A & R Needs for a Multi-user facility for Exobiology Researh

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Background on Exobiology (1)

In the past few years the world has witnessed the discovery of so-called **extremophiles**. These are life forms thriving in extreme environments (such as rocks several kilometers underground, or underwater thermal vents where temperatures exceed +100 degrees Celsius) which were previously considered to be so hostile as not to be able to sustain any form of life.

One of the possible implication of this unexpected proliferation and survivability of life, is that some sort of life could have possibly also evolved on Mars or Europa. It is now commonly believed that Mars had once an atmosphere and surface water, and it is possible that life did evolve on Mars during that wet period. As the extremophiles show, life might even have survived deep in the ground till the present day.

Background on Exobiology (2)

ESA established in September 1996 the Exobiology Science Team whose task was to survey current research in exobiology and related fields. The Team had then to make recommendation to ESA on the nature of a future search for life elsewhere in the solar system.

A major part of the recommendation is to seek evidence of extinct life below the surface of Mars using a group of six instruments. All these are adaptations of instruments which are under development or have already flown on other space missions. Together with their supporting automation means they form an integrated package of analysis equipment (called **Multi-user Exobiology Research Facility**) which should be able to provide the answer to the question:

"Is there evidence here, at this particular landing site,
of previous or existing life?"

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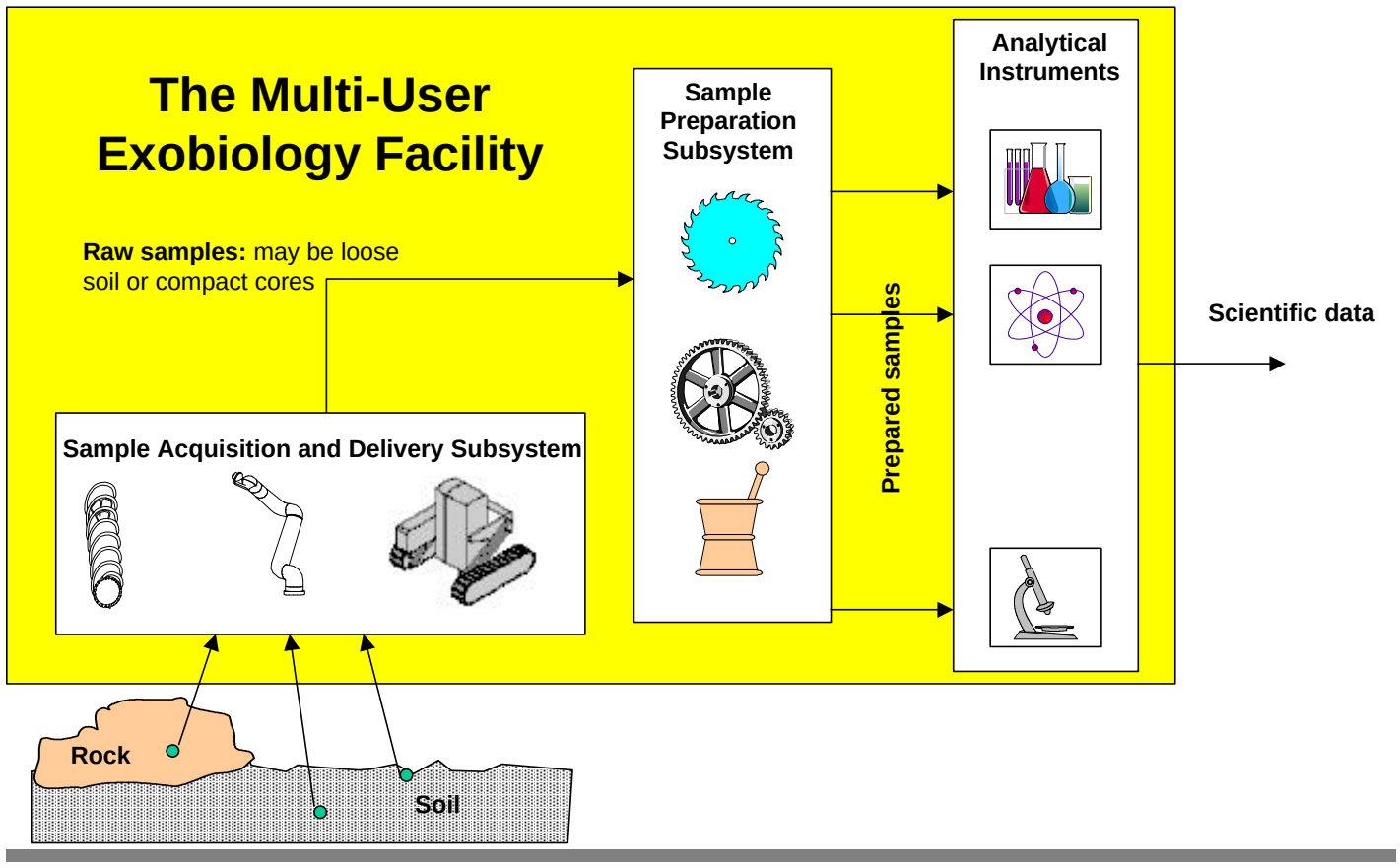
The ESA Multi-user Exobiology Research Facility

Following the Exobiology Science Team's recommendation, ESA initiated in 1999 two parallel phase-A studies on such Multi-user Exobiology Research Facility. The basic assumptions made for the studies were:

- ⇨The facility would be a highly integrated package accommodated on a Mars lander
- ⇨The facility would acquire and analyse samples of soil/rock
- ⇨The facility would consist of 3 functional parts:
  - ❒ a sample acquisition and delivery subsystem: in charge of extracting the samples from the environment and bringing it into the facility
  - ❒ a sample preparation subsystem: which performs the fractionating/reshaping of the samples as needed by each analytical instrument
  - ❒a set of analytical instruments which would be fed with the prepared samples and produce scientific data to be transferred to Earth



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Multi-user Exobiology Research Facility phase-A

The goal of the phase-A studies was to perform:

- ✓an assessment of the development status of the selected set of instruments
- ✓an assessment of instruments resource requirements and operational constraints, as well as sterilisation and contamination issues
- ✓an assessment of sample acquisition and delivery systems
- ✓definition of sample preparation requirements for the different instruments
- ✓definition of a system design concept

Multi-user Exobiology Research Facility phase-A

The two phase-A studies were performed by:

- ✓Kayser-Threde (D) with Brunel Institute for Bioengineering (UK), DLR (d), Laboratoire de Physique et Chimie de l'Environment CNRS (F) and Max-Planck-Institut für Aeronomie (D)
- ✓Officine Galileo (I), with Tecnospazio (I) and Dasa-Dornier (D)

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Multi-user Exobiology Research Facility phase-A

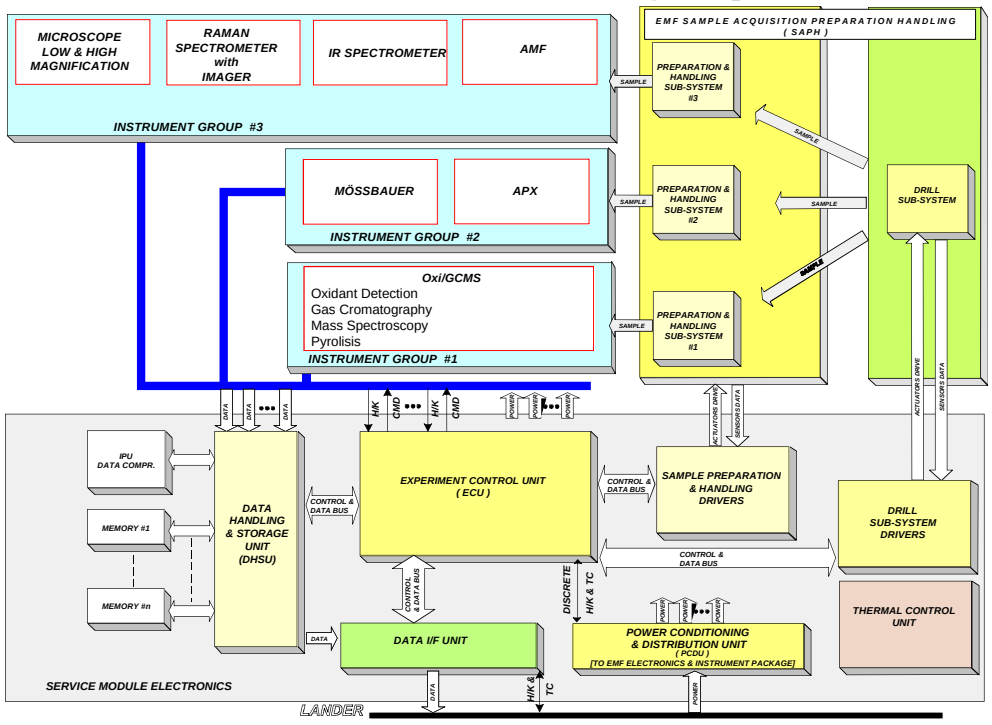
A clear conclusion of the phase-A studies is that:

- The facility will be composed of a rather complex chain of various mechatronics devices which will implement the overall process (sampling-delivering-preparation-analysis).

From the general constraints of a Mars mission it can be furthermore derived that:

- This process will need to be completely automated and remotely controlled.
- Due to the scarce communication to Earth a fairly large amount of autonomy should be implemented.

Multi-user Exobiology Research Facility phase-A



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The automation needs:

1) The Sample Acquisition & Delivery Subsystem (1)

Functional and performance requirements:

- reach up to 2 meters into non-homogeneous regolith of unknown hardness
- reach up to several centimetres into surface rocks/stones
- allow investigation of soil layering (sample at a certain depth, material of that specific layer)
- acquire pristine samples of unknown hardness and coherence
- preserve morphology of the sample
- deliver samples to the Sample Preparation Subsystem

The automation needs:

1) The Sample Acquisition & Delivery Subsystem (2)

Various means have been studied to achieve such requirements:

- a single pipe driller mounted on a robot arm
- a drill-string driller mounted on a robot arm
- a sampling penetrometer mounted on a robot arm
- a drill-string driller mounted on a rover
- a sampling penetrometer mounted on a rover

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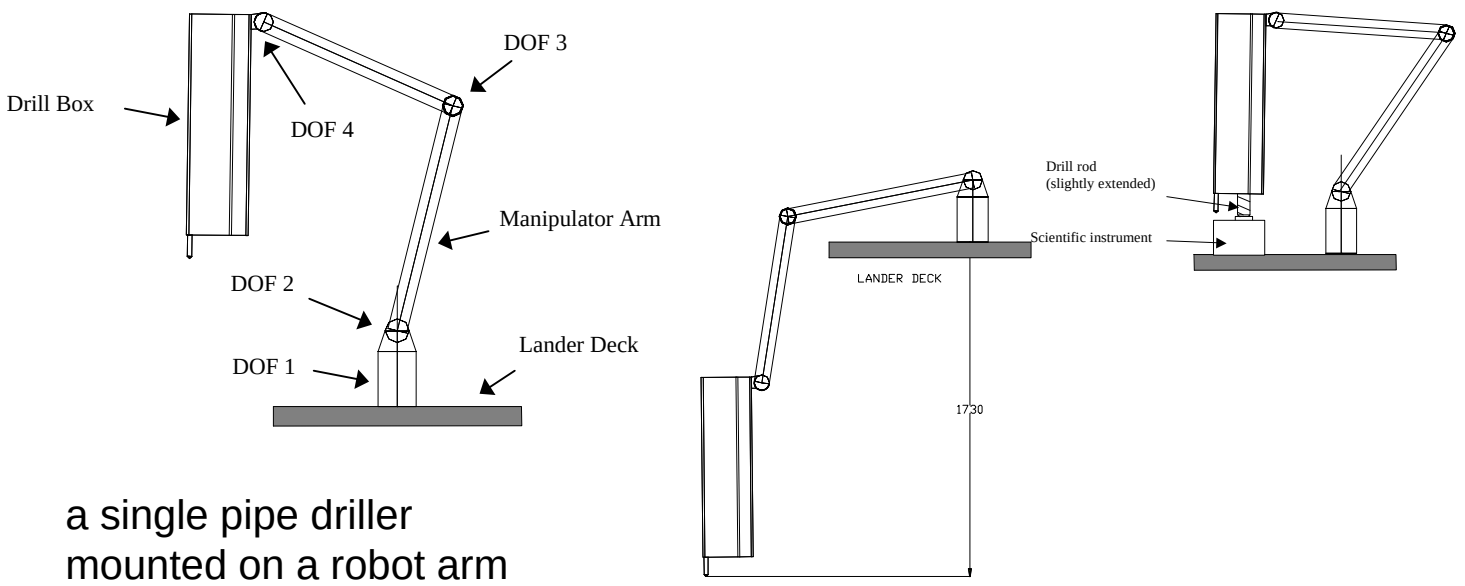
The automation needs:

1) The Sample Acquisition & Delivery Subsystem (3)

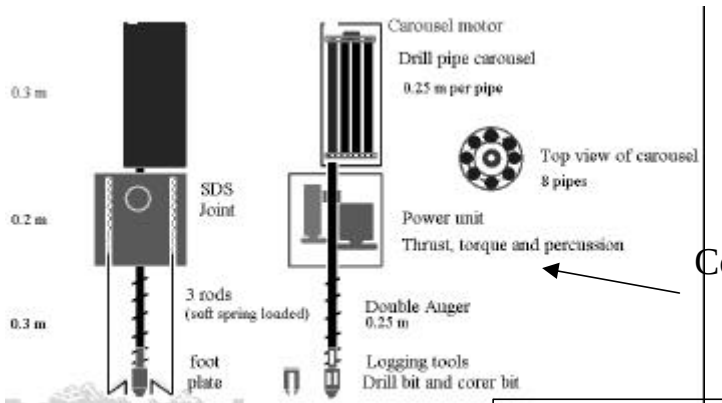


a single pipe driller
mounted on a robot arm

The automation needs:

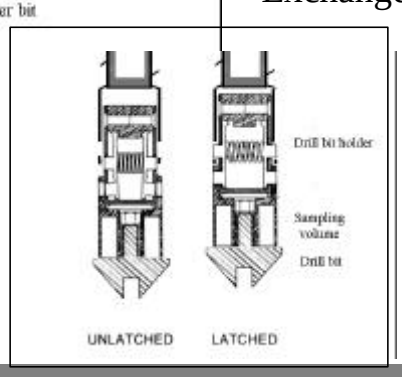
1) The Sample Acquisition & Delivery Subsystem (4)

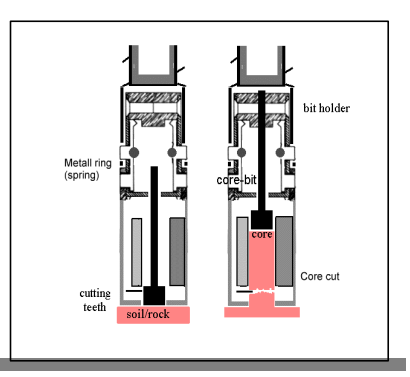
a drill-string driller mounted on a robot arm



Concept for Drill and Carousel

Exchangeable Drill Bits

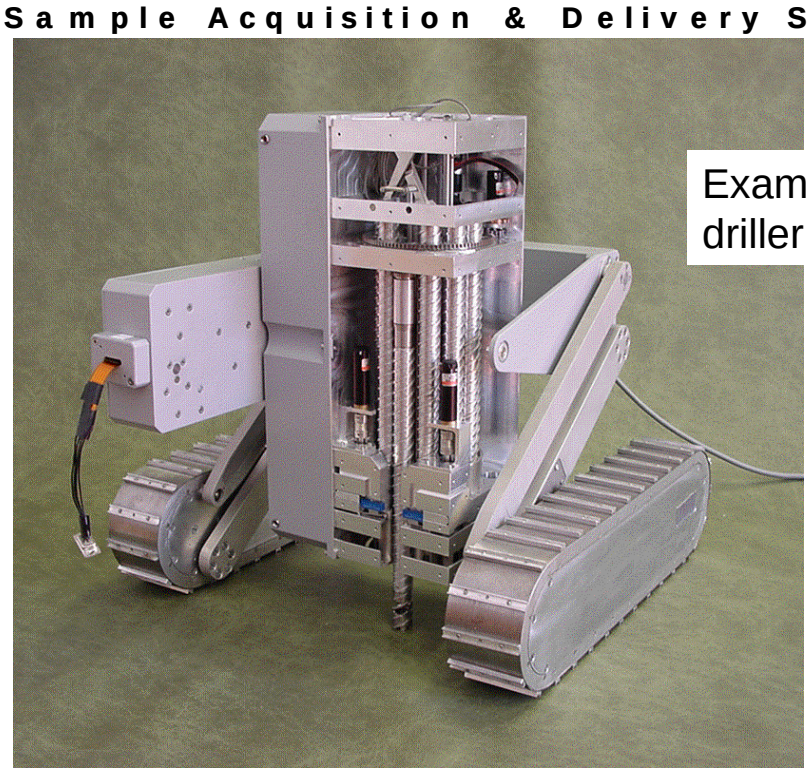




One-way clutch for assembly of drill pipes

The automation needs:

1) The Sample Acquisition & Delivery Subsystem (5)



Example of a drill-string driller mounted on a rover

Needs for automation :
2) The Sample Preparation Subsystem

Basic requirements of the Sample Preparation Subsystem are to

- produce smooth, polished surfaces for optical examination
- reduce material to fine powder (grain size < 10 µ)
- produce a smooth surface of 5 cm diameter required for the APXS
- produce material 0.2 mm deep, held with mica windows, for the Mössbauer Spectrometer
- transfer powder to the pyrolysis ovens and the chemistry sample holders.

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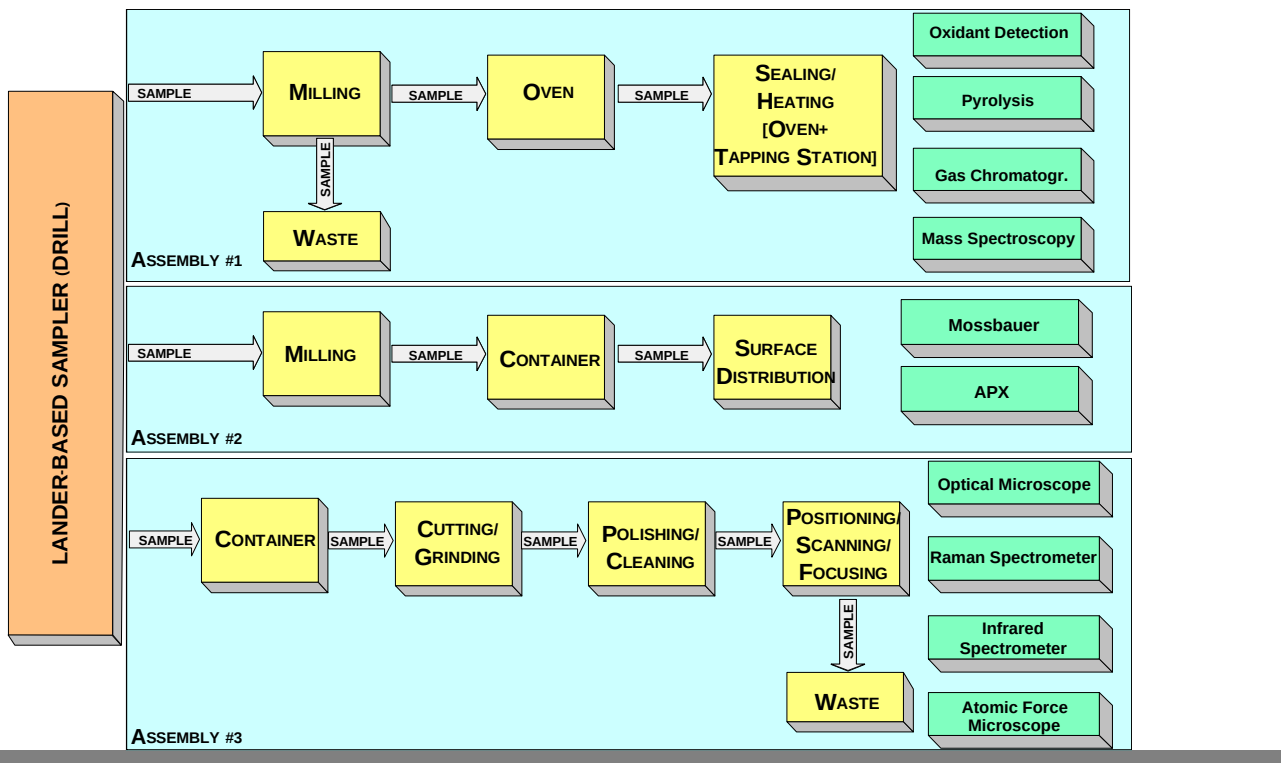
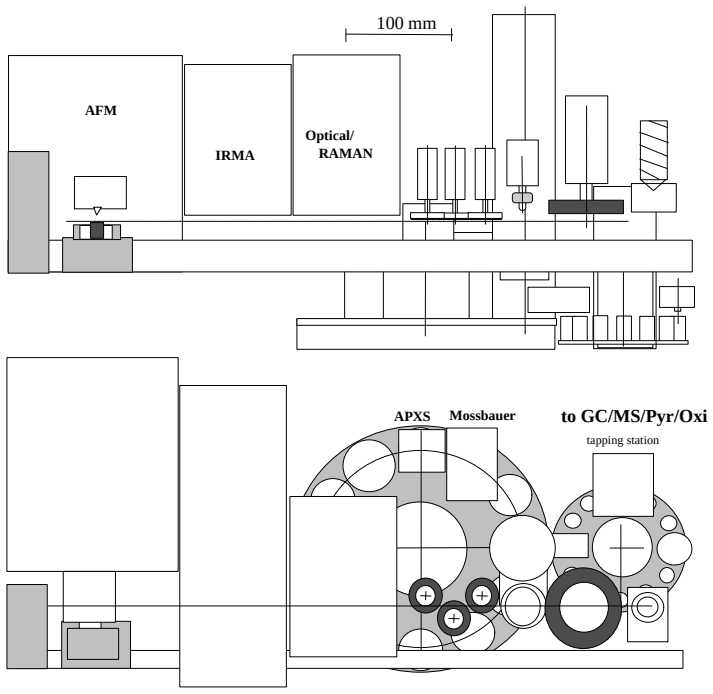
Needs for automation :
2) The Sample Preparation Subsystem (2)



Needs for automation :
2) The Sample Preparation Subsystem (3)



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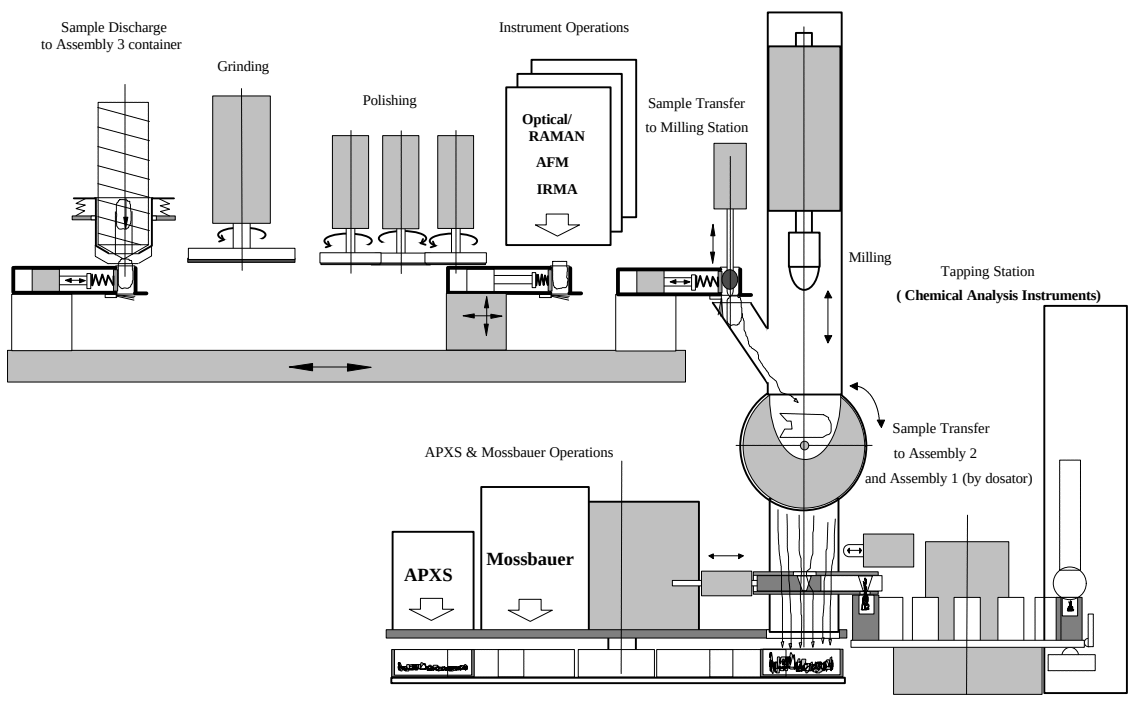
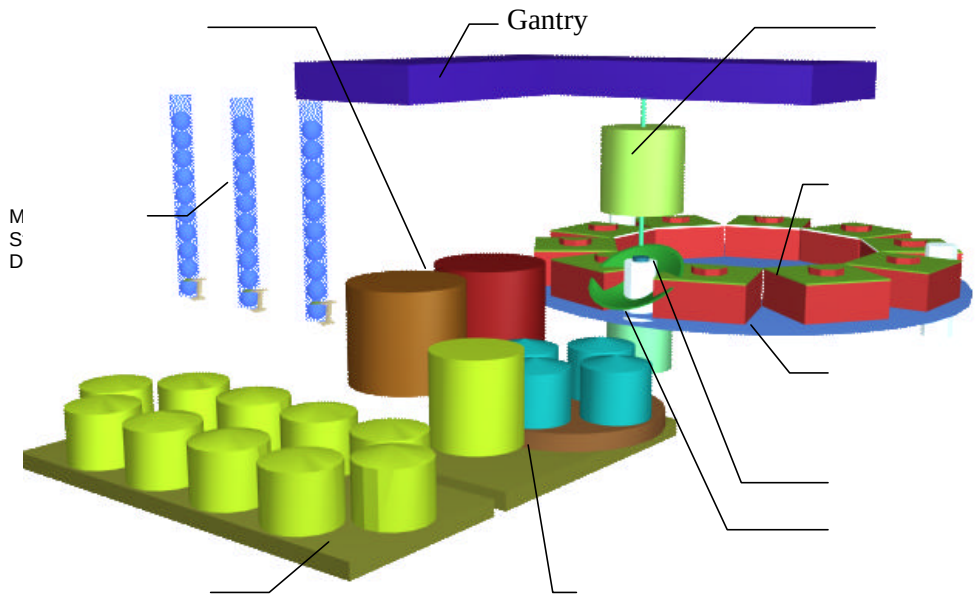
Needs for automation :
2) The Sample Preparation Subsystem(4)



Needs for automation :
2) The Sample Preparation Subsystem (5)



Sample Preparation Workstation

The automation needs:
3) The Analytical Instruments