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A flight of a spaceship along the trajectory “the Earth–the Moon–Mars–the Earth” with one corrective thrust

N. I. Perov (1, 2)
(1) Cultural and Educational Centre named after V.V. Tereshkova, Yaroslavl, Russian Federation. (2) State Pedagogical University named after K.D. Ushinskii, Yaroslavl, Russian Federation (perov@yarplaneta.ru / Fax: +7 (4852) 72-68-37)

1. Introduction

In present, the investigations of the Moon, Mars and small bodies of the Solar system with help of spaceships and artificial satellites with using minimal amount of fuel and maximal mass of scientific techniques with returning at the Earth are of the great interest. Below we are modelling the flight of the interplanetary spaceship with one corrective thrust. The spaceship approaches the Moon and Mars in the gravitational fields of the Sun, the Earth, the Moon and Mars and returns at the Earth. Let’s denote - G is gravitational constant, $\mathbf{r}$ is heliocentric radius-vector of the spaceship, $\mathbf{r}_E$ is heliocentric radius-vector of the Earth, $\mathbf{r}_{EM}$ is geocentric radius-vector of the Moon, $\mathbf{r}_A$ is heliocentric radius-vector of Mars, m_S is mass of the Sun, m_E is mass of the Earth, m_M is mass of the Moon, m_A is mass of Mars, v_E is true anomaly of the Earth, $v_M=v_{M0}+kv_E$ is true anomaly of the Moon, $v_A=v_{A0}+mv_E$ is true anomaly of the Mars. Here, k and m are ratios of the orbital angular velocities of the Moon and Mars in respect of the orbital angular velocity of the Earth ω_E. The orbits of the planets are circle and lie in one plane. The in depended variable is v_E, coincided in the given planar celestial mechanical model with mean anomaly of the planet (the Earth) and $dv_E/dt=\omega_E$). We are needed to find initial velocity d$\mathbf{v}$ of the spaceship in respect of the Earth, initial positions of the Moon and Mars - v_{A0} and v_{M0}, correspondingly, for which the distances between the ship and the Moon and then between the ship and Mars are minimal and almost are equal to the radii of these natural celestial bodies.

2. The Fundamental equation

The differential equation of the spaceship motion we write in the vector form with one independed variable v_E. The unknown function is $\mathbf{r}$. So, for the given five body problem we have

$$(d^2\mathbf{r}/dv_E^2)\,\omega_E^2 = -Gm_S\mathbf{r}/r^3-$$

$$Gm_E\,(\mathbf{r}-\mathbf{r}_E)/\,|\,\mathbf{r}-\mathbf{r}_E\,|^3-$$

$$Gm_M\,(\mathbf{r}-\mathbf{r}_E-\mathbf{r}_{EM})/\,|\,\mathbf{r}-\mathbf{r}_E-\mathbf{r}_{EM}\,|^3-$$

$$Gm_A\,(\mathbf{r}-\mathbf{r}_A)/\,|\,\mathbf{r}-\mathbf{r}_A\,|^3 \qquad (1)$$

3. Example

In a serial of numerical evaluations some unknown parameters are found: dv=11700 m/s (d$\mathbf{v}$ and the vector of heliocentric velocity of the Earth are oriented perpendicularly to each other; v_{M0}=0.727 radians; v_{A0}=0.69027 radians. For v_E =2.861135 rad the distance between Mars and the spaceship is minimal. (The true (mean) anomaly is measured from the initial position of the vector “the Sun – the Earth”). The minimal distances between the spaceship and the Moon and the spaceship and Mars are equal to 0.000012390865 AU=1855 km and 0.000034 AU=5206 km correspondingly. For v_{A0}=0.6903 rad the spaceship collides with Mars (the distance between the spaceship and the center of Mars equals 10^{-5} AU). In this case the effect of “the key holes” takes place, e.g. the negligible variations of the initial conditions give the catastrophe [1]. In Fig. 1 the heliocentric trajectory of the spaceship is presented and boundaries of the movement of the spaceship are orbits of Venus and the Maine belt of asteroids. Fig. 2 illustrates approaching the spaceship and the Moon. Fig. 3 demonstrates the closing approaching the spaceship and Mars. Fig. 4 shows the value of approaching the spaceship and the Earth after dozens revolutions of the spaceship around the Sun.

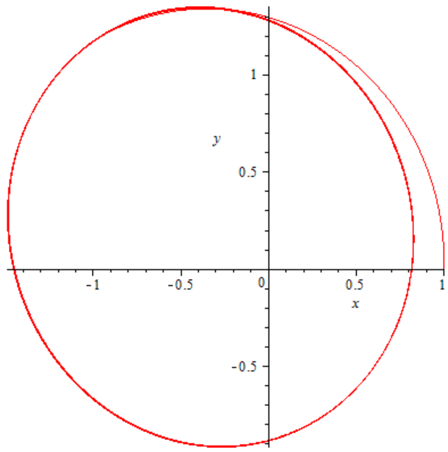

Figure 1: The trajectory of the spaceship in respect of the Sun. The distance is measured in the astronomical units.

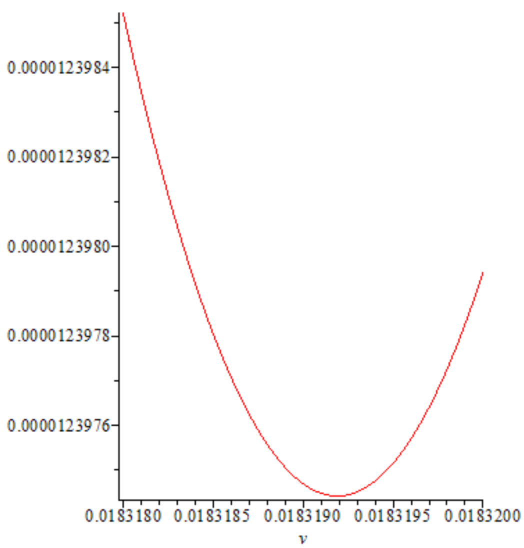

Figure 2: The minimal distance between the spaceship and the Moon is measured in the astronomical units. v is the true anomaly of the Earth is measured in radians.

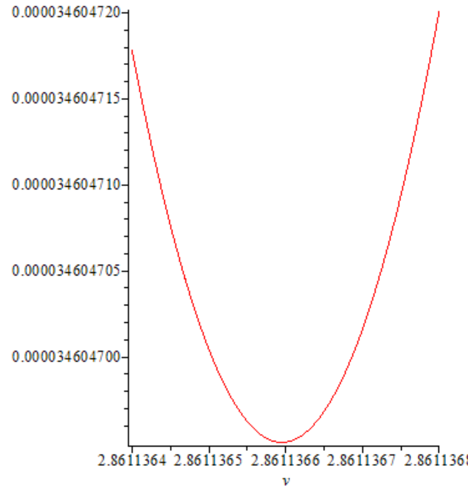

Figure 3: The minimal distance between the spaceship and Mars in astronomical units. v is the true anomaly of the Earth in radians.

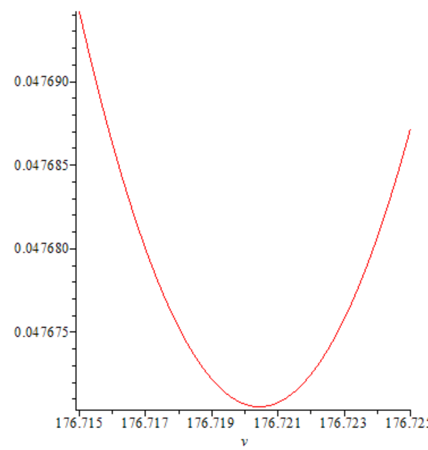

Figure 4: Approaching the spaceship and the Earth. The distance is measured in astronomical units and the true anomaly of the Earth is measured in radians.

4. Conclusions

Searching for the initial conditions for the flights of the interplanetary spaceships with one corrective thrust is refer to the researching method of education and facilitates to organize scientific work of students.

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OpenPlanetaryMap: Building the first Open Planetary Mapping and Social platform for researchers, educators, storytellers, and the general public

N. Manaud[1], A. Nass[2], M. Lewando[3], S. van Gasselt[4], A.P. Rossi[5], T. Hare[6], J. Carter[7], H. Hargitai[8], [1]SpaceFrog Design, Toulouse, France; nicolas@spacefrog.design, [2]German Aerospace Center, Institute of Planetary Research, Berlin, Germany, [3]CodeMacabre, UK, [4]Department of Geoinformatics, University of Seoul, Seoul, South Korea, [5]Department of Physics and Earth Sciences, Jacobs-University Bremen, Bremen, Germany, [6]U. S. Geological Survey, Astrogeology Team, Flagstaff, USA, [7]Institut d'Astrophysique Spatial, Orsay, France,[8]NASA Ames Research Center/ NPP, Moffett Field, USA

Abstract

We will present at this conference the first public version and lessons learnt from *OpenPlanetaryMap*, a new collaborative project to build the first Open Planetary Mapping and Social platform for researchers, educators, storytellers, and the general public. We hope to engage with and collect feedback from the scientific and outreach community.

1. Introduction

The popularity and ubiquity of web interactive maps constitute a powerful leverage for telling stories, educating and engaging a wide and diverse audience with planetary sciences. A few excellent planetary interactive maps [e.g. 1,2,3] exist but they are either too complex for non-experts, or they are closed-systems that do not allow for collaborative learning, social interactions, and reusability of data.

OpenPlanetaryMap (OPM) is a collaborative effort from within the OpenPlanetary community [4] and based "Where On Mars?", a previous outreach project to visualise ESA's ExoMars Rover landing sites candidates [5]. OPM is supported and made possible thank to CARTO [6] through their Grant Program.

Our long-term vision is to build a community around an Open Planetary Mapping and Social platform for space enthusiasts, planetary scientists, educators and storytellers. Our goal is to enable them to easily and collaboratively create and share location-based knowledge and maps of others planets of our Solar System.

2. Objectives

Web Map Interface. As part of this platform, we will develop a web map interface that will make it easy and enjoyable for novice people to discover, search, share, discuss and add their own places on Mars (we will expand to other planets in a second stage). We aim to provide a social experience that will help creating an emotional connection with Mars and incentives to learn and share knowledge about it.

Open Datasets Repository. A key element of the platform will be an open datasets repository containing a curated selection of location-based information and places of interest about Martian geography, topography, geology, weather, climate, scientific missions and discoveries, robotic and human exploration. These scientifically accurate data sets, along with public crowdsourced datasets, will be programmatically accessible and reusable by others to develop third-party applications for specific scientific or outreach purposes.

Basemap. We will also design and implement at least one beautifully crafted vector-based basemap of Mars that will serve as the base layer of our web map interface and enrich its overall user experience. It will be made publicly available to foster the creation by others of theme-based maps of Mars that can be easily shared on the web and social media.

3. Initial concepts

Initially, the places on Mars the audience will learn about will include information from curated datasets, as well as from a public crowdsourced dataset of *Places*. These Places will either be related to a physical object or phenomenon (i.e.: crater, dune, gully, dust devil, cloud), or to a more abstract one that contributes to increasing knowledge of Mars (i.e.: scientific publication, blog article, Wikipedia page, tweet, panoramic image, video, question, story, event). Our audience will also learn from discussions they have with each other, including with planetary scientists.

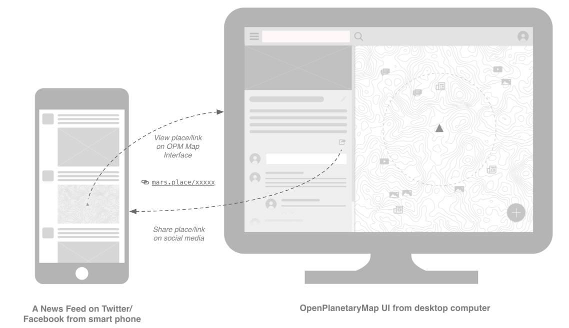

Figure 1: This illustrates the basic concept for the OPM web map interface and sharing places.

One particular requirement that is key to the success of our platform is the capability to handle multiple users and groups for our project team of planetary scientists and cartographers to collaboratively store and manage, publicly and privately share, datasets.

The OPM platform will almost entirely rely on the CARTO Engine and Builder.

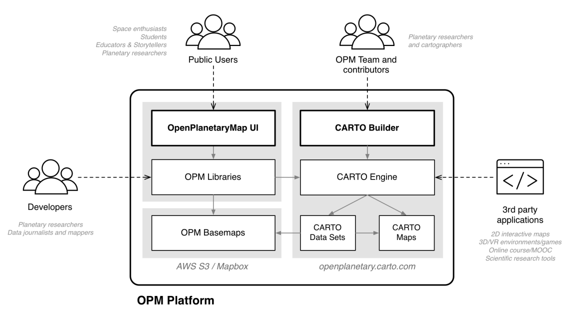

Figure 2: This illustrates how CARTO will fit into the OPM platform, and what users and applications interact with it.

4. Approach

We are a small interdisciplinary and international team of researchers, developers and designers passionate about planetary mapping and cartography. We started to form our team in January 2017 and held a first meeting in Berlin two months later to kick-off the project. Throughout the project, we will adopt an iterative development approach and try to follow a user-centered design process as much as possible; including user research, prototyping and testing methods. We will organize co-located hackathons at planetary data workshops and other events, to learn from potential users and experts, and stay in line with our objectives.

Being collaborative by nature, we will encourage everyone who is interested in this project to contribute [7,8] with their expertise: in planetary cartography, web development, geospatial data processing or any other areas that we haven't yet thought of.

5. Intended outcome and impact

We aim to make novice people feel that Mars is at their reach, both in terms of knowledge and preconceived physical proximity. We want them to use our future web application to quickly and regularly learn something about Mars, just like people head to Google Maps to find their bearings or any location-based information.

With an Open Data and Open Science philosophy in mind, we aim to encourage planetary scientists and mappers to share and collaborate on research data sets in a way that is beneficial to all parties: peers, graduate students, science communicators and the general public.

We aim to encourage science communicators, educators and storytellers to contextualise more their publications or resources by providing better location information, so as to allow their audience for further exploration and better understanding of a related topic or story.

Being an open source project, we also hope to encourage a younger audience of STEM students to apply or acquire new skills in cartography, Geographical Information System (GIS), and programming, by contributing to the OPM software and platform development.

Acknowledgements

We warmly thank the CARTO team for believing in this project and for their outstanding support through their Grant Program. A special thanks go to: Javier de la Torre, Sergio Álvarez Leiva, Andrew Hill, Stuart Lynn, Tyler Bird , Oriol Boix, Carla Iriberri, Dani Carrión, Javi Santana, Alejandro Martínez, and Carlos Matallín.

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A School Competition on the computation of the solar parallax using observations from the Mercury Transit of 9 May 2016 – Results and Discussion

J. J. Zender (1), R. Barnes (1), H. J. Zuidervaart (2), J.J. Benkhoff (1), S. Martinez (3), M.G. Breitfellner (3),M. Almeida (3)

(1)European Space Agency, ESTEC, Noordwijk, The Netherlands (2) Huygens Institute of History in the Netherlands, Amsterdam, The Netherlands (3) European Space Agency, ESAC, Villanueva de la Canada, Madrid, Spain

Abstract

We report on the school event, a competition like activity, around the Mercury transit on 9 May 2016. With the historical background in mind, especially the fact that the Mercury transit data were never used to calculate the solar parallax, we asked all participating schools to do actually this. From the participating schools we received not only interesting results, but very positive feedback on the excitement "to be a scientist" for a day.

1. Introduction

On 9 May 2016 an intriguing and rare event occurred. Seen from most countries in Europe, Mercury, the planet nearest to the Sun, crossed the Sun's surface. Such a phenomenon is better known for the moon, for during such an eclipse it gets dark (or darker), so everyone will notice that something special is going on. But as Mercury is very, very small compared to the Sun, one will never remark such a Mercury-eclipse by oneself.

It was the famous astronomer Johannes Kepler who realized in 1601 that Mercury (or Venus) transits could be observed from the Earth. Later in 1691, Edmund Halley published a mathematical algorithm to compute the solar parallax (from which one can determine the distance from Earth to the Sun) from observations made during the transit. It is sad to note that neither of the both scientists had the chance to witness a Mercury transit during their lifetime.

Well before the event, the ESA Communication Office announced a school competition to observe the Mercury transit and repeat the measurements proposed by Edmund Halley and other scientists since then. Several hints were given on the observation possibilities (telescope, binoculars, solar glasses), and examples of the algorithms in form of written formulae or excel sheet formulae were given. All schools were encouraged to share their data with each other and the needed support was provided by ESA.

2. The Transit Event

Unfortunately, several of the authors had bad weather conditions and could observe only part of the transit event. Several schools however, had acceptable weather conditions and were observing by projection methods or with simple telescopes.

In total, 12 school teams from the United Kingdom, Romania, Germany, Denmark, and Greece participated successfully to the event, covering a total of 148 students and many motivated teachers and parents.

A large variety of observational and computational methods were applied. All but one class was able to provide an estimate for the Sun-Earth distance. Some of the distances were really good, others were far off – but this did not matter, as the students did achieve something, that Halley was never given the gratitude (or should we say the time) to achieve.

Figure 1 Students at the Neues Gymnasium Oldenburg, Germany

Figure 2 Students from 9th Grade of the Tudor Vianu National High School of Computer Science, Romania

3. Discussion

Besides the difficulty in observing the transit, in particular the weather condition, the measurement difficulties, and the algorithmic complexity, the enthusiasm of students and teachers was high.

With some modest efforts, a number of students could execute an astronomical experiment and compute the Sun-Earth distance and learn about science history, instrumentation, and our solar system: be prepared for the next Mercury transit event in 2019.

This event was driven by scientists and supported by the ESA Communication Office. It was therefore for most of the authors a pilot project to find out on the challenges when confronted with young students and their teachers at school. We realized that the participating schools were driven by the enthusiasm of either the teachers or one or several parents, who obviously invested a large amount of their time in the preparation of the experiments and the analysis of the data.

The computation of the solar parallax requires a number of assumptions, depending on the available equipment and its accuracy. We underestimated the efforts for the students on this respect and provided finally the full formalism to compute the solar parallax.

Acknowledgements

The authors acknowledge the permission of the teachers of the Neues Gymnasium Oldenburg, Germany, the Tudor Vianu National High School of Computer Science, Romania, and the Ribe Katedralskole, Denmark, to use the image material in our presentation.

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Astronomy Map of the World

http://www2.warwick.ac.uk/fac/sci/physics/research/astro/people/veras/map
(or search "World Astronomy Map")

Dimitri Veras
Department of Physics, University of Warwick, Coventry CV4 7AL, UK
(d.veras@warwick.ac.uk)

Abstract

I have created an online clickable and zoom-enabled world map — now viewed over 5,400 times — that contains weblinks to institutions where astronomy is either researched professionally and / or and taught in classrooms at the university level. Not included are stand-alone museums, planetariums, amateur astronomical societies, virtual institutes, nor observatories which do not fulfill this criteria. One can click on a marker to access the weblink to the relevant institute. Some markers are very close to one another, so zooming in might be necessary.

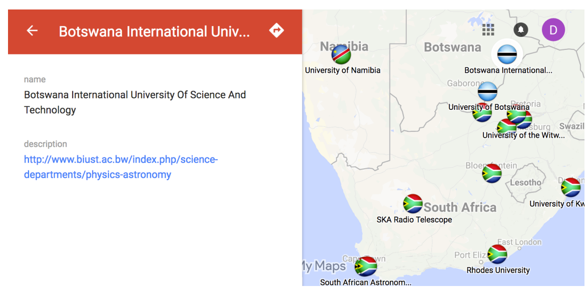
The map currently contains 697 institutes, but is still likely to be missing many, particularly in countries where astronomy's web presence is not pronounced. Therefore, please email me with weblinks of institutes that I have missed.

1. Usefulness

This Astronomy Map of the World has multiple potential uses.

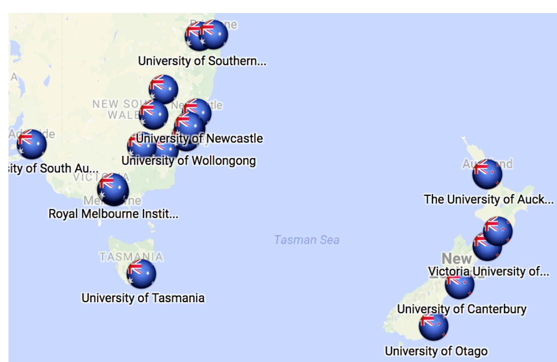
[1] Prospective undergraduate students wishing to study astronomy at university can determine geographically what programmes are available, and easily reach the relevant webpages.

[2] Graduate students wishing to pursue an academic career in astronomy can also can determine geographically what programmes are available, and easily reach the relevant webpages.



[3] Graduate students, postdocs and faculty can use the map to determine where to look for jobs.

[4] Graduate students, postdocs and faculty can use the map to determine where they might give seminars or colloquia when travelling to conferences, collaborations or even holidays.



[5] Researchers wishing to form international collaborations can use the map to determine possibilities.

[6] Journal editors wishing to seek out referees can use the map to obtain lists of researchers.

[7] Amateur astronomical societies who seek professionals to give talks can use the map to determine which researchers are closest to their societies.

Acknowledgements

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Public Outreach with NASA Lunar and Planetary Mapping and Modeling

E. Law (1), B. Day (2)
(1) Jet Propulsion Laboratory, California Institute of Technology. M/S 168-200. 4800 Oak Grove Dr. Pasadena, CA, USA 91109. (Emily.S.Law@jpl.nasa.gov, +01-818-354-6208)
(2) NASA Solar System Exploration Research Virtual Institute. NASA Ames Research Center. M/S 17-1. Moffett Field, CA, USA. 94035. (Brian.H.Day@nasa.gov, +01-650-604-2605

Abstract

NASA's Trek family of online portals is an exceptional collection of resources making it easy for students and the public to explore surfaces of planetary bodies using real data from real missions. Exotic landforms on other worlds and our plans to explore them provide inspiring context for science and technology lessons in classrooms, museums, and at home. These portals can be of great value to formal and informal educators, as well as to scientists working to share the excitement of the latest developments in planetary science, and can significantly enhance visibility and public engagement in missions of exploration.

1. Introduction

This presentation will provide an overview of the uses and capabilities of NASA's Solar System Trek family of online mapping and modeling portals. While also designed to support mission planning and scientific research, this presentation will focus on the education and public outreach capabilities of these web based suites of data visualization and analysis tools.

2. Online Web Portals for Inspiration and Education

NASA's Solar System Treks program of lunar and planetary mapping and modeling produces a suite of interactive visualization and analysis tools. The program is managed by NASA's Solar System Exploration Research Virtual Institute and developed at NASA's Jet Propulsion Laboratory. These tools enable mission planners, planetary scientists, and engineers to access mapped data products from a wide range of instruments aboard a variety of past and current missions, for a growing number of planetary bodies. While originally initiated for mission planning and science, this technology has demonstrated great benefits for public outreach. As a component of NASA's Science Outreach and Education Infrastructure, they are available as resources for NASA Outreach and Science Education programs, and to the greater outreach and education community. As new missions are being planned to a variety of planetary bodies, these tools are facilitating the public's understanding of the missions and engaging the public in the process of identifying and selecting where these missions will land.

The portals provide easy-to-use tools for browsing, data layering and feature search, including detailed information on the source of each assembled data product. Interactive maps, include the ability to overlay a growing range of data sets including topography, mineralogy, abundance of elements and geology.

There are currently three web portals in the program available to the public: Moon Trek (https://moontrek.jpl.nasa.gov), Vesta Trek (https://vestatrek.jpl.nasa.gov), and Mars Trek (https://marstrek.jpl.nasa.gov). More portals for additional planetary bodies are in the works. As web-based toolsets, the portals do not require users to purchase or install any software beyond current standard web browsers. All of the portals provide analysis tools that facilitate the measurement and study of planetary terrain. They allow data products to be layered and adjusted to optimize data visualization. Visualizations can easily be stored and shared. The new Trek interface provides enhanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a first-person visualization of "flying" across the surface of the Moon. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. Such 3D prints are valuable tools in museums, public exhibitions, and classrooms – notably including opportunities for the visually impaired. This interface will become the standard across all of the Trek products including the portals for Mars, Phobos, Vesta, and more. The data visualization capabilities of the portals provide easy access to data from NASA and other agencies, allowing the public to personally explore these destination worlds, and become directly engaged in current missions as well as plans for future exploration.

Using the portals, students and members of the public can conduct their own explorations of planetary surfaces, measuring diameters of craters, creating elevation profiles of peaks and valleys, and plotting traverse paths. A collaboration with DLR resulted in the integration of new Mars Express HRSC data into Mars Trek for a very popular interactive guided tour of fictional astronaut Mark Watney's epic journey across the terrain of Mars from the story, The Martian.

Along with the web portals, the program supports additional clients, web services, and APIs that facilitate dissemination of planetary data to a range of external applications and venues. Prototype touch table and virtual reality clients being developed by the team are of special interest for museums and science centers. Through its APIs, the portal is serving data to a growing community of digital planetariums. NASA challenges and hackathons are also providing members of the international software development community opportunities to participate in tool development and leverage data from the portals. In the 2016 NASA SpaceApps Challenge, 14 projects were created using the Trek data.

3. Summary and Conclusions

Imagery from the international fleet of spacecraft exploring the solar system provides a unique and particularly effective means to engage, inspire, and educate students and the public. NASA's online, web-based Solar System Trek planetary mapping and modeling portals provide exciting, interactive tools of great value to informal educators, as well as to scientists working to share the excitement of the latest developments in planetary science and exploration. The user community is invited to provide suggestions and requests as the development team continues to expand the capabilities of the portals, the range of data and tools that they provide, and partner in new ideas for their application in education and outreach. As the EPSC community looks forward to a new generation of surface and orbital lunar robotic activities, as well as preparation for human return to the Moon and the first human missions to Mars, tools such as the Trek portals will become increasingly essential to engage and involve students and the public.

Acknowledgements

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Transits in our Solar System for educational activities: Mercury Transit 2016 and Total Solar Eclipse 2017

M. Pérez-Ayúcar (1), M. Breitfelner (1)
(1) European Space Astronomy Center (ESAC), Madrid, Spain (mperez@rssd.esa.int)

Abstract

Solar transits are rare astronomical event of profound historical importance and with an enormous potential to engage nowadays students and general public into Planetary Sciences and Space.

Mercury transits occur only about every 13-14 times per century. Total solar eclipses occur around 18 months apart somewhere on Earth, but they recur only every 3-4 centuries on the same location. Although its historic scientific importance (examples, to measure the distances in the solar system, to observe the solar corona) has diminished since humanity roams our solar system with robotic spacecrafts, transits remain a spectacular astronomical event that is used very effectively to engage general public and students to Science and Space in general.

The educational project CESAR (Cooperation through Education in Science and Astronomy Research) has been covering since 2012 such events (Venus transit 2012, live Sun transmissions, solar eclipses, ISS transits ...). We will report the outcome of two major events since last year: the May 2016 Mercury Transit, and the recent August 2017 Total Eclipse. CESAR organizes during these transits educational and outreach events. The driving activity is a live interactive hangout connecting students around the globe (Spain, Chile, USA, …), the remote observing teams, and the scientists at ESAC (European Space Astronomy Center). Live images are transmitted via a specific web in two bands (h-alpha and visible). Questions and answers sessions were performed so that world-wide audience can interact with the scientists and engineers.

For the Mercury Transit in May 2016, a dual observation was made from two separate locations: a twin portable telescope set-up at the IAC (Instituto de Astrofísica de Canarias) Izaña, Tenerife, Spain, and in Cerro Paranal, Chile, achieving a ground baseline parallax of around 10.000km. For the Total Eclipse in August 2017, a team will travel to Wyoming, USA, to transmit live the occultation. CESAR collaborated with several Spanish schools/universities, the ESA Education and Communications offices, the Teide and Cerro Paranal observatories and the ESA projects Bepi Colombo and Solar Orbiter.

In this paper we explain how these two public educational and outreach events were created, what activities they comprised, and the follow up activities expected for future transits..

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Archaeoastronomy as a Tool for Understanding Celestial Phenomena

S. Koufos (1) and E. Chatzichristou (1,2)
(1) Eudemus Observatory of Rhodes, Greece (stratosjmj@hotmail.com) (2) IASA National University of Athens, Greece

Abstract

This is an interdisciplinary approach to science teaching, through archaeoastronomy activities targeted to students of primary and secondary education.

1. Introduction

Archaeoastronomy is the study of the astronomical beliefs, practices, and discoveries of prehistoric and ancient cultures, and the role that astronomical phenomena have played in human societies. The acquisition of knowledge by observing the sky and studying the celestial phenomena (stars, planets, sun, moon, comets, asteroids, meteors, orbits, seasons, etc.). decisively influenced all human cultures.

Archaeoastronomy can be applied to all cultures and all time periods. The meanings of the sky vary from culture to culture; nevertheless there are scientific methods which can be applied across cultures when examining ancient beliefs. It is known, for instance, that many of the monuments and ceremonial constructions of early civilizations were astronomically aligned.

Therefore, the research of the astronomical knowledge and its usefulness/importance for each culture may reveal important anthropological data. Inversely, by studying astronomical alignments we can learn about the development of science and of cosmological thought across cultures.

2. Astronomical legacy and ancient monuments combined

The island of Rhodes has a rich astronomical legacy . It was the place where lived and worked famous ancient Greek astronomers such as Hipparchus, Eudemus and Posidonius. It is rich in monuments, ranging from ancient temples and sacred places of the Hellenistic times to Roman and Venetian fortresses and castes, Catholic churches and Muslim mosques.

We have been very active in developing several activities, in collaboration with the National University of Athens and with the active participation of students from schools of Rhodes, in order to demonstrate the methodology used by our ancestors in aligning monuments in conjunction with their astronomical beliefs and understanding of celestial phenomena.

Azimuths, angular altitude of skyline, star declinations, star attribution and solar season are produced from field measurements and home made software. Students participate in field experiments and collect data which they take along to classroom, providing inspiration and aded value to their science courses at school.

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Planets in a Room

L. Giacomini (1,2,3), F. Aloisi (3) and I. De Angelis (4,3)
(1) Europlanet 2020 RI, (2) IAPS-INAF, (3) Speak Science, Rome, Italy, (livia.giacomini@iaps.inaf.it) (4) Roma Tre University, Dipartimento di Matematica e Fisica, Rome, Italy

Abstract

Teaching planetary science using a spherical projector to show the planets' surfaces is a very effective but usually very expensive idea. Whatsmore, it usually assumes the availability of a dedicated space and a trained user. "Planets in a room" is a prototypal low cost version of a small, spherical projector that teachers, museum, planetary scientists and other individuals can easily build and use on their own, to show and teach the planets

The project of "Planets in a Room" was made by the italian non-profit association Speak Science with the collaboration of INAF-IAPS of Rome and the Roma Tre University (Dipartimento di Matematica e Fisica). This proposal was funded by the Europlanet Outreach Funding Scheme in 2016.

"Planets in a room" will be presented during EPSC 2017 to give birth to the second phase of the project, when the outreach and research community will be involved and schools from all over Europe will be invited to participate with the aim of bringing planetary science to a larger audience.

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Lobachevsky Year at Kazan University: Center of Science, Education, Intellectual-Cognitive Tourism "Kazan – GeoNa – 2020+" and "Kazan-Moon-2020+" projects

A. Gusev and N. Trudkova
Kazan Federal University, Russia (alexander.gusev@mail.ru. / Fax: +7-843-23375125)

Abstract

Center **"GeoNa"** will enable scientists and teachers of the Russian universities to join to advanced achievements of a science, information technologies; to establish scientific communications with foreign colleagues in sphere of the high technology, educational projects and Intellectual-Cognitive Tourism. The Project **"Kazan - Moon - 2020+"** is directed on the decision of fundamental problems of celestial mechanics, selenodesy and geophysics of the Moon(s) connected to carrying out of complex theoretical researches and computer modelling.

1. Introduction

Historically thousand-year Kazan city and the two-hundred-year Kazan federal university (Russia) carry out a role of the scientific-organizational and cultural-educational center of Volga region. The Kazan Federal University is one of the oldest and largest institutes of higher learning in the Russia. It was founded on November 5, 1804. The history of Kazan University abounds in the names of outstanding scientists, staunch revolutionaries, eminent public figures, educators, painters actors. One of the greatest names in the history of Kazan University is Prof. Nikolai Ivanovich Lobachevsky - the founder of non-Euclidean geometry (1826). This year, the Kazan Federal University (2010) celebrates 225 years since the birth of the greatest geometer of mankind, the rector and builder of the Kazan Imperial University, Prof. N. I. Lobachevsky (1892).

2. International Center "GeoNa"

For the further successful development of educational and scientific - educational activity of the Russian Federation, the Republic Tatarstan, Kazan city is offered the federal project - the International Center of the Education, Science, Internet of Technologies and Intellectual-Cognitive Tourism **"GeoNa"** (**Geo**metry of **Na**ture - **"GeoNa"** is developed - wisdom, enthusiasm, pride, grandeur), which includes a modern complex of conference halls (up to 4 thousand places), the Center the Internet of Technologies, 4D Planetarium - development of the Moon, Physics Land, an active Museum of Natural Sciences, Oceanarium, Training a complex «Spheres of Knowledge», botanical and landscape oases. In center **"GeoNa"** will be hosted conferences, congresses, fundamental scientific researches of the Moon(s) and planets, scientific-educational actions: presentation of the international scientific programs on lunar and planetary research; modern lunar databases, exhibition Hi-tech of the equipment, the extensive cultural-education, touristic and cognitive programs. **Ring of Knowledge:** personifies infinity of a way of Knowledge at the limited opportunities of the Human and the Civilization. The Ring connects all objects of a scientific - cognitive complex, showing the uniform approach and a method of researches of the World around of us. Expositions of the Ring will reflect all essential aspects and stages of development of a human Civilization. **4D Planetarium**: 4D video-acoustic representation of the expanding universe, the dynamic world of colliding Galaxies and accretion black holes, system of bewitching planets around of the Sun and exoplanets about other stars of our Galaxy, exploration of the Moon and asteroid hazard, distribution of a reasonable Life to the universe and scientific searches of extraterrestrial intelligence, research and development of near Space, creation of settlements on the next planets. **Physics Land**: Cognitively - training complex for children, schoolboys, students, adult, based on modern achievements of science and technology and their three-dimensional visual and sensual perception. The complex will contain more than 100 simulators and 200 demonstration automated platforms: Flight on the Moon and Mars, Formula - I, Falling in Black hole, Birth of the Universe, Rings of Newton, Machine of time. The complex can simultaneously accept up to 500 children with parents and school teachers.

3. “Kazan-Moon-2020+” project

The Moon in the Russian project “Kazan-GeoNa-2020+”: The Project “The Moon - 2020+” is directed on the decision of fundamental problems of celestial mechanics, selenodesy and geophysics of the Moon connected to carrying out of complex theoretical researches and computer modeling: 1. **Spin - orbital longtime evolution and physical librations of the multi-layer Moon**: a) construction of the analytical theory of rotation of the two / three-layer Moon and reception on its basis of physical libration tables for their application at processing precision supervisions; construction of a Lunar Navigation Almanac. b) The analysis of spin - orbital evolution of the early Moon, an estimation of internal energy dissipation, modeling of the long-term mechanism of maintenance free librations of the Moon. 2. **Geodynamics of a lunar three-layer core**: the analysis of differentiation of a lunar core, detailed elaboration of plume-tectonics of a mantle and a core of the early Moon, evolution of a boundary layer a core - mantle, reconstruction of gravitational and viscous - mechanical interaction of a lunar core and a mantle, resonant dissipation of internal energy, calculation free and forced nutations a lunar core, free fluctuations of system a core - mantle. **3. Selenodesy of lunar farside:** the decision of a reverse problem of lunar gravimetry, construction of geodynamic tidal dissipative model of the lunar crust, mantle and core, Moho boundary, reconstruction initial mascons on the Moon, creation precision topographical and gravitational models of the Moon on modern supervision.

4. References

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Space Detectives: using space to showcase science

S. Tyszka (1), R. Doran (1,2) and J. Saraiva (1)

(1) NUCLIO, Portugal, (2) Universidade de Coimbra, Portugal (jose.saraiva@nuclio.pt)

Abstract

Space Detectives is a story-based activity, run in the course of several days, designed to immerse kids in a fun, intriguing environment based on a storyline that takes them to space and the planet Mars.

1. Introduction

Space is a subject that is sure to attract kids. It fits right into their imaginations and desire to find out all about the Universe. Thus, space has a strong potential to arise in them a passion for science. However, in the school system, the need to follow strict guidelines and to comply with what the curriculum mandates can contribute to make them lose interest in the scientific areas. NUCLIO, a non-profit association that promotes science education for schoolkids, teachers and the general public, designed an activity that takes kids on a journey of the imagination with stops in many scientific fields.

Figure 1: Solving puzzles and finding the story-line.

2. The concept

As the name indicates, the activity is focused on following clues, investigating different matters, solving problems and coming up with answers. It aims to create a fun and intriguing learning environment that motivates participants to conduct their own scientific investigations and develop a personal understanding of their own learning journey.

Figure 2: Using an impact simulator.

3. Implementation

Space Detectives has been run in two occasions, in school holiday periods. The basis has been a story with mystery elements that the kids have to disentangle. In both instances, the storyline was centered on the exploration of Mars, but it required the participants to explore a range of diverse subjects, such as rockets, communication and navigation, binary encoding and decoding, astronomical software, asteroid and impacts, robotics, Solar System exploration, the Martian environment and story-telling.

Figure 3: Tracking a rover on the surface of Mars.

In short, the programme incorporated a strong narrative basis, hands-on activities providing fun moments and encouraging team-building, group discussions, integrated game mechanics and also digital technologies and tools.

Figure 4: Putting together a robot with camera.

4. Results

During the trial implementation phases, we have found that we can inspire intrigue and excitement in a diverse range of subjects, and help in the development of an understanding of context, as well as demonstrate the links between the different subjects.

This activity has not been run in a formal school environment; the participants were self-selected children that very likely already had a penchant for leaning more about space exploration. Thus, their response was good, with peaks of interest that varied between individuals according to their very own preferences.

Plans are being developed to run Space Detectives either as a stand-alone activity or as a tie-in to the European Commission-funded project Stories of Tomorrow to be run in schools of five European countries.

Acknowledgements

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Stories of Tomorrow: schoolkids and the conquest of Mars

J. Saraiva, and the Stories of Tomorrow team

NUCLIO, Portugal (jose.saraiva@nuclio.net)

Abstract

Stories of Tomorrow is a EU-funded project centered on the creation of stories by schoolkids, ages 10 to 13, related to the exploration and colonization of Mars. With that purpose in mind, the project will develop and integrate various tools that will be made available to the teachers and students in the schools where it will be implemented. At the heart of the concept lies the vision for integrated curricula and deeper learning outcomes.

1. Introduction

The idea behind the Stories of Tomorrow project is to give ample room for young students to express their imagination and creativity in coming up with their own views of the future exploration of Mars. This will allow the integration of artistic expression and scientific inquiry, in a STEM + Arts framework.

It aims to contribute to the evolution of children's ebooks, through the development of user-friendly interfaces that will allow young students (10-13 years old) to give a free rein to their ideas and dreams about our future in space and on Mars by creating their own stories, in which can be incorporated AR, VR and 3D printing technologies that will aid in the visualization of those stories.

The creations of the students may take any form of artistic expression, including drawings and paintings, models and constructions, 3D objects, videos and animations, or science theater plays; they will also integrate sound scientific principles that will be presented to the students throughout the implementation of the project.

The consortium created for the project involves 15 partners from Europe, USA, Japan and Australia. It will cooperate in the design of a platform and the development of the storyline mechanism.

2. Activities

The project started at the beginning of 2017, and its school implementation phase starts at the beginning of the 2017-18 schoolyear.

There is a dedicated website already in place [1], that will have a role in the dissemination of the project.

The piloting phase will take place in schools of five countries in Europe (plus Japan), requiring a dedicated time-frame throughout the school year, and the transformation of the visions of the students into e-books that can be shared and viewed online. The plans call for the involvement of some 60 teachers and 3000 students of the 5th to 7th grade in the five countries concerned.

The teachers and students will have access to a wide variety of sources with information on space travel and the exploration of Mars, that will help in the development of ideas and concepts for the stories. They will also get in touch, whenever possible, with scientists involved in the missions to Mars, thus gaining a wider understanding of the issues and questions that they should confront when creating their stories. A Mars booklet will be produced and distributed, containing information on the history of Mars and its environment.

In the meantime, some activities to prepare and train the teachers in the approach employed in the project will happen. These include National Visionary Workshops, taking place in each of the pilot countries between May and June 2017; in July, a Stories of Tomorrow Summer School will gather teachers form all the countries involved, with the objective of introducing them to the concept of digital storytelling as a catalyst for the effective interaction between Arts and STEM disciplines which share similar value, similar themes and characteristics, and thus can be used to promote Deeper Leaning in the students.

Acknowledgements

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Public Engagement in Planetary Science through Europlanet Social Media

T. Heenatigala (1,2)
(1) Europlanet, Portugal (2) Science Office, Portugal (thilinah@astroepo.org / +31 649 099 747)

Abstract

From 'Save the Hubble' campaign to ESA's Rosetta mission, social media has played a major role in public engagement and continues to grow. However, with this growing number of social media platforms and the amount of content that goes public daily, the 'noise' level is high - making it difficult to reach a good, relevant audience. Hence, it's important to use different strategies with the content created, from launching a video to live session to issue a press release. Under the Horizon 2020, the Europlanet Media Centre[1] identifies the importance of using social media for outreach. Europlanet uses primary and secondary social media platforms strategically to engage with the followers and a new audience.

1. Introduction

Social media plays a major role in bringing latest in planetary science to the public and also gives a platform to discuss it. What are the best practices in using social media for science communication and how much should we invest on it? With ever increasing advancements in science, the ways people communicate have drastically changed. With how scientists interacting with peers and public, the ways that scientific information is disseminated, and methods of scientific outreach/education have changed, in many ways becoming more efficient. The use of social media has not only allowed scientists to engage in more efficient public outreach and education but has provided a unique platform for communication and networking within the scientific community.

2. Europlanet on Social Media

While Europlanet has a representation across all the major social media, it focuses on the platforms at two levels. Primarily Facebook, Twitter, and Youtube, where content is posted daily with regular engagement. Also, the most campaigns are run on these platforms. Europlanet also produces regular videos for organisational events, planetary highlights, topical discussions, and also live webinars. Secondarily Europlanet uses Instagram, LinkedIn, Google+ where updates are posted regularly to keep a presence. Each of the platforms serves a different purpose and an audience. Having a presence in different platforms helps to reach a wider audience. Europlanet also maintains a Flickr profile to archive photos from the organisation related events.

3. Best Practices: Europlanet Social Media Campaigns

While there are regular posts across all the social media platforms. Europlanet organises various campaigns to keep the public engaged. From the past campaign results, it clearly shows the public engagement can be spiked and reach a wider audience.

Europlanet social media strategy uses important planetary milestones and events to create campaigns, such as 'Transit of Mercury' featured video animation reached 17K views, Juno mission video reached 9K views. Europlanet also runs a monthly webinar series featuring planetary scientists with various expertise. The first series of webinars focused on general public while the second series is addressed teachers and students as the primary focus.

As another effort towards building a better relationship between scientists and public, Europlanet will focus on getting planetary scientists involved via Twitter in the future. This effort was tested during the EPSC2016 where Europlanet Twitter account was given to few conference attendees to Tweet for Europlanet. This allowed multiple engage and better coverage of the conference.

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Measuring planetary field parameters by scattered “SSSS” from the Husar-5 Rover

Lang Á. (1), Kocsis Á. (1), Balaskó D. (1), Csóka B. (1), Molnár B. (1), Sztojka Á. (1) Bejó M. (1), Joób Z. (1)
(1) Széchenyi István Gimnázium High School, H-9400 Sopron, Templom u. 26. Hungary (mmecurie95@gmail.com)

1. Introduction: HUSAR-5 Rover reloaded

For 2 years ago the Hunveyor-Husar Team in our school made yet a similar project. The ground idea was, we try to keep step with the main trends in the space research, in our recent case with the so called MSSM (Micro Sized Space- Mothership) and NPSDR (Nano, Pico Space Devices and Robots). [1]Of course, we do not want to scatter the smaller probe-cubes from a mothership, but from the Husar rover, and to do it on the planetary surface after landing. We have fabricated the rover with the ejecting tower and we have shown it on the EPSC 2015.

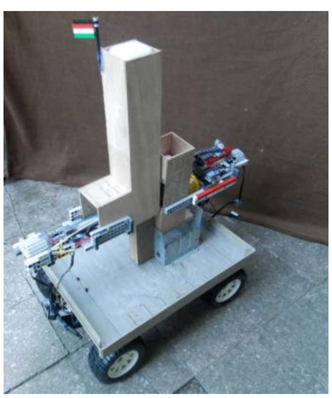

Figure 1: the rover before it

2. The SSSS: Shell-Shape Sensor Sheath

The new shape of the bullet let the SSSS better rolling on the surface. The sensors and the electronic equipment should be placed on the surface and inside the SSSS. The shells would be scatterred on the surface therefore it is worthy to measure and to map that kind of parameters which are non-uniform on the surface. We plan to include inside the cubes a Hall-sensor to measure the magnetic field, a pressure sensor to measure the atmospheric pressure, and a vapor content and a temperature sensor, too. The communication with the Husar rover (or the landing unit Hunveyor) should be organized through Wifi.

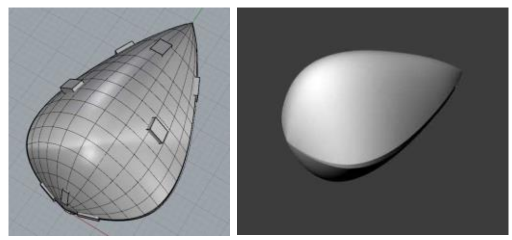

Figure 2: the plans of SSSS

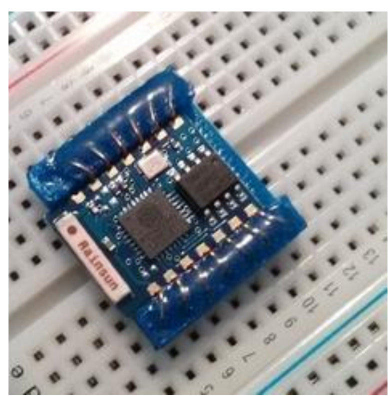

Figure 3: the microcontroller

The „brain” of the cubes will be an microcontroller, which synchronizes the measurements and the transportation of the data. The type of microcontroller is esp 8266-03, it can be programmed with Arduino.

3. The Mission and the Ejection Event

The mission would be carried out in the following way. The rover starts from the lander and advances forward with a uniform speed. (By its distance sensor the rover observes the obstacles and tries to bypass them). This way the pathway of the rover can be traced and the positions of the shells can be estimated. After covering a unit distance the rover stops. A motor draws the string. After that the magazine wheel rotates and the next shell falls in the tube. The motor let the tube off and the limb and the string launch the shell in a specific direction. (This direction is perpendicular to the rover's.) During the stops the rover measures local gravity. The gravity sensor should not be built to the cubes, because it probably does not change in this distance. The rover is controlled by MyRio, the instrument of NI.

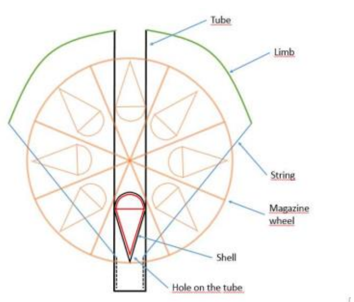

Figure 4: the ejecting system from the top

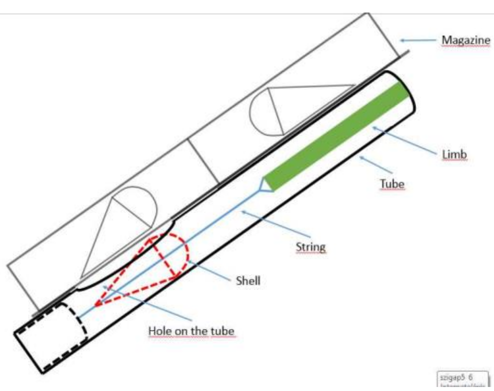

Figure 5: the ejecting system from the side

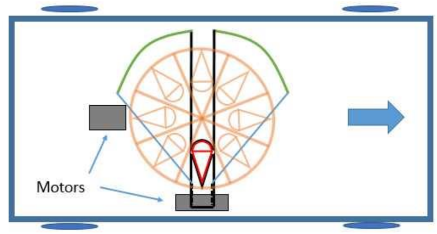

Figure 6: the new HUSAR-5 rover

4. Summary and Conclusions

In this abstract we report a new type of the Hunveyor-HUSAR project planned by students. It based on an earlier mission, but the rover will be rebuilt and the scattered objects have a new forms. The students have got a lot of experience about the problems connecting of constructing a spaceprobe.

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Inclusive Planetary Science Outreach and Education: a Pioneering European Experience

A. Gálvez(1), F. Ballesteros(2), A. García-Frank(3), S. Gil(4), A. Gil-Ortiz(2). M. Gómez-Heras(5), J. Martínez-Frías(6), L. M. Parro(3), V. Parro(7), E. Pérez-Montero(8), V. Raposo(9), J. A. Vaquerizo(7)

(1) *European Space Agency - Headquarters, France*
(2) *Observatorio Astronómico de la Universidad de Valencia, Spain*
(3) *Universidad Complutense de Madrid, Spain*
(4) *Scienseed, Spain*
(5) *Universidad Autónoma de Madrid, Spain*
(6) *Instituto de Geociencias - CSIC/UCM, Spain*
(7) *Centro de Astrobiología - CSIC/INTA, Spain*
(8) *Instituto de Astrofísica de Andalucía-CSIC. Spain*
(9) *Universidad Politécnica de Madrid, Spain*

Abstract

Universal access to space science and exploration for researchers, students and the public, regardless of physical abilities or condition, is the main objective of work by the Space Inclusive Network (SpaceIn). The purpose of SpaceIn is to conduct educational and communication activities on Space Science in an inclusive and accessible way, so that physical disability is not an impediment for participating. SpaceIn members aim to enlarge the network also by raising awareness among individuals such as undergraduate students, secondary school teachers, and members of the public with an interest and basic knowledge on science and astronomy.

As part of a pilot experience, current activities are focused on education and outreach in the field of comparative Planetary Science and Astrobiology. Themes include the similarities and differences between terrestrial planets, the role of water and its interaction with minerals on their surfaces [1], [2], the importance of internal thermal energy in shaping planets [3] and moons [4], [5] and the implications for the appearance of life, as we know it, in our planet [6] and, possibly, in other places in our Solar System and beyond. The topics also include how scientific research and space missions can shed light on these fundamental issues, such as how life appears on a planet, and thus, why planetary missions are important in our society, as a source of knowledge and inspiration.

The tools that are used to communicate the concepts include talks with support of multimedia and multi-sensorial material (video, audio, tactile, taste, smell) and field trips to planetary analogue sites that are accessible to most members of the public, including people with some kind of disability. The field trips help illustrate scientific concepts in geology e.g. lava formations, folds, impact features, gullies, salt plains; biology, e.g. extremophiles, halophites; and exploration technology, e.g. navigation in an unknown environment, hazard and obstacle avoidance, mobility in all types of terrain, etc.

Two analogue sites in the Spanish central region have been selected as they accessible to the target public and close enough to some of the research centres that participate in the SpaceIn project, with three other candidate sites being considered for further activities. The selected analogues for now are in Riba de Santiuste (Guadalajara) and Campo de Calatrava (Ciudad Real), both less than three hours away from the European Space Astronomy Centre (ESAC-ESA), the Centre for Astrobiology (CAB-CSIC/INTA), and Institute of Geoscinces (IGEO-CSIC/UCM), among other SpaceIn participants in or near Madrid. The three other candidate sites are in the Madrid, Toledo and Almeria provinces in Spain.

The talks and field trips also involve preparatory activities such as the generation of maps, navigation tracks, images, digital elevation models and also tactile, audio, video and text materials for workshops and presentations in the participating centres.

This paper describes all these activities and the future plans for traineeships and other activities at European –rather than only local- level.

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Cutting in front with ESTCube-2: How building a satellite makes an attractive employee

K. Bussov (1), E.Oro (1) and H. Ehrpais (1)

(1) Estonian Student Satellite Foundation, Tartu, Estonia

Note: We expect to add more authors before the final submission of paper.

Abstract

Estonian Student Satellite Foundation (ESTCube Foundation) is student founded non-profit space technology education development organization giving students a unique opportunity to gain experience in fast paste space technology industry during their university studies. With mentors varying from industry professionals to world class scientists and emphasis on creating each part of the satellite from the scratch ESTCube differs significantly from usual student satellite organization.

1.Introduction

Estonian Student Satellite Foundation (ESTCube Foundation) is student founded non-profit space technology education development organization. With thriving Estonian technology start-up scene in constant rising the total expenditure on R&D activities in Estonia is steadily increasing. This trend has also given rise to expenditures to salaries in science, technology and innovation sectors. Last ten years has seen the rise from €500 000 investments raised in 2006 to €103 million in investments raised in 2016 by Estonian start-ups. That is a rise of 200 fold. With steadily increasing investments into Estonian technology start-ups country with a population 1,3 million people faces a new challenge which is shortage of qualified personnel. The need for qualified personnel has already lead to thriving start-up Jobattical and Estonian government issuing a simplified working visa process for technology specialists from outside EU. ESTCube Foundation is tackling the issue by providing multidisciplinary approach with hands-on training in space technology development and teamwork to students during their studies in university making graduates with ESTCube experience fully prepared and experienced to take positions with responsibility in Estonia booming technology sector. Students with ESTCube experience have graduated to take positions in MIT, Spire, Starship Technologies, Ministry of Economics and Communications in Estonia and many others.

2.Why ESTCube?

ESTCube-2 differs from your usual student satellites. ESTCube-2 is built on the knowledge of ESTCube-1 by the Estonian Student Satellite Foundation in collaboration with the Finnish Meteorological Institute and Ventspils University College. The Estonian Student Satellite Foundation was founded by students and Estonian entrepreneurs to initiate space industry in Estonia and surrounding countries through providing students a multidisciplinary approach in developing, managing and building space grade satellites from ground up. The main focus in the ESTCube Foundation is aimed at building and testing novel technologies developed in collaboration with other research institutes in Estonia and outside. That creates an environment more similar to a tech start-up rather than a youth or student organization. An ESTCuber needs to be quick on his/her feet, willing to learn, willing to fail, be a good team member, adaptable, take initiative and responsibility and to be ready to deliver. ESTCube is a high pressure and high motivation environment for students. ESTCube is a perfect breeding ground for highly skilled people to enter the high speed tech start-up world.

3.How we work

ESTCube Foundation works as a technology start-up with 14 technical teams and 6 pillar teams. Each team is responsible with their respective field with volunteer mentors and team leads. Volunteer mentors are either ESTCube-1 members or industry professionals. All teams are connected and rely on each other to survive. This sort of organization builds trust and collaboration between different field students as well as with industry. Students learn to take responsibility and to work in teams.

From the downside as ESTCube is volunteer based organization aimed for students we have quite the fluidity within ESTCube members. This means constant trainings of new members and large number of inactive members. This creates a constant challenge to ESTCube management and team leads.

4.Summary and Conclusions

ESTCube Foundation and building ESTCube satellites is a unique challenge for students. Not only for students in different STEM fields but also for students of non-technical backgrounds. Keeping an organization with 70 active members and constantly growing running takes a lot of effort. ESTCube thrives on personal responsibility and on people who are willing to go further and do more and that is why an ESTCuber is an attractive future employee and this is why have an excellent track record of our graduates being hired by world class innovation bringers.

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SpaceTEM: A project for educating Estonian and Latvian students in space technology

H. Ehrpais (1,2), K. Bussov (2), K. Kahn (2), T. Lillemaa (1), T. Teppo (2)

(1) Tartu Observatory, Estonia, (2) Estonian Student Satellite Foundation, Estonia

Corresponding author: Hendrik.ehrpais@estcube.eu

Note: We expect to add more authors before the final submission of the paper

Abstract

SpaceTEM is a project that enables students to participate in a summer programme in Latvia and Estonia to learn about space STEM (science, technology, engineering and mathematics). The main goal of the programme is to give students the possibility to work on challenging projects and provide access to a work culture that promotes values that are useful for future employers. The lead partner of the project is Tartu Observatory and other cooperation partners include University of Tartu, Ventspils University College, Heliocentric Technologies Latvia, Estonian Student Satellite Foundation (ESTCube) and various companies in the space sector. This paper will focus on the ESTCube and Tartu Observatory activities in the program.

1. Introduction

SpaceTEM aims to bring together the different space technology entities including SMEs, universities, research institutions and even policy makers in order to share knowledge and ideas and to collaborate on new activities. By including students in this activity it is possible to educate and prepare the next generation of space technology engineers and scientists. The students will be able to get hands-on experience and learn to operate in the work culture of companies and engineering projects that is an essential part of education that is often not covered enough.

2. Different partners

There are various partners that are participating in the SpaceTEM project including universities, research institutions and various companies.

The Estonian Student Satellite foundation is an organisation that focuses on building nanosatellites. The upcoming nanosatellite ESTCube-2 is also a satellite platform that could be used on an interplanetary mission.

Tartu Observatory is a research institute that focuses on astrophysics, remote sensing and space technology. The space technology group is in close cooperation with the ESTCube team and also is currently building a camera for the European Student Earth Orbiter (ESEO) satellite.

The University of Tartu (UT) is Estonia's oldest and most respected higher education institution. The UT leads the process of harmonising the Estonian and Latvian business support services for space technology.

The Institute of Astronomy is a part of the University of Latvia. Its main research directions are: late evolution stars, solar physics, interstellar medium, minor bodies of Solar System including: Near Earth Objects (NEO), cosmic dust, and space debris, satellite laser ranging (SLR), and development of new instruments and methods.

Ventspils University College (VUC) is one of the most dynamically developing higher education institutions in Latvia. Within the SpaceTEM project, VUC will be one of the hubs providing supervision for interns working on products with high potential for spin-offs.

LSTC will be the Latvian counterpart in the process of harmonising the Estonian and Latvian business support services for space technology.

Garage48 HUB Tartu is the center of entrepreneurial activities in Tartu and one of the most successful and well-known start-up hubs in the EstLat region. They will help in connecting Estonian and Latvian enterprises in space technology.

In addition various companies are taking part of the traineeship program. For the 2017 summer the following companies are listed to be taking on trainees: RD ALFA Microelectronics, Heliocentric Technologies Latvia, Foundation "Institute for Environmental Solutions", Spaceit OÜ, Blue Shock Race SIA, Skeleton Technologies, BSR Liepaja SIA, Pauks SIA, Planet OS, Science Center "ZINOO", Ventspils High Technology Park.

3. SpaceTEM in ESTCube and Tartu Observatory

Students participating in the SpaceTEM project through ESTCube and Tartu Observatory are able to participate in building hardware for a satellite, testing various space technology equipment and doing various space related research.

The students are working up to 8 hours a day during a period of 2.5 months in the summer. The students are working according to a methodology based on Agile principles. They will be working together with other engineers and scientists in teams of up to 10 people related to their topic who try to solve different space technology challenges. As all problems and tasks are handled by the whole team, then this encourages working together as a team.

The participants in the project are expected to participate in the development of actual hardware and software. Through the project the organisations expect to inspire the students to work on the same projects also in the future, so the traineeship is also essential for future projects. Students who work in the space technology field make excellent engineers for many different high technology companies.

4. Summary and Conclusions

SpaceTEM is a project that enables current and future space technology activities and development of space technology industry through creating traineeship opportunities to students. The project unites various institutions, companies and universities from Latvia and Estonia. The project enables Tartu Observatory and ESTCube to build space technology and prepare students to work in various engineering companies.

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NASA's Planetary Defense Coordination Office at NASA HQ

Doris Daou, Lindley Johnson, Kelly Elizabeth Fast, Rob Landis, Victoria P Friedensen and Michael Kelley

NASA Headquarters, Washington, DC, United States

Abstract

NASA and its partners maintain a watch for near-Earth objects (NEOs), asteroids and comets that pass close to the Earth, as part of an ongoing effort to discover, catalog, and characterize these bodies.

The PDCO is responsible for:
• Ensuring the early detection of potentially hazardous objects (PHOs) – asteroids and comets whose orbit are predicted to bring them within 0.05 Astronomical Units of Earth; and of a size large enough to reach Earth's surface – that is, greater than perhaps 30 to 50 meters;
• Tracking and characterizing PHOs and issuing warnings about potential impacts;
• Providing timely and accurate communications about PHOs; and
• Performing as a lead coordination node in U.S. Government planning for response to an actual impact threat.

The PDCO collaborates with other U.S. Government agencies, other national and international agencies, and professional and amateur astronomers around the world. The PDCO also is responsible for facilitating communications between the science community and the public should any potentially hazardous NEO be discovered. In addition, the PDCO works closely with the United Nations Office of Outer Space Affairs, its Committee on the Peaceful Uses of Outer Space, and its Action Team on Near Earth Objects (also known as Action Team 14). The PDCO is a leading member of the International Asteroid Warning Network (IAWN) and the Space Missions Planning Advisory Group (SMPAG), multinational endeavors recommended by the United Nations for an international response to the NEO impact hazard and established and operated by the spacecapable nations. The PDCO also communicates with the scientific community through channels such as NASA's Small Bodies Assessment Group (SBAG).

In this talk, we will provide an update to the office's various efforts and new opportunities for partnerships in the continuous international effort for Planetary Defense.