SGSLR

Space Geodesy Satellite Laser Ranging

Plans for a fully automated SGSLR system

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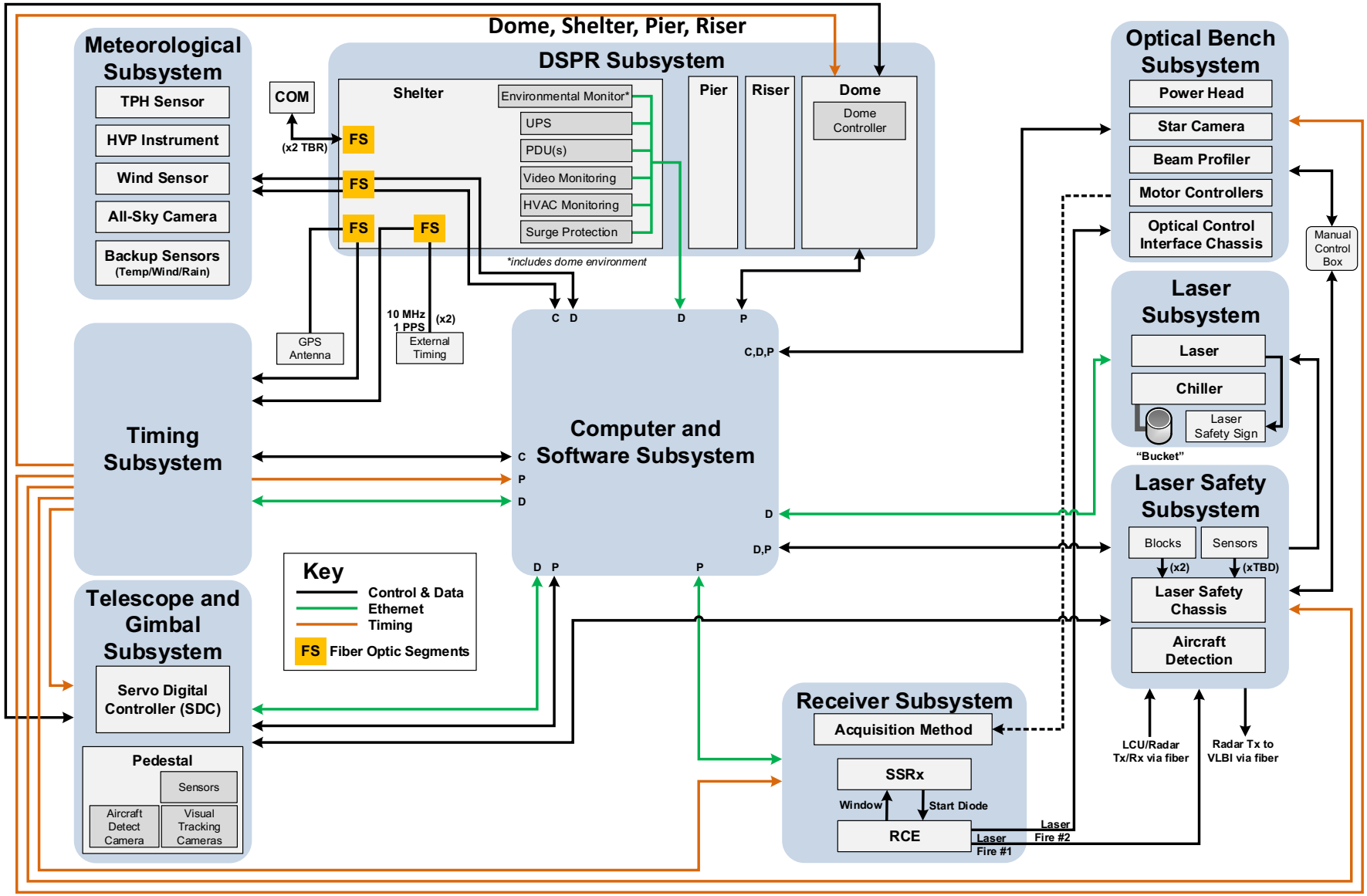
Abstract

The Space Geodesy Satellite Laser Ranging system (SGSLR) is being designed with the goal of full automation. Lessons learned on NGSLR and other systems are being implemented in SGSLR. Automation will be achieved in stages with the first stage being remote operational capability at the McDonald and Ny-Alesund SGSLR systems when many of the operational tasks will already be automated. Ultimately, SGSLR will send science and monitoring data to, and receive commands from, the Space Geodesy Network Operation Center (SGNOC), similar to the way spacecraft now operate. The hardware and software needed to achieve full automation, and the stages of implementation will be discussed.

Part I: Immediate Plans

Simplified SGSLR System Block Diagram



SGSLR's Nine Major Subsystems

- **Timing & Frequency**
  - Monitoring of timing using 2nd GPS
  - Monitoring info sent to SGNOC
- **Meteorological**
  - Automated reading of Pressure, Temperature, Humidity for range correction
  - Horizontal Visibility, Precipitation, Wind, Sky cloud cover for automation
- **Telescope and Gimbal (GTA)**
  - Dome and radar slewed from GTA
  - Visual Tracking Aid – used locally, remotely and sent to SGNOC
- **Optical Bench**
  - Transmit path, Receive path, Star Camera, Motion Control
  - Software can automatically configure all paths for all required modes

All data sent to Central Facility (SGNOC)

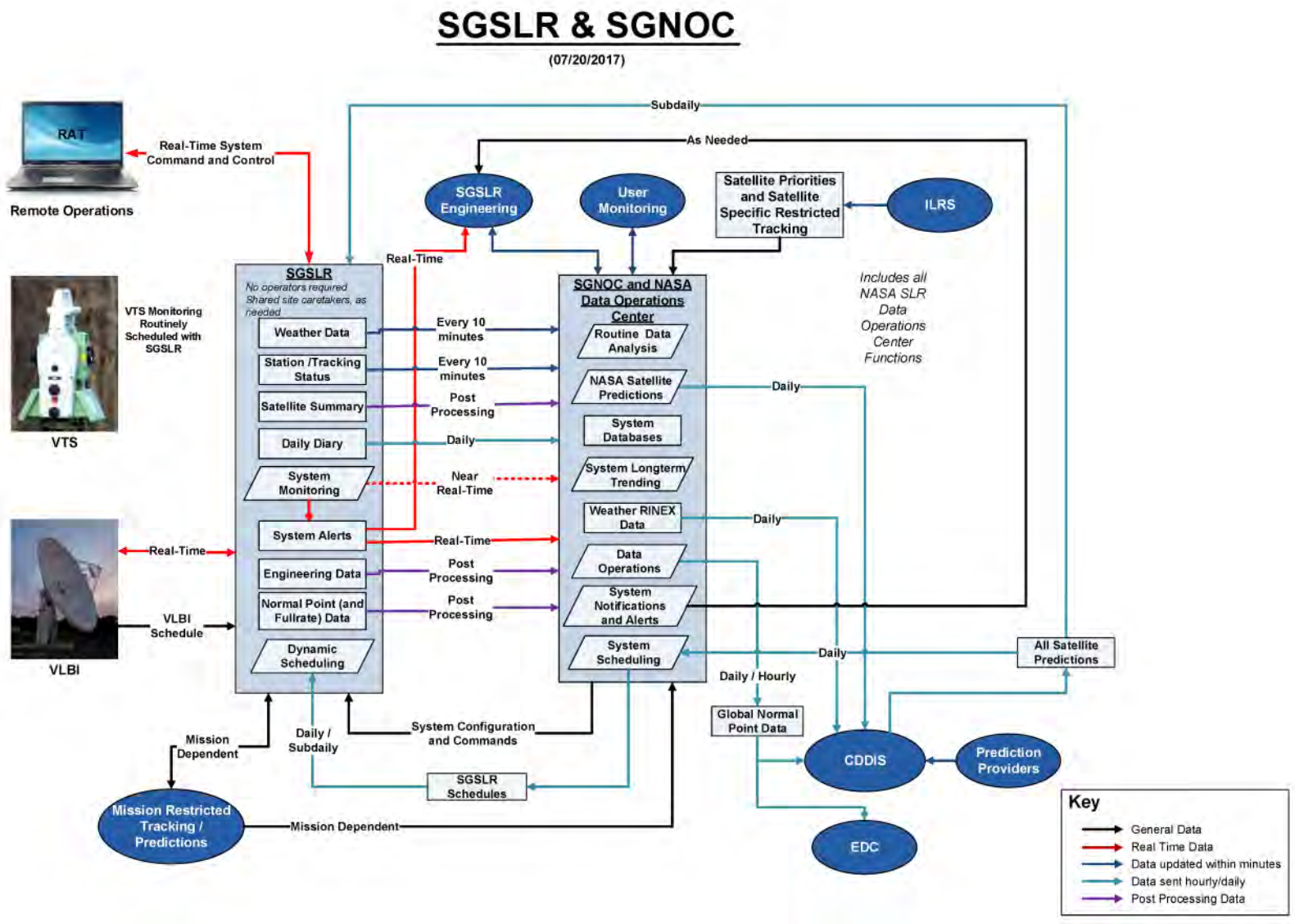
- **Laser**
  - Provide health & diagnostic information to Software
  - Repetition rate controlled by software to automatically avoid trasmit/receive collision
- **Laser Safety**
  - NASA/ANSI compliant, Failsafe, Redundant, Highly responsive hardware controlled
  - Provides information to Software on actions it takes and reasons why
- **Receiver**
  - Range Receiver – Precise signal timing coupled with angular offset info to optimize telescope pointing
  - Adjustable FOV for acquisition
- **Dome, Shelter, Pier, Riser (DSPR)**
  - Software controls power through UPS units and can shut everything down
- **Computer and Software**
  - Ties all subsystems together for manned, remote, and automated operations

Hardware Designed for Automation

SGNOC
Space Geodesy Network Operations Center

- Central Facility Operations Center for entire Space Geodesy Network (SGN) – SLR, VLBI, with GNSS and DORIS support
- May be manned up to 24x7 and watches over all SGN systems, alerting technicians and engineering when needed
- Much of the SGNOC functions will be automated and will operate similarly to how spacecraft Mission Operations Centers do
- Receives real-time status & engineering information from stations
- Provides web based view of the stations and their performance in near real-time (both public view and a restricted/detailed view)
- Provides trending analysis for engineers & managers
- Performs all NASA SLR Data Operations Center functions including receiving science data from SGSLR and forwarding to CDDIS and EDC
- Commands the SGSLR stations as needed
- Control of the SGSLR stations will require the RAT interface at SGNOC
- Generates station schedules

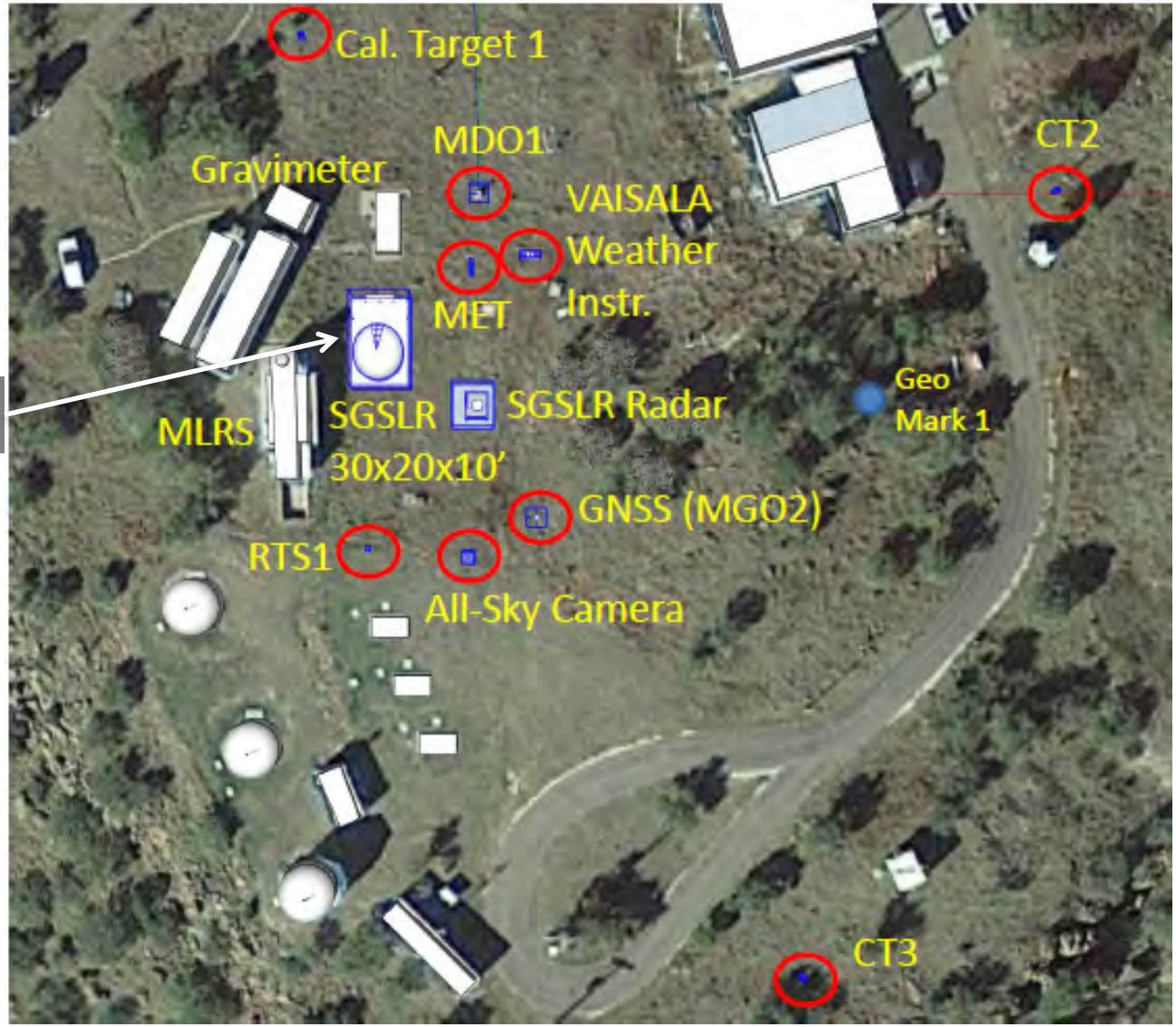
SGSLR External Data Flow



SGSLR Network Deployments

- First systems:
  - McDonald Geodetic Observatory (MGO) – replacing MLRS and being built nearby (800 m) the new SGP MGO VGOS system (early 2020)
  - Ny-Ålesund Geodetic Observatory (NGO) – being built in the same location as the new Norwegian VLBI antennas (early 2022)
  - Haleakala on Maui will follow the first two systems
  - GGAO will be used as a test bed and then an operational system
  - SGSLR systems will replace rest of NASA Network in coming years
- Automation capabilities
  - System is being designed to become fully automated
  - Local and near-remote operations at start
  - Far remote operations within a year after MGO SGSLR
  - Continuing to flesh out automation software and test it
  - Fully automated around 2025

McDonald: preliminary layout



Ny-Ålesund: in progress

SGSLR Modes of Operations

- SGSLR Modes of Operation:
  - Satellite Ranging (science data collection mode)
  - System Calibration (ranging to ground targets and internal cal)
  - Star Calibration (using start to generate mount pointing corrections)
  - Vector Tie System Support (automated survey monitoring)
  - Standby / Maintenance
  - Diagnostics / Simulation
  - Power-up / Shutdown

- Regardless of the mode, operations will be the same whether a human operator is physically present, remotely controlling, or not participating (automated operation). The only difference will be who makes the decisions - not what functions are performed.

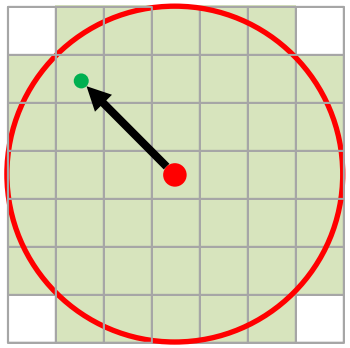
Automated Functions for Near Remote

- Automatically download predictions and schedule and follow tracking schedule *
- Determine when satellite signal returns are captured *
- Bias system to center satellite returns and maximize data rate
- Perform automated ground and star calibrations *
- Automatically change Optical Bench configuration between satellite tracking and ground/star calibrations *
- Collect weather data every 10 seconds and make decisions to not open or close the dome in the presence of rain or high winds *
- Automatically block the laser for aircraft avoidance and other potential safety issues *
- Collect data from all subsystems and monitor performance / identify problems
- Automatically process data (satellite, ground calibration and stars) and determine if performance is adequate *
- Send science, monitoring and performance data to SGNOC *

*** NGSLR was fully able** *** NGSLR was partially able**

Hardware in support of Automation
Receiver (Detector & Event Timer)

- **Provide Closed Loop Tracking**
  - 7x7 pixelated detector array (4 corners unused)
  - Count # of events in each pixel in support of signal detection and to determine satellite location in RFOV
  - Driving signal to central pixel maximizes signal strength



- **Make Precise, High Resolution Timing Measurements For All Pixels Over Long Distances**
  - Start Events: Single measurement per shot
  - Stop Events: Multi-stop, low dead-time
  - Ancillary Events (1pps, etc)

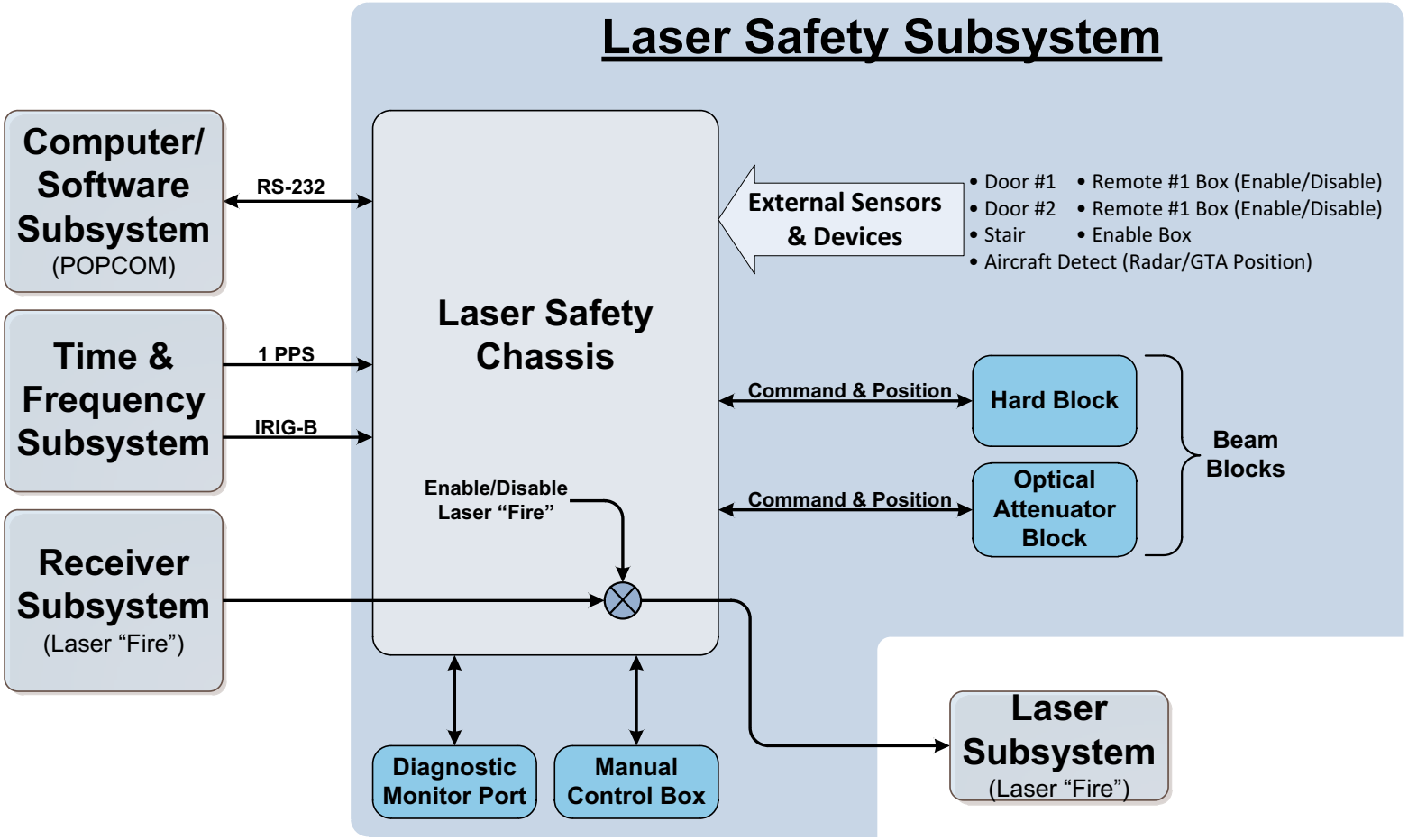
- **Selection based on proven heritage hardware from Sigma Space aircraft and space-flight designs.**
  - Proven on altimeter missions (aircraft & spaceflight)
  - SGSLR hardware with improved higher resolution has been demonstrated in the lab.
  - Demonstration at NGSLR in progress to evaluate in an SLR environment.

Provides ability to determine if system is hitting satellite and to maximize signal strength.

Hardware in support of Automation

Laser Safety Subsystem

Laser Safety Subsystem prevents personnel from exposure to laser light inside or outside the SGSLR shelter and prevents the transmitted laser beam from striking an aircraft.



Provides capability to automatically block the laser for safety related reasons including aircraft avoidance.

What human operator still needs to do for early stage of Remote Operations

- Re-enable the laser to fire after aircraft avoidance or other laser blocking
- Determine where the sky is cloudy and where it is clear
- Final safety and security responsibilities remain with operator
- Operator can still override the schedule and can still enter biases to better optimize but should not have to do this most of the time