Biocontamination Integrated Control of Wet Systems for Space Exploration (BIOWYSE)

Joint Agrospace/MELiSSA Workshop

Rome (Italy), 16-18 May 2018

Vincenzo Guarnieri

ThalesAlenia Space
a Thales / Leonardo company

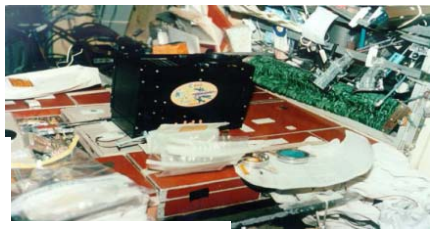
Table of contents

ThalesAlenia Space
a Thales / Leonardo company

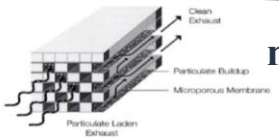
BIOWYSE – Overview

- **Issue**: need for reliable, rapid, significant and safe methods for preventing, monitoring and controlling biocontamination risk in water loops and humid areas in manned Space habitats
- **Solution**: automated integrated portable prototype manufacturing and tests in laboratory and on the field, and design for a flight demo for testing gravity-dependent technologies in Spacecraft
- **Customer base**: several manned space programs, and commercial applications in public and private sectors
- **Benefits for citizens**: Water is the most important resource of everyday life. Its biocontrol is crucial, also when special conditions happen (e.g.: epidemics, catastrophes, isolation)

prevention



monitoring



mitigation

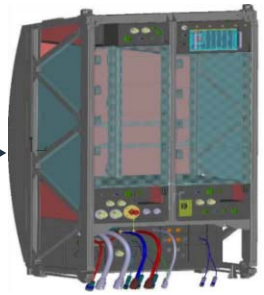
Portable breadboard

Commercial products

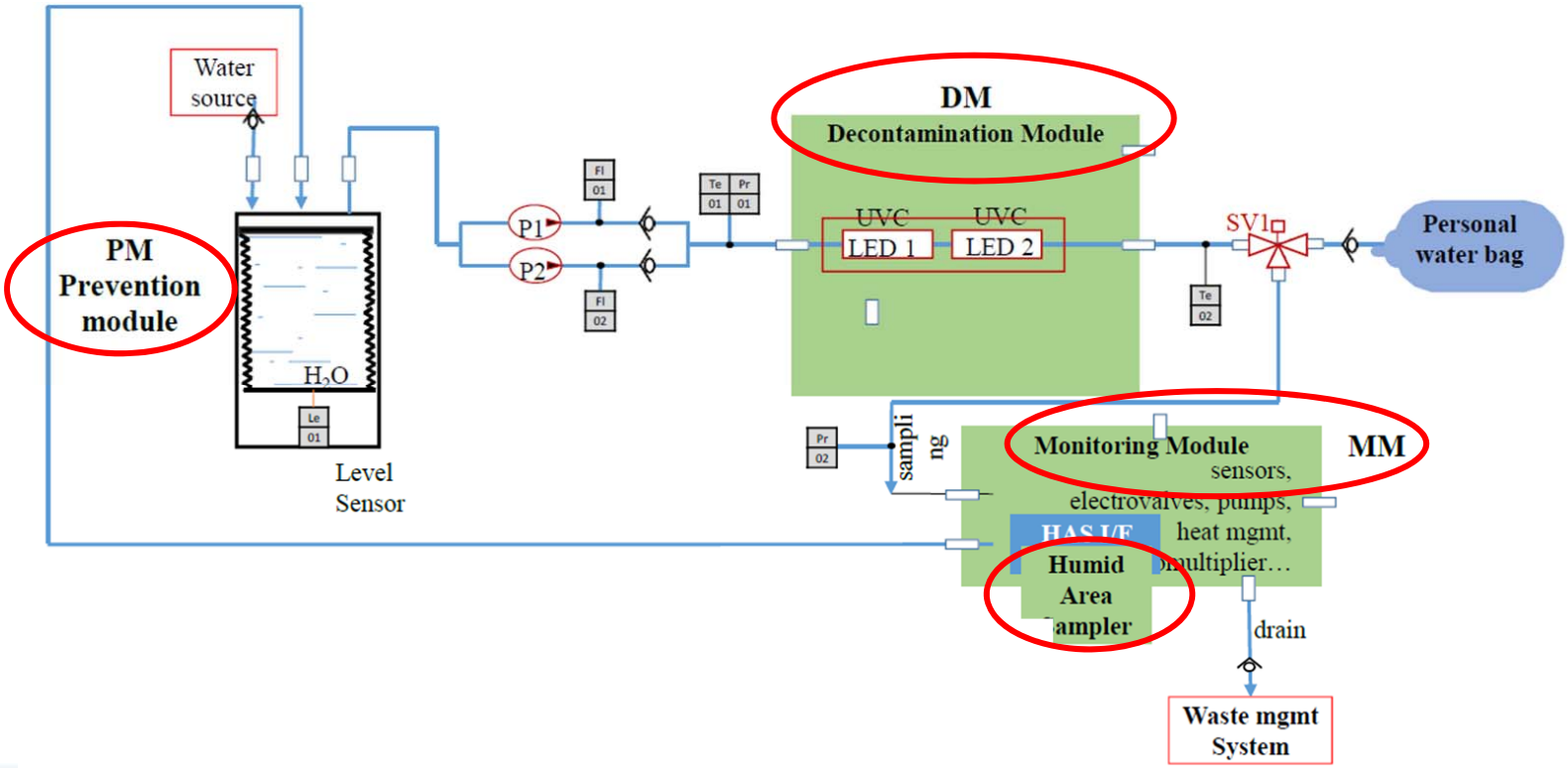
COMPLETE SPACE SYSTEM

BREAD BOARD

FLIGHT DEMO



BIOWYSE active water subsystem and Modules



Inlet and outlet water quality

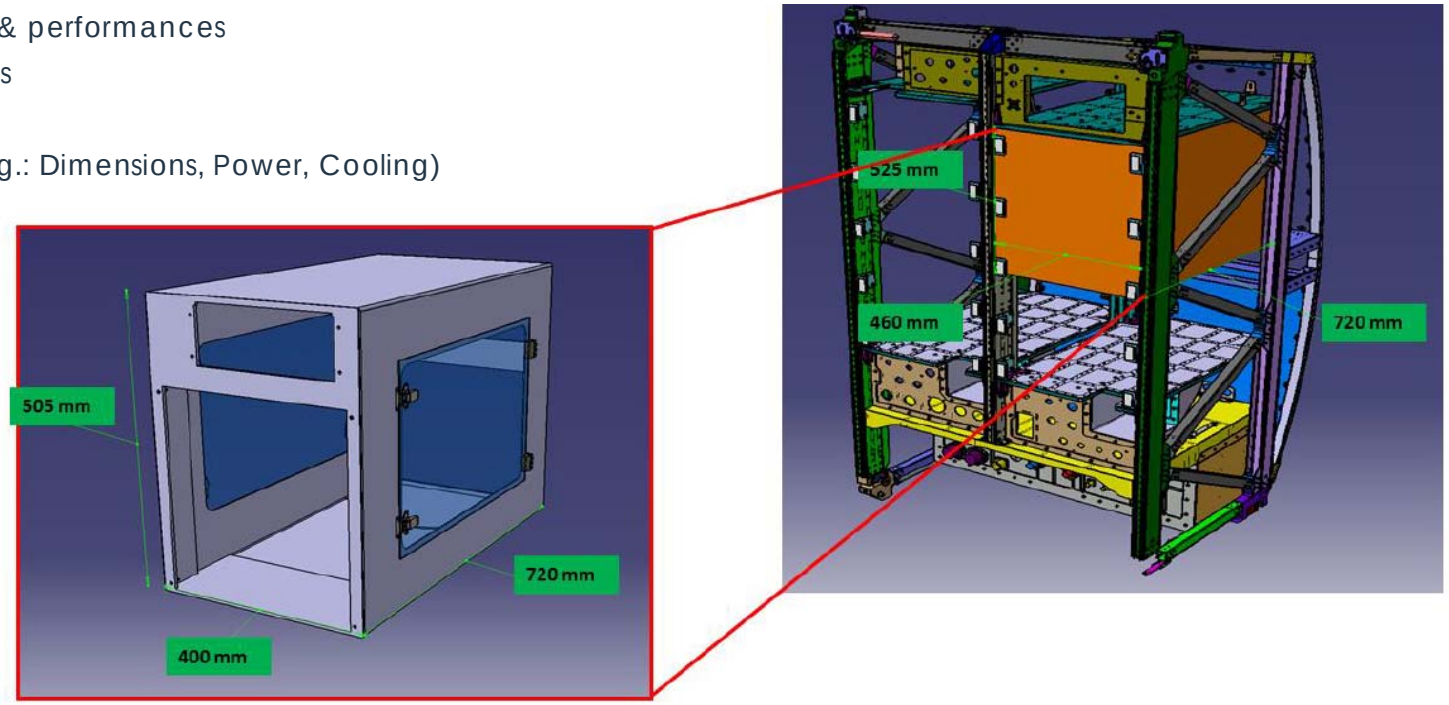
- The **thresholds** for drinking water are fixed to **0.5 pg ml^{-1}** (warning] and **3 pg ml^{-1}** [alarm]. Such thresholds trigger the decontamination cycles
- ATP content of **10 pg ml^{-1}** is the **upper limit** fixed for the **drinkable** water delivered by BIOWYSE
- **10 pg ml^{-1}** corresponds approximately to **10^4 -10^6 cells ml^{-1}** considering an average ATP content per cell ranging between 10^{-4} and 3-5x10^{-5} pg ATP cell^{-1} [*]

%

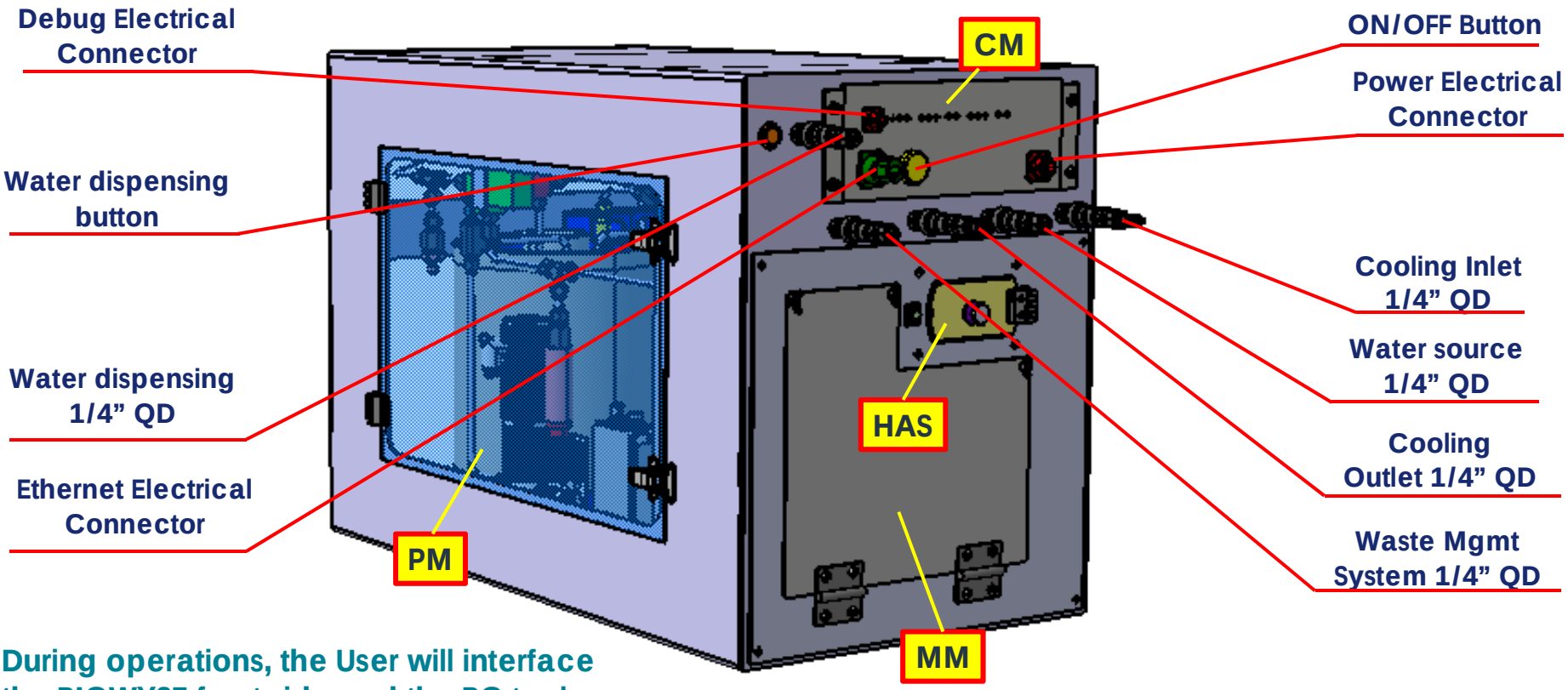
[*] Siebel, E., Wang, Y., Egli, T., & Hammes, F. (2008). Correlations between total cell concentration, total adenosine tri-phosphate concentration and heterotrophic plate counts during microbial monitoring of drinking water. Drinking Water Engineering and Science, 1(1), 1-6.

BIOWYSE Flight concept

- **BIOWYSE has been conceived to be installable into EDR2 drawer**
  - Breadboard & Flight system have same/similar requirements for:
    - Functions & performances
    - Operations
    - RAMS
    - Design (e.g.: Dimensions, Power, Cooling)



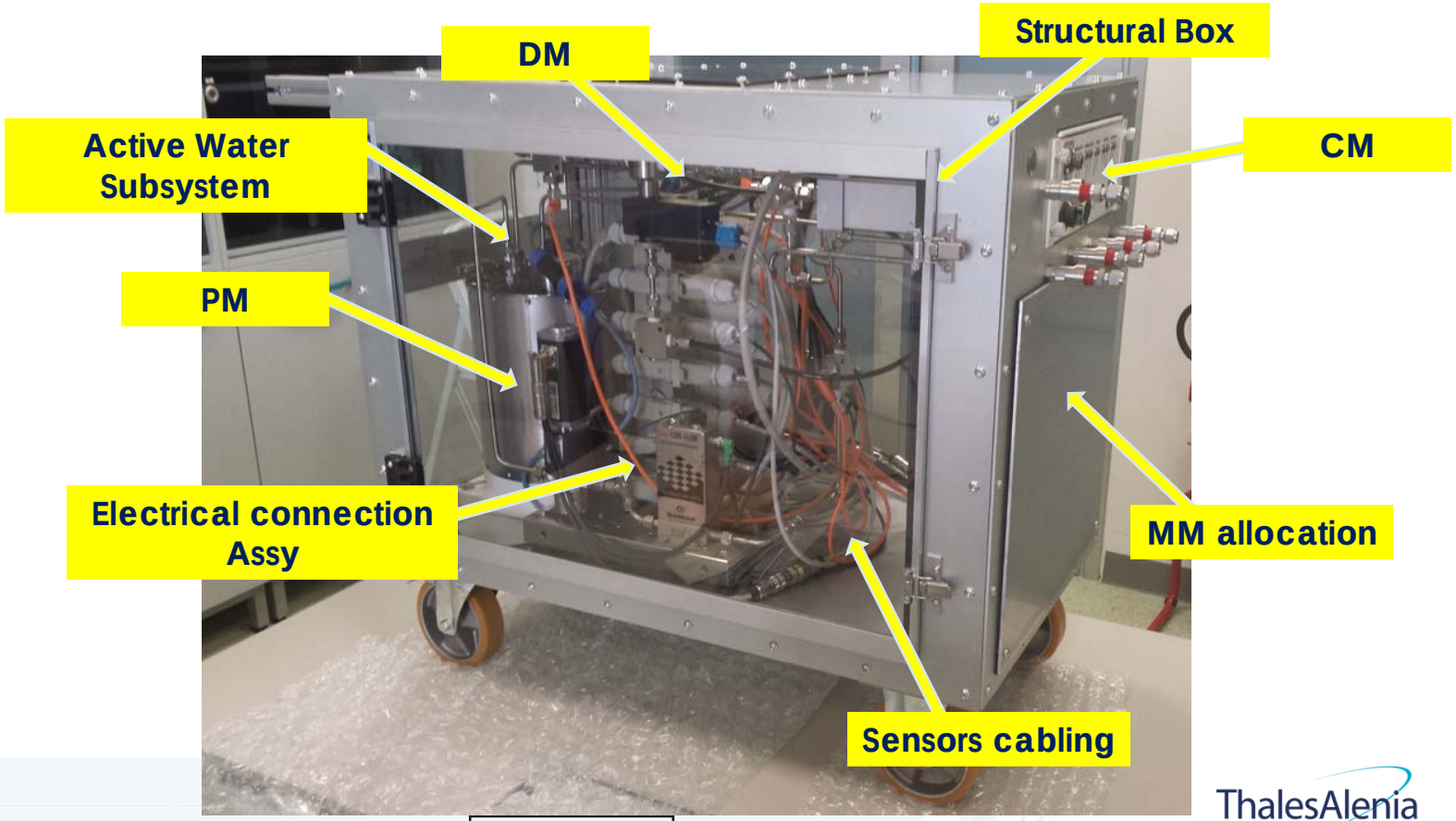
External interfaces



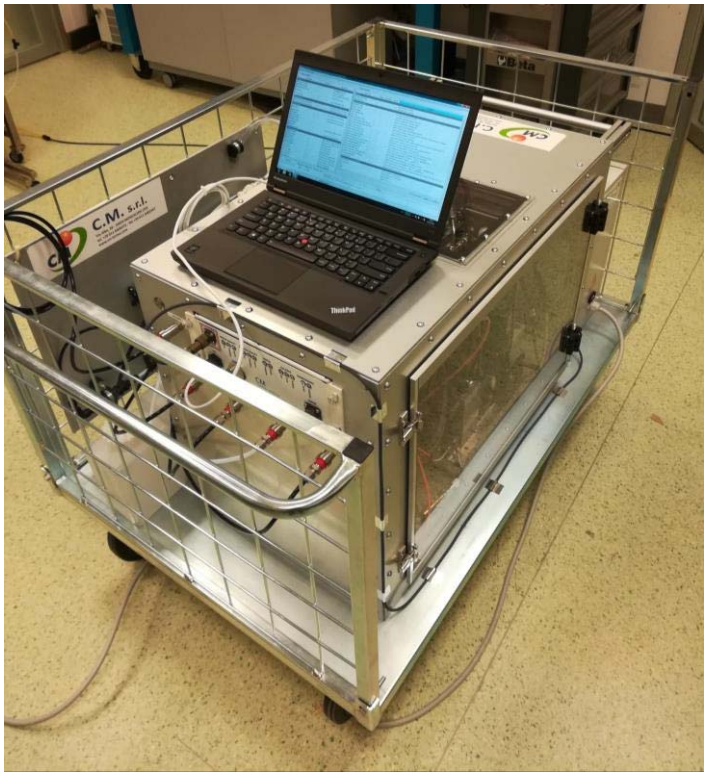
During operations, the User will interface the BIOWYSE front side and the PC tool

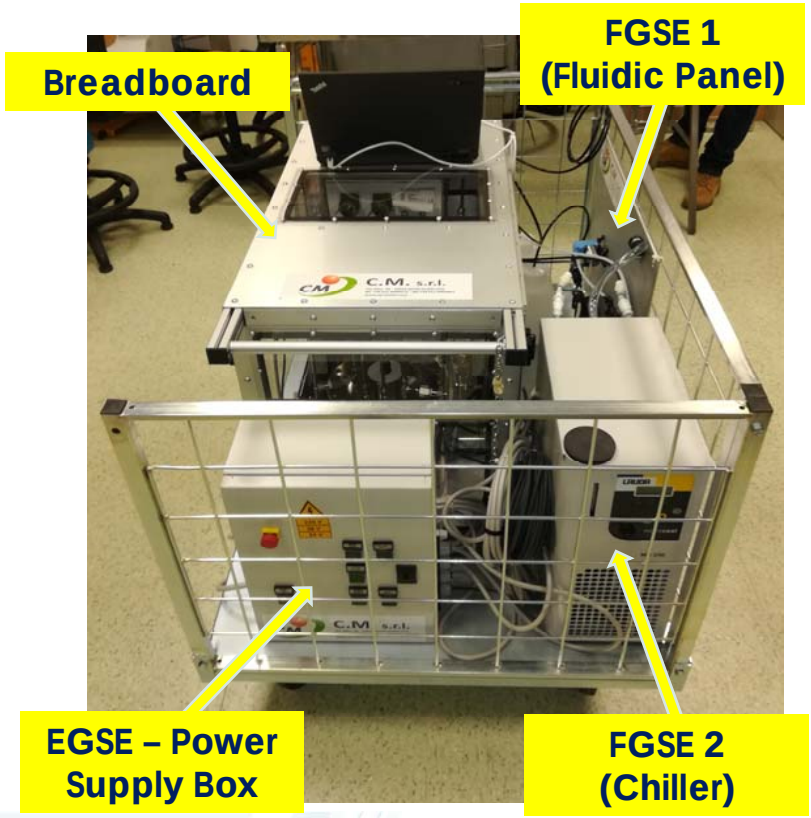
BIOWYSE breadboard

BIOWYSE breadboard



BIOWYSE Breadboard and Support Equipment for field tests





Development logic

- Goal: validating the integrated System for functional and performance requirements

- Integrated breadboard verified in lab and tested on the field, to demonstrate efficiency and reliability on-board spacecraft and in remote terrestrial areas

- Verification test techniques definition, and different analysis approaches application (culture-based, portable flow cytometry, molecular methods) for characterization of microbial community and identification of pathogens in the water

The tests on breadboard will lead to fine-tuning of the BIOWYSE integrated System and consolidation of the key elements for future flight demonstration and utilisation, as well as terrestrial applications

Models philosophy

- BIOWYSE breadboard:
  - includes CAM/COTS items – representative in form, fit & function for in-flight utilization wrt electrical, mechanical & thermal interfaces
  - drawer rack accommodation can be used also as training model for future flight models
  - field tests to confirm reliability & performance of automatic procedures and integrity of mechanical parts after transportation and in different environmental conditions
  - allows updating and improving the System and its parts for commercialization and on-orbit demonstration and future utilisation
- BIOWYSE Flight DEMO:
  - design started since project beginning, looking at EDR-2 as hosting facility on ISS
  - design is progressively refined and optimiz based on all relevant aspects encountered during breadboard deve and verification
  - on-board tests will be aimed at v , MM, operating procedures and CM reliability

not financed by the current EC grant

ThalesAlenia Space
a Thales / Leonardo company

Test Logic

- Laboratory testing
  - to single Modules and to the Integrated Breadboard
  - Modules have been individually validated to ensure required functionality, performances and verify operational procedures
  - Once integrated, some tests are repeated to guarantee System well-functioning
  - Test Sequence at System and SM level include verification of Functional, Operational, RAMS, Design an Interface requirements
- Field testing
  - tests in TAS Cleanrooms (e.g.: Cargo Transportation Bags, Cygnus-PCM)
  - water kiosk (“Punto Acqua”) & in cave (“Grotta del vento”)
- On-orbit testing aimed at validating at least:
  - Prevention Module and Monitoring Modu… …vity conditions and with the ISS microbial population
  - operating procedures with stri… …tions & minimal available crew time
  - Control Module reliability by … cross validation tests

not financed by the current EC grant

Conclusions

- Many teams work on prevention, monitoring and decontamination fields. As far as we know, no team is dealing with an “integrated” system
- BIOWYSE integrated system combines biostatic/biocide action with real-time biomonitoring and almost instantaneous UV-based disinfection
- In automated way, the PM allows preventing microbiological growth and DM allows taking immediate action upon check vs thresholds by the MM
- BIOWYSE is an automated and compact system, meaning low crew time and suitable transportability
- BIOWYSE has full potential for exploitation for ISS and future manned Space Exploration missions and represents an innovative tool with a wide application potential in a large number of situations on Earth

Acknowledgments

BIOWYSE is a project financed by the European Comission H2020 SPACE initiative (project no. 687447)

The author would like to thank the BIOWYSE team for their continuous support of the project:

- Emmanouil Detsis of the European Science Foundation
- Laurent Garrelly, Celia Martinez, Celia François, Anne-Lise Buisson, Clément Faye from GLBiocontrol
- Richard Simons and Jennifer Pagan from AquiSense Technologies
- Francesca Bersani, Donatella Giacosa, from SMAT Torino
- Alessio Mengoni and Elena Perrin from University of Florence
- Rainer Tamm, Taavi Jantson, Ergo Pehtla, Arne Laansoo and Jan Rosin from Liewenthal Electronics
- Simona Rossetti , Caterina Levantesi and Stefano Amalfitano from CNRS - IRSA
- Tomas and Veronika Rousek from A-Etc
- Giorgio Boscheri, Giovanni Marchitelli, Ilaria Locantore, Cesare Lobascio and Antonio Saverino from Thales Alenia Space Italia SpA

ThalesAlenia Space
a Thales / Leonardo company

Thank you for your attention!

Fluid compatibility

The system shall be compatible with fluids having the following characteristics:

- maximum turbidity 8 NTU
- free gas 5%
- TDS 350 mg/l
- maximum TOC 300 mg/l
- Microbial load inlet 10exp5 CFU/ml
- Particles size up to 10 µm
- maximum Inlet Conductivity 700 µS/cm
- minimum UVT (1 cm; 254 nm) >90 %

%