High Performance Gas Expansion System for Halon-FreE CargO Hold Fire Suppression System ECOSYSTEM

Clean Sky 2 – AIRFRAME-ITD

Consortium Partners	Topic Manager
Collins Aerospace	AIRBUS

FAA IASFPF, April 2021

Collins Aerospace

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AGENDA

Adam

- ECOSYSTEM Project Overview
- Objectives and Expected Impact
- Requirements Specification
- Description of the Demonstrator
- System Design Modeling
- Testing at Fraunhofer
- Summary/Next Steps

ECOSYSTEM OVERVIEW

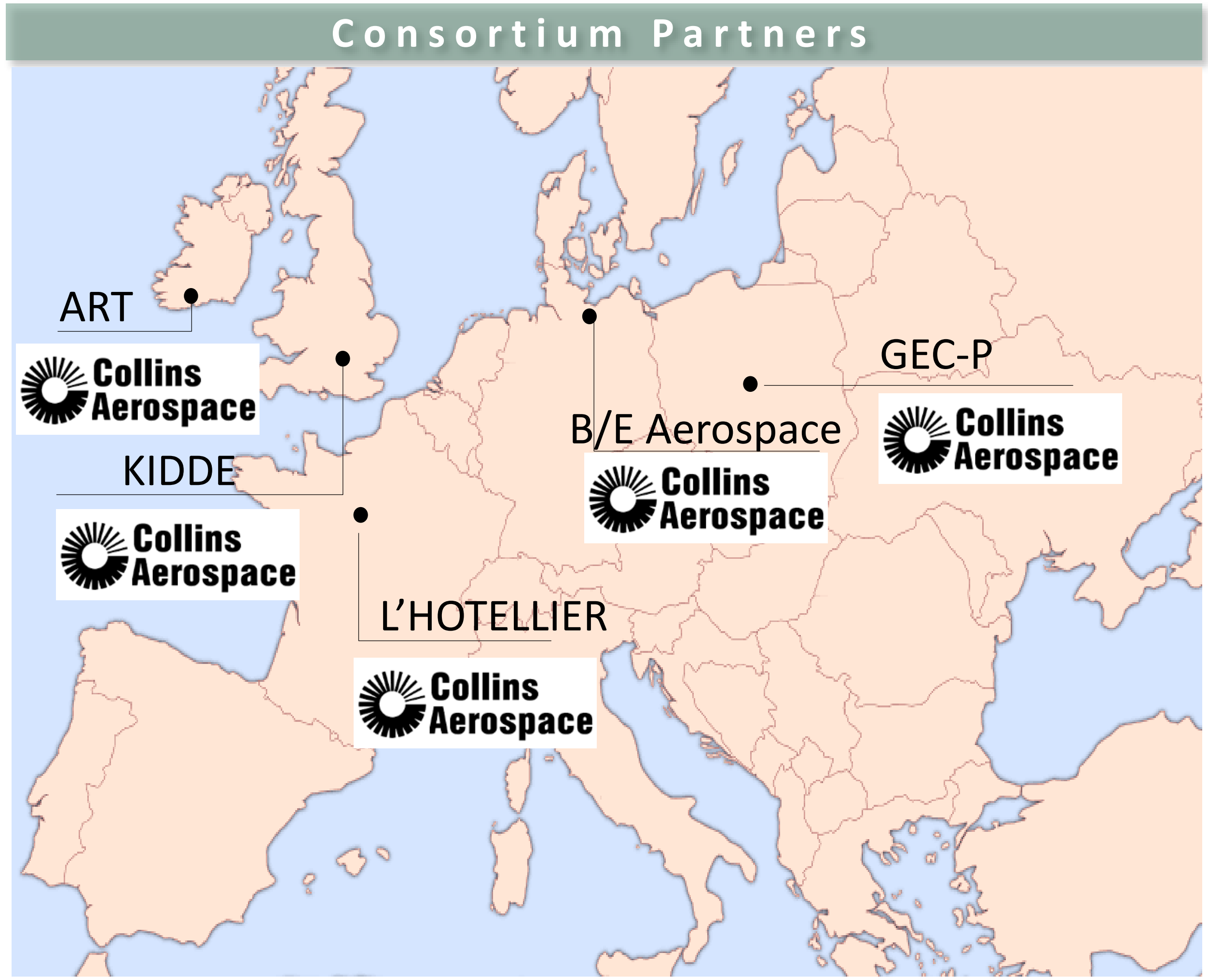
Adam

BACKGROUND

- ECOSYSTEM is an EU funded Clean Sky 2 project
- Project started October 2019 and will run until September 2021
- Max EU contribution of k€699
- Project effort 74 person months
- Topic Leader – Airbus

SCOPE AND POSITIONING

- Develop an environmentally friendly and economically viable halon-free cargo hold fire suppression system
- TRL 5 demonstration in relevant environment at Fraunhofer facility



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PREVIOUS STUDIES

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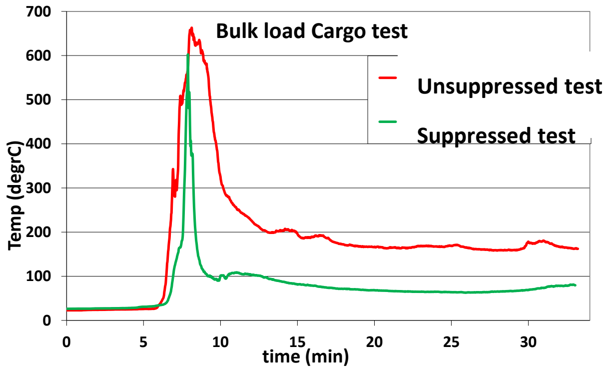
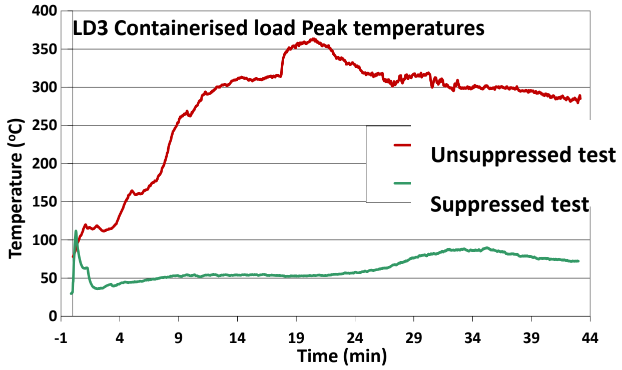
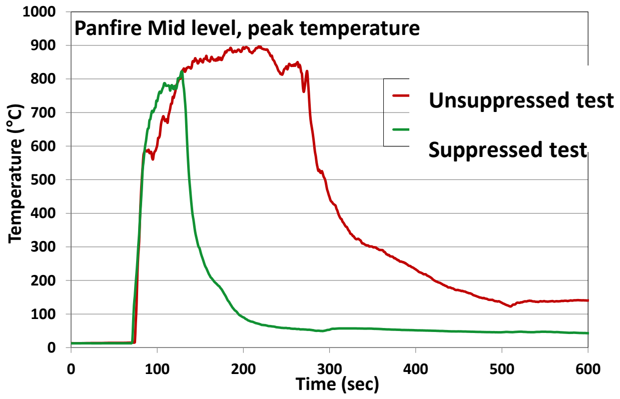
Previous studies with inert gas

- Kidde had previously carried out investigations into inert gas for cargo compartment fire protection at full scale
  - Good results obtained for all 4 MPS scenarios
  - [Link to Kidde Presentation (May 2016, Toulouse)]
- Cranfield EFFICIENT Project
  - EU funded project under Clean Sky 2
  - Demonstrated that nitrogen could pass MPS criteria
  - [Link to EFFICIENT Presentation (October 2019, Atlantic City)]
- Both of the above test programs used “industrial, COTS hardware”
- The aim of this work is to mature the technology to TRL-5, using lightweight components that could be fitted to an aircraft







Sources: Publication data

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ECOSYSTEM OBJECTIVES

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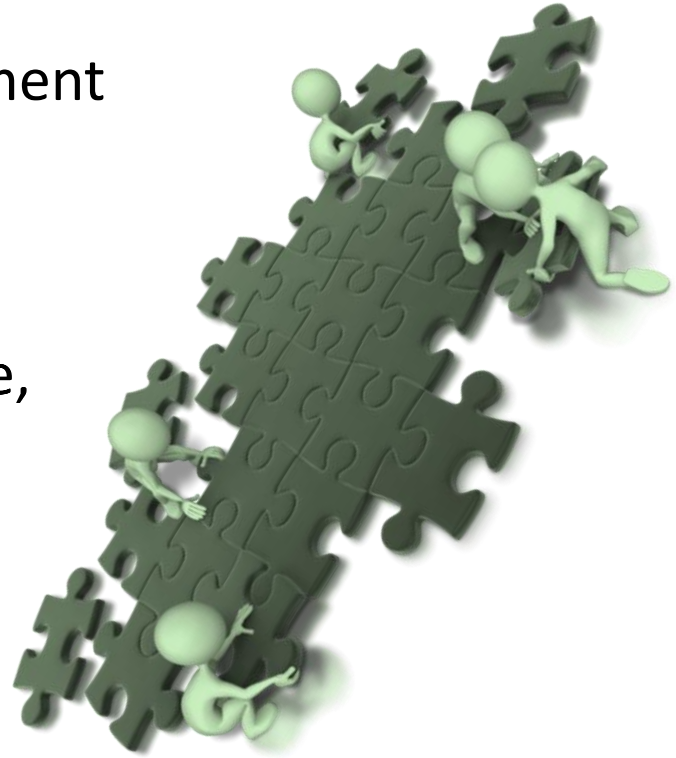
Project objectives:

- Develop requirements and KPIs with the topic manager
- Develop and assess system architecture options with respect to optimal placement and integration of components into demonstrator
- Design system components
- Perform trade studies to evaluate component options based on weight, volume, safety impact, certification complexity
- Perform a thorough safety/risk analysis at system level
- Model performance of demonstrator using CFD and stress analysis
- Characterize system performance at component and system level
- Test prototype at Fraunhofer Institute (Holzkirchen, Germany) and evaluate its performance



EXPECTED IMPACT

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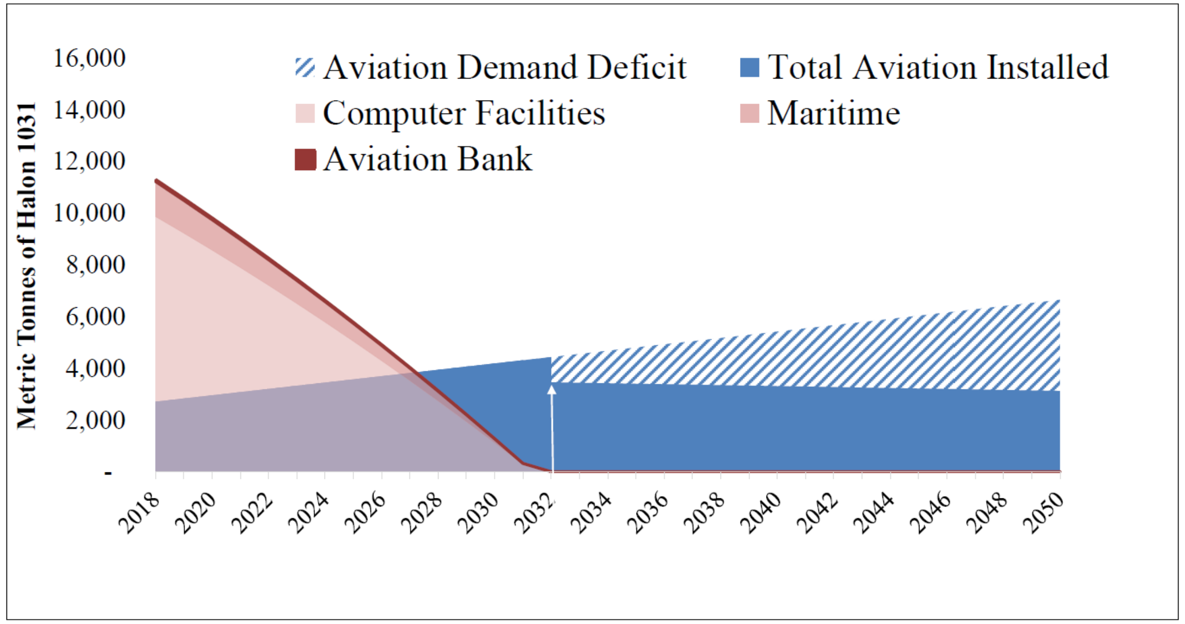
Project expected impact:

- Regulation (EC) No 1005/2009 of the European Parliament on substances that deplete the ozone layer
- Elimination of a highly ozone-depleting and global warming substance
- Replace halon by nitrogen, a sustainable alternative to an ozone-depleting and global warming gas
- Successfully use inert gas in aerospace
- Having this technology at **TRL 5 is a step further to** bringing a **product to market**
- Strengthen European aerospace industry competitiveness



Halon 1301 availability

[Oct18Meeting/Verdonik-1018-XXIX-8.pdf]

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REQUIREMENTS SPECIFICATION

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Demonstrator design needs to meet a set of requirements

- Discharge times for knock-down and long-term suppression
- Oxygen level reduction to below a defined threshold
- Avoid over-pressure in cargo compartment
- Temperature ranges (operating, short time operation, ground survival)
- Flight phases (ground, cruise, descent)
- Bottle size
- System interface

DEMONSTRATOR OVERVIEW

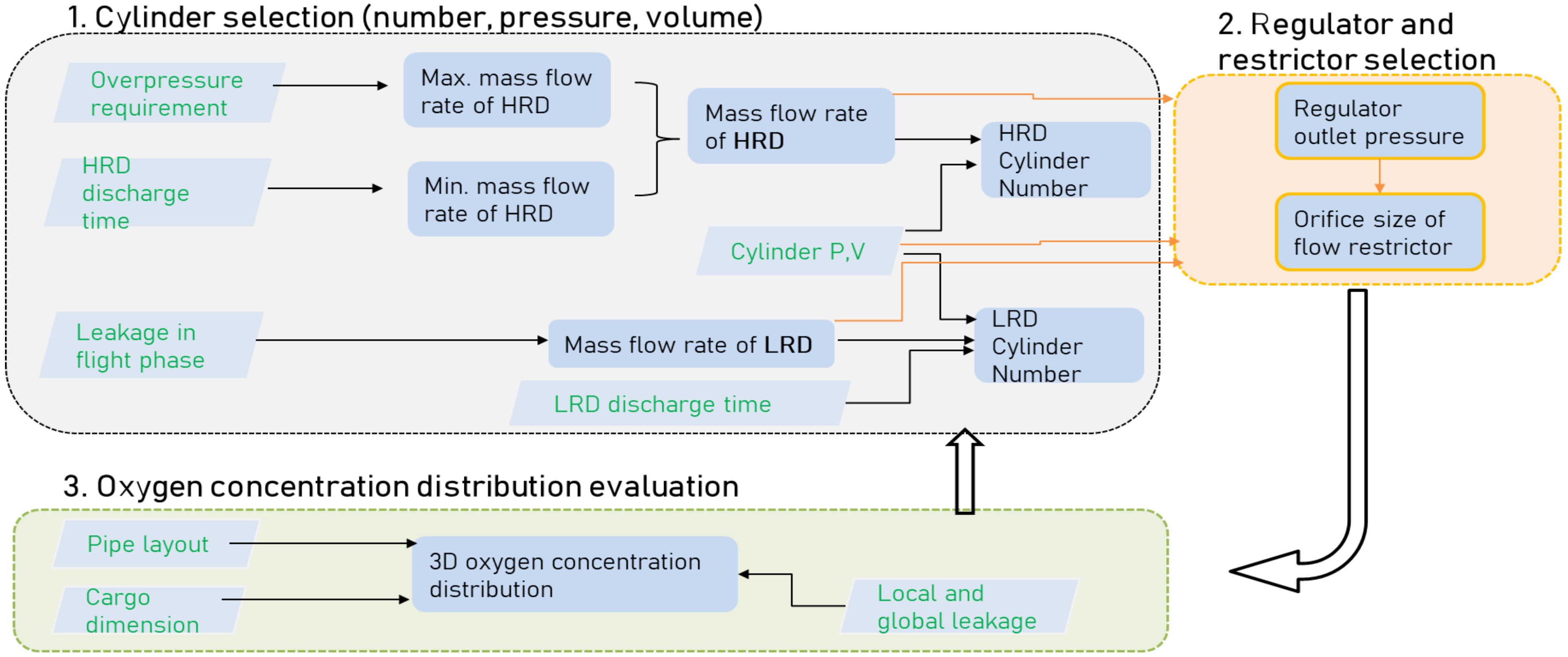
Adam

The Demonstrator comprises of following components

- Lightweight Composite Cylinders – 4 off used for High Rate Discharge (HRD) and 3 off used for Low Rate Discharge (LRD)
- Valve Assemblies – Includes Safety Burst Disc, Pressure Gauge
- Cylinder connected via flexible hoses to 2 Manifolds, (one for HRD one for LRD)
- HRD and LRD lines each have pressure regulator & flow restrictor, to maintain desired flow rate of nitrogen
- Entire demonstrator is housed in a stainless steel fabricated box
- To characterize the mass and volume flow rate of the gas flow a number of pressure transducers, thermocouples and flow meters will be installed within HRD and LRD lines

SYSTEM DESIGN MODELING

Modelling process for components selection



Modelling tools :

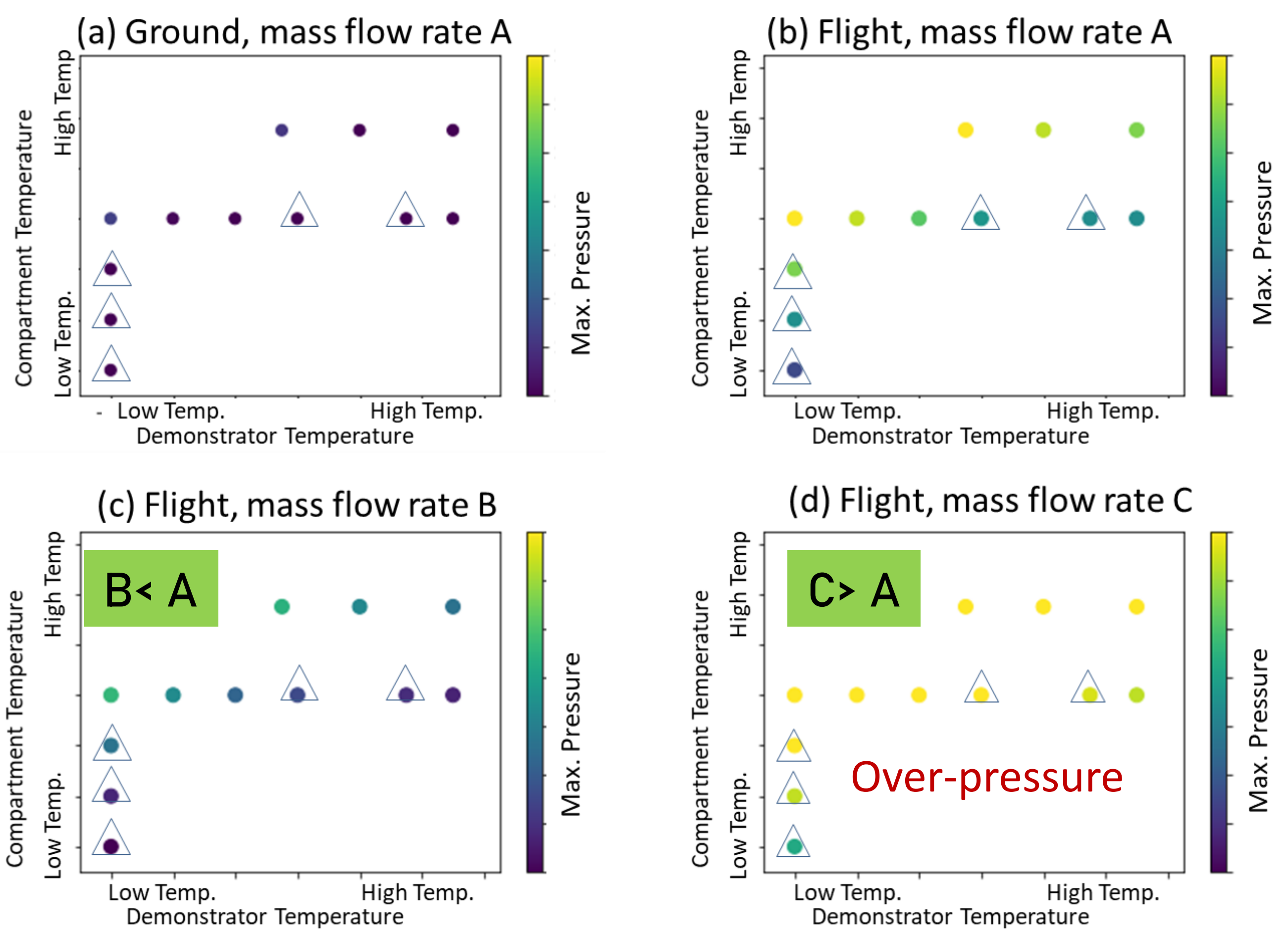
- 0D unsteady code that outputs oxygen concentration (at different flight phases and temperature conditions) to **down-select cylinders** by calculating required mass flow rates.
- 1D hydraulic calculator for pipe network modelling to down-select **outlet pressure of regulator** and **orifice size of flow restrictor**.
- Computational Fluid Dynamic (CFD) modelling to **evaluate oxygen concentration** distribution in three-dimensional cargo compartment.

HRD MASS FLOW RATE

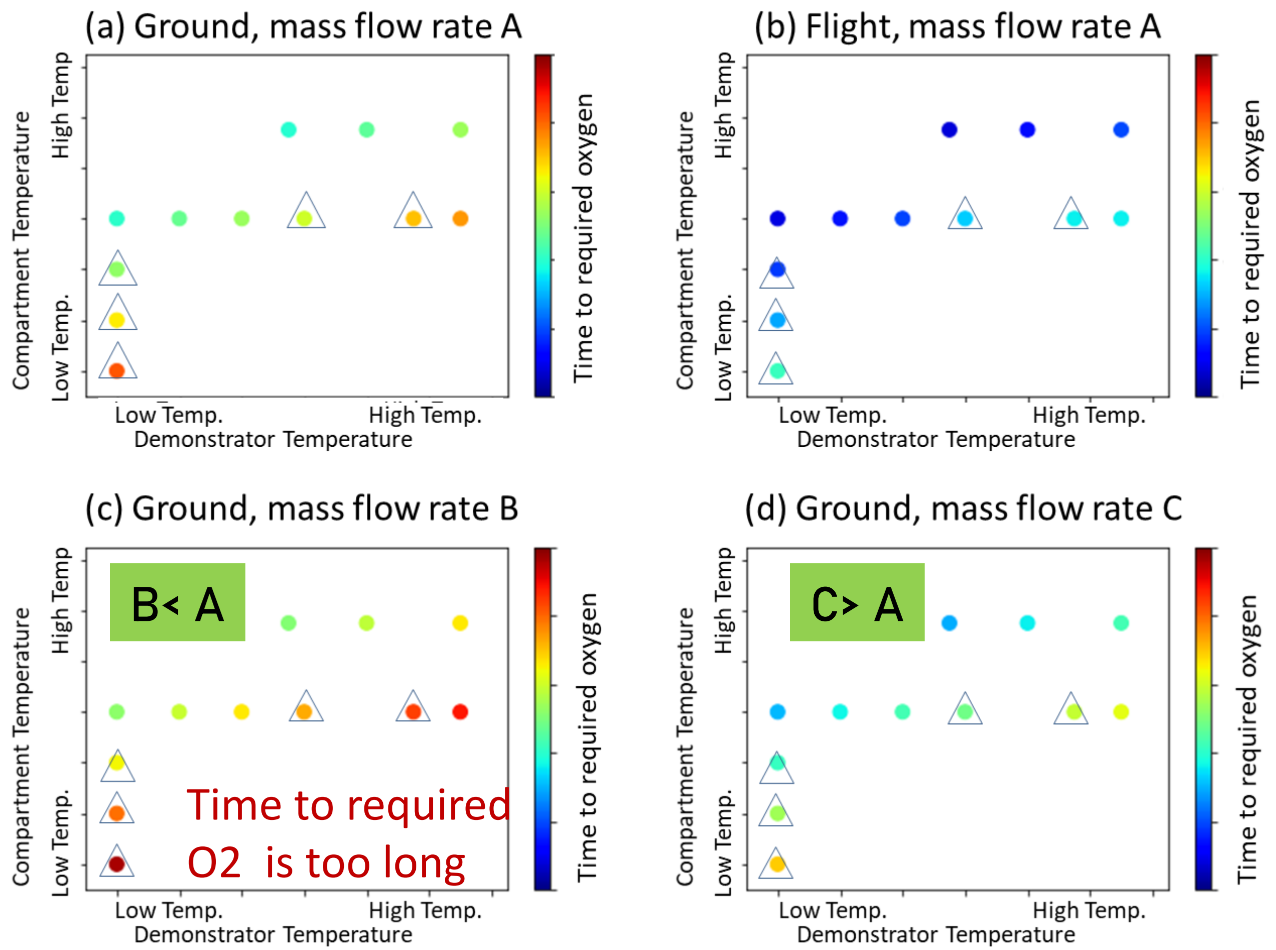
Changmin

Determine required mass flow rate for HRD

Maximum mass flow rate for HRD is restricted by allowed over-pressure



Minimum mass flow rate for HRD is restricted by discharge time to achieve required oxygen concentration



Mass flow rate A is selected for HRD as it meets requirements of over-pressure and discharge time.

REGULATOR AND FLOW RESTRICTOR

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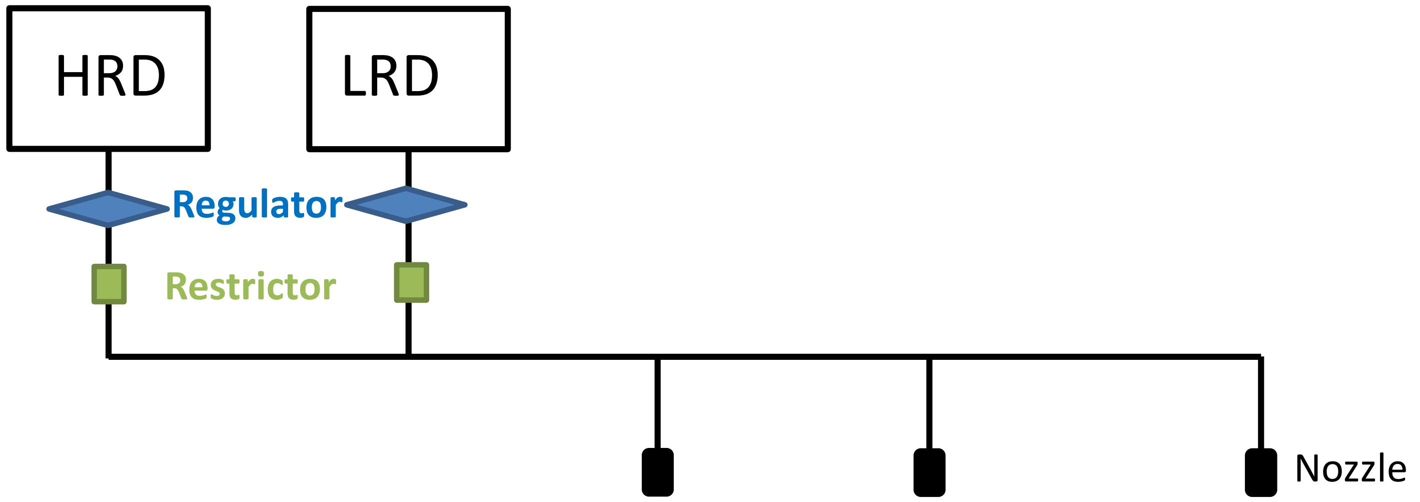
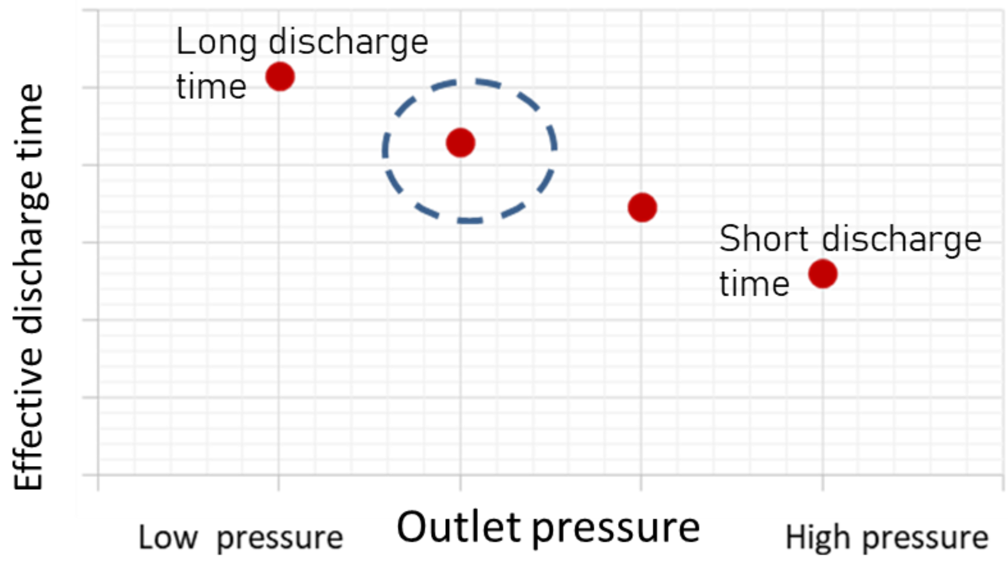
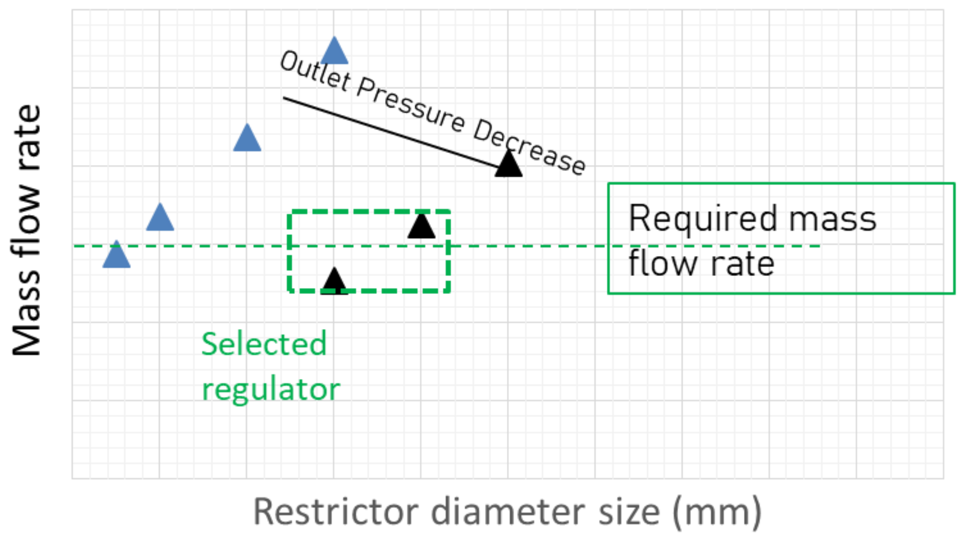
Piping network modelling for regulator and restrictor sizes selection



Regulator outlet pressure of HRD



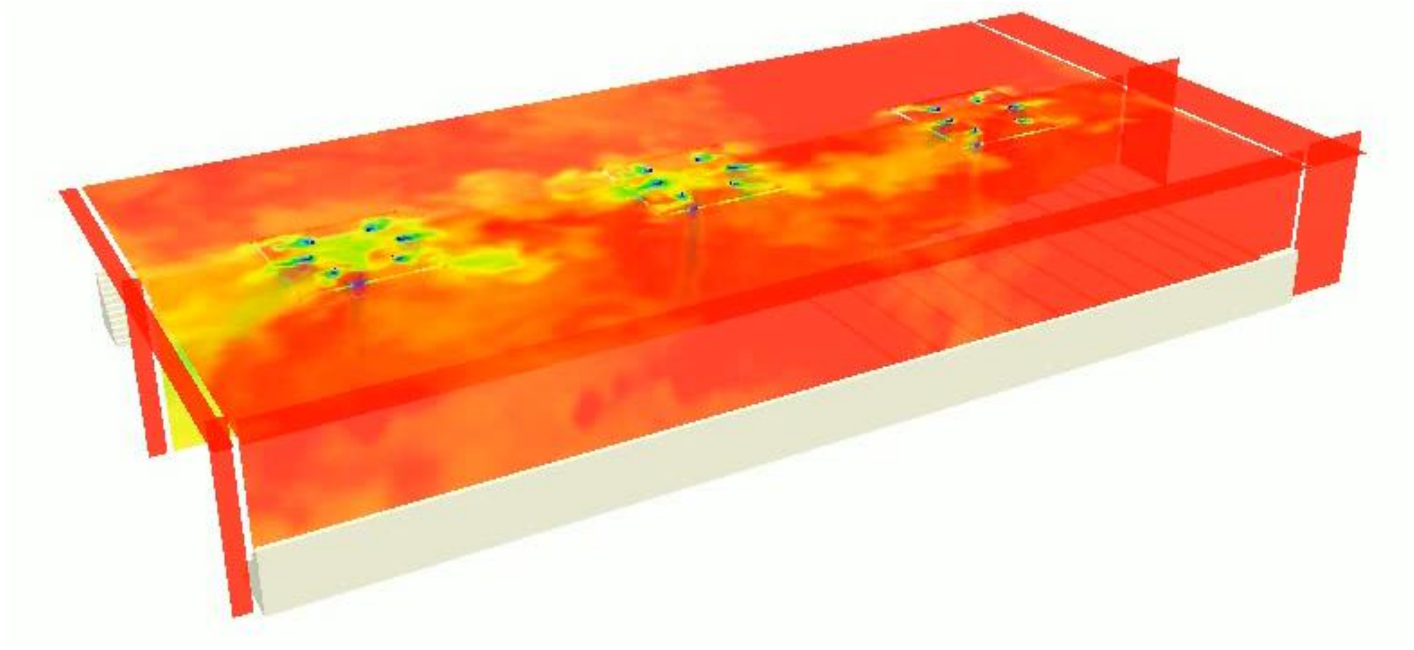
Restrictor Size Selection for HRD and LRD



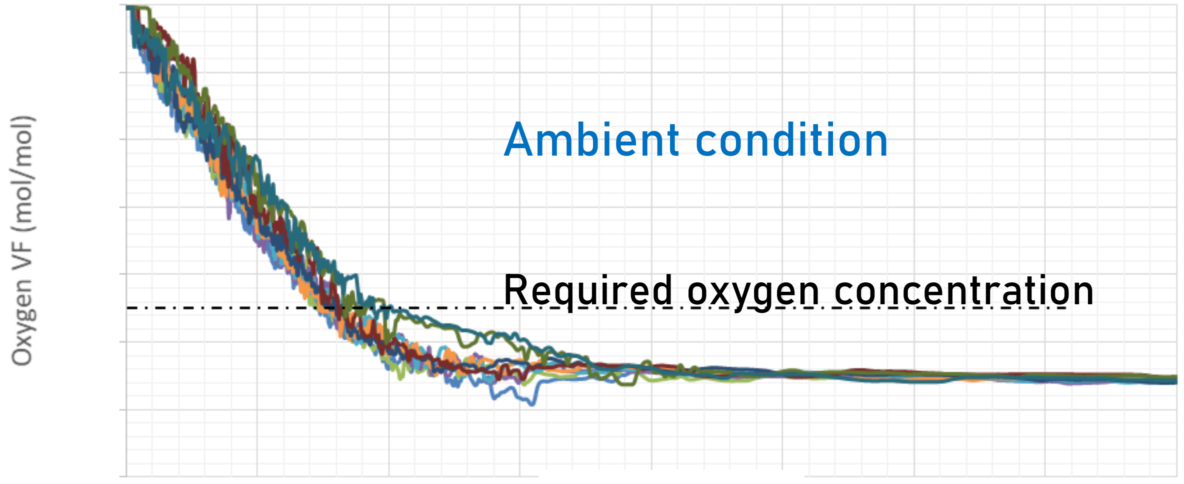
AGENT DISPERSION MODELLING

CFD simulation to evaluate 3D oxygen concentration distribution in cargo compartment

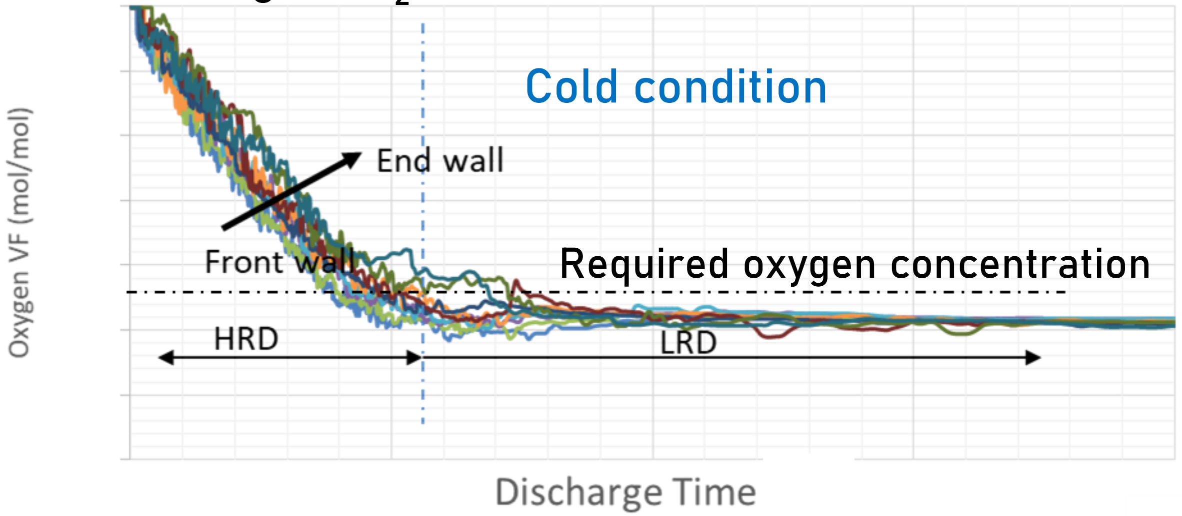
3D oxygen volume fraction



Higher O_2 vol. fraction near floor at LRD stage because of low jet momentum.



Higher O_2 vol. fraction at cold condition



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FRAUNHOFER FLIGHT TEST FACILITY

Adam

ECOSYSTEM demonstrator will be installed and tested at Fraunhofer flight test facility

- Low-pressure chamber:
  - Length: 30 m
  - Internal diameter : 9.6 m
  - Low pressure (absolute): 116 hPa
  - Low pressure (subject testing) : 750 hPa
- Cabin air conditions:
  - Air temperature: -20 °C to +30 °C
  - Relative humidity: 5 % to 65 % at 20 °C
  - Realistic simulations of noise and vibration
- Aircraft outer skin temperature:
  - Temperature: -30°C to +40 °C (for A310 mock-up)
  - Temperature: -55°C to +85°C (for business jet mock-ups)

TESTING AT FRAUNHOFER

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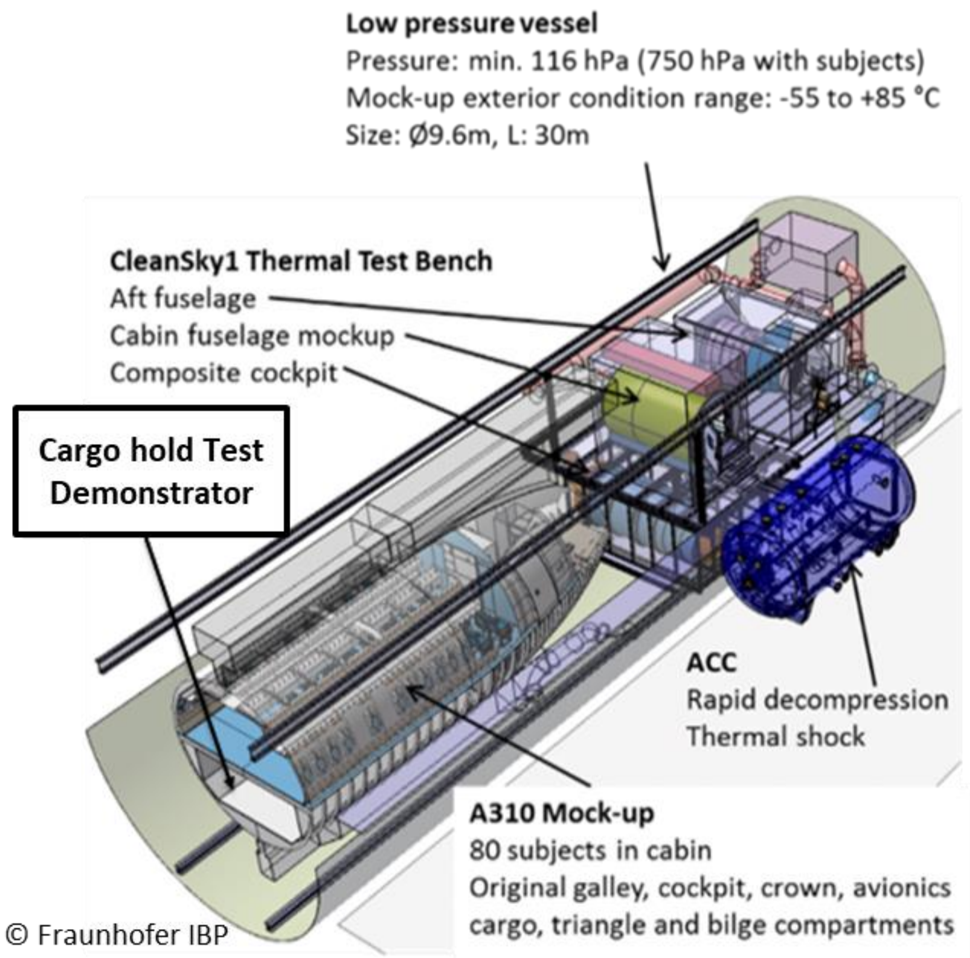
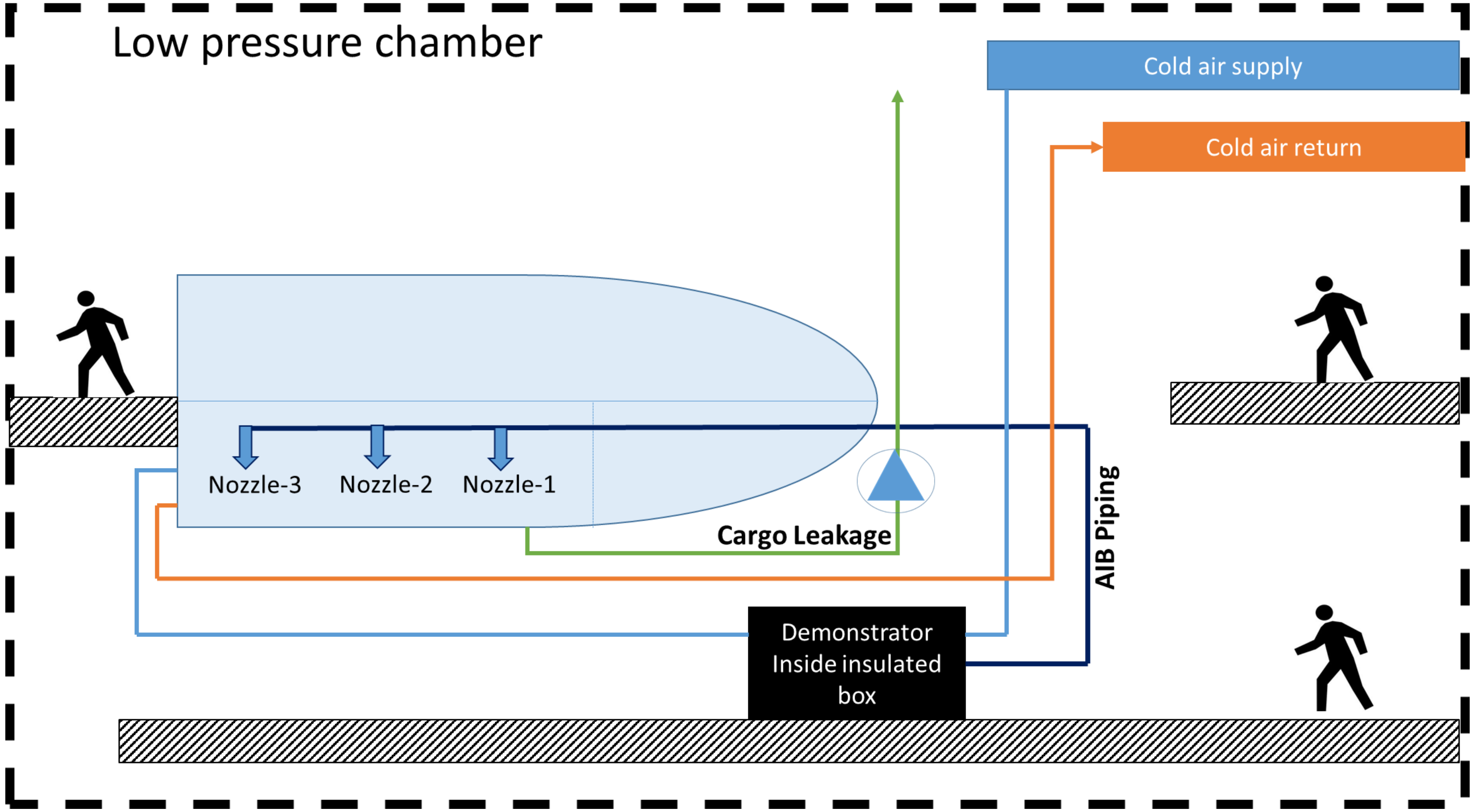


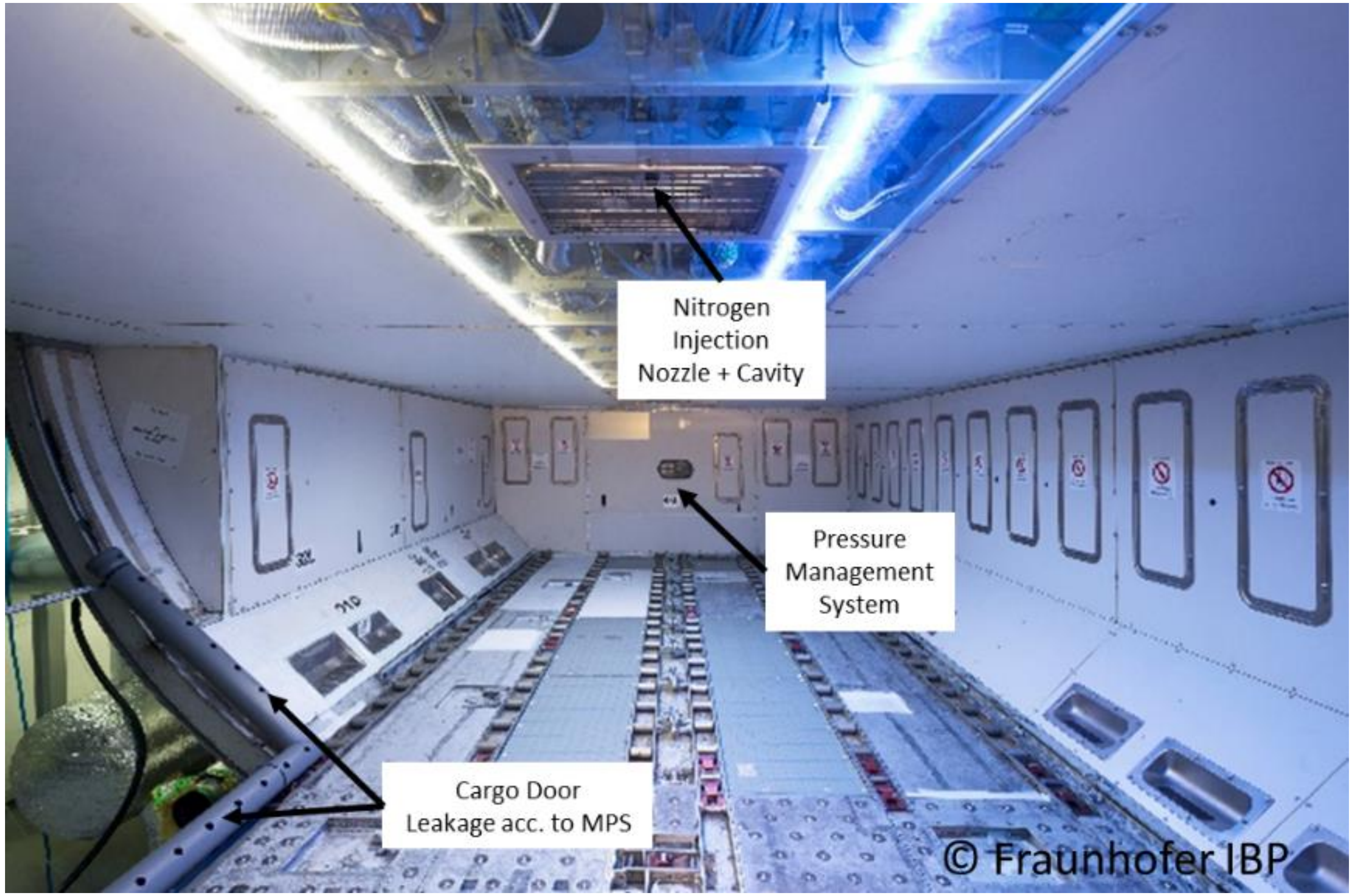


Flight Test Facility virtual tour is available through this link:

https://www.hoki.ibp.fraunhofer.de/vr/virtual-tour_IBP/#tabpanel-Virtueller%20Rundgang%20Fraunhofer%20IBP

CARGO HOLD SETUP

Cargo Hold with door leakage, pressure management system and agent injection nozzles, conforming with MPS requirements



PROJECT STATUS

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- System requirements defined
- Demonstrator design complete, CDR signed off ; components ordered
- Safety/risk analysis at system level has been performed
- Performance of demonstrator has been modelled using CFD; additional flight cases being evaluated
- LRD system performance is being optimized
- Testing at Fraunhofer Institute planned
- Industrialization plan has been completed

SUMMARY AND NEXT STEPS

Adam

- This work represents the next stage in the development of inert gas for cargo compartment fire suppression applications (TRL-5)
- Simulated altitude testing (reduced temperature and pressure) at Fraunhofer represents an exciting next step in the TRL development
- CFD modelling has been used to validate our approach; will reduce the number of tests required at Fraunhofer Institute
- We look forward to reporting the results at a subsequent Forum meeting
- Planned further developments and refinements to the ECOSYSTEM Demonstrator will allow for flight tests to be carried out

ACKNOWLEDGEMENTS

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- Airbus as Topic Manager
  - *Rainer Beuermann, Nadine Gomm, Andre Freiling*
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- Collins Aerospace Team
  - *El Hassan Ridouane, Laurie O'Sullivan, Hitesh Mistry, Francois Petetin, Francois Breton, Detlev Degenhardt, Carlos Manglano, Gerrit Krause, Weronika Batog, Lukasz Turek*
- FAA Tech Center