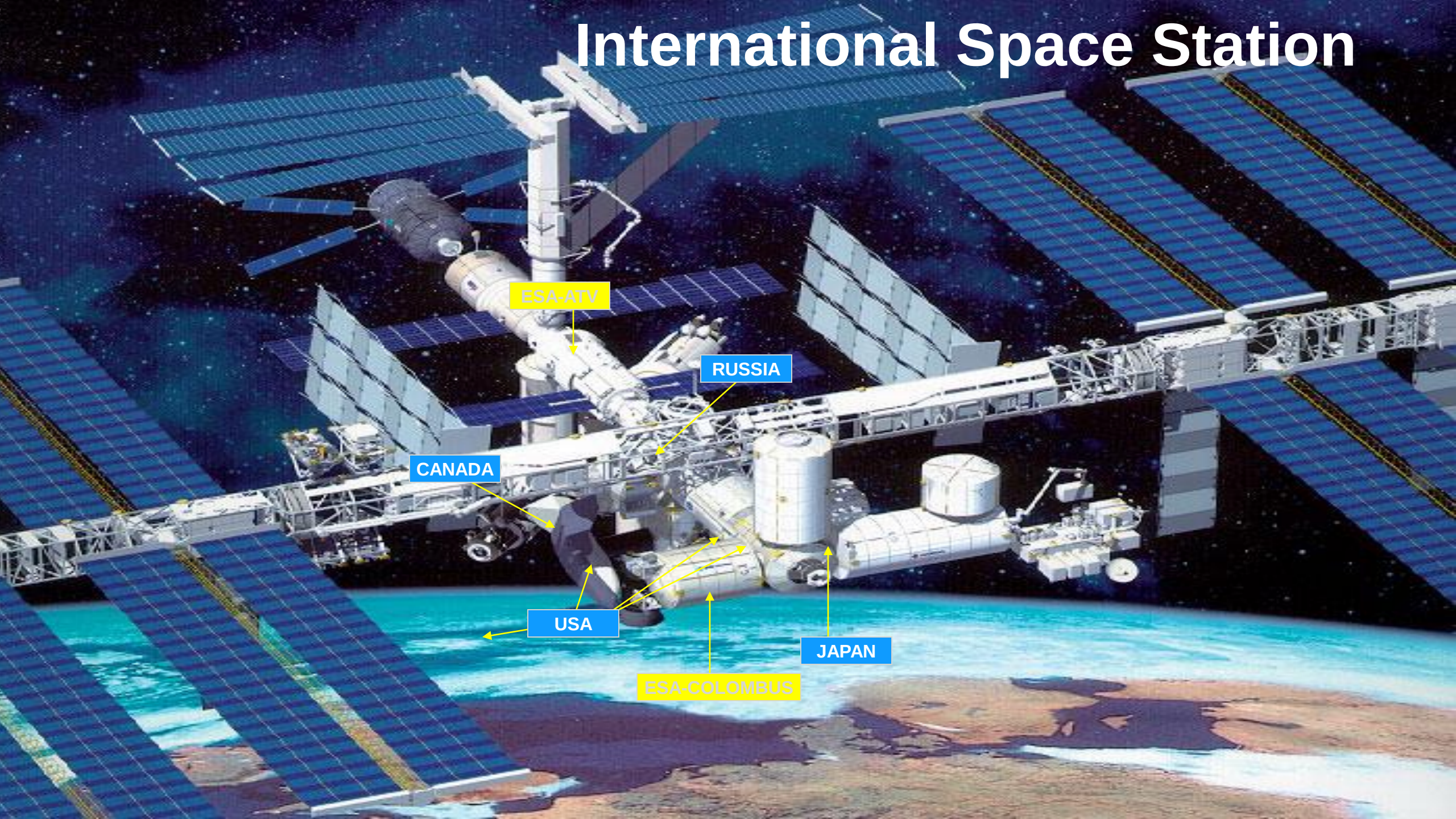
Compréhension et Prévention de la contamination des Véhicules spatiaux habités

Christophe Lasseur

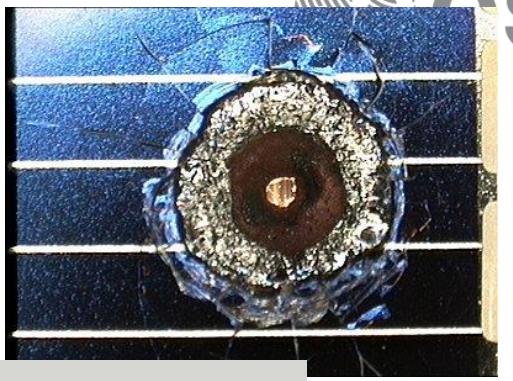
ContaminExpert, Paris, 28th 2019.

Astronautes Européens

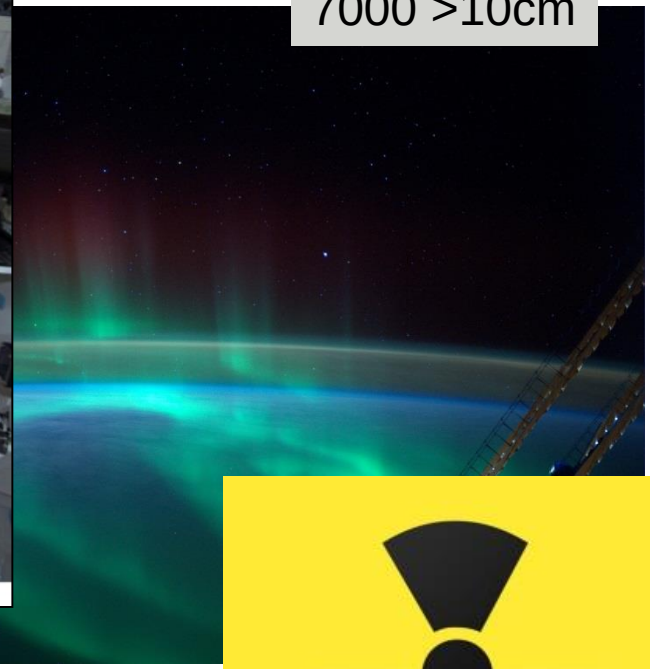
International Space Station



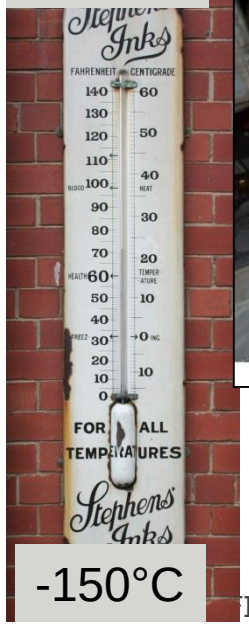
Un Environnement Hostile



7000 >10cm



+120°C



-150°C

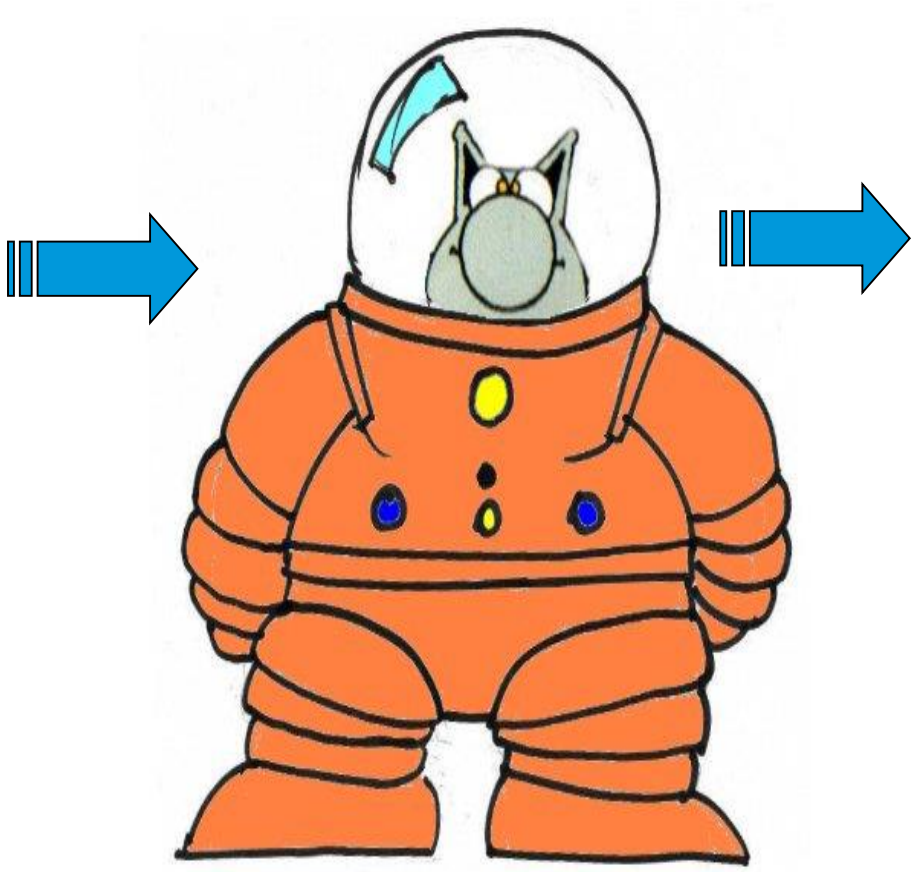
1er Principe de Lavoisier

Entrées:

O_2

Water

Food



Sorties:

Urine

Feaces

CO_2

Transpiration

Contaminants

(Microbial Chemical)

Risque ?

Densité en Surface:

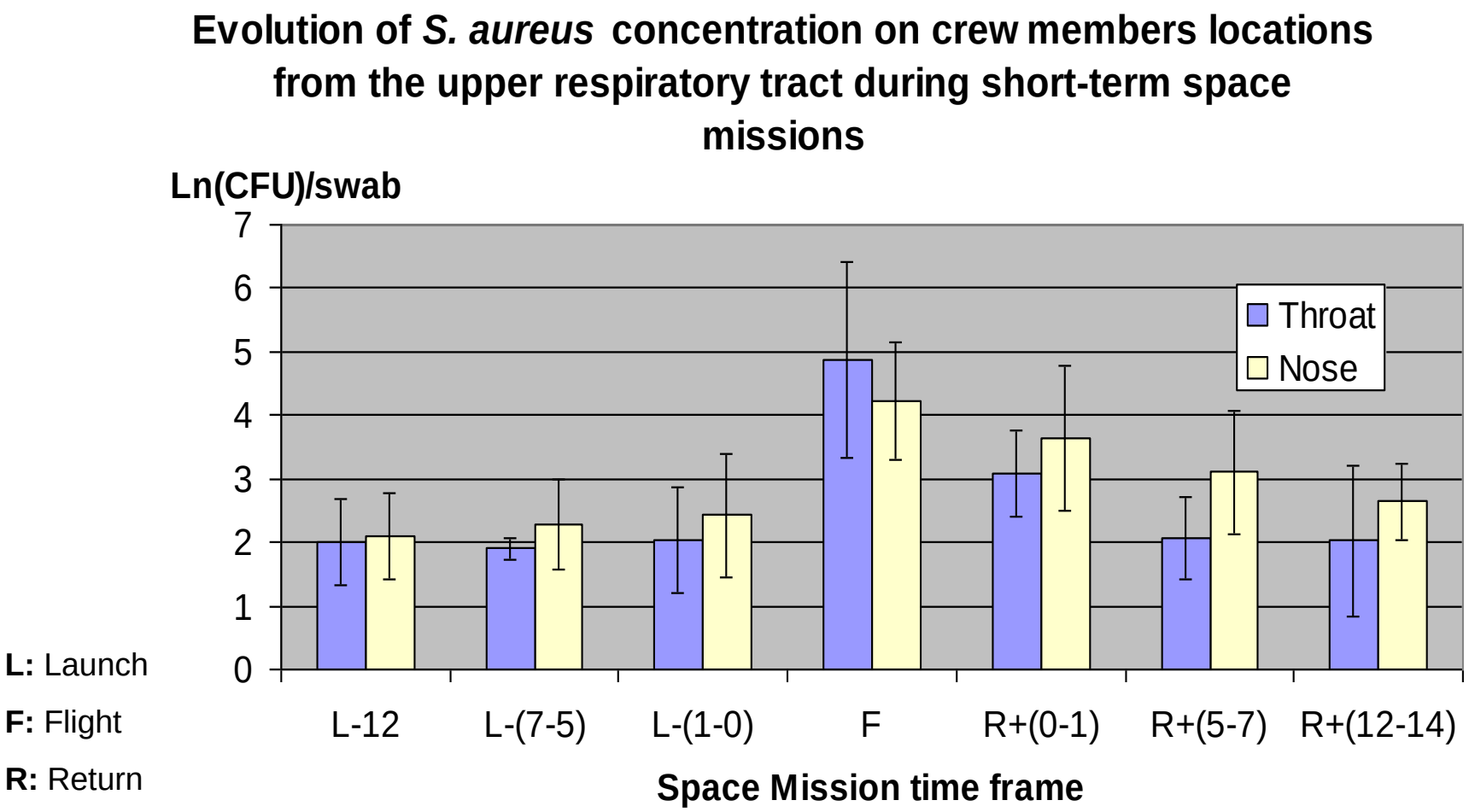
15000 inhab/km2 >> Singapore (7000)

Densité en Volume:

80400 inhab/km3>>> Singapore (2800)

MIR Expérience (Novikova et al.)

MIR Expérience (Ilyin et al.)



MIR Expérience

- Pas d'événement critique d'origine Microbienne,
- Pas d'événement humain (documenté) d'origine microbienne,
- De très nombreux problèmes de Hardware, d'origine microbienne,
- Très très difficile d'obtenir des statistiques fiables sur les vols habités,

- L'Expérience de contamination microbienne de MIR a sérieusement impacté la stratégie Européenne sur ISS.

AUJOURD'HUI

~400 Km

DEMAIN

Systême Circulaire

Le Challenge

Comment choisir et assembler des procédés pour obtenir le degré de recyclage maximum et la sécurité associée ?

Charactérisation= Nouveau Instrument

INSTRUMENTATION: MiDASS

BIOMÉRIEUX

Medical Mycology Advance Access published January 3, 2014

ISHAM
INTERNATIONAL SOCIETY FOR HUMAN AND ANIMAL MYCOLOGY

Medical Mycology, 2014, 00, 1–5
doi: 10.1093/mmy/myt017
Advance Access Publication Date: 0 2014
Short Communication

Short Communication

Usefulness of pan-fungal NASBA test for surveillance of environmental fungal contamination in a protected hematology unit

Marie-Pierre Brenier-Pinchart[1,3,*], Hafid Abaibou[4], Thomas Berendsen[1], Gautier Szymanski[1], Messalia Beghri[4], Sébatien Bailly[1,3], Frédérick Lasnet[4], Anne Thiebaut-Bertrand[2], Claude Mabilat[4] and Hervé Pelloux[1,3]

[1]Laboratory of Parasitology and Mycology, [2]Department of Hematology, University Hospital, [3]Joseph Fourier University, Grenoble I, Grenoble, France and [4]bioMérieux S.A., Chemin de L'Orme, 69280 Marcy l'Etoile, France

MiDASS Indicateurs

	Microorganism	Gram	Origin
Indicators	*Propionibacterium acnes*	+	Human commensal Environment
	Bacillus spp.	+	Environment
	Legionella spp.	-	Water (air condition)
	Candida spp.	yeasts	Human
	Aspergillus spp.	Moulds	Environment
Pathogens	*L. pneumophila*	-	Water (air condition)
	S. aureus	+	Environment
	S. pyogenes	+	Human commensal
	S. pneumoniae	+	Environment
	C. albicans	yeast	Human commensal
	A. fumigatus	mould	Environment

MiDASS Résultats

NASBA perf. in 20 µl tube format	Indicators: quantitative (Requirements: LOD 50 Geq/assay; LOQ 100)				
	P. acnes (16S rRNA)	*Candida spp* (28S)	*Aspergillus spp* (28S)	*Bacillus spp* (16S rRNA	*Legionella spp* (tmRNA)
Sensitivity *Total RNA (Geq)*	< 1	< 0.1	0.01-1	0.1-10	0.1-10
Specificity	2/2 (I) 0/5 (E)	47/47 (I) 4/65 (E)	35/35 (I) 7/65 (E)	10/10 (I) 0/17 (E)	10/10 (I) 0/16 (E)
Quantification 3-log DR	OK	OK	OK	OK	OK

NASBA perf. in 20 µl tube format	Pathogens: qualitative (Yes/No) (Requirement: LOD 1 Geq/assay)					
	L. pneumophila (tmRNA)	*C. albicans* (28S rRNA)	*A. fumigatus* (28S & 18S rRNA)	*S. aureus (Ef-Tu)*	*S. pyogenes* (16S rRNA)	*S. pneumoniae* (16S rRNA)
Sensitivity *Total RNA (Geq)*	0.1	1	1	1	0.1-1	0.1
Specificity	13/13 (I) 5/35 (E)	20/20 (I) 2/88 (E)	3/3 (I) 0/11 (E)	10/10 (I) 0/12 (E)	6/6 (I) 0/6 (E)	2/6 (I) 0/6 (E)

I: Inclusivity; E: Exclusivity

Quantification algorithms for indicators are available and in line with initial specs

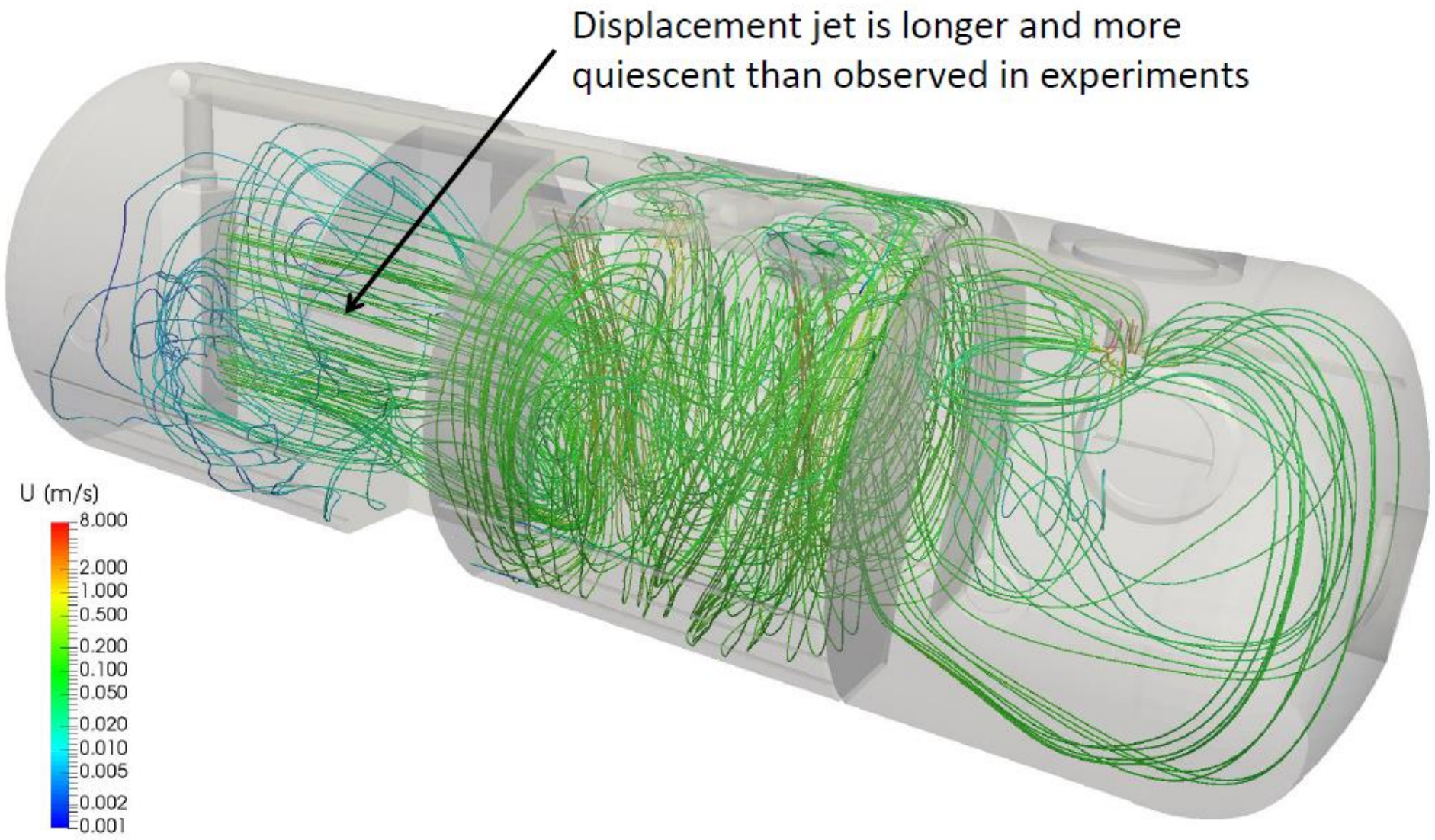
Prédiction & Modélisation

Contamination Modelling

- La Prédiction des contaminations de surface pourrait aider à étudier les contre-mesures,
- En micro-gravité, il ya beaucoup de chance que le phénomène le plus important soit l'impaction,
- Peut-on prédire ces phénomenes en micro-gravité ?
- Plusieurs études:
  - BiosMhars :http://www.biosmhars.eu/
  - BIOMODEXO

Comex HH

Streamlines



Modélisation: Conclusion

- La prédiction particulaire est possible,
- Cependant, il faudra confirmer avec des échantillons microbiens,

Quelques Résultats....

Exceeding of standard on microorganisms contents in FGB during ISS-15, 16 and ISS-17 flights

Air: 98th day of the flight of ISS-16 and 197th day of the flight of ISS-17 CFU/ m³

(standard given in ISS MORD 50 260 :

bacterium 1000 CFU/m³, fungi 100 CFU /m³)

Sampling areas	Fungi	Fungi
FGB	242	1056

Contamination on the panel 408 FGB

Surfaces: 168th day of the flight of ISS-15
CFU / 100 cm²

(standard given in ISS MORD 50 260 :
bacterium 10,000 CFU/ 100 cm², fungi 100 CFU /100 cm²)

Tested surfaces	Bacterium	Fungi
FGB, behind the panel 230	1,5x10²	1,2x10²
FGB, on the panel 408: contamination area	2,8x10⁴	4,0x10⁴
FGB, on the panel 404: contamination area	8,5x10³	5,0x10¹
SM, behind the panel 139	3,8x10³	Non detectet
SM, niche	1,0x10⁴	2,4x10⁴

ISS
AIR Loop

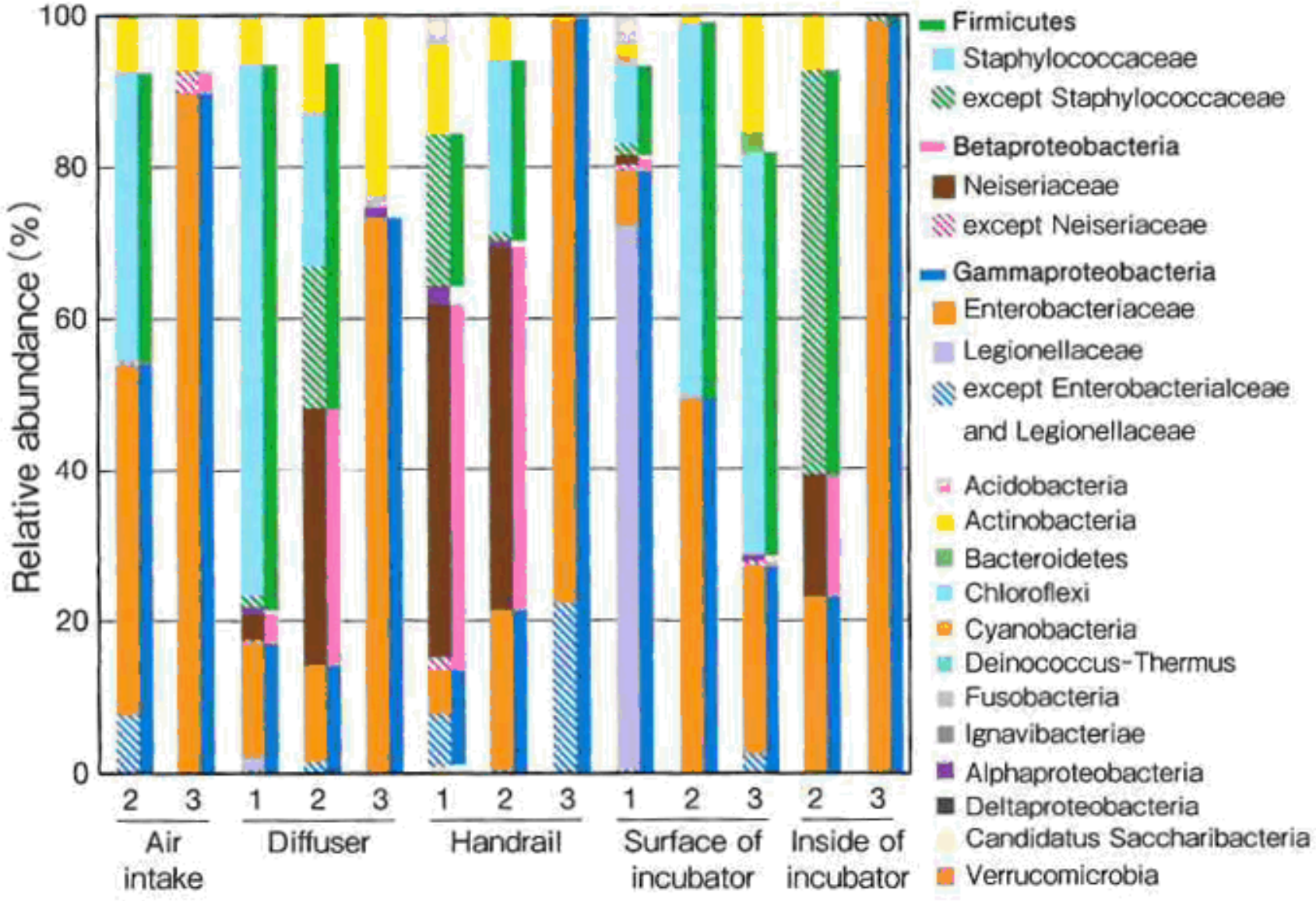


図 1　ISS「きぼう」内機器表面の細菌群集構造
（文献 4，Figure 1 より引用）

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frontiers in Microbiology

ORIGINAL RESEARCH
published: 28 April 2017
doi: 10.3389/fmicb.2017.00671

The Impact of Space Flight on Survival and Interaction of *Cupriavidus metallidurans* CH34 with Basalt, a Volcanic Moon Analog Rock

*Bo Byloos[1,2], Ilse Coninx[1], Olivier Van Hoey[3], Charles Cockell[4], Natasha Nicholson[4], Vyacheslav Ilyin[5], Rob Van Houdt[1], Nico Boon[2] and Natalie Leys[1]**

[1] Microbiology Unit, Belgian Nuclear Research Centre, SCK•CEN, Mol, Belgium, [2] Center for Microbial Ecology and Technology, Ghent University, Ghent, Belgium, [3] Research in Dosimetric Applications, Belgian Nuclear Research Centre, SCK•CEN, Mol, Belgium, [4] UK Centre for Astrobiology, School of Physics and Astronomy, University of Edinburgh, Edinburgh, UK, [5] Institute of Medical and Biological Problems of Russian Academy of Sciences, Moscow, Russia

Microbe-mineral interactions have become of interest for space exploration as microorganisms could be used to biomine from extra-terrestrial material and extract elements useful as micronutrients in life support systems. This research aimed to identify the impact of space flight on the long-term survival of *Cupriavidus metallidurans* CH34 in mineral water and the interaction with basalt, a lunar-type rock in preparation for the ESA spaceflight experiment, BIOROCK. Therefore, *C. metallidurans* CH34 cells were suspended in mineral water supplemented with or without crushed basalt and send for 3 months on board the Russian FOTON-M4 capsule. Long-term storage had a significant impact on cell physiology and energy status (by flow cytometry analysis, plate count and intracellular ATP measurements) as 60% of cells stored on ground lost their cell membrane potential, only 17% were still active, average ATP levels per cell were significantly lower and cultivability dropped to 1%. The cells stored in the presence of basalt and exposed to space flight conditions during storage however showed less dramatic changes in physiology, with only 16% of the cells lost their cell membrane potential and 24% were still active, leading to a higher cultivability (50%) and indicating a general positive effect of basalt and space flight on survival. Microbe-mineral interactions and biofilm formation was altered by spaceflight as less biofilm was formed on the basalt during flight conditions. Leaching from basalt also changed (measured with ICP-OES), showing that cells release more copper from basalt and the presence of cells also impacted iron and magnesium concentration irrespective of the presence of basalt. The flight conditions thus could counteract some of the detrimental effects observed after the

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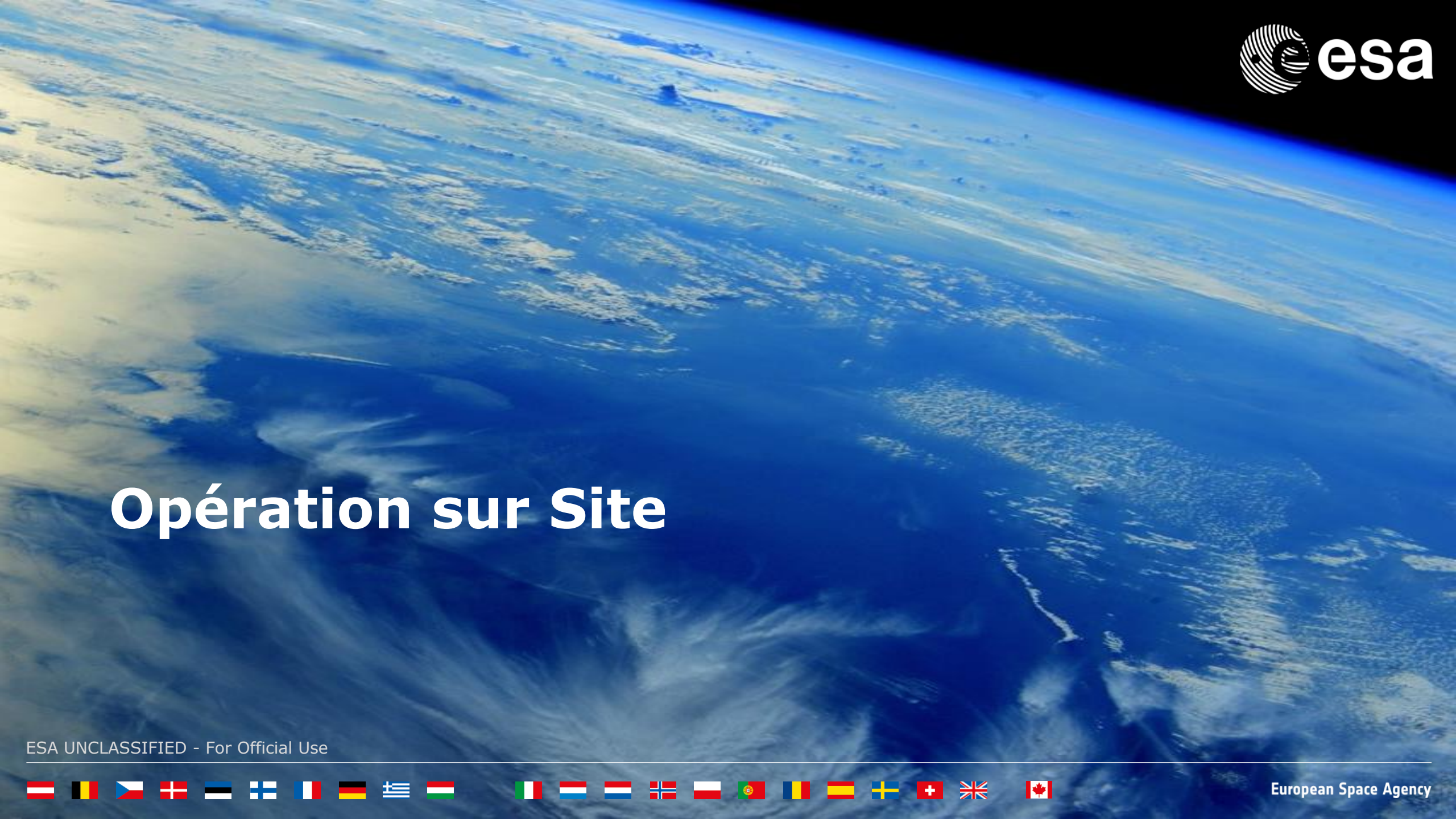


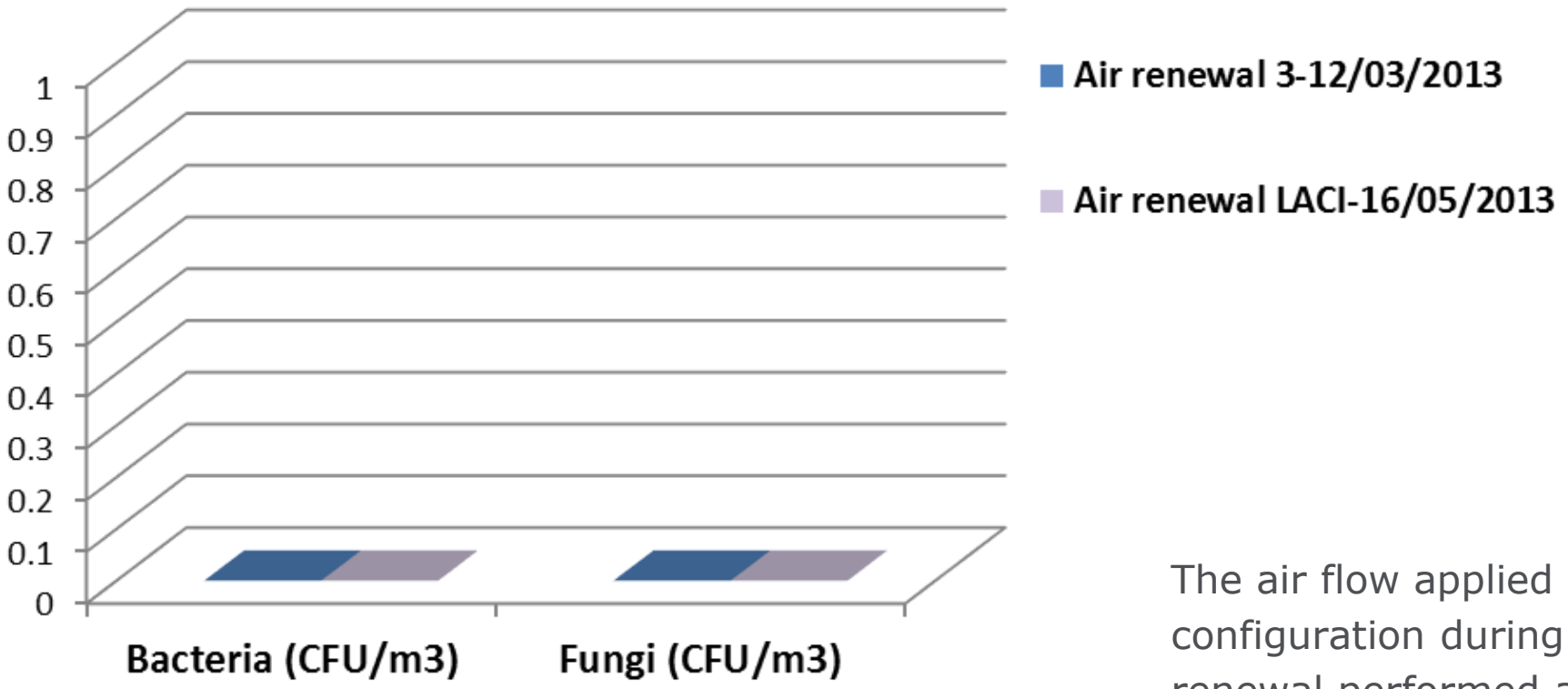
Opération sur Site

Evolution

- Au début de l'ISS, nous exigions seulement une propreté "visuelle",
- Notre expérience (et les résultats Russes…) ont convaincu la communauté Internationale de… progresser,
- Toutefois, la communauté spatiale vient des Sciences dures , et on peut dire que les microbes ne furent pas toujours les plus résistants….
- CONCLUSION : tous les cargos Européens ont été produits et lancés avec des nouveaux standards de qualité,

Opération

ATV Microbial Air Quality After Late Access



The air flow applied during all open configuration during LACI operations and the air renewal performed after closure allowed to maintain the very good quality of the ATV4 PM atmosphere which remain stable from S5c final closure to LACI closure

CONCLUSION

- La propreté microbienne est un volet important de l'exploration habitée,
- Aujourd'hui nous ne sommes toujours pas capable d'avoir une charactérization fiable de nos véhicules en opération,
- De nombreuses études sont en cours:
- - BioMolecular instrumentation ,
- - Nouveau matériaux,
- - Prédiction et modélisation,
- - Opération,

La communauté microbienne spatiale reste une petite communauté et nous vous invitons à declarer votre intérêt.


MAX. LOAD ON BR
LCAM COMPLETE
3 PERSON
(OR 382
SUPPORT S
165 kg
DISTRIBU
1442

Le Dernier !