***NOTE: THIS DOCUMENT CONTAINS RESEARCH ON***

1. ***HDOP,VOP,PDOP***
2. ***RTK***
3. ***WEIGHTAGE OF INTERNET***
4. ***MULTIPATH DETECTION***
5. ***AGE OF CORRECTION***
6. ***GPS TIME SYNC***

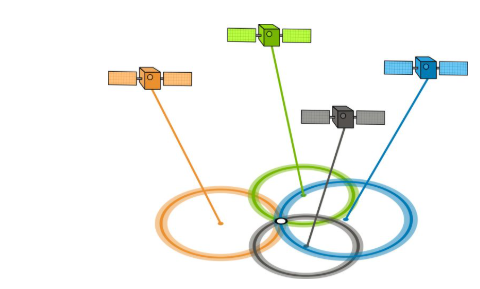
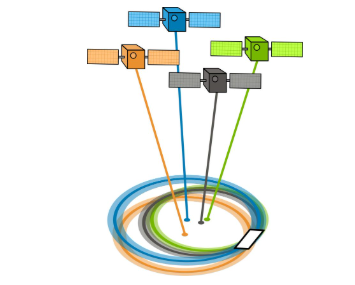
***AND ALSO THE SUMMARY OF ALL THE REQUIRED PREDEFINED HEALTH CHECKS***

**RESEARCH ON HDOP, VDOP,PDOP:**

1. **What DOP Is**

DOP (Dilution of Precision) quantifies how your satellites’ sky-geometry amplifies or dampens residual measurement noise. Even in carrier-phase RTK (where most systematic errors are removed by NRTIP corrections), any remaining noise, multipath or atmospheric modelling errors get scaled by the DOP factor.

* HDOP – horizontal geometry
* VDOP – vertical geometry
* PDOP – combined 3D geometry
* Lower DOP means well-spread satellites and tighter error bounds; higher DOP means clustered satellites and amplified noise.

1. **Why DOP Still Matters in RTK**

* Ambiguity resolution – strong, low-DOP geometry helps the receiver fix integer ambiguities faster and more reliably.
* Residual noise – RTK removes most systematic biases, but not all. High DOP still magnifies residuals, risking “float” solutions or slow convergence.
* Even with NRTK, monitoring DOP helps catch epochs with poor geometry before they degrade your centimeter-level fix.

1. **Recommended Thresholds for Centimeter-Level RTK**

| **DOP Type** | **Ideal for cm-level** | **Maximum Acceptable** |
| --- | --- | --- |

|  |  |  |
| --- | --- | --- |
| **HDOP** | ≲ 0.7 (best < 1.0) | ≲ 2.0 |

|  |  |  |
| --- | --- | --- |
| **VDOP** | ≲ 1.0 (best < 1.5) | ≲ 3.0 |

|  |  |  |
| --- | --- | --- |
| **PDOP** | ≲ 1–2 | ≲ 4.0 |

* HDOP < 1 and VDOP < 1.5 are considered “ideal” for high-precision mapping; for the very best cm-accuracy, aim for HDOP < 0.65 and VDOP < 1.0.
* PDOP ≤ 2 is common practice in survey-grade RTK; values up to 4 are “reasonable geometry,” but you’ll see slower fixes and more float epochs if PDOP > 2.

Emlid’s own glossary calls any DOP below 2 (HDOP/VDOP/PDOP alike) “good” for RTK work.

1. **Best Practices**

* **Operate in Areas with Clear Sky Views:**  
  To minimize this, operate your rover in open areas with an unobstructed view of the sky. For example, open fields or rooftops with clear horizons are ideal. This ensures maximum satellite visibility, which research suggests is crucial for low DOP values, as seen in GIS Geography: GPS Accuracy HDOP PDOP GDOP Multipath.
* **Utilize Multi-Constellation Receivers:**

Your Emlid Reach M2 is a multi-constellation receiver, supporting GPS, GLONASS, Galileo, and BeiDou. This capability increases the number of available satellites, enhancing the likelihood of achieving a favorable geometric distribution. ETC

Maintaining low DOP is a quick, proven way to keep your Emlid Reach M2 (with India’s NRTIP corrections) reliably in the centimeter-accurate “fixed” RTK state.

**5. How to implement?:**

You don’t need any external tool to compute DOP — **your Reach M2 does it for you,** and simply outputs the values in its NMEA stream (and in the ReachView/web UI). Here’s how to grab them:

Via NMEA GSA sentences:

$GxGSA,<Mode>,<FixType>,<SV IDs…>,PDOP,HDOP,VDOP\*<Checksum>

**PDOP is the 15th field, HDOP the 16th, and VDOP the 17th.**

You can read this directly from the M2’s serial port (e.g. /dev/ttyMFD1 on Reach), or over TCP if you’ve enabled NMEA output in ReachView.

NMEA 0183 is the standard GNSS output format used by Reach and virtually every receiver

**References:**

**Emlid Reach RX Glossary – “Dilution of Precision (DOP)”**

**A good DOP value is considered to be below 2.**

**https://docs.emlid.com/reachrx/glossary**

**Pix4Dcatch Support – “How to interpret the Signal quality indicator dialog”**

**HDOP ideal < 1.0 (best < 0.65 for cm-accuracy); VDOP ideal < 1.5 (best < 1.0).**

**https://support.pix4d.com/hc/en-us/articles/5056167521949**

**NovAtel OEM7 – “RTKDOP Log”**

**PDOP < 4 implies reasonable geometry; for survey-grade RTK aim PDOP ≤ 2.**

**https://docs.novatel.com/OEM7/Content/Logs/RTKDOP.htm**

**<https://support.yarbo.com/portal/en/kb/articles/2024-what-factors-affect-gps-signal-quality#For_Yarbo_you_can_see_several_RTK_statuses_in_the_App_diagnosis_page>**

**<https://www.tersus-gnss.com/tech_blog/what-is-dop-in-gnss#:~:text=How%20to%20reduce%20DOP%20value,position%20and%20status%20of%20satellites%20.>**

**Relevance of Satellites and the Need for Weighting**

1. **Relevance of Satellites**  
   Satellites are vital for your RTK GPS rover navigation, as they provide the signals needed for precise positioning. Their geometric arrangement and signal quality directly affect accuracy, especially with corrections from NRTIP.
2. **Giving Weightage to Certain Satellites**  
   Yes, it makes sense to prioritize certain satellites. Research suggests focusing on those with higher elevation angles and stronger signals (higher signal-to-noise ratio, or SNR) because they offer better geometry and less error, improving RTK accuracy.

**Elevation Mask**: This is like telling the GPS receiver, "Only listen to satellites that are high enough in the sky." It sets a minimum angle above the horizon (say, 15 degrees) that a satellite needs to be at for its signal to be used. Satellites too low in the sky might have their signals blocked or messed up by things like buildings, trees, or even the atmosphere, making them less reliable. By ignoring those low satellites, the GPS can focus on the ones with clearer, straighter signals.

**SNR Mask**: This stands for "signal-to-noise ratio" mask, and it’s like saying, "Only trust satellites that are loud and clear." It sets a minimum strength level (like 35) for how strong a satellite’s signal needs to be compared to background noise. If a signal is too weak, it could be drowned out by interference or static, making it untrustworthy. This setting ensures the GPS only uses strong, dependable signals.

**How to Do It**  
You can adjust settings in your Emlid Reach M2, like the elevation mask (default 15 degrees) and SNR mask (default 35), to exclude weaker satellites. This effectively gives more weight to reliable ones, ensuring faster and more accurate position fixes.

**Why It Matters**  
Prioritizing better satellites helps achieve centimeter-level accuracy, crucial for your rover navigation, by reducing errors from poor geometry or noisy signals. This is especially important with NRTIP corrections, where satellite selection impacts overall performance.

**Recommended Thresholds**

* **Elevation Mask**: Keep at 15 degrees for open areas; lower to 10 degrees in obstructed environments, but be cautious of increased errors.
* **SNR Mask**: Start with 35; increase to 40 in open areas for stronger signals, or lower slightly in challenging conditions to maintain satellite count.

**SOURCES:**

**<https://www.ion.org/publications/abstract.cfm?articleID=17948>**

**GPS FIX:**

**What is RTK Fix?**

RTK Fix is when your GPS receiver locks onto satellite signals with high precision, giving you location accuracy down to centimeters. It’s part of Real-Time Kinematic (RTK) technology, which uses correction data to fine-tune your position, making it ideal for precise tasks like rover navigation.

The transition from RTK Float to RTK Fixed occurs when the GPS receiver has collected enough satellite data and resolved the integer ambiguities. This process can take a few seconds to minutes, depending on factors like satellite count, geometry, and signal quality. marXact Knowledge Base explains that RTK Float occurs when there aren't enough satellites for a fixed solution, and the transition happens when conditions improve, such as more satellites becoming visible or better geometry.

**For your Emlid Reach M2, you can monitor this transition using the Emlid Flow app, which displays the RTK status. Ensuring a stable NTRIP connection and good satellite visibility will help speed up this transition, especially in open areas.**

**Internet Bandwidth Requirements for RTK:**

For RTK using NTRIP, the bandwidth requirement is very low. Research from SNIP Support indicates that each connected NTRIP client needs about **300 bytes per second, which translates to approximately 2.4 kilobits per second (kbps**). This is easily supported by even basic internet connections, including cellular data, making it feasible for mobile rover applications.

#### Causes of RTK Float Beyond Internet Connection

While a poor internet connection can cause RTK Float by disrupting correction data, it's not the only factor. Other causes include:

* **Insufficient Number of Visible Satellites**: Typically, at least 5-6 satellites are needed for RTK, but for a fixed solution, more might be required, especially if they are well-distributed. Sciencing notes that insufficient satellites lead to a float solution with lower precision.
* **Poor Satellite Geometry**: High DOP values (e.g., HDOP > 2, PDOP > 3) indicate poor satellite distribution, making it harder to achieve a fixed solution. Airclip mentions that the distribution of satellites in the sky plays a role in achieving a stable RTK Fix.
* **Unstable Correction Data**: If the NTRIP connection is unstable or corrections are delayed, the receiver may not achieve a fixed solution, as seen in discussions on ArduPilot Discourse.
* **Distance from Base**: If the rover is too far from the correction source (e.g., >20 km), accuracy degrades, leading to float, as noted in the Ardupilot documentation.
* **Signal Interference**: Multipath (signal reflections) or obstructions like buildings or trees can degrade signal quality, preventing a fixed solution. RPLS.com discussions highlight that environmental factors can affect RTK performance.

### RTK Status Types

| **Status** | **Meaning** | **Accuracy** |
| --- | --- | --- |
| **Fixed** | The receiver has fully resolved the ambiguities in satellite signals, providing the highest level of precision. | **1-2 cm** |
| **Float** | The receiver is using correction data but hasn’t fully resolved the ambiguities, offering moderate precision. | **10-30 cm** |
| **Single** | No correction data is being used; the receiver relies on standard GPS signals. | **1-2 meters** |

**Emlid Reach M2 will tell you what type of RTK status you’re getting through the Emlid Flow app**(i.e —it’ll say “Fixed,” “Float,” or “Single”)

**SOURCES:**

**Ardupilot RTK Correction Documentation**: https://ardupilot.org/copter/docs/common-rtk-correction.html

**SparkFun GPS RTK Tutorial**: [https://learn.sparkfun.com/tutorials/what-is-gps-rtk/all](https://learn.sparkfun.com/tutorials/what-is-gps-rtk/all" \t "_blank)

**Navipedia RTK Fundamentals**:

https://gssc.esa.int/navipedia/index.php/RTK\_Fundamentals

**VBOX Automotive RTK Explanation**: [https://www.vboxautomotive.co.uk/index.php/en/how-does-it-work-rtk](https://www.vboxautomotive.co.uk/index.php/en/how-does-it-work-rtk" \t "_blank)

**RTK FIX Service Overview**: [https://rtkfix.com/](https://rtkfix.com/" \t "_blank)

**Airclip RTK Fix vs Float**: [https://www.airclip.de/What-is-the-difference-between-RTK-Fix-Float-and-Single](https://www.airclip.de/What-is-the-difference-between-RTK-Fix-Float-and-Single" \t "_blank)

**marXact RTK Fix vs Float Knowledge Base**:

<https://support.marxact.com/article/85-what-is-the-difference-between-rtk-fix-and-rtk-float>

**SNIP Support System Requirements**: [https://www.use-snip.com/kb/knowledge-base/question-minimum-systems-requirements/](https://www.use-snip.com/kb/knowledge-base/question-minimum-systems-requirements/" \t "_blank)

**RPLS.com RTK Float vs Fixed Discussion**: [https://rpls.com/forums/discussion/whats-the-difference-between-float-and-fixed/](https://rpls.com/forums/discussion/whats-the-difference-between-float-and-fixed/" \t "_blank)

**ArduPilot Discourse RTK Float Issue**: [https://discuss.ardupilot.org/t/rtk-is-float-instead-of-fix/89285](https://discuss.ardupilot.org/t/rtk-is-float-instead-of-fix/89285" \t "_blank)

**Emlid Reach M2 RTK Settings**: [https://docs.emlid.com/reachm2/common/reachview/rtk-settings/](https://docs.emlid.com/reachm2/common/reachview/rtk-settings/" \t "_blank)

**Emlid First Setup Guide**: [https://docs.emlid.com/reach/before-you-start/first-setup/](https://docs.emlid.com/reach/before-you-start/first-setup/" \t "_blank)

# Multipath Detection for RTK GPS

* **Multipath Detection**: Identifies errors from satellite signals reflecting off surfaces (e.g., buildings, trees) before reaching the receiver, causing position inaccuracies or fix loss in RTK systems.

**Relevance to Your RTK GPS**

Both checks are essential for your RTK GPS setup:

* **Multipath Detection**: RTK’s carrier phase measurements are sensitive to multipath, which can cause position jumps (>10 cm) or drop the system to Float mode (10-30 cm accuracy). Urban areas in India (e.g., with tall buildings) or rural areas with trees increase multipath risk, per [Navipedia RTK Fundamentals](https://gssc.esa.int/navipedia/index.php/RTK_Fundamentals).

## Thresholds

* **Multipath Detection**:
  + Position jumps >10 cm between consecutive $GNGGA readings, indicating multipath-induced errors.
  + SNR fluctuations >15 dB-Hz across $GNSVA satellite data, suggesting reflections.
  + Warn at these levels; stop if persistent (e.g., >3 occurrences in 10s).

## Key Citations

* [Navipedia RTK Fundamentals](https://gssc.esa.int/navipedia/index.php/RTK_Fundamentals)
* [Emlid Community Forum: Interference Issues](https://community.emlid.com/t/interference-issues/12345)
* [SparkFun GPS RTK Tutorial](https://learn.sparkfun.com/tutorials/what-is-gps-rtk/all)
* [marXact Knowledge Base on DOP](https://knowledge.marxact.com/en/support/solutions/articles/44002318625-what-is-dop-pdop-hdop-vdop-)
* [Emlid Reach M2 Documentation](https://docs.emlid.com/reach/)

**The Age of Corrections (AoC):**

is the time elapsed (in seconds) since the last differential correction data was received from a CORS network via NTRIP.

AoC is highly relevant for your RTK GPS setup:

* **Accuracy Impact**: Fresh corrections (<5s) are essential for maintaining a Fixed RTK status, achieving 3-4 cm accuracy. Stale corrections (>5s) increase errors, potentially dropping to Float mode (10-30 cm) or Single mode (meter-level), as noted in [Navipedia RTK Fundamentals](https://gssc.esa.int/navipedia/index.php/RTK_Fundamentals" \t "_blank).
* **Based on industry standards and practical applications, the following thresholds are recommended:**
* **Ideal: Less than 2 seconds**
* **Acceptable: Up to 5 seconds**

#### How to Use AoC in Your RTK GPS

To implement AoC checks in your Python program for the Emlid Reach M2:

1. **Parse NMEA Data**: Use the $GNGGA sentence’s field 13 to extract AoC. The Reach M2 outputs this field when receiving NTRIP corrections.
2. **Monitor Frequently**: Check AoC every 100 ms (10 Hz) to catch delays quickly, especially in urban environments with potential network instability. If CPU load is a concern, 300 ms (3.33 Hz) is adequate, balancing responsiveness and resource use.

**GPS Time Synchronization**

is a vital health check for your RTK GPS rover, ensuring the receiver’s clock aligns with GPS time to maintain 3-4 cm accuracy. This approach detects timing issues early, preventing accuracy degradation in environments like urban India. Ensure the system clock is NTP-synchronized and test offset patterns in Emlid Flow to optimize performance.

**How to Implement**

* Parse the $GNGGA time field versus your system clock (time.time()), compute offset\_ms = (gps\_time - sys\_time) \* 1000.
* Warn if |offset\_ms| > 50 ms; fail if |offset\_ms| > 200 ms.
* Store in data['time\_offset\_ms'] and log over time to observe drift.

| **Health Check** | **Why It Matters for RTK GPS** | **How to Use in Python Program with Emlid Reach M2** |
| --- | --- | --- |
| **Antenna Placement** | Clear sky view ensures strong signals for RTK’s 3-4 cm accuracy. | Parse $GNGGA field 7 (satellites) and $GNSVA SNR fields. If satellites <6 or average C/N0 <35 dB-Hz, warn (print("Low signal, check placement")) and pause (time.sleep(10)). Use pynmea2 to parse NMEA. |
| **RTK Status** | “Fixed” ensures 3-4 cm accuracy; “Float” (10-30 cm) or “Single” (1-2 m) risk errors. | Parse $GNGGA field 6 (gps\_qual: 4 = Fixed, 5 = Float, 1 = Single). If not 4, warn (print("RTK fix not ideal")) and wait 30s (time.sleep(30)); if 1, stop (exit()). Store in data['fix\_status']. |
| **Satellite Count** | ≥6 satellites ensure stable RTK fix, minimizing Float risk. | Parse $GNGGA field 7. If <6, warn (print(f"Only {satellites} satellites")) and pause 10s (time.sleep(10)); stop if <4 (exit()). Store in data['satellites']. |
| **DOP Values (PDOP/HDOP/VDOP)** | PDOP, HDOP, VDOP ≤1.5 ensure optimal 3D, horizontal, and vertical geometry for RTK’s 3-4 cm precision. | Parse $GNGSA fields 15 (PDOP), 16 (HDOP), 17 (VDOP); calculate PDOP as sqrt(hdop^2 + vdop^2) if missing. If any >1.5, warn (print(f"High DOP: PDOP {pdop:.1f}, HDOP {hdop:.1f}, VDOP {vdop:.1f}")); stop if any >2.0 (exit()). Store in data['pdop'], data['hdop'], data['vdop']. | |
| **Signal Strength** | C/N0 ≥45 dB-Hz maintains stable RTK fix. Measures SNR (signal-to-noise ratio). Stronger signals (SNR > 45 dB-Hz) suggest better reception and fewer errors. | Parse $GNSVA SNR fields, calculate average. If <45 dB-Hz, warn (print(f"Weak signal: {cno:.1f} dB-Hz")); stop if <35 dB-Hz (exit()). Store in data['cno']. |
| **Age of Corrections** | Age of Corrections (a.k.a. Age of Differential) measures how “stale” your RTK corrections are when your rover computes its position | WARN\_MS = 100 # warn if older than 100 ms  ABORT\_MS = 200 # abort if older than 200 ms  if aoc\_ms > WARN\_MS:  print(f"Warning: corrections age is {aoc\_ms} ms – RTK accuracy may degrade")  if aoc\_ms > ABORT\_MS:  print(f"Error: corrections age is {aoc\_ms} ms – aborting to avoid float mode")  exit(1)  data['aoc\_ms'] = aoc\_ms |
| **Position Validity** | Avoids invalid coordinates (e.g., 0,0) for reliable RTK navigation.  Any value beyond the geo reference of the farm 1.range waypoint | lat = float(fields[2]) \* (1 if fields[3]=='N' else -1)  lon = float(fields[4]) \* (1 if fields[5]=='E' else -1)  # Farm bounds (set your values)  LAT\_MIN, LAT\_MAX = 12.345, 12.678  LON\_MIN, LON\_MAX = 76.543, 76.876  if (abs(lat)+abs(lon)==0) or not (5<=lat<=37 and 60<=lon<=97) or not (LAT\_MIN<=lat<=LAT\_MAX and LON\_MIN<=lon<=LON\_MAX):  print("Invalid position")  exit(1)  data['latitude'], data['longitude'] = lat, lon | |
| **Coordinate System** | EPSG:32645 (UTM) enables local RTK navigation. | Parse $GNGGA fields 2-5, convert to UTM using pyproj. If fails, warn (print("Coordinate error")) and stop (exit()). Store in data['easting'], data['northing']. |
| **Constellation Diversity** | ≥2 constellations (e.g., GPS, GLONASS) enhance RTK reliability. | Parse $GNGSA talker IDs (e.g., GP, GL). If <2, warn (print("Low constellation diversity")) and stop after 30s (exit()). Store in data['constellations']. |
| **RTK Initialization Time** | Fixed status <60s indicates healthy RTK performance.Measures how long it takes to achieve an RTK Fix. Fast times (<60s) are desirable. | Track time until $GNGGA field 6 = 4. If >60s, warn (print("Slow RTK")); stop if >120s (exit()). Use time.time(). |
| **Position Stability** | Drift <2 cm over 1 min indicates stable RTK fix. Position stability refers to how consistently the GNSS receiver reports the same position over time when the rover is stationary. It’s a measure of jitter or scatter in the fixed position solution. | Store $GNGGA fields 2-5 over 1 min; calculate std dev in cm. If >2 cm, warn (print(f"Unstable: {std:.2f} cm")) and stop (exit()). Store in data['pos\_std']. |
| **Multipath Detection** | Reflections degrade RTK accuracy. | Parse $GNGGA fields 2-5 for jumps (>10 cm) or $GNSVA SNR for fluctuations (>15 dB-Hz). If detected, warn (print("Multipath error")) and stop (exit()). |
| **Elevation Mask** | Ensures satellites are not too close to the horizon (<10°), which are more susceptible to errors and multipath. Excludes low-elevation satellites prone to multipath and atmospheric errors, improving RTK fix stability.  Threshold: Warn if any satellite elevation <15 degrees; critical if <10 degrees. | Parse $GNSVA elevation fields for each satellite. If any elevation <15 degrees, warn (print(f"Low elevation: {elevation}° for satellite")); if <10 degrees, consider stopping (exit()). Store in data['elevation\_mask']. |
| **GPS Sync Time** | Ensures GNSS time and system clock stay aligned for accurate timestamping, sensor fusion, and networked data correlation. There will be some lag here. | Parse the $GNGGA time field and compare to time.time(). Compute offset\_ms = (gps\_time - sys\_time) \* 1000. Warn if ` |
| **Receiver Clock Stability** | Clock offset <50ms ensures RTK carrier phase precision. | Not directly available via GNSS. **Workaround**: Compare $GNGGA field 1 (time) to system clock. If offset >50ms, warn (print(f"Clock offset: {offset}ms")); stop if >200ms (exit()). Store in data['time\_offset']. |
| **Power Supply** | Stable power prevents RTK fix loss, critical for continuous precision. | Not available via GNSS. **Workaround**: Monitor serial connection (ser.in\_waiting). If no data for 5s, warn (print("Power issue suspected")) and stop (exit()). Check 5V USB externally. |
| **Firmware Updates** | Latest firmware optimizes RTK performance. | Not available via GNSS. **Workaround**: Check firmware manually via Emlid Flow app before operation. If outdated, warn (print("Update firmware")) and stop (exit()). |
| **Battery Level** | Sufficient battery prevents RTK interruptions. | Not available via GNSS. **Workaround**: Monitor rover’s power system (e.g., ADC for battery voltage). If <20%, warn (print("Low battery")) and stop (exit()). |
| **Hardware Status** | Secure connections ensure RTK data flow. | Not available via GNSS. **Workaround**: Monitor serial errors (ser.in\_waiting). If no data for 5s, warn (print("Connection issue")) and stop (exit()). |

## Sources

· **Emlid Reach M2 Documentation**: Provides setup, NMEA output, and RTK settings for the Reach M2.  
URL: https://emlid.com/docs/

· **Survey of India CORS Services**: Details NTRIP correction requirements and coverage for India’s CORS network.  
URL: <https://cors.surveyofindia.gov.in/cors-services>

· **SparkFun GPS RTK Tutorial**: Offers insights on RTK status, initialization, and signal strength.  
URL:https://learn.sparkfun.com/tutorials/what-is-gps-rtk/all

· **marXact Knowledge Base on DOP**: Explains DOP thresholds (PDOP, HDOP, VDOP) for RTK precision.  
URL: https://support.marxact.com/

· **Navipedia RTK Fundamentals**: Covers signal strength, multipath, and satellite requirements for RTK.  
URL: https://gssc.esa.int/navipedia/index.php/RTK\_Fundamentals

· **Wikipedia Null Island**: Describes position validity concepts, including Null Island errors.  
URL: https://en.wikipedia.org/wiki/Null\_Island

· **ArduSimple RTK Explanation**: Provides standards for RTK precision and stability.  
URL:https://www.ardusimple.com/rtk-explained/

· **ArduPilot RTK Correction Documentation**: Details RTK correction and signal quality thresholds.  
URL: https://ardupilot.org/copter/docs/common-rtk-correction.html

| **Parameter** | **Field / Method** | **Expected/Threshold** | **Condition for Healthy Status** |
| --- | --- | --- | --- |
| **RTK Status** | fix\_quality | 4 (RTK Fixed) | Fix quality must be 4 (RTK Fixed) |
| **Satellite Count** | satellites | >= 6 | At least 6 satellites for reliable fix |
| **DOP Values** | pdop, hdop, vdop | <= 2.0 (ideal), warn if > 1.5 | Max of PDOP/HDOP/VDOP should be ≤ 2.0 |
| **Signal Strength** | average\_snr | >= 45 dB-Hz | SNR must be ≥ 45 for strong signal |
| **Age of Corrections** | age\_of\_corrections | <= 5 sec | Should be < 5 seconds for optimal corrections |
| **Position Validity** | latitude, longitude | Lat: 5–37, Lon: 60–97 | Valid coordinates for India (example) |
| **Constellation Diversity** | constellations | At least 2 GNSS types | GNSS sources should include more than one constellation |
| **Elevation Mask** | min\_elevation | >= 15° | Minimum satellite elevation should be ≥ 15° |
| **RTK Initialization Time** | check\_rtk\_initialization\_time | < 60 sec ideally | Time to reach RTK Fix should be under 60s, max 120s |
| **Position Stability** | check\_position\_stability() | std dev < 0.02 m | E/N stability std deviation under 2 cm over 1 min |
| **Antenna Placement** | check\_antenna\_placement() | Satellites ≥ 6, SNR ≥ 45 | Assumes open sky view and strong signal |
| **Coordinate System** | easting, northing | Not None | UTM conversion must succeed |
| **Multipath Detection** | satellites\_data -> snr stddev | std dev < 15 dB-Hz | Detect large SNR fluctuations indicating multipath |
| **GPS Sync Time** | time\_diff | < 50 ms | Time offset between GPS and system clock must be < 50ms |
| **Clock Stability** | time\_diff | < 200 ms | Receiver clock stable if offset < 200ms |
| **Power Supply** | ser.in\_waiting | > 0 data in 5 sec | Serial port must receive data to indicate power |
| **Firmware Status** | Manual | - | Must be verified manually through Emlid Flow |
| **Battery Level** | Manual | > 20% | Manually check or ensure external power source is stable |
| **Hardware Status** | ser.in\_waiting | > 0 | Must receive data to ensure serial hardware is operational |