**PLANETARY TERRAIN TABLES (TESTYARDS), INTERACTIONS AND EXPERIMENTS IN THE HUNVEYOR PROGRAM: A NEW TOOL IN PLANETARY SCIENCE EDUCATION.** Sz. Bérczi[1], S. Hegyi[2], Gy. Hudoba[3], I. Ságodi[4], Z. Horváth[5], H. Hargitai[6], M. Polgári[7,8], I. Gyollai[7], A. Gucsik[8], P.G. Vizi[9], [1]Eötvös University, Faculty of Science, Dept. of Materials Physics, Cosmic Materials Space Res. Group, 1117 Budapest, Pázmány P. s. 1/a. Hungary, (bercziszani@staff.elte.hu), [2]Pécs University, Faculty of Science, H-7624 Pécs, Ifjúság u. 6, (hegyis@ttk.pte.hu), [3]Óbuda University, Faculty of Electrical Engineering, Inst. of Computer Technology, Székesfehérvár, Hungary (hudoba.gyorgy@amk.uni-obuda.hu), [4]Szekszárdi Garay János High School, H-7100 Szekszárd, Szent István tér 7-9. Hungary, (ibolyasagodi5@gmail.com), [5]Budai Ciszterci Szent Imre High School, H-1114 Budapest, Villányi út 27.Hungary, (hozoli.mail@gmail.com), [6]Eötvös University, Budapest H-1088 Múzeum krt. 6-8. Hungary, (hargitaih@caesar.elte.hu), [7]Institute for Geological and Geochemical Research, RCAES, ELKH, H-1112 Budapest, Budaörsi u. 45, Hungary, (rodokrozit@gmail.com), (gyildi@gmail.com), [8]Eszterházy Károly Catholic University, Fac. of Science, H-3300 Eger, Leányka str. 6, Hungary, [9]MTA Wigner RCP H-1121 Budapest, Konkoly Th. 29-33. (vizi.pal.gabor@wigner.hu),

**Introduction:** Hunveyors are a series of educational spacecraft models developed in formal educational frameworks in Hungary. Our previous efforts focused on building the spacecraft model (Hunveyor lander, and Husar rover types), and designing measurements students can perform. In this new series of experiments, the possibilities for variation are expanded by being able to modify and manipulate the terrain (terrain table model, or sand table) where the lander operates [1,2] The testing terrains may have a set arrangement (e.g. a mosaic of soil types), or changes may be induced (wind forms by blowing, changing light conditions, etc.)

**Testing terrain table model (Fig. 1.) with variable components:** In the Hunveyor Husar (lander, rover) program, the educational robot ensemble took surface measurements of the planet. These are designed, built and the experiments are carried out and evaluated as a joint work of teachers and students. The aim of the research was also to examine the extent to which high school students' physical science knowledge and interest in science can be deepened by carrying out robotic measurements on a simulated physical planetary surface. The method was not to get the results ready for the student, but get them involved in the measurement, design and construction work at as many points as possible.

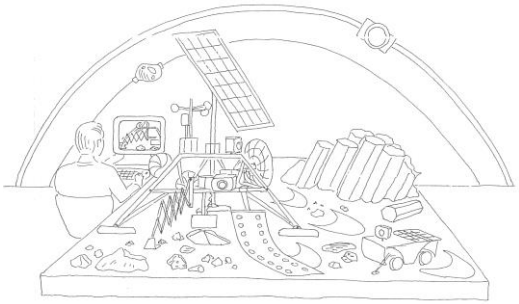

*Fig. 1. The arrangement of the Hunveyor-Husar educational planetary landed and rovering models in the TESTYARD, supported with various instruments for the students experiments*

The experimental background was: the space probe model, which has already landed on the planetary body, is on the field table: that is now the Hunveyor-18. (The model is running on the loaned Hunveyor-16 model from Székesfehérvár, Fig. 2.) The novelty in the Hunveyor experiment series now is the field table that is also involved in the design, experiments and measurements.

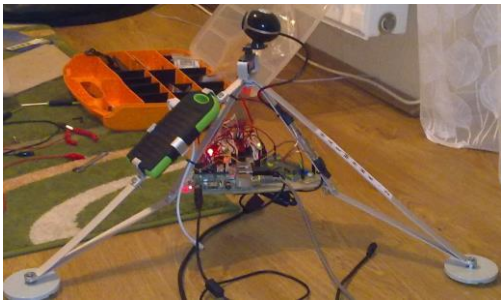

*Fig. 2. The Hunveyor-16 model built by Máté Tóth, student of Dr. Hudoba at Székesfehérvár.*

**Testing terrain table characteristics:** On the terrain table, several important environmental factors, physical parameters (e.g., magnetic field, soil type, moisture content, temperature, pH, etc.) may be modified as if events were taking place on the surface of a planet. The size of the table is 2 meters by 3 meters (placed in the physics hall of the Szent Imre High school). The materials to be measured and the space-adjusting aids arranged on it are as follows: soil types, magnetic coils with which the magnetic field can be created and changed, the possibility of adding moisture and various chemical substances, heating units, light sources, etc. Adjusting the planet's surface conditions is also part of the experiment.

On the “planetary testing table,” the following planetary physical, environmental-physical experiments and measurements are included in the work plan so far.

**pH -** Measurement of the acidity-alkalinity of each soil region (similar to previous Husar-5 measurements). We arrange as surface mosaic of 4 different soil types

with different acid-base pH. Mapping this pH-field is one of the top tasks for the Husar-18 rover. [4]

**Light -** Measuring the incoming light and examining its usability as an energy source (Hunveyor-2) light can play an important role on the test terrain table. Pécs University's Hunveyor-2 group first lit solar-powered rovers with conventional bulbs. But reliable results (solar charging) were achieved only with our LED lamps mounted on the field and adjustable with natural light and sunlight. After illuminating the planetary terrain table and considering the role of light, we call the attention of the terrain table builders to the heating of the terrain table, too. This may induce new measurement and testing possibilities.

**Magnetism -** Measurement of the magnetic field on the field table in the vicinity of Hunveyor-18 – and estimation of the magnetic particle content of the soil on a carpet containing hidden magnetic patches (we saw such experiment on Pathfinder and performed such measurements on Hunveyor-9). [5]

**The effects of the wind -** Formation of wind-blown forms of surface debris as a function of wind speed (testing of air-blowing devices). The change of soil forms can be studied under winds of different strengths. In addition to the hair dryer, we also blew the air with a fan removed from a car and recorded the changes with a camera. (The fan removed from the car after the performance is a stage of development of the industrial vacuum cleaner).

**Soil moisture -** The change of soil moisture is examined by measuring the electrical flow conditions of the soil areas.

**Temperature conditions -** Temperature measurements on the particulate surface and in the light shade show different values. (The latter can be supplemented by heating some areas on the terrain table a bit, others cooling - the use of a thermal imager is also considered. N.B., architects now recommend underfloor heating and ceiling cooling to their home builders.) In a planetary model experiment, a heated or cooled terrain table will motivate for more experiments, and the simulation practice will be even closer to real-world conditions. (A practical realization is: Arduino student's has several modules with sensors, for example for soil, temperature, infrared emission, vibration, microphone sound, water level sensors.)[6]

**Smart phone** - An additional device can be a mobile phone that serves as a mini spacecraft module with its own platform, instruments and software.

**Benefits, summary:** Although the test terrain table has been used before with the Hunveyor-Husar educational space probe modules [7,8], the present research focuses on the terrain table itself. In what area of planetary sciences does this system help to develop the student's knowledge? What physics chapters and measurements can we teach differently? First: the planetary environment forms a system. System approach is useful to reveal more complex systems in the experiment: (1) the side of the measuring spacecraft models and (2) the side of the testyard table. (In fact, a third player is involved: smart phone capability.) Examples are: measurement of magnetic field, of temperature field, of pH field of soils grainsize field around the modules, with magnetic properties of materials, grinds, soils, effect of liquid on the electrical conductivity of soils, effect of wind current on the surface forms of fine-grained materials.

**Summary of the work:** Students gain knowledge and are motivated to conduct their own experiments through the framework of the Hunveryor, Husar – terrain table setting together with teachers, in a joint work. This experiment also simulates cooperation between mission scientists and co-planning, execution and post-measurement analysis of the experiments. With their knowledge of the disciplines of planetary environmental physics, the students are expected to be even more open to other natural and environmental sciences, and the method can be successfully applied to talent management as well.

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