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Bringing Space to Main Street: A Legacy in Space Education

An Interview with Satellite Pioneer Gil Moore

Ravi Deepak

Taksha University (TU) and Journal of Small Satellites (JoSS)**
*(*NASA Research Park, Moffett Field, California, USA)*

26th Anniversary of the AIAA/USU Conference on Small Satellites

In August 2012, during the 26th Annual AIAA/USU Conference on Small Satellite (SmallSat) at its home on the Utah State University (USU) campus in Logan, Utah, I had the tremendous opportunity to interview one of the great pioneers of the small satellite community, Gil Moore. As we walked together through the USU library's exhibit on the school's historic small satellite program, Gil and his supportive wife, Phyllis, recalled their remarkable, more than 60-year journey to bring Space "back to the front page of the local newspaper (Staehle, 2013)," inspiring students around the world.

Early Crowd Science

Some of Gil's early introductions to space research occured during his time at New Mexico State University (NMSU), where he eventually worked with the Harvard Meteor Project with Harvard Professor Fred Whipple to capture displays of meteor showers using Baker-Super Schmidt cameras. Before that experience, however, he assisted with Dr. Wernher von Braun's V-2 research at White Sands, where he and 200-1000 students helped to collect and analyse radio telemetry records and photos in the basement of their dormitories. He noted at that time that while the students were encouraged to participate in the research, they were not provided the opportunity to create their own research experiments or projects.

By 1957, he was working as a member of Project Moonwatch, which was conceived by Professor Whipple, who recognized, even then, that "satellites" would

Photo 1: Gil and Phyllis Moore in front of the USU Library's Small Satellite Exhibit

be the future of space research and activity. Initiated by the Smithsonian Astrophysical Society's International Geophysical Year (IGY), Project MoonWatch was an early operation involving what is often referred to these days as "crowd science," or the coordination and use of citizen-collected data in mass amounts. Moonwatch established a network of students, amateur scientists, and professionals to track and photograph early satellites. Whipple would receive Moonwatch tracking data by Teletype, with data analysis managed by MIT physicist and distinguished researcher Luigi Jacchia. Dr. Jacchia's and Whipple's analysis of these data led to exciting advances in Space knowledge, including discovery of the Earth's equatorial bulge.

The success of Project Moonwatch's use of "crowd science" went far beyond merely providing researchers with more data in the advance of Space science and understanding. MoonWatch engaged and inspired thousands of amateurs and students to participate in Space research activities. This experience profoundly influenced Gil, as he gained an understanding of how to engage the world in Space science, "bringing Space to Main Street."

An 'Infectious Enthusiast'

Gil moved from New Mexico to Ogden, Utah, to run the AstroMet Division of Thiokol, a manufacturer of sounding rockets. During one of Sandia Corporation's sounding rocket launches from Wallops Island, Virginia, Gil worked with junior high school students to help design a small experiment to measure acceleration effects on crystal oscillator timing devices. While presenting a paper on this experiment at the 1976 International Aeronautical Federation (IAF), he included mention of then-student Robert Staehle's and the other students' experiments on Skylab, to provide examples of student-driven and student-designed experiments that were scientifically relevant.

Staehle, a researcher at the Jet Propulsion Laboratory (JPL), had been selected as one of 19 high school students earlier on, to submit small experiments to fly on Skylab. While his preliminary experiment on Skylab had not been successful (due to overheating), it led to Rob's introduction to one of his "longest-serving mentors," Gil Moore (Staehle, 2013). Staehle, who later replicated his experiment for flight on Skylab-2, recalls Gil as being an "infectious enthusiast" and promoter of student-driven experiments.

Throughout his career at Thiokol, Gil purposefully promoted "hands-on" student involvement in Space science as necessary engagement with the public. This crusade of his went beyond Skylab, and into the Shuttle program, during which he persuaded NASA to include the participation of high school and university students in its Small Self-Contained Payload Program, the first of which, the "Get Away Special (GAS-001)," was launched aboard Space Shuttle Columbia on June 27,

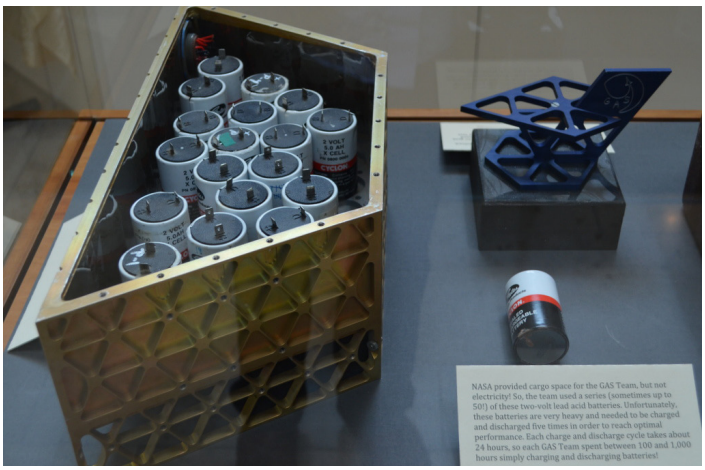

Photo 2: While NASA provided the caption space, the GAS can teams designed their own power budget and systems for the experimental cannisters

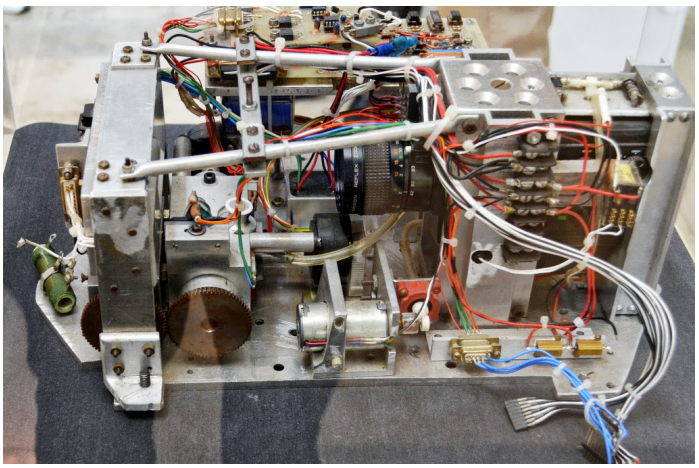

Photo 3: GAS Can experiment to test bubble formations in microgravity; and a follow up experiment would've been to blow epoxy resin in Space to create space structures.

1982 on its STS-4.

Following the GAS announcement, Gil began a fruitful partnership with USU Physics Professor Rex Megill. Rex and Gil collaborated on the USU experiment that flew on GAS-001, following which, Gil became adjunct faculty at the University. The GAS team, at USU and partner educational institutions, flew a number of noteworthy student-driven experiments and components, including the bubble experiment (as seen in Photo 2). Another notable experiment was the FUNBOE, Follow-Up Nucleate Boiling On-Flight Experiment, to explore how water boils in microgravity. Most of the experiments explored the GAS team's creativity and thrift, since they were designed on shoe-string budgets, using surplus or commercial off- the-shelf components.

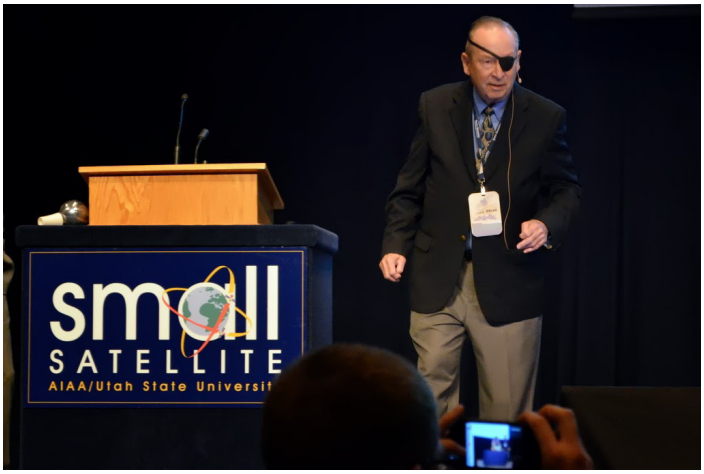

Photo 4: Gil Moore on Stage at the SmallSat Conference 2012

Gil and Rex went on to organize the Northern Utah Satellite (NUSat), built in collaboration with Professor Bob Twiggs, inventor of the CubeSat, who was then at Weber State. Supported by 26 other organizations, corporations and educational institutions, and Gil's wife Phyllis, who helped gather materials and keep the students focused, NUSat launched in 1985. While the downlink was not established with NUSat for approximately a year due to technical difficulties with the ground station, a connection was eventually established to collect data for about six months.

The GAS Program's success helped to bring Colonel Frank Redd to USU, after retiring from the U.S. Air Force, to pursue his passion for Space and teaching. In 1987, during the school's centennial celebration, Frank proposed to Gil and Rex to create a dialogue for the small satellite community, resulting in the annual AIAA/USU Conference on Small Satellites (SmallSat) in Logan, Utah.

Shining Brighter

Following the success of NUSat, Gil moved to the U.S. Air Force Academy to become the Schriever Chair of Space Systems Engineering. In 1996, he retired from the Academy to start a new project -- aimed to reach even more students and schools, extending worldwide, if possible -- Project Starshine, in partnership with the U.S. Naval Research Lab and NASA.

Starshine was a 1997 micro-satellite designed as an educational outreach mechanism via the GAS, and later, the Hitchhiker Programs. Starshine-1, launched in 1999, was a 19-inch diameter sphere covered in mirrors that were polished by students at some 1,000 schools. The mirrors would reflect visible light back to earth during twilight, allowing the satellite to be tracked and observed by a network of over 30,000 students from more than 43 countries, overall. Teachers at these schools could use the Web and workshops to teach students about atmospheric drag, solar activity, and other Space science topics. Starshine-1's success with engaging students and schools led to two follow-up missions in 2001, Starshine-2 and -3, both slightly more complex systems, including laser retro-reflectors and other scientific instruments.

The POPACS Project

Last August (2012), Gil's enthusiasm was focused on his latest satellite project, POPACS (Polar Orbiting Passive Atmospheric Calibration Spheres), which will passively measure the density changes in Earth's upper atmosphere from solar flares and coronal mass ejections (CME). Three spheres of different masses will be ejected from a newly-developed Canisterized Satellite Dispenser (CSD) into highly elliptical orbits. As described in presentation to the 26th Annual AIAA/USU SmallSat Conference, the U.S. Strategic Command will radar track the metallic spheres throughout their lifetimes (over the next 10 years or so). Students from par-

ticipating universities around the world will use the resulting two-line orbital element sets (TLEs) to optically track the spheres with "Go To" telescopes, calculating their own orbits of the spheres, measuring the way in which the orbits decay, and determining the density of Earth's atmosphere at the location of each sphere's perigee passage. A primary focus of the students will be the way in which the Earth's upper atmospheric density in northern and southern auroral regions responds to solar flares and coronal mass ejections (CMEs), and the way in which those effects propagate equator-ward. The U.S. Naval Research Laboratory (NRL) will make independent computations of atmospheric density from the Space Command's tracking data, providing its results to the students for comparison (Holemans, Moore, and Kang, 2012).

No longer using Teletype as a means of sending and receiving tracking data, today's students virtually and instantly connect on the internet to transmit such information. And no longer calculating orbits the way that Dr. Jacchia did for the Moonwatch Project, they can input the conditions and calculate the orbital changes instantly, by computer. There has been a great distance crossed to bring Space to Main Street, and with the Small Satellite and CubeSat revolution, the experience gained will illuminate the future of Space science and inspire the next generation of Space researchers.

References

Author's Note: This article is based on information received in an interview from Aug 15-16, 2012, with Gil and Phyllis Moore at the AIAA/USU Conference on Small Satellite, Logan, Utah, and supplemented by sources including:

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Learn more about Gil Moore by talking with him at the annual SmallSat Conference, or visit:

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