- **Contact Phone**: +1518292344

II. Geolocation System Overview

A. Method of Geolocation

1. **Internal Geolocation Capability**
    - The device uses built-in GPS receiver:
        - Internal geolocation sensor:

          Quectel L26-T GNSS module supports concurrent reception of GPS, GLONASS, BDS, Galileo and QZSS

        - Quectel L26-T accuracy:

          Horizontal Position Accuracy①Autonomous: 1.5 m CEP
          .①: CEP, 50 %, 24 hours static, -130 dBm, more than 6 SVs.

        - Device data access its geographic coordinates:

          The device connects to the GPS module using the internal UART interface. The textual data received from the GPS module is parsed and analyzed, and geographic coordinates are extracted. The coordinates are then stored and used by the AFC firmware module when performing channel inquiry request to the AFC server.

2. **External Geolocation Device or Service**
    - N/A

B. General Geolocation Process

1. **Initialization and Setup**

    - Initialization steps after power on and factory reset:

        1. ***UART interface initialized***
        2. ***Geolocation module is connected.***
        3. ***Geolocation data retrieved and analyzed***
        4. ***AFC SW module issue a channel inquiry request to AFC server using geolocation coordinates***

    - Describe any configuration settings or user interactions required to enable geolocation functionality.

        No configuration settings or user interactions are needed to activate the geolocation module, its automatic and can't be disabled.

2. **Continuous Operation**

    - Detail how the device continuously monitors and updates its geolocation information during normal operation.

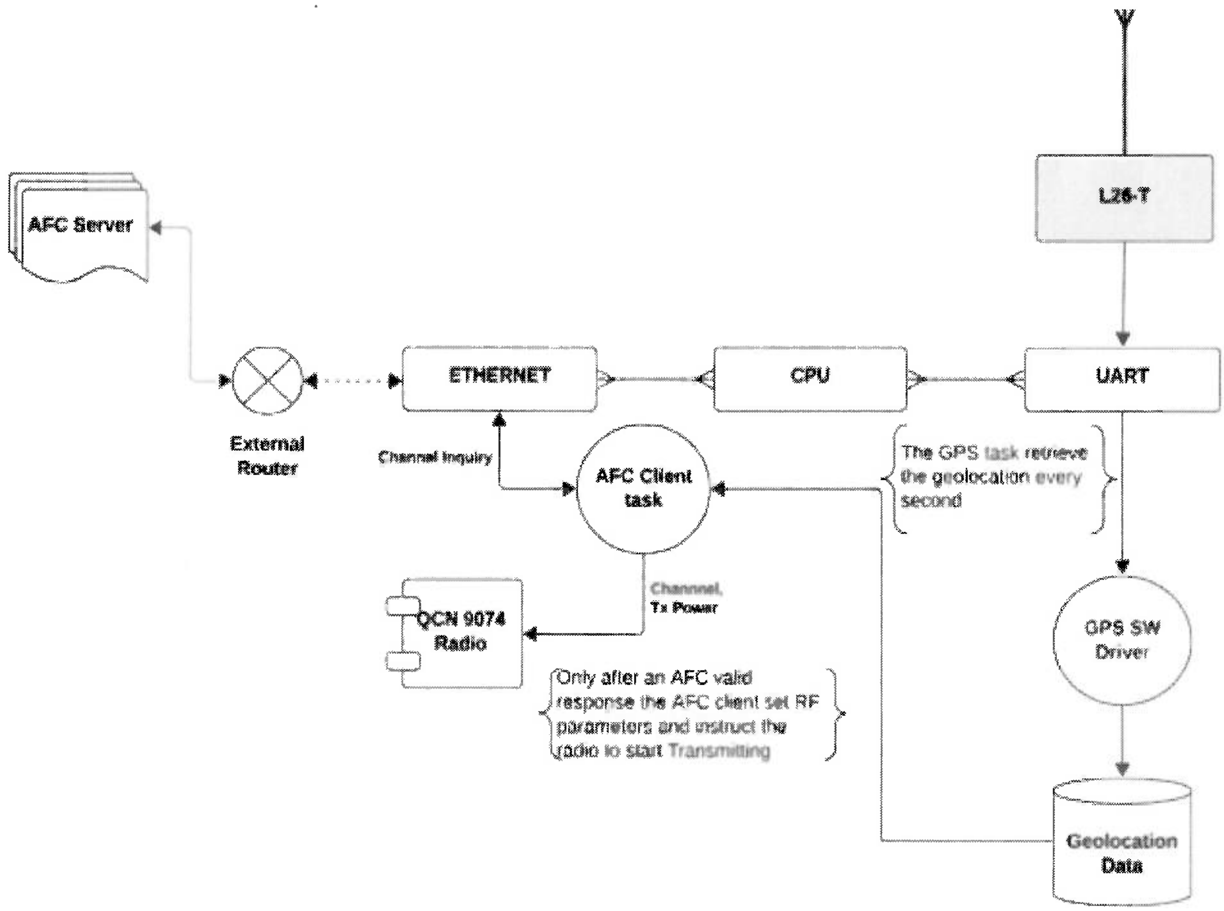
        The L26-T module sends every second a GPPA message containing geolocation information using the NEMA protocol. This text messages arrive using the UART peripheral to a GPS software module that analyzes, parse and extracts the geolocation information from the message. Then stores the information in an internal database. The device continuously and in real time updates its display and issue log messages when the information is retrieved. The information is updated continuously, and its quality and satellite counts are observed continuously.

- Discuss any algorithms or techniques used to improve the accuracy and reliability of geolocation over time (e.g., averaging multiple location readings, using sensor fusion).

The L26-T performs continuous location adjustments and corrections according to its all-data sources (acquired satellites) The module using statistical analysis and SBAS methods to continuously improve its accuracy and self corrects using new data acquired for additional satellites. Because of L26-T impressive accuracy 1.5-meter CEP the device uses the coordinates as its real time data communicated to the AFC system.

C. Geolocation System Block Diagram

Include a block diagram that illustrates the major components and their interconnections within the geolocation system. Label each component clearly and provide a brief description of its function in the context of geolocation.



<u>L26-T</u>: Quectel geolocation module communicates using NEMA protocol location, time and altitude to the CPU.

<u>UART</u> – Serial communication peripheral via the CPU communicates with L26-T.

<u>GPS SW Driver</u> – The software module responsible for communicating with L26-T retrieve the geolocation coordinates and store them in an internal database.

***AFC client** – This software module is responsible for:*

1. ***Communicating with the AFC server establishing secure HTTPS session***
2. ***Using the Geolocation database and other information sending a channel inquiry request to the AFC server***
3. ***Analyzing the response from the server***
4. ***Decide and activate de-activate the radio RF module with the allowed EIRP.***
5. ***Repeat these steps hourly.***

***Ethernet** – Communication peripheral to the outside world using this interface the AFC client communicates with the AFC server*

***QCN9074 Radio** – Responsible for bi-directional RF communication with the fixed client. It is configured and activated by the AFC client because of the AFC response (or lack of) received from the AFC server.*

--------------------------------External Components to the device--

Router – This is an external network device which connects the device to the Internet.

***AFC Server** – The system that sends responses that give permission to the device to transmit on specific channel and what is the allowed EIRP*

> ***Note: a. The external components of the Router and AFC server are depicted to make the picture complete regarding the Geolocation in its function as data for the AFC process.***
>
> > ***b. In the fixed client case the external components are accessed via the QCN9074 component using RF protocol to access the Standard Power AP and from that the AP transfers packets to its Ethernet to access the AFC system.***

III. Location Uncertainty Determination

A. Confidence Interval Calculation

1. Methodology

L26-T is an ultra-compact, single-band multi-constellation module featuring high precision timing and standard precision positioning. It is designed and manufactured according to the IATF 16949: 2016 standard. Designed for navigation applications, L26-T can receive and track GPS, GLONASS, Galileo, BDS, and QZSS signals, output multi-GNSS raw data, and use SBAS to enhance accuracy and reliability. The built-in LNA ensures better performance even in harsh environments such as dense urban canyons. For high-precision timing applications, the module can synchronize with the Coordinated Universal Time (UTC) at a nanosecond resolution. This outstanding timing performance is crucial to a variety of applications demanding high accuracy time and frequency stability. L26-T also leverages AGNSS data, resulting in a significantly reduced Time to First Fix (TTFF). The AGNSS feature enables high sensitivity acquisition even on the module's first start-up, when precise location, time, and frequency are still unknown.

2. Data Sources and Measurements

- Data Sources:

  As described above the L26-T module gathers all satellite data and produces a location with CEP of 1.5m. The result communicated to the device is the sum and average statistical calculation of all connected satellites

- Location uncertainty

  The device relies on the L26-T declared 1.5m CEP and from that using the formulae:
  95% location uncertainty ~ 2 X CEP = 3m

- Accuracy and precision:

  According to the L26-T datasheet Quectel specified a 1.5m CEP for location accuracy. The device is always at a fixed location that gives a 2D ellipse (radius) with 95% location uncertainty of 3m, according to above formula

B. Testing and Validation

Quectel GPS modules are ubiquitous and a very popular choice for embedded GPS devices with global recognition. The L26-T module built-in the device relies on accuracy measurements after going extensive testing at Quectel labs. The device has the module built-in, and the GPS module is tested during the calibration and acceptance testing of the radio. The device is fixed after installation.

1. **Test Setup and Procedures**

- Test setup:

  - ***ATP station with device + GPS antenna connected.***
  - ***The GPS antennas is outdoor, and satellites are visible.***
  - ***The same setup is in a different location***

- Test environment & information

  Two ATP stations with a GPS antenna. The antennas have satellite visibility (at least 3 satellites). The radio (and the built-in GPS).
  The locations are ascertained using external devices including mobile phones for a base line comparison. The device continuously displays and logs L26-T communications (every second). The geolocation information is communicated using the NEMA protocol. The logs are converted to a csv file for further analysis using Excel. The location uncertainty is then analyzed regarding to the real time information the module sends to the device.

- Test procedure:

  After the radio is powered on and as part of the functionality tests the following is tested:
  - ✓ ***The GPS module is alive and 'talking' with the UART***
  - ✓ ***The geolocation coordinates are retrieved and recorded (also displayed)***
  - ✓ ***The coordinates are compared with known coordinates of the two stations***

2. **Test Results and Analysis**

- Present the results of the testing in a clear and organized manner (e.g., using tables, graphs).

Parameter	Value
Latitude average	*3252.0425*
Longitude average	*03516.6979*
Max distance from average	*0.0025772*
Max distance from average [m]	*4.8012467*
Altitude Average	*304.74667*
Max Altitude distance [m]	*0.9266667*

Table 1: GPS Data summary

- Analyze the test data to demonstrate that the calculated location uncertainty meets the 95% confidence level requirement.

The above table (Table 1) depicts a summary of ~700 samples of GPS data logged from the Test Setup immediately after power up and sampled every second. This scenario presents the worst-case scenario because the coordinate value is not extracted from the most satellites acquired, in normal operation all satellites are already acquired, and calculations are corrected and adjusted continuously
The coordinates are shown in NEMA format:

<Latitude> ddmm.mmmmm - example 3149.33477
<Longtitude> dddmm.mmmmm example: -11706.94845
Where d stands for degree digit, and m for minute digit.

Note: a. In our test raw data, the longitude leading zero is omitted.
b. One minute in our calculations is equal 1863 meter, which is the equatorial value and it is the longest (worst case).

Step 1: Calculate the average coordinates value from all the samples.
Step 2: Calculate distance of the sampled coordinate from the average coordinate using dist = sqrt[square(LAT-avgLAT) + square(LON – avgLON)]
Step 3: Find the maximum distance which is ~4.8 meters
Step 4: Compare with our declared uncertainty of 3 meters radius which is maximum distance of 6 meters, and the conclusion 4.8 < 6

For the altitude, the procedure is the same steps with the conclusion that the max distance is ~1 in which is less than 2 meters declared vertical uncertainty (including maximum mounting poll height of 1 meter)

- Discuss any observed variations or outliers in the test results and explain how they were addressed or accounted for.

  The averaging was done on the entire sample set in the worst case, it is clearly demonstrated by the data that the L26-T continuously adjust the data and results are converging with more satellites acquired.

IV. Geolocation Accuracy After a Power Cycle (Optional, if applicable)

A. Device Stability and Movement Detection

As mentioned above the test data collected in worst case scenario after power cycle in which the L26-T still acquiring satellites. The device is always at a fixed location, so movement is not applicable.

1. **Power Cycle Impact on Geolocation**

   - Explain how a power cycle affects the device's geolocation system, including any initialization procedures or recalibration requirements.

     After a power cycle the device automatically acquires satellites, all calibration and adjustments needed are done automatically inside the module, no configuration is required or applied to the L26-T module by the device.

- Describe the measures taken by the device to ensure that the geolocation accuracy is maintained or quickly restored after a power cycle.

  Geolocation information is retrieved continuously from the module every second, after at least 3 satellites were acquired after power up. As demonstrated by the test data the real time coordinates are automatically and continuously adjusted by the module.

2. **Movement Detection Mechanism**

   The device is fixed, and the coordinates are always sampled, so this section is not applicable.

B. Testing and Demonstration

Not Applicable

V. Daily Contact with AFC and Grace Period

A. AFC Communication Protocol

1. **Frequency and Method of Contact**

   - Explain how often the device contacts the Automated Frequency Coordination (AFC) system (at least once daily as required).

     The device contacts the AFC system every hour and after a power cycle or a reboot.

   - Describe the communication protocol used for the device to interact with the AFC (e.g., HTTP(S) requests, specific API calls).

     The Channel Inquiry request is done over HTTPS using TLS 1.2 protocol. The device identifies with a serial number and with authorization header containing a security token.

- Provide details about the message format and content exchanged during the communication with the AFC.

The message format is for <u>channel inquiry only</u>, specifying the channel CFI requested. For example:

{"version": "1.4","availableSpectrumInquiryRequests": [{"requestId": "Telrad-1000","deviceDescriptor": {"serialNumber": "041A04005E30","certificationId": [{"rulesetId": "US_47_CFR_PART_15_SUBPART_E","id": "ARA-BAXE6X"}]},"location": {"ellipse": {"center": {"latitude": 40.322935,"longitude": -117.64081},"majorAxis": 3,"minorAxis": 3,"orientation": 0},"elevation": {"height": 10.0,"heightType": "AMSL","verticalUncertainty": 2},"indoorDeployment": 2},"inquiredChannels": [{"channelCfi": [29],"globalOperatingClass": 131}]}]}

2. **Authentication and Security**

- Discuss the authentication mechanism used to ensure the device's identity when communicating with the AFC.

  The AFC request includes the unique serial number of the radio. In addition the Authorization header includes a security token that is configured by Telrad in which without it the AFC server will reject the request.

- Explain the security measures implemented to protect the integrity and confidentiality of the communication (e.g., encryption, digital signatures).

The entire communication with the AFC server is encrypted using agreed upon cypher and encryption keys as the HTTPS protocol requires. The messages are encrypted differently for each session (request/response). Specifically: TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384. This cipher suite provides strong encryption and authentication by combining:

- ***ECDHE (Elliptic Curve Diffie-Hellman Ephemeral) for key exchange,***
- ***RSA for digital signatures,***
- ***AES-256-GCM for encryption, and***
- ***SHA-384 for message authentication.***

B. Grace Period Handling

This section is not applicable, the device contacts the AFC server every hour and it will stop transmitting immediately if instructed by the AFC response or in the event that the AFC server is out of reach or not verified.

VI. Security of Connection to External Geolocation Source (if applicable)

Not Applicable

VII. Conclusion

A. Summary of Geolocation Capabilities

Summarize the key features and capabilities of the device's geolocation system, emphasizing its compliance with the relevant FCC requirements (e.g., 95% confidence level for location uncertainty, daily AFC contact, etc.).

The BreezeAXE 6X uses its built in Quectel L26-T GPS module to determine its geolocation coordinates in real time every second. The device sends a channel inquiry request every hour to the AFC system using secured HTTPS protocol using modern cipher and encryption method.
The request includes all required parts by FCC including unique serial number and contain location (3 meters) and vertical (2 meters) verified uncertainty values.
The device uses its AFC client software module to directly activate/de-activate its RF module, ensuring that transmission will only occur if permitted and with the allowed EIRP value provided by the AFC server system. In the case that connection with the AFC system is lost or the channel no longer allowed during normal operation (already transmitting in a channel with allowed EIRP) the device will stop transmitting immediately

B. Declaration of Compliance

State that the device, as described in this report, complies with the geolocation requirements set forth in the FCC regulations for the 6 GHz band (Part 15 Subpart E).

C. Future Improvements and Monitoring

1. **Planned Enhancements**
   - If there are any planned improvements or upgrades to the geolocation system in the future, briefly describe them.

- Explain how these enhancements will further improve the device's geolocation accuracy, reliability, or security.

  Currently, enhancements are not planned and Telrad (the company) plans to collect relevant data to ensure compliance and customer satisfaction.

2. **Ongoing Monitoring and Maintenance**

   - Describe the procedures and processes in place for ongoing monitoring of the geolocation system's performance.

     The device displays all geolocation data in its WEB interface and internal and external logs. Before any contact with the AFC system is attempted the geolocation system is verified and an alarm is raised if the L26-T module male-functions or satellite count is less than 3. A tick counter is kept ensuring that the module is communicating every second and its values are within permitted range from the running average.

   - Explain how the company will address any issues or discrepancies that may arise during the device's operation to ensure continued compliance with FCC requirements.

     In case of any male-function including discrepancies affecting compliance like GPS module, The company has an ordered procedure to support using remote and local support, or RMA if the issue can't be fixed. The company is continually in contact with its customers and the AFC system provider to detect any issues as soon as possible and provide immediate solutions or device replacement. As detailed previously, the device will not transmit if the GPS or other compliance affecting issue is detected.

D. Signatures and Dates

- **Signature of Authorized Representative**: [Signature]

12/10/2024

- **Date**: [Month, Day, Year]

Please note that this template is a general guideline and should be customized to fit the specific characteristics and capabilities of the device being reported. Additionally, ensure that all information provided is accurate and supported by appropriate testing and documentation.

Telrad Networks Ltd.