# Updated Rover Health Check Module Summary

The Rover Health Check Module performs comprehensive pre-operation checks to ensure the rover is ready, focusing on environmental conditions, GPS health, internet connectivity, and RTK-specific requirements. Recent updates have introduced stricter thresholds for GPS accuracy and a new check for RTK base station connection, reflecting a focus on high-precision positioning.

## Environmental Checks

**Temperature and Cloud Cover:** The check\_environment method ensures the operating temperature is below 60°C to prevent hardware damage or sensor inaccuracies due to heat ([GIS Geography](https://gisgeography.com/gps-accuracy-hdop-pdop-gdop-multipath/)). Cloud cover is assessed against a 90% threshold, with excessive cover triggering a warning due to potential impacts on optical sensors or solar panels. This check is not GPS-related but is critical for system health.

## GPS Health Checks

The module includes several GPS-specific checks to ensure reliability and accuracy, with updates to support RTK precision:

* **Satellite Count and HDOP:** The check\_gps\_health method verifies that at least 6 satellites are visible and the Horizontal Dilution of Precision (HDOP) is ≤3.0. HDOP measures the geometric quality of satellite configuration for horizontal positioning, with lower values indicating better accuracy ([GIS Geography](https://gisgeography.com/gps-accuracy-hdop-pdop-gdop-multipath/)).
* **GPS Fix Type:** The check\_gps\_fix\_type method ensures the fix type is at least 3 (RTK float), with higher types like RTK fixed (type 4) offering superior accuracy. This is a change from the previous requirement of type ≥1, reflecting the need for high-precision positioning ([ArcGIS GpsFixStatus](https://help.arcgis.com/en/arcgismobile/10.0/apis/arcgismobile/api/ESRI.ArcGIS.Mobile~ESRI.ArcGIS.Mobile.Gps.GpsFixStatus.html)).
* **GPS Accuracy:** The check\_gps\_accuracy method checks that Vertical Dilution of Precision (VDOP) is ≤3.0 (tightened from ≤4.5) and position accuracy is within 2.0 meters (improved from ≤5.0 meters), ensuring precise vertical and overall positioning.
* **GPS Position Validity:** The check\_gps\_position\_validity method validates latitude (-90 to 90 degrees) and longitude (-180 to 180 degrees) ranges and warns about proximity to null island (0,0), a common GPS error indicator.
* **RTK Base Station Connection:** The new check\_rtk\_base\_station\_connection method ensures the rover is connected to the RTK base station, which provides real-time corrections for centimeter-level accuracy ([SparkFun RTK](https://learn.sparkfun.com/tutorials/what-is-gps-rtk/all)).

## Internet Connectivity Check

**Internet Connectivity:** The check\_internet\_connectivity method verifies an active internet connection with a speed of at least 0.5 Mbps (previously 1.0 Mbps) to receive RTCM corrections. These corrections are essential for RTK positioning, achieving high accuracy by correcting GPS signal errors ([Wikipedia RTK](https://en.wikipedia.org/wiki/Real-time_kinematic_positioning)). This check supports GPS but is not GPS-based.

## Additional GPS-Specific Checks

The module includes further GPS-focused assessments to ensure optimal performance:

* **GPS Signal Strength:** Ensures signal strength is ≥25.0 dB-Hz for reliable operation. Note that the code's method default is 15 dB-Hz, but the intended threshold is 25.0 dB-Hz as per initialization.
* **GPS Constellation Distribution:** Verifies that at least two constellations (e.g., GPS, GLONASS, Galileo, BeiDou) are used, enhancing reliability ([SparkFun GPS Basics](https://learn.sparkfun.com/tutorials/gps-basics/all)). The method default is 1 constellation, but the intended threshold is 2.
* **Satellite Geometry (GDOP):** Checks Geometric Dilution of Precision (GDOP) ≤6.0, ensuring favorable satellite positioning for accuracy.
* **GPS Time Sync:** Ensures synchronization between GPS and system time within 1.0 second.
* **Position Stability:** When stationary, checks for minimal drift (≤0.5 meters) over time, indicating stable GPS performance. The method uses a 2.0-meter threshold, but the intended threshold is 0.5 meters.
* **Age of Differential Corrections:** For RTK modes, ensures corrections are recent (≤30 seconds).
* **Multipath Detection:** Identifies signal reflections that could cause errors, with an indicator ≤0.7 (method default is 0.9, but intended is 0.7).
* **Environment Interference:** Detects environmental factors affecting GPS signals, with a level ≤0.6 (method default is 0.8, but intended is 0.6).
* **Coordinate System Configuration:** Confirms the use of the expected coordinate system, defaulting to WGS84.

## Summary Table

| **Check Type** | **Description** | **GPS-Related?** | **Key Parameter** |
| --- | --- | --- | --- |
| Environment | Temperature and cloud cover | No | Temperature <60°C, Cloud <90% |
| GPS Health | Satellite count and HDOP | Yes | Satellites ≥6, HDOP ≤3.0 |
| GPS Fix Type | Type of GPS fix | Yes | Fix Type ≥3 (RTK float or fixed) |
| GPS Accuracy | VDOP and position accuracy | Yes | VDOP ≤3.0, Accuracy ≤2.0m |
| GPS Position Validity | Latitude and longitude ranges | Yes | Valid ranges, not near 0,0 |
| Internet Connectivity | Connection and speed for RTCM corrections | No, supports GPS | Speed ≥0.5 Mbps |
| RTK Base Station Connection | Connection to RTK base station | Yes | Connected |
| GPS Signal Strength | Ensures adequate signal strength | Yes | Strength ≥25.0 dB-Hz |
| GPS Constellation Distribution | Multiple constellations used | Yes | Min 2 constellations |
| Satellite Geometry | GDOP for satellite positioning | Yes | GDOP ≤6.0 |
| GPS Time Sync | Synchronization with system time | Yes | Time Diff ≤1.0s |
| Position Stability | Minimal drift when stationary | Yes | Change ≤0.5m |
| Differential Corrections | Age of RTCM corrections | Yes, for RTK | Age ≤30s |
| Multipath Detection | Checks for signal reflections | Yes | Indicator ≤0.7 |
| Environment Interference | Detects factors affecting GPS | Yes | Level ≤0.6 |
| Coordinate System | Ensures correct system (e.g., WGS84) | Yes | Matches expected system |

**Failsafe Module**

#### Module Purpose and Context

The Failsafe Module is explicitly stated to handle system-level safety, distinct from navigation-specific safety, which might be managed by another module like a farm\_safety module. Its primary role is to monitor critical systems—GPS, internet connectivity, module communication, temperature, signal stability, and navigation drift—and trigger a failsafe mode when predefined conditions are violated. This ensures the rover enters a safe state to prevent potential damage, navigation errors, or operational failures, especially in environments requiring high precision, such as precision agriculture or surveying.

The module's design reflects standard practices in autonomous systems, where failsafe mechanisms are essential to handle unexpected situations or system failures. For instance, in drones, failsafe modes might include returning to home or landing when battery is low or signal is lost, similar to how this module ensures rover safety under adverse conditions.

#### Initialization and Configuration

The module begins with initialization in the \_\_init\_\_ method, setting up various status flags, timestamps, and thresholds. Key parameters include:

* **GPS Stale Threshold:** 30 seconds, after which GPS data is considered stale.
* **Internet Timeout:** 10 seconds, for checking connectivity for RTCM (Real-Time Correction Messages) corrections.
* **Module Communication Timeout:** Increased from 5 to 15 seconds, ensuring modules communicate properly.
* **Temperature Threshold:** 60°C, to prevent hardware damage.
* **Drift Thresholds:** Defined at minor (0.2m), moderate (0.5m), severe (1.0m), and critical (2.0m), with actions escalating based on severity and persistence.
* **RTK-Specific Settings:** Includes monitoring RTK status, correction age (15 seconds timeout), and minimum RTK ratio (3.0) for reliable fixed solutions.

#### Monitoring and Failsafe Triggering Logic

The module's core operation is driven by the start\_monitoring method, which launches a daemon thread running the \_monitor\_loop. This loop, executing every second, checks various failsafe conditions, each with specific logic based on the rover's actions:

* **GPS Status Check (**\_check\_gps\_status**):**  
  If the rover's actions lead to no GPS updates for more than 30 seconds (e.g., entering an area with poor signal), the module logs a warning and triggers failsafe with reason GPS\_STALE\_DATA. This ensures the rover doesn't navigate with outdated data, potentially causing errors.
* **Internet Connection Check (**\_check\_internet\_connection**):**  
  If the rover's actions result in losing internet connectivity for RTCM corrections (e.g., moving out of network range), and the last check is over 10 seconds ago, it triggers failsafe with reason INTERNET\_CONNECTION\_LOST. This is critical for RTK, as corrections are needed for centimeter-level accuracy.
* **Module Communication Check (**\_check\_module\_communication**):**  
  If the rover's internal modules fail to communicate for more than 15 seconds (e.g., due to hardware issues), it triggers failsafe with reason MODULE\_COMMUNICATION\_FAILURE, ensuring system integrity.
* **Temperature Check (**\_check\_temperature**):**  
  If the rover's operations cause the system temperature to exceed 60°C (e.g., prolonged operation in hot conditions), it triggers failsafe with reason OVER\_TEMPERATURE, protecting hardware from damage.
* **Signal Stability Check (**\_check\_signal\_stability**):**  
  If the rover experiences frequent signal losses (e.g., due to environmental interference), and there are 5 or more loss events in a 60-second window, it triggers failsafe with reason SIGNAL\_INSTABILITY, indicating unreliable GPS data.

#### ****Drift Status CheckMonitor****: **Monitor**: Continue normal operation, suitable for very minor drifts.

#### **Slow Down:** Reduce speed to minimize further deviation.

#### **Realign:** Perform a realignment to correct the course, with a cooldown period (realignment\_cooldown = 60.0) to prevent excessive adjustments.

#### **Pause:** Temporarily halt movement to assess the situation.

#### **Failsafe:** Enter failsafe mode, which involves stopping the rover and potentially triggering recovery attempts.

#### For minor or moderate drifts detected in check\_safety, the system calculates a recovery target. This involves:

#### Determining a drift angle (either +45° or -45°, chosen randomly).

#### Computing a recovery index based on the lookahead steps and turn distance, adjusted for the drift angle.

#### Returning a dictionary with recovery data, including the trigger index, drift angle, drift vector, and recovery target, which likely informs the navigation module (e.g., navigate\_to\_point or follow\_path\_precisely) to adjust the rover's path.

#### For severe drifts, the FailsafeModule triggers failsafe mode, pausing the SafetyModule via on\_failsafe\_triggered and logging the event. Recovery attempts are then managed by the \_attempt\_recovery method, with a maximum of 5 attempts (max\_recovery\_attempts = 5) before potentially remaining in failsafe mode.Recovery Mechanism and Logic

After entering failsafe, the \_attempt\_recovery method is triggered if not in progress and after the recovery interval (60 seconds). It attempts recovery, logging the attempt, and executes a callback if provided. If successful, \_clear\_failsafe resets the state, logging recovery, and updates timestamps to prevent immediate re-triggering. If recovery fails after maximum attempts (5), it logs an error but allows future attempts, maintaining flexibility.

For example, if the rover regains GPS signal during recovery, it might resume operation; otherwise, it stays in failsafe, ensuring safety.

#### Advanced GPS Integrity Checks and Rover Actions

The module includes comprehensive GPS checks, enhancing reliability when the rover performs actions affecting GPS data:

* **Position Jump Detection (**update\_gps\_position**,** \_check\_position\_jump**):**  
  If the rover's movement results in a sudden position jump (e.g., GPS glitch), calculating speed from distance and time, and exceeding 1.5x the max speed (2.0 m/s, or 3.0 m/s), it triggers failsafe with reason GPS\_POSITION\_JUMP.
* **Heading Consistency (**update\_gps\_heading**,** \_check\_heading\_consistency**):**  
  If the rover's heading changes abruptly (e.g., due to sensor error), exceeding 45°/s, it triggers failsafe with reason GPS\_HEADING\_INCONSISTENCY.
* **Altitude Anomaly (**update\_gps\_altitude**,** \_check\_altitude\_anomaly**):**  
  If the rover's altitude changes unrealistically (>1.0 m/s, e.g., due to GPS error), it triggers failsafe with reason GPS\_ALTITUDE\_ANOMALY.
* **DOP Thresholds (**update\_gps\_dop**):**  
  If the rover's GPS data shows high dilution of precision (HDOP >5.0, PDOP >7.0, VDOP >7.0), it triggers failsafe with reason GPS\_HIGH\_DOP, indicating poor satellite geometry.
* **Satellite Monitoring (**update\_gps\_satellites**):**  
  If the rover has fewer than 6 satellites used or detects multipath (SNR drop >10 dB), it triggers failsafe with reasons GPS\_CONSTELLATION\_WEAK or GPS\_SIGNAL\_MULTIPATH, ensuring reliable GPS data.
* **RTK Status:**  
  If the rover loses RTK fix or correction data ages beyond 15 seconds, it triggers failsafe with reasons like RTK\_FIX\_LOST or RTK\_CORRECTION\_TIMEOUT, critical for precision tasks.

These checks ensure the rover's actions don't lead to unsafe navigation, with failsafe as a last resort.

#### Table: Summary of Failsafe Triggers and Actions

|  |  |  |  |
| --- | --- | --- | --- |
| **Condition** | **Trigger Threshold** | **Failsafe Reason** | **Action** |
| GPS Data Stale | >30s since last update | GPS\_STALE\_DATA | Stop, attempt recovery |
| Internet Lost | >10s since last check | INTERNET\_CONNECTION\_LOST | Stop, attempt recovery |
| Module Communication Failure | >15s since last comm | MODULE\_COMMUNICATION\_FAILURE | Stop, attempt recovery |
| Over Temperature | >60°C | OVER\_TEMPERATURE | Stop, attempt recovery |
| Signal Instability | ≥5 losses in 60s | SIGNAL\_INSTABILITY | Stop, attempt recovery |
| Significant Drift | ≥3 severe events in 5min | SIGNIFICANT\_DRIFT | Stop, attempt recovery |
| Persistent Drift | ≥10 consecutive events | PERSISTENT\_DRIFT | Stop, attempt recovery |
| Position Jump | >5m jump or >3m/s speed | GPS\_POSITION\_JUMP | Stop, attempt recovery |
| Heading Inconsistency | >45°/s change | GPS\_HEADING\_INCONSISTENCY | Stop, attempt recovery |
| Altitude Anomaly | >1m/s change | GPS\_ALTITUDE\_ANOMALY | Stop, attempt recovery |
| High DOP | HDOP>5, PDOP>7, VDOP>7 | GPS\_HIGH\_DOP | Stop, attempt recovery |
| Weak Constellation | <6 satellites used | GPS\_CONSTELLATION\_WEAK | Stop, attempt recovery |
| Signal Multipath | SNR drop >10 | GPS\_SIGNAL\_MULTIPATH | Stop, attempt recovery |
| RTK Fix Lost | Not RTK\_FIXED, if required | RTK\_FIX\_LOST | Stop, attempt recovery |