EXOMARS
PLANETARY PROTECTION IMPLEMENTATION

BY D.B.MARGHERITIS

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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

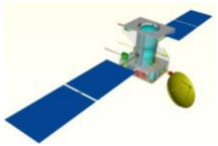
EXOMARS MISSION OVERVIEW

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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

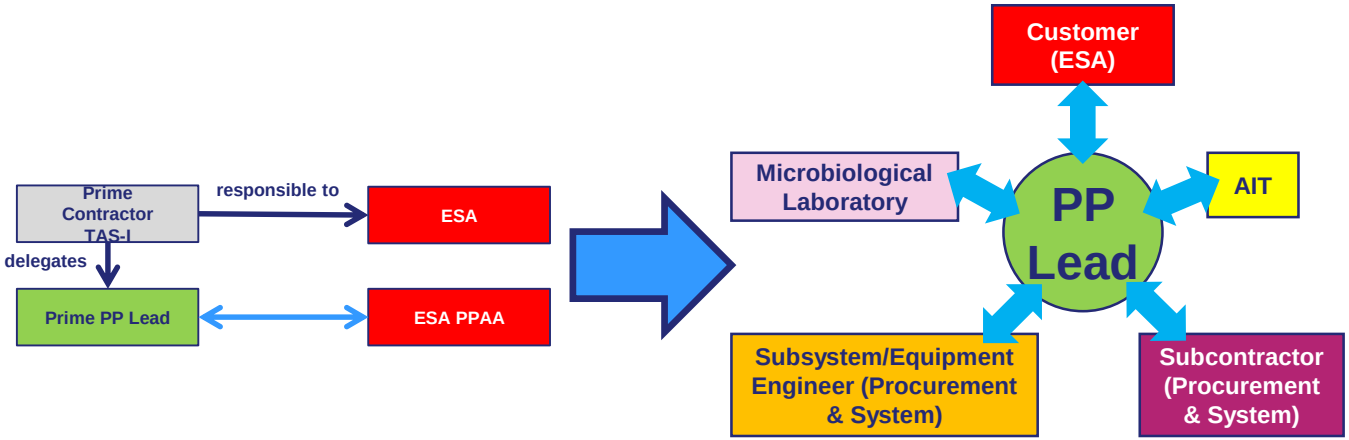
Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS 2016 MISSION – CATEGORY IVa – PP IMPLEMENTATION

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2016 MISSION

///PP Management and Organization



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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2016 MISSION

SCC Spacecraft Composite (TGO +EDM)

///Impact Probability constraints

1. **The probability of impact on Mars** by the **Proton Upper Stage Breeze-M** shall be ≤ $1x10^{-4}$ 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 ≤ $1x10^{-2}$ for the first 20 years after launch, and
     ≤ $5x10^{-2}$ 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 < $5x10^{5}$ 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%.

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

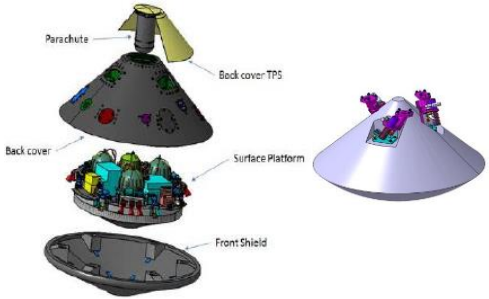
EXOMARS – 2016 MISSION

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

- **Total** bioburden ≤ $5x10^5$ bacterial spores

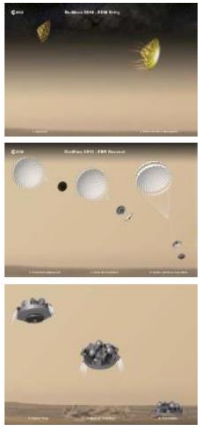
  Total: surface, mated, and encapsulated

- Exposed internal and external **surface** bioburden ≤ $3x10^5$ bacterial spores
- Average surface bioburden **density** ≤ 300 bacterial spores/m^2



///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



Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2016 MISSION

///Bioburden Assay Plan

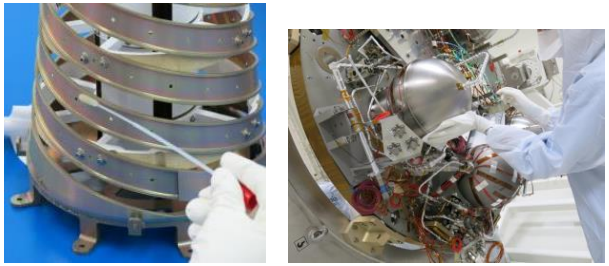
- **for each item before sterilization**
- **before closing not-accessible surfaces**
- **during AIT/AIV, Env.Test activities**
- **at launch site**
- continuously updated

///Microbiological Laboratory (MBL)

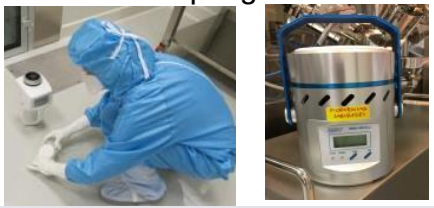
- **Certified** ExoMars MBL with certified personnel
- Choice of **centralized** activity at TAS-I Turin (exception ESTEC (NL) MBL for EDM payloads)

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

Surface sampling of HW and CR



Air sampling of CR



Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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**

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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



Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2016 MISSION

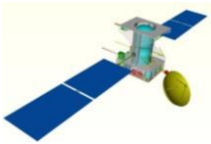
///Recontamination Prevention

- 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



Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

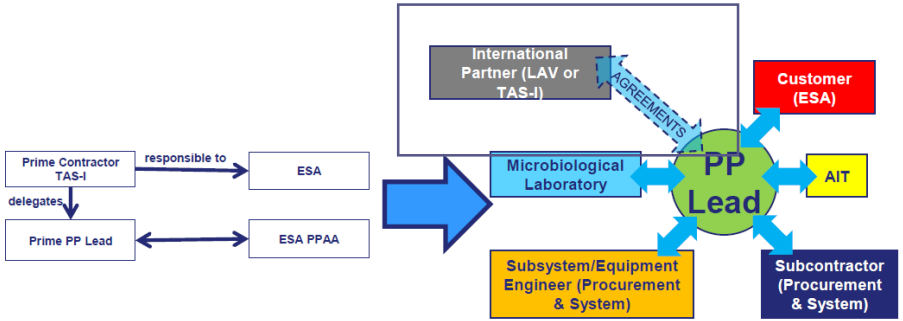
EXOMARS 2022 – RSP MISSION - CATEGORY IVb - PP IMPLEMENTATION

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2022 MISSION

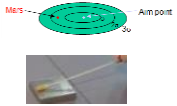
///PP Management and Organization

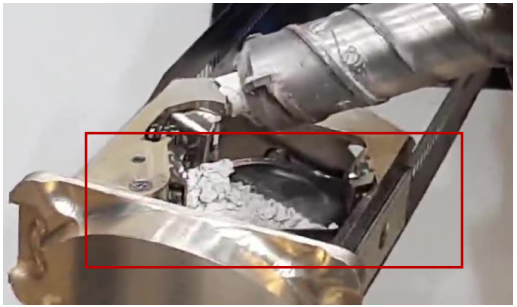
- **Lavochkin** (LAV), Prime of the Russian industries
  - developer of the Russian DM
  - Responsible for SCC AIT and associated PP implementation
- **Thales Alenia Space** – Italia (TAS-I), Prime of the European industries
  - developer of European mission elements and associated PP implementation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



///PP Requirements

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





Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

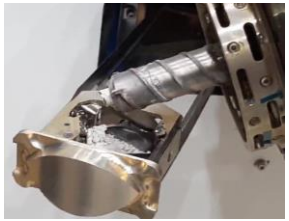
EXOMARS – 2022 MISSION

///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**

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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

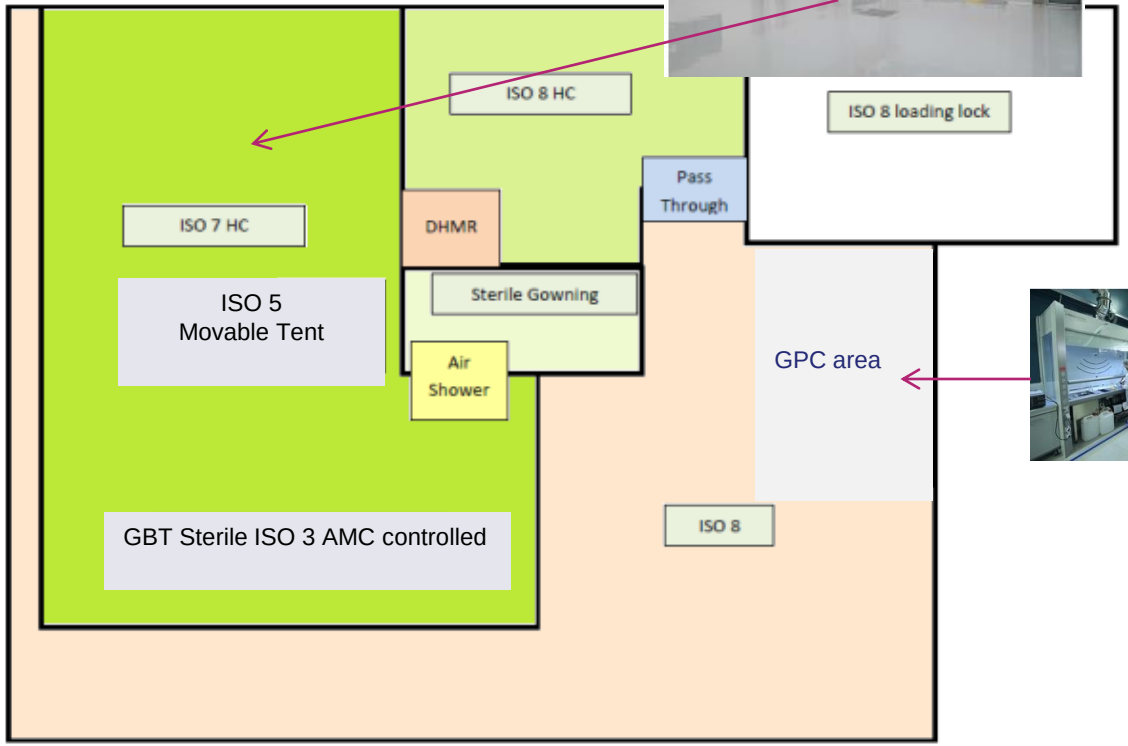
Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2022 MISSION

///New Controlled Environments in TAS-I Turin

ISO 5 Movable Tent

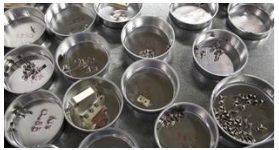
Glove Box Train (GBT)



Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

EXOMARS – 2022 MISSION

///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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

///Recontamination Prevention

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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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)	**$5x10^5$ Total** (Surface +Encapsulated hard landing)	159508	68.1
Descent Module (DM) **including RM**	$2x10^5$ Surface	**$3x10^5$ Surface**	51931	82.6
Rover Module (RM)	$2x10^4$ Surface	**$2x10^4$ 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)

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

///PP Documentation and reviews

Title	Preliminary	Final	PPAA Approval/Review	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

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

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 esential to achieve the compliance of the PP requirements in the EXM RFM mission

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007

Thanks for your attention!

Questions?

diana.margheritis@thalesaleniaspace.com

Date: 04/12/2023
Ref: Not referenced
Template: 87201590-QCI-TAS-EN-007