Efficient Power-aware Resource Constrained Scheduling and Execution for Planetary Rovers

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Universidad de Alcalá

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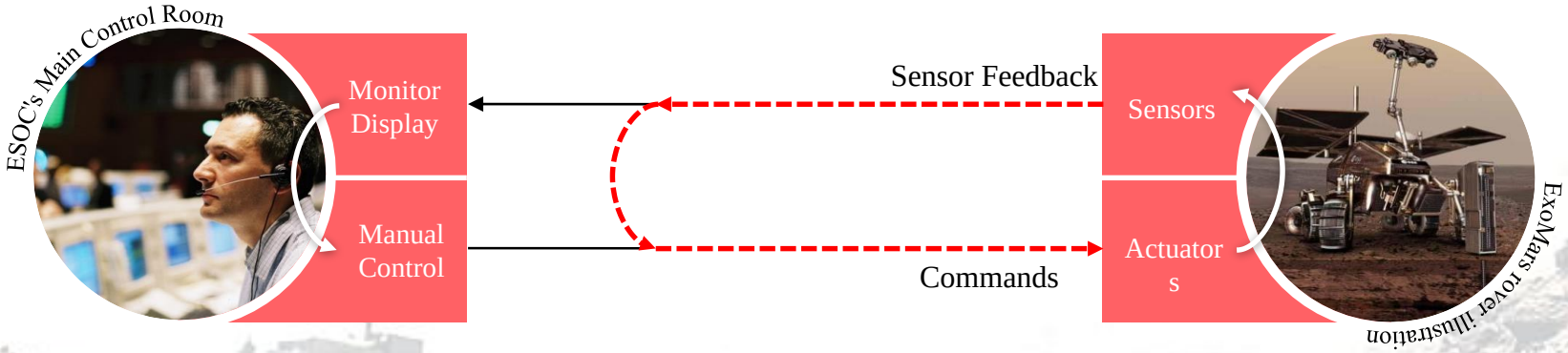
Main Research Line

Increase the on-board autonomy keeping the human in the loop:

- synthesis of nominal mission plans from high-level goal descriptions
- plan adaptation/modification to face with contingent situations
- opportunistic science
- hazard prediction
- Etc.



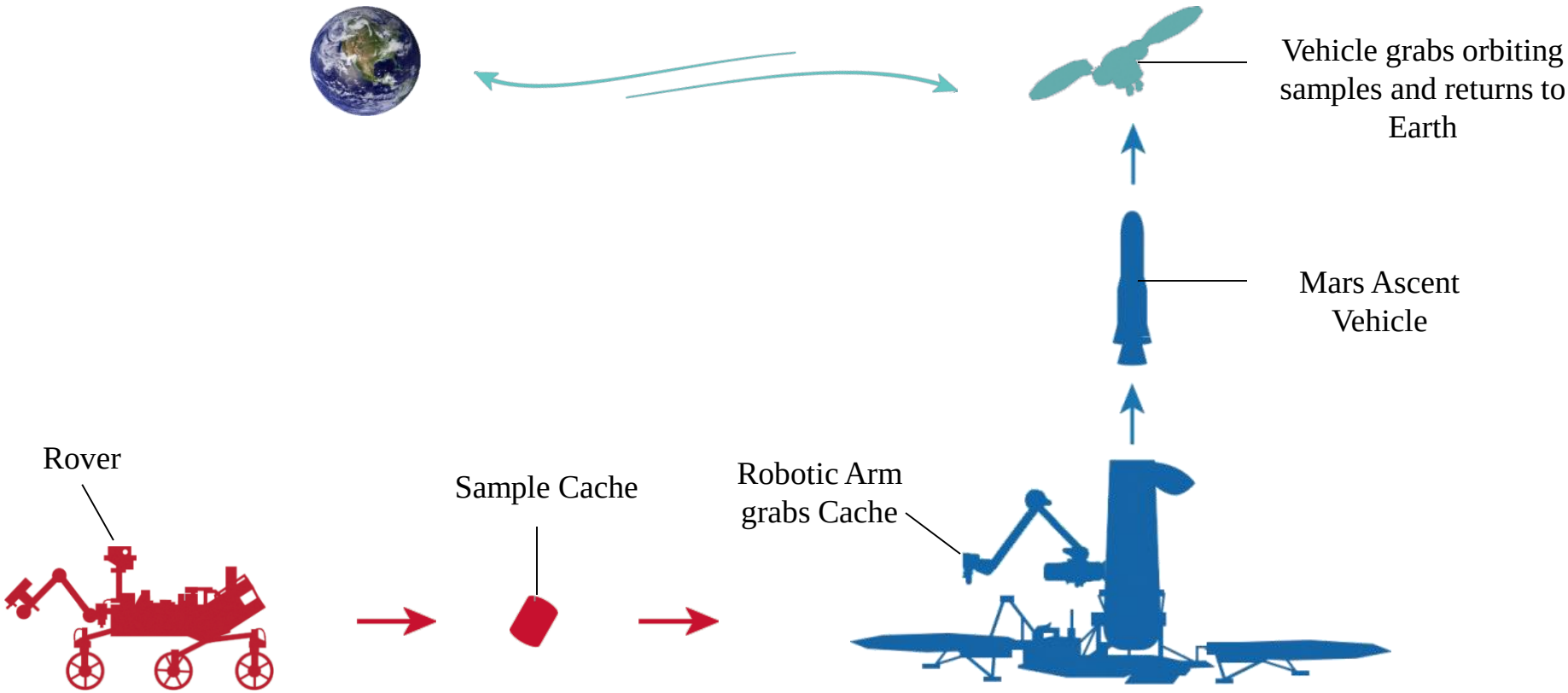
Control Execution Loop: supervisory mode (mixed-initiative)

Our contribution

We present a model-based **autonomous controller** for planetary rover-mission operations that combines:

- **Robust constraint-based robot action scheduling** – Synthesis of feasible command sequences to achieve the mission goals, considering temporal and resource constraints + ***energy requirements***
- **Proactive schedule execution management** – Execution of the rover commands while preserving plan's consistency against the environmental uncertainty

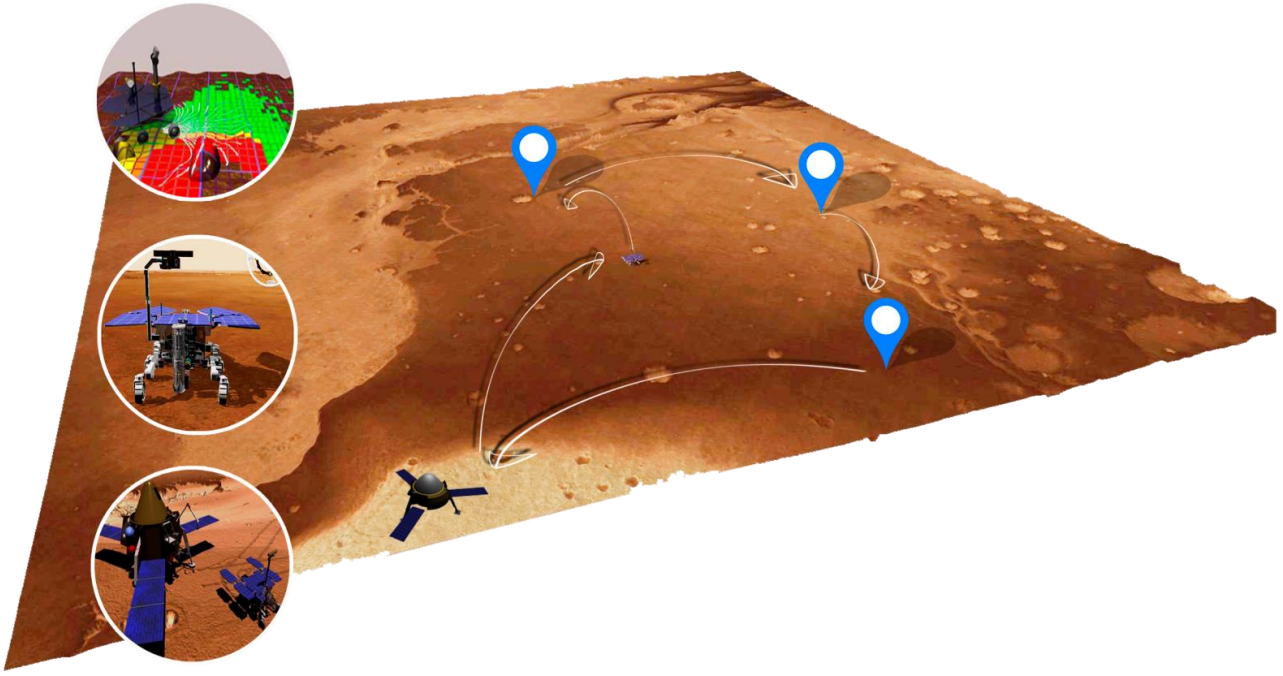
The Mars Sample Return Mission Scenario



The Power-Aware Resource Constrained Mars Rover Scheduling Problem (PARC-MRS)

- Set of experiment cycles $\mathbf{E = \{Exp_1, ..., Exp_n\}}$ are scheduled as a set of partially ordered sequences of activities to be executed by a rover

- Experiment cycle: $\mathbf{Exp_i = \{Nav_{S \rightarrow i}, Drill^i, Nav_{i \rightarrow F}, Rel^i_F\}}$



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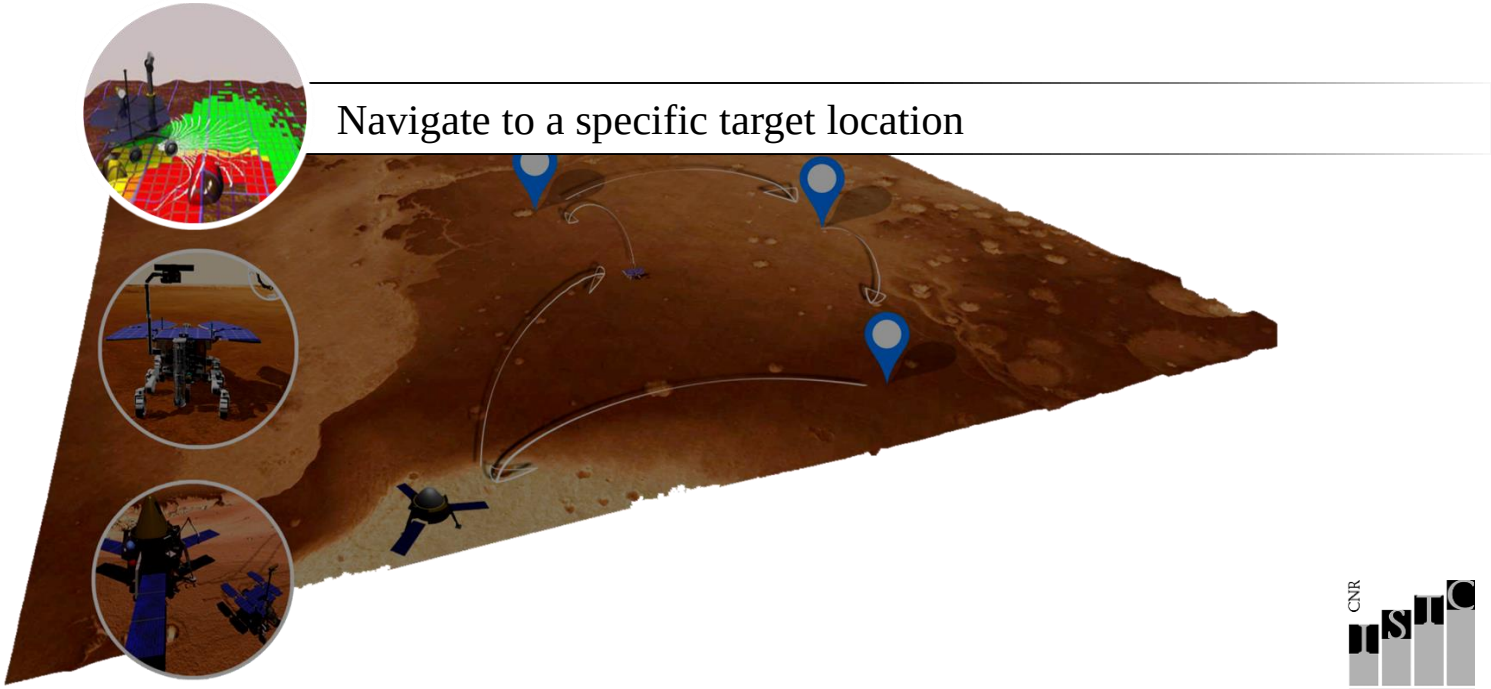

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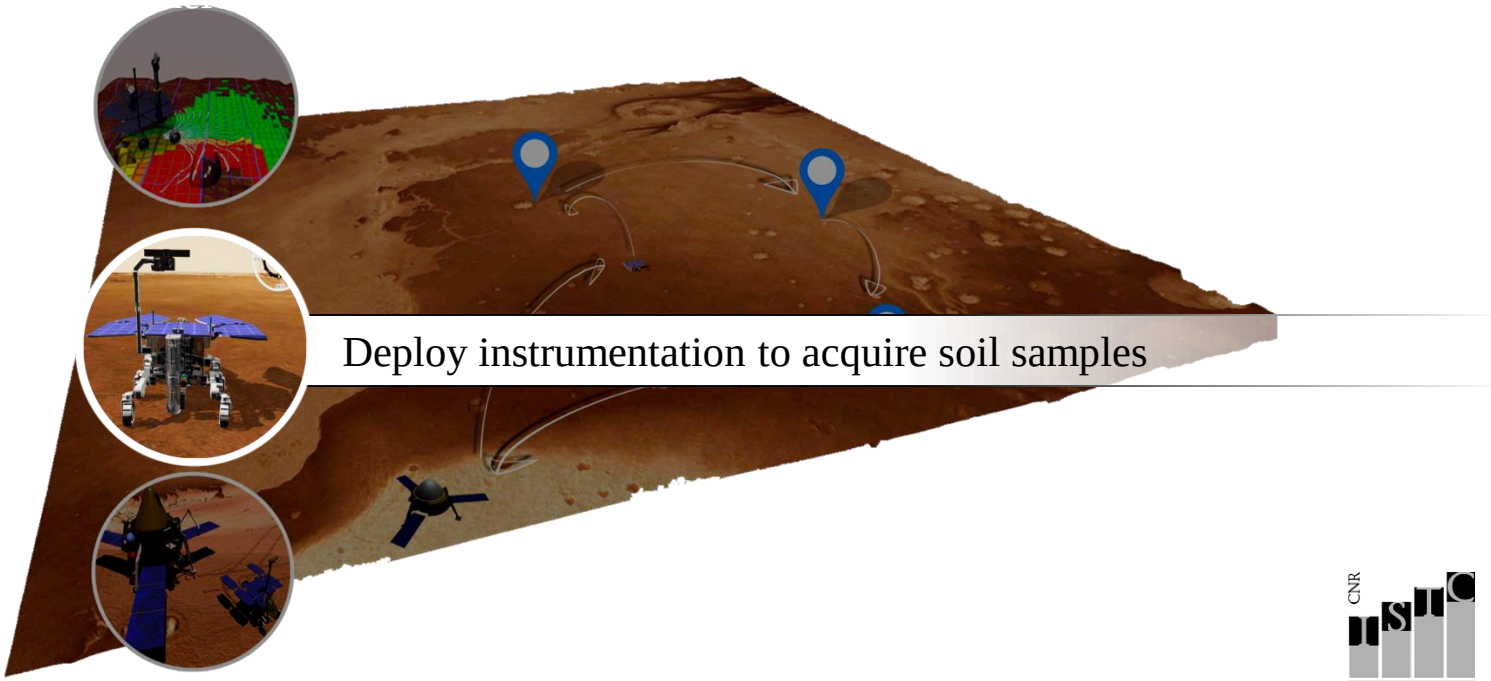

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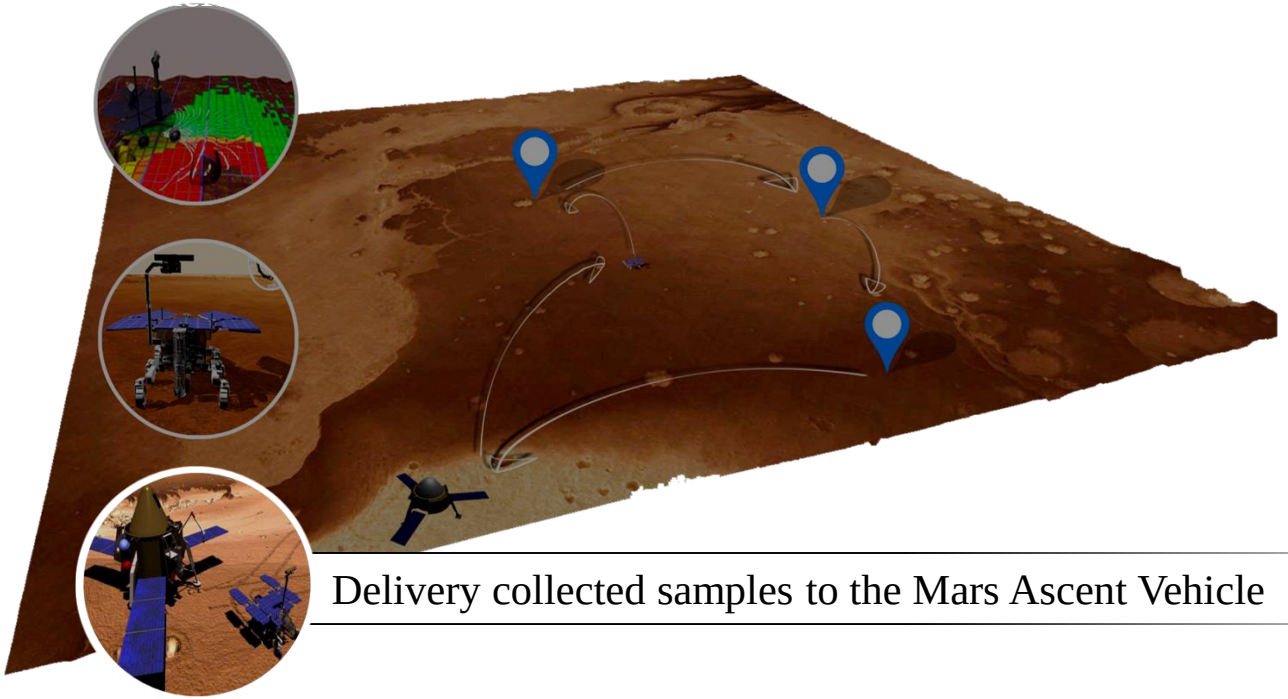
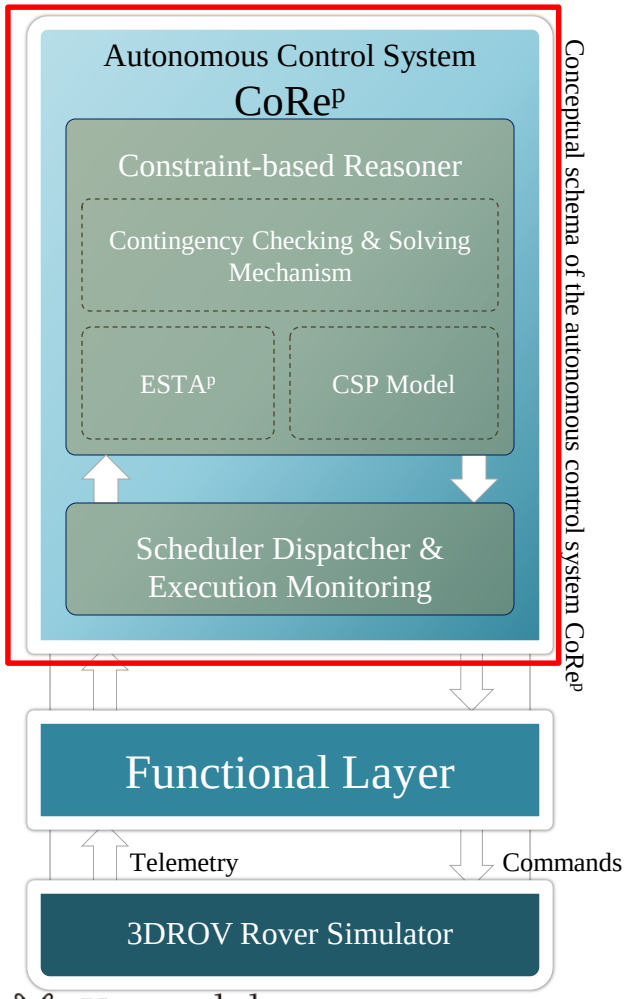


Delivery collected samples to the Mars Ascent Vehicle

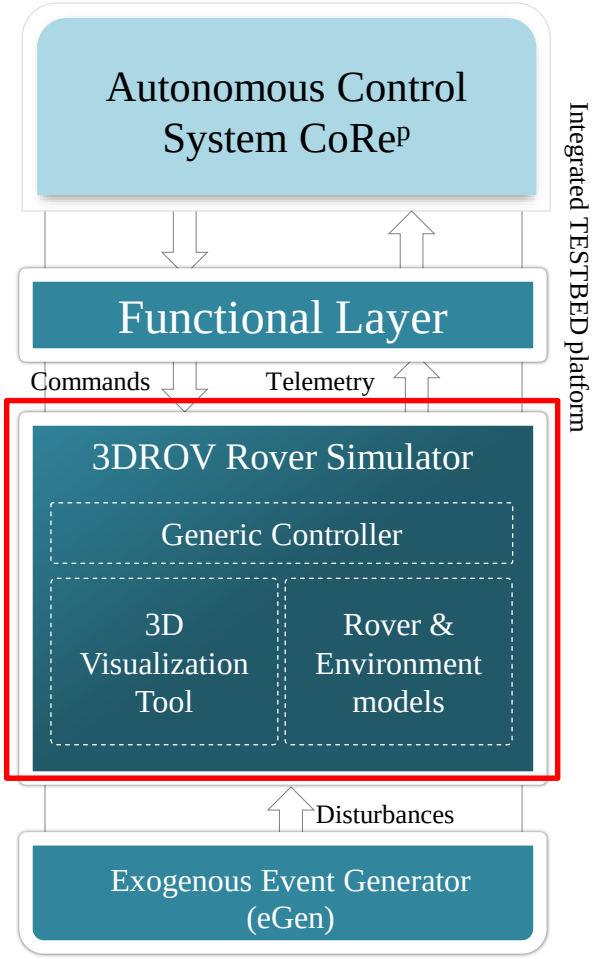
The Power-aware Autonomous Control Architecture CoRe^p



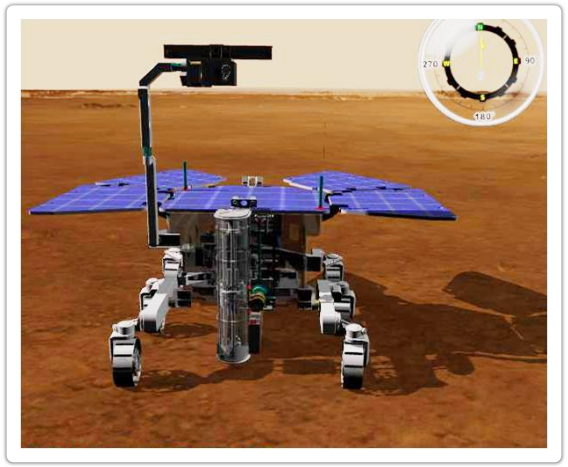
Mission execution management process:

1. Synthesis of feasible and robust baseline schedule solutions (ESTA^p)
2. Timely dispatch the nominal schedule, monitor the execution evolution, on the basis of the telemetry received: **rover position and orientation, command execution status and battery state of charge (SoC)**
3. Update the internal mission execution model
4. Detect possible misalignments between planned and real rover behavior, in terms of timing and resource usage **(consistency checking)**
5. Provide (on-line) alternative schedule solutions in case of contingencies **(consistency solving)**
6. Provide continuous makespan optimization

An Analysis on the Performance of the Execution Control Process



- **Testing workbench platform** integrated with ESA's ***3DROV*** (an advanced software simulation platform):
  - Validate the whole CoRe^{p} autonomous control architecture
  - Perform an experimental analysis on the performance of the main control architecture's capabilities



3DROV screenshot

An Analysis on the Performance of the Execution Control Process

- **Two simulations (MSR_0 and MSR_1)** of the same PARC-MRS problem instance:
  - **MSR_0**: All experiments scheduled from the beginning, and 3DROV as unique source of uncertainty used
  - **MSR_1**: All but one experiments scheduled from scratch (one is injected *on-the-fly*), and a set of exogenous events are injected
- Analysis of the experimental results is provided for both simulations:
  - On-line makespan optimization capabilities
  - Real Vs. modeled Battery State of Charge evolution

Would you like to know more?

See you at 11:30

Social Session 2B (Acquario Room)

Palazzo Giordani