

EXOMARS PLANETARY PROTECTION IMPLEMENTATION

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COSPAR PANEL ON PLANETARY PROTECTION, 6 DEC. 2023, VIENNA (AT)

EXOMARS MISSION OVERVIEW

/// **ExoMars project was a broad International Cooperation between ESA and Roscosmos with Instrument contributions from NASA**

/// **Thales Alenia Space – Italia (TASinI) was the European ExoMars program Prime Contractor**

/// **Two missions:**

/// **ExoMars 2016**, launched in March 2016

/// **ExoMars Rover and Surface Platform**, planned to be launched in 2022, canceled

/// And currently **ExoMars Rosalind Franklin Mission (RFM)** to be launched in 2028

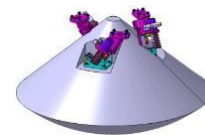
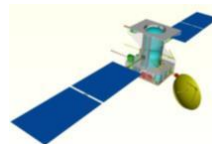
EXOMARS MISSION OVERVIEW



EXOMARS MISSION OVERVIEW

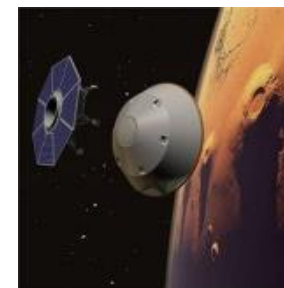
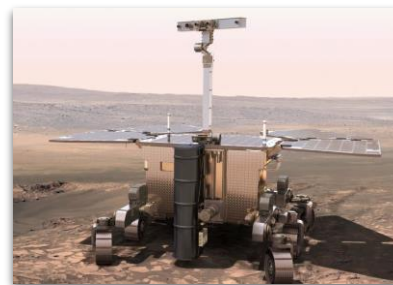
///ExoMars 2016 Mission: **Category IVa**

- // Lander system **not** carrying instruments for investigation of Martian life and **neither land nor access** a Mars special regions
- // Planetary Protection Category III for the Trace Gas Orbiter (TGO)



///ExoMars Rover and Surface Platform Mission : **Category IVb**

- // Lander system **carrying** instruments for investigation of extant or extinct Martian life and **neither land nor access** a Mars special regions

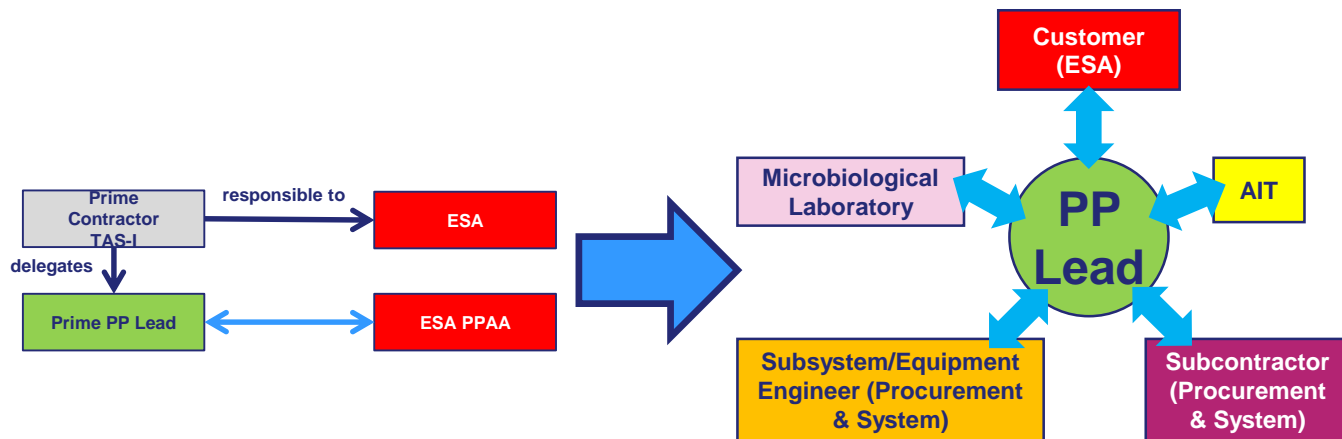


EXOMARS 2016 MISSION – CATEGORY IVa – PP IMPLEMENTATION



EXOMARS – 2016 MISSION

///PP Management and Organization



/ P-PPL define, organize, manage and follow the **PP activities** at all levels

SCC Spacecraft Composite (TGO +EDM)



/// Impact Probability constraints

1. The probability of impact on Mars by the **Proton Upper Stage Breeze-M** shall be $\leq 1 \times 10^{-4}$ for the **first 50 years** after launch

2. One of the following conditions shall be met:

- The probability of impact on Mars by the SCC shall be $\leq 1 \times 10^{-2}$ for the **first 20 years** after launch, and $\leq 5 \times 10^{-2}$ for the time period from **20 to 50 years** after launch.

OR

- The **total bioburden of the SCC**, including surface, mated, and encapsulated bioburden, shall be $< 5 \times 10^5$ bacterial spores.

- Calculated as the sum of probabilities of crash due to different failure causes: failures generated by MM impact, operator error, overheating, MSA and TGO failures
- Obtained: **0.869%**.

EXOMARS – 2016 MISSION

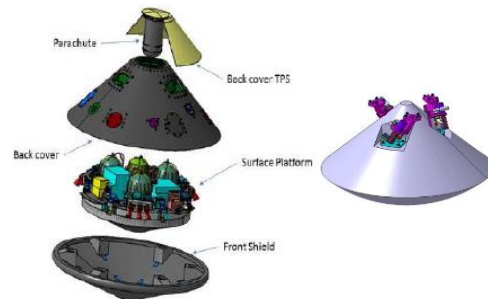
///Bioburden constraints for EDM at launch (cat. IVa)

! Total bioburden $\leq 5 \times 10^5$ bacterial spores

Total: surface, mated, and encapsulated

! Exposed internal and external **surface** bioburden $\leq 3 \times 10^5$ bacterial spores

! Average surface bioburden **density** ≤ 300 bacterial spores/m²



///Bioburden Budgets

! Surface b. budget

▪ Surface bioburden **constraints**

▪ allocated for **all** EDM elements

▪ **measured** by bioburden assay procedures

! Encapsulated b. budget

▪ **No constraints**; to be included in the total bioburden

▪ allocated only for **hard landing** EDM elements

▪ **estimated/ measured** by dedicated tests



EXOMARS – 2016 MISSION

///Bioburden Assay Plan

- / for each item before sterilization
- / before closing not-accessible surfaces
- / during AIT/AIV, Env.Test activities
- / at launch site
- / continuously updated



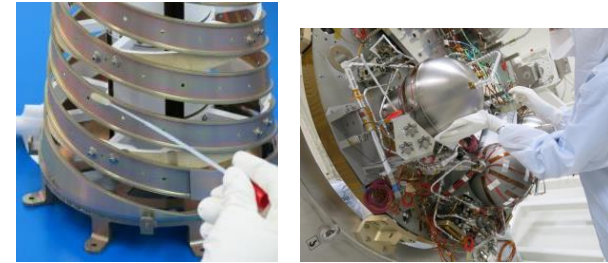
///Microbiological Laboratory (MBL)

- / Certified ExoMars MBL with certified personnel
- / Choice of **centralized** activity at TAS-I Turin (exception ESTEC (NL) MBL for EDM payloads)



///Bioburden assays as per ECSS-Q-ST-70-55C tailored for ExoMars

Surface sampling of HW and CR



Air sampling of CR



EXOMARS – 2016 MISSION

///Sterilization processes

Bioburden reduction process

Followed by European Industries and Agency

DHMR

ECSS-Q-ST-70-57C

HYDROGEN PEROXIDE

NA

UV RADIATION

NA

GAMMA RADIATION

NA

- To reduce surface, mated and encapsulated spores
- Required item compatibility with DHMR
- Items NOT compatible with DHMR process: cleaned with IPA 70% and assayed
- Required compatibility with 70% IPA and water for all the flight HW
- Preparation of Bioburden Reduction PLAN for each flight HW



EXOMARS – 2016 MISSION

/// Controlled environments

- ISO 8 or better, **ISO 8 HC** in TAS-I
HC Highly Controlled: low level of bioburden on CR surfaces and airborne
- **ISO 7 HC in TAS-I, ISO 7 HC Portable Tent (PT)** in TAS-F/Baikonur Cosmodrome (KAZ) - **EDM integration and opened EDM activities**
- ISO 8 with precautions in TAS-F /Baikonur Cosmodrome (KAZ)
TGO integration, EDM/TGO mating, , fueling EDM and TGO, launch stack assembly, fairing (Baikonur)



/// ISO 7 HC, ISO 8 HC bioburden controlled environments

- HEPA Air filtration , Rigorous cleaning and maintenance procedures, Rigorous bioburden monitoring, Strict sterile garment policy

EXOMARS – 2016 MISSION

/// Consumable materials

- ! Test campaign to choose the consumable materials
- ! Choice of **centralized** consumable materials

/// Training Program

- ! Level 1: Members of the project team, sub-contractors and instrument providers
- ! Level 2: **Mandatory** for all personnel working in bioburden controlled environments
- ! Level 3: Supervisors



EXOMARS – 2016 MISSION

///Recontamination Prevention

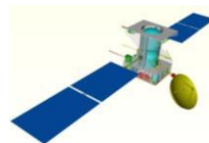
- Continuous cleaning and bioburden monitoring of flight HW and CRs up to launch
- Use of sterile alcohol wiping, covers/biobarriers/ packaging material, fluids
- Dedicated and cleaned transport containers



- **During Env. Tests:** Vibration test, Acoustic test, TVTB test,
EDM recontamination due to the TVTB test included in the final Bioburden Budget



- **TGO:** PP req. implemented by the Prime in order to **avoid the EDM recontamination during the launch**
 - TGO external surfaces ≤ 1000 sp/m² verified pre-launch
 - External TGO MLIs DHMR processed



EXOMARS – 2016 MISSION

///At Baikonur Cosmodrome (KAZ)

- ! Bioburden assay plan including assays onto **SCC, Rocket, TCU train and Launch Pad**; Analysis b.recontamination at launch
- ! Controlled ISO 8 env. ; ISO 7 HC PT; Microbiological Laboratory

///PP personnel involved at TAS-I during the different phases of Project 2016

- Phase A: 1 (PP-Eng)
- B: 2 (PP-Eng) + 1 (MBL)
- CD: 2.5 (PP-Eng) + 3 (MBL)
- E1 (LC): 1.5 (PP-Eng) + 2 (MBL)

///Bioburden constraints for the EDM at launch, obtained results:

	PP requirement (Max. at Launch)	Values achieved	Margin achieved (%)
Average surface density [spores/m2]	300	73	75.66
DM Total surface spores	300000	151360	49.54
SCC Total spores	500000	291601	41.67

/// Total Bioburden assays performed for ExoMars 2016 mission: 3236

78 % of b.assays on the SCC & rocket with zero CFU result

EXOMARS 2022 – RSP MISSION - **CATEGORY IVb** - PP IMPLEMENTATION



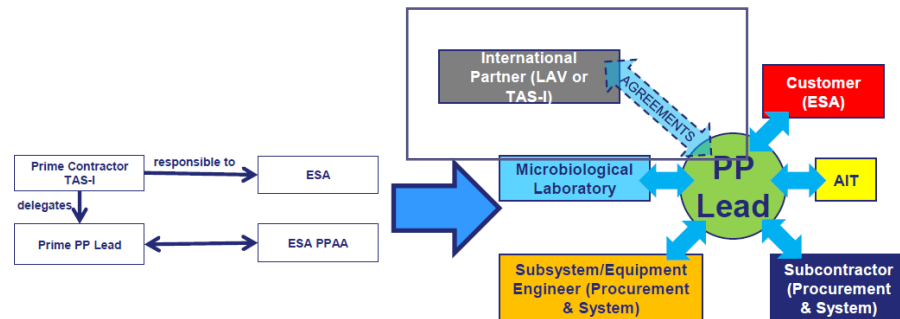
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EXOMARS – 2022 MISSION

///PP Management and Organization

- **Lavochkin (LAV)**, Prime of the Russian industries
 - developer of the Russian DM
 - Responsible for SCC AIT and associated PP implementation
- **Thales Alenia Space – Italia (TAS-I)**, Prime of the European industries
 - developer of European mission elements and associated PP implementation
 - Responsible for the SCC requirements and design



///PP Requirements

- General
- Impact probability
- Bioburden
- Mars samples contamination requirements

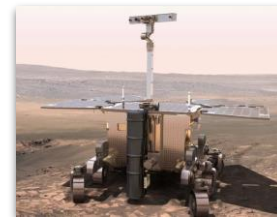


EXOMARS – 2022 MISSION

///PP Requirements – UCZ Bioburden

- RM subsystems involved in the acquisition, delivery, and analysis of Martian samples for life detection shall be ≤ 0.03 bacterial spores/m²

Identification of RM **Ultra Clean Zone (UCZ)** or
RM volume and surfaces in contact with Martian samples



///PP Requirements - Mars samples contamination

- The **maximum terrestrial organic** contamination level per substance class and **per gram of Martian samples** for life detection shall be **in the order of nanograms**

EXOMARS – 2022 MISSION

///Several certified Microbiological Lab.s

TASinI Turin (IT)
ADS Stevenage (UK)
OHB Bremen (GE)
IBMP (Ru)
ESTEC (NL)
Bioclin (F)
NASA (USA)



///Several sterilization processes



Bioburden reduction process	Followed by European Industries and Agency	Followed by LAV
DHMR	ECSS-Q-ST-70-57C	ECSS-Q-ST-70-57C
HYDROGEN PEROXIDE	ECSS-Q-ST-70-56C	NA
UV RADIATION	NA	LAV procedures
GAMMA RADIATION	NA	LAV procedures

- Required item compatibility with the selected sterilization process; use of ECSS-Q-ST-70-53C

EXOMARS – 2022 MISSION

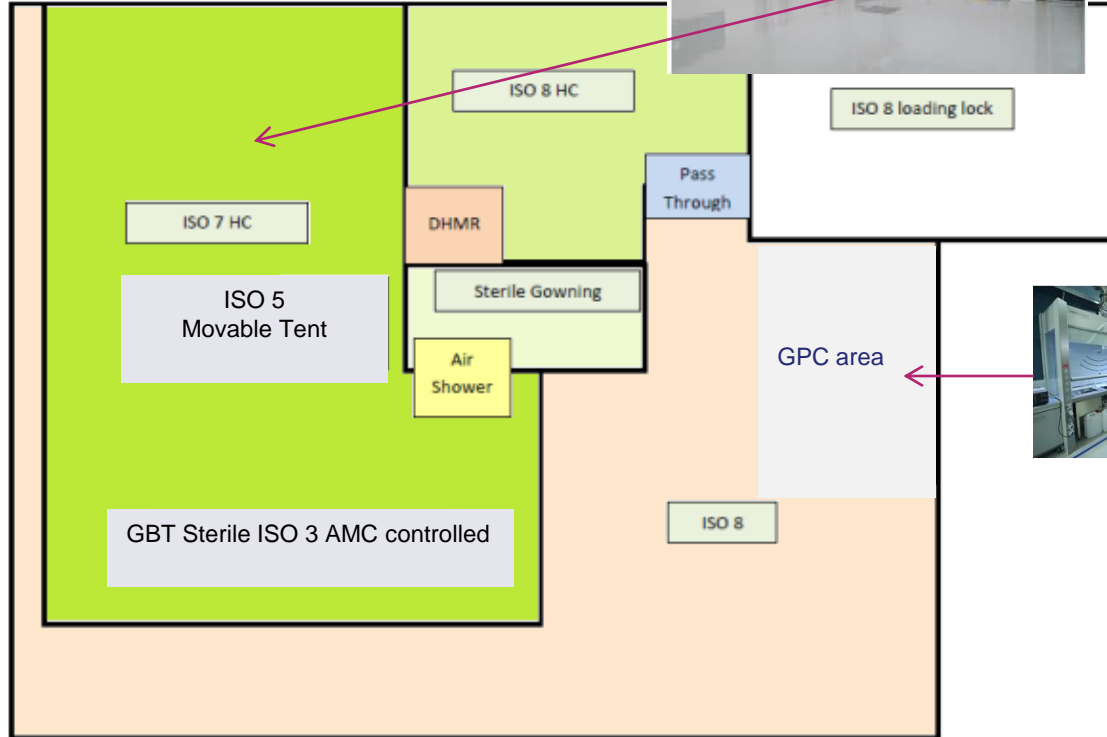
///New Controlled Environments in TAS-I Turin



ISO 5 Movable Tent



Glove Box Train (GBT)



///Bioburden & Mars Sample Contamination Requirement

■ UCZ parts

- Disassembled, cleaned and packed
- 4-log sterilization to achieve 0.03 bacterial spores/m²
- Transportation into an sterile environment ISO 5 w/o breaking sterilization chain



GBT: UCZ integration facility



EXOMARS – 2022 MISSION

///Recontamination Prevention

/ SCC, DM Environmental tests in TAS-F (Fr); RM in ADS Toulouse (Fr)

DM/RM recontamination due to the TVTB test included in the final Bioburden Budget

/ CM

- PP req. implemented by the Prime in order to **avoid the EDM recontamination during the launch**
 - CM ext.surfaces ≤ 1000 sp/m²; ext. CM MLIs DHMR processed



EXOMARS – 2022 MISSION

///PP personnel involved at TAS-I during the different project phases

- Phase A: 1 (PP-Eng)
- B: 2 (PP-Eng) + 1 (MBL)
- CD: 3.5 (PP-Eng) + 1.5 (MBL)
- E1 (LC): 1(PP-Eng) (estimated)

///Bioburden constraints obtained results @ 02.2022:

[units = #spores]	Max @Delivery	Max@Launch	Current Value @ 02.2022	Current Margin [%]
SCC	4x10 ⁵ Total (Surface +Encapsulated hard landing)	5x10⁵ Total (Surface +Encapsulated hard landing)	159508	68.1
Descent Module (DM) including RM	2x10 ⁵ Surface	3x10⁵ Surface	51931	82.6
Rover Module (RM)	2x10 ⁴ Surface	2x10⁴ Surface	3157	80.2
SCC average surface bioburden density		300	10.2	96.6

/// **12.205 assays performed for EXM 2022 by TASinI and LAV** (excluded assays performed by ADS and OHB)

EXOMARS – 2022 MISSION

///PP Documentation and reviews

Title	Preliminary	Final	PPAA Approval/R eview	EXM 2016	EXM 2022	
PP Requirements	PRR	SRR	A	Y	Y	Set of PP reqs
PP Plan	SRR	PDR	A	Y	Y	Primary planning describing how the project meets the PP reqs
PP Implementation Plan	PDR	CDR	R	Y	Y	Provide information about the detailed implementation of the PP reqs in line with the PPP
Pre-Launch PP Report	FAR	FRR	R	Y	Y	To demonstrate the project meets the PP reqs, in particular bioburden allocations
Post-Launch PP Report		No later than 6 months after launch	R	Y	TBW	To account for effects of events from submission of the Pre-launch PP report
Extended Mission PP Report		Before the commitment for the extended mission	R	NA		To provide evidence of continuing compliance with PP reqs considering the activities of the extended mission phase
End-of-Mission PP Report		No later than 6 months after end-of-mission	R	TBW	TBW	To describe the degree to which the project meets the PP reqs throughout the complete mission
Organic Materials Inventory	CDR	FRR	R	Y	Y	To document the org. material on the spacecraft

- PRR: preliminary requirement review; SRR: system requirement review; PDR: preliminary design review; CDR: critical design review; FAR: final acceptance review; FRR: flight readiness review

EXOMARS 2028 ROSALIND FRANKLIN MISSION (RFM) CURRENT STATUS

///On going

- **Re-built of ex-russian EDLM flight items**
- **NASA cooperation** for **provision** of RM RHU, Launch Service and key elements of lander propulsion sys.

///Maintenance since 2022

- **Bioburden assays planned to check and maintain** the bioburden level of the existing **European EXM RSP flight HW** that can be **re-used** in the EXM RFM mission
 - On flight HW, support equipment, during aseptic operations
 - Monitoring of the bioburden controlled CRs of TAS-I Turin site
 - Planned Functional/verification tests

The extensive experience of TAS-I in Planetary Protection acquired in both EXM 2016 and 2022 missions will be essential to achieve the compliance of the PP requirements in the EXM RFM mission

Thanks for your attention!

Questions?



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