Status of SLR upgrades at the U.S. Naval Research Laboratory's Optical Test Facility

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Abstract

The Naval Research Laboratory's satellite laser ranging facility was originally installed in 2001. Over the last decade many of the components of this system have become hard or impossible to find replacements for. Two years ago NRL began to seek funding for repairs and upgrades to bring the system back to full functionality. L3 Brashear was contracted to evaluate the existing system and repair or replace all degraded or obsolete hardware and software.

Additionally, NRL has been working towards installing two additional laser ranging systems. A 1 kHz system transmitting at 1064nm and a 50 Hz system transmitting at 1560nm are currently being developed and installed.

The details of these repairs and upgrades will be presented here.

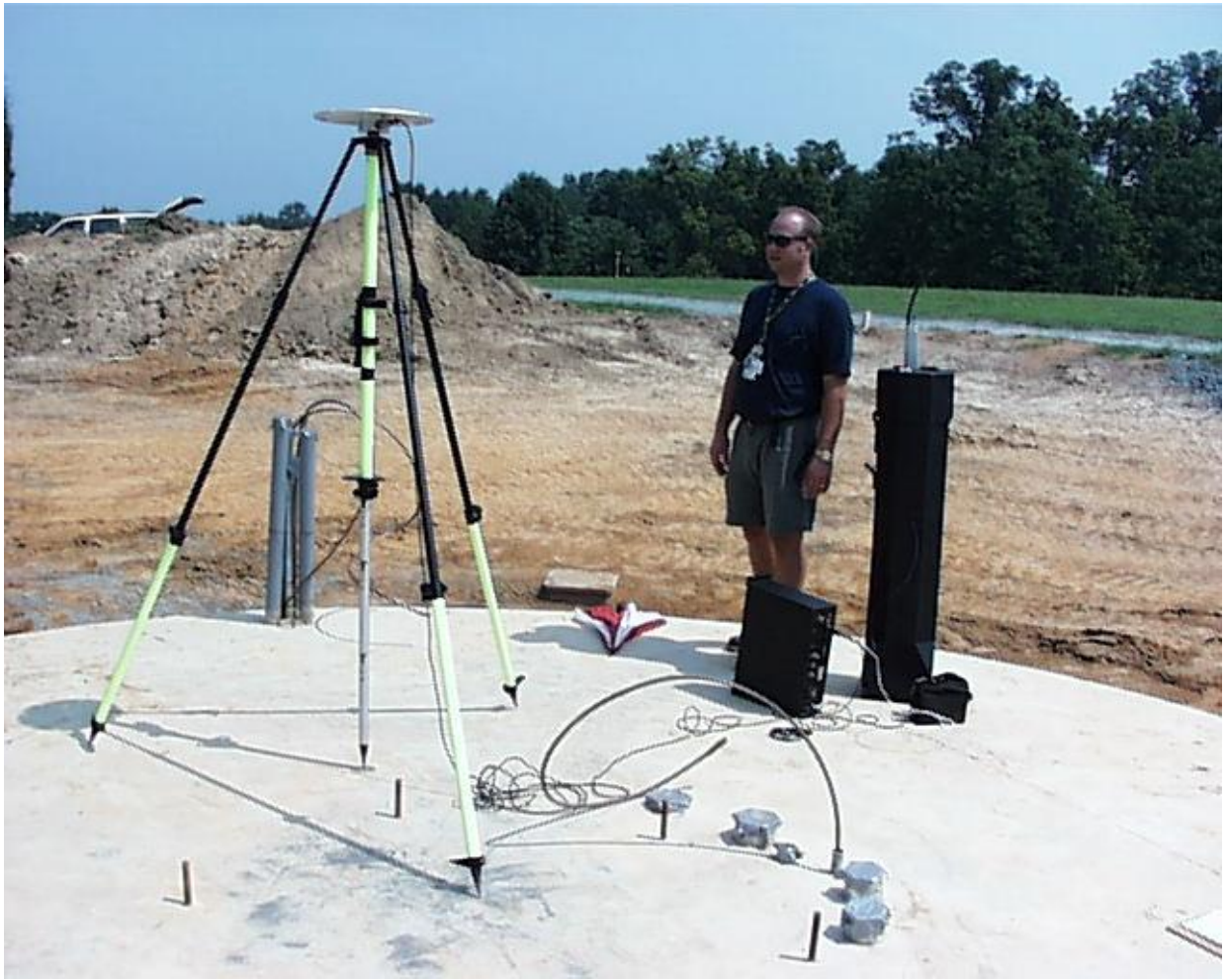
Telescope Purchase

- Aug 1998 – 7th iteration on SOW
- Feb 18 – 1999 NRL Contracts declared bids due
- Arrival on site July 2002 from L3 – Brashear (Pittsburgh, PA)
- First ranges on September 31, 2002

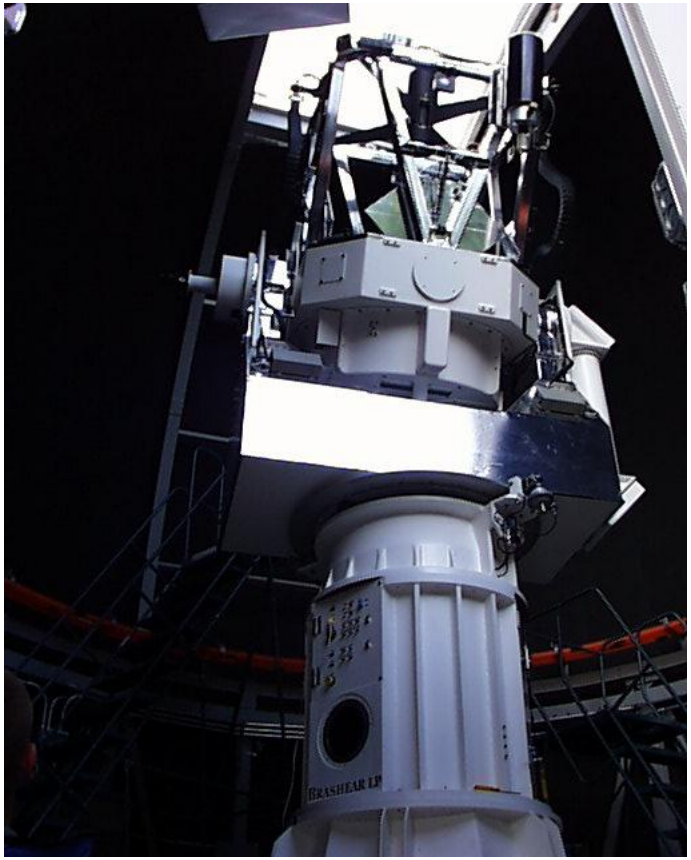
Site preparation - 2001

- Site preparation of the Naval Research Laboratory's (NRL) Optical Test Facility (OTF) began at the Midway Research Center (MRC), a NRL field site, in Stafford, Virginia in early 2001.

Surveying telescope pier marker



Installed 1-meter Telescope



Current OTF station details

- L3-Brashear 1-meter Telescope
  - Blind pointing accuracy better than 7 microradians while traveling at 25 deg/sec
  - Jitter: Better than 75 nanoradians RMS in Azimuth, 125 nanoradians RMS in Elevation
  - Precision better than 10 nanoradians
  - Wavefront quality: λ/64 primary, λ/12 at f/89 on optical bench
- Honeywell Event Timer
  - Enables sub-centimeter accurate range measurements
  - Provides 2 picosecond timing accuracy
  - Time tags over 6000 events per second
- 1064 nm high peak power laser for SLR
  - 200 ps pulse width at 10 Hz repetition rate
  - Typically transmit 100mJ/pulse
- SBIG CCD512 x 512 pixels, 25 micron pixel size, Integrating CCD
- Xybion Intensified CCD, 300 microradian field of view, EFL 12 meters, operation at 30 fps
- Honeywell Air-search radar with safety interlocks to laser system
- Honeywell interlock system
- Timing via GPS
- NRL developed software control system for tracking and ranging
- Single calibration retro mounted to metal radar tower

Reasons for upgrade

- Issues with telescope system stability related to:
  - 15 Year old technology
  - Various component failures
  - Lack of available off-the-shelf spares
- Goals:
  - Increase functionality
    - Sun avoidance
    - State vector tracking
    - Interface options
  - Increase automation
    - Improve user interface
  - Increase ranging accuracy
    - 3 new calibration piers added in 2013

Telescope System Upgrades

- L3 Brashear contracted to refurbish telescope system
  - Goal: meet or exceed all original performance specifications
  - Clean telescope optics
  - Replace all degraded components with latest technology
    - Control system
    - RMI
    - Focus controller
- Telescope system was rebaselined in September 2013
  - Telescope system performed better than at-install following more than 10 years of use!

Telescope System Upgrades: Hardware

- Focus drive assembly being replaced
  - Zero backlash design
  - Use of absolute encoder means no more limit searches at startup
  - Realignment of the secondary is primary concern
- Amplifiers being replaced
  - New design serviceable

Telescope System Upgrades: Computing

- Real time control computer being replaced
  - Upgrading real time operating system
  - 3.4GHz Intel i7 Quad core processor
  - Sun avoidance software now included
  - All internal cards will be new and supported by manufacturer for many years.
    - RMI, IRIG, etc..
  - Plenty of timing margin for real time processes
  - New TCP and UDP Ethernet control interfaces

Telescope System Upgrades: Software

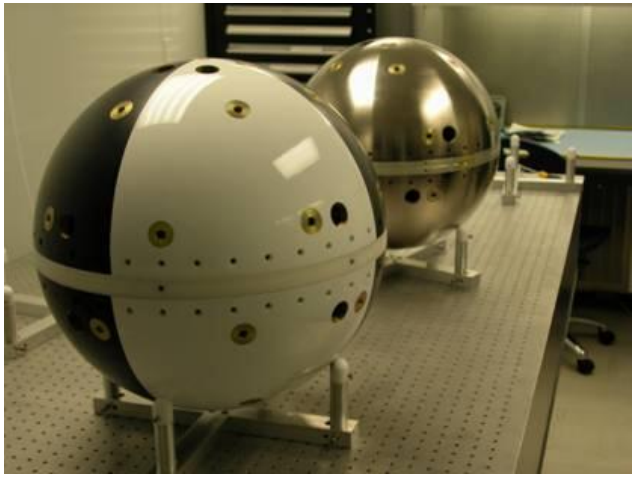
- New Telescope Control System GUI (TCS-GUI)
  - Porting original VB application to C#
  - Updating interface to reflect NRL preferences
  - Star and lens calibrations will now be performed from TCS-GUI instead of telnet session into control computer.
  - Mostly aesthetic changes, all existing functionality will persist in new version

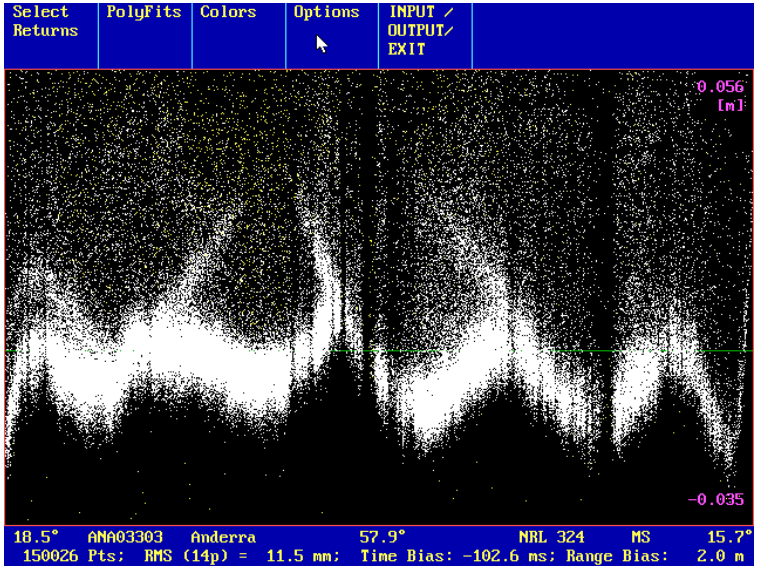
New Calibration Piers

- 3 new calibration piers installed
  - Concrete piers shielded with PVC
  - Accepts retro reflector and GNSS antenna at top
- Increases quality of calibration measurements
- Ongoing work:
  - Is there stress across the Potomac? Confirm GGAO/OTF baseline from 2002
  - Demonstrate the ground plane effects on the new composite pier design with thermal sleeve
  - Establish seasonal height differential

2014 Plans

- Updating NRL software control system for pointing, tracking and ranging control.
  - To support kHz ranging
  - To increase automation
  - To leverage new calibration piers





kHz ranging results (right) from ANDE mission (above)

Ongoing system upgrades

- 50Hz 1560nm ranging system
  - 1064nm shifted to 1560nm using a raman cell.
  - 200mJ/pulse at 1560nm, 450mJ/pulse at 1064nm
  - 3 nsec pulsewidth
  - Energy/pulse is likely ~ 1 mJ/pulse.
- 200Hz to 1kHz 1064nm ranging system
  - 100 picosecond pulse width
  - 1.4 mj/pulse at 1kHz , 2.3 mJ/pulse at 200 Hz
  - divergence is adjustable but will most likely be ~100 microradians
- Laser sources ready for install

Questions