
RICERCA

D4.5.3: Implementation of the customizations necessary for the instrumentation to make it airborn

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1. INTRODUCTION

This deliverable was prepared under the ITINERIS project as part of Work Package 4 (Atmosphere), which focused on integrating atmospheric Research Infrastructures by fostering synergy and cross-boundary developments.

The activity aimed to bolster Italy's role in the EUFAR (EUropean Facilities for Airborne Research) consortium—an international non-profit association that coordinated European instrumented aircraft operations and drew on the expertise of environmental and geoscience specialists in airborne measurements. Italy, through the CNR (Consiglio Nazionale delle Ricerche) and OGS (Istituto di Oceanografia e Geofisica Sperimentale), already participated in this network with its scientific aircraft and instrumentation. To reinforce that involvement, the project secured additional scientific instruments suitable for installation on crewed aircraft; these systems were intended for in-situ characterization of atmospheric particulate matter on airborne platforms.

WP 4 (Atmosphere) promotes cross□infrastructure synergies between ground□based observatories, tethered platforms and aircraft. The Seneca upgrade complements coastal lidar stations (Task 4.12) and marine aerosol cruises (WP 5) by providing in□situ closure measurements aloft. Figure 1 of the previous report (see §2 of D4.5.2) illustrates these links. The present deliverable reports on the progress achieved under ITINERIS activity 4.5, which seeks to equip the OGS PA□34 Seneca III research aircraft with a complete, ACTRIS□compliantsuite of aerosol, optical□radiativeand meteorological sensors. This work positions Italy to contribute routine vertical aerosol profiling to EUFAR and EARLINET, thereby addressing key gaps identified in southern□Mediterranean climate assessments.

Accordingly, this deliverable, produced under WP 4.5, provides a progress report on the procurement of airborne instrumentation and the customizations carried out on both the equipment and the aircraft to enable their operation aloft.

During the REPORTING period we completed: (i) procurement of all primary instruments; (ii) factory acceptance and laboratory calibration; (iii) preliminary mechanical and electrical integration studies; and (iv) drafting of the certification programme in cooperation with Boggi Aeronautics Design Organisation.

2. SCIENTIFIC RATIONALE

The topic of the scientific relevance of airborne observations in the Mediterranean areas has already been extensively addressed in the previous report (see §2 of D4.5.2), to which the reader is referred for further details and context. Here we briefly summarize the main scientific question the airborne observations can tackle.

The Mediterranean Basin is recognised as a climate□change hotspot: mean surface air temperature is already +1.5 °C above pre□industrial levels—35 % greater than the global mean rise. Four classes of aerosol perturb the regional radiative budget:

1. Mineral dust – Saharan lofting events increasingly frequent under projected desertification
2. Biomass□burning smoke – Pyro□convection injects absorbing particles to the upper troposphere and occasionally the lower stratosphere

3. Marine biogenic aerosol – Eutrophication alters plankton blooms, modulating organic sea□spray production.
4. Urban–industrial pollution – Expected to decline, but its vertical redistribution during heatwaves remains uncertain.

Remote□sensing networks provide horizontal fields but lack vertical resolution below 8 km; a dedicated research aircraft can directly sample these layers, validate lidar retrievals and supply size□resolved optical properties for model parameterisations. Prior Italian in□situ campaigns have been episodic (balloons, zeppelins, IAGOS transit flights) leaving pronounced temporal.

3. DESCRIPTION OF THE ACTUAL SENECA III FACILITY

The turbo□charged PA□34□220T offers a service ceiling of 7 620 m and a cruise speed of ≈ 333 km h^{-1} while carrying 250–300 kg of payload. Existing remote-sensing kits (RIEGL VQ□480II lidar, SPECIM Aisa□Eagle hyperspectral imager, iMAR FSAS INS) remain installed, giving the platform multi□domain capability. A detailed description of the aircraft and its current payload is provided in the previous report (see §2 of D4.5.2), to which the reader is referred for further information.

4. INTEGRATION OF AEROSOL MEASUREMENT SYSTEMS ON BOARD SENECA III

The upgrade of the Seneca III research aircraft and payload involved a comprehensive set of modifications and integrations to allow airborne aerosol and meteorological research with high-resolution, ACTRIS-compliant instrumentation. This section outlines the installed systems and their technical characteristics, reflecting both the selection criteria and the design constraints of the platform.

The primary goal was to enable vertically-resolved, size-resolved and composition-sensitive aerosol measurements, supported by accurate meteorological context data. The integration process encompassed mechanical, electrical and aerodynamic considerations, from the placement of inlets and probes to the layout of racks and power distribution inside the cabin. Furthermore, all designs took into account relevant EASA airworthiness regulations and ACTRIS interoperability standards, ensuring compatibility with European airborne research infrastructure.

To achieve these goals, the aircraft is intended to be equipped with a state-of-the-art sampling system, microphysical and optical aerosol instrumentation, and a high-frequency meteorological probe, whose detailed description is presented in the last report (see §4 of D4.5.2). To allow the instrumentation mounting and operation onboard the aircraft, the installation of dedicated power converters and inverters is envisaged to ensure clean and stable power for each subsystem, while the layout of racks and sensor positions was optimised for both airflow integrity and operational efficiency. Detailed feasibility and certification studies were conducted in parallel, culminating in the submission of a Major Change application for the aircraft to EASA (see §6).

In the sections that follow, the instrumentation, power supply architecture, and payload layout are described in detail, with specific reference to their operational roles, technical specifications and installation constraints.

4.1 List of the instrumentation

Sampling system. The Brechtel ISO□1200 isokinetic inlet (delivery due Q4 2024) guarantees representative transmission from < 10 nm to 4 µm across 40–90 m s^{-1} true−air−speed. An ISO−90 bend and SP025 splitter distribute flow to cabin racks.

Microphysics package.

Table 1 lists the instruments dedicated to the microphysical characterization of the atmospheric particulate.

Instrument	Size/Range	Output	Typical Power
TSI WCPC 3789	2 nm–3 µm	CN concentration	200 W AC
TSI FMPS 3091	5.6–560 nm	1 Hz size dist. (32 bins)	250 W AC
TSI APS 3321 (*)	0.5–20 µm	PM mass & counts	90 W AC
TOPAS OPC LAP-323	0.25–32 µm	Optical size dist.	51 W AC

(*) Installable in alternative to TOPAS OPC LAP-323

Table 1: Microphysical package

Optical package. Magee AE33 aethalometer supplies black carbon concentration and wavelength□dependent aerosol absorption coefficient, while Ecotech Aurora 3000 nephelometer obtains the aerosol scattering coefficient at 450/525/635 nm. Combining these two instruments the single□scattering albedo will be calculated.

Meteorological package. Aventech AIMMS□30 probe delivers 50 Hz wind vectors, turbulence, T, P, RH and true air speed, enabling eddy□covariance aerosol flux calculations.

Calibration and maintenance intervals follow ACTRIS guidelines (version 2.1, 2023), ensuring inter□comparability with other European fleets.

4.2 Electrical provision

Table 2 defines the dedicated power architecture: an 800 W 12→28 V DC□DC converter plus a 1 000 W pure□sine inverter feeding a 220 VAC bus housed in the nose bay. Peak and typical loads are summarised below (adapted from Table 3 of the certification programme):

Sub-system	Voltage	Typical W	Max W
FMPS 3091	220 VAC	170	250
WCPC 3789	220 VAC	100	200
AE33	220 VAC	25	90
Aurora 3000	220 VAC	80	120
LAP-323	220 VAC	21	51

Subtotal AC		**396**	**711**
ISO-1200 inlet	28 VDC	56	—
AIMMS-30 + ARIM200	28 VDC	13	—
Data loggers (× 2)	28 VDC	64	—
Subtotal DC		**133**	—

Table 2. Definition of voltage and power (peak and regime) requirement for the instrumentation.

The combined margin (> 20 %) satisfies CS 23.1351 electrical□system reserve requirements. Wiring, breakers and receptacles follow the AC 43.13□1B norm. An EMI test is mandated post□installation to verify compatibility with avionics.

4.3 Payload layout – inlet, meteo probe and racks

4.3.1 External installations

Figure 1: Brechtel - Isokinetic inlet probe system

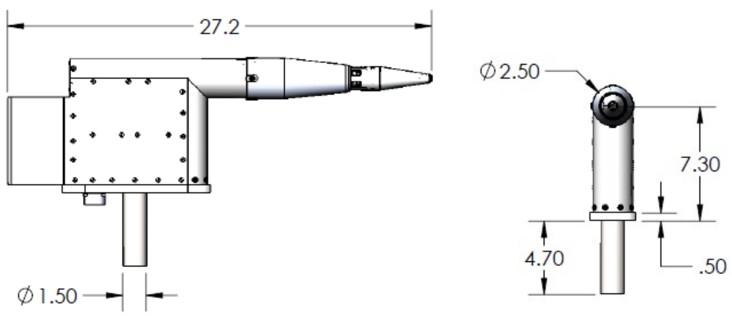

Figure 2: Brechtel P/N 83-00042-01 overall dimensions (inches)

Figure 1 locates the Brechtel inlet on the cabin roof at fuselage; a stainless doubler spreads local loads.

Figure 3: Aventech probe P/N ARIM200 with VECTRAX-OEM719-A30 processing module

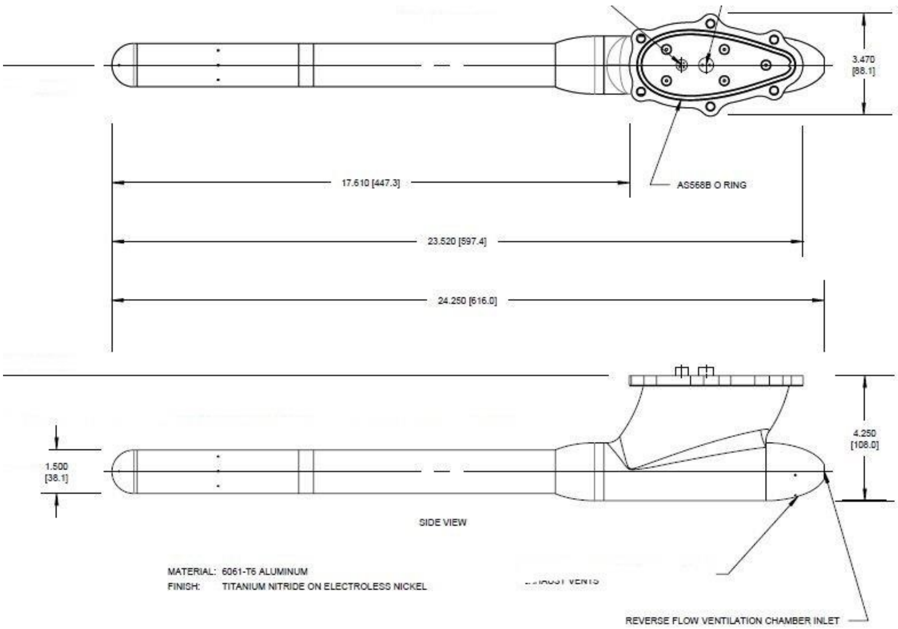

Figure 4: Aventech probe P/N ARIM200 overall dimensions in inches and [mm]

Figure 2 provides its clearance envelope for CFD analysis. The Aventech ARIM200 wind probe (combined pitot + GPS) is mounted aft at station 130 (Figures 3–4), ensuring undisturbed flow while respecting antenna keep□out zones.

Figure 5: Proposed probe position

Figure 5 Displays the probe positions. Streamline simulations have been carried out and ensure negligible mutual interference when both probes are operated concurrently.

4.3.2 Internal installations

Three modular aluminium racks house the scientific payload (Figure 6).

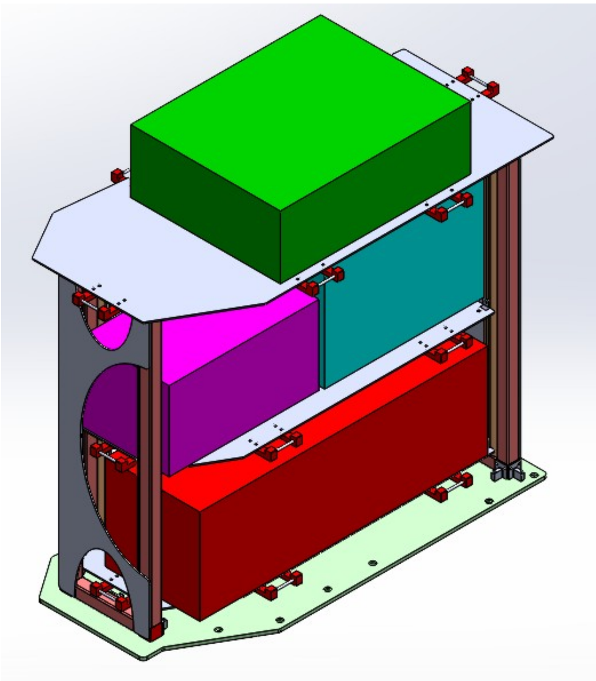

Figure 6: Proposed design for rack P/N P34P002-1000-0

These are: FWD rack – replaces RH front seat; carries WCPC 3789, Aurora 3000 and system UPS; Baggage□bay rack – supports FMPS 3091 and AE33; isolators attenuate vibration; Trap□door rack (optional) – installs over cabin hatch under STC 10086036 for campaigns requiring APS 3321 or spare channels.

For each rack, the maximum weight and volume of each equipment, that can be installed and fixed using appropriate belts, will be defined following the structural analysis and the cabin inspection results.

Table 3 of the certification document (See Annex) assigns shelf mass limits (≤ 15 kg) and electrical pinouts; a selector switch in the cabin enables three crew/instrument configurations (C□1, C□2, C□2b) described in the previous report.

Structural substantiation utilises FAR 23.561 emergency□landing loads with 1.33 safety factor; FEA indicates ≤ 20 % margin on rack attachment fittings. A cabin inspection will confirm no adverse impact on the designated emergency exit (Figure 10 of the certification programme, See Annex)

5. RESEARCH COLLABORATION AGREEMENT BETWEEN CNR-ISAC AND OGS

The bilateral CNR-ISAC/OGS agreement (see §5 of D4.5.2), effective 1 Nov 2023 – 31 Oct 2025 (automatic extension upon project prolongation), delineates roles: CNR□ISAC provides scientific payload and coordinates certification; OGS supplies aircraft. However, the current installation and flight testing of the instrumentation will not be performed within the project timeframe. Therefore, future developments will necessarily require an extension of the agreement between OGS and CNR to ensure operational continuity and deployment.

6. APPLICATION TO EASA

On **21 May 2025** an application for Major Change was submitted to EASA via the applicant portal, referencing this certification programme (Change P34P002-00, see Annex). The Agency's allocation number will be inserted. The application will remain valid until **31 December 2025**, then should be renewed at a minimal cost.Key forthcoming milestones, outside the project's timeframe, may include, from month X of EASA approval for Major Change:

- From X to X+4 – Prototype installation & cabin inspection (MC7)
- From X+5 to X+9 – Flight-test campaign (6 sorties, envelope expansion + aerosol payload validation)
- From X+10 to X+16 – EMI test & STC package delivery to EASA
- From X+17 – Issue of STC and operational deployment in field campaigns

Acceptance of the change will authorize permanent installation of the probes, racks and electrical provision, unlocking a **fully vertically-resolved aerosol research capability** for Italy in time for collaborative experiments

7. CONCLUSION

This deliverable has reported the advancements achieved within ITINERIS WP 4.5, aimed at enabling advanced airborne aerosol and meteorological observations using the Seneca III research aircraft. The customization and integration of scientific instrumentation have been carefully planned and partially implemented, including procurement, system calibration, power provision layout, and mechanical design for airborne installation.

While the physical integration and flight testing of the payload will occur beyond the project's timeframe, the technical foundation and certification pathway have been clearly defined. The application for Major Change, submitted to EASA in May 2025, sets the stage for operational deployment of a fully equipped airborne observation platform in subsequent years.

The work performed under WP 4.5 therefore represents a substantial step forward in reinforcing Italy's capacity to contribute to international aerosol research initiatives and atmospheric field campaigns. Continued collaboration between CNR-ISAC and OGS will be essential to complete the installation, secure regulatory approval, and ensure long-term scientific exploitation of the platform.

ANNEX

Attached is the document submitted to and accepted by EASA, containing:

- the project description (section 2)
- classification of the modification and the activities agreed upon to ensure compliance with regulations for each technical panel (section 4)
- documentation to be prepared (section 7)
- milestones (section 10), which represent a provisional timeline.