E&Q Engineering
Solutions and Innovation

Title: **An exploration rover wheel in the context of a Self-Replicating Rover based on 3D Printing Technology (REPROV)**

21/04/2013

20130421_EQ_ESA_3D Printing Contest

SPACE APPS CHALLENGE: **2013 ESA 3D Printing contest**

Edition: **1**

1. ABSTRACT

An original conceptual 3D design of an exploration rover wheel, suitable for printing, in the context of a more ambitious project called "**Self-Replicating Rover based on 3D printing technologies (REPROV)**" has been carried out and physically printed for the ESA 3D Printing contest.

2. THE SELF-REPLICANT ROVER BASED ON 3D PRINTING TECHNOLOGIES

The **self-replicating machine** is a concept principally proposed by Von Neumann in the forties of the last century. A self-replicating machine can be defined as a system that is capable of autonomously manufacturing a copy of itself **using only raw materials obtained from its environment**.

The **Self-Replicating Rover (REPROV)** is an ambitious concept that could be even catalogued as a science-fiction project, **based on 3D printing technology** with the goal of designing a rover by means of the **capabilities of a self-replicating machine** and also capable of manufacturing other objects and systems from raw material found in planets, moons and asteroids.
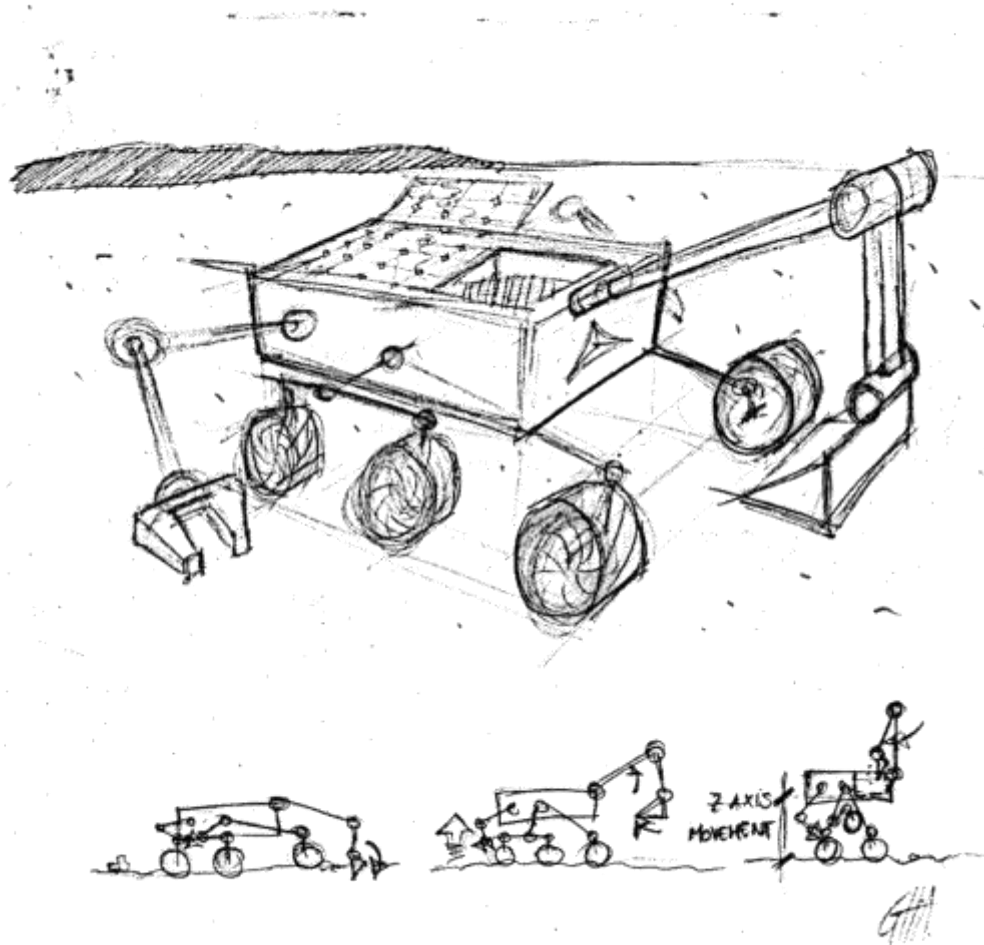

Figure 1. Original sketch of REPROV. General view and details of some movements.

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The main **architecture** of the REPROV has been envisioned as consisting of **five main systems** (excluding common systems such as the energy or the navigation systems and other auxiliary systems):

- ✓ **Rover platform** (provides mobility and serves as structural skeleton or mounting-base of the other systems)
- ✓ **Extracting system** (including sensors and equipment to find and identify the appropriate raw material and robotic shovels to collect it)
- ✓ **Raw material processing system** (processes raw material and feeds the 3D printer)
- ✓ **3D printer** (including hardware and software of the whole REPROV)
- ✓ **Manipulation system** (including robotic arms and tools capable of manipulating the printed objects and assembling the cloned rover)
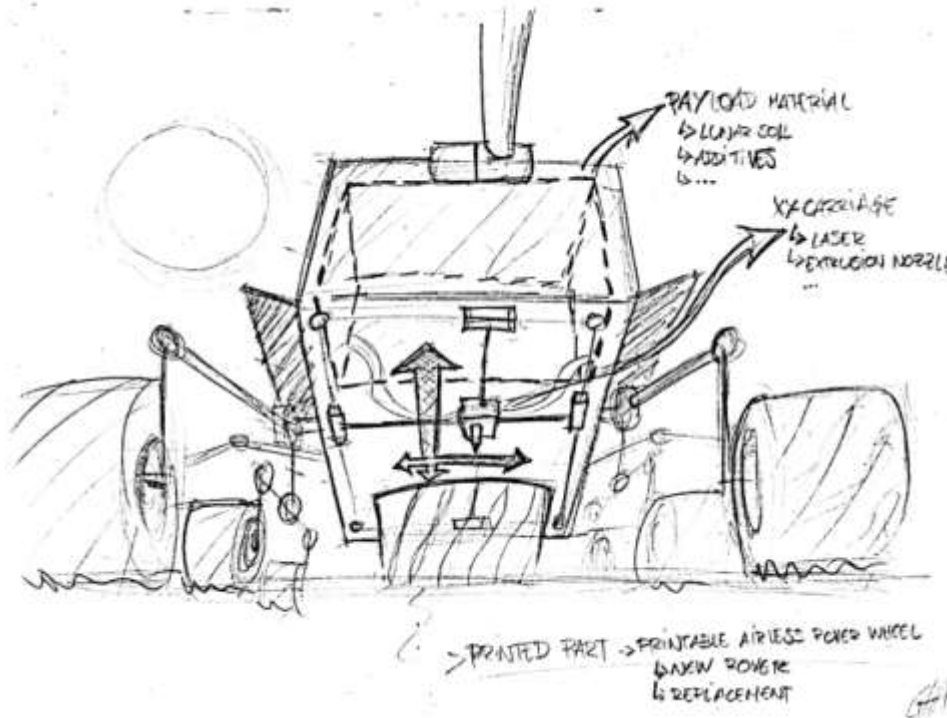

Figure 2. Original sketch of 3D printing process. REPROV prints a new rover wheel.

The potential exploitation of REPROV in space could be impressive in areas such as **mining, space bases and colonization.** Even though in present and future state-of-the-art the rover couldn't fulfill the mission of replicating the totality of its parts, some of them would be transported from Earth saving a great percentage of the total weight of a fleet of self-replicating machines.

Given the intrinsic difficulty and complexity of REPROV the contest team considered that is out of the scope of the "ESA 3D Printing contest" and for this reason only a wheel design of the own REPROV has been presented to the contest (it could be considered as a replicating part or partial REPROV replication).
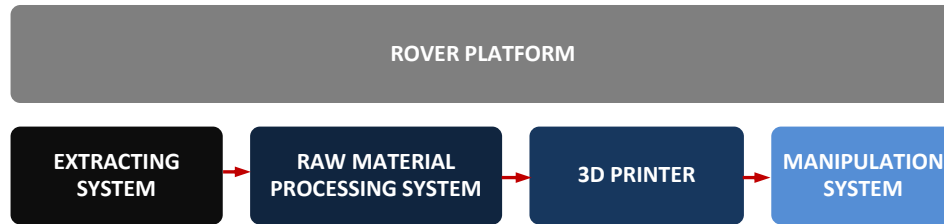
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Figure 3. REPROV main systems.

3. EXPLORATION ROVER WHEEL

Some of the engineering design requirements of the exploration rover wheel that have been addressed are the following:

- ✓ **Wheel-soil interaction** (considering characteristic regolith properties)
- ✓ **Skidding and traction** considering reduced gravity conditions -i.e. Mars, Moon or other natural satellites- (see tread pattern)
- ✓ **Stiffness and damping** (notice curved spokes with variable width design)
- ✓ **Very low-weight** (optimized weight under constraints)
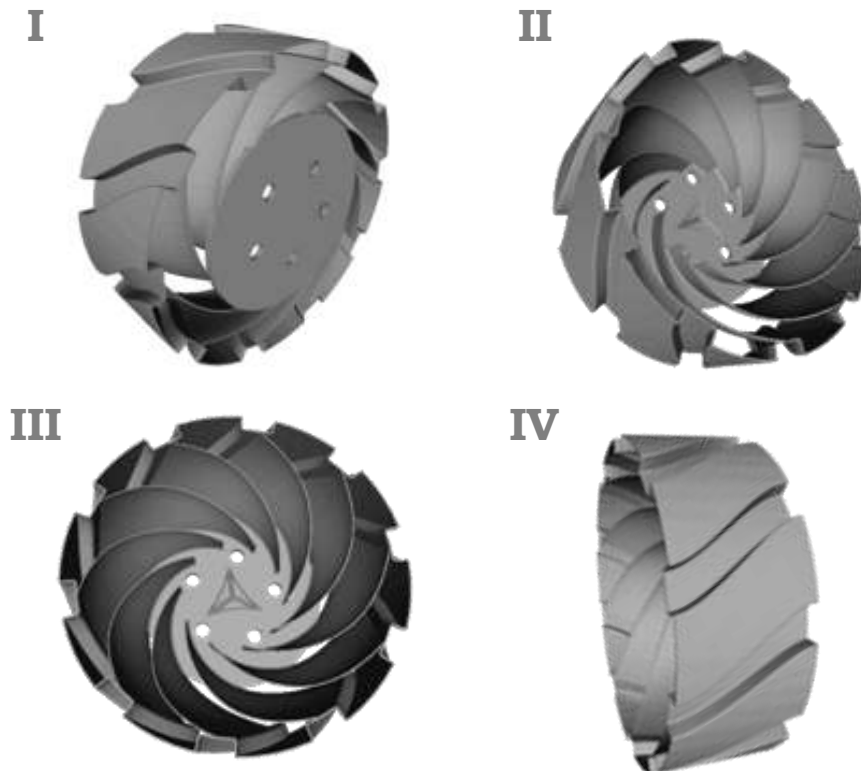- ✓ **Simplicity of manufacturing**

Figure 4. Exploration rover wheel design by E&Q Engineering[1].

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[1] Hubless wheel design to include company logotype.