# SGSLR

## Space Geodesy Satellite Laser Ranging

# SGSLR Safety & Security across Global Locations

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# Abstract

SGSLR Safety & Security across Global Locations

The first deployments of the new Space Geodesy Satellite Laser Ranging (SGSLR) systems will be to the **Goddard Space Flight Center and the McDonald Observatory in the United States, and to Ny-Ålesund in Norway**. Personal safety, system safety, laser safety, and physical security will have many common approaches between these locations, but will differ due to national laws and regulations as well as specific requirements of the local sites. Both the internal communications network and the internal network security approach for SGSLR will be the same for all sites, but the connections to the external network may vary between locations. This presentation will describe the safety and security plans for SGSLR, and explain the differences between the sites.

# Acknowledgments

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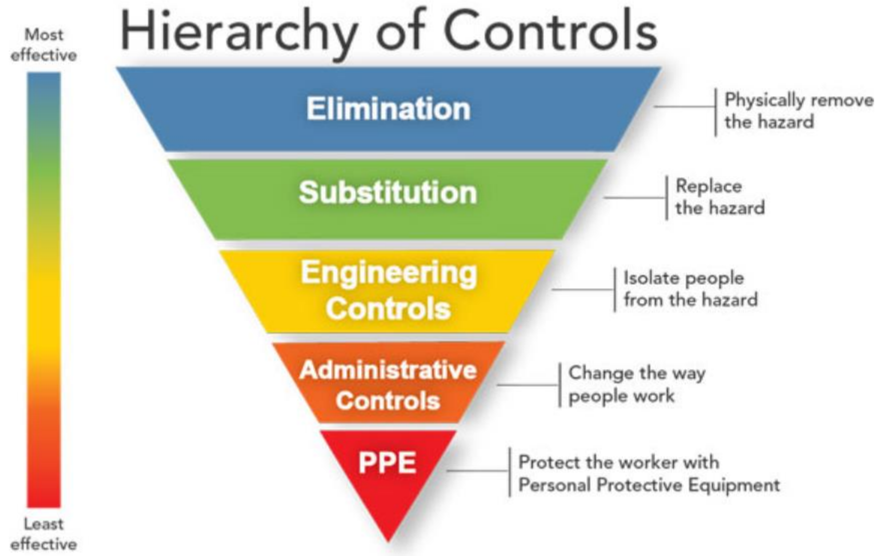
# Introduction

- SGSLR Safety
  - Human (within the system and exterior to it)
  - Instrumentation (within the system and exterior to it)
  - Aircraft
- SGSLR Security
  - Physical
  - Internet
- Space Geodesy Network Operations Center (SGNOC)
  - real-time monitoring of each SGSLR station
- Site specific safety & security
- Conclusions

# SAFETY

# SGSLR SAFETY

- Identify hazards (hazard analysis)
  - Ensure these cover maintenance, alignment, calibration, as well as operations (may be different for each)
  - Look at public access, proximity to nearby activities
- Identify each hazard’s risk (before and after mitigation)
- Develop mitigation plan for each hazard (follow hierarchy of controls)
- Generate a Safety Plan
- Modify hardware, facility, site as needed (and as possible)
- Develop procedures needed and train operators (with regular review / updates)
- Provide & use proper Personal Protective Equipment (PPE)/Safety Equipment (goggles, etc.)
- Safety verification and ongoing assessment
  - Routine Safety Inspection
  - Periodic testing
  - Communication of system health and failures
  - Periodically review the system safety



# Hazard Analysis

- Hazard Analysis – different for the way each system is operated and for each specific location.  Perform this analysis during system development and continue to review throughout the life of the system.
- Where regulations for the host country differ from NASA's – use those that are the most stringent.
- Hazard analysis is **important for human operated system on-site**
  - Hardware controls and operational procedures to minimize risks
- It is **very important for remote operations**
  - More hardware safety features required and use of cameras essential.
- It is **critical for automated operations**
  - Experience with remote operations will guide safety
  - All potential paths for things to go wrong must be examined
  - Software needs to be very carefully and thoroughly vetted – all code paths must be examined and/or tested (NASA required external verification for autonomous ops)

# Examples of Human Safety Hazards

- Slips, trips, and fall hazards (roof top, stairs, hatch access)
- Pinch point / caught between hazards (GTA, dome)
- Fires, building / room egress issues
- Electrical hazards
- Chemical hazards
- Laser damage (eyes, skin) both inside to operators and outside in the path of the ground target
- Medical emergencies
- Severe weather
- Local wildlife (animals, pests and plants)
- Unauthorized access to facility and criminal activity

# Examples of Human Safety Hazard Mitigations

- Interlocks (foot pads, door sensors, etc) to cause beam to be blocked
- Enclose beam in laser room where feasible
- Fail safe electronics
- Laser kill switch (laser disable button)
- Egress from rooms and buildings that are well designed and well known
- Reliable telecommunication for local on-site operators / technicians
- Secure site that greatly reduces the risk of non-authorized access
- Foot traffic eliminated during laser ranging to ground targets and use of ND filters to make laser eye-safe
- Procedures for laser operations
- Procedures for laser work and system alignment
- Personal Protective Equipment (PPE) / Safety Equipment

# Examples of System Safety Hazards

- Severe weather, including winds, rain, snow accumulation, ice
- Lightning strike (direct or nearby)
- Fire – interior or exterior (wildfires)
- Unauthorized access to facility or system computers
- Detector damage from backscatter or sun
- Electrical hazards, including surges and power outages

# Examples of System Safety Hazard Mitigations

- Design system to withstand expected / potential weather
- Control access with physical and internet security
- Backscatter and stray light protection for the detector
- Lightning protection: counterpoise, air terminals, fiber optic external data interfaces (see poster on this subject by Donovan) – at GGAO and MGO sites
- Surge suppression
- Fire detection
- Fire protection (that won't damage instrumentation)
- UPS units to allow graceful emergency shutdown if possible

# Examples of Aircraft Safety Hazards

- Laser exposures exceeding Maximum Permissible Exposure (MPE) limit contacting aircraft during operations
- Laser exposures causing visible disruption for aircraft

# Aircraft Safety Hazard Mitigations

- Identify users of the airspace (planes, helicopters, balloons, gliders, parachutists, etc.
- Determine best method (for the site) to ensure laser doesn't hit aircraft
  - Various methods include: radar, ADSB, no-fly zone, eye-safe laser pre-fire, cameras, …
  - All methods have some issues – a combination of more than one is normally needed
- Calculate the Nominal Ocular Hazard Distance (NOHD) and ensure that the method of aircraft avoidance covers the distance required
- Use fail safe design features in laser safety subsystems
- Use aircraft avoidance or ground calibration safety methods every time the laser fires external to the system
- Develop outdoor part of Laser Safety Plan (in concert with indoor plan)

# SECURITY

# SGSLR Physical Security

- Limited access to site: restricted fenced-in area or remote site
- Keycard or some method of determining who enters the site and facility with date/time
- Keep personnel out of laser path to ground target
- Prevent unauthorized people from climbing onto roof
- Ensure dome access and laser room access stops the laser from firing
- Ensure dome access stops the GTA and dome from moving (except under special conditions for maintenance and testing – use separate procedures and trained personnel)

# SGSLR IT Security

- Reduce risk of unauthorized access:  use two factor authentication
  - SGSLR looking to use Yubikeys with password
- Track who is accessing the system: record all log-ins to the system
  - Will have separate admin computer for this
- Make access to each computer difficult - do not directly connect local computers
  - Subsystems are grouped into Virtual Local Area Networks (VLANs)
  - Each VLAN has it's own subnet to isolate traffic from the other VLANs
  - Traffic between VLANs is forced to route through a firewall
  - Firewalls are by design ‘deny any’ traffic devices, rules are set to permit only traffic needed
- Use VPN for users to connect remotely to station and for the station to connect remotely to Space Geodesy Network Operations Center (SGNOC)

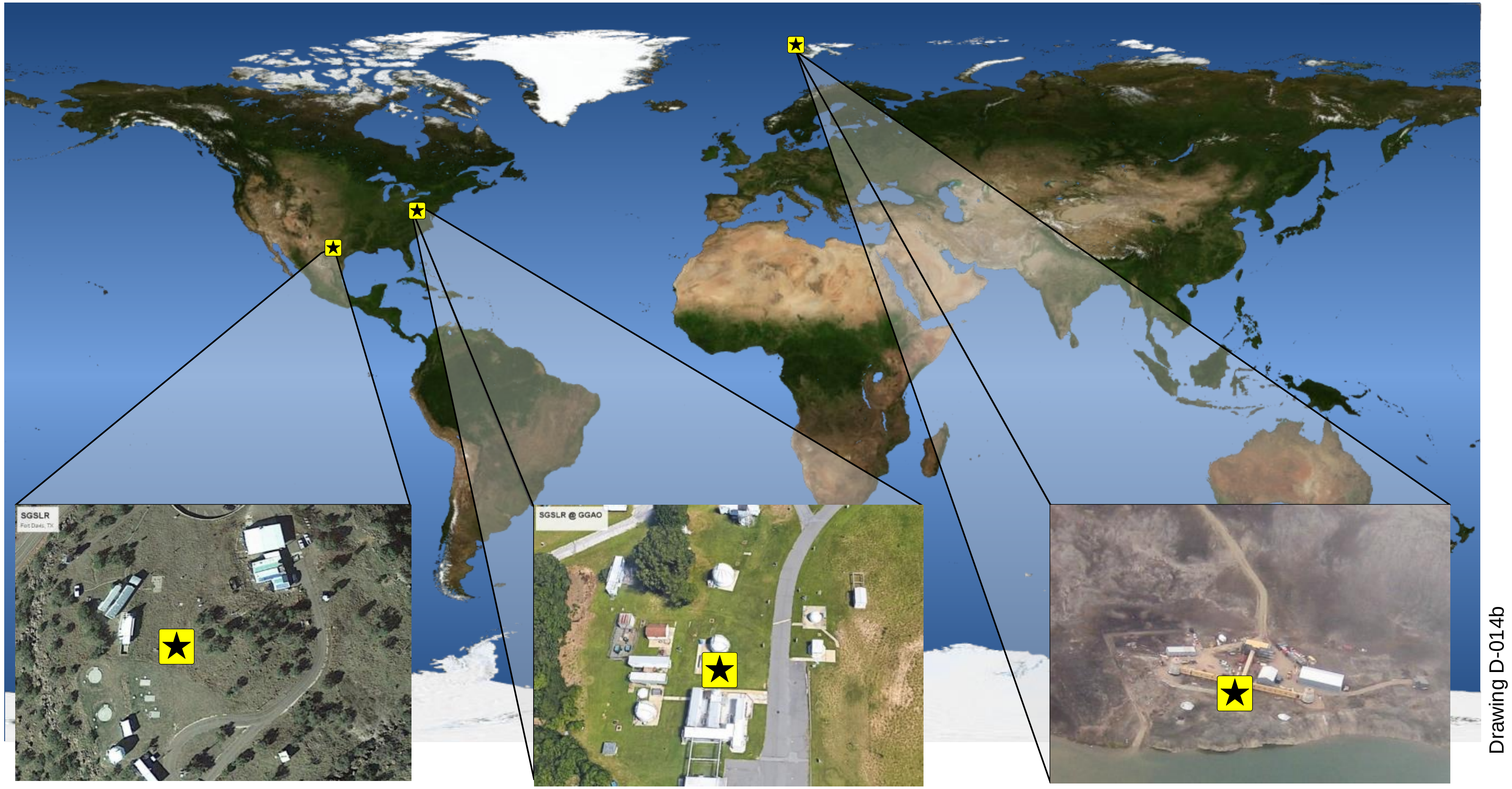
# SGNOC

# SGNOC

- Space Geodesy Network Operations Center
  - Similar to a Mission Control Center
- All SGSLR facilities will communicate regularly with SGNOC through VPN
  - Normal point data will be transmitted
  - Predictions obtained
- Each SGSLR facility can operate independently if needed for a period of time but normal mode of operations is to communicate with SGNOC
- SGNOC provides central facility to monitor the system in real-time
  - Health & Safety
  - Security (cameras)
  - Performance

# SITE SPECIFIC SAFETY & SECURITY

# SGSLR Sites




**McDonald Observatory, TX**

(MGO)

**Greenbelt, MD**

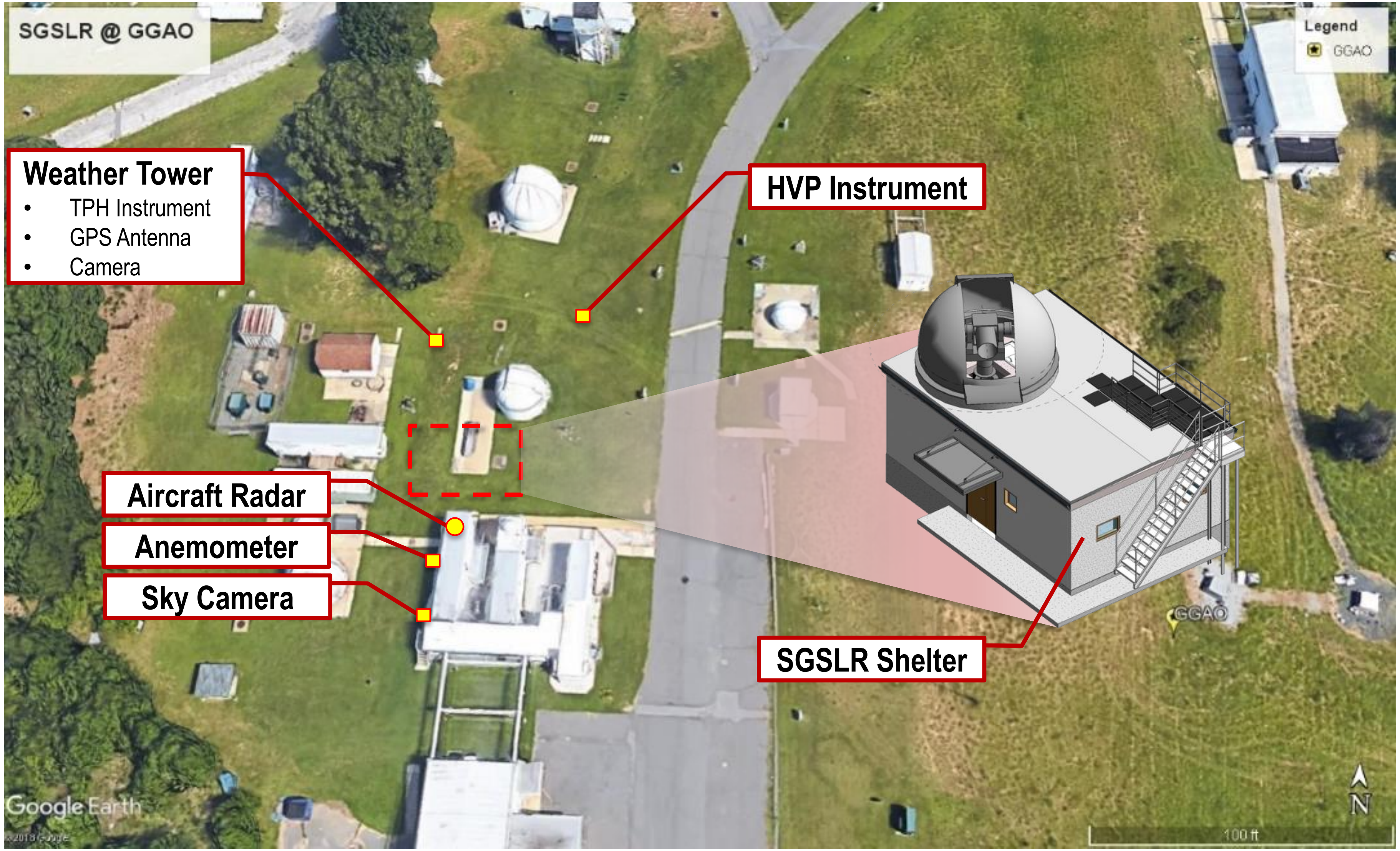
(GGAO)

**Ny-Ålesund, Norway**

(NGO)

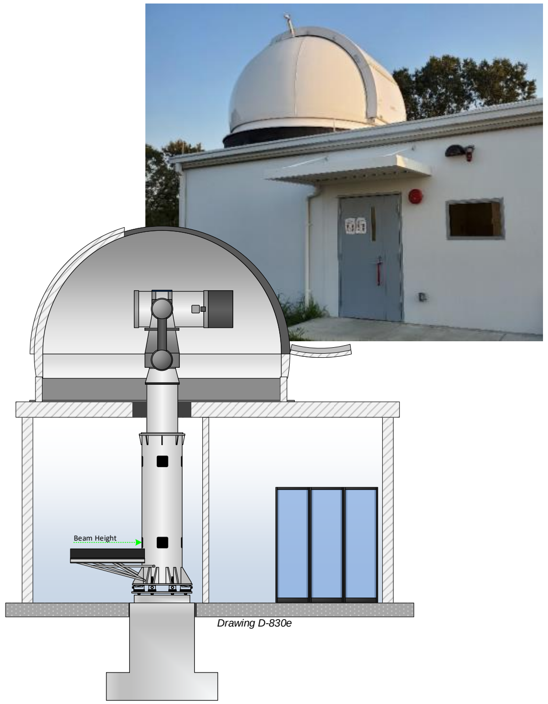
# Goddard Geophysical & Astronomical Observatory (GGAO)

# Site Layout: GGAO



# GGAO Site Specific Safety/Security (1 of 2)

- Security / Safety
  - Fenced in area surrounding entire GGAO with controlled entry
  - SGSLR facility will require smartcard access to enter
  - Fire alarms will be tied to GSFC central facilities desk
  - Emergency responders are nearby



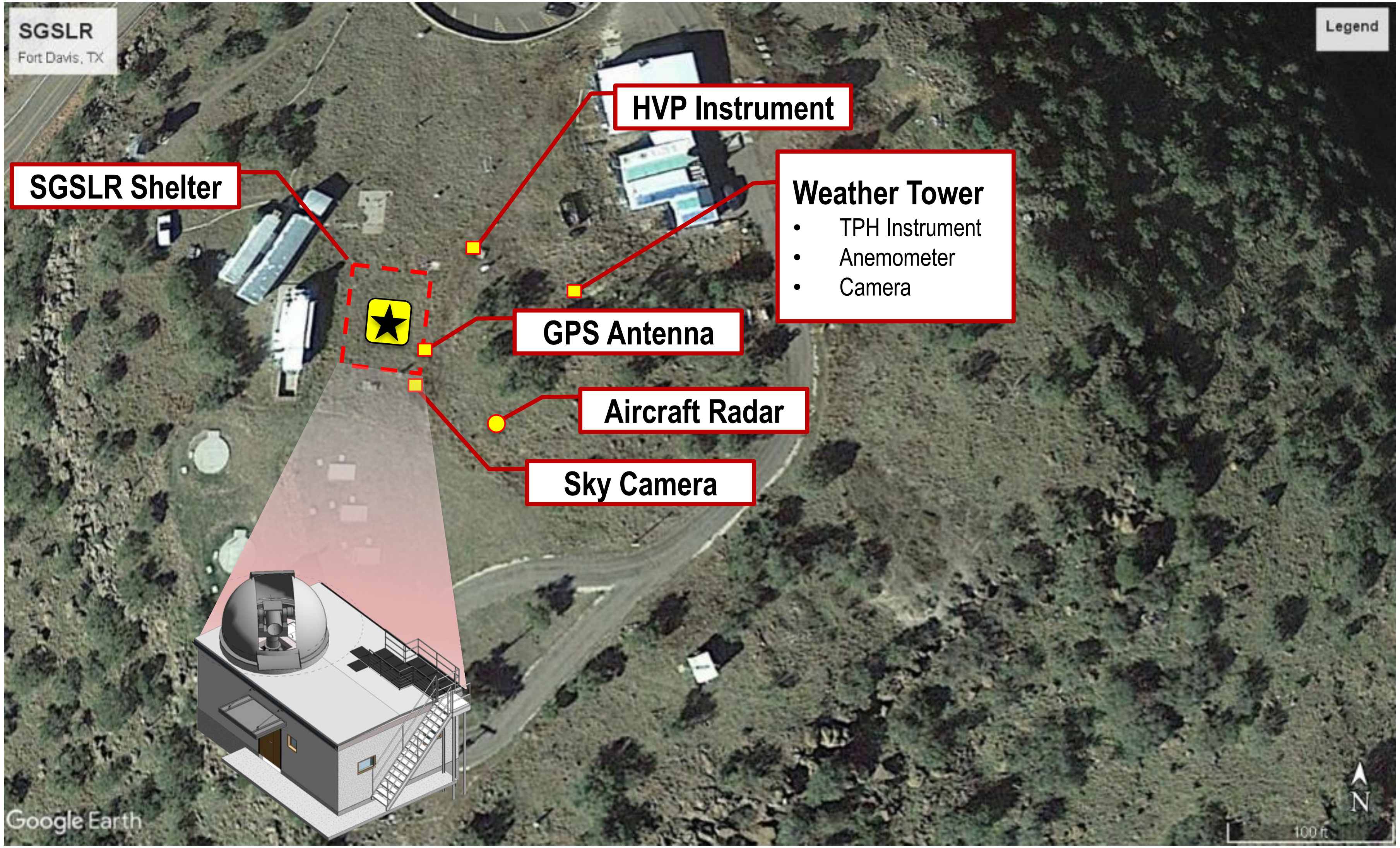

- Site Specific Considerations
  - Radar in use for aircraft avoidance
  - VLBI shielded from radar by pointing mask
  - Pointing masks protect other ground items from getting illuminated with either laser or radar
  - Normal SGSLR Laser Safety Subsystem for indoor/outdoor safety

# GGAO Site Specific Safety/Security (2 of 2)

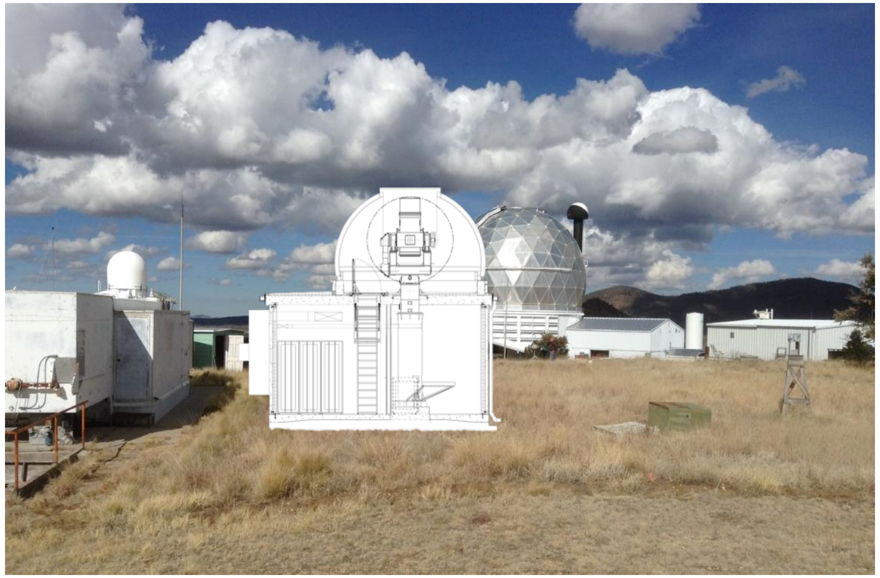
- **Safety**
  - Close proximity to multiple airports – lots of aircraft traffic in the sky
  - Severe weather not normally an issue
  - Wildlife not a big problem
  - Proximity to quick emergency response
- **Security**
  - Fence provides site protection from unauthorized personnel
  - Multiple other experiments going on at GGAO – procedures, signage and restricted access to prevent access from unauthorized personnel going into SGSLR areas

# McDonald Geophysical Observatory (MGO)

# Site Layout: MGO (Mt Fowlkes)



# MGO Site Specific Safety/Security (1 of 2)



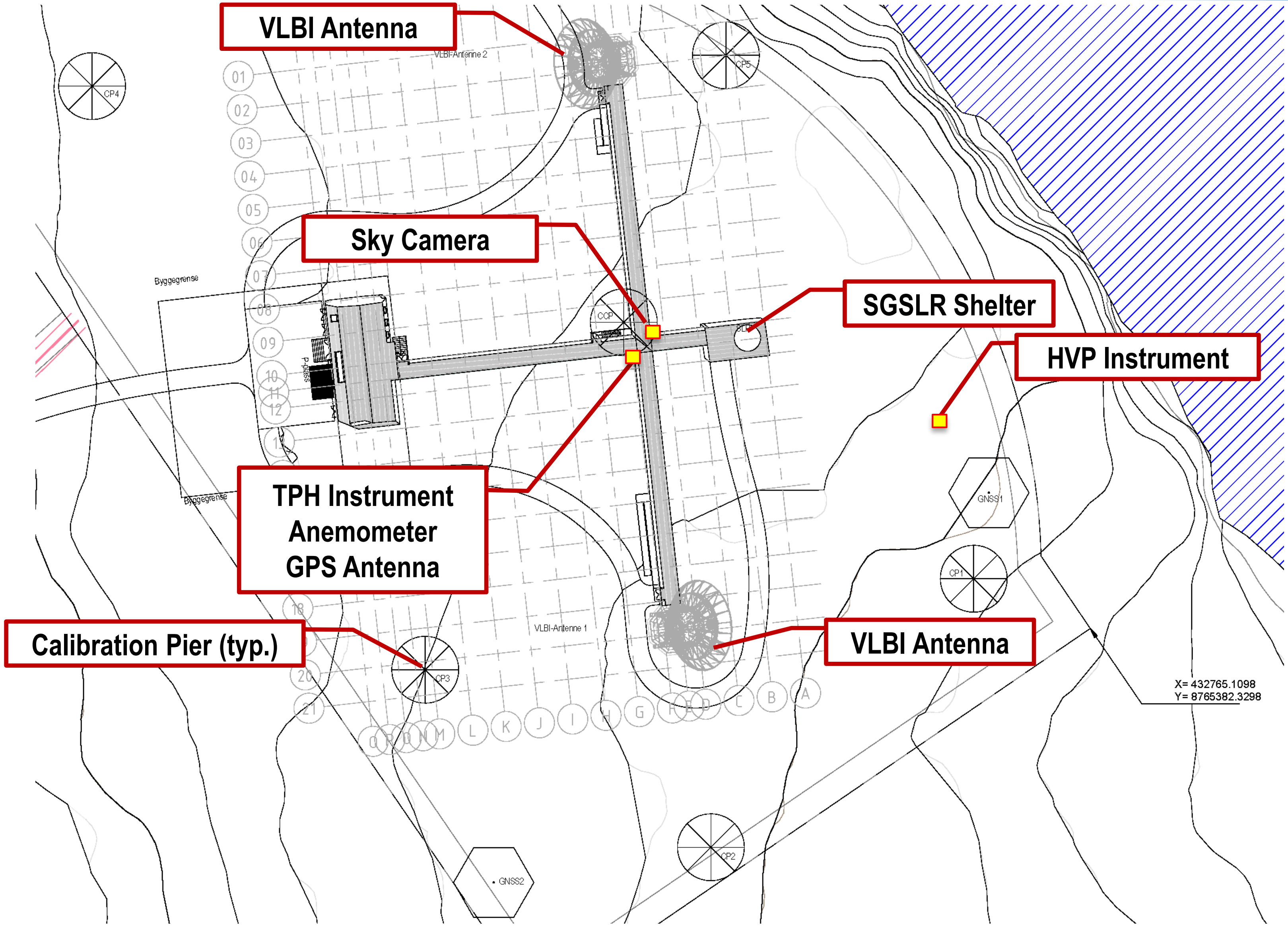
- Security / Safety
  - Remote location provides limited access
  - No cell phone service but land line phones suffice
  - SGSLR facility to use key for access plus sign-in book
  - Fire alarms will be tied to McDonald Observatory fire response
- Site Specific Considerations
  - Radar in use for aircraft avoidance
  - VLBI shielded from radar by natural barrier (800 meters and large elevation drop)
  - Pointing masks protect other ground items from getting illuminated with either laser or radar
  - Normal SGSLR Laser Safety Subsystem for indoor/outdoor safety

# MGO Site Specific Safety/Security (2 of 2)

- Safety
  - Much less aircraft traffic than GGAO – but laser safety handled similarly
  - Severe weather not normally an issue
  - Wild fires do occur and can be very dangerous
  - Wildlife can be a hazard (mountain lions, snakes, …)
  - Proximity to quick emergency response of local McDonald Observatory personnel but distant from hospitals and other support
- Security
  - Remoteness provides limits on access, but public is nearby at Visitor's Center and at the Hobby-Eberly Telescope (HET) facility
  - Other experiments going on at MGO – procedures, signage and restricted access to prevent access from unauthorized personnel going into SGSLR areas

# Ny-Ålesund Geophysical Observatory (NGO)

# Site Layout: (NGO)



# Ny-Ålesund Site Specific Safety/Security (1 of 2)

- Security / Safety
  - Extremely remote location provides limited access
  - No phone service
  - SGSLR facility built by Norway with keycard access
  - Fire suppression at facility

- Site Specific Considerations
  - Radar not allowed
  - Laser safety will include "No Fly Zone" around site and Laser Kill Switch operated from the local and Longyearbyen airport personnel – still assessing possible other options
  - Pointing masks protect other ground items from getting illuminated with laser
  - Normal SGSLR Laser Safety Subsystem for indoor safety

# NGO Site Specific Safety/Security (2 of 2)

- Safety
  - No Fly Zone will reduce but won't eliminate aircraft
  - Arctic temperatures – but moderated by North Atlantic Current
  - Periods with 24 hours of night (and periods with 24 hours of day)
  - Wildlife is dangerous (polar bears)
  - Remote location of SLR station means that the system must be operated remotely
- Security
  - Remoteness provides security from entry by unauthorized personnel
  - But there are other experiments at NGO – so procedures, signage and restricted access will be used to prevent unauthorized personnel going into SGSLR areas

# CONCLUSIONS

# Conclusions

- Safety and Security need to be assessed and planned for from the start of a new SLR design and/or site
- Safety is a continuing process
  - Regularly verify that safety hardware and procedures are working
  - Review operations and maintenance for new hazards as things change
  - All SLR stations should follow laser safety best practices to ensure aircraft are not lased
- Security of SLR systems is very important
  - Needs to have more thought as systems are operated remotely and/or autonomously
- IT Security is a responsibility of all SLR stations
  - Becoming a major risk as hacking becomes a global issue

SGSLR at GGAO

# THANK YOU!