McDonald Ranging: 30 Years and Still Going

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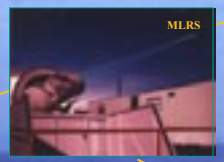
ABSTRACT

The McDonald Laser Ranging Station (MLRS), a part of the NASA SLR network, ranges to artificial satellites and the Moon. It was built to replace the McDonald Observatory 2.7-m lunar-only system that operated through the mid-1980's. It is built around a computer controlled 0.76-m x-y mounted Cassegrain/Coudé reflecting telescope and a short pulse, frequency doubled, 532-nm, neodymium-YAG laser with appropriate computer, electronic, meteorological, and timing interfaces. An aircraft radar allows it to operate with a single operator. The MLRS is located on Mt. Fowlkes at McDonald Observatory, near Fort Davis, Texas. The MLRS's epoch timing system makes all targets equivalent to the observer and a crew will routinely range to many different targets, from the closest of artificial satellites to the Moon, during a single shift. Over the years it has undergone a host of modifications and up-grades. This poster describes the system as it exists now and summarizes some of the most recent changes.



In 1982 TLRS visits saddle

During the first 15 years of LLR efforts, using the 2.7 m (now the Harlan Smith Telescope), McDonald Observatory was the only facility routinely ranging to the Moon. Sharing time with regular astronomical programs ranging operations were carried out in 45 minute session per day, for 21 day per lunation. At the beginning range accuracy was around 30 cm but by the time it was decommissioned in 1985 its range accuracy reached 15 cm.

While data accuracy improved about an order of magnitude in the following decades, the early data still plays an important role in separating effects with long characteristic timescales.

In 1985 a dedicated, station started regular operations in the saddle between Mt. Locke and Mt. Fowlkes. With new, improved timing system, better computing and laser technology, in spite of the reduced aperture size (0.76 m), it produces finer quality satellite and lunar data. **MLRS** has a frequency doubled 120 milliJoule per pulse, 200 picoseconds pulse length neodymium-YAG laser, firing at 10 times per second. The 25 picoseconds epoch timing system with the internal calibration system produces LLR normal points close 1 cm accuracy.

The saddle site had problems. Atmospheric conditions combined with less than perfect pad stability had significant impact on the data quality. In early 1988, the station as a unit was moved to Mt. Fowlkes.

THE TEXAS RANGERS:

Six dedicated people (and one cat) are working in the Davis Mountains in West Texas at the ranging station. They are hardly seen, but without them there would not be laser ranging there. Here they are, introducing themselves in their own words:

In 1960 I began tracking satellites by radio using Doppler shift techniques while working for New Mexico State University's Physical Science Laboratory in Las Cruces, NM. Working as a slave laborer ($1.80/hour), I was stationed in Alaska and on four islands in the South Pacific. After graduation I worked for a two-bit company in Austin that dismissed 1400 employees on Friday the 13th, March 1970. McDonald Observatory called on Saturday the 14th. They offered a similar job but with a bigger satellite; the Moon. I was told that my job might last only 2.5 years. So far, it has lasted over 32 years. If you disregard the method of tracking, I've been tracking satellites for over 42 years.

To experience the other end of high technology, I play the washtub bass as an entertainer, musician.

I was employed at White Sands Missile Range for 6 years where I worked on optical systems; high speed filming of missile firings and bomb drops. I moved to to GSFC, and worked on one of the first satellite ranging systems as a laser technician and operator. I then moved to Texas in July of 1969 to operate the laser for ranging to the Moon and satellites. I has lived and worked here ever since.

My hobbies are fishing, hunting and traveling.

As a college graduate, 16 years ago I drove to MLRS to interview and worked here ever since. We started with 2 targets, now range to over twenty. I've done LLR all 16 years and still find it fun. My wife, two children and I were born and raised in Texas. We were told, the best way to go is through Alpine, in the mountains of W. Texas. The name conjured up dreams of snow covered, pine filled mountains. We did find cactus filled, desert mountains, but 45 miles further we found the pine trees, and occasionally get snow.

I have many hobbies, including building CO_2 laser I use to do wood burning artwork. I have also built a laser light show and like to hunt and fish.

I graduated from Texas A&M University in December of 1989 with a degree in Computer Science. I started working for MLRS in December of 1990 as a ranger. I am also involved in some of the computer operations.

Aside from ranging I enjoys teaching, I am a classroom assistant at the local elementary school. I also teach Catechism classes for St. Josephs Catholic Church. When I am not ranging or teaching I hike or enjoy a good game of volleyball.

I graduated from Texas Tech in 1969 with a BS in EE. My husband was in the USAF. With our sons we went on tours which took us as far as Japan. He retired and came to the Observatory. I started at MLRS in 1990. I do inventory, purchasing, take care of Hare, and anything else that needs to be done.

A quarter time job leaves room for other activities. I turn digitized photos of our show dogs into machine embroidery for clothes I make. For the last six years Earl and I have been building our retirement home, "Earth Ship", out of recycled tires, cardboard, and aluminum cans.

I am the newest member on the MLRS team. Satellite Laser Ranging is the newest, and without question the most unique type of work I have ever done. Straight out of college, I went into landscape maintenance, installation, and garden design. Later I attended culinary school and after graduating I worked in several restaurants.

My hobbies include cooking, golf, gardening (quite a challenge in West Texas), and playing the guitar.

Hare, a.k.a The Laser Cat, has been busy keeping mice in check since 1993, following in the footsteps of her predecessors.

Employing a cat was found to be the most eco-friendly (and people friendly) method to protect equipment at MLRS.

RECENT UPGRADES, ADDITIONS

In 1999 the crew started 24 hours a day seven days a week operations relying on only four observers. To manage single person operations, an aircraft detecting radar was installed. The radar is slaved to the telescope, and when it detects an aircraft it block the laser light from entering entering the telescope.

Two corner cubes, mounted on the secondary mirror's spider structure, are used for internal calibration, and to determine the collimation of the laser/telescope system. The corners need to be covered separately for collimation. Small, remotely activated motors were assembled, that rotate an optical block in front of either of the cubes.

Some satellites come in such a rapid succession, that the operator has very little time to enter into the pass log the correct detector ID manually. A switch was installed on the sliding mirror, that direct the returning light to either the Varian or the MCP PMT. The computer automatically reads and enters this information.

A circular bubble was mounted on the telescope as a work around if one of the absolute encoders fail. Knowing the position of the centered bubble permits the "zeroing" of the up/down counter. The pointing is repeatable to ~ 0.5 arcminute. It is good enough to find a star in the filed and refine the pointing.

When a lunar retroreflector is in the dark, there is very little to guide on, that is, to keep the telescope pointing to the place from where data comes. The X-Y stage was installed in August of 1992, to observe using offset guiding. The stage allows the camera to be looking at different part of the Moon from what the laser and detector are looking at. By offsetting the camera and moving it over into the sun-lit part, the operator can bring and hold a feature under a crosshair and keep the telescope pointing directly at the target.

Crew + laser +

MPC or Varian

++

Accurate timing system

+

MLRS TARGETS:

During the past 33 years the McDonald Station has acquired the following targets:

Satellites

ADEOS, Ajisai, Beacon-C
CHAMP, *Diademe-C,D*
ERS-1, 2, Etalon-1,2
ENVISAT, Fizeau (Meteor-2), GEOS-3
GLONASS-5,62,63,65-72,78-82,84,88
GFO-1, GFZ-1, GPS-35,36
GRACE-A,B, Jason, LAGEOS-1,2
LRE, Meteor-3,3M, *MP-2*, *MSTI-II*
Reflector, Resurs-3, Starlette
Starshine-3, Stella, SUNSAT
TiPS-1,2, TOPEX , WESTPAC, *ZETA*

Lunar reflectors

Tranquility (Apollo 11)
Frau Mauro (Apollo 14)
Hadley (Apollo 15)
Lunakhod 2

Names in *italics* are objects which cannot be reached by MLRS during daytime. OCA and MLRS are the only stations operating that ranged to the targets marked in red.

Photo and graphics credits

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