LANDING SITE MODELLING FOR THE PULI / HUNVEYOR-15 LUNAR ROVER PROTOTYPE. T. Látos[1], M. Deák[1,2] and Sz. Bérczi[3] [1]Puli Space Technologies Ltd. 1161 Budapest, Csömöri út 161. (tamas.latos@pulispace.com), [2]Eötvös University, Dept. of Physical Geography Institute of Geography and Earth Sciences, Budapest 1117, Pázmány P. s. 1/a, Hungary (dmarton@elte.hu),[3] Eötvös University, Dept. G. Physics, Cosmic Materials Space Research Group, Budapest 1117, Pázmány P. s. 1/a, Hungary, (bercziszani@ludens.elte.hu)

Indroduction: Today the private industry is becoming more and more important, even in the field of lunar exploration. The goal of the international competition, the Google Lunar X-Prize (GLXP) is to send a private-funded rover to the Moon - the Hungarian Team Puli Space is also participating. According to the rules of the GLXP, the first team, who's probe capable roving 500 meters and streaming HD video arrives before the next national lander, will be the winner.

Team Puli is now in the second stage of development ("Iteration 2"), cooperating with the Hungarian educational space probe program: "Hunveyor". This rover will be the first prototype what is able to be tested on a ground-modeling table. It serves an educational porpuse, but hopefully it is also a basis for a "sharp" lunar rover.

Our goal was creating a grond modeling-table, where we can test the basic movement capabilities of our rover. We designed a field reflecting the morphology of the lunar mare areas, and tried to find a good mechanic analogy for the lunar soil.

Rover concept: During the design of the Hunveyor-15, GLXP requirements were considered greatly – our primary goal was, that the rover should be able to cross any surface obstacles possible on the Moon. One of the most important parts of the rover – just like in the case of the Lunar Buggy designed by Ferenc Pavlics – are the wheels. We did not use "traditional" wheels whith hoops, but tried a new, wheel-leg ("WHEG") concept. It has only spokes which are not only in the dimension of the not-present hoops, but also 45°, and 90° diverged as well (Fig. 1.).

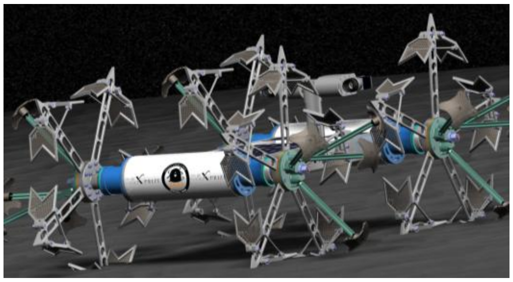

Fig. 1.: The Concept of the Hunveyor-15

Due to this design the rover is able to have higher stability even on rough terrain, move tipped and climb over obstacles approximately the same size as he is.

Ground modeling: The ground modeling-table consists of three different morphologic segments, where we can test different aspects of the rover. Our goal was to simulate the movement capabilities of our rover on the typical morphology of the landing site candidates of Team Puli Space (see: [1]). For this, we designed a 32 m^2 ground modeling table (Fig. 2.).

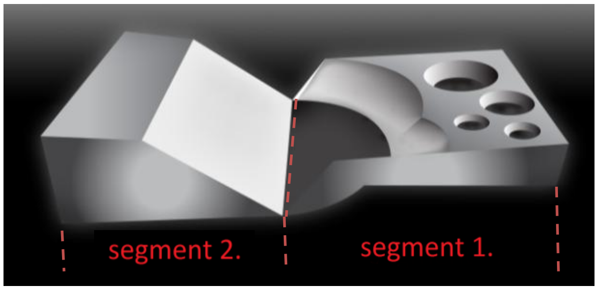

Fig. 2.: The view plan of the table

The first and second segment is covered in 20 cm with our moon-dust analogy and the surface cover of the third is variable.

<u>Segment 1:</u> The biggest area on the table tries to simulate the morphology of the lunar mare areas. The most important elements of this segment are the relatively small (up to 2,5 m radius) impact craters. We tried to make a diverse morphology, so there are overrid landforms as well. During the creation of the craters we used the typical 0,14-0,2 depth-diameter ratio [2]. For the size-density distribution of the craters we also used data determined in earlier publications [3]. We tried to consider the age of the craters, so we simulated ejecta, eroded landforms – for example fractured rims. Thus we created craters with the following radii: one 2,5 m, one overridden 1 m, one 0,75 m, one 0,5 m and two 0,3 m forms. In our experience, creating bigger craters than these would have been rather pointless, because the change of surface morphology would be so small, that in itself it wouldn't affect the movement capabilities of the rover.

<u>Segment 2:</u> For the analysis of movement on different slope grades, we designed a 3,4 m x 4 m area, with an adjustable slope, connecting straight to Segment 1. We'll use this to simulate slope grades, which are absent in the static morphology on other

parts of the table. Moving diagonally upwards is easier on steep crater terrain – we'd like to test that on this area of the ground-modelling table too. The adjustable area will have two different stages (Fig. 3.): in the first case the upper component will be horizontal – so we can simulate quick changes in the morphology, experienced for example by climbing out of a crater. The second version is, that the upper component will continue without change in the slope inclination compared to the lower component. In this case we can simulate movement in longer, steep areas.

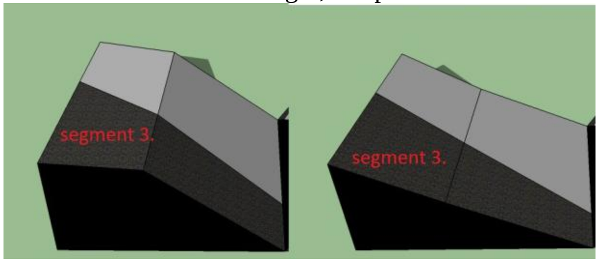

Fig. 3.: The two stages of the adjustable area

Segment 3: The surface on the side of segment two will be changeable. We have different plates covered with diverse size and homogenity of dust and rocks, from the size of 0,2 mm to 50 mm. Using this we can analyize the movement capabilities of our prototype on different types of surface cover.

Simulating moon dust: Altough there are lunar simulants designed directly for these tasks – for example the JSC-1 [4], we tried to find new moon dust analogies for our ground-modeling table. We analized grinded limestone (Fig. 4/A), grinded glass fiber (Fig. 4/B.) and hydrated alumina - $Al(OH)_3$ (Fig. 4/C.).

Every one of the samples had approximately the same grain size distribution as mature lunar soils (peak around 40 μm [5]), we decided to use hydrated alumina. The density is very similar to the moon dust (1,15 g/cm^3 in comparion of moon dust's 1-1,5 g/cm^3 [6]), but what is more important, the particle shape is similar to the shape of the moon dust grains.

The grinded glass-fiber turned out to be too dense, and due to the size and shape of it's grains, they're sticking too hard to eachother, so they do not show the loose structure of the lunar soil.

The grinded limestone shows better similarities to the moon dust, but only when the grains are distributed evenly according to their size. As soon as they are mixing – even by gravitational movement – they became adhesive. This type of dust would be better than the grinded glass-fiber, but the shape of the grains shows almost no similarities to the lunar soil.

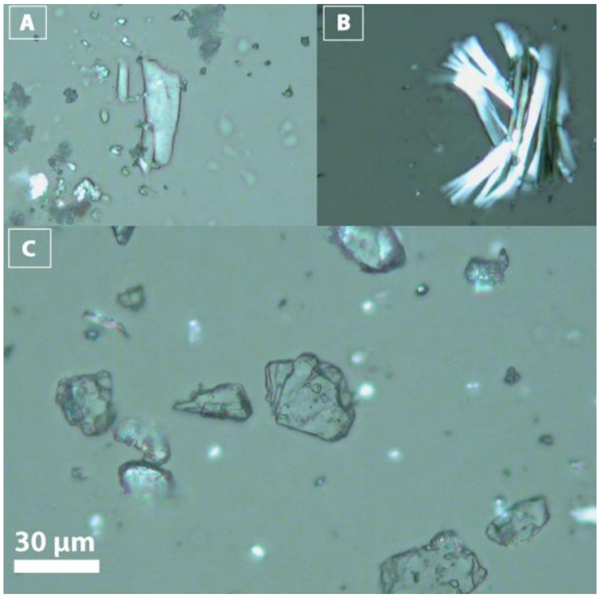

Fig. 4.: Images were captured by a ZEISS axioskop, under 200X maginification with partially crossed nicols
A: grinded limestone, B: grinded glass fiber, C: hydrated-alumina

Future plans: We plan to analyze further samples, for example grinded basalt – which would be a better chemical analogy (although the goal of this research is to find only a mechanical analogy). We plan to analyze the particle shapes and grain size even further, describing their geometry by mathematical numbers and to compare it to lunar soil samples.

We also plan to develop our ground-modeling table, adding some more functions, like simulating illumination with reflectors or lunar gravity with cranes.

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