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Simulation Of ExoMars2020's Rover Network Using SystemC

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Goals and Tasks

This project was created as a R&D project of two French students from IPSA.

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Main tasks:

- Implement the rover’s network model on SystemC using information from open sources.
- Implementing a log-system to record results of the simulation through Open Database systems.
- Creating a parallel model by splitting the current network.
- Creating a configuration interface to configure the resulting rover's network model

The mission of ExoMars2020 rover

The ExoMars2020 mission has for goal to search evidence of past or present life on the surface and/or subsurface of Mars.

The rover will explore the planets surface and subsurface by using of multiple scientific instrumentation: **PanCam**, **ISEM**, **CLUPI**, **WISDOM**, **ADRON-RM**, **Ma_Miss**, **MicrOmega**, **MOMA**, and **RLS**.

Thanks to it list of scientific instrumentation **the rover will:**

- Explore the surface of Mars by analyzing its origin of formation and its geological composition.
- Map the surface and subsurface in 2D and 3D to localize icy spots.

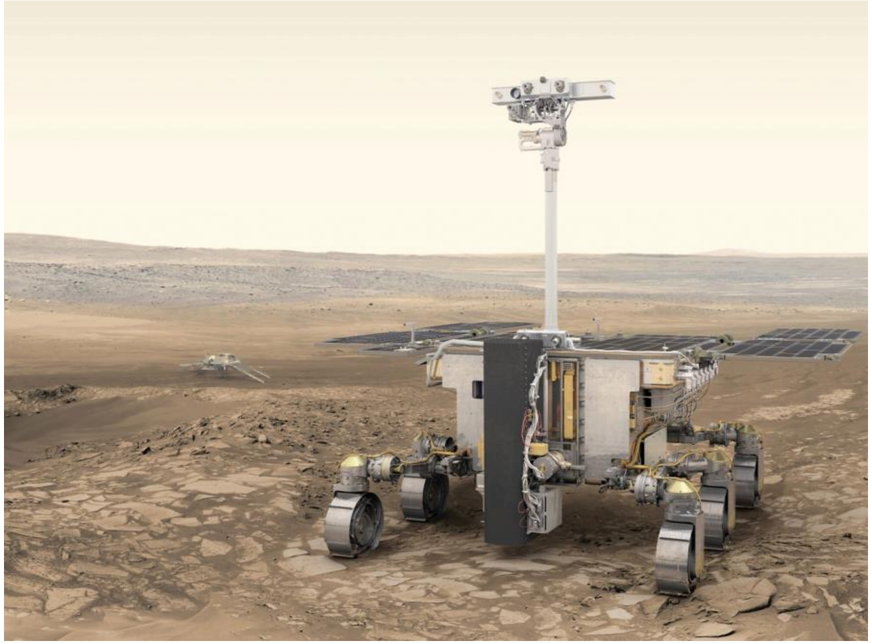

Fig.1 - The Landing platform and ExoMars2020 rover

- List the types of rocks and take very close-up images of them to study the geology of Mars.
- Take samples of the soil and will return it to Earth.

On-board instrumentations of the rover

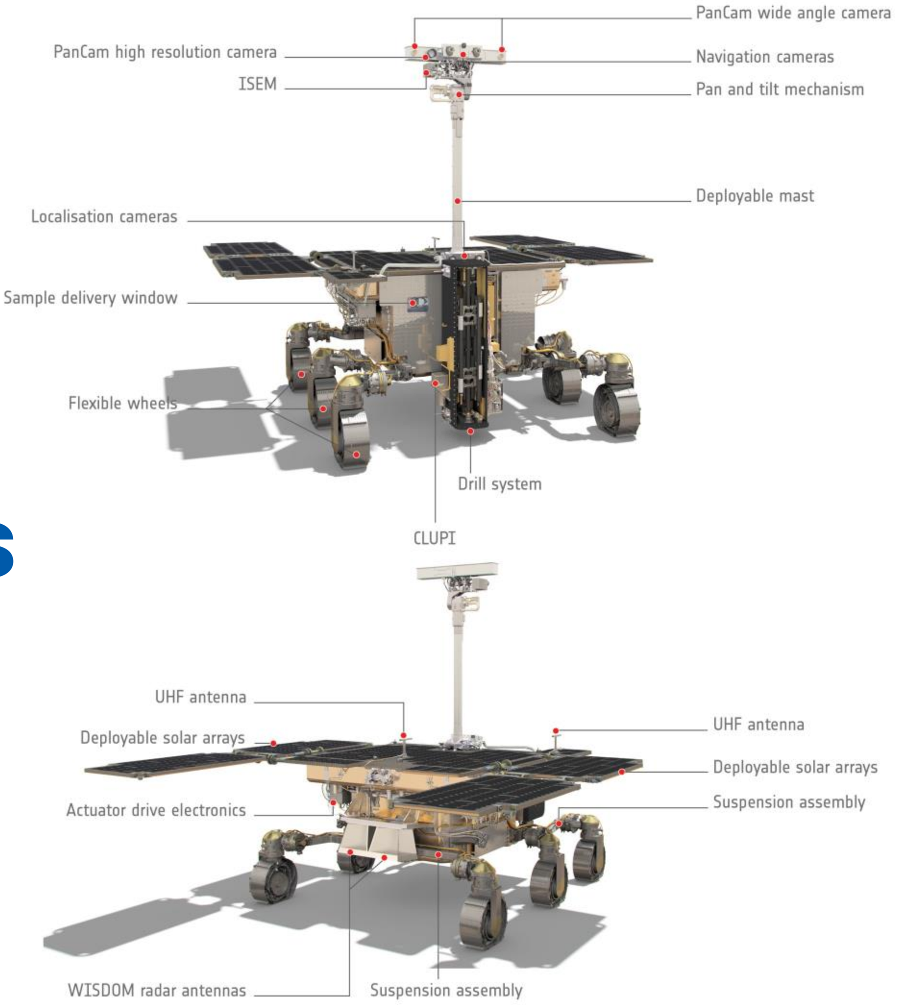

Fig. 2 – On-board instrumentations of the ExoMars2020 rover

Cameras

PanCam (*Panoramic Camera System*) is used to record 2D & 3D images of Mars' surface. PanCam included:

- 2xWAC – Wide Angle Camera
- 1xHRC – High Resolution Camera.

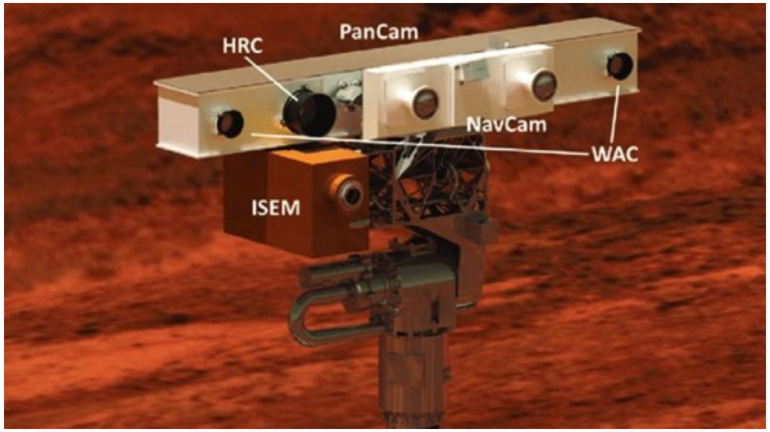

Fig. 3 - The PanCam module

CLUPI (*Close-Up Imager*) is a high-resolution camera which goal is to take close picture of rocks to be able to detect each details of these ones.

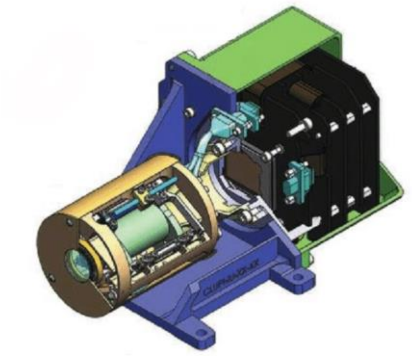

Fig. 4 - The CLUPI module

Spectrometers (1/3)

ISEM (*Infrared Spectrometer of ExoMars*) is used on the rocks near of the rover, it obtain the spectrometer of these rocks and then get information about the geological composition of the planet surface.

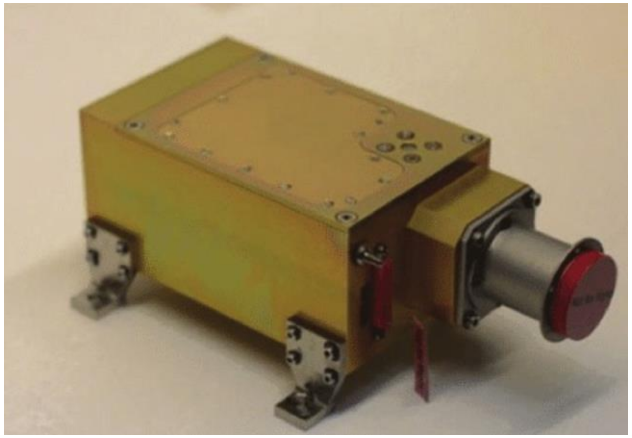

Fig. 5 - The ISEM module

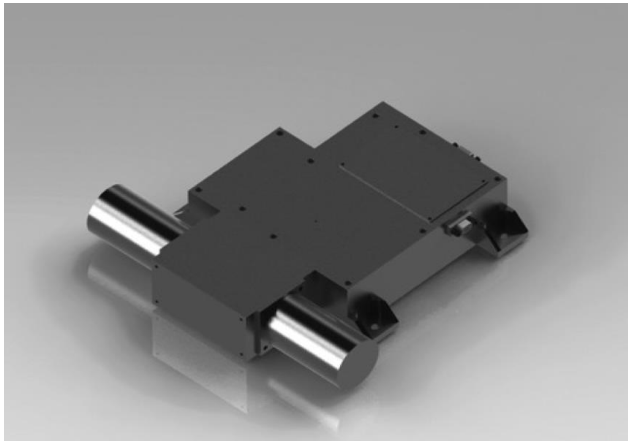

Fig. 6 - The ADRON-RM module

ADRON-RM (*Autonomous detector of radiation of neutrons*) is a neutron spectrometer that detects neutron radiation from the sub/surface of the planet.

Spectrometers (2/3)

Ma_MISS (*Mars Multispectral Imager for Subsurface Studies*) is a spectrometer located in the drill of the rover. It is used to determine horizontal and vertical composition of the Martian soil.

Fig. 7 - The Ma_MISS Module

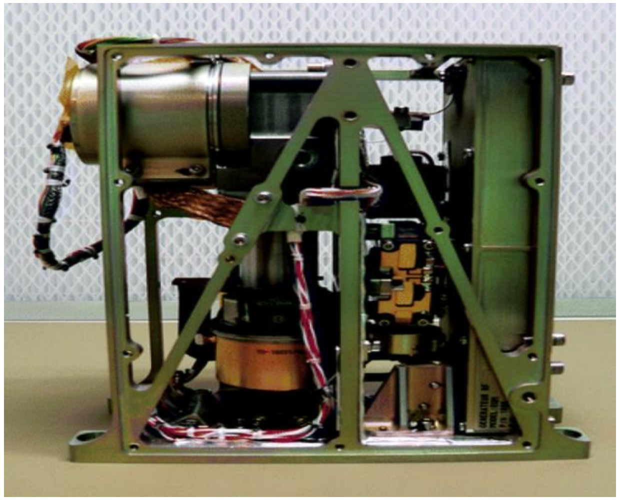

Fig. 8 - The internal structure of the MicrOmega module

MicrOmega is an infrared hyperspectral microscope made to identify composition of Martian soil samples at a grain scale, after their gathering by the drilling system.

Spectrometers (3/3)

RLS (*Raman Laser Spectrometer*) is a spectrometer uses the Raman effect to determine the mineralogical composition and find life signatures in Martian soil samples is a none-destructive way.

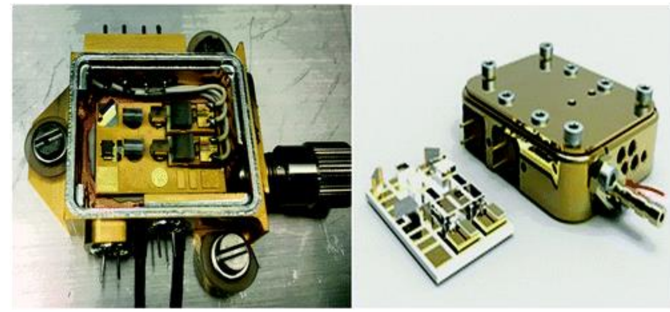

Fig. 9 - The RLS module

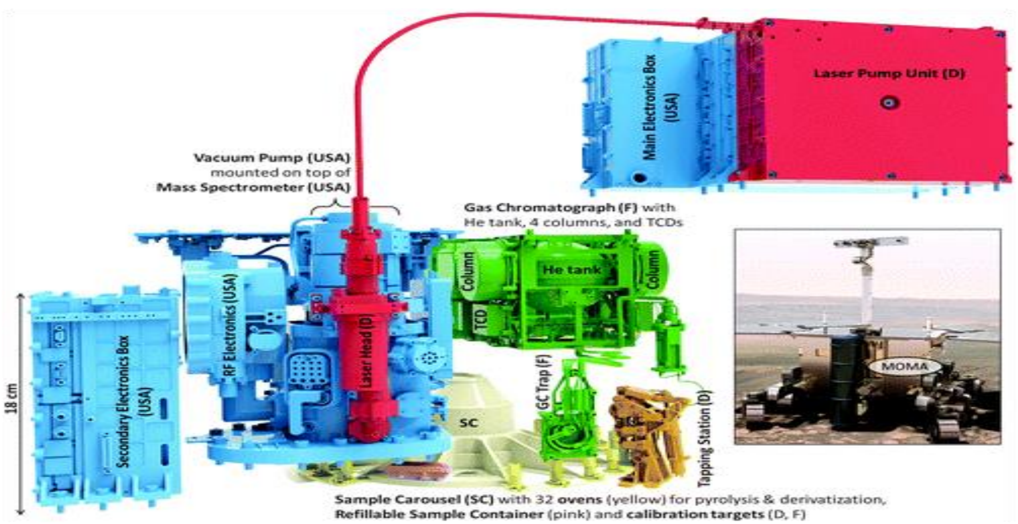

Fig. 10 - The MOMA Module and its components

MOMA (*Mars Organics Molecule Analyser*) is an instrument designed to detect organic molecules in Martian soil and environment.

WISDOM

WISDOM (*Water Ice Subsurface Deposit Observation on Mars*) is a ground penetrating radar which will help to notify and describe the type of the shallow surface that under the rover.

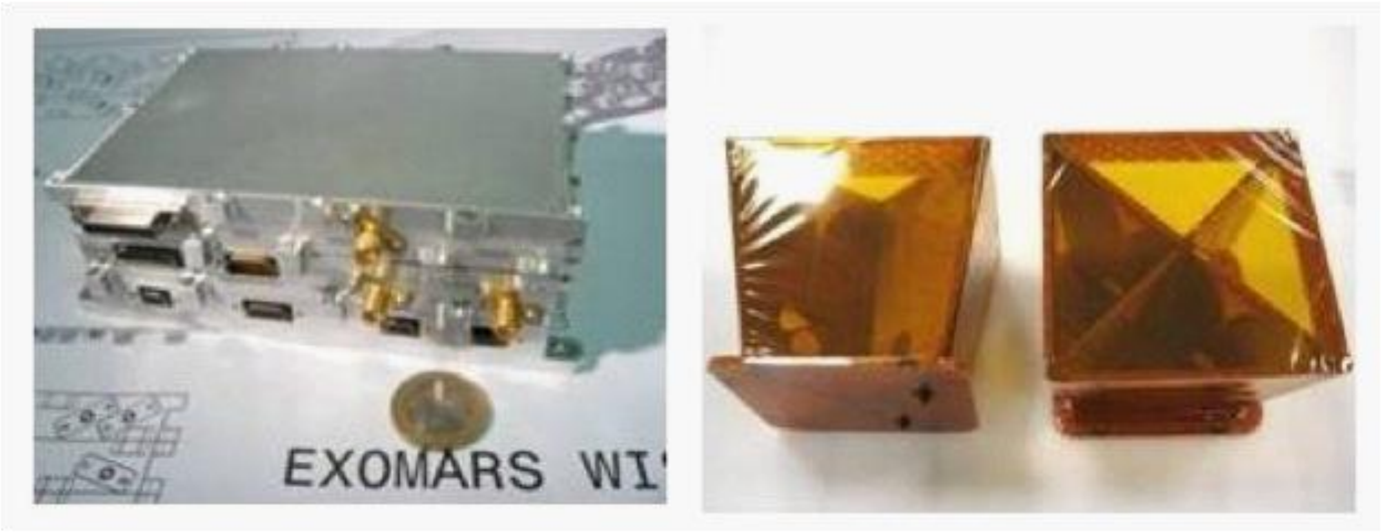

Fig. 11 - The WISDOM module (left) и its antennas (right)

Related work

- In «**Mechanical simulation of the Exomars rover using Siconos in 3DROV**» the authors modelled the ExoMars2020 rover using 3DROV, a planetary rover simulation framework, and after adding SICONOS successfully simulated the behavior of the rover on a planetary terrain.

- «**ESA ExoMars: Pre-launch PanCam Geometric Modeling and Accuracy Assessment**» focusing on the Panoramic Camera system PanCam. The authors focus on the modelling of the computer vision algorithms behavior on both single and multiple sites analysis, to determine the distance error induced by the cameras resolution and algorithms themselves.

- In «**Airbus Defence and Space**» Airbus provides a top view model of the ExoMars' rover to see the placement of the electronic box and the cables that are connecting the instruments (Fig. 12).

- The authors from «**ESA–G. Porter**» have created a Lego-model to choose what is the best way to drive the rover from its lander module (Fig. 13).

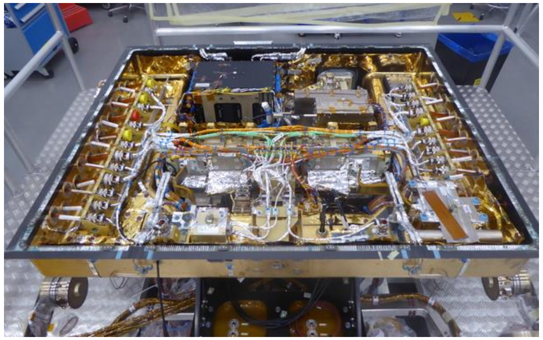

Fig. 12 –OnBoard Electronics Module

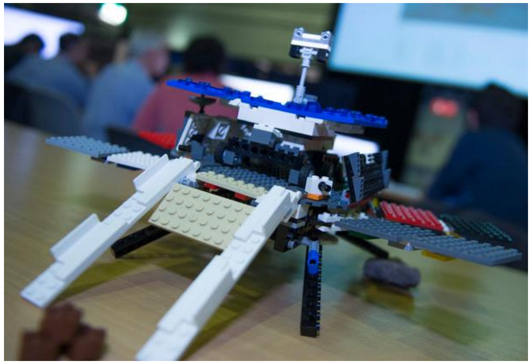

Fig. 13 – The rover's Lego-model and landing module

The rover's simulation network model

The simulation model implements:

- Network and Packet layer of SpaceWire, as well as a part of the Exchange layer. We didn't implement the Error End of Packet (EEP) and error link recovery at this level.
- Transport layer is implemented RMAP protocol. It implement of two modes in write and read type and all packet handling functions.
- The SystemC Core for simulation and C++ environment to determining the basic functionality of the above protocols.

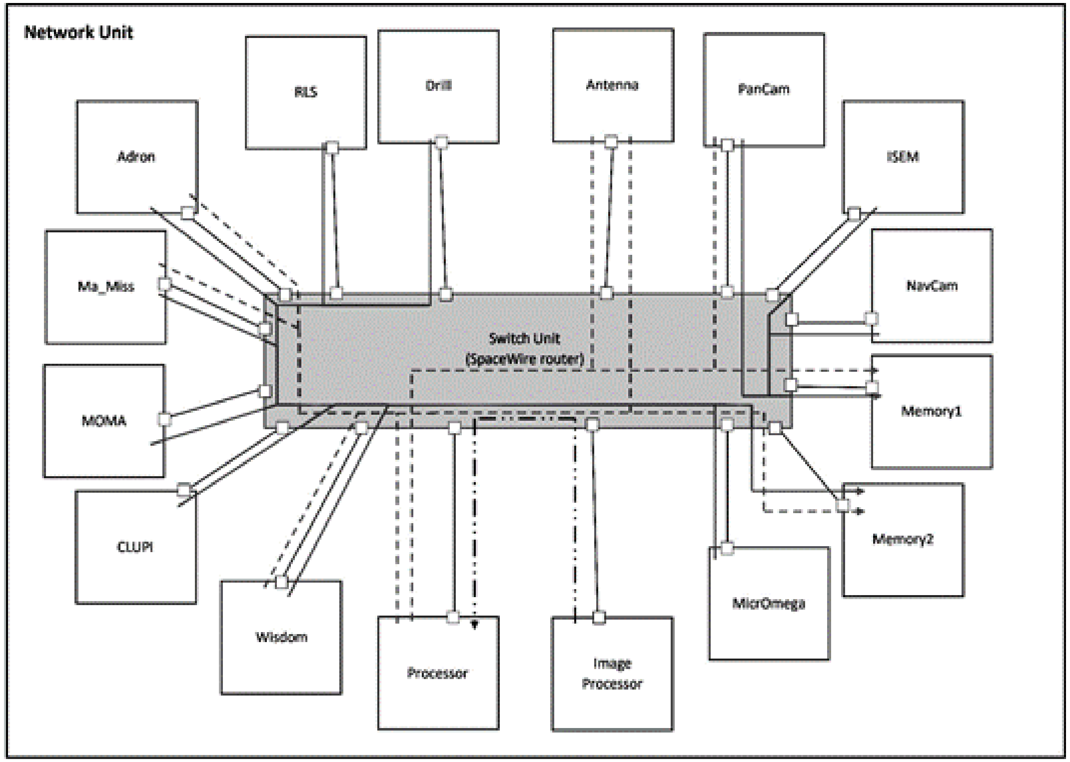

Fig. 14 - Single structure of the ExoMars2020's network

The rover's parallel network model

- Non-intersecting network data flows are selected.
- Based on the selected data flows, the network is splitted into two independent parts (segments) where each part will have own SpaceWire router.
- An image processor and a command processor are added to each resulting network segments.

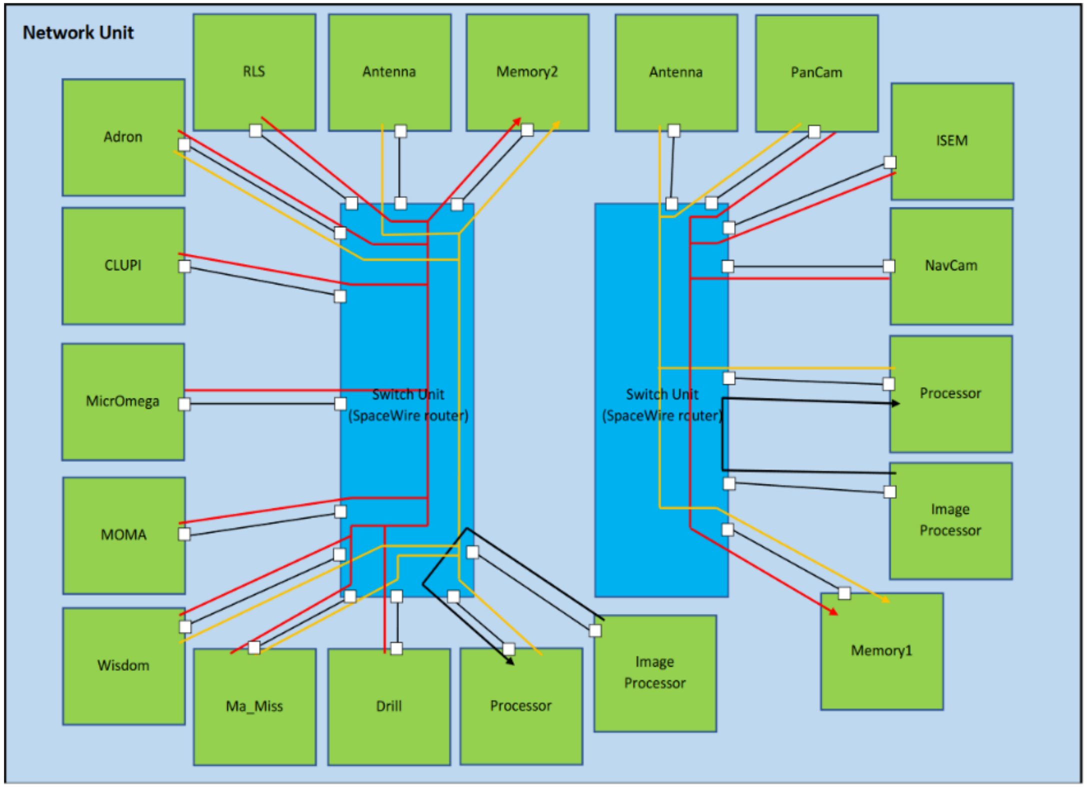

Fig. 15 - Parallel structure of the ExoMars2020's network

Result of the parallel model

- ***We used SQLite as database:***
1. Open Source Project.
2. Embeddable.
3. SQLite stores the entire database as a single cross-platform file on a host machine.
4. Easily included and linked to C/C++ projects.

- We got on a quad-core machine an **increase of performances by a factor 4**, only by running two sub-simulations on two different core without using database.

- We have **no significant performance increase is noticed** when using database logging.

- **Only one** process in SQLite **can be making changes to the database** at any moment in time.

TABLE 1. COMPARISON OF THE TIME EXECUTION'S RESULTS IN SEQUENTIAL IMPLEMENTATION AND PARALLEL IMPLEMENTATION

Model	Not using SQLite	Using SQLite
Single	24.07 s	54.19 s
Parallel	6.28 s	50.47 s

TABLE 2. SPECIFICATION OF THE TEST PC

CPU	Intel Core i5 6th family
Numbers of Cores	4
RAM	8 GB DDR4
HDD	HDD 5400 rpm

Configuration interface to configure the network model

- Model mode (single/parallel) and time simulation settings.
- Node parameters: logical address, frame sizes, speed transmission, error rate generate.
- Packet parameters: amount and size of packet, packet period, start transmission time.
- Database viewer of simulation results.

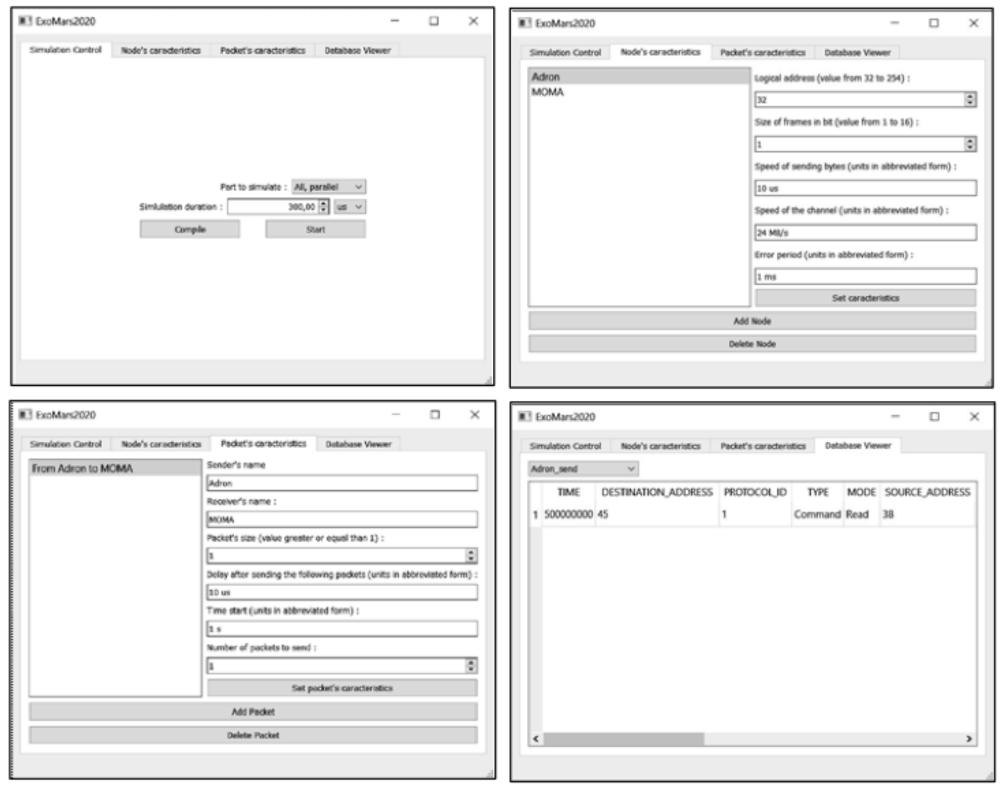

Fig. 16 – Example of Configuration interface

Conclusion

- **We developed** and **ran** a model of the network of ExoMars2020’s rover using SystemC.
- Because little information about the network itself was distributed (most information concerns the scientific research) this model may **not be totally relevant**, but is **a strong basis for future simulations**, if more details about the network’s structure were to be revealed.
- **A database log system was implemented** as well and proved to be efficient to study results of the simulation, while not being efficient when using the parallel implementation of the model. Other database management systems should be studied to be able to run efficiently in parallel.
- Taking advantage of the fact that the network of Exo-Mars2020 **can be split in two independent parts**, we succeeded to divide the modelling time by 4, when not using databases.
- We are still working on a GUI to configure the network and adapt to further information about the network, and study the results of the simulation.
- Information about the results of the parallel model and the database **will be used** in current and future projects of Institute of High-Performance Computer and Network Technologies, SUAI.