Education and Public Outreach: Lunar Orbiter and ISEE-3

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Any space mission worth doing should have an education and public outreach (EPO) component. An EPO effort helps to efficiently disseminate information to those with a specific interest in a particular mission. Done properly it also serves as a means to spur interest in space exploration in general amongst a much broader audience. With the use of various Internet and social media resources an effective EPO effort can now reach an audience in ways that were not possible a decade ago. Our team has undertaken two projects, the Lunar Orbiter Image Recovery Project and the ISEE-3 Reboot Project, both of which involved historic NASA space missions, spacecraft, and data. We conducted these efforts utilizing a wide range of crowd sourced, crowd funded, open data, and EPO methods and did so with a great deal of success. We believe that the time is right for NASA and other space agencies to expand their use of similar methods so as to further engage the public in the exploration of space.

Introduction

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Recently, with the advent of sophisticated online crowd sourcing and crowd funding platforms, a strategically managed space mission EPO effort can now personally engage a wide audience in the generation and analysis of mission data as well as the actual funding of mission activities. Both activities can serve to provide an engaged group of participants at little or no cost while also allowing novel sources of funding to fill in gaps that might otherwise be ignored.

Crowd funded and crowd sourced EPO activities can also generate a wide range of enthusiastic supporters whose efforts can assist in keeping a mission going using novel or non-traditional means of support while also reaching sectors of the population who are not normally targeted by traditional space mission EPO efforts.

Everyone is asked to pay the taxes that support government funded space efforts. So why shouldn't everyone have a chance to be personally involved in how these space projects are conducted? And if limited government resources cannot fully support the sort of EPO activities a space project might desire to conduct, shouldn't there be alternate ways to allow citizens to mount EPO efforts using alternate means of support?

Lunar Orbiter and ISEE-3

Our team has conducted two crowd funded and crowd sourced projects involving NASA space missions. The Lunar Image Recovery Project (LOIRP) and the ISEE-3 Reboot Project. Both efforts utilized the raising of substantial sums of money from thousands of individual donors, used donated/volunteer service in a wide variety of fields, required novel agreements with NASA, and produced end results that would not have been possible were it not for the use of external, non-traditional methods. Indeed both projects were equally enabled and conducted by use of Internet-based social media and collaboration platforms. The effect of these projects is additive as well. We would never have been able to attempt - much less accomplish - the ISEE-3 Reboot Project without the expertise gained from LOIRP - and the proof of concept that it provided.

These tasks would have also been impossible without the foresight and enthusiastic support of NASA - specifically the Science Mission Directorate, the Human Exploration and Mission Operations Directorate, Ames Research Center and the Solar System Exploration Research Virtual Institute (formerly the NASA Lunar Science Institute). The most important thing our friends at NASA did was allow us to try new ways of doing things.

Lunar Orbiter Image Recovery Project

We're Back !

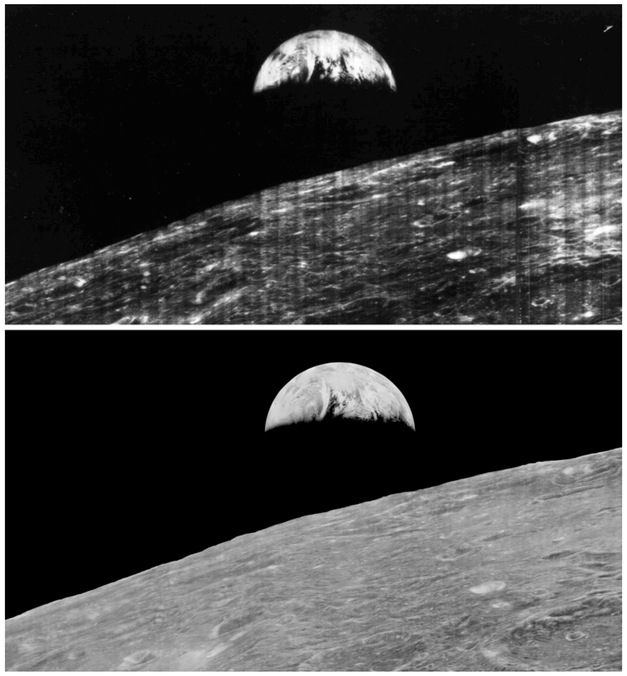
Between 1966 and 1967 NASA send 5 Lunar Orbiter spacecraft to map the Moon. Their primary purpose was to image the surface so as to allow the identification of potential landing sites for the upcoming Apollo lunar missions. In addition, considerable effort was also put into using the Lunar Orbiters for scientific studies of the Moon. Photos taken of the surface were taken by film cameras. The film was chemically processed in lunar orbit. the images scanned, and analog data sent back to Earth. On Earth the analog data was stored on data tapes for archival purposes. The main use of imagery was derived from photographs of images that appeared on a kinescope. These images were rephotographed several times, with a loss of resolution with each generation of images. That said the quality of these images was sufficient to meet mission objectives.

The archival data tapes were rarely used and ended up in storage. Eventually all but one of the original collections of data tapes were destroyed and the tape drives used for the project were sold as scrap surplus. In the 1990s an effort was made to try and recreate the capability to access the data tapes but was halted prematurely due to lack of funding.

in 2007 our team stumbled across references to this 1990 retrieval attempt on the Internet. Through additional sleuthing we discovered the location of the sole remaining collection of data tapes and some surplus FR-900 tape drives. Using private funds and effort we obtained ownership of the drives and borrowed the tapes and set up operation inside un-used space inside an abandoned McDonald's restaurant at NASA Ames Research Center. Had we not used this building it would have been torn down.

After a year of submitting proposals we managed to get some seed money from NASA to refurbish the drives and retrieve one image. A year later we released a newly retrieved version of the iconic Lunar Orbiter 1 "Earth rise" image. We received considerable media exposure at this point - and with it attention from a growing audience of interested people all over the world. In the process of generating visibility we also attracted expertise from around the world. This process is infectious and self-perpetuating. In many cases former Lunar Orbiter employees would send us boxes of material that had been sitting in their garages for decades waiting for someone to find value in them once again.

When our NASA funding began to run out in 2009-2010 we turned once again to private fundraising. In 2013 we mounted a crowd funding campaign with eventually resulted in over $100,000 in donations. Why did people give us money? It would seem that we had provided a compelling narrative about what we were doing, why were were doing it, why no one else was doing it, and how we were doing it in a bare bones, collaborative fashion inside an abandoned fast food joint. There was a undeniable hack chic to this as well - something that serve us well in the future.



Above: original Earth rise image from 1966. Below image retrieved by LOIRP in 2008.

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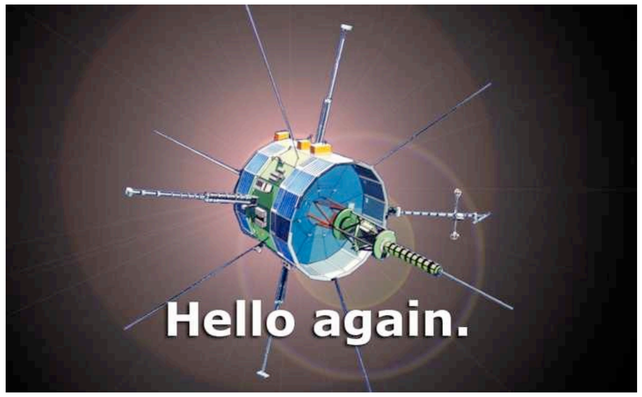
Impressed with our ability to conduct this project NASA was able to provide some additional funding such that we were able to complete the retrieval of 99% of the images taken by all five Lunar Orbiters. We are now preparing all imagery for formal submission to the Planetary Data System in a format consistent with how other NASA missions submit their data.

Throughout the LOIRP we have strived to use Internet and social media tools to keep our growing audience informed of our progress and when necessary to ask them for help. At present we are working to put a comprehensive website online wherein all of our imagery in its newly retrieved native resolution is available to anyone, anywhere, to use - free of copyright. Much of or imagery rivals and often exceeds that obtained by the modern Lunar Reconnaissance Orbiter.

When we embarked upon the LOIRP we were told that the task was impossible. Skeptics said that millions would be needed to recreate the tape drives; the tapes would be unreadable; documentation is incomplete; people who worked on the program were retired or dead; and besides Lunar Orbiter data is not needed since NASA has better imagery. In each case we sought alternative means and external sources of expertise to surmount these perceived obstacles.

Just as we were having the celebration party in early April 2014 for the completion of LOIRP data retrieval another visitor from the past came knowing on our door mere days later. That visitor was ISEE-3.

The ISEE-3 Reboot Project



The International Sun Earth Explorer 3 (ISEE-3) was launched in 1978 as part of a trio of spacecraft to measure a variety of things in the vicinity of Earth that would be lumped under the term "space weather" today. When its original mission was completed some enterprising NASA engineers and scientists concocted a plan whereby a series of unusual orbital flybys of Earth and the Moon, with precise engine firings, would eventually flight ISEE-3 on a course to make the first close encounter with a comet.

Having accomplished this encounter - plus another, ISEE-3 was left to pursue its own path around the sun in perpetuity. Some inspired foresight let the team to do some engine maneuvers so as to send ISEE-3 on a slow path back toward the Earth-Moon system decades later on 10 August 2014 - 36 years - almost to the day - from when it first left. With the exception of a few intermittent listening sessions over the decades ISEE-3 faded into history.

Despite repeated attempts by Bob Farquhar, the orbital dynamicist who conceived of ISEE-3's amazing trips across the inner solar system, NASA was only mildly interested in devoting resources to any rescue attempt. As 2014 approached very real budgetary issues precluded such an effort. Time was short and any attempt to do anything to alter ISEE-3.

By March 2014 several groups, most notable AMSAT-DL at Bochum Observatory had managed to detect a signal from ISEE-3 since the last people to command the spacecraft more or less left everything "on". Articles began to appear as to how it was impossible to do anything to save ISEE-3 since the hardware no longer existed, the command codes were lost, the expertise was no where to be found ... in other words the same litany of reasons used to discourage us from attempting the LOIRP effort. Since we had already been through the LOIRP gaunt;et we were not deterred by the naysayers.

We were intrigued by this challenge and began to make inquiries. Soon we were talking to NASA. No one said "no". After a few days we had a teleconference with NASA HQ and told them we were going to start a crowd funding effort on 14 April. No one at NASA said "no". So we proceeded. With several days we had raised 10% of our initial $125,000 goal. Prompted by this clear evidence of public interest NASA engaged in discussions with us that eventually resulted in a precedent-setting Space Act Agreement wherein we sought to command and control ISEE-3 using private funds and expertise.

Our entire crowd funding effort was done via blogs and social media. We did not seek out space media or self-identified space advocates. Rather we attempted to tell a narrative about a disco-era spacecraft that was coming back to Earth - and how we were going to wake it up, fire its engines and "make it do science again". Moreover we stated our intention (also in our Space Act Agreement) to use the spacecraft for citizen science and in so doing make its science data available to as many people as possible as soon as we possibly can.

The response was startling. We did random samples of our donors and supporters in social media and found them to be almost totally new to the notion of supporting space exploration - at least in terms of being self-identified as space advocates. We estimate that over 95% of or donors were new to overt participation in a public space effort. We passed our initial goal of $125,000 well before our deadline and then passed a stretch goal of $150,000 to eventually reach $159,602. The sheer number of small donations stunned us. 959 of our 2,238 donors (43%) gave $10. Another 477 of our donors (21%) gave $50. In other words 64% of our donors made rather small donations.

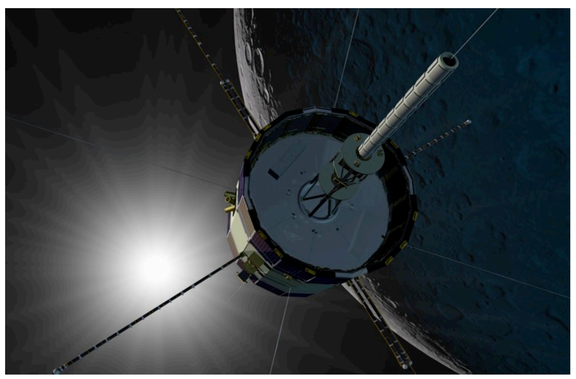
The confidence that our effort inspired allow us to secure the ability to spend funds before we had even finished raising them Within weeks we had struck a deal with the Arecibo Observatory and were on site installing a special transmitter we had custom built for us in Germany. We also installed software defined radios we purchased from our partner Ettus Research. We obtained the necessary technical documentation to recruit the command language and operations capability by going though piles of documents in the basements and storage units of original program participants.

On 29 May 2014, a mere 6 weeks after our project began we contacted and took command of ISEE-3. We soon reactivated its science instruments and obtained science data. In the weeks that followed we were able to utilize NASA's Deep Space Network to do ranging activity to mail down ISEE-3's precise location. Then, on 2 July, we managed to fired the spacecraft;s propulsion system to complete a near perfect spin up maneuver.

Subsequent experience with the propulsion system has been disappointing. After one session we realized that we needed help. So we used social media to ask for help. Within hours it was arriving. Soon we had experts assisting us and a new plan was formulated. While we are still having issues with the propulsion system, we have coaxed some activity out of it - due mostly to this crowd sourced propulsion expertise - much of which was obtained with the assistance of our now-strong social media following.

As this presentation is being published we are weeks away from a flyby of the Moon. Regardless of whether we are able to do the required propulsion maneuvers to place ISEE-3 in an orbit near Earth we will continue to be able to receive useful science data from it regardless of its location in the solar system. The spacecraft will eventually be configured into science mode so that all available power will be focused on science instrumentation. We expect that more than half of the original science instrumentation suite will be providing usable science data. We are establishing an "ad hoc" DSN composed of radio telescopes and antennas around the world so as to be able to receive science data from the spacecraft.

We will soon begin to host a large citizen science program online with the assistance of a significant, large information services partner whose identity will be announced shortly. As for how long ISEE-3 continues to operate, we only have history to go by. After 36 years, five times the expected radiation exposure, a dead battery, lack of a computer, and an aging propulsion system it still works. NASA has determined that our operational experience alone more than justifies this effort.



Looking Backward and Forward

If humanity is going to truly explore deep space spacecraft that can function for a century or more will be needed. Voyagers 1 and 2 and ISEE-3 have shown that simple systems can do that so long as some original technical expertise is retained. Moreover, data that we receive at one point in time may yield more information in the future than was considered when a mission left Earth. Our experience with LOIRP has shown us that we can derive imagery from nearly half a century ago that rivals and even exceeds what "modern" spacecraft provide today.

Neither of these projects would likely have been accomplished in-house at NASA. Standard agency processes would have made their price beyond what could be justified. Moreover the pressure to develop new missions often eclipses prior efforts before their full potential can be achieved. These two projects would have been equally unlikely had not a group of motivated citizens found a way to put forth a compelling narrative - one that convinced NASA to try new things - and provided the general public with a way to personally affect how space related projects are accomplished - and do so with minor contributions.

In an op ed written by one of us in the 19 July 2014 edition of the New York Times

We suggested that "there doesn't need to be an entrance exam for people who want to explore space, and we've proved it," and that "NASA likes to say that "space is hard," but to make itself relevant to the people whose taxes fund it, it must get outside its comfort zone. To its credit, NASA saw the potential of our project to reach beyond the traditional audience. The interactions via social media with our supporters have borne this out. Imagine what feats of exploration might be possible if an empowered and engaged citizenry realized that exploring space is really something anyone can do.

For more information on the Lunar Orbiter Image Recovery Project visit http://www.moonviews.com

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