Columbus Eye – High Definition Earth Viewing from the ISS in Secondary Schools

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In spring 2014, SpaceX launched the NASA High Definition Earth Viewing (HDEV) payload to the International Space Station (ISS). HDEV consists of four commercially available high definition (HD) cameras. It is one of the first payloads launched on a Dragon spacecraft, which has previously carried resupply items. HDEV was mounted to the ESA Columbus module by the station’s robotic arm. The cameras cover three different perspectives: aft, forward, and nadir view. Hence, the HDEV payload offers the unique possibility of combining human space missions and earth observation into one outreach project. The German educational project “Columbus Eye”, which is executed by the University of Bonn and is funded by the German Aerospace Center (DLR), aims at the implementation of the ISS live imagery and videos in a web portal: www.columbus-eye.uni-bonn.de. It primarily serves as a learning portal for pupils where interactive teaching materials will be provided. Based on the experiences of the project FIS (German for “Remote Sensing in Schools”) and its learning portal (www.fis.uni-bonn.de/en), the material should motivate the students to work consciously with the HDEV footage in order to learn about curriculum relevant topics in the field of Science, Technology, Engineering, and Mathematics (STEM). Exhibiting a spatial resolution of ~280 m, the HDEV data is well suited for observing sudden and rapid changes and processes of the land surface and the atmosphere like volcano eruptions along the ISS orbital track. Furthermore, a data archive is currently developed, providing HDEV imagery free of charge via an open source web Geographic Information System (GIS). Columbus Eye accompanies the ISS mission of the German ESA astronaut Alexander Gerst (May to November 2014). A nationwide road show at German schools links his mission and the fascinating bird’s-eye view of the HDEV payload. The road show has already involved an event during which pupils from a secondary school in North Rhine-Westphalia have talked to the astronaut via ham radio. Another live call between pupils and the ISS is also contemplated. This paper presents the educational valorisation of the HDEV footage as well as its interactive implementation for teachers and pupils in a learning portal. It will demonstrate the possibilities earth observation and human space missions provide for STEM education. The paper addresses the question of how characteristics of space missions can be used to enhance fascination of earth observation imagery in the light of problem-based learning in everyday school lessons.

I. HIGH DEFINITION EARTH VIEWING (HDEV) – FOUR CAMERAS, THREE PERSPECTIVES

A dragon spacecraft of the American company SpaceX delivered a platform containing four commercial off-the-shelf (COTS) cameras to the International Space Station (ISS) in April 2014. Subsequently, the Canadian robotic arm mounted the platform on the Columbus External Payload Adapter (CEPA) of the ESA Columbus Laboratory. This automated process was carried out for the first time in the ISS program. The cameras are part of the High Definition Earth Viewing (HDEV) experiment assigned to the ISS expeditions 39/40, 41/42, 43/44, and 45/46 [1]. Once installed, the main purposes of NASA’s HDEV experiment are to test the robotic installation of external payloads and to examine the suitability of COTS HD cameras for upcoming space missions to the
Moon and to Mars. Hence, the cameras are exposed to the extraterrestrial radiation.

In total, four cameras of the Japanese companies Panasonic®, Sony®, Hitachi® und Toshiba® are part of the HDEV experiment. The first two are parallel installed. According to that, earth observation of the ISS is conducted in three perspectives: aft, forward, and nadir view (Fig. 1). They provide not only beautiful live images showing the Sun and the Moon rising and setting but also regular images of landscapes that are difficult to access, such as mountain ranges, deserts, and tropical rainforests.

Usually, the cameras are part of a cycle where every camera is subsequently switched on. By using NASA’s Telescience Resource Kit (TReK) and the implemented HDEV commander the cameras can be commanded and the cycle can be changed [2]. In doing so, it is possible to select the ISS perspective needed for scientific purposes e.g. for remote sensing of the earth surface with the nadir camera. Its spatial resolution is moderate around 280 m and can be compared to that of MODIS-sensor (Moderate-Resolution Imaging Spectroradiometer) onboard of TERRA/AQUA satellites [3]. The nadir swath is 530 km. The combination of the ISS dynamics, its repetition rate, and the different perspectives makes the HDEV experiment suitable to observe cloud dynamics and formations, meteorological phenomena like hurricanes as well as rapid environmental processes and their related patterns like volcano eruptions and bush fires.

II. COLUMBUS EYE – HDEV IN SCHOOLS

II.1 From Space to the Internet: the Learning Portal Columbus Eye

Another goal of the HDEV experiment is the application of the ISS footage in schools. Accordingly, an agreement between NASA and the German Aerospace Center (DLR) paved the way for an HDEV education project in Germany: ‘Columbus Eye – Live-Imagery of the ISS in Schools’. The project is carried out at the University of Bonn and funded by DLR on behalf of the German Federal Ministry of Economic Affairs and Energy (BMWi). It shall disseminate the HDEV footage and thereby intensify the knowledge about the ISS expedition 40/41 involving the German astronaut Alexander Gerst in schools [4].

Earth observation from space is normally accomplished by multispectral sensors mounted on satellites. Their data can be used efficiently in class for all present relevant phenomena, patterns and processes of the coupled human-environment system listed in the educational standard for the subjects geography (e.g. earthquakes [5], floods [6], open pit mining [7], and urban areas [8]) and biology (photosynthesis [9]). Furthermore, the physical and mathematical background of remote sensing and satellite images meet the curricula of physics (reflection [10]), computer science (image enhancement [11]), and mathematics (statistics [12]).

The combination of earth observation data with space travels now offers the opportunity of strengthening natural science education: it bundles a high degree at descriptiveness, a motivating effect, as well as ways for problem-oriented working, the strengthening of spatial orientation competence, method competence, and practice skills related to tangible career prospects [13, 14, 15].

In many cases, the encouragement of integrating work with earth observation data fails because of confusing, difficult, or ineffective didactical preparation of information [16]. To overcome the determined problems, a comprehensive and well structured learning portal on remote sensing (www.fis.uni-bonn.de/en) has been developed in the course of the project „Remote Sensing in Schools (FIS)“, equally sponsored by DLR. By means of a great range of digital and interactive learning material, all fundamental aspects of remote sensing are considered.

The positive experiences of FIS lead to the development of another online portal for pupils and teachers especially for the dissemination of the HDEV footage: www.columbuseye.uni-bonn.de. Since May 2014 the Columbus Eye portal is online and contains the NASA’s HDEV live stream and background information of the NASA experiment and the ESA mission of Alexander Gerst. Currently, a telemetry and command data base is constructed by implementing the TReK software in order to establish a direct link between the Department of Geography at the University of Bonn and the HDEV payload (Fig. 2). Subsequently, the HDEV footage archived in Bonn will be uploaded and be accessible free of charge by the interested public via an OpenLayers®-based web-GIS.
Fig. 2: The command and processing link developed for the German HDEV partners in Bonn: the footage of the cameras mounted at the Columbus laboratory of the ISS are sent via the Tracking and Data Relay Satellite (TDRS) across the TDRS ground terminals at NASA White Sands Complex and the Payload Operation Integration Center (POIC) in Huntsville to the Department of Geography at the University of Bonn.

What is more, is the didactic valorisation of the fascinating material and their integration in an observatory section of the portal. While archiving the footage is important the main goal of the project is the didactic valorisation of this fascinating material.

II. ‘Let Me Have a Go’: Pupils Working with HDEV Footage

In the course of school education, conveying media literacy to pupils is regarded as a main educational task. Within this field, the successful and effective handling of “new media” is of paramount importance [17]. Accordingly, the learning portal’s development is inspired by the didactic principles of constructivism. Constructivism treats learning as an active process. Through learning, present perceptive, thinking, and behavioural patterns are adjusted to new information, so that new insights emerge [18]. Wherever possible, the Columbus Eye project tries to encourage these natural processes of information and knowledge build-up. Sheer watching the ISS HDEV videos is fascinating but does not create a sustainable knowledge exceeding first impression of the Earth’s surface and its land-cover patterns. The next two stages are to inform the pupils and – above all – to let them interact with the HDEV footage.

Specific tools for watching, informing about, and interacting with HDEV are developed in Columbus Eye in order to encourage discovery-based learning in terms of a practice-oriented approach. Hence, parallel to gaining methodical competences in the field of earth observation from space and digital image processing, dealing with new media on the whole is encouraged. The pupils shall learn to deal with new media in a differentiated way by reflecting the methods at hand critically. Altogether, interactive confrontation with earth observation data can make a contribution to the preparation for studying and the working world, because secure handling of IT is a basic prerequisite in many professions today.

Figure 3 shows a flash-based interactive learning framework in the information stage. An ISS flight over South America moving from the coast of Chile to the Argentinean coast has been transformed into one large panorama shot. While the flight just took 5 min the extent of the image is 2,000 km covering a variety of the South American landscape like cliffs, humid river valleys, arid steppes, the Andes, the Pampa, and beach resorts. The tool highlights places where the pupils can gather background information of the processes and patterns un-perceptible while just watching the video. Exemplarily, a white dot appears to be a ‘cloud’. This is due to the high reflection in all three visible colour segments. In reality, however, the cloud turns out to be Salinas del Bebedero, an Argentinean salt mining district which is gradually silting up the surrounding area.

Fig. 3: Screenshot of an interactive learning tool developed in Columbus Eye to integrate HDEV images and inform pupils about patterns, processes, and phenomena of the regional landscape.

Again, earth observation data mirrors the world’s radiances recorded from a bird’s eye view and stored regularly pixel-by-pixel. While maps contain highly reduced content and serve to quickly mediate specific information remotely sensed images provide the unmediated biophysical context of the coupled human-environment system. In order to handle the manifold information of this image data a land-cover classification can transform the complexity into a simple land-cover map showing the most important patterns at a first glance. According to that, the learning tool is added a simple method comparable to supervised minimum-distance classification. The pupils are able to mark relevant training areas exhibiting a distinctive spectral mixture [19]. Afterwards, other areas sharing the spectral similarities of the training areas are
automatically selected and put together in one class. The
user can repeat the steps until the image has turned in to
a land-cover map.

Finally, from the evidence of their own eyes and by
virtue of their own analyses, the pupils can see how
deceptive images from space can appear, and how
complicated their evaluation can be. At the same time,
working with those images from the ISS orbit
demonstrate how powerful remote sensing techniques
are and how massively human interference affects our
environment.

II. III From Space to Class – Examples of HDEV on tour

Whereas the Columbus Eye portal forms the
backbone of the project another important pillar is
the ongoing road show. It brings the HDEV footage and
the mission of Alexander Gerst in the classes. The project
especially focuses on secondary schools. Curricular
topics are captured and taught by using the mediation of
HDEV imagery embedded in learning tools.

Nevertheless, a so called research day in a primary
school has shown that earth observation education with
HDEV imagery is also possible with youngest pupils.
During the event, pupils in the age of 6 to 9 got in touch
not only with HDEV videos but also with high
technology of remote sensing. A half-range
spectroradiometer was applied on objects collected by
the pupils. In doing so, they saw how the reflection of
different objects changed with their colour. Being part
of a learning circuit, a simple RGB-classification was
conducted to an image of their hometown. In order to
consolidate the digital method, the pupils moved to
another station where they converted an image into a
map by drawing it on a transparency. The circuit was
closed by a memory learning game pairing images taken
from above with pictures from the ground. A survey of
related homework revealed a first ignition for earth
observation.

Columbus Eye took also part at an Amateur Radio
on the International Space Station (ARISS) event held at
the Alleestraße, a high school in Siegburg, Germany
(Fig. 4). On September 1, 2014, at 3.12 p.m., a group of
twenty boys and girls made a radio call to orbit from the
school, using the call sign DN6KW to talk to Alexander
Gerst on the ISS. While asking 17 questions dealing
with living and working in space, Columbus Eye
streamed HDEV live videos so that the call from the
ground was accompanied by imagery from above. Thus,
pupils were able to see things from an astronaut's
perspective while at the same time conducting a
correspondence with him, firing up their enthusiasm for
manned space flight.

III. CONCLUSIONS

If the actions and goals of Columbus Eye are
condensed, two catchwords will emerge:
1. „Extensive dissemination": The ISS-HDEV
footage is integrated in the Columbus Eye learning
portal (www.columbuseye.uni-bonn.de) containing a
live stream of the ISS, a web GIS where the HDEV
footage is archived and open accessed, and the
observatory comprising the interactive learning material
on HDEV.

2. „Selective Intensification": A road show brings
HDEV and the ISS-expedition of Alexander Gerst in
schools. The ISS live footage as well as the
backgrounds of earth observation and space travels will
be directly taught to pupils. The advanced education of
their teachers may also be a way to multiply the
recipients and spread the knowledge of remote sensing
from space in a sustainable fashion.

All in all, HDEV and the journey of the ISS are the
core element to arouse interest for STEM subjects,
encourage discovery-based learning, and inform about
aerospace practices. The pupils experience a new and
unfamiliar dynamic bird’s-eye view, and, according to
that, the value of earth observation and space
technologies to monitor ongoing processes of the
coupled human-environment system directing the
Earth’s future.

REFERENCES
Definition Earth Viewing (HDEV),
http://www.nasa.gov/mission_pages/station/resea
rch/experiments/917.html (last access: 2014-09-
10).
(HDEV) Payload Ground Software User’s
Guide, Houston.
[3] Lindsey, R. & Herring, 2002, D., Moderate-
Resolution Imaging Spectroradiometer –
NASA’s Earth Observing System, Greenbelt.


