La Société Savante de l'Aéronautique et de l'Espace
SPACE PROPULSION 2016
02>06MAY 2016 · ROMA

Marchionni Massimo

United Kingdom

Airbus Defence and Space Ltd

ID : 3125379

Title : Solar Orbiter Purge System: Modelling with Ecosim

Theme :

Resume :

To answer the second science question of ESA's Cosmic Vision programme: "How does the solar system work?" the Solar Orbiter mission was proposed by the European Scientific Community and selected by ESA as first medium-class mission. Solar Orbiter is specifically designed to identify the origins and causes of the solar wind, the heliospheric magnetic field, the solar energetic particles, the transient interplanetary disturbances, and the Sun\'s magnetic field itself. The near-Sun part of the operational orbit will enable the spacecraft to approach the Sun as close as 0.28 AU during part of its orbit. Solar Orbiter will carry 10 different in-situ and remote sensing experiments, some of which are suites of multiple sensors. Combined, these experiments will perform a comprehensive range of scientific measurements with the aim of unravelling the mysteries that shroud the workings of the inner heliosphere. These experiments are:
• EPD: Energetic Particle Detector
• EUI: Extreme Ultraviolet Instrument
• MAG: MAGnetometer instrument
• METIS: Multi Element Telescope for Imaging and Spectroscopy
• PHI: Polarimetric and Helioseismic Imager
• RPW: Radio and Plasma Wave experiment
• SOLOHI: SOLar Orbiter Heliospheric Imager
• SPICE: SPectral Imaging of the Coronal Environment
• STIX: Spectrometer / Telescope for Imaging X-rays
• SWA: Solar Wind Plasma Analyser
In order to protect some of aforementioned instruments, a Purge System delivering pure, dry, clean nitrogen to instruments thus allowing controlled contamination-free environment throughout the AIT process until launch has been designed and is currently under realisation in line with Airbus experience on Aeolus, EarthCARE and Lisa Path Finder. This paper presents the basic modelling activities (via Ecosim Pro & associated ESPSS libraries) planned and ongoing to prove the system suitability to cope with different flushing scenarios (in ambient during AIT phase in clean-room, in the chamber during TVAC re-pressurization & finally during air-transportation). The forecasted test campaign to validate the model and pave the way to system acceptance is shortly described too.

SP3125379

Solar Orbiter
Purge System: Modelling with Ecosim
Airbus D&S, Stevenage

M. Marchionni, SolO Purge System Architect
N. Croisard, SolO System Engineer

Space Propulsion Conference 2016, 4th of May, Rome

AIRBUS
DEFENCE & SPACE

Agenda

- Solar Orbiter Mission
- Contamination & Heritage
- Description of the System
- Orifices & Filters
- Model Calibration
- Validation & Verification
- TVAC & Transportation
- Conclusions

AIRBUS DEFENCE & SPACE

Solar Orbiter Mission

"How does the Solar System Work?"

- Closer than ever – 0.28 AU
- In-situ & Remote measurements
- 10 Instruments
- Suites of sensors.

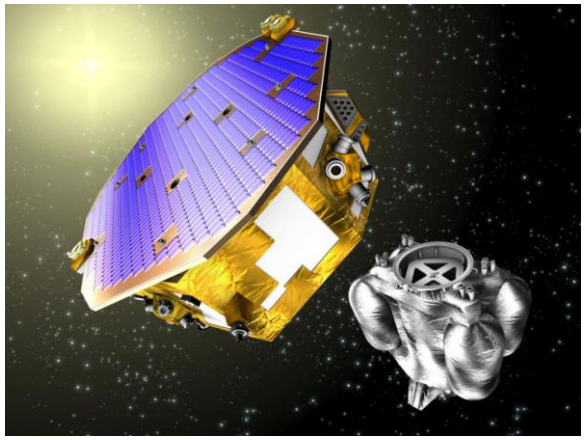
- **EPD:** Energetic Particle Detector
- **EUI:** Extreme Ultraviolet Instrument
- **MAG:** MAGnetometer Instrument
- **METIS:** Multi Element Telescope for Imaging and Spectroscopy
- **PHI:** Polarimetric and Helioseismic Imager
- **RPW:** Radio and Plasma Wave experiment
- **SOLOHI:** SOLar Orbiter Heliospheric Imager
- **SPICE:** SPectral Imaging of the Coronal Environment
- **STIX:** Spectrometer / Telescope for Imaging X-rays
- **SWA:** Solar Wind Plasma Analyser

AIRBUS DEFENCE & SPACE

Contamination: Airbus DS Heritage

Molecular

Particulate



Lisa Path Finder

ADM-Aeolus

Earth CARE

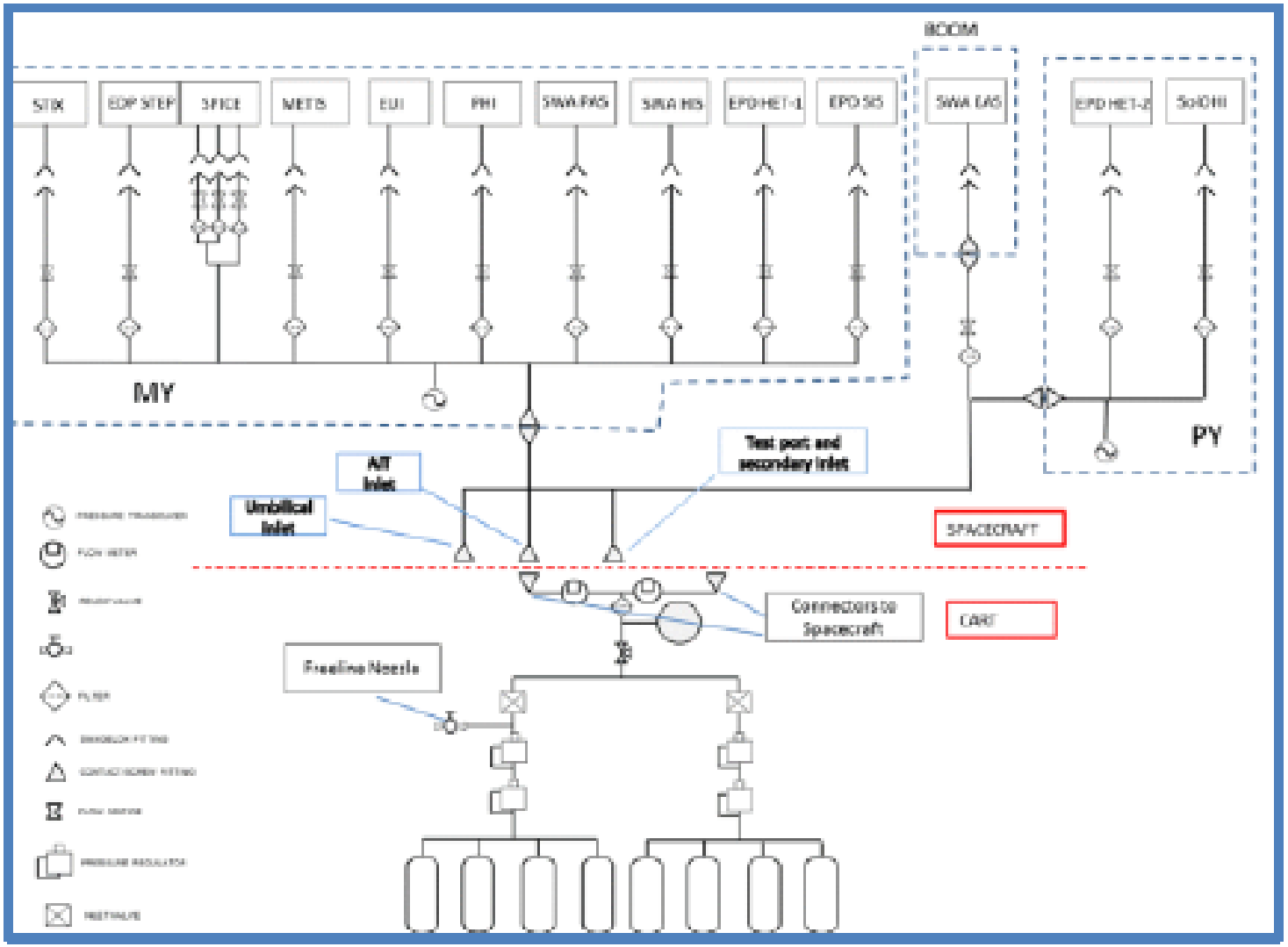
Bunny Suites for ATV

AIRBUS DEFENCE & SPACE

Purge System Schematics

Purge System

- S/C side
- Purge Cart

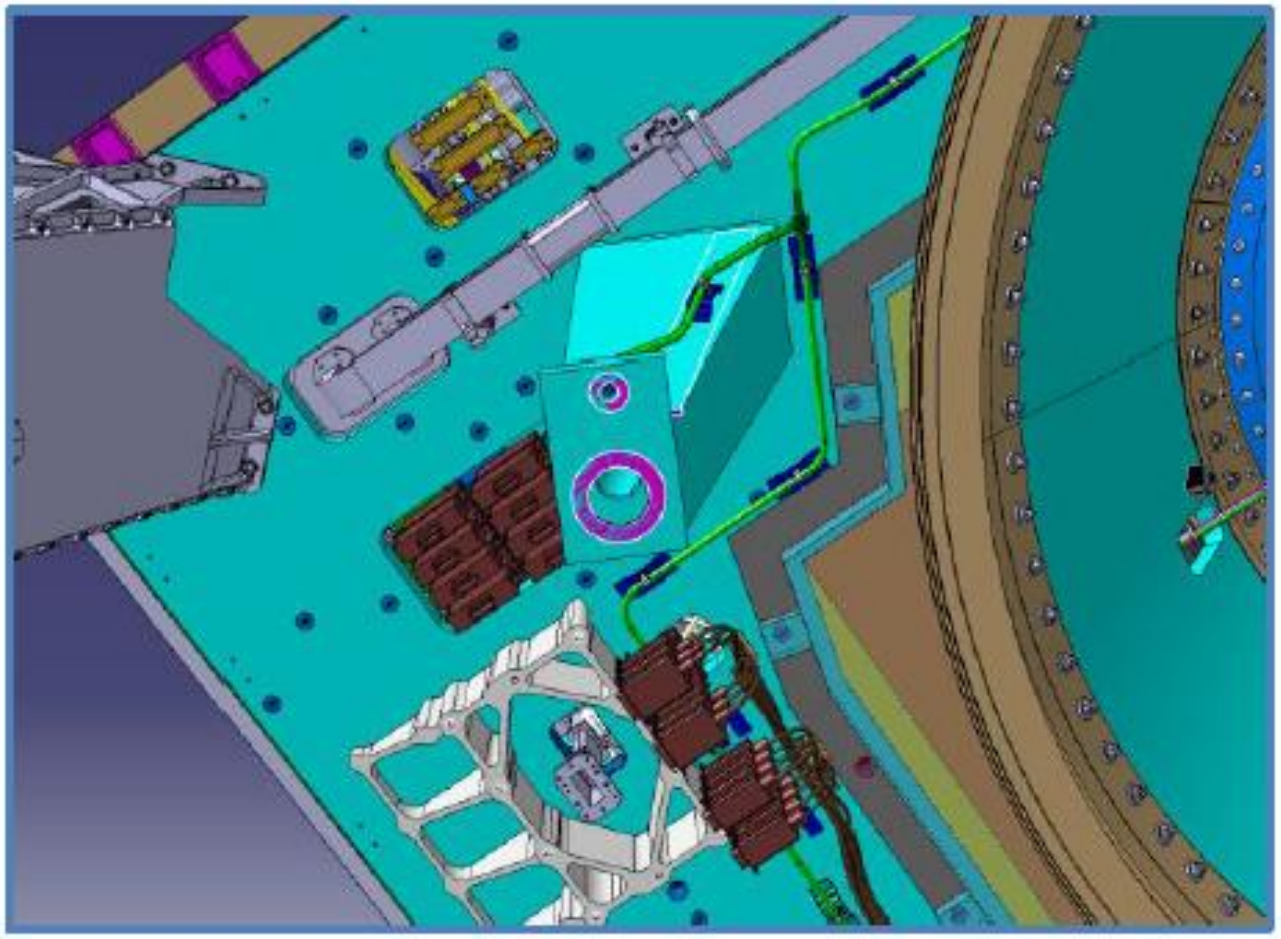


AIRBUS DEFENCE & SPACE

Operational Life

During the complete AIT flow!!!

- Panel Level
- S/C Level
- TVAC
- Transportation
- Launch Site
- Launch Pad



AIRBUS DEFENCE & SPACE

Orifice Sizing

$$A_{ori} = \frac{Q_2}{M_{ori}\sqrt{\gamma R T_{ori}}} \frac{1}{C_D} \frac{\rho_2}{\rho_{ori}}$$

Commercially Available (from Beswick)

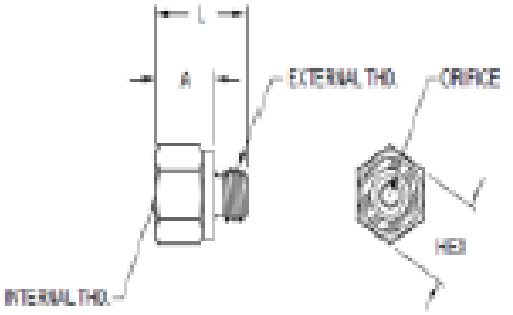
- Easy to install
- Large set of D's
- Look-up table

10-32, M5 or M3 Threaded Orifice – Drilled

Description: 10-32, M5 or M3 internal to external threaded fitting with micro drilled orifice. Choose orifice size from "Orifice Selection Table" on page 76.

Material: Brass, 303 or 316 stainless steel.

Seals: For CC-1010- and CC-M5M5- : One Buna-N O-ring, OR-516-40-B. Optional materials: EPDM, Viton®, Silicone, Teflon®, AFLAS®, Chemraz®, Fluorosilicone, and Neoprene. For CC-M3M3- : One Buna-N O-ring, OR-M3-B. Optional materials: EPDM, Viton®, Silicone, and Fluorosilicone. See page 1.



Part Number Brass	Part Number 303 Stainless	Part Number 316 Stainless	Internal Thread	External Thread	Installed Height A	L	Hex Size	Maxium Orifice Size
CC-1010-XXX	CC-1010-XXX-303	CC-1010-XXX-316	10-32	10-32	9/32	7/16	5/16	N/A
CC-M5M5-XXX	CC-M5M5-XXX-303	CC-M5M5-XXX-316	M5 X 0.8	M5 X 0.8	9/32	7/16	5/16	N/A
	CC-M3M3-XXX-303		M3 X 0.5	M3 X 0.5	5 mm	8 mm	5 mm	0.0625

AIRBUS DEFENCE & SPACE

Orifice Model Calibration

Verification of preliminary sizing

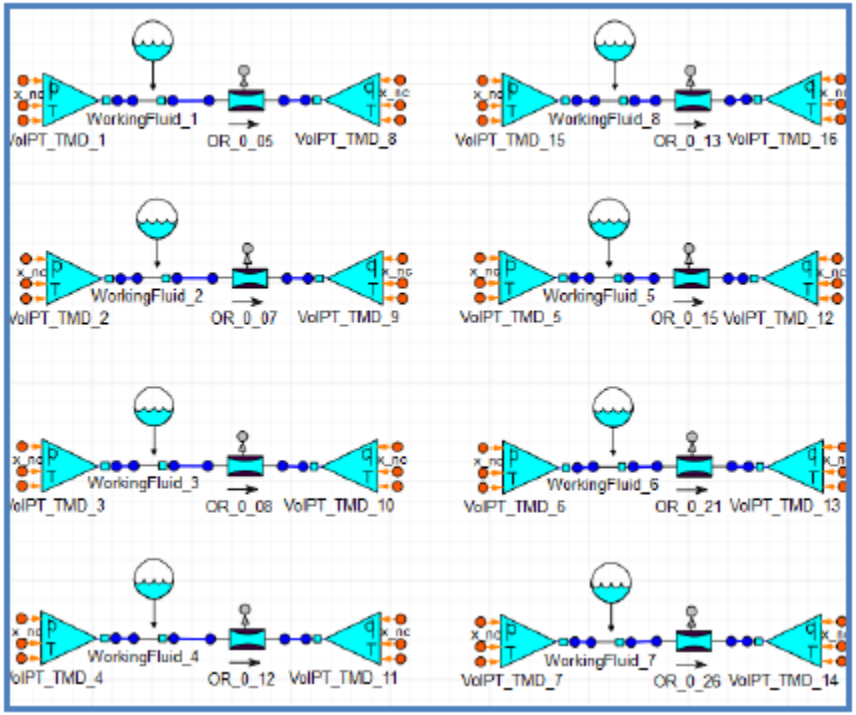
Laminar regime

Suitable for dynamic sim's

"Min" & "Max" values

Support design evolution

Q_{Eco} [SLPH]	Q_{Xls} [L/h]	v [m/s]	Re [-]	M [-]
2.91	4.77	0.0243	422	0.00007
7.52	9.34	0.0629	1093	0.00018
10.81	12.20	0.0883	1570	0.00026
28.85	27.46	0.2412	4192	0.00069
33.87	32.23	0.2831	4921	0.00081
45.10	42.90	0.3770	6552	0.00108
88.39	84.09	0.7388	12842	0.00212
135.49	128.90	1.1326	19685	0.00324

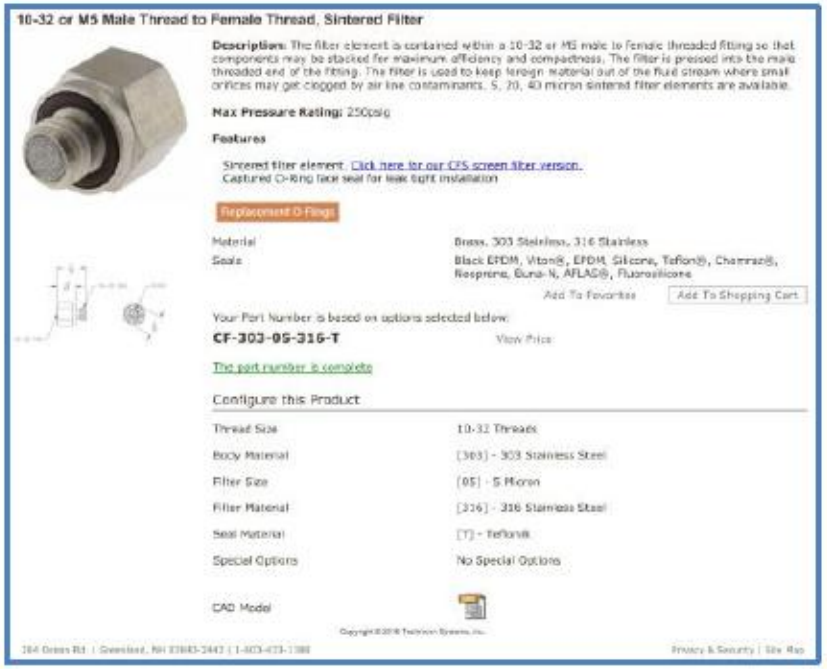


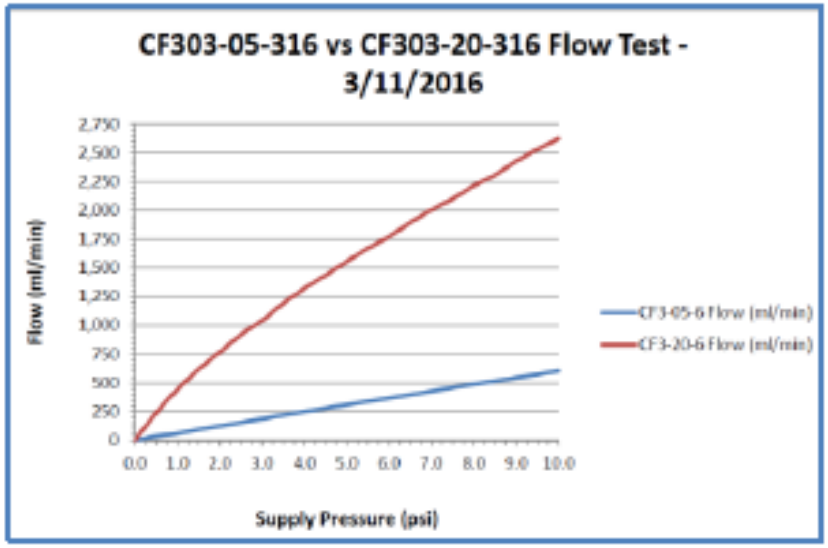
AIRBUS DEFENCE & SPACE

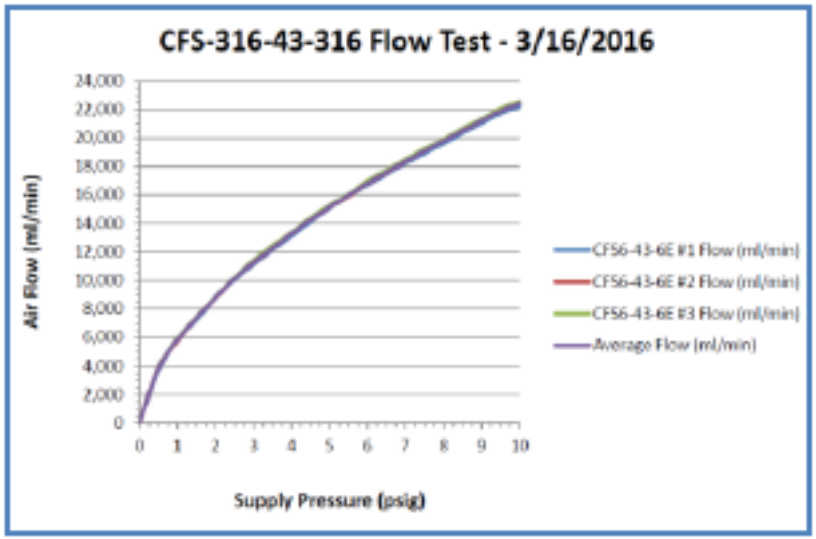
In-line Filters

From Beswick

- Graphs for pressure drop
- Select ref. point
- Select formula order
- Test





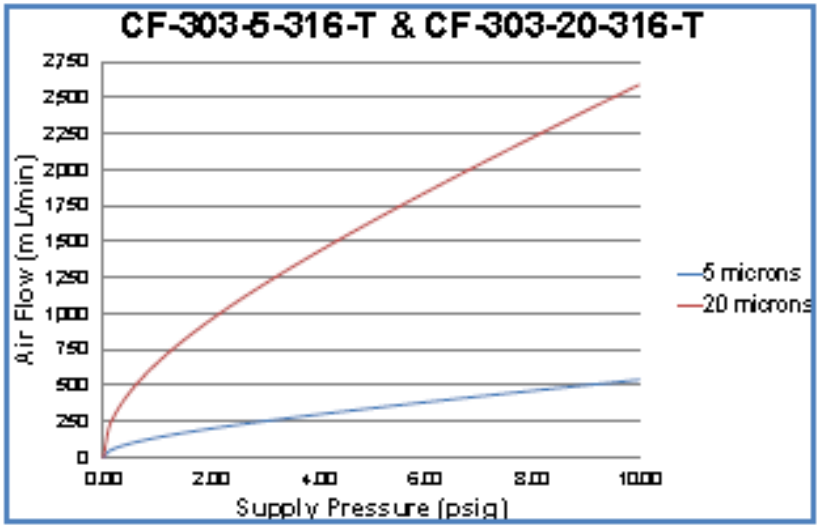


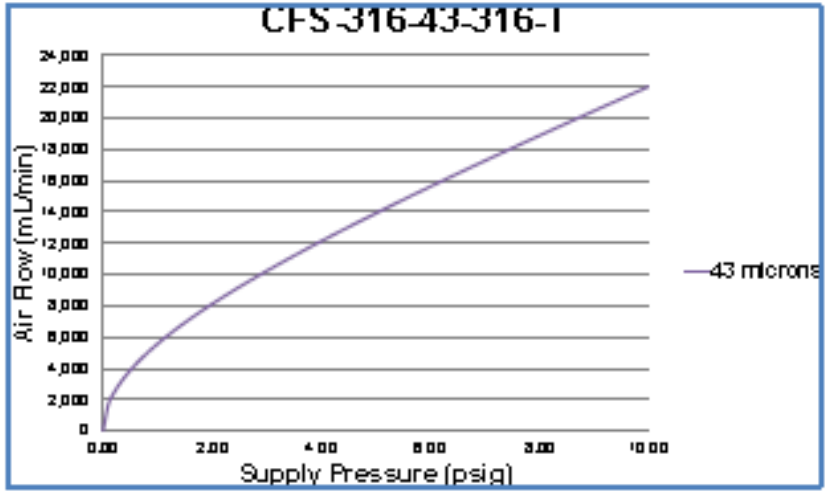
AIRBUS DEFENCE & SPACE

Filter Model Calibration

Model Results

- Comparison
- Scattering
- CF series
- CFS series





	CF-5	CF-20	CFS-43
p_{ref} [psi]	23.89	24.39	24.89
Δp_{ref} [psig]	9	9.5	10
p_conv	14.7	14.7	14.7
p_{ref} [bar]	1.63	1.66	1.69
Δp_{ref} [barg]	0.61	0.65	0.68
$\dot{m}_{ref}$ [mL/min]	500	2500	22000
$\dot{m}$_conv	0.06	0.06	0.06
$\dot{m}_{ref}$ [L/h]	30	150	1320
ρ_{av} [kg/m^3]	1.55	1.57	1.59
$\dot{m}_{ref}$ [kg/s]	1.29E-05	6.54E-05	5.83E-04
$\Delta\dot{m}_{ref}$ [%]	-0.51	-0.50	-0.50

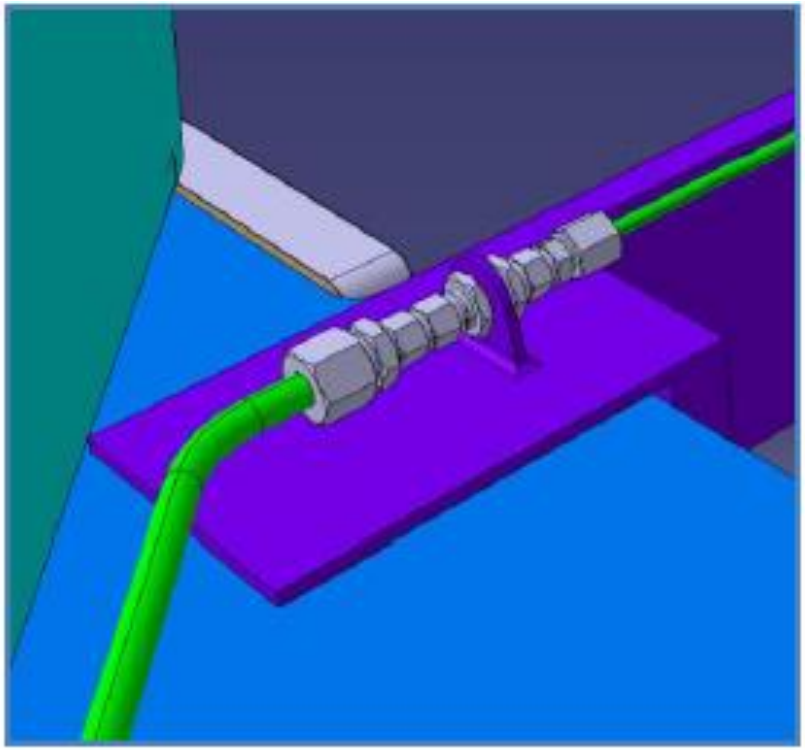
AIRBUS DEFENCE & SPACE

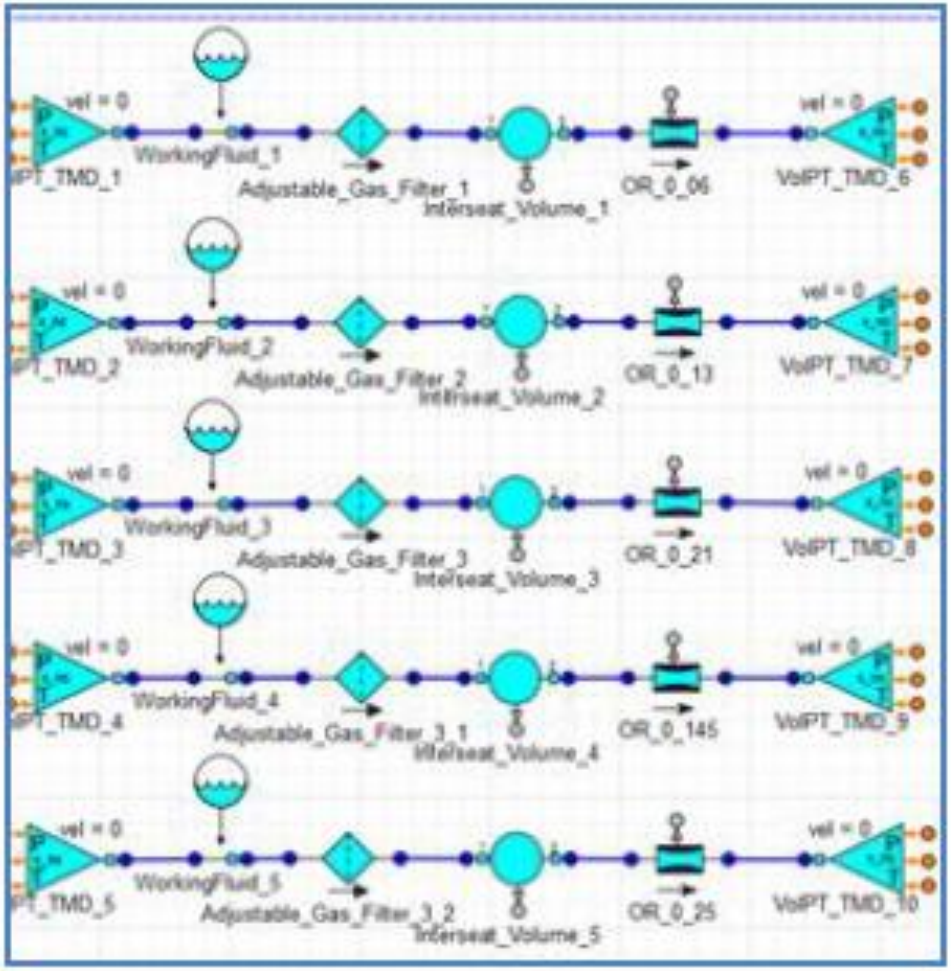
Stack Termination

Orifce & Filter

+

Mech. couplings





AIRBUS
DEFENCE & SPACE

Feed Pressure Iteration

Tolerance on feed pressure

+

Tolerance on feed temperature

=

«Min»

&

«Max»

Results			1st iteration	
OR / FIL	MIN SLPH	MAX SLPH	MIN SLPH	MAX SLPH
013 / 20	4	60	17.86	37.39
0145 / 20	12	80	21.82	43.84
025 / 43	80	160	83.45	153.16
018 / 20	20	100	29.47	56.62
021 / 20	67	100	59.54	109.80
010 / 5	5	20	5.28	9.84
06 / 5	3	8	3.25	8.46
011 / 5	6	15	6.63	13.29

Results			2nd iteration	
OR / FIL	MIN SLPH	MAX SLPH	MIN SLPH	MAX SLPH
013 / 20	4	60	36.75	50.00
0145 / 20	4	60	36.75	50.00
025 / 43	4	60	36.75	50.00
018 / 20	80	160	98.27	134.28
021 / 20	10	60	36.75	50.00
010 / 5	16	72	43.10	58.55
06 / 5	20	100	55.66	75.48
013 / 20	3	8	4.04	6.80

AIRBUS DEFENCE & SPACE

Validation & Verification

Procurement of several units

Test separately

Test combined

300 – 500 test points

Model tailoring

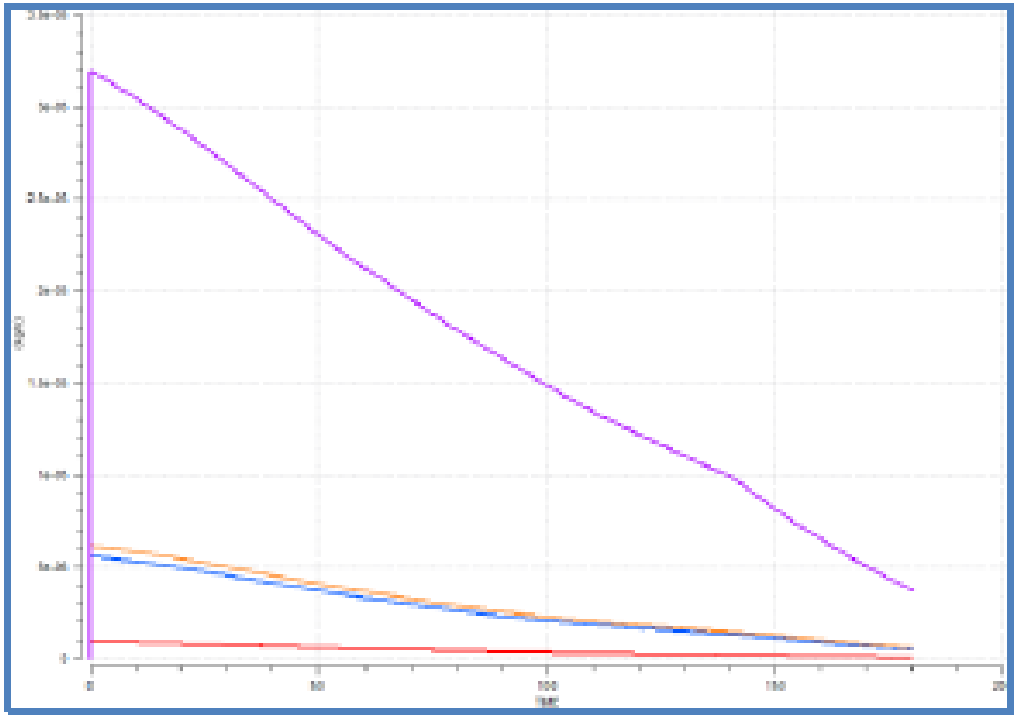
Final verification (acceptance)

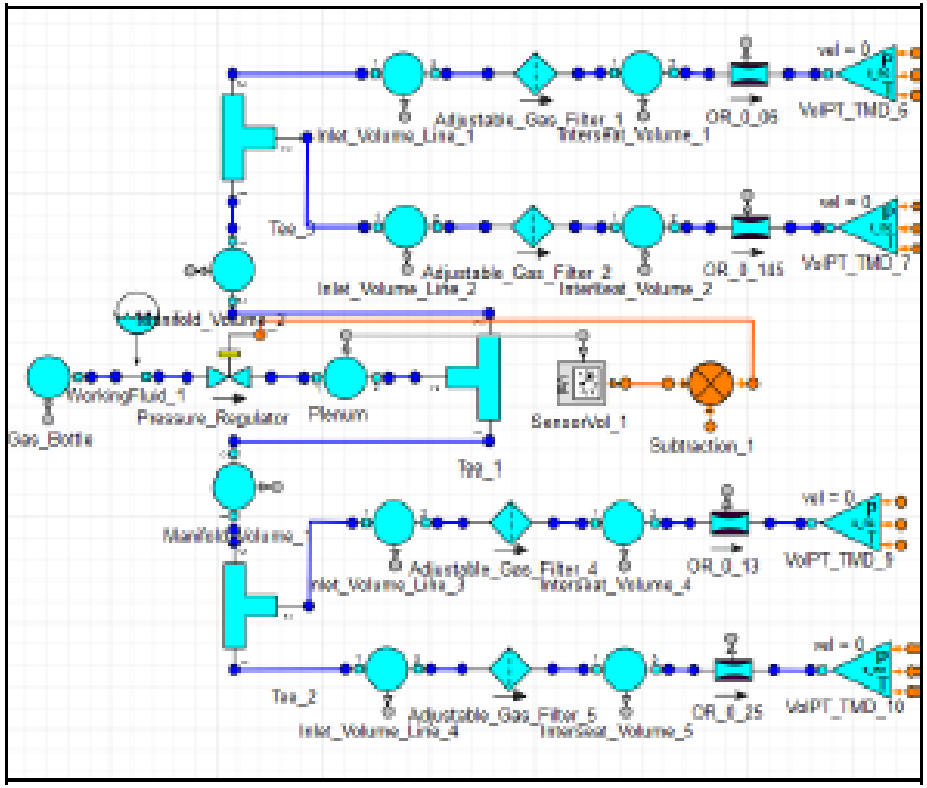
V&V	QTP	ATP, 1	ATP, 2
CF-316-5-316-T	3	4	4
CF-316-20-316-T	3	10	10
CF-316-40-316-T	1		
CFS-316-43-316-T	2	1	1
CC-1010-004-313-C	1		
CC-1010-005-313-C	2		1
CC-1010-006-313-C	2	1	
CC-1010-007-313-C	2		1
CC-1010-008-313-C	2		1
CC-1010-009-313-C	2		1
CC-1010-010-313-C	2	1	
CC-1010-011-313-C	2	2	
CC-1010-012-313-C	1		
CC-1010-013-313-C	3	5	5
CC-1010-0145-313-C	2	2	2
CC-1010-156-313-C	1		
CC-1010-16-313-C	1		
CC-1010-18-313-C	2	1	1
CC-1010-020-313-C	1		1
CC-1010-021-313-C	2	2	
CC-1010-022-313-C	1		
CC-1010-0225-313-C	1		
CC-1010-024-313-C	2		2
CC-1010-025-313-C	2	1	
CC-1010-026-313-C	1		
CC-1010-028-313-C	1		
TOTAL	45	30	30

AIRBUS DEFENCE & SPACE

Transportation

- Air transportation not yet authorised
- Performance of Cart Regulator
- Pressure control approach (& logic)





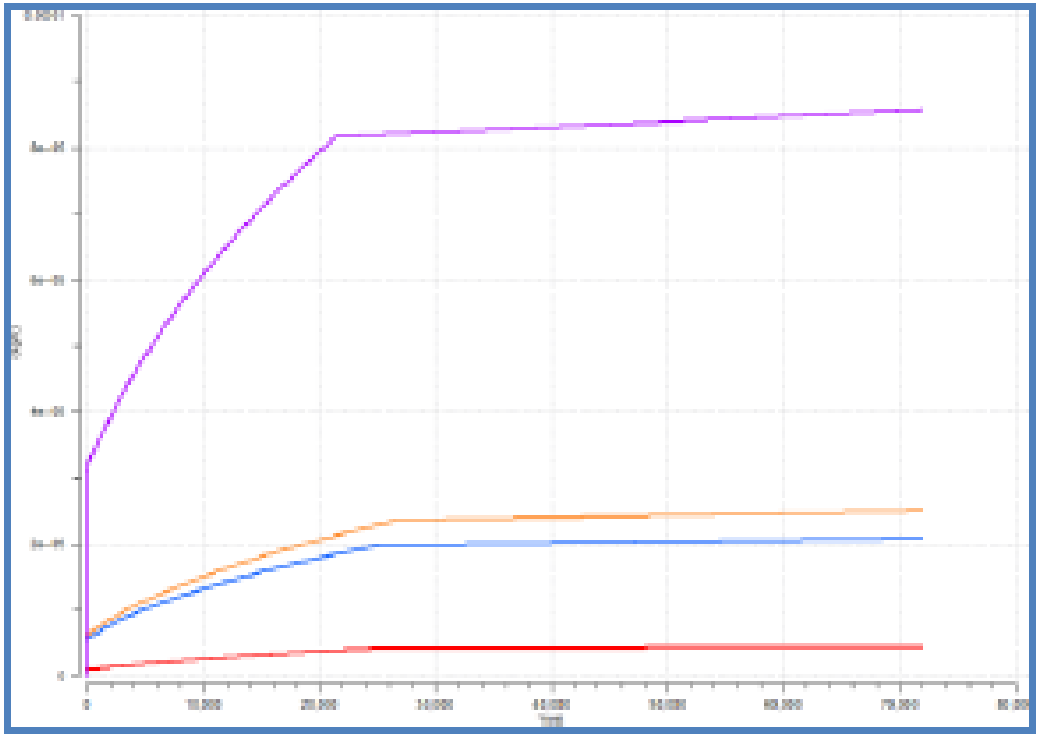
- Manual vs. S/W control

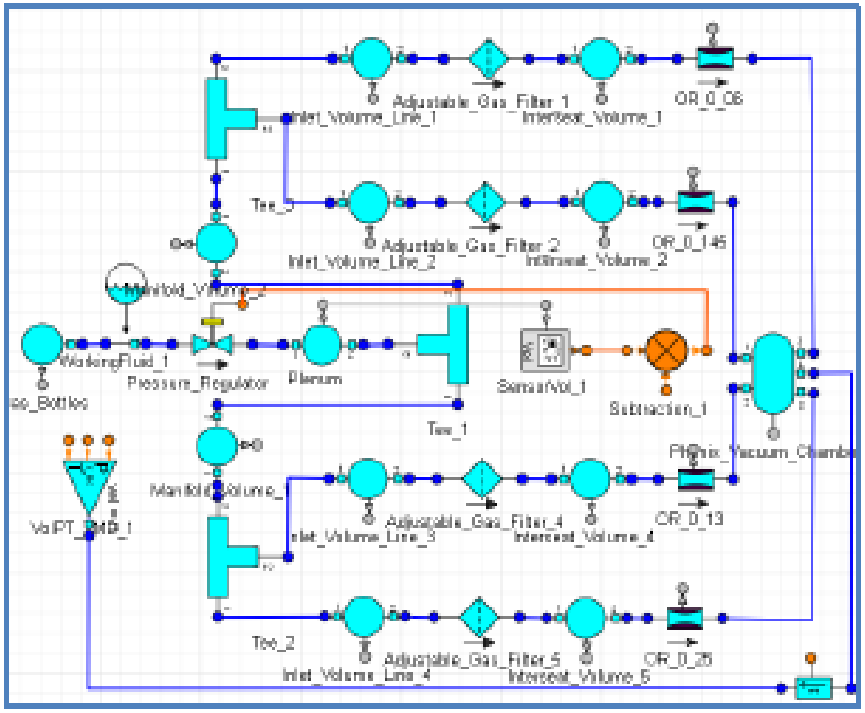
Transport Container fille with GN2

AIRBUS DEFENCE & SPACE

TVAC

- Facility not yet confirmed
- Definition of bleed valve
- Minimum pressure purge still required





- Facility not yet confirmed
- Definition of bleed valve
- Min p purge still required

AIRBUS DEFENCE & SPACE

Conclusions

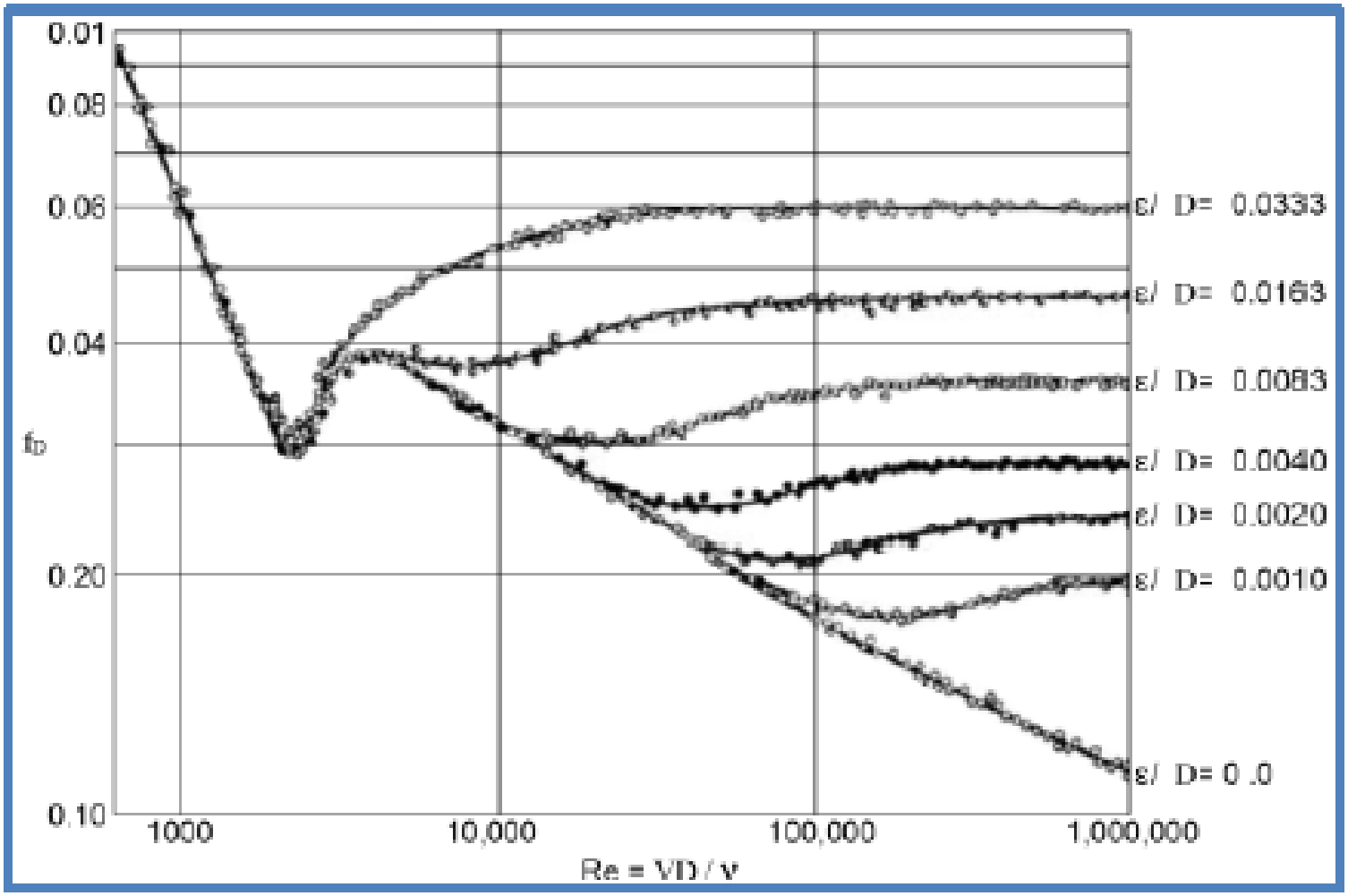
- Sizing concluded
- Impact of tolerances
- Design Iterations
- Dynamic model main components
- Test planning and evaluation
- TVAC
- Transportation

AIRBUS DEFENCE & SPACE

Questions?

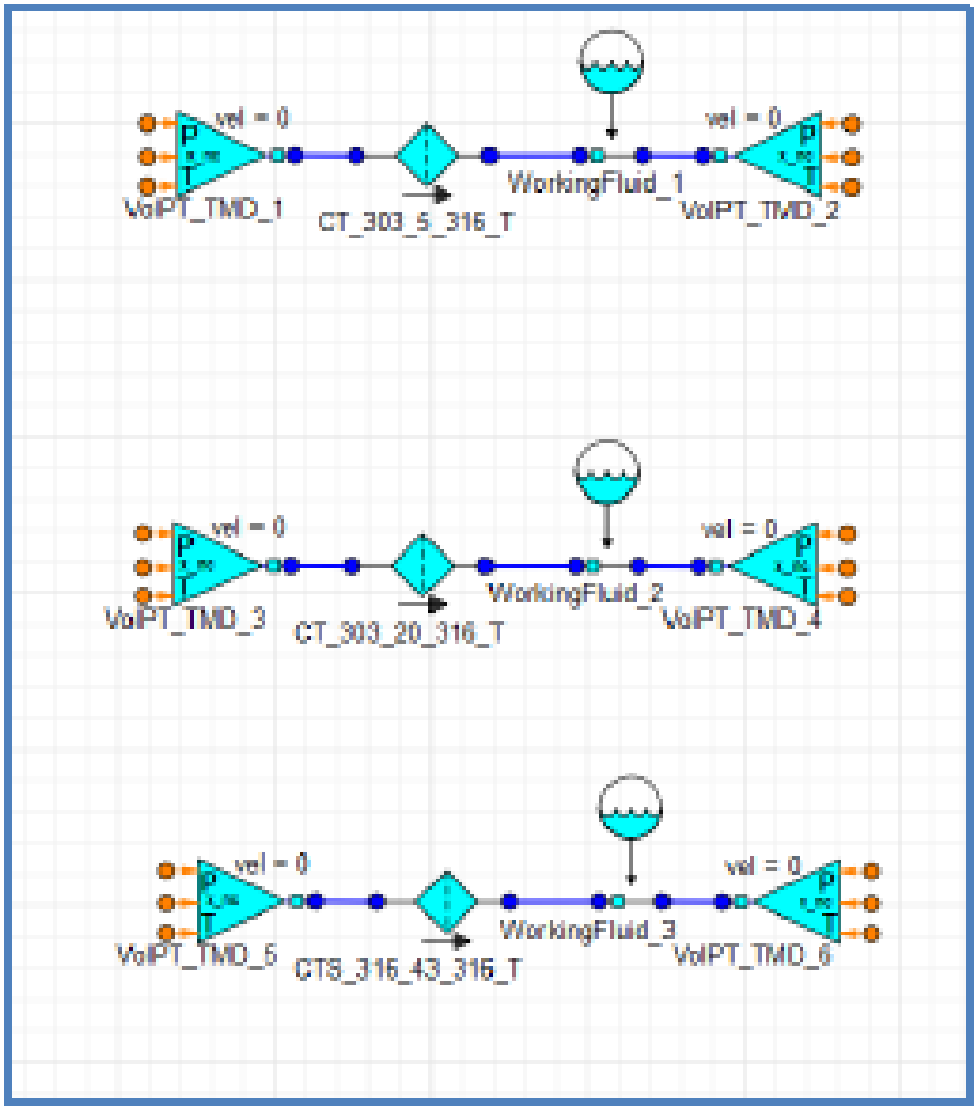
AIRBUS
DEFENCE & SPACE

Back-up (1/4)



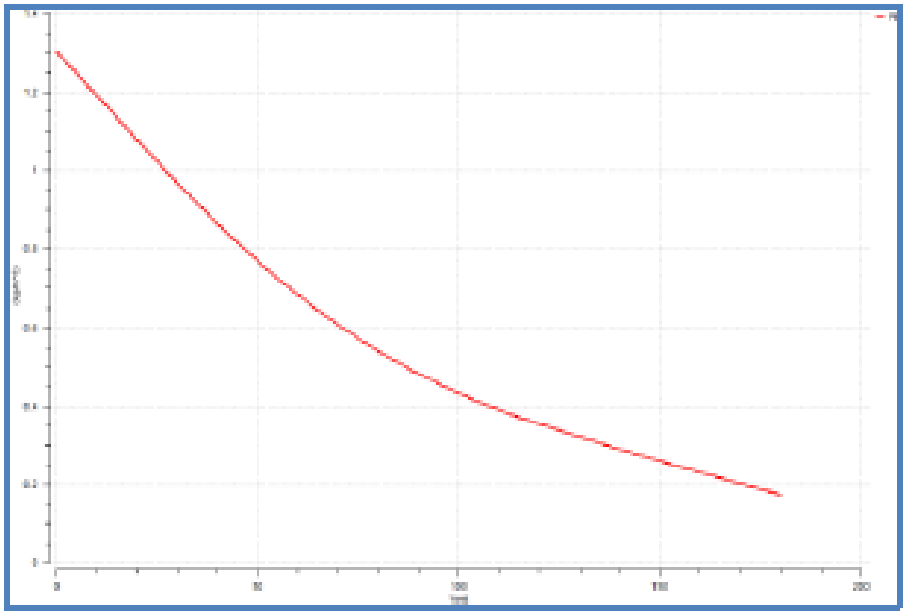
AIRBUS
DEFENCE & SPACE

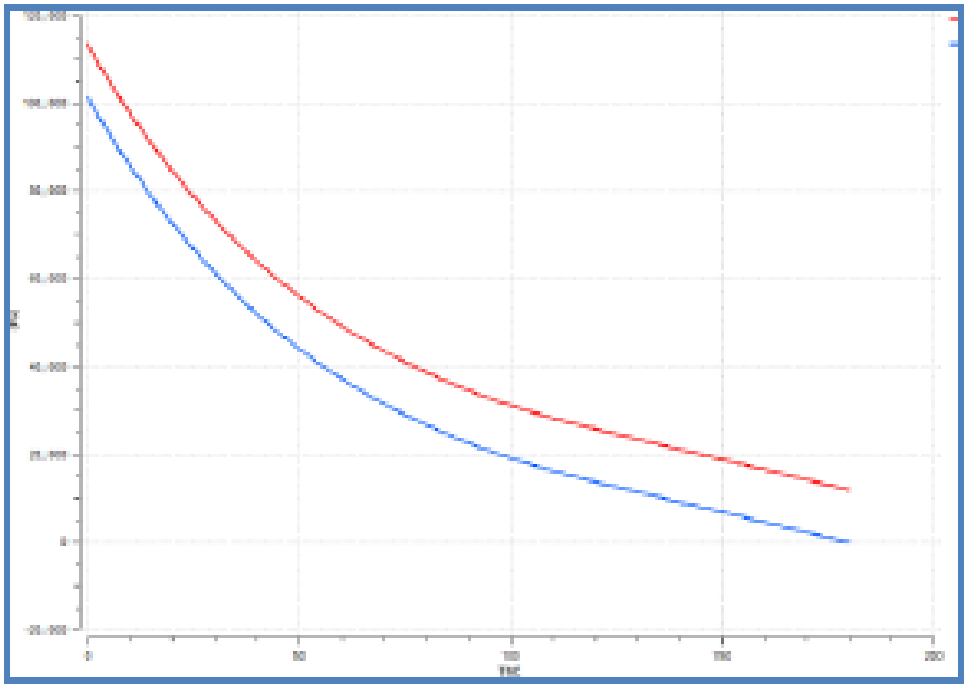
Back-up (2/4)



AIRBUS
DEFENCE & SPACE

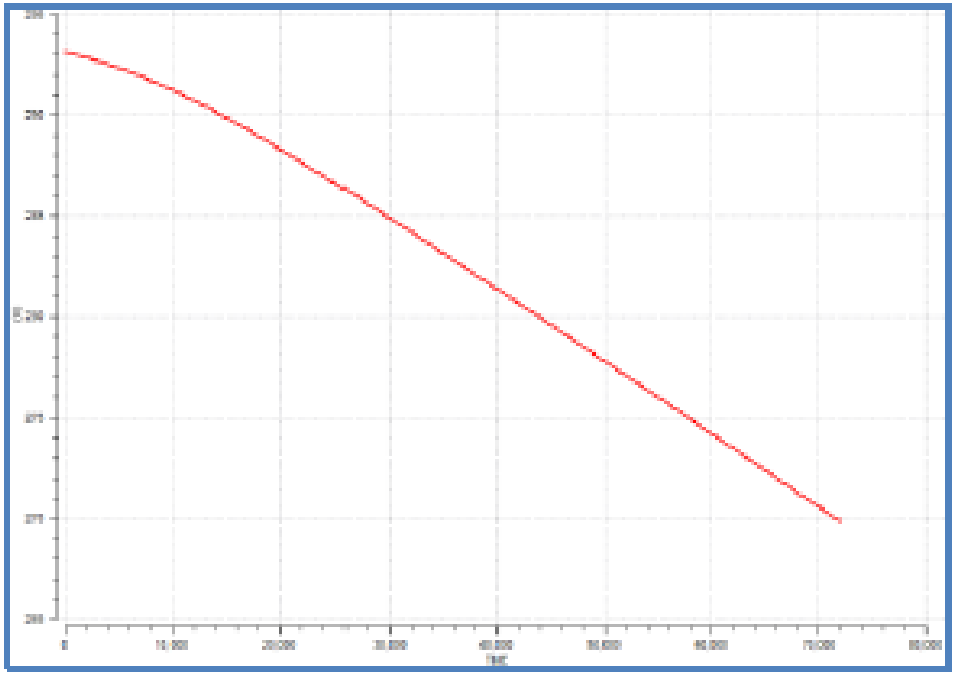
Back-up (3/4) Transportation

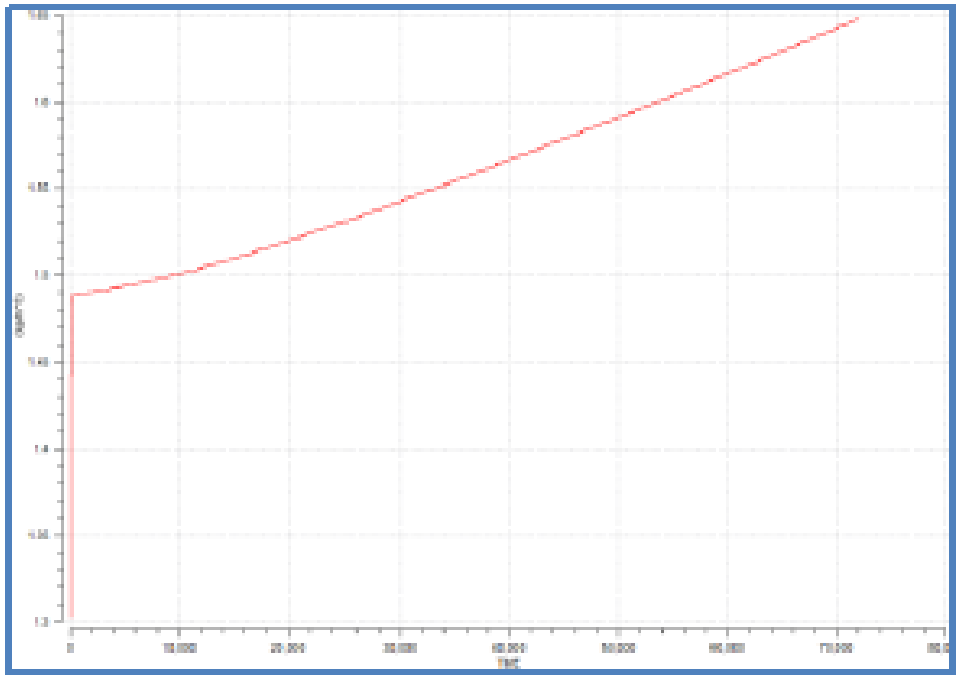




AIRBUS
DEFENCE & SPACE

Back-up (4/4) TVAC





AIRBUS
DEFENCE & SPACE