Implementation of the LASER Traffic Control System at Haleakala Observatories

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INTRODUCTION

The University of Hawai'i Institute for Astronomy Haleakala Observatories (HO) was for many years occupied only by Mees Observatory and the LURE Laser Ranging Observatory. The LASER system at LURE could operate at night without disturbing other science operations because Mees is a solar observatory.

Since 2000, several astronomical observatories have been built at HO, and more are being planned. Laser ranging operations ceased at LURE in 2004, but is now being carried out by the Transportable Laser Ranging Station (TLRS-4) since 2006.

In order to prevent scattered laser light from interfering with the science operations of the optical observatories, HO is implementing a version of the Laser Traffic Control System (LTCS). W.M. Keck Observatory primarily developed the LTCS, with additional support provided by several other Mauna Kea observatories. The LTCS can predict when telescopes and laser beams will enter each other's field of view, allowing the observatories to take preventative action.

The system currently supports laser guide star adaptive optics (AO) operations at Mauna Kea Observatories (MKO) Hawaii, the Canary Islands (Spain), and in Chile.

This poster paper will discuss the features of the LTCS, the limitations when SLR observatories are included in the current system, and the implementation of a test system at the Haleakala Observatories. This is just a brief explanation of the system as it is being implemented at HO. For an in-depth explanation of the LTCS, please access the original papers written by the designers of the system ***[1,2,3]***.

SYSTEM DESCRIPTION

The LTCS as implemented at the Mauna Kea Observatories was designed to solve the problem of how to keep the light from an AO laser (via Rayleigh scattering or from the fluorescence caused by the guide star) from entering into the Field Of View of other telescopes on the mountain

The LTCS is web based, and is implemented as a client/server system. Each participating observatory is a client to the LTCS, and must provide access to a URL (Universal Resource Locator) file that describes that particular system for the LTCS.

Following is a sample URL file generated by the TLRS-4 system. This file is stored once per second in the WWW file structure of a Linux system at TLRS-4 running an Apache Web Server.

TIMESTAMP1=1304228999	# Time of URL update in Unix Seconds
TELESCOPE=TLRS4	# Telescope Name
RA= 4.60881	# Telescope Right Ascension in Hours
DEC= 61.87089	# Telescope Declination in Degrees
EQUINOX=2011.32943300	# Equinox and Epoch of coordinates
FOV=1.667	# Diameter of telescope Field Of View (FOV)
LASER_IMPACTED=NO	# Telescope is (or is not) LASER sensitive
LASER_STATE=ON	# Telescope is (or is not) projecting LASER light
LOG_DATA=ON	# Flag to enable/disable logging of pointing data
TIMESTAMP2=1304228999	# Time of URL update in Unix Seconds

The LTCS uses the configured positions of the participating telescopes, along with the information contained in the URL files, to calculate the FOV cones of telescopes and laser beams. From this the intersection of the cones can be calculated and appropriate action taken.

The LTCS has a sophisticated priority scheme. For the HO implementation, the TLRS-4 laser was given lowest priority and will shutter the laser when any collision situation arises.

SATELLITE LASER RANGING vs. ADAPTIVE OPTICS LASERS

The LTCS was not designed to include SLR into the mix of observatories. It was obvious that some of the features of the Mauna Kea system would not work at HO as intended without modification. The most obvious difference in requirements for SLR is that the SLR systems are not tracking in sidereal mode. The AO systems are (generally) only tracking in sidereal mode.

A second major difference is the tracking speed of an SLR system when compared to an telescope tracking in sidereal mode. The all-sky images below (Figure 0) show the TLRS-4 laser on the sky over an 9 minute period while tracking LAGEOSII (a relatively slow moving target). The Pan-STARRS Observatory domes can be seen on the left of the image.

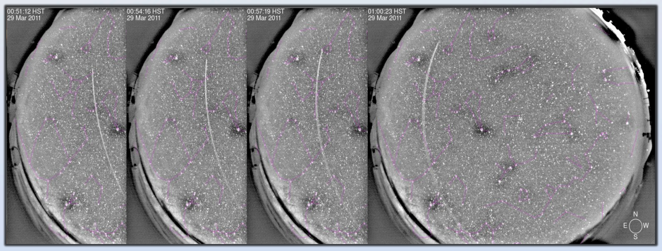

Figure 0

LTCS AT HALEAKALA

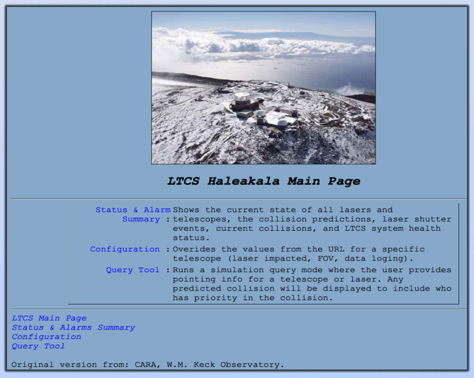

Figure 1.

The LTCS system is currently operating at HO in a simulation mode only. Full implementation is still several months away. The simulation has shown that a useful LTCS system that incorporates SLR is *probably* possible with only modifications to the configuration files.

The main LTCS screen is shown in figure 1. From here each observatory is able to view the status of the system and to make changes to their own system configurations.

The "Query Tool" provides sidereal tracking telescopes with the ability to determine if a collision will occur now, or in the future. This tool was not designed to provide accurate information to SLR observatories.

In order to overcome the differences noted above, the update rate for reading the TLRS-4 URL was set to the system minimum of one second and the declared FOV of the laser system was set to the maximum 1.667 degrees. The actual divergence of the laser beam at TLRS-4 is about 0.02 degrees. This added spatial and temporal buffer compensates for the fast tracking speed of the laser, and the fact that the Pan-STARRS telescopes have an extraordinary 3.0 degree field of view (full angle).

Also, the configurable altitudes that locate the sodium layer (minimum and maximum altitude) for the LTCS were changed so that satellites being tracked from a 300 Kilometer orbital altitude up to 20,000 Kilometers orbital altitude would mimic a Laser Guide Star and cause a collision alert if the satellite is tracked through the FOV of another telescope. The maximum altitude for Rayleigh Scattering was left unchanged at 50Km.

A method to integrate the LTCS into the TLRS-4 Laser Interlock system has been devised. Currently, if a collision occurs, a "SHUTTERED" event is entered into the LTCS log and the *Status & Alarm Summary* GUI is updated. Once this integration is completed, a laser/telescope collision will be handled as a laser interlock violation, which will automatically shutter the laser until the operator manually clears the alarm.

SIMULATED COLLISION

The following panels are screen shots of a simulated collision between the TLRS-4 laser and Pan-STARRS.

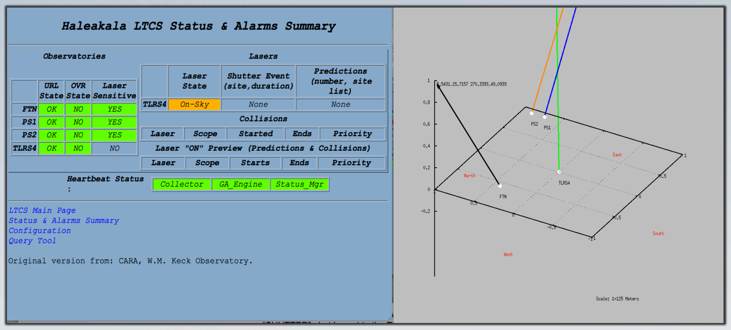

Figure 2

The above screen capture (Figure 2) shows the LTCS *"Status and Alarms Summary"* web GUI on the left, and a real-time 3-D plot of the simulation on the right. The 3-D plot is not part of the LTCS but runs independently on the host system. It was added as part of the simulation tests done at HO. It can be manipulated in real time (i.e. grabbed with the mouse and rotated about the origin, which is configured to be TLRS-4) and provided real time visualization during the installation tests.

The LTCS "*Observatories"* panel shows that there are 4 active observatories with one (TLRS-4) being an active laser system. The "*On-Sky*" message indicates that the laser currently is being propagated.

On the right of the LTCS panel is the *"Predictions"* indicator that warns of future collisions. The prediction algorithms are assuming all telescopes are tracking in sidereal mode. The TLRS-4 is not tracking in sidereal mode so any prediction involving TLRS-4 is not reliable, and the impending collision was not predicted.

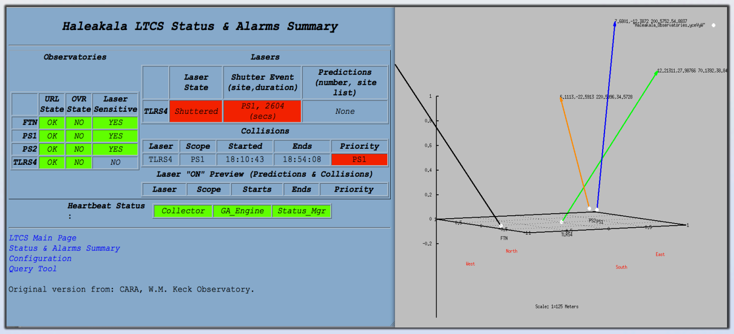

Figure 3

The second screen capture (Figure 3) shows the system indicating a collision has occurred. At the time of collision, a "SHUTTER" alert is sent to the LTCS log file. Because the LTCS was configured with the TLRS-4 laser being lowest priority, the TLRS-4 will receive the alert and block transmission of the laser.

As mentioned before, the *"Shutter Event Duration"* calculation will not be accurate when an SLR system is involved. The calculated duration shown is 2,604 seconds. The actual duration of this simulated event was about 60 seconds.

CONCLUSIONS

- The LTCS is a mature software system that has been installed at three astronomical sites that are operating laser guide stars in support of adaptive optics systems.
- The basic design of the system has shown that it can be used by SLR sites that are also home to optical telescopes only.
- In order to be used at sites that operate SLR and AO lasers along with optical telescopes, methods to handle combined Laser Guide Star and SLR targets will need to be developed. Interface changes to support non-sidereal target modeling would prove beneficial for astronomical and SLR use. This feature enhancement has been discussed and may be added to LTCS in a future update.

REFERENCES

1. *Implementation of a Laser Traffic Control System supporting Laser Guide Star Star adaptive Optics on Mauna Kea.* *Summers. et al. 2003. Proceedings of the SPIE (2003) Vol. 4839.*
2. *Second Generation Laser Traffic Control; Algorithm Changes Supporting Mauna Kea, La Palma, and Future Multi-Telescope Laser sites. Douglas Summers, WM Keck Observatory. Nikolaos Apostolakos, Rene Rutten, Gordon Talbot, Isaac Newton Group.*
3. *Observational Impact of Scattered Light from the Laser Beam of a Laser Guide Star Adaptive Optics System. Y.Hayano and M.Iye, NAO of Japan. H.Takami and N.Takato, Subaru Telescope, NAO of Japan. W.Gaessler. Max-Planck-Institute for Astronomy. Y.Minawo. University of Tokyo. P.Wizinowich and D.Summers. W.M.Keck Observatory.*