Multibody Simulations **of a Martian Rover**

By **Team D.I.A.N.A, Politecnico di Torino**

Team DIANA (Ducti Ingenio Accipimus Naturam Astrorum), is a Students Team of Politecnico di Torino working in the research and development of robotics for space applications. The Team produces engineering models of rovers using the latest technologies. Team DIANA wants to bring space robotics to a new level, while providing a platform for experiential learning.

Since its inception in 2008, Team DIANA has created the Lunar Rover Amalia for the Google Lunar XPrize and the Rover T0-R0 (Figure 1), the Martian rover prototype that took part in the European Rover Challenge in Poland in September 2018. In 2019 the team started working on a new Martian rover which is currently being produced and will be tested at the 2019 edition of the European Rover Challenge.

Designing for space always means venturing into the unknown. The primary challenge in the development of a Martian rover is in the uncertainty of the environmental conditions that it is going to operate in. The rover is designed to be able to walk on Martian-like soil, to perform tasks and tests, collect samples and navigate autonomously while withstanding Martian-like geologic conditions (Figure 2). European Rover Challenge represents an unparalleled opportunity for the Team to test the Rover's mobility system in a Martian-like environment. To test the capabilities of T0-R0 rover, during the European Rover Challenge 2018, we simulated the Martian soil in its harshest forms using multi-body simulations in Adams. Since the characteristics of the competition soil were unknown, a virtual study with the worst case conditions were performed. This allowed us to identify the specific motors needed to power up the rocker boogie mobility system and to define the dimensions of the transmission system and suspension springs.

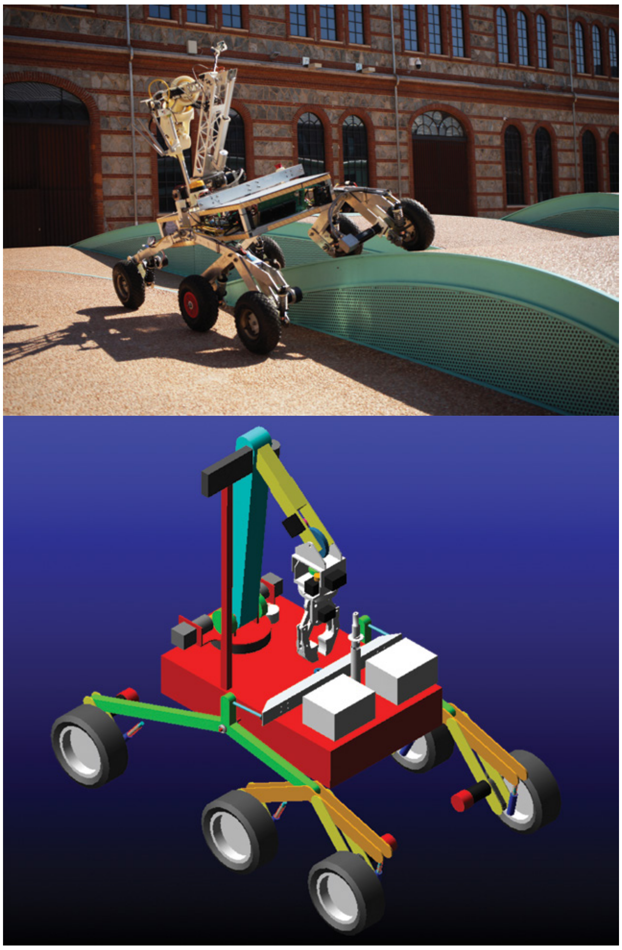

Figure 1 The T0-R0 rover and its Adams model

In the preliminary design stages of the T0-R0 Rover, uncertainties concerning the mobility system were resolved thanks to Multi-body simulations in Adams. T0-R0 Rover is based on a rocker boogie mobility system, with six wheels and four independent electric motors. This system allows stabilization of the rover's payload (electronics, computer and batteries) during navigation on rough soil, with rocks and obstacles.

The first step in the simulation process was the construction of the rover model in Adams/View with a simplified geometry, with correct dimensions and inertial proprieties of the involved parts. Then the entire model was verified, and roads with soft soil and a model of a pneumatic wheel (Figure 3) were added thanks to

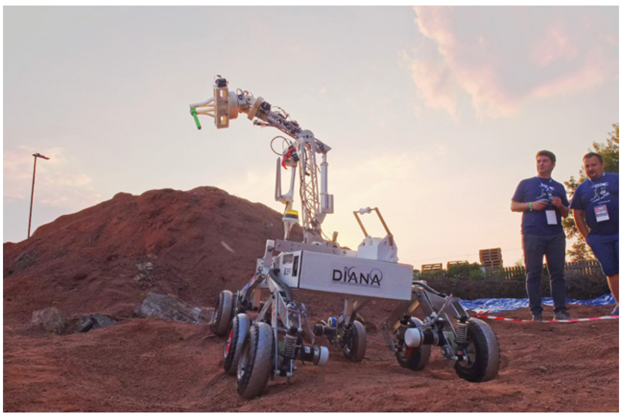

Figure 2 Testing of the T0-R0 rover on soft soil

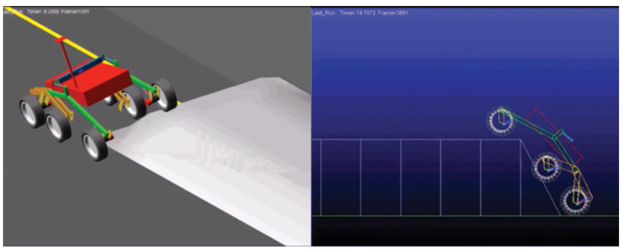

Figure 3 Virtual Testing of the Rover using Adams

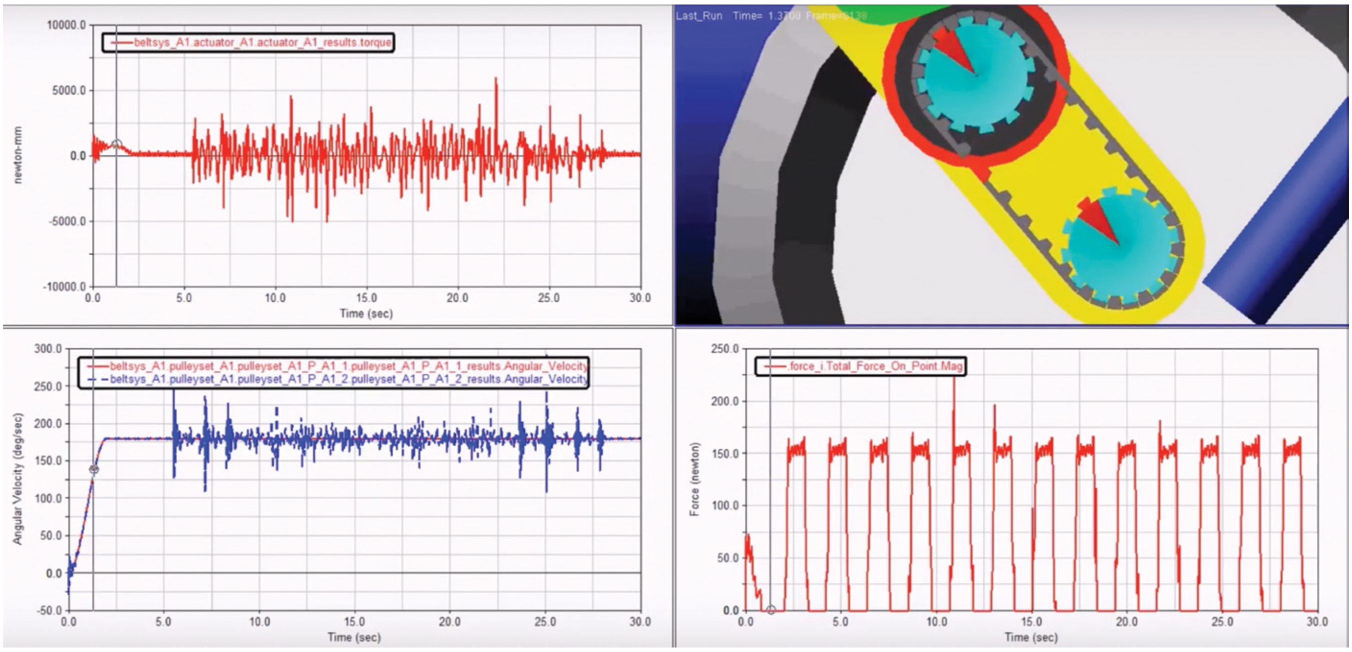

Figure 4 Belt Transmission Systems Model Using Adams/Machinery

Adam/Tire tool to evaluate the power required for the motors to achieve a speed of 3 Km/Hr.

The parametric nature of Adams allows an understanding of the relationships between the design elements in the model and the performance requirements. For example, it was possible to change the position of the hinges that connect the rocker to the chassis with ease, saving a considerable amount of time. Furthermore, the use of design variables allowed us to capture the effect of variation of certain parameters on the dynamic behavior of the vehicle.

Adams also allowed us to model the belt transmission system (Figure 4) using the Adams/Machinery tool. The study of the deformations and the stresses to which the springs are subject to were carried out considering the vehicle in different operative conditions, for example in presence of an irregular path or when encountering obstacles.

The simulations performed in the virtual Adams environment allowed the team to explore limits of the structure and to build a rover capable of walking on Martian-like terrain and performing all the required operations with the construction of a single prototype and one short year of development. The rover, once built, performed as expected in the tasks of the competition and on Martian soil, confirming a good capability of motion on the terrain thanks to the insight obtained from simulations.

The Team is now designing a new rover (Figure 5) with steering wheels to achieve better maneuverability while performing tasks. Adams is being used to study the geometries of the steering mechanism of the new mobility system. The new Rover will be tested through the participation at the 2019 edition of European Rover Challenge.

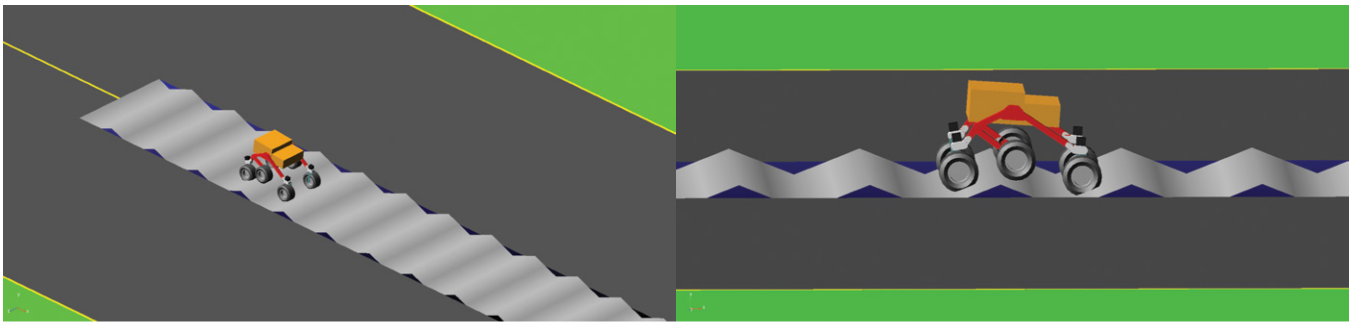

Figure 5 Testing of the new rover for the 2019 European Rover Challenge