SGSLR acquisition and tracking automation

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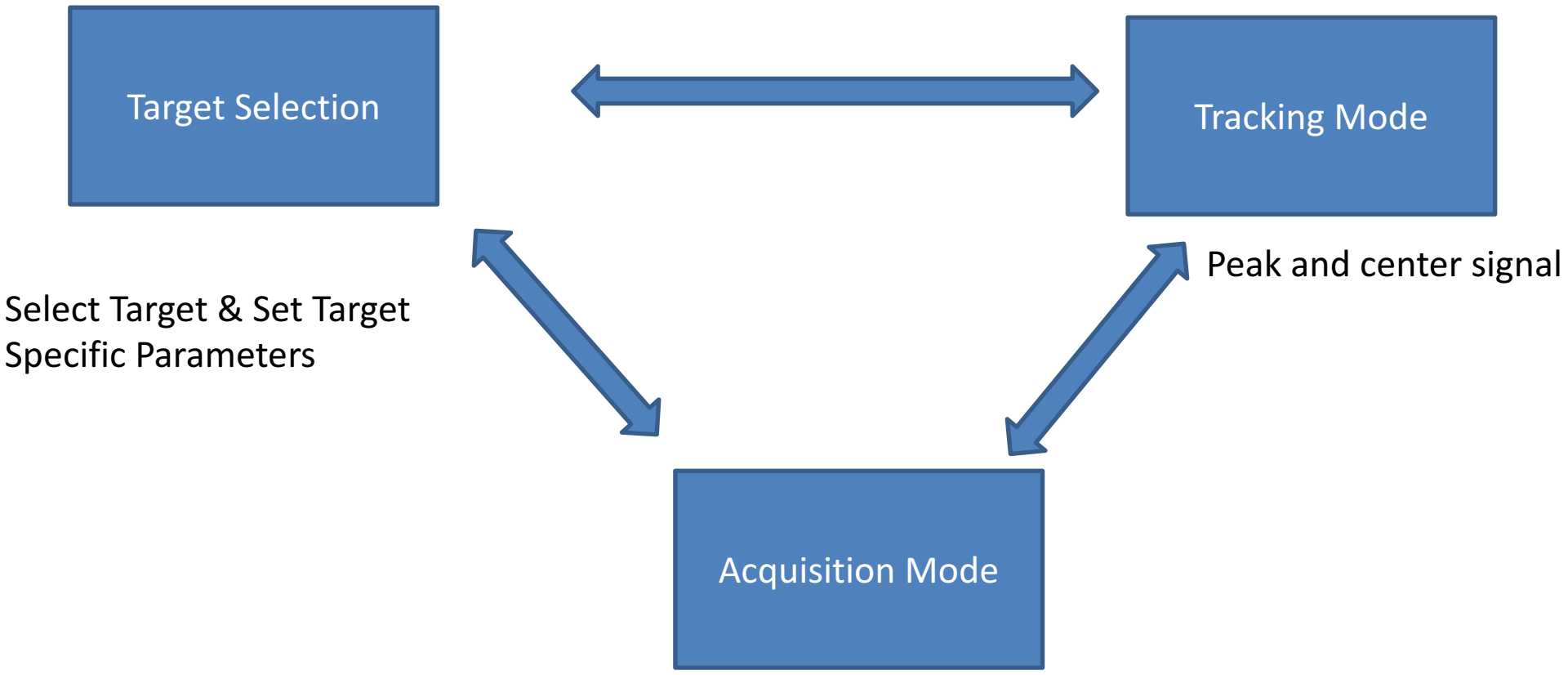
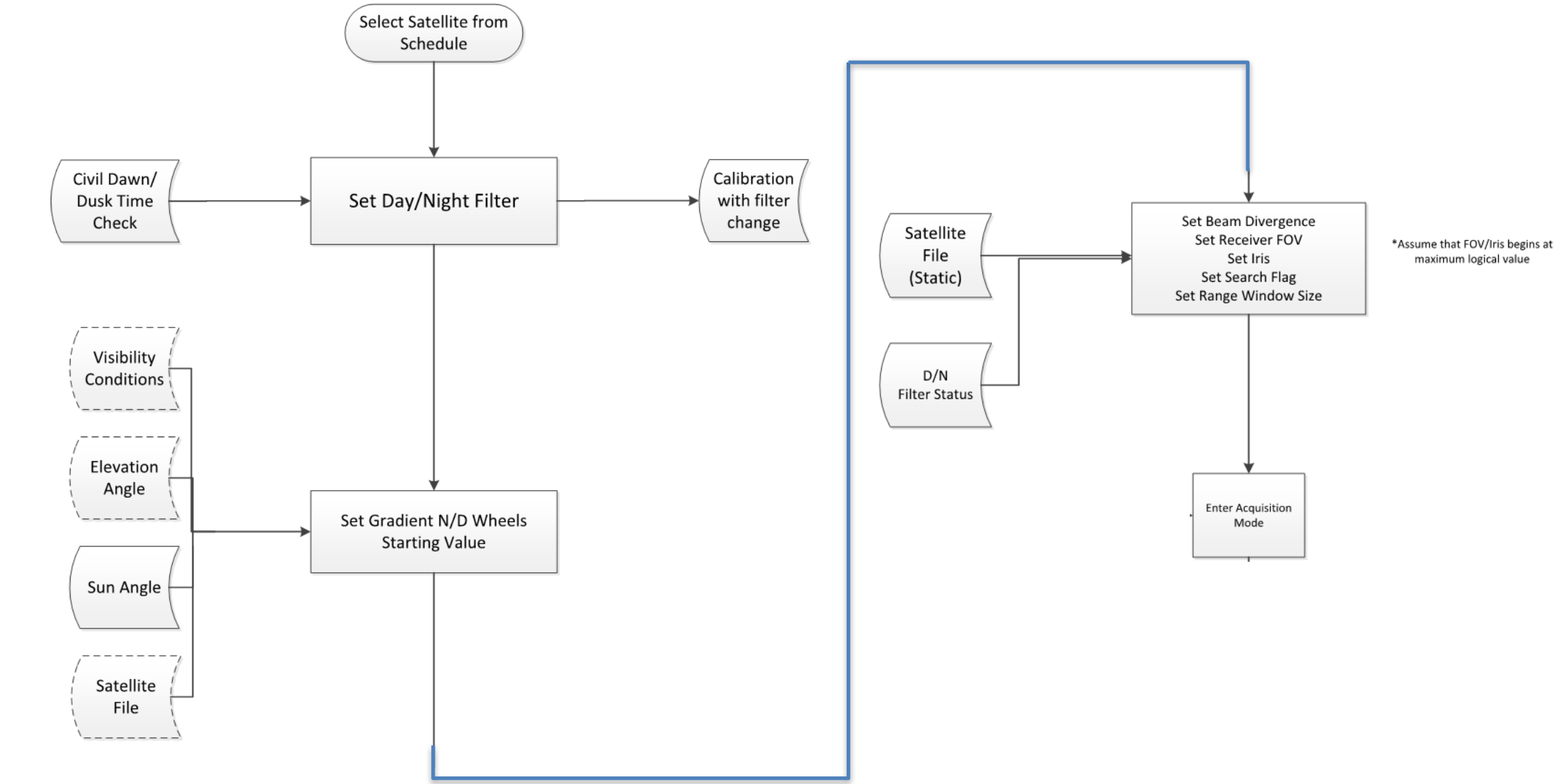
Acquisition and Tracking Loop



Target Selection

- Select a target based on evolving target priority/availability
- For SGSLR, these parameters are target specific
  - Beam Divergence
  - Receiver FOV (changes based on previous tracking success/failure)
  - Range Window
  - Search flag

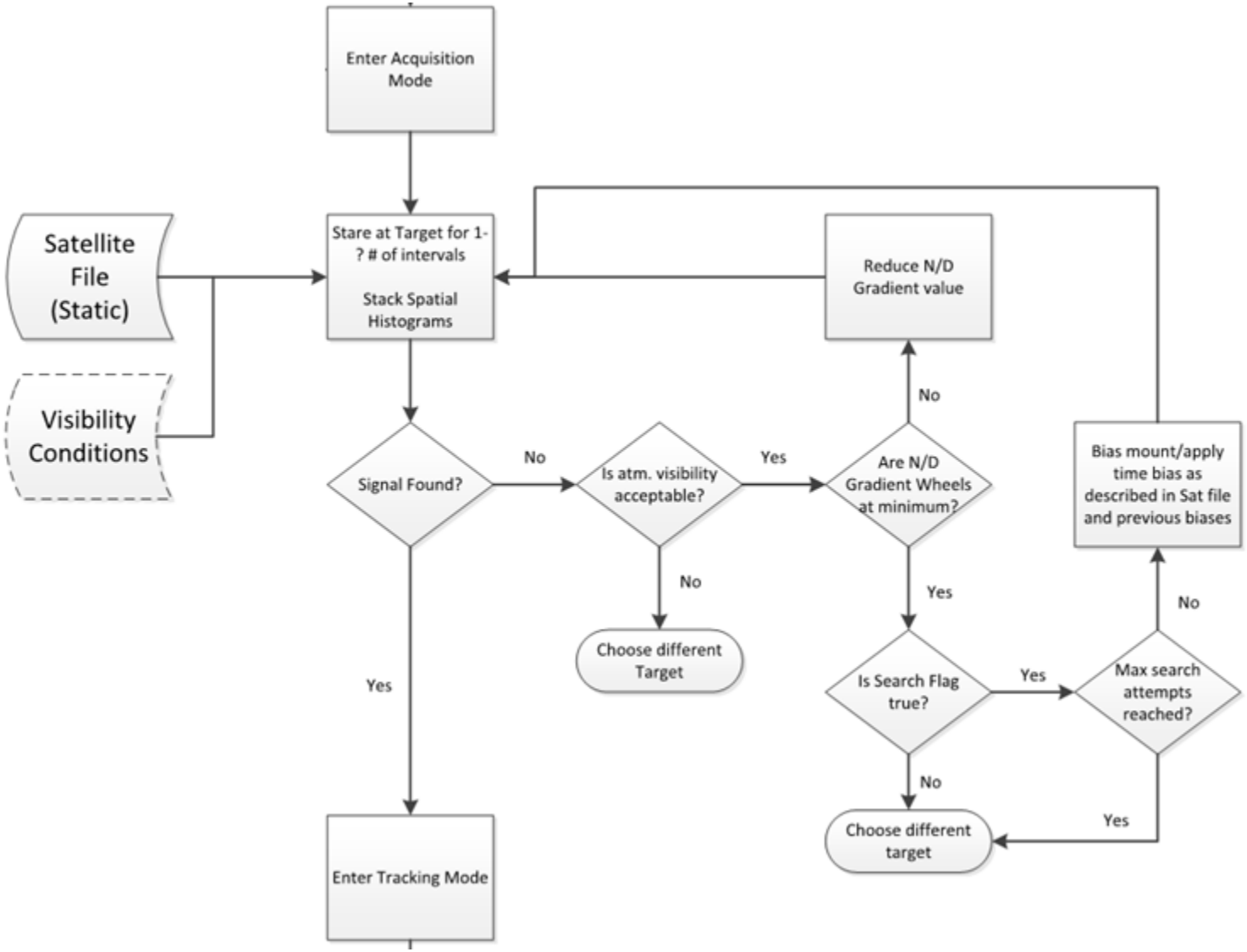
Target Selection



Acquisition Mode

- Recognizing Signal vs Noise
- Do we see immediately?
- Determine if it's worth searching
  - Weather/ Visibility
- Search if no signal is found
  - Are we allowing maximum signal through the receive path?
  - Bias mount/apply time bias (value determined by satellite and previous recorded biases
- When to say "when"

Acquisition Mode



Distinguishing Signal from Noise

- 3-sigma detection
- Receiver FOV encompasses 49 pixels

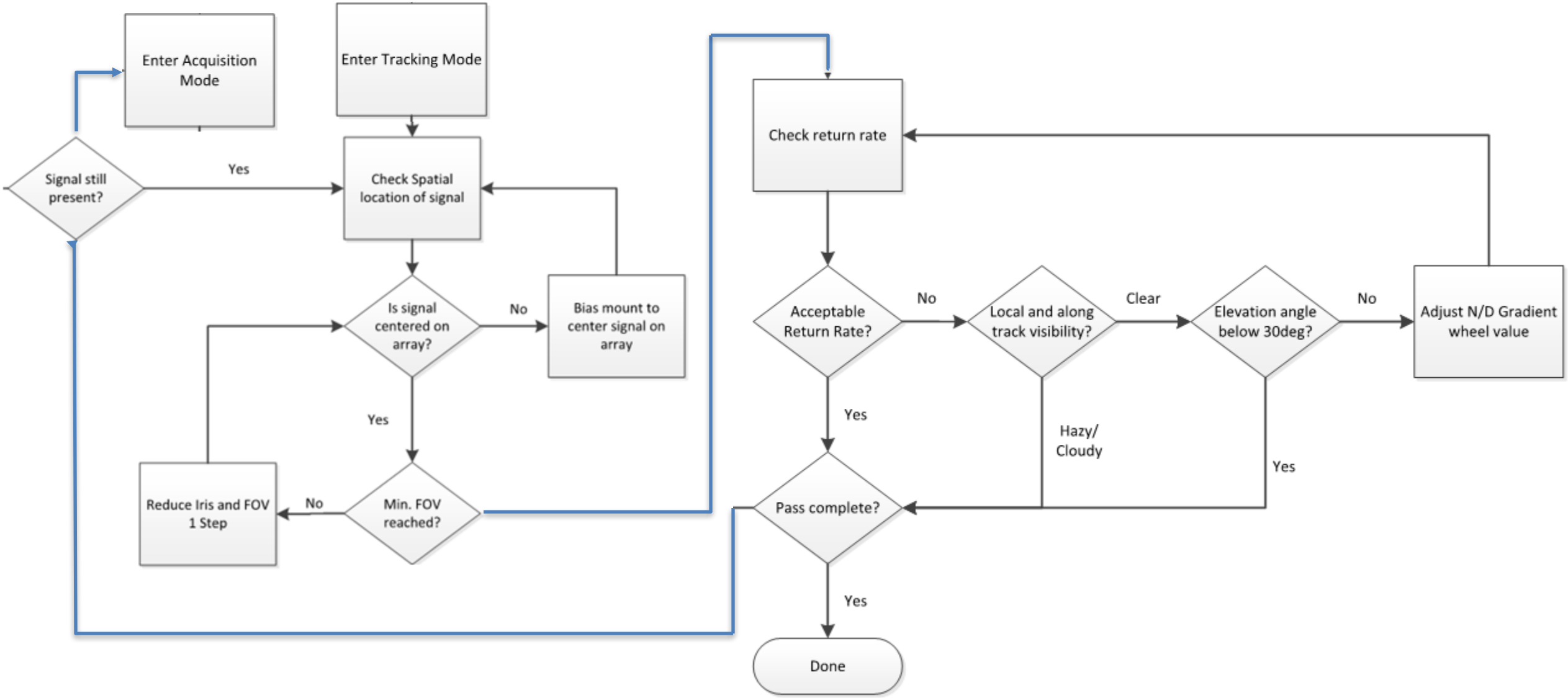
Characteristics	SGSLR value
Per pulse laser energy transmitted	1.5 mJ
Optical throughput: transmit	0.78
Optical throughput: receive	0.54
Satellite retro-reflector response	Variable
Cirrus cloud contribution	Medium
Diameter of telescope	0.5 meters
Detector counting efficiency	0.28
Maximum Solar Noise	15 MHz

Satellite & elevation	Expected pes/fire	Seconds needed to stare in order to find signal
Starlette at 10^o	> 0.1	< 1 second
Starlette at 20^o	> 0.9	< 1 second
LAGEOS at 10^o	> 0.009	< 40 seconds
LAGEOS at 20^o	> 0.1	< 1 second
GNSS at 20^o	> 0.007	< 62 seconds
GNSS at 25^o	> 0.015	< 14 seconds
GNSS at 30^o	> 0.02	< 8 seconds

Tracking Mode

- Can’t see signal for X seconds? Drop back to acquisition mode
- Center signal on the SPAD array via mount biases
- Reduce FOV resolution and close down IRIS
- Center signal in range window and reduce width
- Rinse and repeat until a determined minimum is reached
- Assure Single photon mode
  - Check the weather and elevation so that we are not chasing our tail
  - If clear and above X degrees, adjust ND wheels to get an acceptable return rate

Tracking Mode

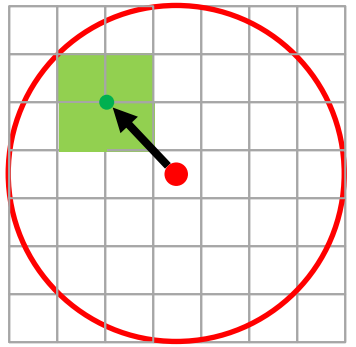


The Observers

Weather Conditions
MET
Horizontal Visibility and Precipitation Sensor
Cloud Camera

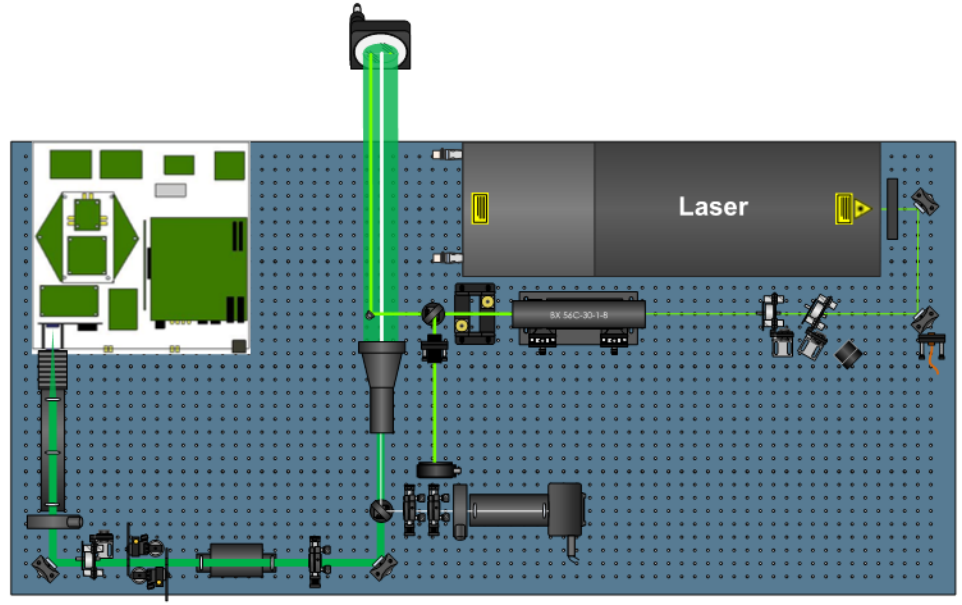
Spatial	Range
SPAD Array	14 asec total / 2 asec per pixel – 60 asec total / 8.6 asec per pixel

Temporal	Range
Event Timer	15 ps resolution



The Controllers

Control	Range/Value
ND Wheels	0-4 OD
Variable Beam Expander	6-30 arcseconds
Mount pointing	1 arcsecond
Spectral Filter	In – 80% Transmission
Receiver FOV	14-40 arcseconds
Receiver FOV Iris	14-40 arcseconds
Risley Prisms	0-60 arcseconds
Range Window	100 ns – 10 us



Spatial and Temporal Histogramming

- Spatial
  - Requires multi-element detector to resolve angular space
  - SGSLR will have a 7x7 SPAD array
- Temporal
  - Requires event timer with sufficient stability and resolution
- Combining Spatial histogramming with coarse temporal histogramming reduces false positives significantly

Spatial and Temporal Histogramming

30% noise rate, no signal

Method of Signal Detection	Valid signal detections (%)	False Positive Signal Detections (%)
3σ detection	0 (0 %)	245 (14.56 %)
3σ detection + temporal validation	0 (0 %)	1 (0.05 %)

50% noise rate, 0.65 % signal rate

Method of Signal Detection	Valid signal detections (%)	False Positive Signal Detections (%)
3σ detection	648 (37.80 %)	131 (7.64 %)
3σ detection + temporal validation	635 (36.93 %)	0 (0.0 %)

50% noise rate, 1% signal rate

Method of Signal Detection	Valid signal detections (%)	False Positive Signal Detections (%)
3σ detection	1438 (83.90 %)	34 (1.98 %)
3σ detection + temporal validation	1438 (83.90 %)	0 (0.0 %)

Noise rate varied 25-75% (33 second period), signal rate varied 0.3-1 % (50 second period)

Method of Signal Detection	Valid signal detections (%)	False Positive Signal Detections (%)
3σ detection	750 (43.76 %)	108 (6.30 %)
3σ detection + temporal validation	747 (43.58 %)	0 (0.0 %)