

WE LOOK AFTER THE EARTH BEAT

# Remote Manipulation (RM) System for Mars Sample Receiving Facility (MSRF) - outline of activities and early results of European Space Agency (ESA) Technology Development

activity financed by the Mars Robotic Exploration Technology Programme (MREP) of D/HRE, supported technically by D/TEC

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Ref.:

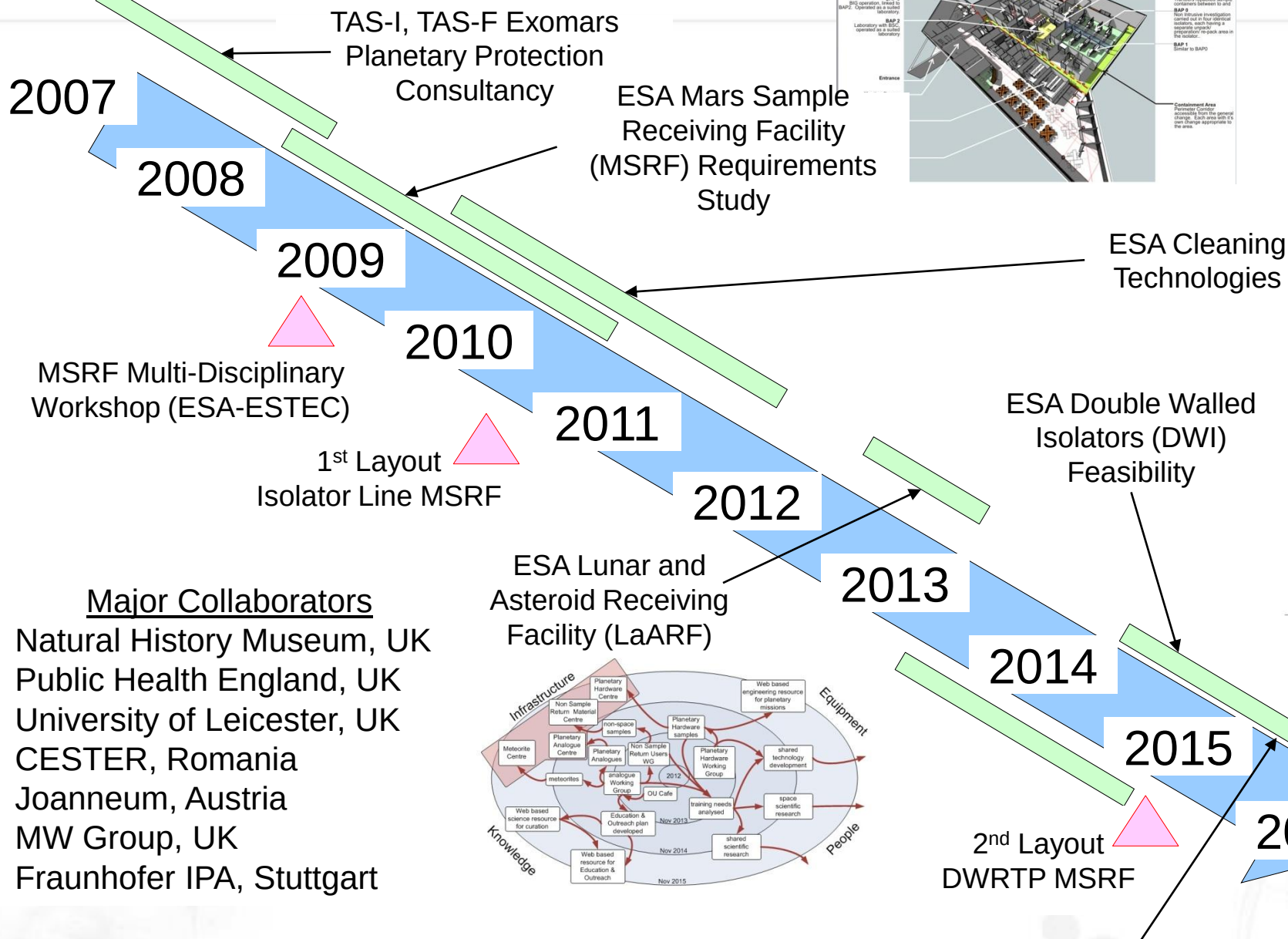
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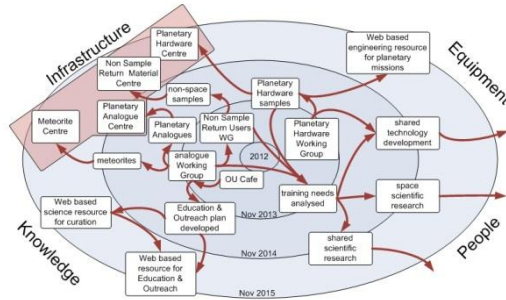


# TAS-UK MSRF Past Activities

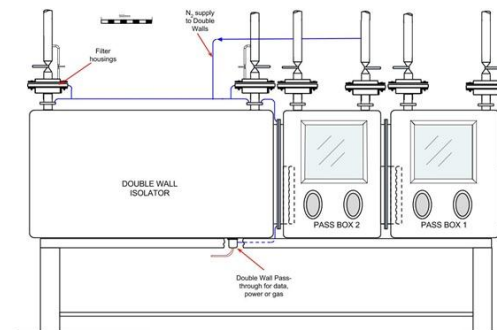


## Major Collaborators

Natural History Museum, UK  
Public Health England, UK  
University of Leicester, UK  
CESTER, Romania  
Joanneum, Austria  
MW Group, UK  
Fraunhofer IPA, Stuttgart



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## ESA Technology Demonstrators

DWI RM



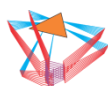
## 3rd Layout

'Consolidated Inventory'

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# ESA MSRF Requirements Study Trade Off Results 2010

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## ✈ Sample Handling Environment Trade Off:

- ✈ Temperature +18C with the potential to store / investigate pristine samples at 20C. Determined once the exact nature of the samples is known.
- ✈ Atmospheric composition Inert. N2 but potentially Argon
- ✈ Low Relative Humidity replaced with inert gas atmospheric contamination levels
- ✈ Pressure 1 Atm Low pressure was considered extensively but determined to offer no benefits.
- ✈ Terrestrial Contamination, Ultra low particulate and Organics, Specific levels of contamination control have not been defined as they depend on the detection levels of future instrumentation, but species of chemicals to be controlled have been identified.

## ✈ Containment/Contamination Trade Off by each MSRF area

- ✈ As layers of containing hardware removed, fewer man-in-suit operations (which gives operational flexibility) more Robotic Manipulation (better containment and lower contamination)

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# Operational Analysis (2010) to determine RM duty cycle & MSRF lifetime

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- Best, standard and worst case used (isolator line)
  - best case, 20 samples, BAP0 with initial characterisation, etc.
  - standard case, 32 samples, BAP0 with initial characterisation, etc.
  - worst case, 44 samples, separate BAP0 and initial characterisation, etc.

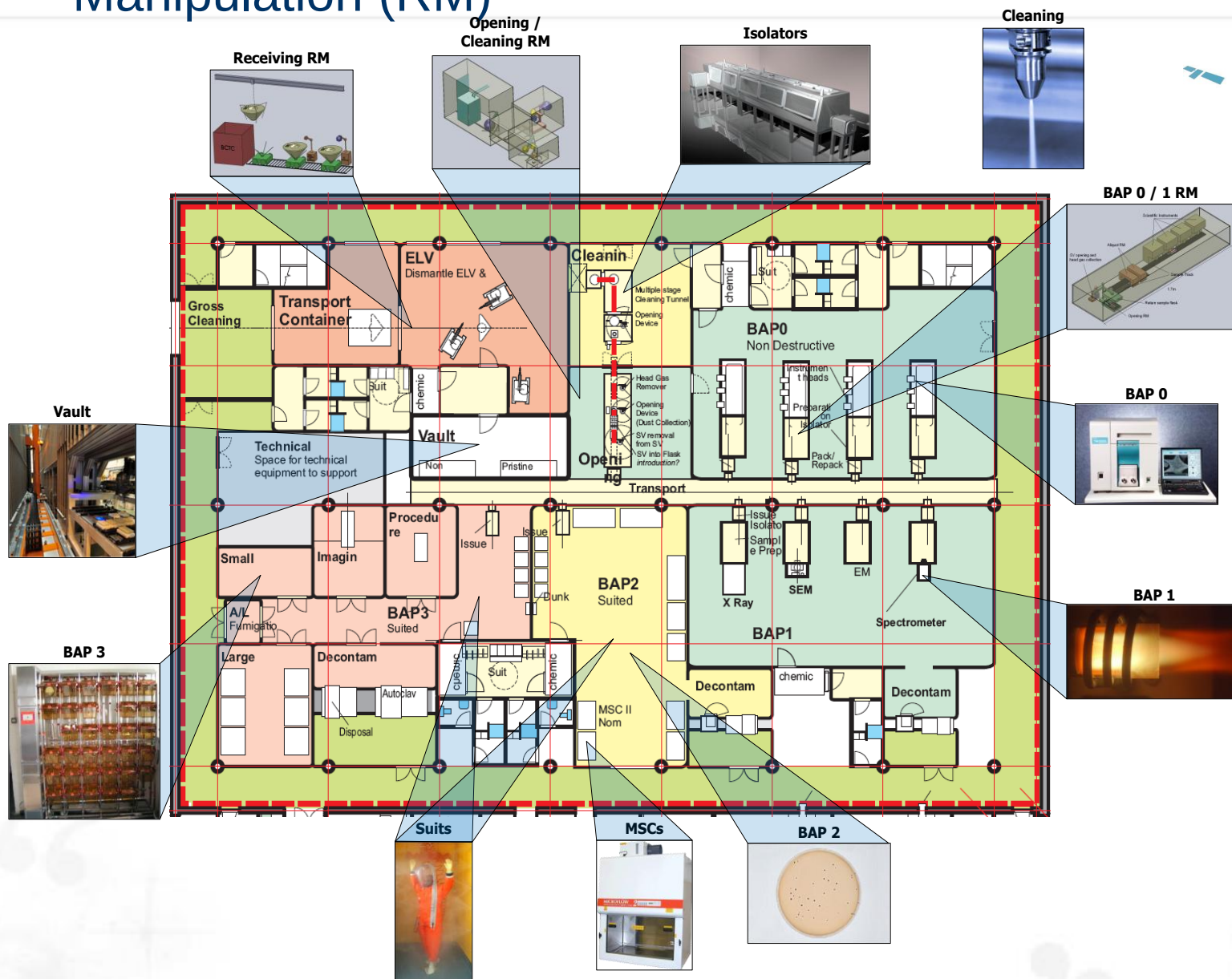
| Scenario         | Processing time in BAP0 | Processing time in BAP1 |
|------------------|-------------------------|-------------------------|
| 1: Standard Case | 685hrs (100%, 17.1wks)  | 509hrs (100%, 12.7wks)  |
| 2: Worst Case    | 1614hrs (236%, 40.3wks) | 1739hrs (342%, 43.5wks) |
| 3: Best Case     | 344hrs (50%, 8.6wks)    | 165hrs (32%, 4.1wks)    |

- 19 RM systems considered, 2 with highest duty cycle were
  - Transport, all tasks, 480 reps (standard), 1320 reps (worst)
  - Return Vault “Replace sample in Return Vault” 272 reps (standard), 748 reps (worst)
- The main conclusion for the operational analysis is that a many different sample types from many different locations would significantly increase the duration & amount of sample of the biohazard/life detection (BH/LD).



# Isolator Line MSRF (2010) - different types of Remote Manipulation (RM)

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## Biohazard Assessment Protocol (BAP)

- BAP 0  
Non-invasive testing
- BAP 1  
Invasive testing
- BAP 2  
Microbiology & Cell Culture
- BAP 3  
Animal Tissue/ Animal Testing

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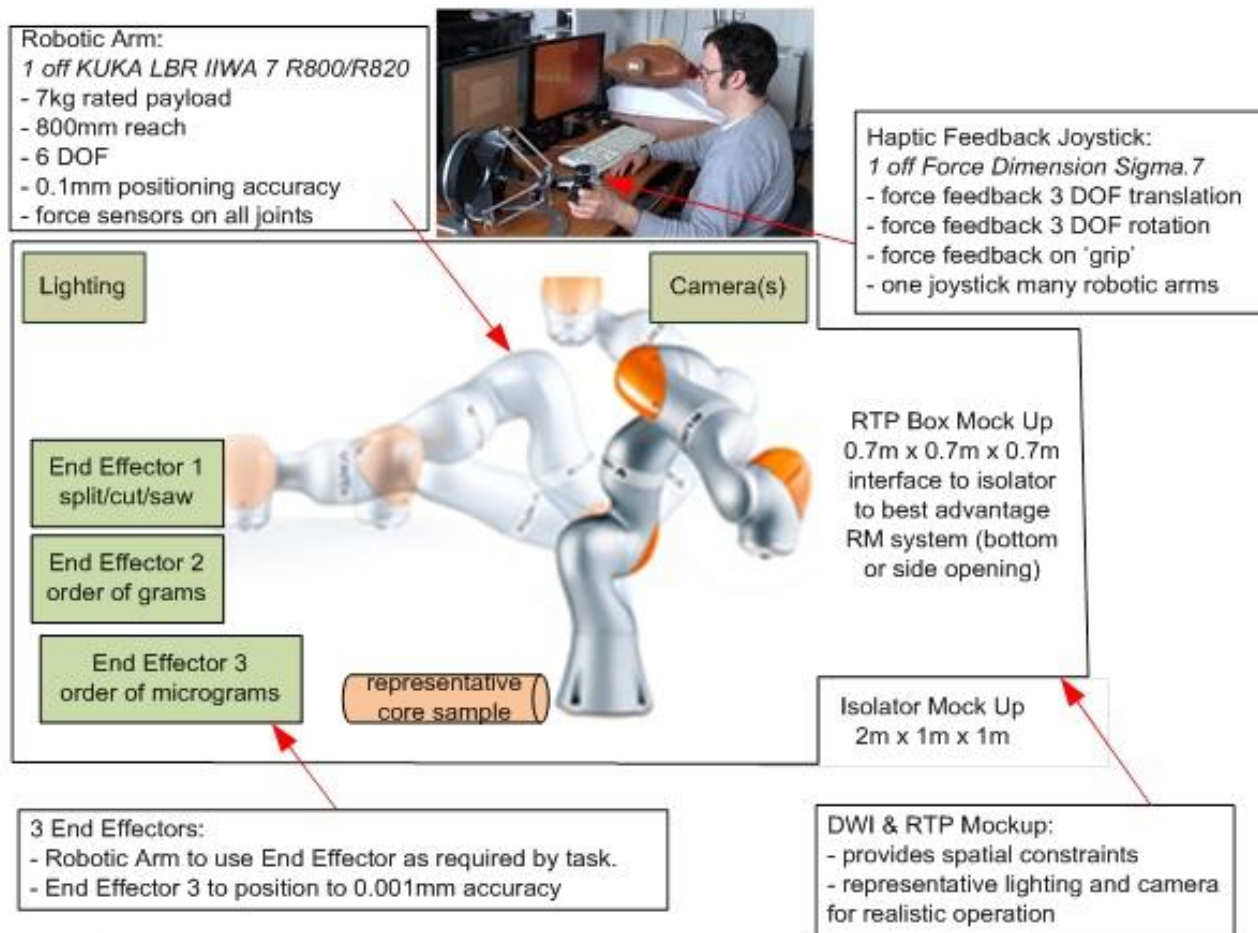
# Failure Modes, Effects and Criticality Analysis (2010 FMECA) to determine required RM reliability

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- ✈ The FMECA considered 70 failure cases and there were no items which scored a criticality of 'very high', but there were 3 items which scored a criticality of 'high' (CN=8 or 9), these were:
  - ✈ **OL 04 Sample handling/cleaning failure (in Opening Lab)**  
Opening the BC, checking and cleaning the SC, opening the SC, removing the SFs and SVs
  - ✈ **PB 04 Containment system failure, Safety Cabinet failure (in Pass Box)**  
Transfer through Pass Box
  - ✈ **CUL 06 Sample handling failure (in Curation lab)**  
Transport samples between the opening isolator, vault, BAP0 processing area and BAP1 processing area
- ✈ All of these failure modes address a failure in the RM system which immobilises the sample/ST in that process area. Such an incident would lead to the total cessation of all sample handling activities until the failure is resolved. In this case a change to the design was recommended to redesign the RM systems in these areas so that they are redundant.

# TAS-UK Current Activities – proposed\* RM systems ‘breadboard’ & 3 technology demonstration tests

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## 3 Technology Demonstration Tests (using ‘breadboards’ to determine performance of technology)

- Curation RM Breadboard Ambient Operation
- Microscope - demonstration of a scientific operation
- RM Reliability Assessment



\*as costed for in proposal, but exact breadboard and demonstrations depends on 1<sup>st</sup> part of feasibility study

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# Haptic Feedback – demonstration hardware

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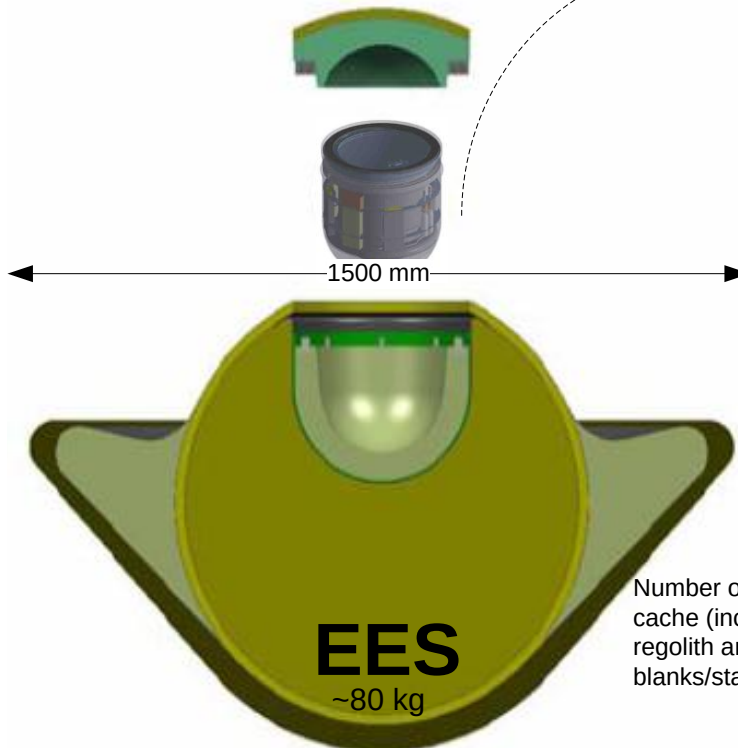
# Five top design drivers for MSRF

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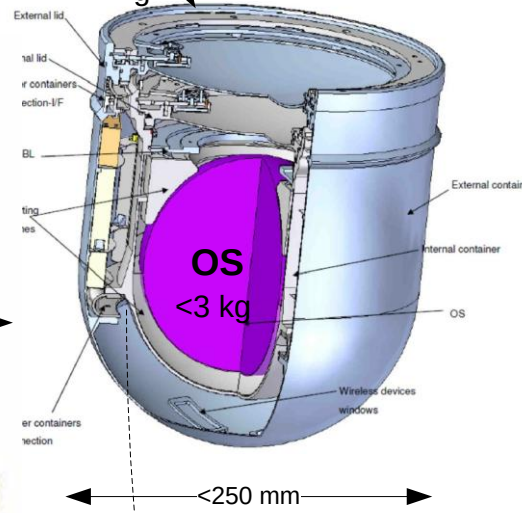
## Returned Sample Material Types [AD7]

- Core samples
- Atmospheric
- Regolith
- Adhering
- Witness plates
- (Head) Gas

### 3. Returned Sample Material Types



## Schematics of the Bio-Containment (BC) system [RD14]



## containing hardware consisting of:

- Earth Entry System (EES)  
(Earth surface pressure 1000mbar)
- Orbiting Sample (OS)  
(pressure: 50 mbar to 500 mbar TBD)
- Sample Container (SC)  
(Mars surface pressure 5mbar)
- Sample Tube (ST)  
(Mars surface pressure 5mbar)

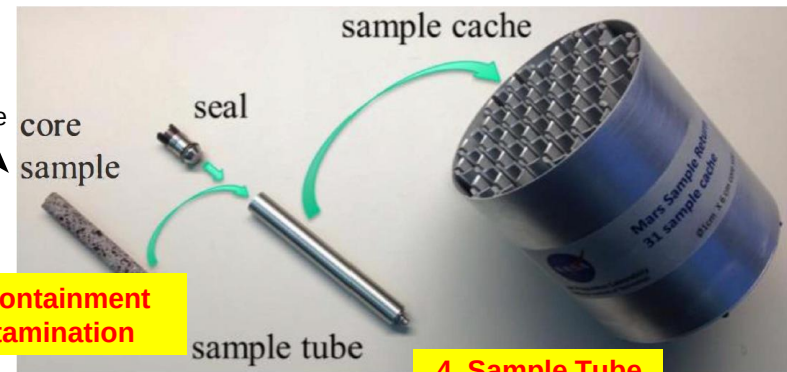
Mass of sample material in each Sample Tube (ST)  
~ 20g for core sample, regolith

Cores will be of a single, specific diameter within the range 0.5 to 1.5 cm, and a length of up to 10 cm, with a minimum core length not greater than 2 cm

Minimum Sample Volume per Sample Tube (ST)  
(Rock or Regolith) = 8 ml for core sample, regolith

Number of samples in the cache (includes: rock, regolith and/or dust, blanks/standards) = 38

### 1. Biocontainment 2. Contamination



### 4. Sample Tube

Sample cache concept used for NASA Mars2020 Technology Demonstration of Sample Tube sealing [RD12]

[RD12] "Sample Tube Seal Testing for Mars Sample Return", Paulo Younse, et al., 2014 IEEE Aerospace Conference, Big Sky, April 2014 biocontainment concept

[RD14] "Design, breadboarding and testing of a Bio-Containment system for Mars Sample Return mission", S. Senese et al. IAC63, Naples, 2012

[AD7] "Report on the workshop outputs from the Working Group on Scientific Investigations to be conducted in the Mars Sample Receiving Facility, E913-010\Working group report, Draft"

### 5. BH/LD Instruments

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# Report on the workshop outputs from the ESA Working Group on Scientific Investigations – sub-samples and BSL4+

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## General remarks

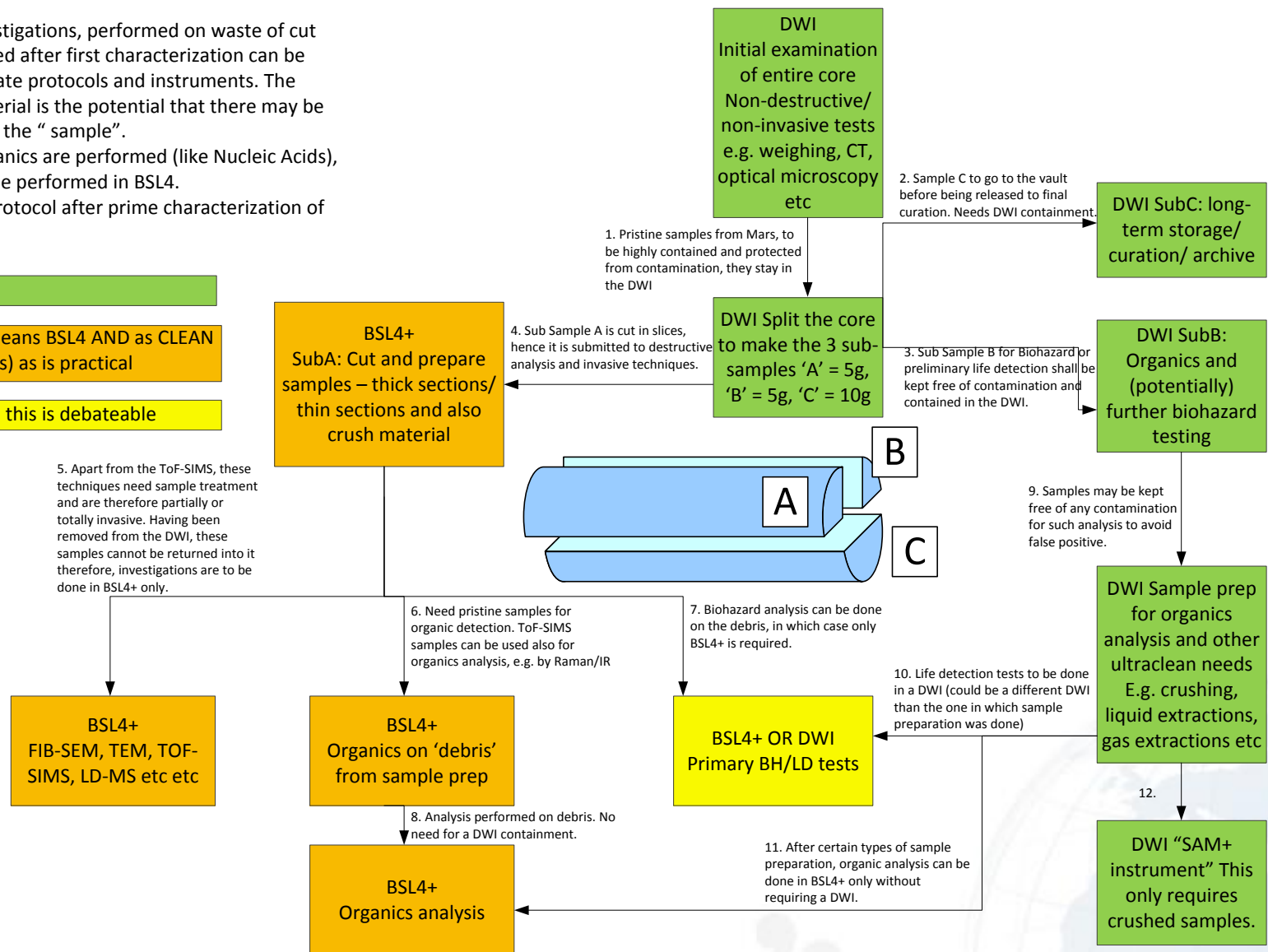
- Geological context investigations, performed on waste of cut slices, or material obtained after first characterization can be done in BSL4. It will validate protocols and instruments. The reason to use waste material is the potential that there may be interesting organics from the “sample”.
- Once extractions of organics are performed (like Nucleic Acids), the sample analysis can be performed in BSL4.
- Allow flexibility in the protocol after prime characterization of the sub sample.

## KEY

GREEN = DWI

ORANGE = 'BSL4+' this means BSL4 AND as CLEAN (organics and particulates) as is practical

YELLOW = BSL4+ OR DWI this is debateable



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# 'Consolidated Inventory' – what is needed for BH/LD?

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## inside DWI:

### Non-invasive imaging techniques +(GC-MS)

-  Weighing
-  X-ray tomography
-  Optical microscope
-  Raman spectroscopy
-  Reflectance Infra-red ?
-  Environmental SEM
-  EPR ?

### Invasive imaging techniques

-  SEM-FIBS ?
-  TEM ?
-  TOF-SIMS ?
-  LDMS ?
-  PIXE ?
-  XANES ?
-  Thin/Thick section (optical 30µm/100µm)
-  Ion probe ?

## inside BSL4+\*:

### Invasive extraction based techniques

-  GCMS
-  LCMS
-  Optical imaging
-  TOF-SIMS
-  LDMS
-  RAMAN Infrared
-  Confocal microscopy
-  IR microscopy

\*Pharmaceutical grade gloved isolator

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# Any Questions?

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Comment written by:  
**Sandra**  
Age... 66  
Town/Place... Swansea  
Country... United Kingdom  
Football Team... I don't follow football  
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