Visual Moonbounce: Images and Video in Moonbounce Technology

Daniela de Paulis

Back in October 2009 I got in touch with the CAMRAS team (PI9CAM) at Dwingeloo radio telescope in The Netherlands, with a proposal for an artistic project.

For the last few years I had been thinking about moonbounce, in fact since first hearing an echo from the Moon I had been amazed by this technology. When I got in touch with CAMRAS I had the idea of moonbouncing some footage for one of my film projects. Jan van Muijlwijk (PA3FXB) replied enthusiastically to my suggestion and started looking into various possibilities, the result being that moonbouncing a video clip was not impossible but rather difficult – so why not still images instead, would that be an option? And so we started our collaboration.

Figure 1: Daniela de Paulis with the CAMRAS team at the Dwingeloo radio telescope

History and Development

Up till then I had the opportunity to read about and hear some moonbounced sounds on the Internet. Other artists used moonbounce in their work, the most well known examples of that being 'Echoes of the Moon' by American composer Pauline Oliveros and 'Earth-Moon-Earth' by British artist Katie Paterson. They both used moonbounce in their sound works. Pauline Oliveros created her piece 'Echoes from the Moon' in 1987, after watching on television the first Moon landing in 1969. She performed the piece several times, working with ham radio operators Dave Olean K1WHS in Maine and Mark Gummer N2IQ in Syracuse, New York. During her performances Oliveros sent sounds from her microphone to a phone line, receiving the echoes after approximately two and a half seconds. She also involved the audience, people used to queue in her

events and 'seemed to get a big kick out of hearing their voices return-processed by the Moon' ('Notes on Echoes from the Moon', Pauline Oliveros).

Twenty years after, in 2007, Katie Paterson used moonbounce in another remarkable work, called 'Earth-Moon-Earth', where she sent to the Moon and back, with the help of a group of radio amateurs in Japan, Beethoven's 'Moonlight Sonata' converted into Morse code. The moonbounced sounds were then converted back into notes and played as a piano piece [1].

Other artists used moonbounced sounds in their music or sound works – but what really triggered my curiosity was the possibility of 'seeing' the traces of the 768,000 kilometres journey to the Moon and back. What if moonbounce could communicate visually this amazing journey?

This is how I thought of moonbouncing visual data, and in my art projects I refer to this visual communication via the Moon as 'Visual Moonbounce'.

Being very often in The Netherlands for my artist residencies, contacting the CAMRAS team at Dwingeloo radio telescope was the most obvious option – and, as it turned out, the most appropriate one. Dwingeloo radio telescope is not only able to receive good enough quality pictures from the Moon, thanks to its 25 metres diameter and additional technical features, but was also open to this artistic collaboration.

Immediately after our initial contact, Jan started experimenting with possibilities of moonbouncing images using the MMSSTV software. The very first test was carried out on 6 December 2009 when Jan sent to the moon the portrait of his 3 metres dish in the back garden of his house. The signal was received by the Dwingeloo dish. In Jan's words: "We were thinking about asking some big dish stations to do a test with us, but on 6 December 2009 I was at home while the Dwingeloo dish was also on the air (a situation that does not happen very often) so I thought why not do a first SSTV try myself! I phoned Dwingeloo to suggest that I could send an SSTV signal, and so I did [...] Later on 26 February 2010 we successfully exchanged pictures with HB9Q in Switzerland and the first two way EME SSTV contact was made."

Figure 2: First image to be moonbounced to PI9CAM: Jan van Muijlwijk's 3 m dish

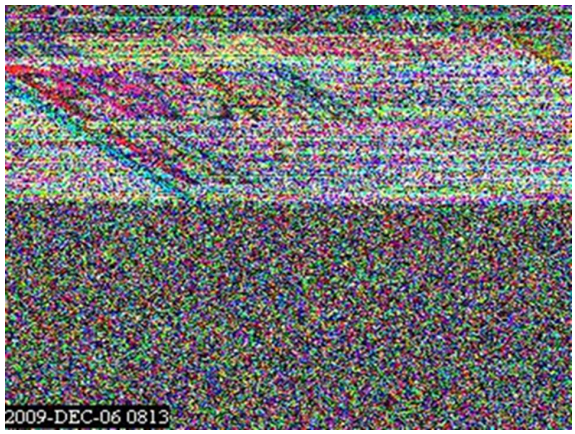

Figure 3: The result of the first experiment, 6 December 2009

The result of this first experiment was very promising, although the original image was not recognizable at this point. Several attempts followed until the moonbounced images started becoming more and more clear.

The noise showing in any moonbounced image is what makes it interesting and evocative of the long journey to the Moon and back. The radio signals containing the information of the image become weaker while travelling the long distance. This is one

of the causes for the distortion of the original colours and shapes in the image, other causes being the poor reflective qualities of the Moon's surface, the Doppler shift and the lunar libration, amongst others.

Figure 4: One of the first images ever to be moonbounced on SSTV (courtesy: NASA)

During transmission the MMSSTV software converts the colours and pixels of the image into sounds that are then converted into radio waves; these are sent to the Moon and after bouncing off they are received by Dwingeloo radio telescope, converted into sounds and then back into image using the same software. The sounds produced by each moonbounced image are unique to that image; in fact no two moonbounced images will ever be alike due to the continuously changing astronomical conditions.

Sending images via the Moon is not however a completely new thing. In the history of development of moonbounce technology, mainly carried out in its early days by the US Navy, it is possible to trace back the initial experiments with images. When the “Radar Division of the Naval Research Laboratory upgraded the Moon Relay system [...] by using the ultra high frequency (UHF) band [...] the experimental Moonbounce system was transformed into a fully operational lunar relay” [2]. This new, more efficient system was officially launched on 28 January 1960. “As part of the inaugural ceremonies, pictures of the aircraft carrier *USS Hancock* were beamed from Honolulu to Washington via the Communication Moon Relay system. The transmitted facsimile [see next page] featured thousands of *Hancock* officers and seamen spelling out ‘Moon Relay’ to a worldwide audience” [3]. “The completed system used eighty-four-foot-diameter (twenty-eight-meter-diameter) steerable parabolic antennas and 100-kilowatt transmitters installed at Annapolis, Maryland, and Opana, Oahu, with receivers at Cheltenham, Maryland, and Wahiawa, Oahu. The system operated at frequencies around 400 megahertz, it could accommodate up to sixteen teleprinter channels operating at the rate of sixty words per minute, and it was capable of processing teletype and photographic facsimiles” [4].

Another interesting example of visualizing the Moonbounce process is a study made by radio amateur Andrea Mancini (IW4CJM) “with the cooperation of the Radioastronomy Association 'Bagnara di Romagna', on how to ‘write’ on the Moon [...] The actual writing is obtained using audio tones within the transmitter’s audio band, so that, if *Spectran* is used to decode, numbers and letters will appear on the screen [...] I needed to increase

the letters' size from 100 to 800 Hz, using Spectran left-to-right scan. Subsequently, I have been able to obtain the same result with up/down Spectran scan, which is the normally used mode," says Mancini in his text for the EME conference in Florence in 2008.

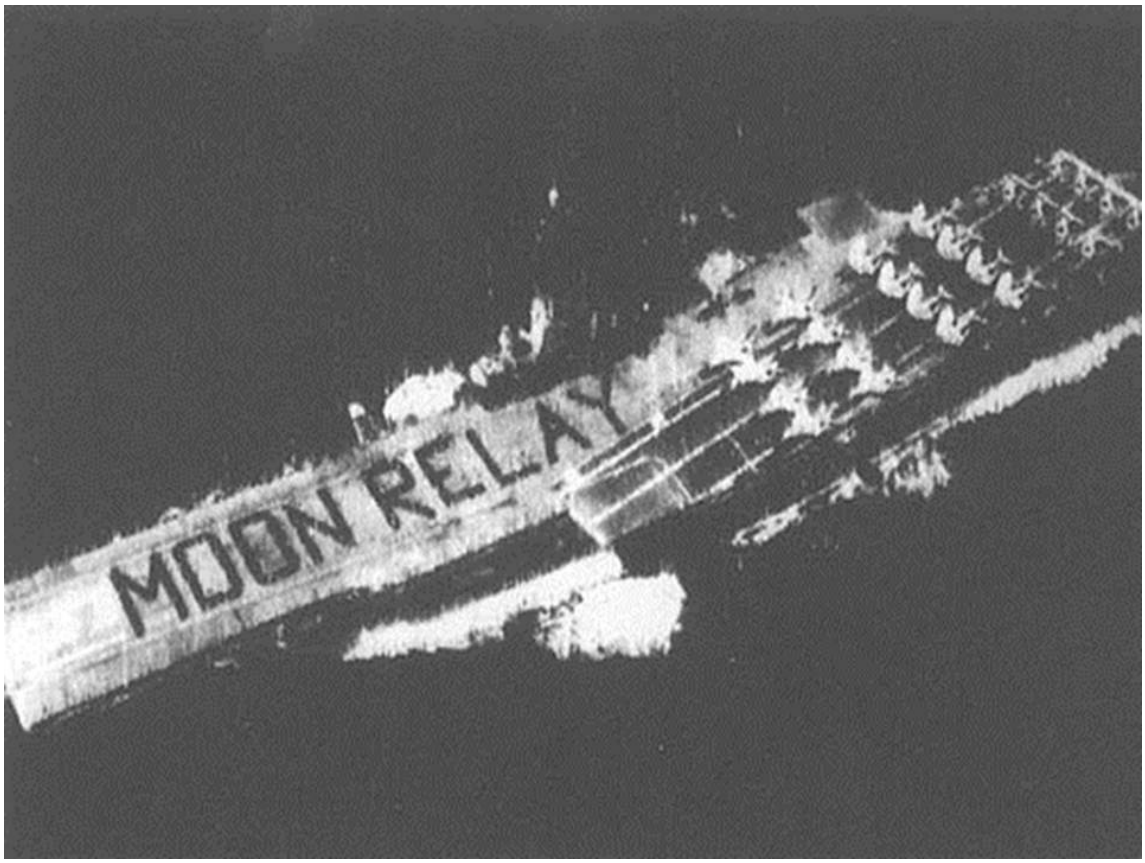

Figure 5: Facsimile picture of the USS Hancock with ship officers and crew spelling out 'Moon Relay'. This picture was transmitted via the Moon from Honolulu, Hawaii, to Washington, DC on 28 January 1960 (courtesy US Navy, NASA).

"After this change, I was ready to 'write' on the Moon, and the first tests, carried out on May 5, 2004, were successful [...] The signal from the 7-meter dish was sent while the dish itself was slowly moved at a steady speed across the surface of the moon, from the east to the west limb [...] While experimenting, I noticed that the text had a better definition if, instead of a single tone, two were used [...] I called this 'the painter's theory'" [5].

Into Live Performance

When the technology of moonbouncing images using the MMSSTV was fully tested by Jan, the CAMRAS team and some international collaborators – Bruce Hálàsz PY2BS in Brazil, Daniel Gautschi HB9Q in Switzerland and Howard Ling G4CCH in the UK – I started working on ideas for using this great technology within a live performance. After some research I came up with the title for the project, 'OPTICKS', inspired by the 1704 essay by Isaac Newton on the reflections, refractions, inflections and colours of light.

During the first performances of OPTICKS in fact we used to moonbounce monochrome images of the seven colours of the light spectrum. In general however the title

aims at suggesting the phenomenon of reflection and refraction of the radio waves by the Moon's surface, through a poetic and philosophical link between Moonbounce and the light spectrum.

Figure 6: The OPTICKS title received by moonbounce

The first performance of OPTICKS took place on 30 October 2010 at 01:00 UTC at Extrapool, an experimental art venue in Nijmegen in The Netherlands. Images of the seven colours of the spectrum were sent by Howard Ling in the UK to the Moon, received by Jan at Dwingeloo radio telescope and projected in real time at the exhibition space. The building up of each colour (72 seconds for each image on 'Robot 72' mode in the MMSSTV setting) was accompanied by a sound score composed especially for the project and played live by Spanish composer Enrique Tomas (www.ultranoise.es).

Enrique composed a seven minutes score, especially tailored for EME technology, in which each minute corresponds to a musical note. The sounds were moonbounced and incorporated in the live show.

The idea of having a sound score was also inspired by the Newton's essay. The great scientist in fact believed in the hidden connection between the musical notes, the seven days of the week, the seven colours of the light spectrum and the seven celestial bodies known in his time. “Newton constructed the colour music disc dividing the spectrum into the seven colours [...] to be fitted in between the eight notes of an octave. The colour music disc in OPTICKS analogizes music to colour, just as its prototypes (of Plato, Ptolemy and Kepler) had connected music to planets and other qualities” [6].

Enrique, an experienced sound artist, enthusiastically took the challenge of composing sounds for moonbounce, and this is how he describes his experience: “The specifications of the project, with a maximum length of each piece of 72 seconds, a reduced spectrum between 400 and 2800 Hz and a monaural playback were an important constraint. Also I took into account the fact that my audios will be distorted due to the transmission through the atmosphere, the vacuum space and the reflection on the surface of the moon” [7].

This structure of the OPTICKS performance was used a few more times, including the show at the Amsterdam Planetarium in November 2010. The project however changes continuously so to be always different and unpredictable. Occasionally new collabora-

tors join in. After the first few live events I decided to replace the images of the seven colours of the spectrum with images submitted by the public attending the live event. Also I decided to replace the sound score with a verbal interaction with the audience, talking and answering questions.

During the show it is possible to hear in the background the sounds produced by the MMSSTV while the images return from the Moon. Because each colour corresponds to a unique tone in the software, the connection between colours and sounds suggested by Newton is intrinsic to the MMSSTV software.

During each live performance, Jan and the CAMRAS team appear in a video call and answer questions from the audience. Usually, after moonbouncing four of five images a pause is needed, in fact the power amplifiers and coax cables become very hot and need to cool down to avoid burning. Every OPTICKS event is a bit of an adventure, and we always experienced some technical problems either before or even during the live event. The problems are sometimes caused by a slow Internet connection (the images in fact are received live at any location thanks to a remote desktop control software called *TeamViewer*); or at other times there are problems due to high winds at one of the locations involved, or other technical failures at one of the stations. However, despite the complex technicality we never had to cancel a single performance so far!

Jan, Howard, Bruce and I have presented OPTICKS many times already, always with the enthusiastic response of the audience. One of my favourite performances was in collaboration with RAI Radio 2 programme 'Rai Tunes', directed by Italian DJ Alessio Bertallot. The programme can be followed both on the radio and on the web where it is possible to see the video for the event. The images submitted by the radio listeners, including some iconic images from popular culture, such as Pink Floyd's 'The Dark Side of the Moon' album cover, were sent to the Moon by Howard in the UK and received by Jan at Dwingeloo while some classical and pop music tunes accompanied the event [8].

One of the most interesting performances of OPTICKS so far was presented as part of Global Astronomy Month (GAM) 2012 in collaboration with Astronomers Without Borders [9]. For this occasion CAMRAS collaborated with Prof. Lech Mankiewicz, together with radio operators from ARISS Polska: Armand Budzianowski SP3QFE, Andrzej Matuszny SP6JLW, Jacek Masłowski SP6OPN and Paweł Matuszny SQ6OPG. The Polish team in a few weeks upgraded their equipment in order to participate in the live Visual Moonbounce performance scheduled for the 28 April 2012 at 18:00 UTC.

Several tests conducted by Jan and Armand preceded the event. The reliability of the Internet connection was one of the main technical issues the Polish team needed to solve, their station being located in the middle of a forest, also they had to find out what power levels could be safely used in order to send SSTV without overheating their amplifiers.

The OPTICKS live performance for GAM 2012 was presented live from Dwingeloo radio telescope: inside the cabin, CAMRAS radio amateurs Dick Harms, Theo Dekkers, Eene de Weerd, together with Jan, radio astronomer Roy Smits and myself, presented the event on Ustream for an international audience, moonbouncing images submitted by people of all ages and from all around the world. During the live event the moonbounce activities were temporarily paused for transmitting the image of Dwingeloo radio telescope followed by images of the primary colours (Red, Yellow, Blue) to a star called Upsilon Andromedae, 44 light years away. The Dwingeloo antenna rotated to track this star – together with the cabin and all of us inside – in front of the astonished audience following the event on the web. Upsilon Andromedae is believed to be hosting four planets, one of which, we hope, will receive the images in 2056 (centenary of the

Dwingeloo radio telescope official opening) and perhaps it may respond sometime in 2100.

For the OPTICKS performance for GAM 2012, the Polish team surprised us all with a special call sign, starting with the prefix of their country, SN2012GAM, that was used on some of the images moonbounced during that night. After the performance I printed the moonbounced images and sent them back as a card to the people from all over the world who submitted them, together with my message certifying the authenticity of the journey to the Moon and back. A certificate from both the CAMRAS and the Polish team has also been created to accompany the pictures. Some of the recipients of these images wrote back to me with a 'thanks' message, saying how much they appreciated the experience of being 'astronauts', even if only virtually. For further recordings and information, see [10–14].

As part of GAM 2012 I also presented a B/W video called 'le Voyage dans la Lune' (2011-2012), whose title is inspired by a famous French movie, made by George Méliès in 1902 and considered the first Science Fiction film in history [15]. Similarly, moonbounce can be considered the first form of Space travel that allowed humankind to 'touch' another celestial body, by means of radio waves. My version of 'le Voyage dans la Lune' is composed by 26 images of the lunar phases taken by Michael Oates (Manchester Astronomical Society) who kindly offered them to me for the project. The 26 images have been moonbounced from Brazil to Dwingeloo in September 2011, using the SSTV mode B/W 12. I joined the moonbounced images together into a moving sequence and added the sound which has been provided by JAXA (Japan Aerospace Exploration Agency). The sound is called 'Moonbell' and uses laser altimeter data from one of the sensors of the lunar orbiting satellite Selene/Kaguya, transforming the altitude data into musical intervals [16]. The area I chose to 'sonify' is on the far side of the Moon, starting at the Korolev crater and continuing across the highest point. I used a very slow version of the sound in order to suggest the rhythmic steps of someone walking on the Moon.

Since the very first experiment on 6 December 2009, Jan, Bruce, Howard, Daniel and Armand sent many images to the Moon and back, not only for OPTICKS and for my artistic research but also for Visual Moonbounce enthusiasts, including Patrick Barthelow AA6EG who is proposing to use this technology for STEM education.

The Future

The future of Visual Moonbounce is already looking very interesting. The video 'le Voyage dans la Lune' is my very first attempt to use Moonbounce with moving images. However Jan, Armand and I have been discussing possibilities to moonbounce short films in a near future.

Besides my suggestions of using video clips and possibly 3D effects, Jan, Bruce, Howard and Armand are also developing ways to receive pictures with higher definition. Here is an example:

Figure 7: André Kuipers' portrait moonbounced using Robot 72 mode

This image of Dutch astronaut André Kuipers was first moonbounced by Jan on 25 February 2012 using the MMSSTV software in 'Robot 72' mode, taking 72 seconds for the whole picture. Jan also tried the 'Scottie DX' mode, taking 269 seconds and so promising better image quality, but the first attempts were spoiled by the changes in Doppler shift over this rather long time period. By careful manual correction (like many operators do with drifting digital EME signals that otherwise would be undecodable) it was possible to receive a nearly perfect picture:

Figure 8: Same moonbounced image as Figure 7,
using Scottie DX mode with continuous manual Doppler correction

After a live OPTICKS performance, Howard G4CCH also tried both a Scottie DX picture (269 seconds) and a picture in the faster Scottie 1 mode (110 seconds). The difference is visible but not very big, so Scottie 1 might be a nice higher-quality alternative to Robot 72 and takes only about 40 seconds more.

Conclusion

Experimenting is an important process for artists, radio amateurs and scientists alike.

Something that started as a playful experiment for an art project might lead to many interesting pioneering ideas in this fascinating technology called Moonbounce, and beyond even that.

Being a small part of this adventure is for me an amazing experience. I will never be grateful enough to CAMRAS, Jan, Daniel, Bruce, Howard and Armand for making 'visible' the journey to the Moon and back.

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8. http://www.youtube.com/watch?v=s92lLLgFuOs
9. http://www.astronomerswithoutborders.org/gam2012/all-programs/1071-opticks-2012.html
10. A recording of the OPTICKS performance for GAM 2012 (unfortunately the first ten minutes are missing): http://www.ustream.tv/channel/opticks2012
11. Also a nice video made by Armand about the GAM 2012 event can be viewed here: http://www.youtube.com/watch?v=-6-a8ygDKrA
12. An article about the same event in Polish: http://sp3qfe.net/
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14. Updates and further information on the OPTICKS project can be found here: www.opticks.info
15. https://vimeo.com/41287703
16. *Moonbell: Listening to the Topography of the Moon*: http://wms.selene.darts.isas.jaxa.jp/selene_sok/about_en.html

Appendices

Some further comments on Visual Moonbounce by Jan, Bruce, Daniel and Armand.

Jan van Muijlwijk PA3FXB

OPTICKS, a real winner!

When Daniela contacted CAMRAS in 2009 and asked if it was possible to transfer movies via moonbounce I could not have guessed that this would lead to the many amazing EME SSTV events we have done during the last few years.

I very well remember the first very enthusiastic Skype call we had. During that call it became obvious to me that EME and art could bring about great projects. A real win-win situation!

However movies via moonbounce were not possible with our dish and amateur radio power levels, but we suspected that non-moving images could be successfully transferred via the moon using SSTV. We started experimenting and this resulted in the first EME SSTV contact between PI9CAM and HB9Q on 23 cm on February 26, 2010. This was followed by the first EME SSTV contact on 70 cm between the same stations on April 18, 2010. After that we asked Howard G4CCH and Bruce PY2BS to try EME SSTV with us.

It worked fantastically well and Daniela started to work out a way of doing this in a real life performance. Therefore it was needed that the pictures we received in Dwingeloo could be relayed via the internet one way or the other. We did many tests using Skype to send the audio but we all know that VOIP technique often has 'hiccups'. Most of the time that resulted in lost synchronization in the received picture. We had to find another way…

We found that using *Teamviewer* – a nice way of showing your computer screen to someone else via the Internet. The latest versions of *Teamviewer* also make it possible to transfer voice and/or video so with only one piece of software we can do it all!

When we started to do those art projects I really had some explaining to do at CAMRAS :-) Many purely technical people do not have warm feelings towards art (to say the least…) but as soon as we started working on these projects – and as more and more people experienced the enthusiasm those performances created – they changed their minds about art. At least this type of art :-)

So there we are, a great artist and a BIG dish, what a wonderful combination!

I am sure we will be surprised by the creative things we are going to experience in future.

Jan PA3FXB (team PI9CAM)

Daniel Gautschi HB9CRQ

I was approached by Jan of the PI9CAM-team in February 2010 with the proposal to try SSTV off the Moon, I had never ever worked on SSTV on any band. Jan sent me the download-link for the SSTV software… and a few days later we tried the first ever SSTV QSO on 1296 MHz EME. I have to admit that I did not really know how to run this software, but nevertheless we succeeded easily to complete the first ever SSTV QSO off the Moon (on any band!) and to exchange several pictures. In April 2010 we had a second QSO, which was the first ever SSTV QSO on 432 MHz EME. Again it was an easy and very nice QSO, since I had learned a little more about the SSTV software, the

received pictures were even better than those received on 1296 MHz two months before. It was very exciting and a great pleasure to be part of PI9CAM's effort and it was an honor to be their partner for the first ever EME SSTV QSO!

Daniel HB9CRQ

Bruce Hálàsz PY2BS

My station is situated on a residential building in the city of Sao Paulo, on the 28th floor. The dish I use has 4.6 m diameter, and my power amplifier delivers 900 W, which means 600 W at the antenna after the cable loss up from the apartment to the roof is taken in account.

The main issue I had to solve for running SSTV for OPTICKS was the power amplifier cooling as the maximum usage rate until then was WSJT, on which the transmitter cools down for 70 seconds after each 50 seconds transmitting cycle.

But, on the SSTV mode OPTICKS uses, the transmitting period lasts for 72 seconds, which required an even longer cooling interval after each transmitted frame. The solution was exchanging the fans for extra high flow ones, that, although very noisy, provides cooling good enough in a way that just a few seconds between the frames are required for operating within a safe temperature range.

I'm building up, and plan having ready in a few months a new and larger 5.1 m dish, which should increase the transmitted signal by nearly 1 dB, which I expect, will slightly improve the quality of the received pictures.

Poland to the Moon, or There and Back Again as SN2012 GAM

Armand Budzianowski (SP3QFE) and Andrzej Matuszny SP6JLW

It is March 2012. Krystian Górski (SQ2KL) – initiator of many interesting events, such as the first ARISS school contact in Poland – got in touch with Armand Budzianowski (SP3QFE) and suggested sending images line by line, to the Moon and back to Earth on the centimeter band. This would be part of a collaboration with the amateur radio team PI9CAM, operating the 25m diameter radiotelescope in Dwingeloo, The Netherlands, with CAMRAS receiving and decoding the pictures. Armand said: "well it is interesting, but we don't have sufficient equipment to do this". After the call he checked all the information about this project and he discovered that it was called OPTICKS, an art work by Daniela de Paulis, the artist from Italy who in cooperation with the PI9CAM team at Dwingeloo radio telescope, Howard Ling (G4CCH) from Great Britain and Bruce Hálàsz (PY2BS) from Brazil performed a similar event in 2011 during Global Astronomy Month.

In the HAM world this kind of technique in which pictures are sent line by line is call SSTV – Slow Scanning Television – because at the beginning of commercial TV, when the Internet didn't exist, amateurs radio operators wanted also to send their portrait to their remote HAM friend and they connected the camera as the video receiver by some special analogue system to the conventional transceiver. Because of the narrow band (in comparison to commercial TV) the image could only be sent line by line. These days we have very fast computers, which reuse that old analog system to convert image into sound, which is then sent on the HAM band. This technique is old, and the transfer of the image in the computer age is slow, but there is big advantage… in this technique we can get very high ratio between signal and noise, for that reason the technique is still used on the HF HAM bands.

Krystian goes ahead, and during another call with Armand (SP3QFE) says that it was possible to take part in the project in cooperation with the Group ARISS in Poland and the operators of one of the famous Polish EME station **(E**arth **M**oon **E**arth), which is located in Kłodzko Valley. He found a group of amateurs who wanted to provide us with their equipment for the experiment. The Kłodzka Grupa EME is a group of the operators: Andrzej (Andy) SP6JLW, Jurek SP6OPN and Piotr SQ6OPG. In this case Armand agreed to check technical details and if it was possible, to join the GAM 2012 event. Krystian introduced our group of collaborators. They are: Prof. Lech Mankiewicz (the initiator of the "Moon Bounce" in Poland), Dr. Agata Hoffman (Polish Academy of Children), Elizabeth Kowalczyk (Foundation Challenger Poland), Aleksandra Sójko, Jan Pomierny.

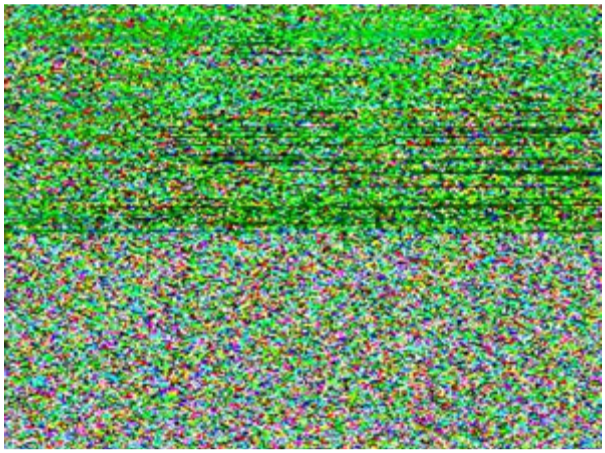

Figure 1: Picture noise at the Polish station EME group Kłodzka
Above: reflected from the Moon
Below: solar and cosmic noise when the Sun 'blinded our station'.

Armand kept in touch with Andrzej SP6JLW and they started discussing the details. It turned out that many items were to be checked, tested and refined in order to meet the basic technical requirements set by CA Muller Radio Astronomy Station (CAMRAS) in Dwingeloo for joining the EME SSTV broadcast during the **G**lobal **A**stronomy **M**onth (GAM 2012). We didn't have too much time, but the deadline was real with very small margin. Eventually we had two points to do: first, preparing an EME station transmitter for continuous operation for about 90 seconds at 23cm band of greater powers and second, establishing the high speed Internet connection for communicating with the CAMRAS team during the event, including the transfer of video. Many valuable tips on SSTV have been obtained during discussion on the SP7PKI forum. After preparing the equipment such antennas, radios, etc. for the journey from Warsaw, Krystian SQ2KL and Armand SP3QFE chose the train to the Kłodzko Valley to test the station and the Internet. All tests were successful. We started SSTV system, we received and decoded locally the first images on the 23cm. Additionally we found the Internet service provider to get the transfer 4Mbits in both way. Skype worked properly. In this situation, we announced to the Netherlands that we could join the celebration of GAM in 2012 as another transmitting station together with the British and Brazilian stations. Both the Italian artist Daniela de Paulis, project coordinator of the Visual Moon Bounce project and Jan van Muijlwijk (PA3FXB) expressed their great enthusiasm, but the high-speed Internet at the base of the GSM technology using the direction antenna was still uncertain. The location of our radio stations on the hillside of the mountains, in the middle of the woods, gave us a lot of limitations in getting fast to the Internet.

In a very short time we got a special radio license to work in our experimental station with a special call sign SN2012GAM. Our colleague Dionizy SQ6EIQ got involved and helped us with legal issues, which can cause problems to inexperienced HAM operators. Until the end of this year the special sign SN2012GAM will appear from Poland on the HF, UHF and VHF bands for tropo contacts.

Unfortunately the event on the April 28 was still uncertain, because amateur radio stations from Brazil and Great Britain could not broadcast on that day images to the Moon on the 23cm band! Immediately Jan and Daniela asked us about our availability. It was a shock for us, because it was a very high responsibility.

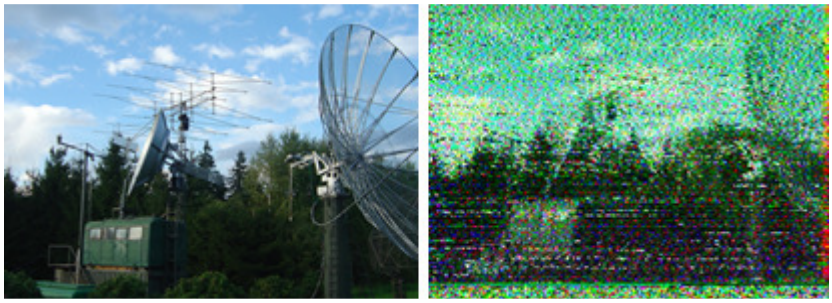

Figure 2: Our first image sent to the Moon from Poland... received and decoded by Dwingeloo radio telescope and the team PI9CAM

Although the thermal test for the station was successful, Andrzej and Jurek were not satisfied. After our consultation via phone, we concluded that they will do the second configuration of the radio station, which will be ready to work with higher powers right at that moment. They started working the day after Easter. The result of their work went beyond our dreams! Thermal tests were very positive. We only had to test the system in practice. Unfortunately, due to scientific research carried at Dwingeloo radio telescope, the closest possible date for the CAMRAS team to use this equipment for HAM radio activities was the 21st April. On this day we were on our 6.5m diameter antenna, we were "blind" because the Moon was about 2 degrees away from the Sun for the whole day. For our system this angle is not enough to listen to the radio signals, because of the very high background from the Sun. However on this day we could send the images to the Moon :). On the 21st April, we established the Internet connection between our station and Jan van Muijlwijk's (PA3FXB) at Dwingeloo radio telescope and discussed the details of the event. Besides the Internet problem we had to see how the station in Brazil and in the UK sends the pictures the Moon and back to the radio telescope in The Netherlands, from where the pictures are sent to the museum, where Daniela de Paulis does her presentation for the public. Such presentation always involves emotions for the visitors of the museum. Suddenly, just before the event when we didn't expect it, Jan asked us to send one picture from Poland via the Moon. We were not ready for it.... well, the station was ready to transmit on SSTV but we did not have the images ready. We sent the first image we had. It was a picture of our radio station. We followed on the monitor through the Internet how our picture appeared in the Netherlands ....At the beginning there was the blue sky, when we spotted some clouds we calmed down. In a moment we heard John's words (PA3FXB): "Excellent! Good job! (...) ". Phew... we did it, with success! The quality of the received picture exceeded our wildest expectations. We were happy! After the first picture, we knew that we were ready for the event.

After the event at the museum, we sent to the Moon a few images using various SSTV modes. Everything went smoothly. On this day we summarized that only close cooperation of radio amateurs with different experiences and of different generations could help us getting this success. "Thanks to the involvement of Polish HAM operators, we can be sure that the event will be a great demonstration of the capabilities of modern technology, whit a great emphasis on science outreach, addressed especially to young children. It is they who are primarily writers of images that we send in the direction of the Moon," said in an interview Prof. Lech Mankiewicz, the Director of the Center for Theoretical Physics in Warsaw. OPTICKS and Visual Moonbounce are another way next to MoonKAM, virtual telescopes and NASA's Mission Planner tests to grab the attention of children and young people for exploring Science and Space exploration, in this case through our amateur radio hobby.

Figure 3: On 28th April 2012, this work by Julia Kazimierczak, The Violin Comet*, began the official webcast of OPTICKS during GAM 2012.*

It was a big day. Over 8 hours on the bus in one way to Kłodzko Valley for Armi. Two months ago we started our preparation and it was difficult to believe that today it was the day. The first tests had already started at about 16:00. Despite the great preparation, the PI9CAM team received our pictures before the event. We sent as many images as possible, not just those that were originally chosen as the most interesting and fulfilling the technical conditions. Everything went smoothly, although there were moments with high level of adrenaline with big concerns about the evening live performance! We were very careful. On that day, according to weather forecasts came a strong wind, which could cause much damage, ranging from damage to the antenna to cut off of our power supply and consequent turn off of the transmitter for the event. On the other hand, the wind perfectly cooled the transmitter! Wind was also often changing the position of the antenna of the high-speed Internet and we feared that eventually the antenna would fail during the online event. We then established a direct telephone connection with the radio telescope in the Netherlands. We used this option several times to discuss important details. Please note that all our contacts with the operators at Dwingeloo took place during the live broadcast on the Internet. We had to be one hundred percent available for the operators at the radio telescope and invisible to those viewing the show. We got connected at 19:00 local time, although the start was scheduled for 20:00. While waiting our excitement grew. Broadcasting began at about 20:20, then after the second image we breathed. None of us remembers how the event ended,

but you can check the video recordings. Nobody did check the time. A few minutes after posting the first picture painted by 16 years old Julie Kazimierczak, *The Violin Comet*, with our call sign of the station, we got a text message from Hubert SQ9AOL that the first picture was already on krótkofalowcy.org media. Thank you! Immediately, there were other messages of congratulations, including one from Jack SQ8AQO – the President of Association of HAM “Delta” in Poland. We began broadcasting the images selected by Daniela de Paulis, and submissions from around the world for the competition Moon Bounce GAM 2012, which had been selected and approved by Daniela and Jan. Then we sent one of the art works contest announced by the Polish Foundation Challenger also chosen by Daniela and Jan. It was an illustration made by 8 years old Maria Misan from Gdansk, Poland with the map of Poland on the Moon, featuring the callsign SN2012GAM prepared by Karol Fijałkowki from Warsaw. We had to send some of the images with our call sing because of the law requirement in Poland. After the show other activities followed at Dwingeloo. After that we sent the next six images submitted from around the world for the OPTICKS GAM 2012 event.

Figure 4: The image POLAND to the Moon or there and back again by Karol Fijalkowski, Warsaw.

The activities were closely planned. Communication with the Netherlands TEAM and transmitting of SSTV images: Armand SP3QFE. Preparation of the transmitter, frequency control and the accuracy of the antenna alignment, control EME beacon, and the preparation of the amplifiers for broadcast: Andrzej SP6JLW. The most important function was by Jack SP6OPN, he controlled the temperature of the PA and corrected the motion of the antenna, thing that with such strong winds was not easy. He had to decide "go / no go". Without his agreement, even though the team from the Netherlands asked to broadcast, we could not start the transmission of video! Paul SQ6OPG was the cameraman. The film was recorded very well...but due to our emotional response (there was no swearing though) the film remains for internal use only.

After the summary from Kłodzko Valley had been given, the PI9CAM team received and decoded: 10 works from the children contest, "My Journey into Space", published by the Foundation Challenger Poland, 31 works from the contest "We Fly to the Moon," published by the Klodzko EME Group ARISS Poland and PAC, plus the images of five of the schools and organizations that have come forward to us with a request to send their logos on a journey of over 700,000 km!

The Kłodzka EME Grupa had output power between 600 W to 750 W depending on the wind outside. The high frequency power amplifier (PA) has been made using 16 transistors BLV958. All transmissions on both 23 and 13 cm bands have been done using the 6.5 m diameter dish. The users of this station – Andrzej, Jacek, Paweł and ourselves – made the technical changes themselves.

The entire Polish team warmly thanked Jan and Daniela for their endorsement of our work, which was supported and co-ordinated by prof. Lech Mankiewicz, Hands-On Universe, Poland and Astronomia.pl portal. In the event also took part: Foundation Challenger Poland, Portal and publishing AstroNautilus Kosmonauta.pl.

Mission accomplished, excitement wore off, and that's when we make a quick decision: SN2012GAM station run on 13cm band. At almost 13cm last day EME CONTEST EUROPEAN competition. The whole team stayed at the station until late on Sunday 29 April. We were working hard in competitions CW and SSB. The end result was 42 QSO and multiplier 37 is a very good result, especially since we worked half the time for the competition and there was a very strong wind. Now, we are convinced that the Polish mark SN2012GAM is known in the world of EME.

Figure 5: The last image sent from Poland to the almost 800,000 km journey Portrait submitted by Tina Michetti (Belgium).

While preparing for the project I knew little about EME, now thanks to the CAMRAS team, Daniela de Paulis and the excellent EME mentors from the Kłodzka Grupa EME, I know much more about the microwave amateur radio and this technique of communication using the Moon as the relay. We thank everyone for their help, cooperation and joint achievement.

Credits

Text by: Armand SP3QFE and Andrzej SP6JLW, with consultation of Daniela de Paulis, Jerzy SP6OPN, Piotr SQ6OPG, Krystian SQ2KL, Elizabeth Kowalczyk, and prof. Lech Mankiewicz.

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Figure 4: This image has been made using a composite image which was an Astronomy Picture of the Day. Composite Image Credit: T A Rector, I P Dell'Antonio, NOAO, AURA, NSF (http://apod.nasa.gov/apod/ap010906.html). Further credits to: Daniela de Paulis, www.opticks.info, CAMRAS www.camras.nl, Hands-On Universe, Europe, www.euhou.net, Kłodzko group EME, ariss.pzk.org.pl. Further use under a Creative Commons license.

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Web links

http://www.vmb.arisspolska.info

http://pzk.org.pl/news.php?readmore=2296

http://www.facebook.com/events/112164298918240/

http://www.arisspolska.info/?p=2874

http://mikrofale.iq24.pl/default.asp?grupa=167772&temat=137321&nr_str=2 # 935 885

http://mikrofale.iq24.pl/default.asp?grupa=167772&temat=137321&nr_str=1

http://www.astronomerswithoutborders.org/gam2012/all-programs/1071-opticks-2012.html

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