NASA's Next Generation Space Geodesy Network Typical Core Site Requirements and Layout

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Introduction

- The Space Geodesy Project (SGP) at NASA has been defining the *requirements and layout for a "typical Core" geodetic site*:
  - Includes SLR, VLBI, GNSS, and DORIS (CNES) stations, tied together with a Vector Tie System (VTS).
- Within programmatic constraints, Core Site (CS) identification follows a *systems engineering process*
  - Site characteristics are pitched against identified requirements.
- Here is an abridged version of the process leading to identification, and the layout of an *idealized CS with unencumbered terrain*.

SGP Objectives and Science Requirements

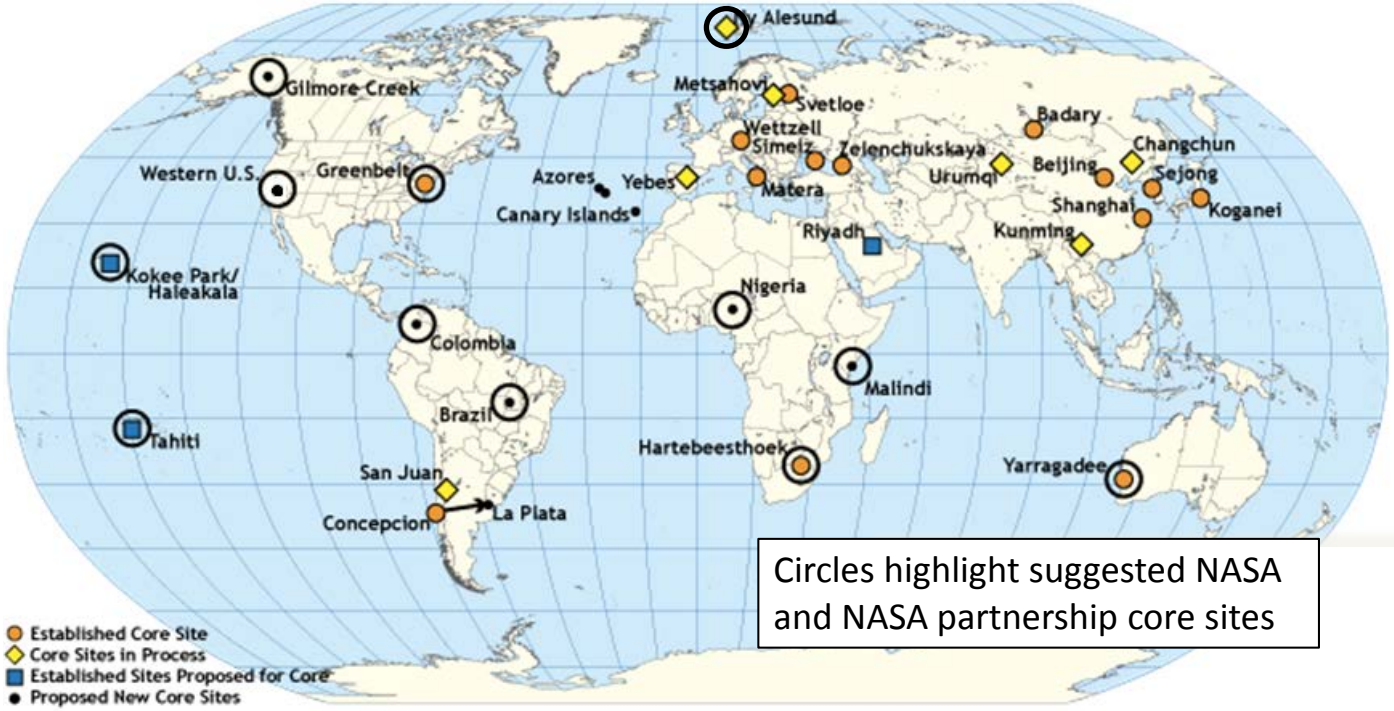
- **SGP0.1**: SGP shall continue to operate, maintain, and where applicable, upgrade the current NASA Space Geodesy Network.
- **SGP0.2**: SGP shall contribute to building, operating, and maintaining a new global network of integrated geodetic stations.

- **SGP1.1**: SGP shall ***contribute to a stable Terrestrial Reference Frame*** (TRF) that meets the needs of NASA's Earth orbiting missions, Earth Surface and Interior Program, and deep space navigation.
- **SGP1.2**: SGP shall ***contribute to measurements of Earth orientation parameters*** (EOP) that meet the needs of NASA's Earth orbiting missions, Earth Surface and Interior Program, and deep space navigation.
- **SGP1.3**: SGP shall ***contribute to determining accurate precision orbits*** to meet the needs of NASA's geodetic, Earth observation, navigation and space science missions.

Sea-Level Change: Global Site Distribution

SGP1.1.1: SGP shall support the measurement of regional and global sea level change.

PRIB3.1 (Baseline Requirement TRF): Co-located global geodetic network shall permit the realization of the ITRF with the following attributes *Accuracy*: ≤ 1 mm (1-Sigma) in X,Y,Z (decadal scale); *Stability*: ≤ 0.1mm/yr (annual scale).



Circles highlight suggested NASA and NASA partnership core sites

Choosing Stations within a ~1000 km area around the "simulation sites" does not affect the resulting ITRF accuracy attributes.

ITRF Site Stability / Continuity

SIT3.1: ITRF Site Stability / Continuity

SIT3.1.1: SGP Site shall ***be located away from major plate boundaries*** and known active faults (> 100 km) and on bedrock.

SIT3.1.2: SGP Sites shall ***only have secular (linear) motion***, with stable rates, varying by ≤0.1 mm/y over a minimum of three (3) years

SIT3.1.3: The area surrounding the site shall be largely ***unaffected from loading transients***, i.e. historically no frequent major droughts or floods recorded, and local extraction or injection of underground liquids (water, oil, etc.) shall not result in significant (>10%) loading amplitude variations over time.

SIT3.1.4: At least ***one GNSS Station shall remain*** at any legacy SGP Site after decommission.

SIT3.1.5: If a Site is to be de-commissioned and there is an operational SLR Station, said SLR Station shall ***not be decommissioned until the new SGSLR*** Station at the Site is verified to operate as expected.

SIT3.1.6: If a Site is to be de-commissioned and there is an operational VLBI Station, said VLBI Station shall ***not be decommissioned until the new VGOS*** Station at the Site is verified to operate as expected.

NSGN Site Data Acquisition Requirements

SIT3.2: NSGN Site Data Acquisition Requirements

SIT3.2.1: The ***average SGSLR Data*** generated by each NSGN Site shall be 16 Gbits/week

SIT3.2.3: The ***average VGOS Data*** generated by each NSGN Site shall be 55 TByte/day for non-real-time data collection (3080 Tbits/week).

Site Infrastructure

SIT3.3: Site Infrastructure Requirements

SIT3.3.1: NSGN Sites shall have ***broad-band internet communications*** for near real-time data transfer and instrument control and monitoring.

SIT3.3.2: ***Electrical power*** shall be available to NSGN Sites.

SIT3.3.3: A *typical* NSGN Site shall have an ***area*** (1000 x 1000) sqf (305 x 305) sqm

Non-ITRF NASA Science Requirements

SIT3.4: Non-ITRF NASA Science Requirements

SIT3.4.1 (Altimetry): A well distributed NSGN network of SLR Stations shall support a total of 24-30 passes per day with a NP accuracy of 1 cm.

SSR2 (Plate Tectonics/POD): The NSGN network shall be well distributed around the globe, and shall have a long history of operation.

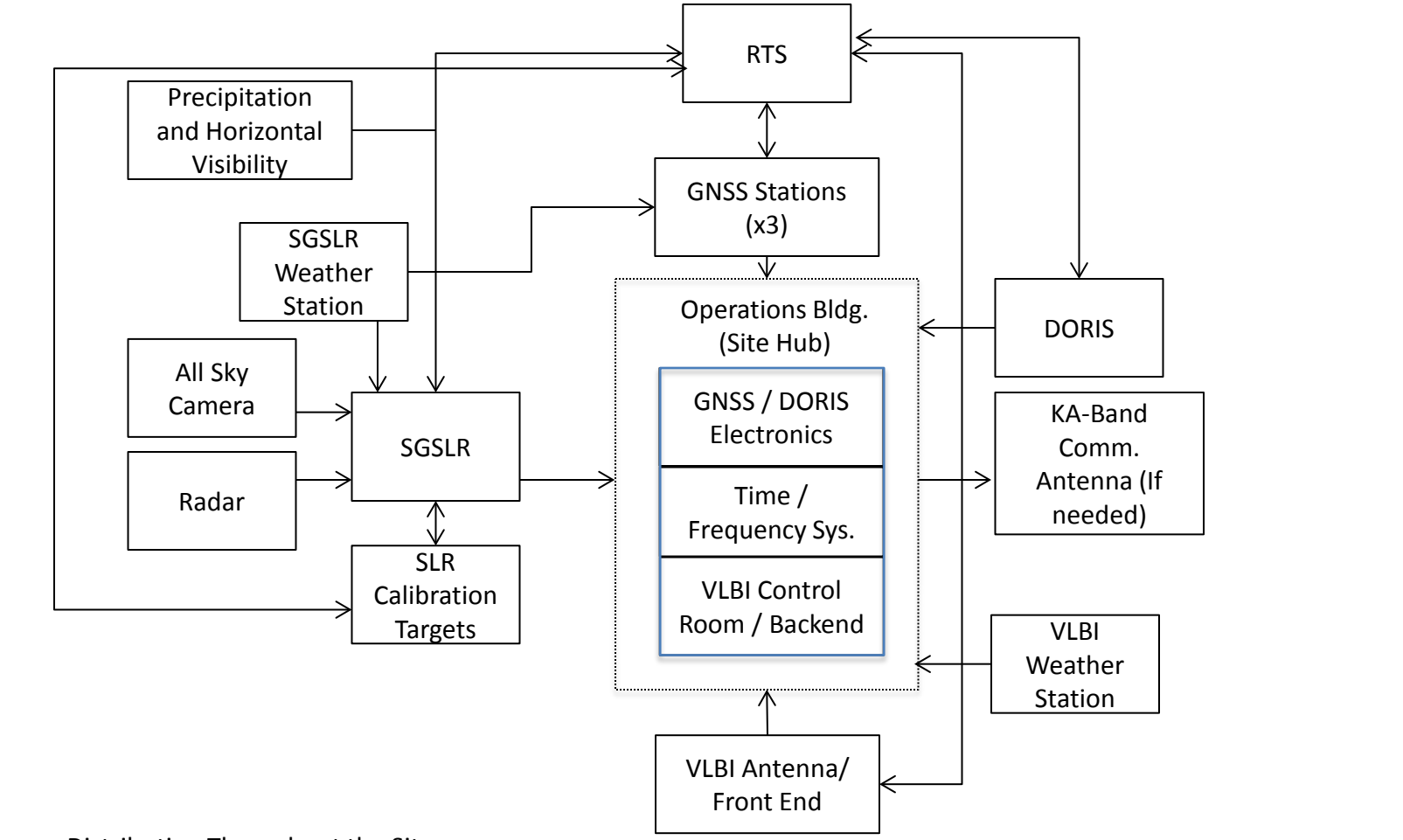
Site Preparation - *Technical*

- Site Preparation Activities
  - Site visit and prepare detailed engineering requirements report
  - Soil borings and geotechnical report
  - Perform detailed topographic survey
  - Civil design / prepare construction documents
  - Competitive bids / award construction contract
  - Construction activities
  - Site occupancy review and acceptance

Site Preparation - *Programmatic*

- US Sites
  - National Environmental Protection Agency (NEPA) requirements
    - Environmental Assessment
    - Sediment & Erosion Control / Storm water Management
  - Site ownership and required agreements
  - Status
- International Sites with NASA participation require:
  - Approved agency-to-agency agreement(s)
  - Initial site assessment
  - Compliance with US Executive Order 12114 - Environmental effects abroad of major Federal actions, http://www.archives.gov/federal-register/codification/executive-order/12114.html

Site Block Diagram



Site Infrastructure

Item	Description / Infrastructure	Qty	Unit *
	GENERAL SITE WORK		
1	Security Fence	4000	LF
2	Access road, asphalt, 1000' x 20'	2222	SY
3	Site Road, asphalt, 1000' x 18'	2000	SY
4	HV Overhead Power & Xfmr	1	LS
5	Underground Power on Site	1000	LF
6	Underground Communications Duct	1500	LF
7	Water Distribution on site	300	LF
8	Septic Tank and Drain Field	1	LS
9	Operations Building, 25' x 40'	1000	SF
	VGOS VLBI Site		
1	Earthwork	1	LS
2	Antenna Foundation, 26'x 26' x5'	126	CY
3	Reflector assembly area, access area	5000	SY
4	Power & 480V - 208/120 V Xfmr	1	LS
5	Grounding & lightning Protecion	1	LS
6	Electronics Shelter, 12' x 20'	240	SF
7	Underground conduit	100	LF
	SGSLR Site		
1	Foundation & Pillar for Telescope	4	CY
2	Concrete Pad for Shelter 12’ x 16’ x 1’	7	CY
3	Power 208/120V, 3-ph, 60 Hz, 100 Amp	1	LS
4	Grounding & Lightning protection	1	LS
5	Underground conduit	50	LF

* LF = Lineal Feet; SY = Square Yard; LS = Lump Sum (meaning “a good guess”); SF = Square Foot; CY = Cubic Yard

Site Facilities

Facility	Location
Office space (500 sq. ft. or ½ Ops Bldg.)	Operations Bldg.
Lab/engineering space (500 sq. ft. or ½ Ops Bldg.)	Operations Bldg.
Storage space	Operations Bldg.
Communications (telephone, Internet/LAN)	Site level
Bathroom/kitchen/rest areas	Operations Bldg.
Environmental control (localized)	Site/station level
Backup power/communications system	Site level
Site/station security system	Site/station level
Personal protection system	Site level

Electrical Power Supply Requirements

- Assume Site nominal Voltage 240V, frequency 50-60Hz.
- Power conversion carried out at the individual Stations, unless noted otherwise. Approximate total power needs follow.
- GNSS ~ 1.2kW
- VLBI ~ 31kW
- DORIS ~ 900W
- SGSLR ~ 12.0 to 20.8kW

DRAFT

Core Site Optional Instrumentation

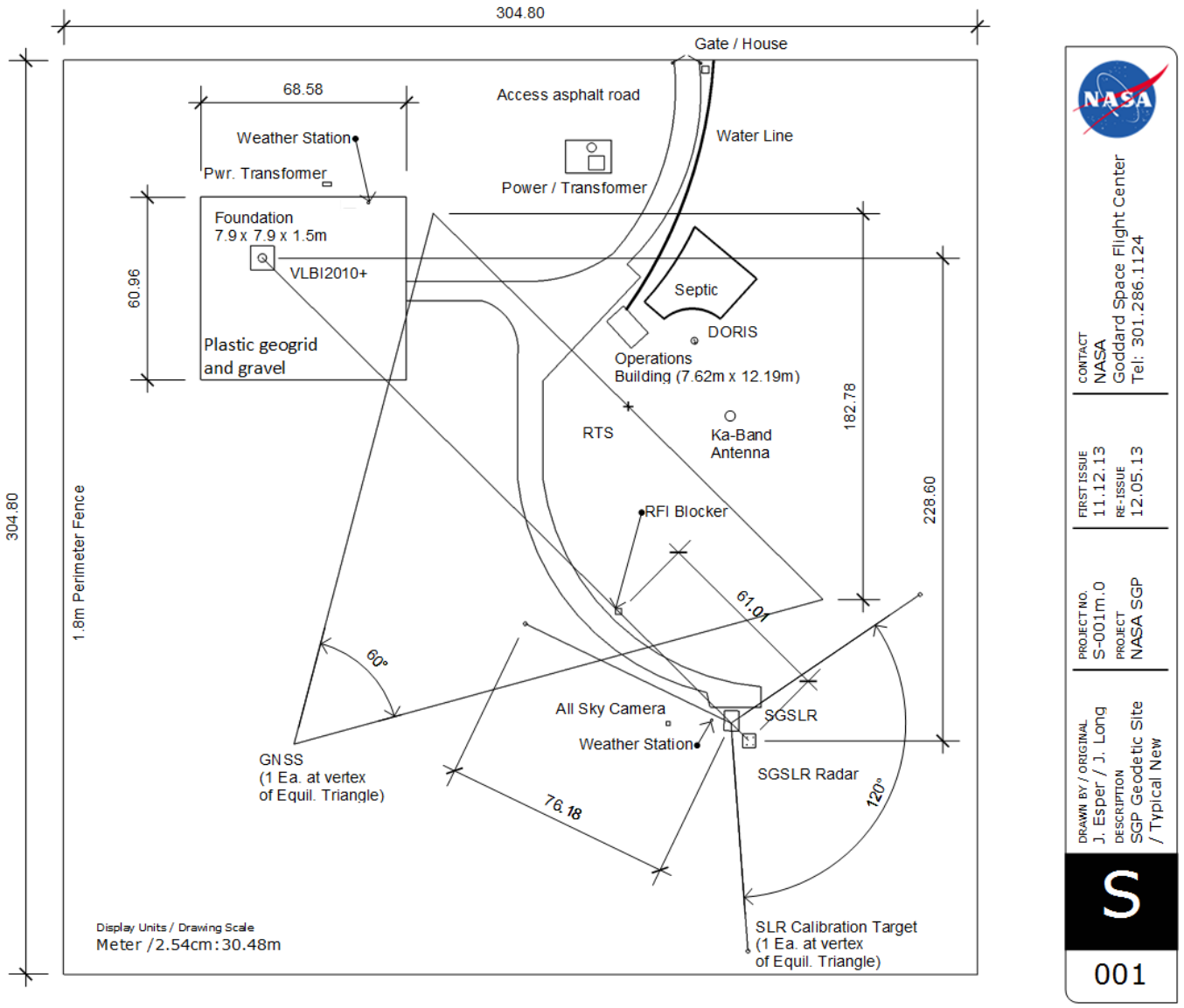
- This equipment list covers components that would *enhance* the applicability of SGP Sites in support of NASA science.
- They are *not considered essential* to the operation of the core geodetic techniques.

External Measurement Systems		
	Tilt meters	Site level
	Seismometer	Site level
	Water vapor radiometer	Site level
	Gravimeter	Site level

Typical Site Layout: Guidelines and Assumptions

- Overall dimensions are 1000’ x 1000’
  - A controlling dimension is the separation of VLBI antenna and SGSLR radar at 750’
  - Buffer zone of ~200’ between SG instruments and the fence line.
- Layout offers strong geometry for inter-comparison surveys and TRF orientation
  - The four space geodesy techniques form a quad figure of ~500’ per side
  - The three GNSS form an equilateral triangle ~600’ per side
- RTS is near center of site and close to Ops. Bldg. (Site Hub) to minimize cable lengths
- DORIS is near Ops. Bldg. to keep cable lengths short, and located to block line-of – sight to VLBI
- SGLSR has three calibration targets 120 degrees apart at a distance of 250’
- Ops. Bldg. is centrally located: dimensions: 25’ x 40’
- GNSS receivers are located in OPS Bldg.
- VLBI site has an level assembly area constructed of plastic geogrid and gravel; 200’ x 225’
  - Pre-fabricated shelter for backend electronics to keep cable length reasonable (~120 feet)
  - Antenna foundation is 26’ x 26’ x 5’thick
  - Data transmission from antenna to electronics and to the Ops building via fiber optic lines.
- Accommodation for septic system, water line, and external power conversion
- Accommodation for 3-meter Ka-band antenna for remote Site installations.
  - Connected to Ops building via fiber optic lines.

Site Layout Drawing



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DRAWN BY / ORIGINAL
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DESCRIPTION
SGP Geodetic Site
/ Typical New

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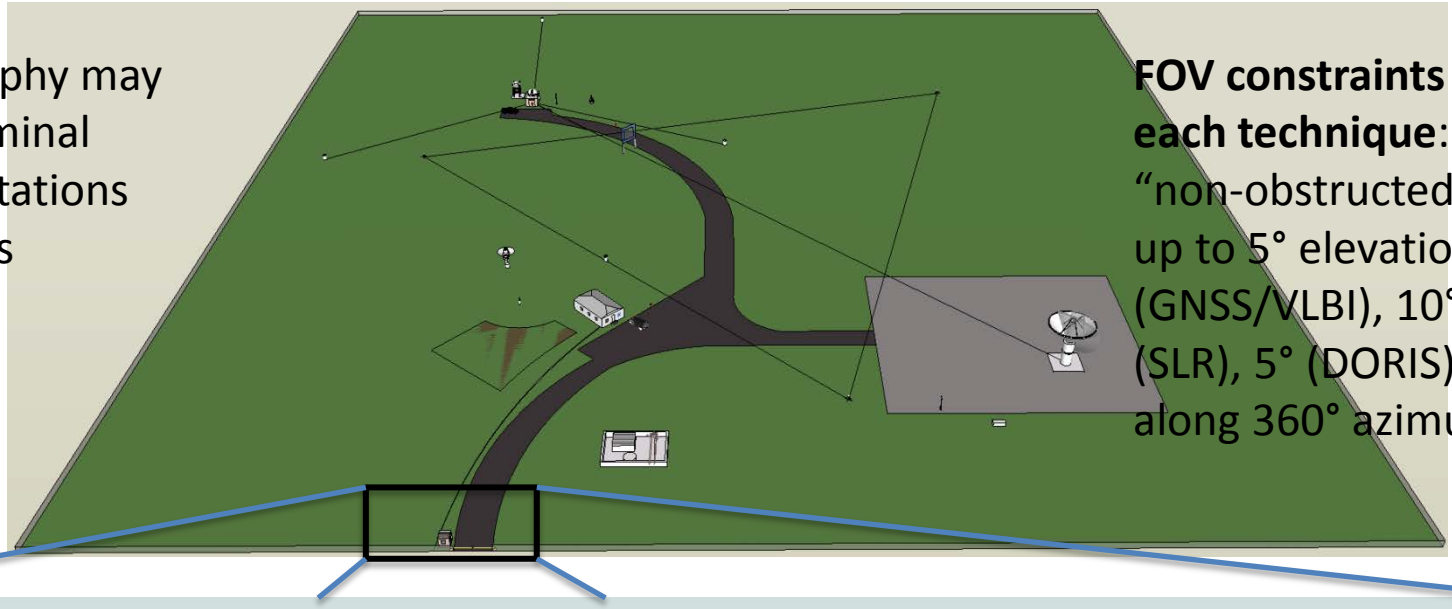
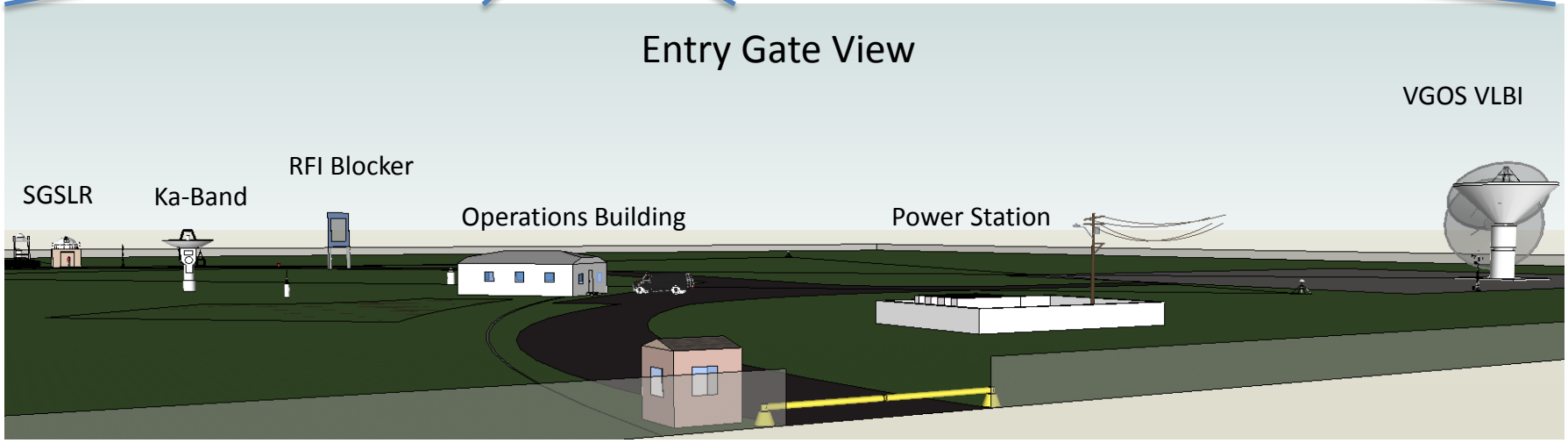
3D Model – Flat Terrain

Local geography may alter the nominal location of Stations and buildings



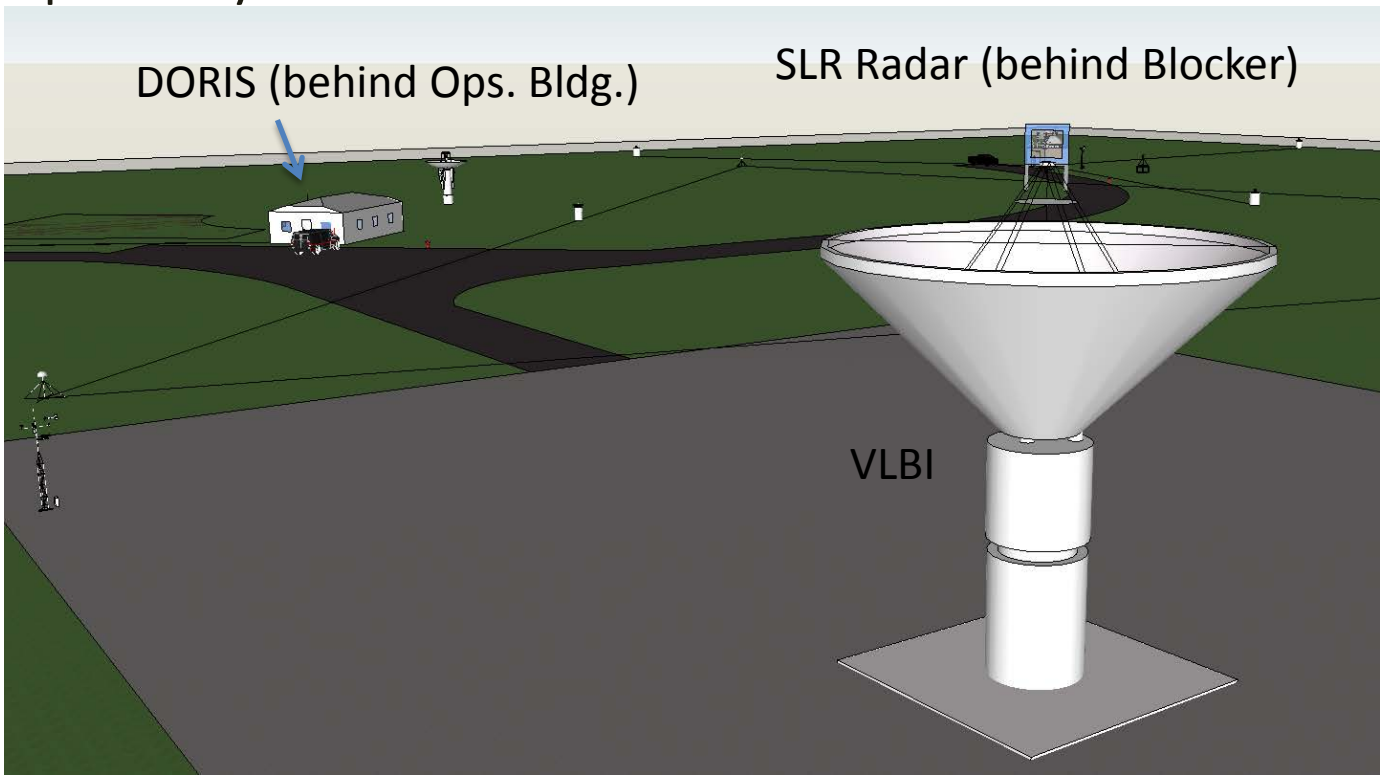
FOV constraints for each technique: "non-obstructed view up to 5° elevation (GNSS/VLBI), 10° (SLR), 5° (DORIS), along 360° azimuth".

Entry Gate View

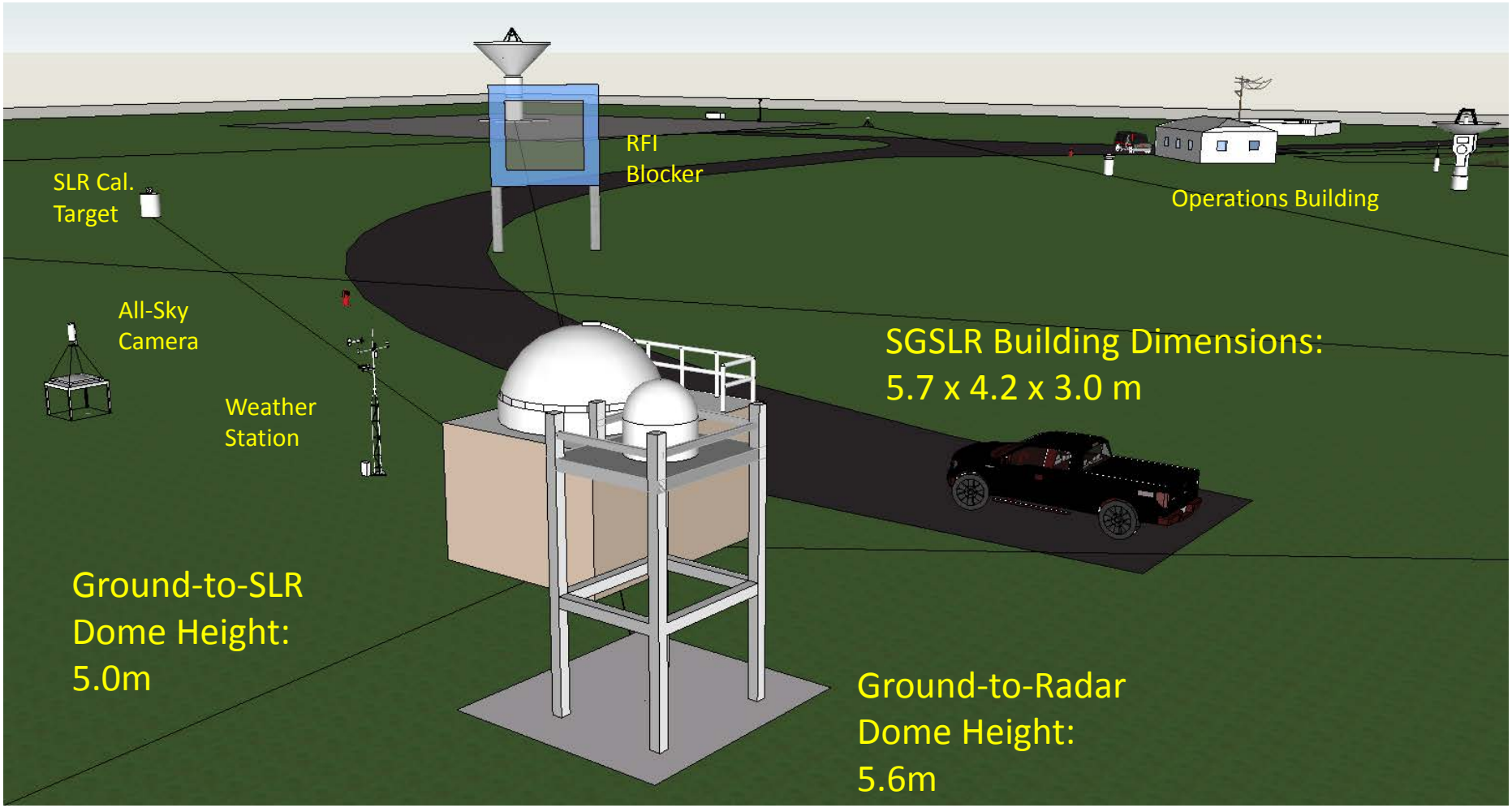


View from VLBI

- Most sensitive to Radio Frequency Interference (RFI).
- Sources: (1) SLR Radar; (2) DORIS Beacon; (3) Local Broadcasts (variable, sometimes unpredictable)
  - SLR Radar and DORIS are located behind SLR and Ops. Buildings, respectively.

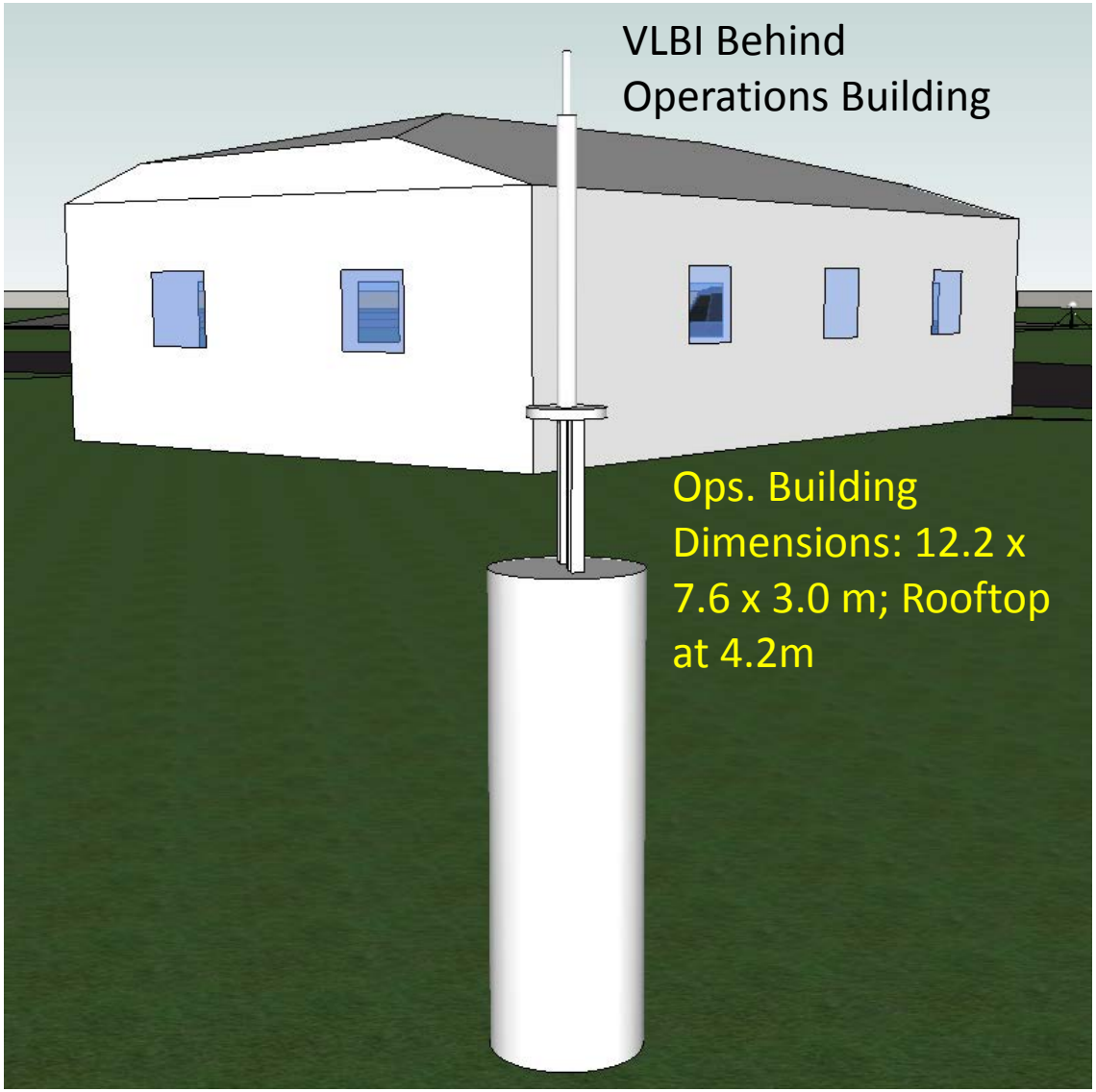


View from Space Geodesy SLR (SGSLR)

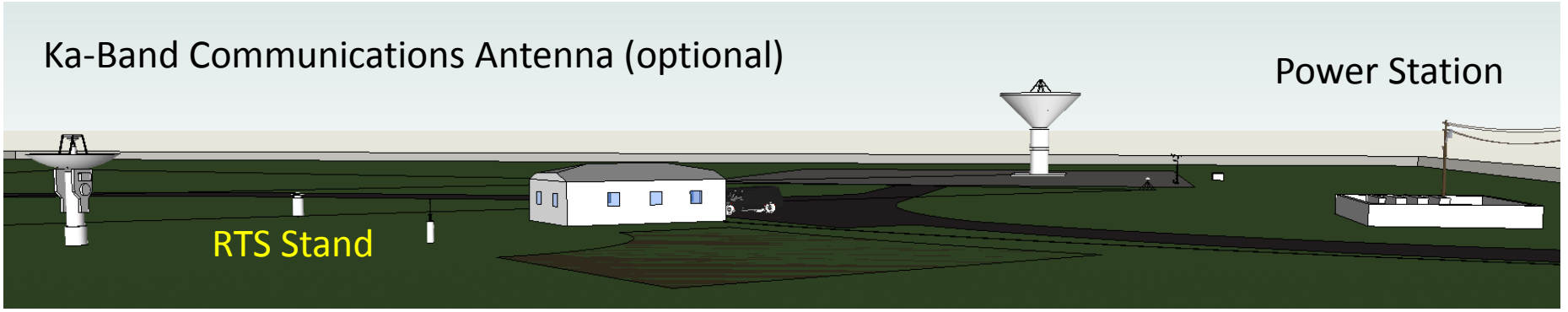


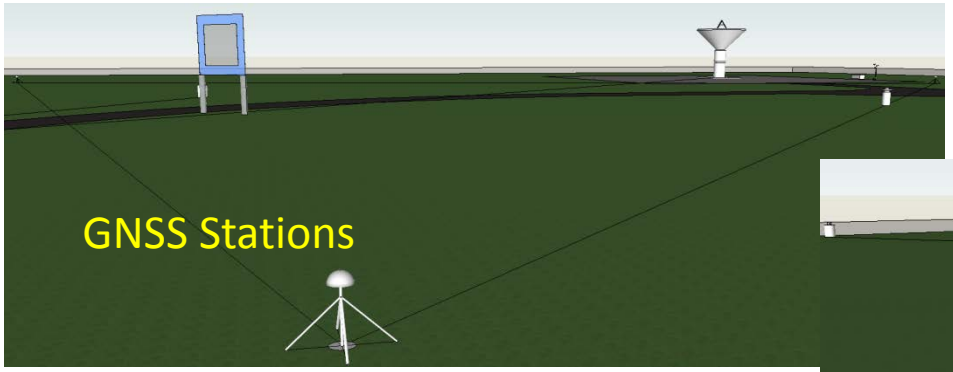
Approximate building dimensions shown

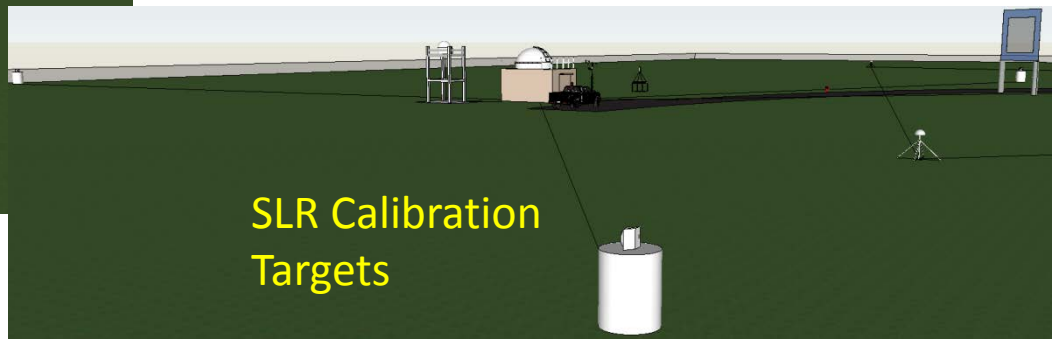
View from DORIS Beacon



Various Perspectives

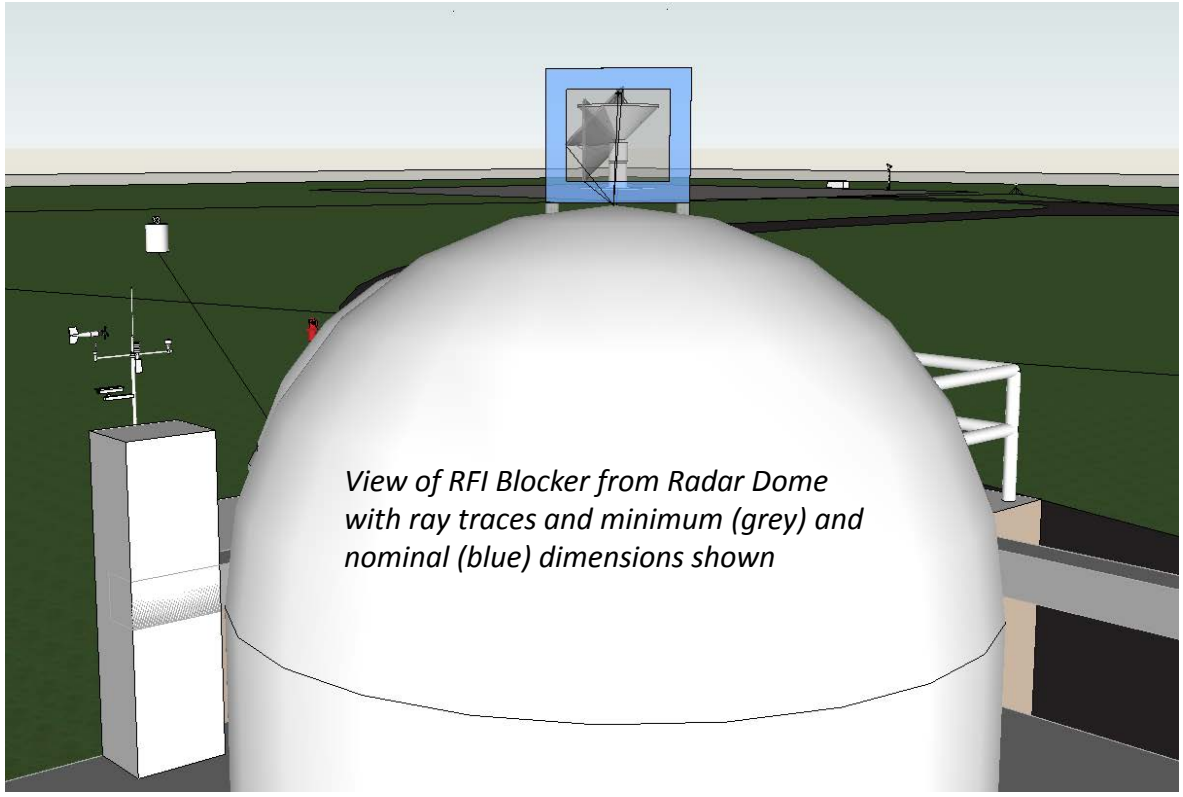




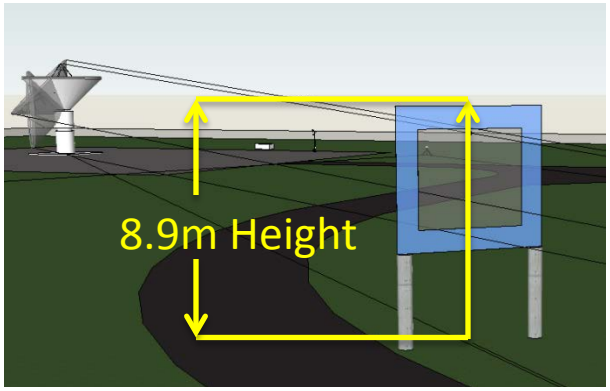


RFI Blocker – SLR Radar

- Minimum distance from SLR Radar 61m
- Dimensions 4.2m x 3.7m min; 5.9m x 5.4m nominal (includes a 20% linear size margin)
- RFI noise << -80 dBW at VLBI antenna location
- Mesh material (~79% open) to minimize wind-loading (e.g. http://www.twpinc.com/wire-mesh/TWPCAT_11/p_100X100T0011W48T)



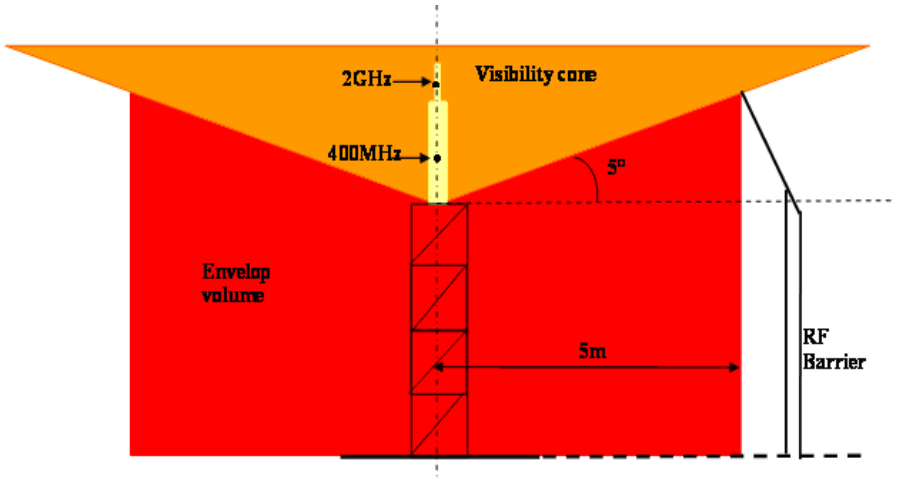
View of RFI Blocker from Radar Dome with ray traces and minimum (grey) and nominal (blue) dimensions shown



RFI Blocker size takes into consideration full range of motion of VLBI antenna, and distance to SLR radar. Its centerline is located along the Radar-VLBI baseline.

DORIS Beacon Barrier

- DORIS barrier must be considered for two frequencies; 2GHz and 400MHz.
- Barriers modeled for 6 degrees in azimuth and elevation



- The requirements are :
  - No metallic object must be located within the envelope volume (except for the DORIS antenna nominal support).
  - Nothing must stand within the visibility cone, apart from the antenna itself.
- This implies :
  - the barrier should be placed at 5m from the antenna and
  - the barrier should raise a height that does not exceed the limit of the visibility cone
  - rem. : a derogation could be made to take a value slightly higher for the visibility cone (between 5 and 8°)