SGSLR

Space Geodesy Satellite Laser Ranging

Current Status and Plans for Test and Deployment of the First NASA SGSLR System

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Abstract

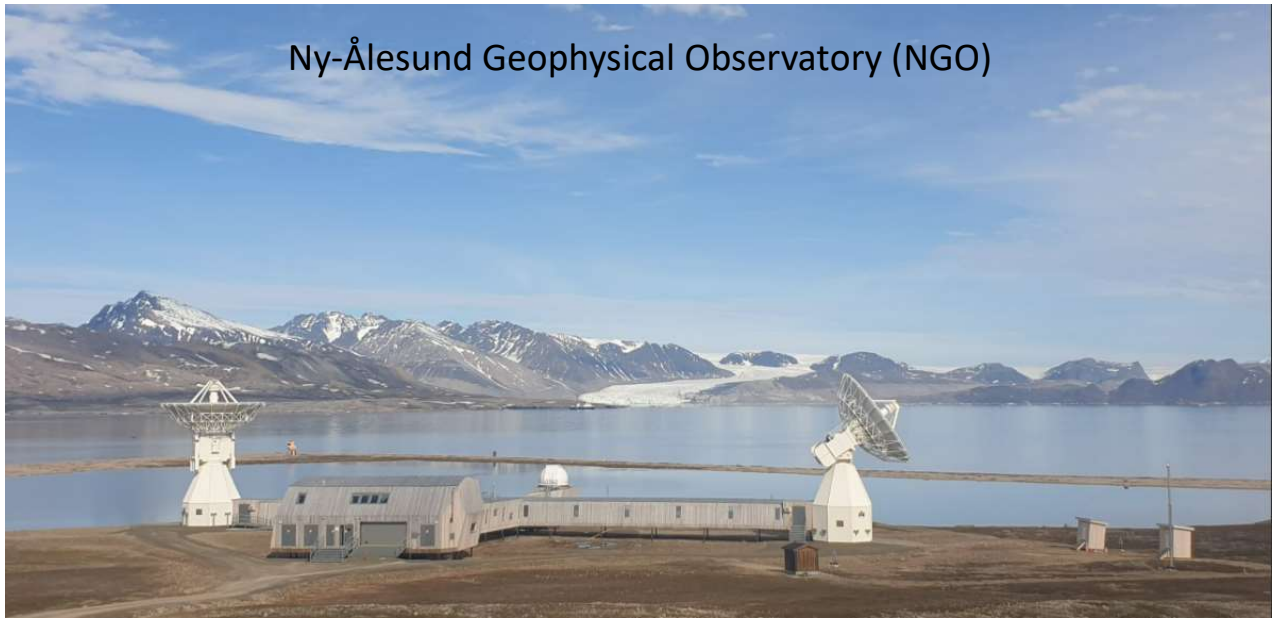
Current Status and Plans for Test and Deployment of the First NASA SGSLR System

Over the last decade the Space Geodesy Project has been progressing toward the development and deployment of NASA's next generation network of geodetic stations (https://space-geodesy.nasa.gov). The Satellite Laser Ranging (SLR) part of this effort is called Space Geodesy Satellite Laser Ranging (SGSLR). Significant progress has been made in the development of SGSLR's nine subsystems, and many of these subsystems are completed or are nearing completion. The next major step will be the Integration and Testing (I&T) of all subsystems into the first SGSLR system which will start before the end of 2022. Verification testing (collocation) with NASA's legacy operational SLR system, MOBLAS-7, is planned for early 2024.

The first SGSLR system is being developed for Kartverket, also known as the Norwegian Mapping Authority (NMA). The system will be installed at Ny-Ålesund in Svalbard, Norway. The planned start of operations is early 2025.

This presentation will give the current status of development, the testing and deployment plans, and the future of NASA's SGSLR global network.

Acknowledgments


Ny-Ålesund Geophysical Observatory (NGO)

The authors would like to thank our colleagues from Kartverket (NMA), Gro Grinde, Gøril Breivik, and Ole Klingan, for their support of the SGSLR development and deployment efforts.

We would also like to acknowledge and thank all our colleagues at NASA, KBR, Hexagon, AIMM and others, who have worked and continue to work on making this new NASA SLR system a reality.

Outline, Related Talks and Reference

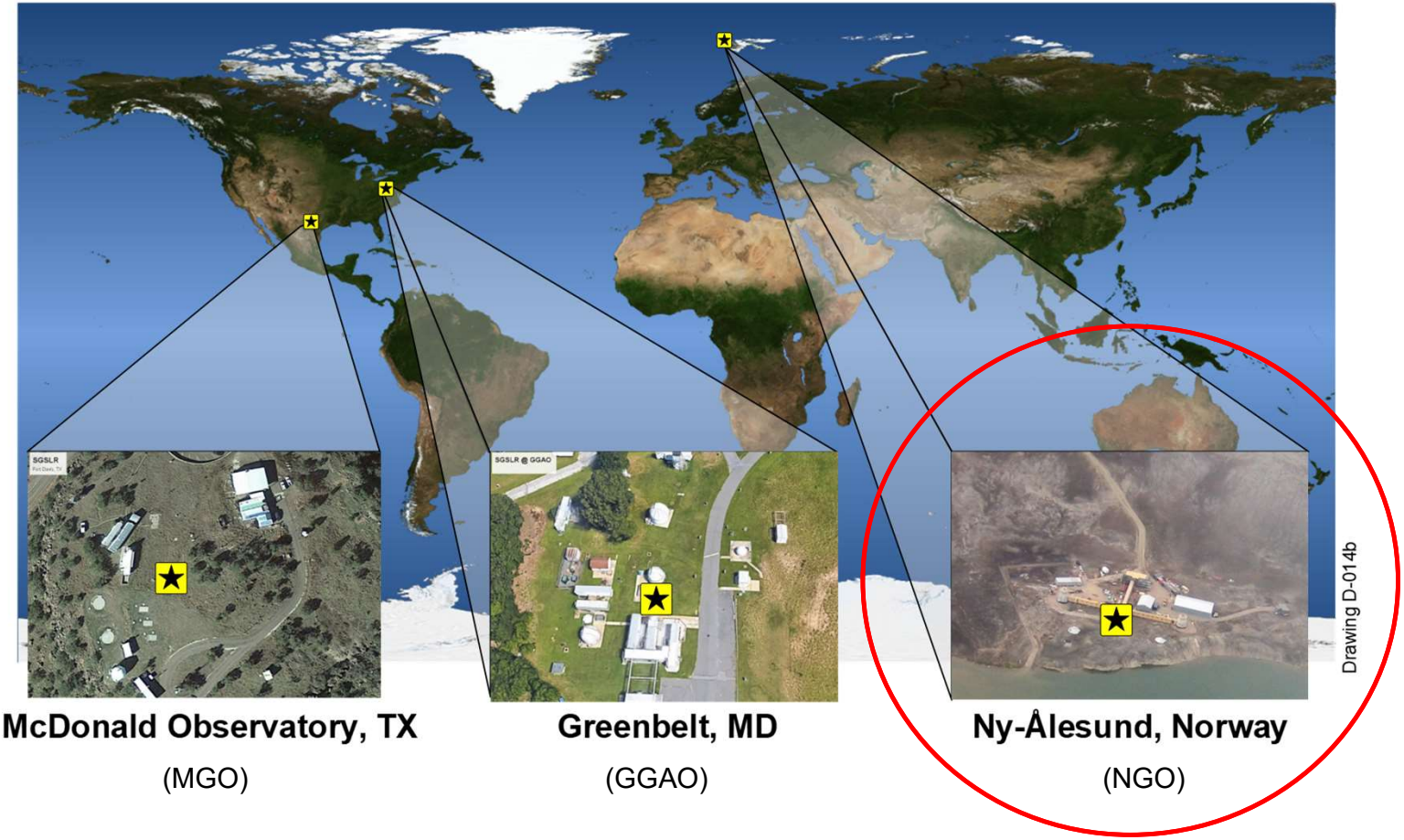
- System Development
- Integration & Testing
- Verification
- Deployment & Commissioning
- SGSLR Network Future Plans

Related talks:

- Presentation on SGSLR and the Ny-Ålesund site by **Gøril Breivik**, following this talk
- Presentation by **Evan Hoffman** on Friday morning "Laser Safety at NASA's New Laser Ranging Stations"
- Poster by **Christopher Clarke** "SGSLR Receiver Detector Testing and the Pulse Width Calibration Technique"
- Poster by **Ole Klingan** on laser safety at Ny-Ålesund

Reference: "NASA's satellite laser ranging systems for the twenty-first century," McGarry, J.F., et al, Journal of Geodesy (2019) 93:2249-2262, https://doi.org/10.1007/s00190-018-1191-6.

NASA's first 3 Systems in new SGSLR Network



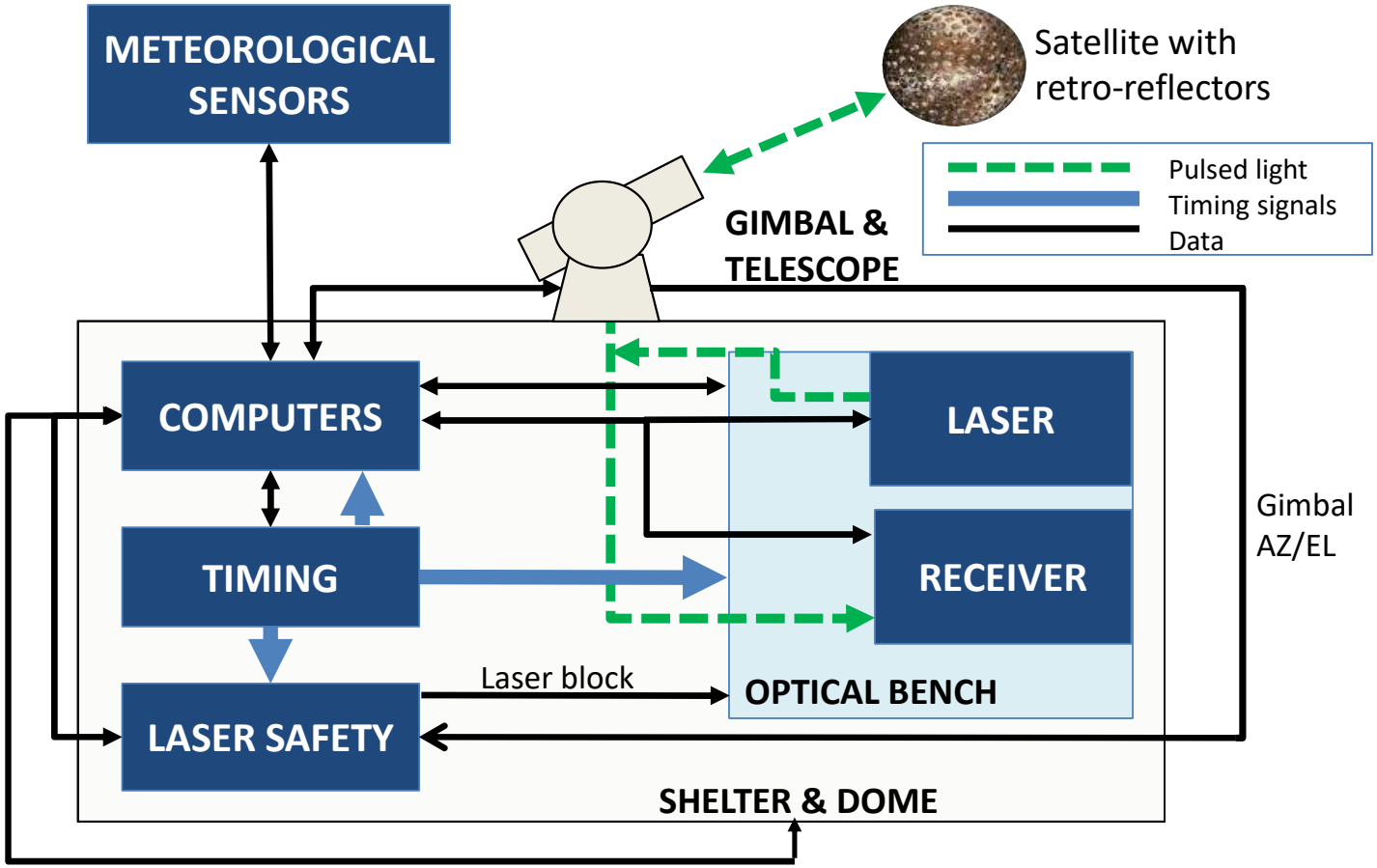
McDonald Observatory, TX
(MGO)

Greenbelt, MD
(GGAO)

Ny-Ålesund, Norway
(NGO)

SGSLR System Block Diagram

Nine Subsystems:
1- Gimbal & Telescope (GTA)
2- Optical Bench (OB)
3- Receiver
4- Laser
5- Laser Safety (LSS)
6- Time & Frequency (T&F)
7- Meteorological (MET) – weather instrumentation
8- Shelter, Dome & Riser
9- Computers & Software



SGSLR Development Status (GTA)

- Gimbal & Telescope Assembly (GTA)
  - Gimbal & Mass Simulator (GMS) was installed and used to perform star calibrations & sunlit satellite tracks with good results
  - GTA #1 successfully completed Factory Acceptance Testing (FAT) at the Cobham Lansdale facility
  - GTA #1 is now installed at Goddard Geophysical & Astronomical Observatory (GGAO)
  - GTA #2 (for Ny-Ålesund) is currently going through FAT in Lansdale

GMS at GGAO

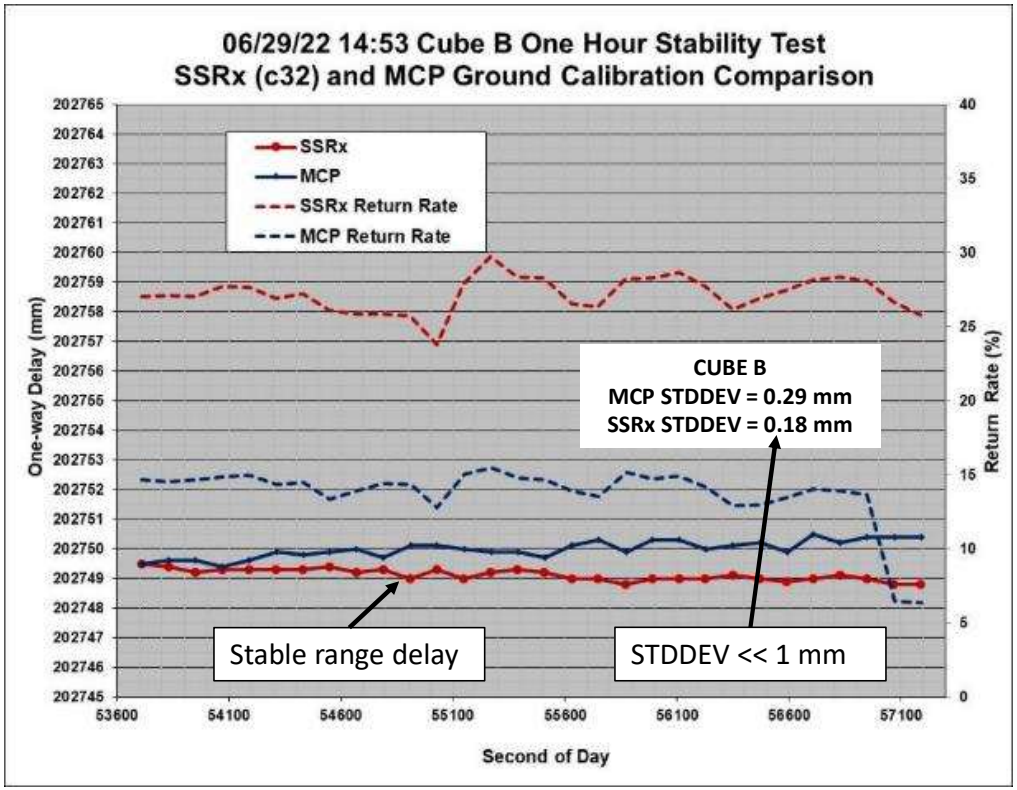
GTA#1 at Cobham Lansdale with a few of SGSLR team

GTA#1 at GGAO

SGSLR Development Status (Receiver)

- Receiver
  - SigmaSpace pixelated detector (SSRx)
  - Demonstrated ground ranging to a single cube using the SSRx receiver with good results: submillimeter standard deviation and millimeter stability over an hour. Currently performing multi-cube array ground testing.

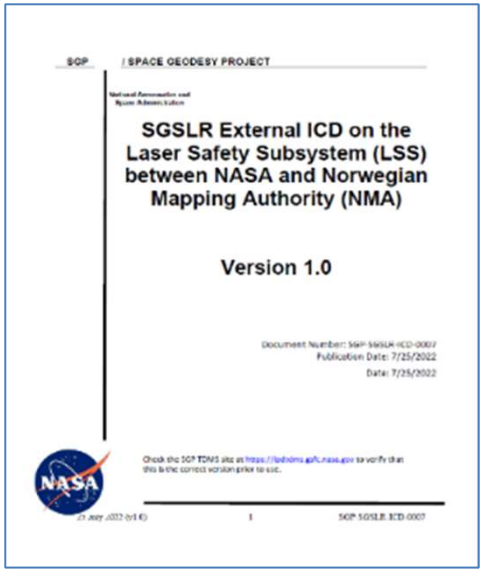
SSRx test setup at 1.2m Telescope Facility



Analysis of data from ground ranging at 1.2m Telescope (analysis by C. Clarke)

SGSLR Development Status (LSS)

- Laser Safety Subsystem (LSS)
  - KBR's Laser Hazard Reduction System (LHRS) for GGAO built and passed Factory Acceptance Testing (this contains the radar that is used to avoid aircraft). Cannot use at Ny-Ålesund.
  - NMA is developing an ADS-B for aircraft avoidance at Ny-Ålesund.
  - NMA and NASA have completed the Preliminary Version of the Interface Control Document (ICD) between the SGSLR Laser Safety Subsystem and the Norwegian Aircraft Avoidance System.


SGP / SPACE GEODESY PROJECT

SGSLR External ICD on the Laser Safety Subsystem (LSS) between NASA and Norwegian Mapping Authority (NMA)

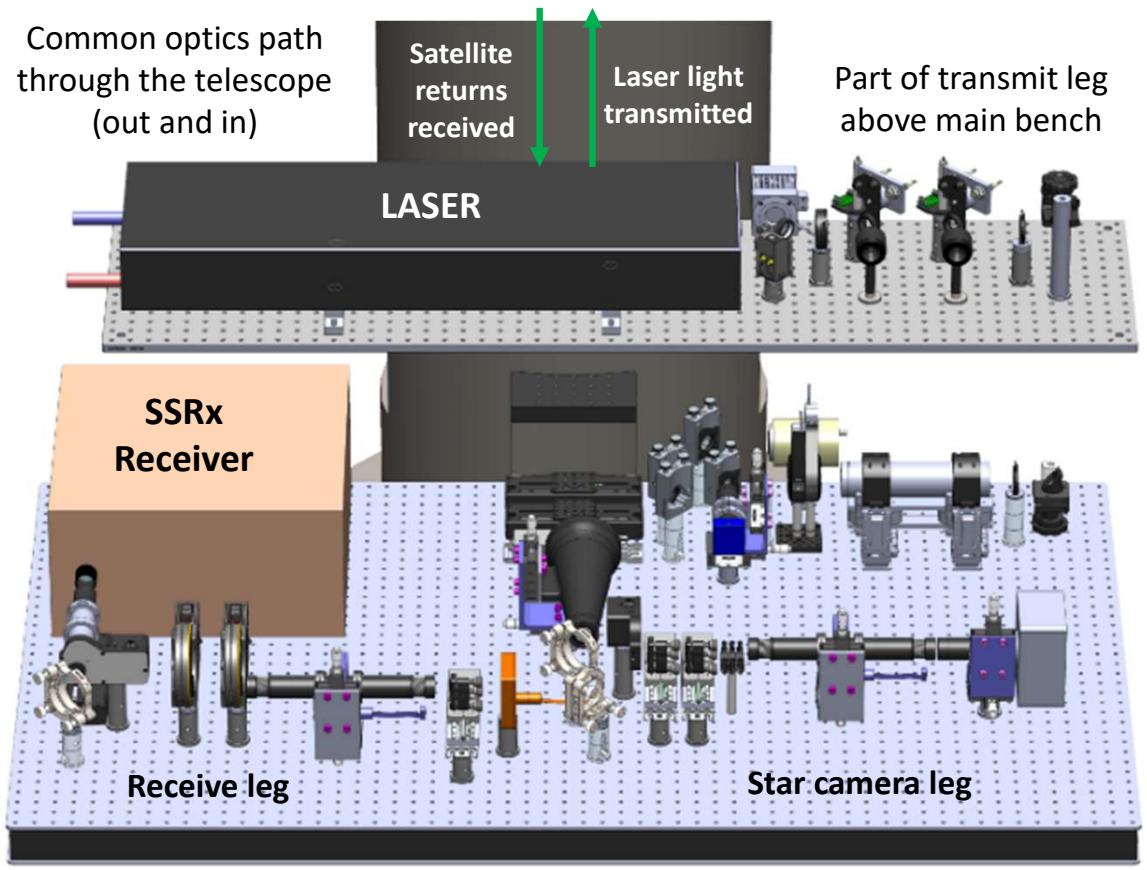
Version 1.0

SGSLR Development Status (T&F)

- Time & Frequency (T&F)
  - GGAO version built, installed it in SGSLR shelter and working
  - A separate T&F unit is in Software Lab at GGAO
  - The Ny-Ålesund and McDonald Geophysical Observatory (MGO) T&F subsystems have been built and are in long term testing in KBR lab. These units have proved to be accurate, stable, and meet SGSLR requirements.

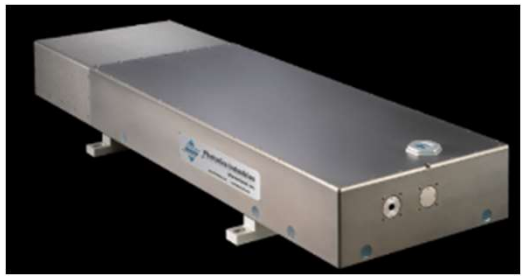
SGSLR Development Status (OB)

- Optical Bench (OB)
  - Design completed
  - Components in assembly
  - Once assembled each component will be tested in lab
  - Bench will be fully assembled in lab and tested before moving to SGSLR facility for testing with rest of the subsystems



SGSLR Development (Laser & Weather)

- Laser



Photonics Industries (current)

Bright Solutions (potential future)

- Meteorological Instrumentation
  - MET4A units procured and in use (Paroscientific) Temperature, Pressure, Humidity monitors
  - Have identified anemometer (Vaisala) and horizontal visibility and precipitation monitors (Vaisala) – will procure next year
  - Sky camera not yet fully identified

sky camera

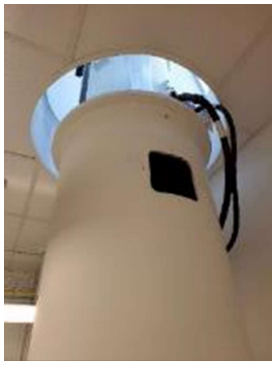
anemometer

Precipitation & horizontal visibility

MET4A

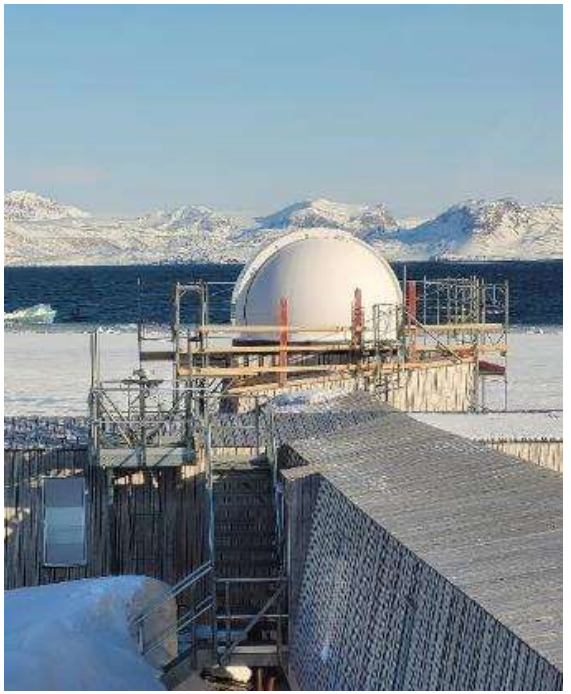
SGSLR Development Status (Dome/Shelter)

- Dome, Shelter & Riser
  - GGAO Shelter built and in use – will be used for all I&T work
  - McDonald shelter built
  - Baader domes installed at GGAO, Ny-Ålesund and McDonald Geophysical Observatory (MGO)
  - Risers installed at GGAO and at Ny-Ålesund



SGSLR riser at GGAO

SGSLR shelter & dome at GGAO



SGSLR shelter & Baader dome at Ny-Ålesund

SGSLR shelter & dome at MGO with Baader dome installation team

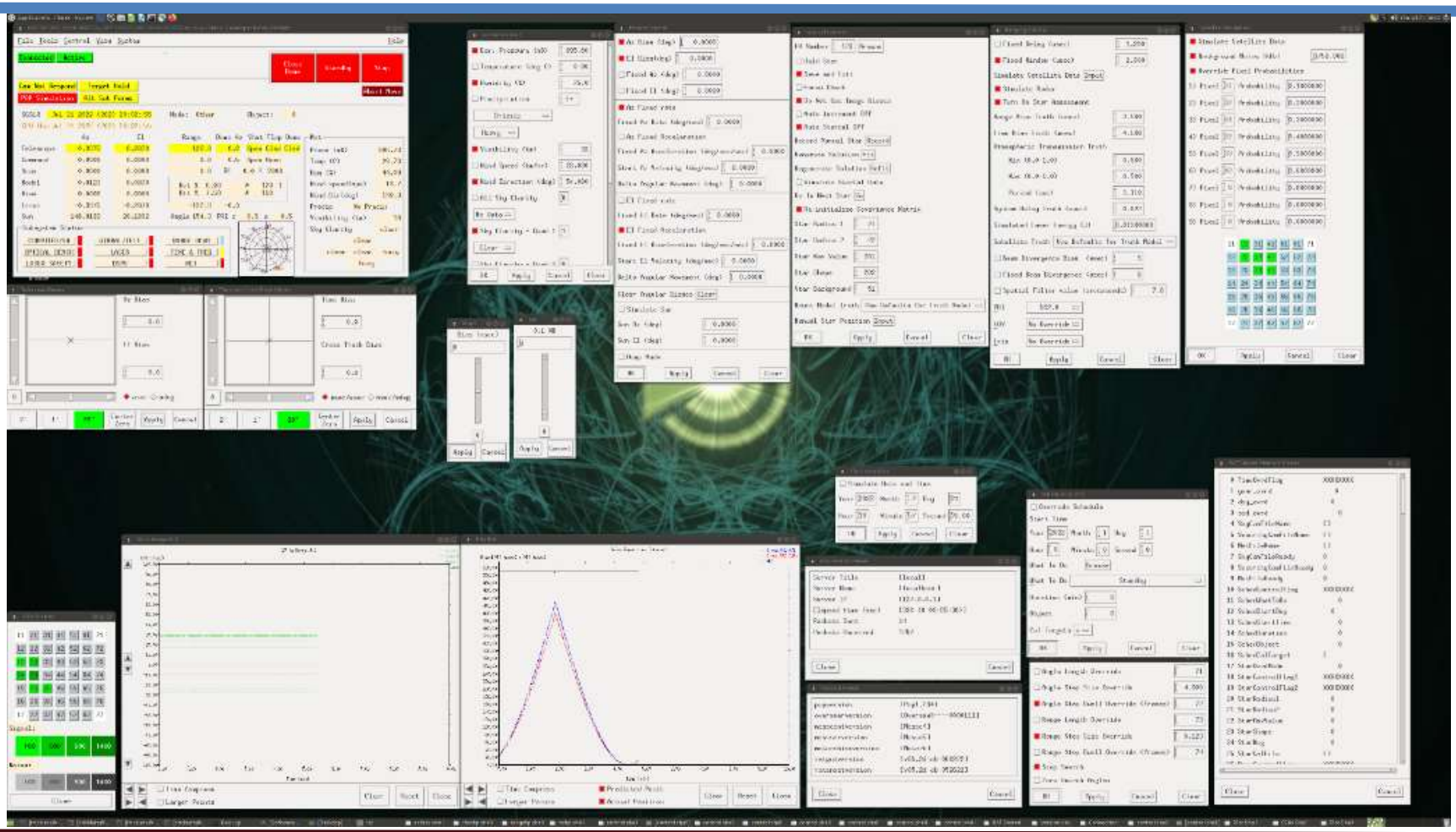
SGSLR Development Status (C&S)

- Computers & Software (C&S)
  - Ranging Software has successfully demonstrated simulated tracking of satellites and performed simulated star calibrations by using the GTA, Dome, RCE and SSRx simulators in the Software Lab
  - Software has been successfully tested with actual hardware
    - Tested with Gimbal & Mass Simulator (GMS) and Dome – successfully used for star calibrations and sunlit satellites using Test Software that is very similar to the Operational Ranging Software
    - Range Control Electronics (RCE) – successfully tested with Ranging Software in Software Lab with prototype unit
    - T&F – unit in Software Lab has been used continuously with Ranging Software for 2+ years
    - MET4 tested with SGSLR software in Software Lab
    - Vaisala precipitation and horizontal visibility has been used in SGSLR prototype system (NGSLR)
  - Preliminary operator interface (ratgui) is currently in use and ready for start of I&T

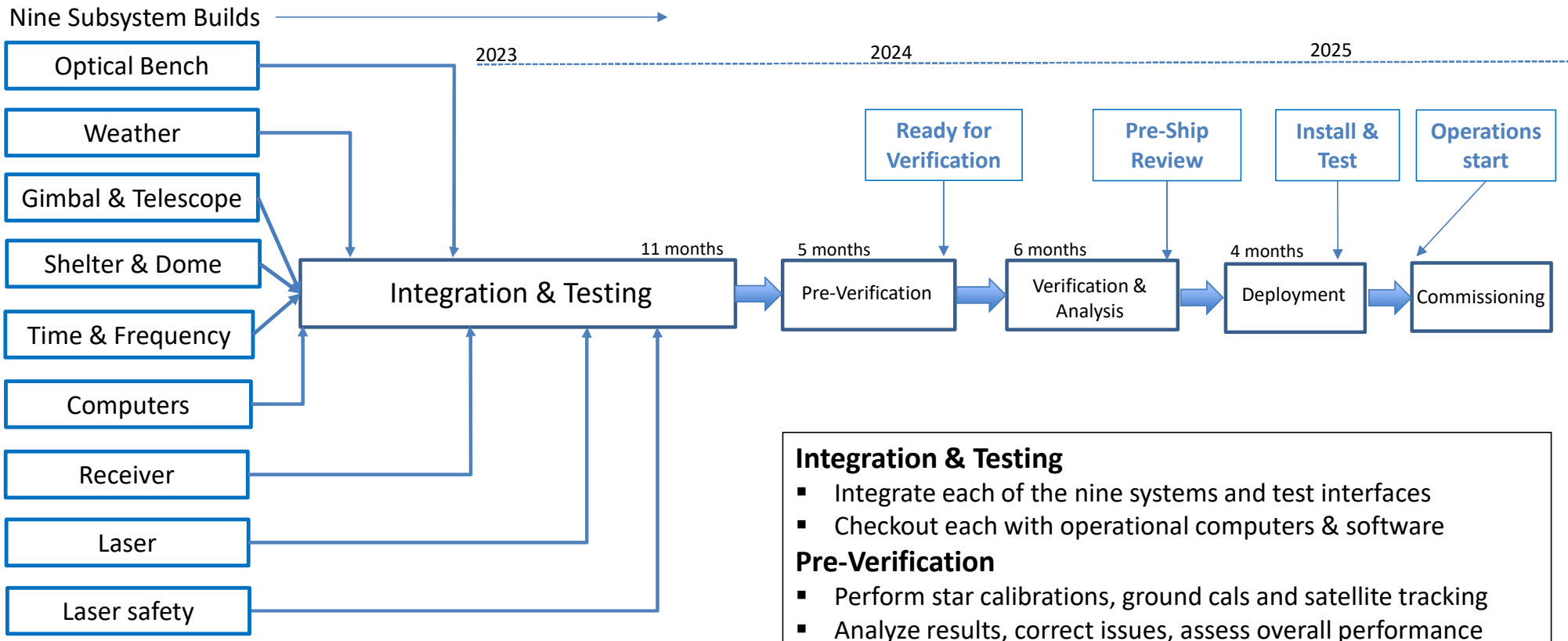
RATGUI == Remote Access Terminal Graphical User Interface

Example of RATGUI displays

Screen shot from R.Ricklefs



SGSLR Development to Operations Flow Diagram



Integration & Testing

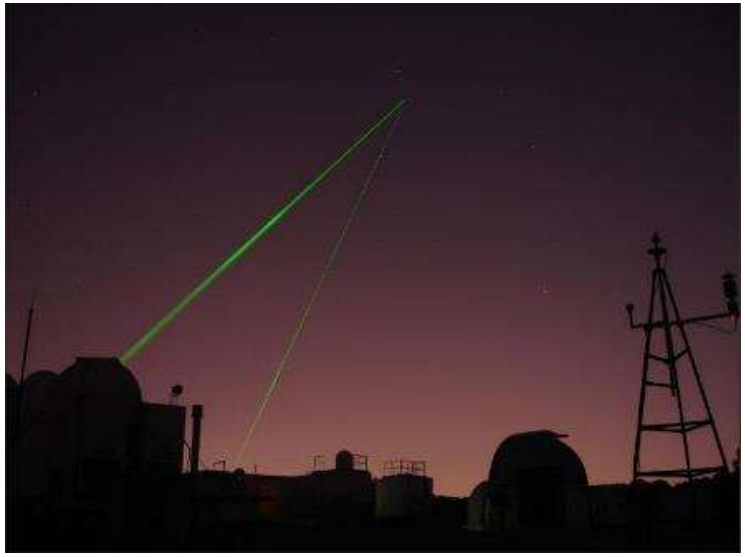
- Integrate each of the nine systems and test interfaces
- Checkout each with operational computers & software

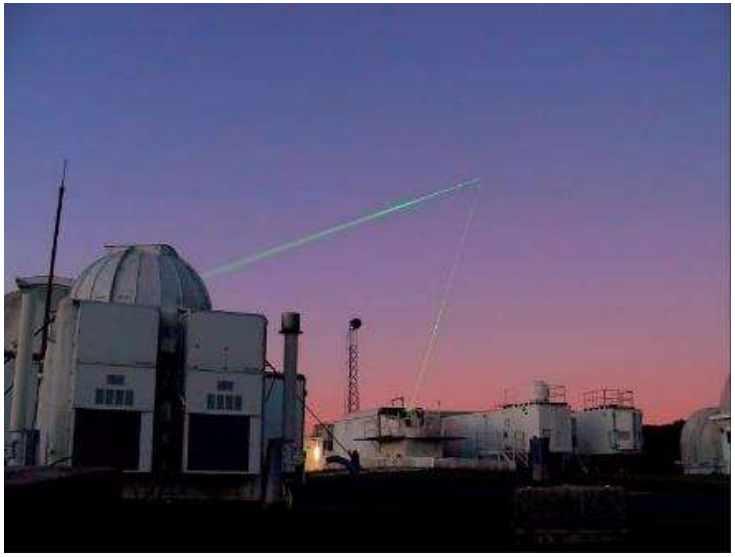
Pre-Verification

- Perform star calibrations, ground cals and satellite tracking
- Analyze results, correct issues, assess overall performance

All stages through Verification are at GGAO

Verification (Collocation)





- Collocation verifies that SGSLR meets its satellite laser ranging requirements
- SLR Collocation is a test and calibration to verify a system's performance by inter-comparison (i.e. comparing simultaneous ranging data to that of a known standard, MOBLAS-7).
- This analysis is an excellent engineering tool available for rapid identification of systematic error sources in a new SLR system at the few millimeter level. It has helped NASA SLR achieve uniformity and consistency of performance across its current global SLR network.

Deployment, Commissioning and Beyond

Deployment & Installation

- Install system in the existing shelter/dome and test all subsystems
- Perform star calibrations, range to ground targets, track satellites
- Ensure system performance is good

Commissioning

- Begin first operational satellite tracking (collect data during quarantine)
- Training during Installation and Commissioning (and some at Goddard)
- Ends in Operational Readiness Review and hand-over NGO system to NMA

Future Activities

- The NASA Team will continue software development, maintenance, and upgrades during Commissioning and throughout Operations

SGSLR Network Plans

- First SGSLR system will be deployed to Ny-Ålesund in 2024 and start operations in early 2025
- Texas (MGO) SGSLR will be the next system, followed by Maryland (GGAO) and Hawaii
- NASA will replace the rest of its Legacy SLR network over the next decade at approximately one system per year

SGSLR at GGAO

THANK YOU!