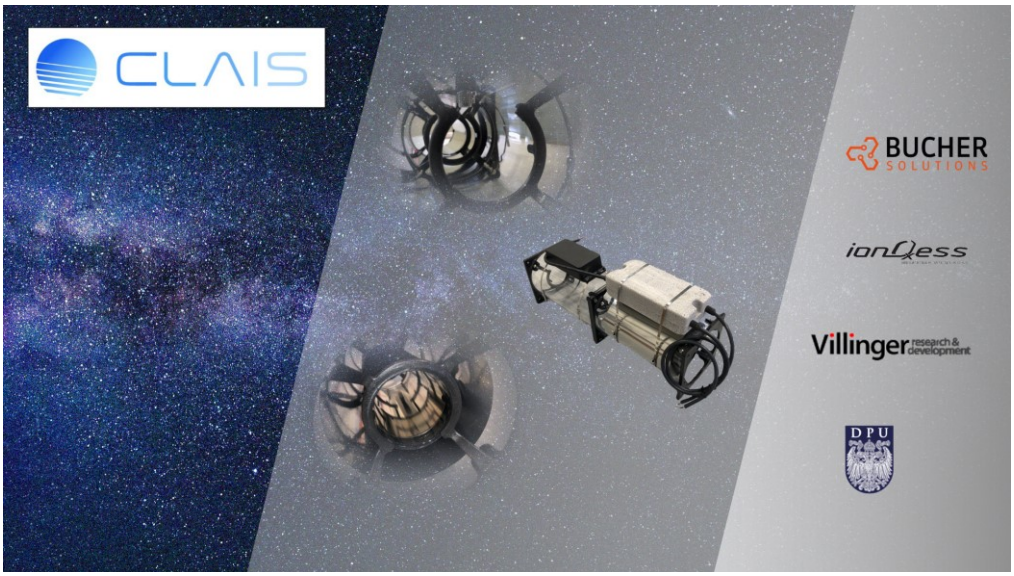

Innovative unit for the ECLS System used for air revitalization focused on air disinfection and cleaning (ADC) - Clean Air in Space (CLAIS)

Executive summary

Feasibility study – Phase A

RFP 3-17934/22/NL/GLC/ov

Affiliation(s): bucher.solutions GmbH (Prime), Villinger GmbH (Sub), IonOXess GmbH (Sub), Danube Private University (Sub)

Activity summary:
The CLAIS project focuses on an air disinfection and treatment unit that enhances the cleanliness level of enclosed spaces beyond conventional filter systems. The device is designed to effectively remove fungi, viruses, bacteria, and odors from the air, achieving a purification level of 99.999% and beyond. It shall be installed as an extension of the ECLSS and significantly contributes to the health and well-being of the crew, diminishes the proliferation of unwanted microbial growth in sinks, and enables the extension of disinfection intervals for equipment.

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Project management	Lukas Bucher, BSc.

Signatures

Project management	Digital signiert von Lukas Bucher, BSc_ (MCI) DN: C=AT, OU=CEO, O=bucher.solutions GmbH, CN="Lukas Bucher, BSc_ (MCI)", E=info@bucher.solutions Grund: I am the author of the document Ort: 6100 Mösern, Austria Datum: 09-04-2024 16:42:29 Foxit PhantomPDF Version: 9.7.5 Lukas Bucher
ESA	Malgorzata Holynska Cathal Mooney

Version history

No.	Description	Status
01	Creation of the document	finished

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1 Premise

1.1 General

1.1.1 Sources, Responsibilities

Creator of the template	Client, recipient
BUCHER SOLUTIONS bucher.solutions GmbH Moeserer Dorfstraße 11 6100 Moesern Austria	esa SPACE SOLUTIONS ESA European Space Agency 24 Rue du Général Bertrand CS 30798 75007 Paris France

Table 1: Creator of the template

1.1.2 Legal Bases, Duplication

The legal basis can be found in the funding agreement with the ESA that was valid at the time of signing.

1.1.3 Purpose of this document

As part of project CLAIS, documents are sent to the ESA, which are intended to depict and communicate the progress of the project.

1.1.4 Integrity

The consortium strives to develop all conceivable information within the framework of the project and to make it available to ESA. The documentation is prepared with the utmost care and submitted with all imaginable completeness.

1.1.5 Revision, changes

The mission is clearly defined. The documents are prepared on the basis of the project description. All changes are constituted in the version history and can be traced using the description.

2 The project CLAIS

2.1 Project overview

2.1.1 What is the CLAIS project?

Project CLAIS is about an air disinfection and treatment unit, which, after common filter systems, increases the cleanliness level of closed rooms.

The whole project consists of four phases, A, B, C & D

- Phase A is a feasibility study for the use of the terrestrial CLAIS system in space applications.
- In Phase B, a prototype will be designed, planned, constructed and manufactured according to ESA specifications.
- In Phase C, performance tests will be carried out and the system will be thoroughly tested.
- In phase D the system shall be tested intensively on security and be prepared for space application (final construction).

2.1.2 What does the device look like?

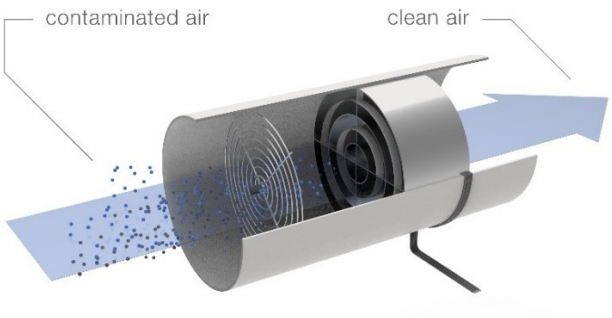

Figure 1: CLAIS-System (rendered CAD)

The CLAIS-device consists of two technologies - one works on the principle of an electrostatic precipitator, the other works with cold plasma. It has a separate control unit, which is integrated into the Express Rack of the Columbus capsule and communicates with the space station and ground support equipment via various interfaces.

2.1.3 How is the device designed?

- Process unit
  - PU Connectors
  - PU Cables
  - PU Temperature Sensor
  - PU Heat Element
  - PU Electrode ION
  - PU Electrode VIL
  - PU High Voltage Cable
  - PU Circuit Board
  - PU Body
- Operation Unit
  - OU Connectors
  - OU Cables
  - OU LED
  - OU Switches
  - OU Body
- OU-PU Connection
  - OPU Cables
- OU-EXPRESS Rack Connection
  - OE Cables
- Pipes
- Environment

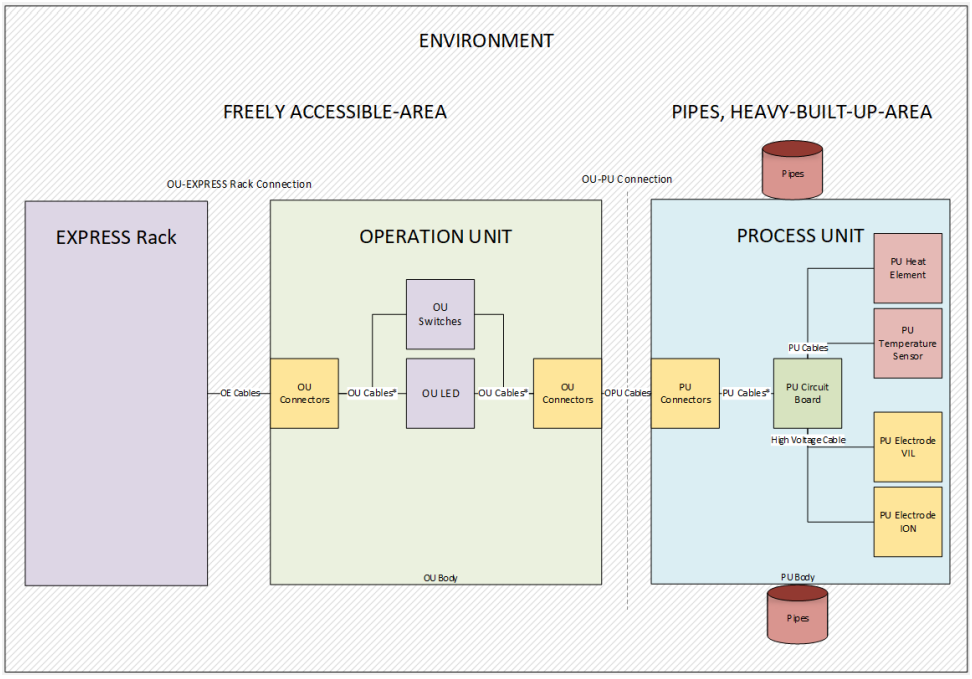

Figure 2: Structure of CLAIS and its definitions

2.1.4 Why is CLAIS needed?

Common filter systems can only partially remove small particles, viruses and bacteria, fungal spores and odor-causing substances. CLAIS starts working where common systems stop and can purify air to almost 100%. Enclosed spaces, such as in manned spacecraft and stations, cannot be ventilated externally and must be supplied with (re-)treated air.

Current Standard								
DIN EN ISO 14644-1							EG / GMP	
Cleanroom Class	Maximum acceptable number of particles per cubic meter and particle size (cross section dimension)						Cleanroom Class	KBE/m³ (colony forming units)
	0,1 µm/m³	0,2 µm/m³	0,3 µm/m³	0,5 µm/m³	1,0 µm/m³	5,0 µm/m³		
ISO 1	10	2						
ISO 2	100	24	10	4				
ISO 3	1000	237	102	35	8			
ISO 4	10000	2370	1020	352	83			
ISO 5	100000	23700	10200	3520	832	29	A / B	<1
ISO 6	1000000	237000	102000	35200	8320	293	(B)	10
ISO 7				352000	83200	2930	C	100
ISO 8				3520000	832000	29300	(C)/D/E/F	200
ISO 9				35200000	8320000	293000		

Table 2: Clean room classes and particle loading

With the help of CLAIS, the highest cleanroom class can potentially be achieved.

2.1.5 Who is involved in Project CLAIS?

bucher.solutions GmbH is in charge of project management, is the specialist at the normative and regulatory level and also offers experience in the field of mechanical and process engineering. **Villinger GmbH** and **IonOXess GmbH** supply the technology and are the specialists and suppliers for the respective components. The **Danube Private University** are experts in environmental conditions and have measuring equipment to determine emissions and air quality.

2.1.6 How far has the project/the device progressed?

The entire CLAIS project is currently completing phase A - feasibility study. Submission for Phase B has already begun.

The two technologies are almost fully developed (TRL 8 each; max. TRL 9 possible). CLAIS combines the advantages of both technologies at a current development level of TRL 1-2. At the end of the further project phases B, C, D a TRL 9 is achieved.

2.1.7 Where should CLAIS be installed?

Finally, the CLAIS is to be integrated into the ECLSS of the ISS and subsequently implemented as standard in manned space stations and vehicles. Following the CLAIS project, there are countless commercial applications such as aircraft, public transport, schools, medical and pharmaceutical industries.

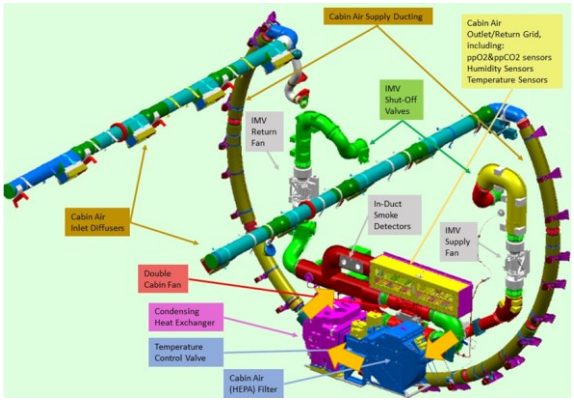

Figure 3: Construction drawing (extraction) of air supply ACLS Columbus

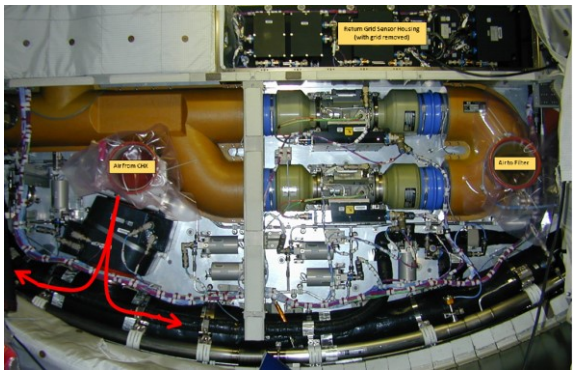

Figure 4: Photo of air supply Columbus ACLS (backside)

The system is expected to be integrated into the supply air ducts of the Columbus capsule, after the ECLSS on both sides. On the one hand, it serves to refresh the already pre-cleaned air and, on the other hand, it prevents contamination of the environment during a filter replacement on the ECLSS.

2.1.8 Are there any unwanted effects?	Detailed analyzes show that no undesirable by-products such as ozone or nitrogen oxides are produced. Particles <400nm are separated and after treatment the air is almost 100% pure. The training for the crew's immune system is less pronounced, but infections brought along can be better contained and the formation of odors and mold can be minimized. Other influential effects are not known. External laboratories have confirmed that a significant reduction in pathogenic germs can be achieved.
2.1.9 How secure is the CLAIS?	Extensive research into standards and guidelines, where almost 4,000 pages were processed, was incorporated into the planning of the device. Furthermore, extensive risk analyzes (over 300 pages in total) were carried out, where materials were evaluated, defects were simulated, and scenarios were played out that could have an impact on the safety of the crew or the equipment. Aspects such as flammability, safety shutdowns, fail-safe communication, installation position, outgassing and much more were also taken into account.
2.1.10 Benefit	CLAIS can improve crew safety, well-being and make spacecraft and stations more comfortable. Furthermore, areas that are difficult to access are less affected by biological contamination and disinfection intervals can be extended if necessary. It contributes to the preservation of existing assets and can extend the operational life of equipment in manned missions.

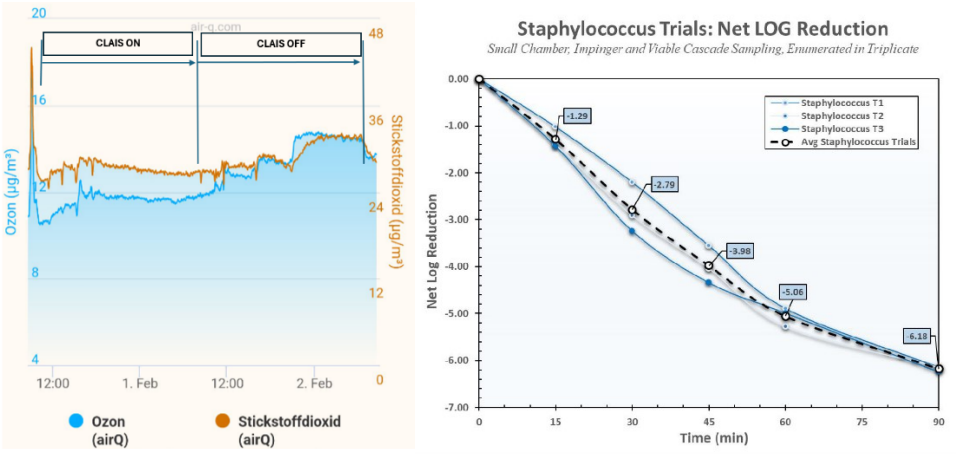

Figure 5: Left: 48h measurement of ozone and nitrogen oxide concentration, 24h with plasma (left, CLAIS ON), 24h without plasma (right, CLAIS OFF); Right: Log reduction of Staphylococcus epidermis (surrogate for MRSA)

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