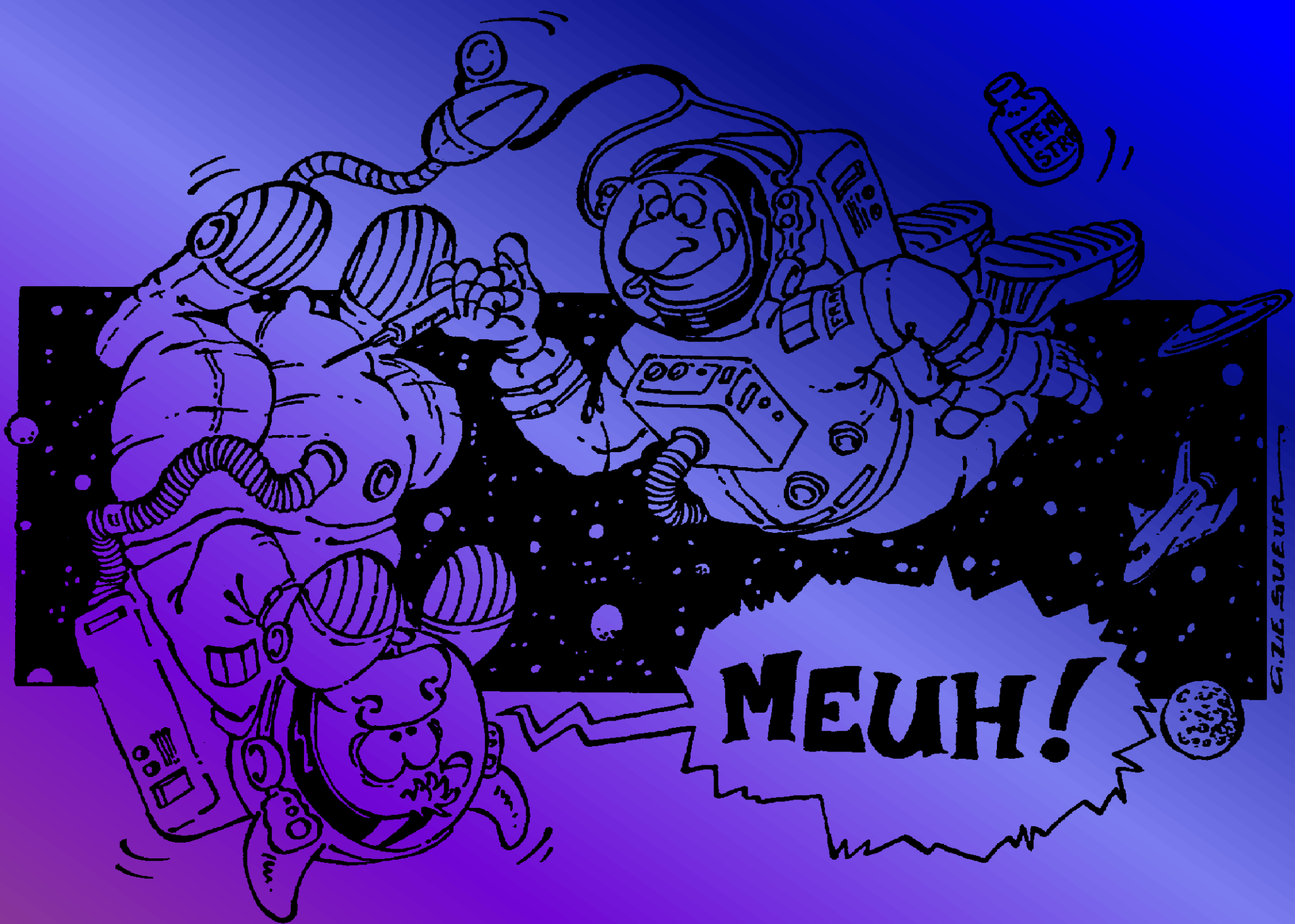




MEUH!

G. DE SUEUR

# Facility or facilities ? That is the question!

**Michel VISO**

CNES, Paris, France, [michel.viso@cnes.fr](mailto:michel.viso@cnes.fr)

**With contributions from**

**Francois RAULIN**

Université Paris XII & Paris VII, Créteil Cedex, France, [rauln@lisa.univ-paris12.fr](mailto:rauln@lisa.univ-paris12.fr)

**Andre DEBUS**

CNES, Toulouse , France, [andre.debus@cnes.fr](mailto:andre.debus@cnes.fr)



CENTRE NATIONAL D'ÉTUDES SPATIALES

# Mars Sample Return : former statements!

## ■ 1997: MARS SAMPLE RETURN ISSUES AND RECOMMENDATIONS

“Samples returned from Mars by spacecraft should be contained and treated as though potentially hazardous until proven otherwise. No uncontained martian materials, including spacecraft surfaces that have been exposed to the martian environment, should be returned to Earth unless sterilized.”

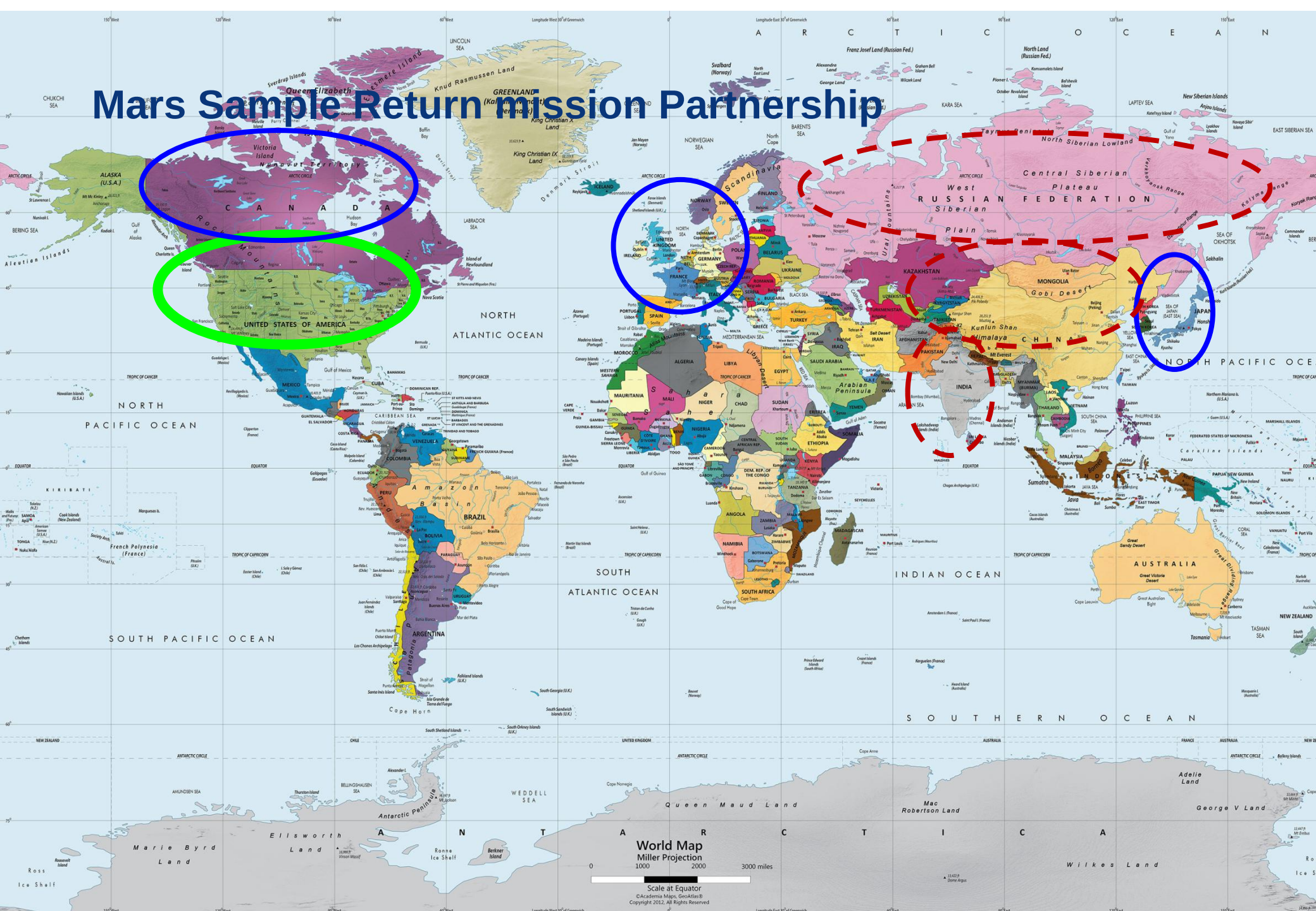
## ■ 2002: The Quarantine and Certification of Martian Samples

“A major obstacle to design for the Mars quarantine facility is the problem of combining biological containment with clean room conditions. It is essential that work on the solution of this problem be started immediately...”

## ■ 2002: A DRAFT TEST PROTOCOL FOR DETECTING POSSIBLE BIOHAZARDS IN MARTIAN SAMPLES RETURNED TO EARTH

“Clarity of meaning is essential to the implementation of any process especially when the process involves international agreements. Therefore, absolute consistency should be used in the language for any documents and charters associated with the eventual final protocol”.

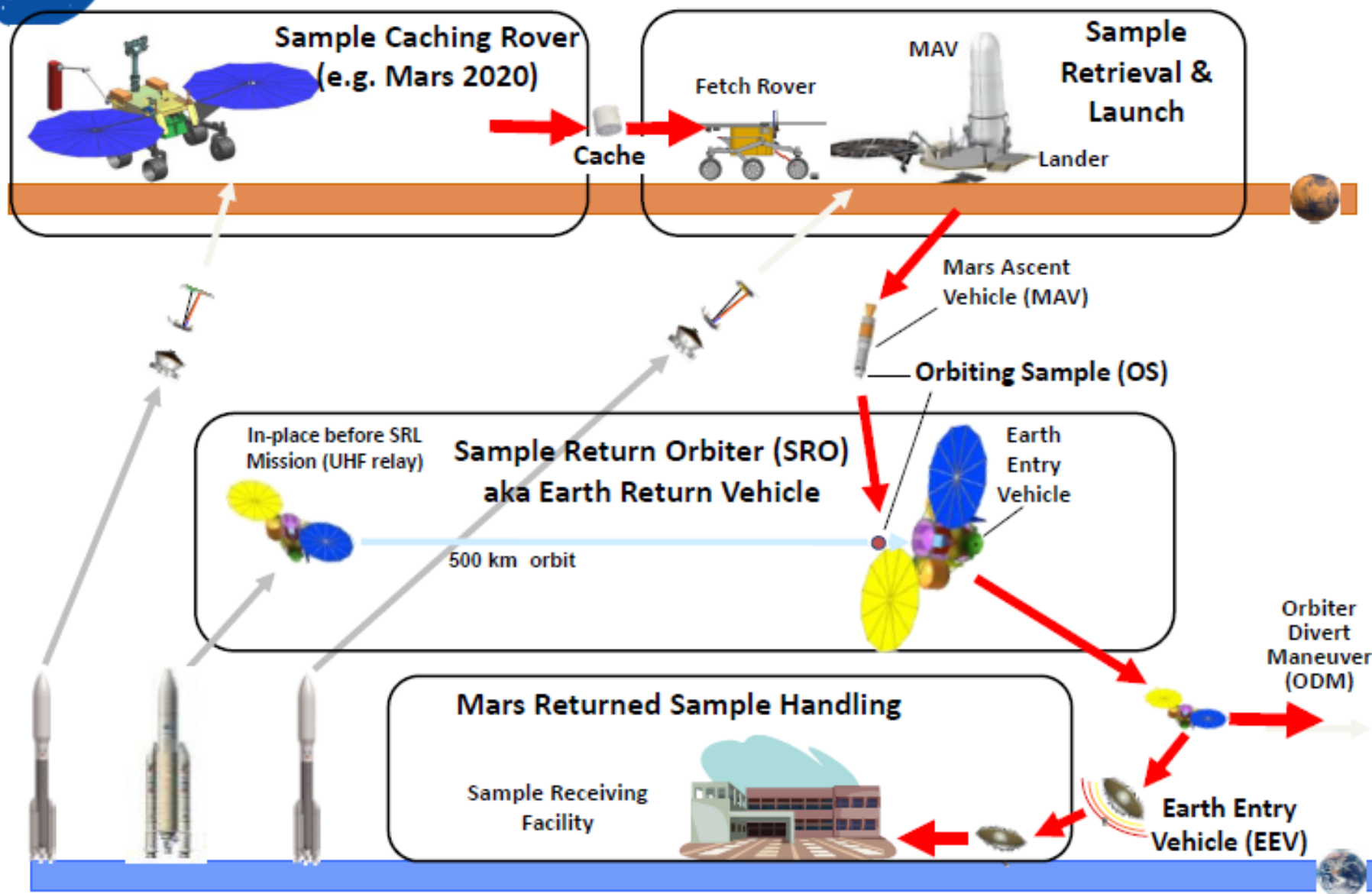
# Mars Sample Return Mission Partnership







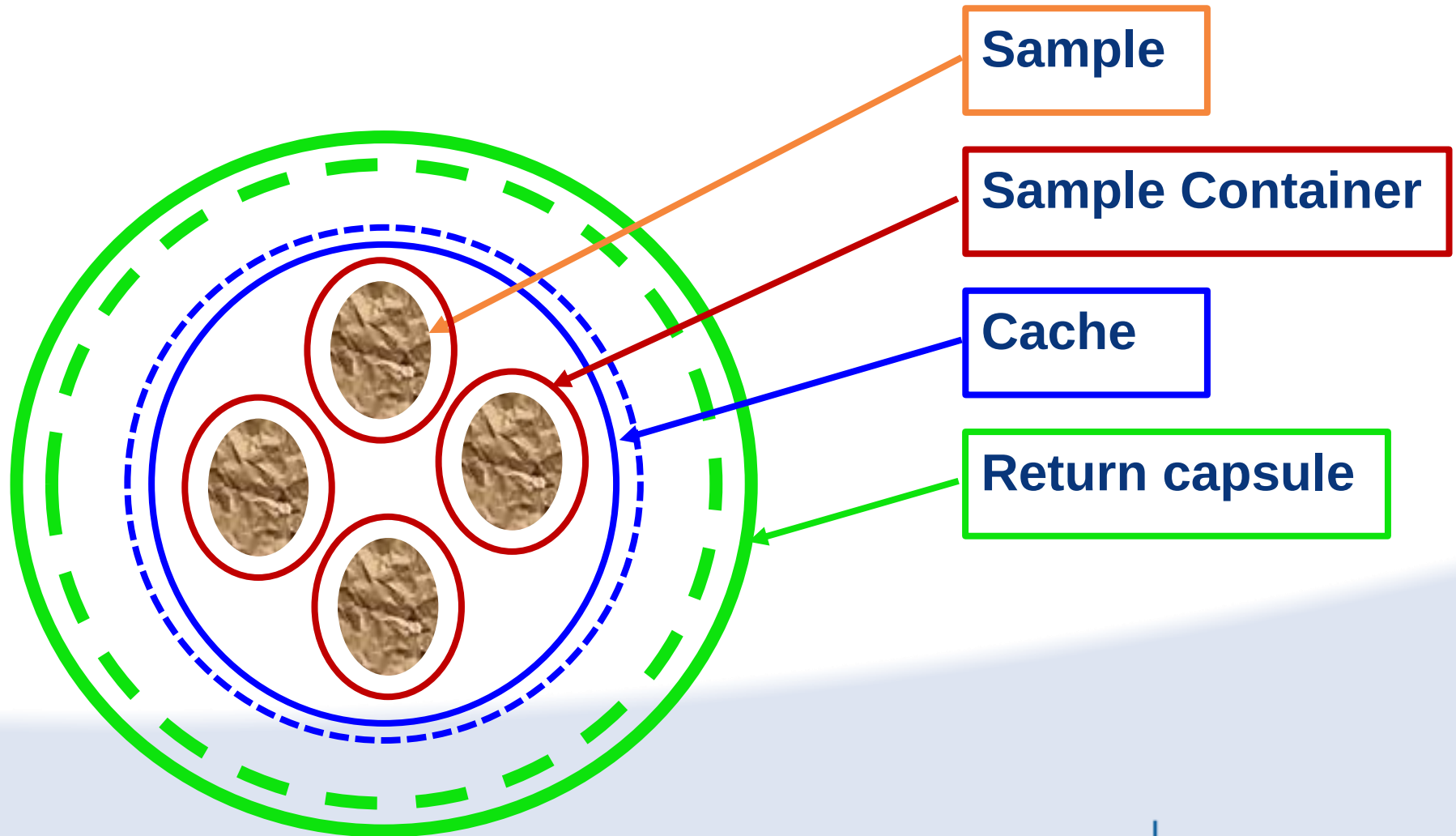
# Four-element Robotic MSR Campaign Concept (for reference)



# Mars Sample Return : proposed statements

- MSR will be an international cooperative mission, Mars samples will be an asset for mankind and will be treated accordingly
- The samples even shared and distributed will remain part of a unique “batch” which will be under the supervision of an international “body” for management and distribution.
- The samples will be considered as non-commercial items

# Матрёшка

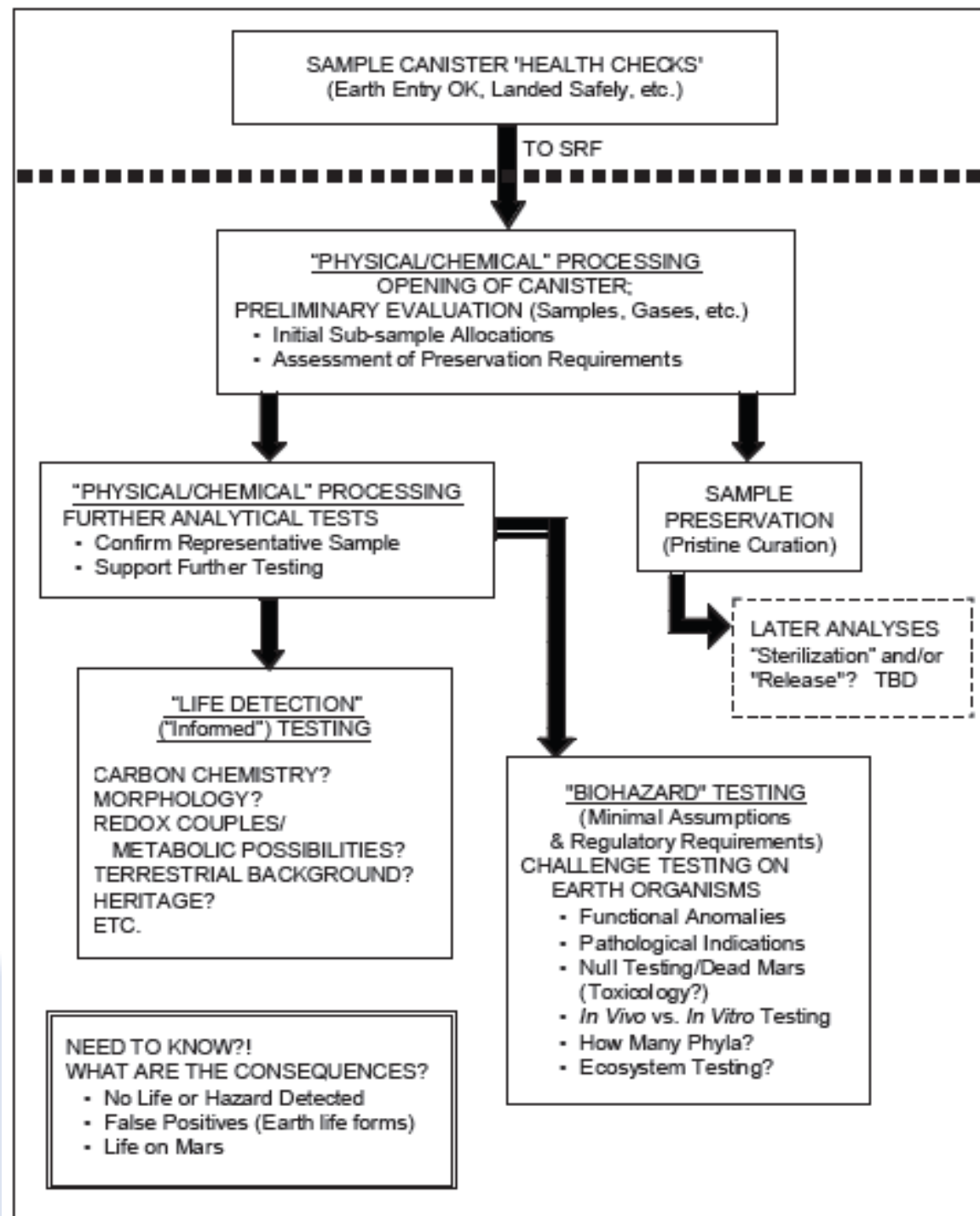


# Mars Sample Return : what could be collected?



|                                                                     |                       | Number                          | Mass              |                   |
|---------------------------------------------------------------------|-----------------------|---------------------------------|-------------------|-------------------|
| Sample Type                                                         | Mechanical Properties | Proposed science floor, 1st MSR | Mass/ sample (gm) | Total Sample Mass |
| <b><i>Case B. Cache from a previous mission is NOT returned</i></b> |                       |                                 |                   |                   |
| Sedimentary suite                                                   | rock                  | 20                              | 10                | 200               |
| Hydrothermal suite                                                  | rock                  |                                 |                   |                   |
| Low-T W/R suite                                                     | rock                  |                                 |                   |                   |
| Igneous Suite                                                       | rock                  |                                 |                   |                   |
| Other                                                               | rock                  |                                 |                   |                   |
| Lander-based sample                                                 | rock or reg.          | 4                               | 20                | 80                |
| Regolith                                                            | granular              | 4                               | 15                | 60                |
| Dust                                                                | granular              | 1                               | 5                 | 5                 |
| Ice                                                                 | ice or liquid         | 0                               |                   |                   |
| Atmospheric Gas                                                     | gas                   | 1                               | 0.001             |                   |
| Cache from previous mission                                         | rocks                 |                                 |                   | 0                 |
| <b>TOTAL</b>                                                        |                       | <b>30</b>                       |                   | <b>345</b>        |





# Ambient conditions around the item of interest

## ■ External ambient conditions

■ Protection of the samples and protection of the environment « nothing coming in, nothing coming out » samples can be considered as « pristine »

■ No chemical protection for the samples but nothing coming out

■ No biological protection of the samples but nothing coming out

| PPL-type                       | Biocontainment  | Cleanliness | ‘Ambient’ Conditions                                                      | Used For:                                                                                          |
|--------------------------------|-----------------|-------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| <b>PPL <math>\alpha</math></b> | Maximum (BSL-4) | Maximum     | Mars-like (pristine);<br><i>Although at 1 atm w/inert gas environment</i> | Incoming container and materials; some preliminary tests; sample bank/storage; some Life Detection |
| <b>PPL <math>\beta</math></b>  | Maximum (BSL-4) | Maximum     | Earth-like                                                                | Life Detection; some Physical/Chemical; TBD                                                        |
| <b>PPL <math>\gamma</math></b> | Maximum (BSL-4) | Moderate    | Earth-like                                                                | Some Biohazard testing, some Physical/Chemical processing, and animal testing                      |
| <b>PPL <math>\delta</math></b> | Strict BSL-3-Ag | Ambient     | Earth-like                                                                | Some Biohazard testing; ‘post-release’ tests TBD                                                   |

# Mars Sample Return : functional analysis

■ **Landing site step: A sample capsule lands somewhere on a continent**

♦ **Function: to search, to check and to secure then to transport**

**Open conditions**

**Capsule and cache step: the Earth return capsule untouched arrives in a dedicated facility**

♦ **Function: to check, to place in right ambient conditions, to open the capsule; to open the cache and then to identify, to sort and to characterize sample containers.**

**PPL  $\alpha$**

# Mars Sample Return : functional analysis

## Sample Container distribution step

**Option 1 : all containers are then treated at the same place**

**Option 2 : Containers are distributed among the various PARTNERS of the mission**

**Each sample container (special case to be described for atmospheric samples) is then considered as a unique sample. Then transferred in each appropriate partner's curation facility**

**PPL  $\alpha$**



# Mars Sample Return : functional analysis

**Samples Step:** retrieved from the samples containers and in appropriate ambient conditions are then treated according with the appropriate plan

- ♦ **Function:** sample characterization, identification, classification and division. Sample allocation to further steps

**PPL  $\alpha$**

■ **Long term storage:** samples are preserved for future generation analysis.

- ♦ **Function:** to store in appropriate conditions to be considered in the future as “pristine” samples

**PPL  $\alpha$**

# Mars Sample Return : functional analysis

**Short term storage: samples are preserved for distribution and analysis after the end of the quarantine**

- ♦ **Function: to be characterized and stored in appropriate conditions to be immediately released after sterilization or released unsterilized after the end of the quarantine.**

**PPL  $\alpha$**

**Quarantine distribution: samples are selected to undergo under quarantine, physical/chemical processing, life detection and biohazard testing;**

- ♦ **Function: allocate samples after checking that they are representative**

**PPL  $\beta$**

# Mars Sample Return : functional analysis

## ■ Physical/chemical analysis: restricted to those “required in support of planetary protection.

- ◆ Function to characterize and describe the individual samples to be tested in further life detection and Biohazard testing

**PPL  $\beta$**

## ■ Life detection analysis : restricted to those “required in support of planetary protection.

- ◆ Function to detect specific evidence whether life of any kind exists in the sample, or rule out the presence of such evidence of life.

**PPL  $\gamma$**

# Mars Sample Return : functional analysis

## ■ Biohazard testing: testing Martian samples against various organisms from bacteria to animal and vegetal cells

- ◆ Function: to determine if samples from Mars pose any threat to terrestrial organisms or ecosystems, regardless of whether the samples are found to contain life-forms or non-replicative hazards.

**PPL  $\gamma$**

## ■ Biohazard testing: Post release tests of Martian samples against various organisms

- Function: to determine broad spectrum potential effects of Mars terrain on living terrestrial systems

**PPL  $\delta$**

| PPL-type            | Biocontainment  | Cleanliness | ‘Ambient’ Conditions                                                      | Used For:                                                                                          |
|---------------------|-----------------|-------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| <b>PPL</b> $\alpha$ | Maximum (BSL-4) | Maximum     | Mars-like (pristine);<br><i>Although at 1 atm w/inert gas environment</i> | Incoming container and materials; some preliminary tests; sample bank/storage; some Life Detection |
| <b>PPL</b> $\beta$  | Maximum (BSL-4) | Maximum     | Earth-like                                                                | Life Detection; some Physical/Chemical; TBD                                                        |
| <b>PPL</b> $\gamma$ | Maximum (BSL-4) | Moderate    | Earth-like                                                                | Some Biohazard testing, some Physical/Chemical processing, and animal testing                      |
| <b>PPL</b> $\delta$ | Strict BSL-3-Ag | Ambient     | Earth-like                                                                | Some Biohazard testing; ‘post-release’ tests TBD                                                   |

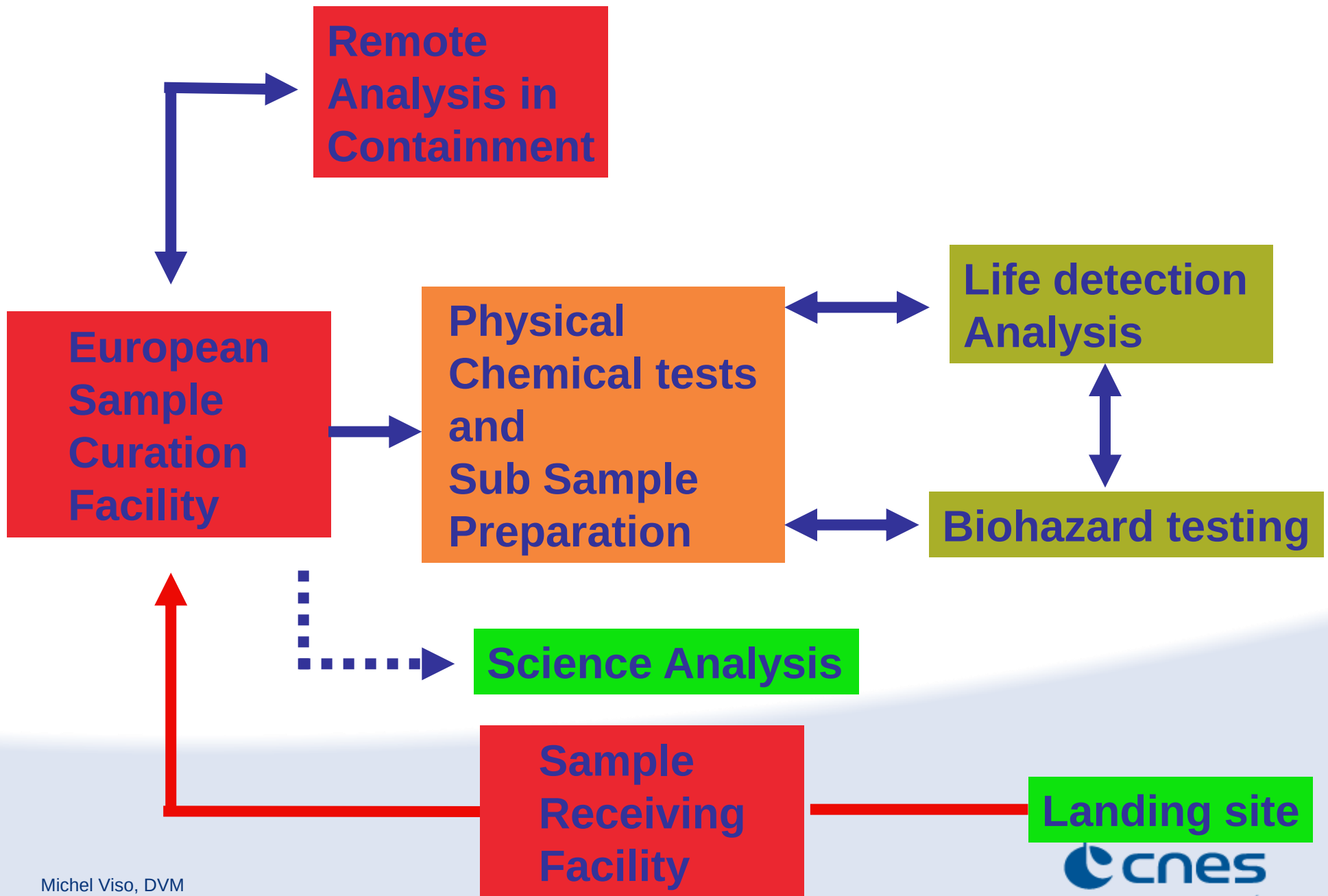
# Mars Sample Return : functional analysis

- **Landing site step: the Earth return capsule lands somewhere on a continent**
  - ♦ **Function: to search, to check and to secure then to transport**
- **Capsule step: the Earth return capsule untouched arrives in a dedicated facility**
  - ♦ **Function: to check, to place in right ambient conditions, to clean, to open the capsule; to identify, to sort and to characterize sample containers; to open with appropriate care each sample containers.**
- **Samples Step: retrieved from the samples containers and in appropriate ambient conditions samples are then treated according with the appropriate plan**
  - ♦ **Function: sample characterization, identification, classification and division. Sample allocation to further steps**



# Mars Sample Return : functional analysis

- Long term storage: samples are preserved for future generation analysis.
  - ♦ Function: to store in appropriate conditions to be considered in the future as “pristine”
- Short term storage: samples are preserved for distribution and analysis after the end of the quarantine
  - ♦ Function: to be characterized and stored in appropriate conditions to be immediately released after sterilization or released unsterilized after the end of the quarantine.
- Quarantine distribution: samples are selected to undergo under quarantine, physical/chemical processing, life detection and biohazard testing;
  - ♦ Function: allocate samples after confirming that they are representative



# Recommendation

- No backward track for the samples
- Be modular and with fully independent modules : all the treatment of fluids (air, water, effluents) must be fully separated and sized accordingly.
- Avoid the single point of failure catastrophe
- Modules could be adjacent or spread across various European countries (national pride, money, industry...)

**US - KISS  
KEEP  
IT  
SIMPLE  
STUPID**

**French - KISSS**

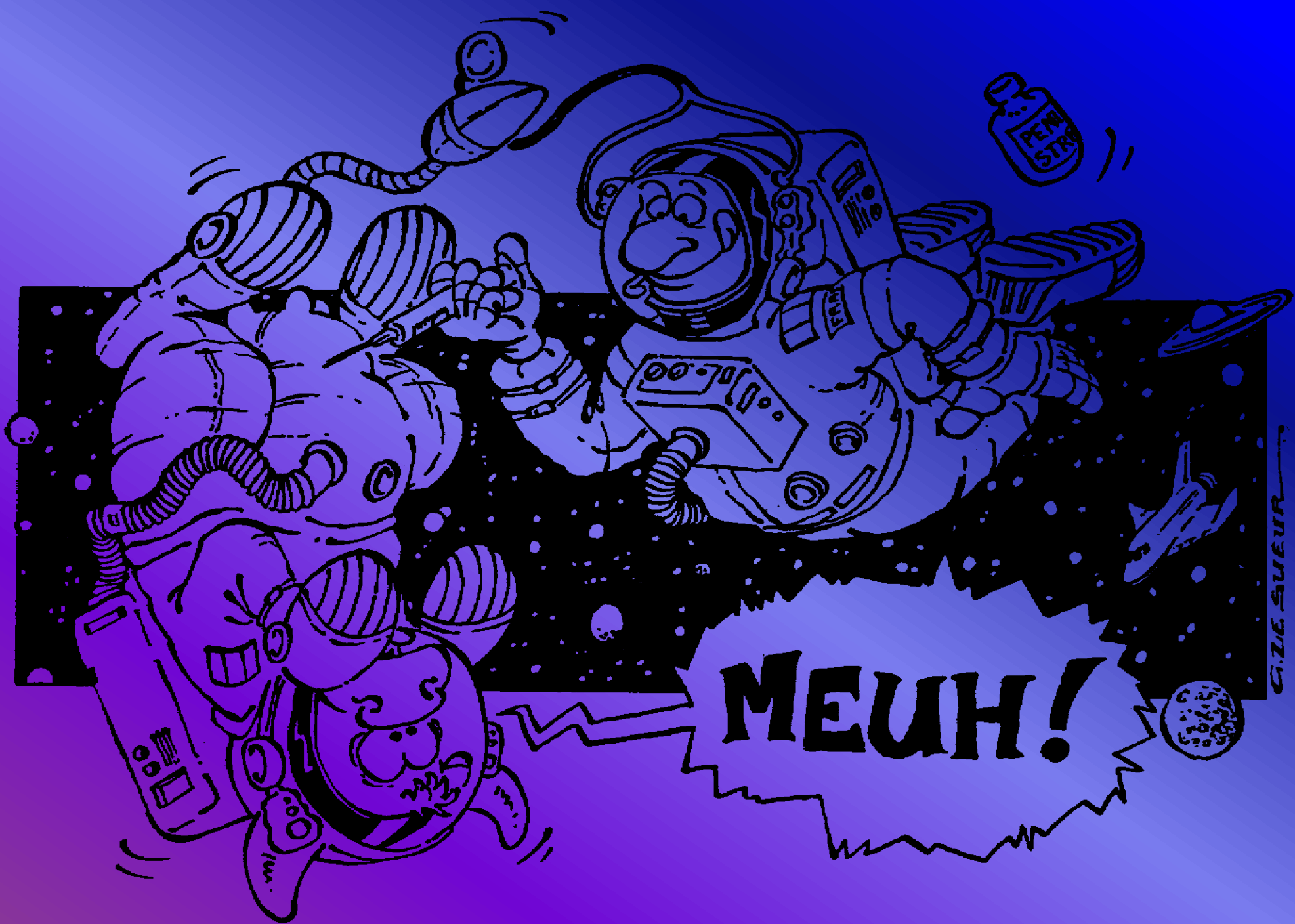
**KEEP**

**IT**

**SIMPLE**

**STUPID**

**SHARABLE**



# Mars Sample Return : Cooperation or distribution

■ At least three different approaches:

1

Exclusive

1

Remote  
Analysis in  
Containment

Remote  
Analysis in  
Containment

Remote  
Analysis in  
Containment

Sample  
Identification  
Curation  
Receiving  
Facility

Physical  
Chemical tests  
and  
Sub Sample  
Preparation

Life detection  
Analysis  
Biohazard testing

Science Laboratories

Landing site



# Mars Sample Return : Cooperation or distribution

■ At least three different approaches:

1

**Exclusive**

2

**Distributive**

2

**Remote  
Analysis in  
Containment**

**Remote  
Analysis in  
Containment**

**Remote  
Analysis in  
Containment**

**Sample  
Identification  
Curation  
Receiving  
Facility**

**Physical  
Chemical tests  
and  
Sub Sample  
Preparation**

**Life detection  
Analysis  
Biohazard testing**

**Life detection  
Analysis  
Biohazard testing**

**Science Laboratories**

**Landing site**

2

**Remote  
Analysis in  
Containment**

**Remote  
Analysis in  
Containment**

**Remote  
Analysis in  
Containment**

**Sample  
Identification  
Curation  
Receiving  
Facility**

**Physical  
Chemical tests  
and  
Sub Sample  
Preparation**

**Life detection  
Analysis  
Biohazard testing**

**Life detection  
Analysis  
Biohazard testing**

**Science Laboratories**

**Landing site**

3

Remote  
Analysis in  
Containment

Remote  
Analysis in  
Containment

Remote  
Analysis in  
Containment

Sample  
Identification  
Curation  
Receiving  
Facility

Physical  
Chemical tests  
and Sub Sample  
Preparation

Life detection  
Analysis  
and  
Biohazard testing

Physical  
Chemical tests  
and Sub Sample  
Preparation

Life detection  
Analysis  
and  
Biohazard testing

Landing site

Science Laboratories

# Mars Sample Return : Cooperation or distribution

■ At least three different approaches:

1

**Exclusive**

2

**Distributive**

3

**Cooperative**

3

Remote  
Analysis in  
Containment

Remote  
Analysis in  
Containment

Remote  
Analysis in  
Containment

Sample  
Identification  
Curation  
Receiving  
Facility

Physical  
Chemical tests  
and Sub Sample  
Preparation

Life detection  
Analysis  
and  
Biohazard testing

Physical  
Chemical tests  
and Sub Sample  
Preparation

Life detection  
Analysis  
and  
Biohazard testing

Landing site

Science Laboratories

# The draft protocol : a first step

- States that Martian samples have to be kept in containment during a quarantine
- Refers to 1997: MARS SAMPLE RETURN ISSUES AND RECOMMENDATIONS

“Samples returned from Mars by spacecraft should be contained and treated as though potentially hazardous until proven otherwise. No uncontained martian materials, including spacecraft surfaces that have been exposed to the martian environment, should be returned to Earth unless sterilized.”

**which has to be discussed and modulated**

# The draft protocol : a first step

- States that Martian samples have to be kept in containment during a quarantine
- Includes the quarantine process in the overall mission
- Refers to 1997: MARS SAMPLE RETURN ISSUES AND RECOMMENDATIONS which has to be discussed and modulated
- Defines a logical processing flow for samples to be tested in quarantine
- Does not define sufficiently the progressive approach leading to the sample future (**contained** or **released**)

We have to prepare the following ones



# iMars preliminary proposal

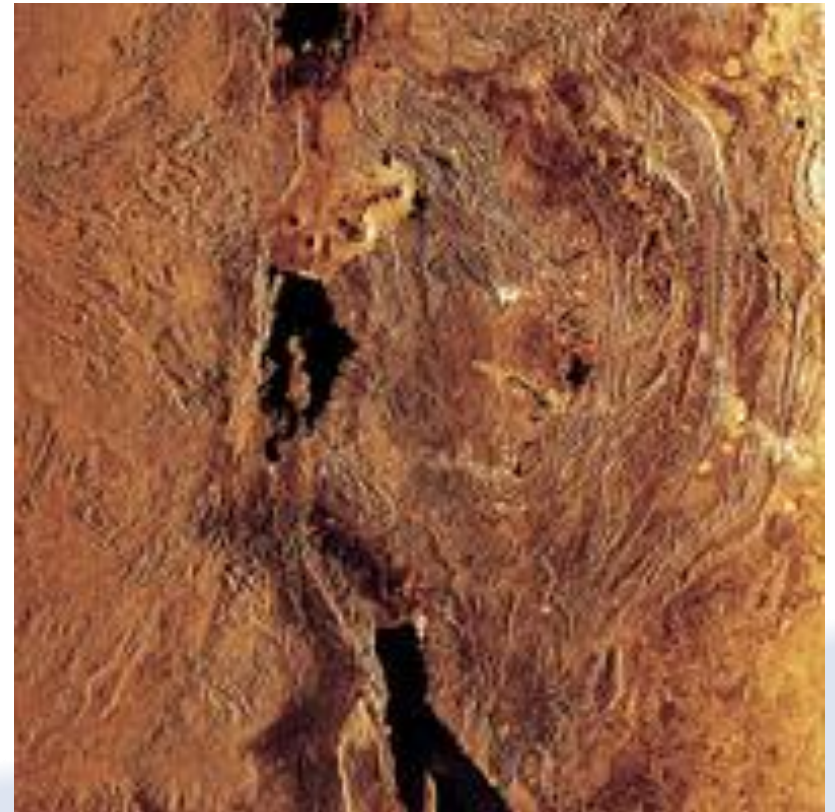
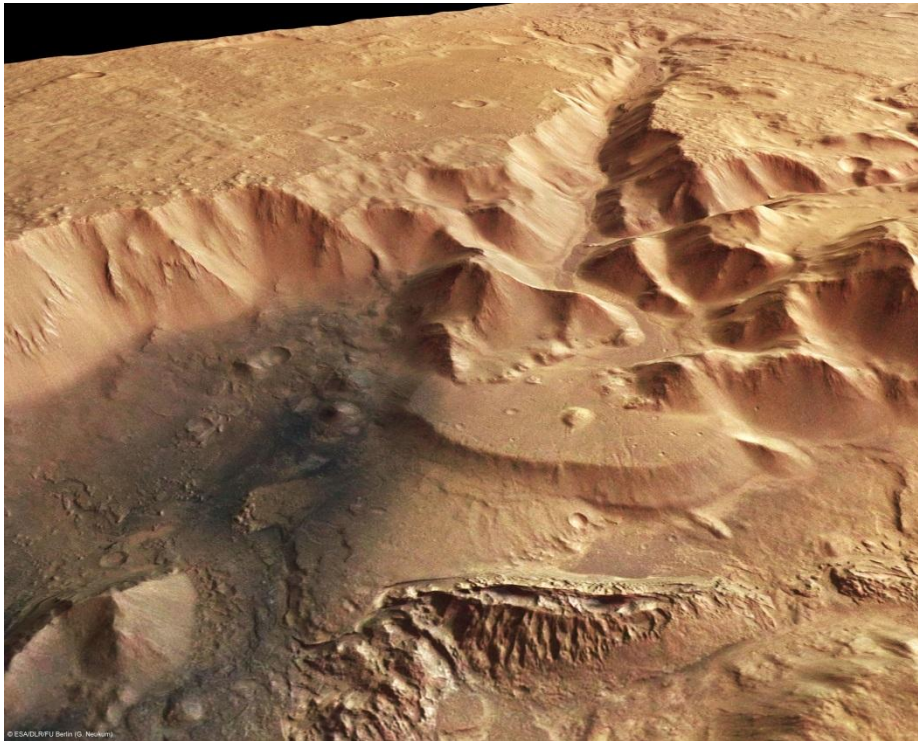


■ ...

- Protection of the martian samples from terrestrial contamination throughout all mission phases and breaking the chain of contact between Mars and Earth during sample return introduce considerable complexity in the mission design
- The sample receiving and containment facility is a long lead item for which planning and work must begin in the pre-project phase--*full development, approval, and commissioning covers one decade*
- Communication with the public will be of particular importance with respect to the sample containment facility and must start early as well
- Contamination control on sub-system and system level exceeds what is required for one-way missions, including *challenges in SRF & curation*

# Draft protocol proposed improvement

- To define more precisely the functions to be fulfilled before defining the actions
- To elaborate about the definition of “representative sample” for physical chemical processing, life detection and biohazard testing
- To develop in the frame of iMars, for instance, a more cooperative approach of the management of Martian samples on Earth
- Management of Martian samples on Earth is not specifically a space activity thus this requires an implication of a broad community of scientists and policy makers, far beyond the space agencies



**Thank you for your  
attention**

**Questions and  
comments are  
welcome!**