LoRaWAN Network Coverage Analysis in the Transportation Sector: A Real-World Approach

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Goal of the work

- An analysis of the coverage is performed, which mainly concerns the needs of the transportation sector

- A real-world approach is achieved by building a special measurement module that mimics a prototyping process

- After measurements, an initial evaluation will be performed

Measurement Approach

- Takes place in two networks: The Things Network- / Industries (TTN/TTI) and The Peoples Network (TPN)

- Measurement along German railroad lines

  - From inside the train

  - Along the German ICE-Network

- Module should attempt to continuously send GNSS data over LoRaWAN to a backend application at short intervals

- Interval is based on the EU regulation on the time on air to 1%

  - SF10, 13 bytes payload, and 125 kHz bandwidth resulted in airtime of approx. 411ms → **1 min interval is chosen**

Measurement Modules

- During the experiment, two measurement modules are built, as a need for improvement was identified

- Revised Module B (see Fig. 1)

  1. Microcontroller incl. Expansion Board

  2. new LoRaWAN Module incl. antenna

  3. Accelerometer

  4. new GNSS-Sensor incl. patch antenna
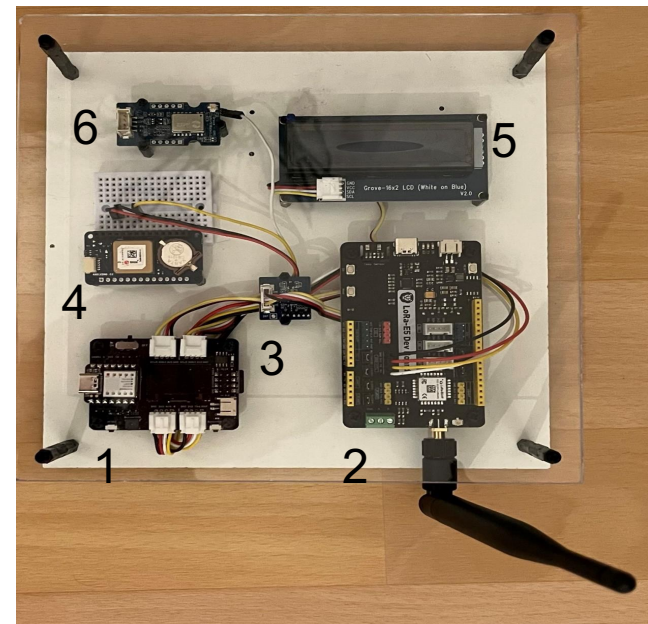
  5. LC-Display

  6. Fallback GNSS-Sensor

Figure 1: Module B

Measurement Route

- The route was redefined two times according to test measurements

- The final route driven is shown in Table 1 (TTN/TTI)

- Route is based on the German ICE network

Date	Start	Over	Destination
07/18/22	Berlin	Magdeburg – Erfurt – Halle	Erfurt
07/19/22	Erfurt	Nuremberg - Wuerzburg	Frankfurt/Main
07/20/22	Frankfurt/Main	Mannheim – Colgone – Hagen	Cologne
07/21/22	Cologne	Bonn – Muenster – Dortmund - Hamm	Muenster
07/22/22	Muenster	Bremen – Hamburg – Luebeck	Hamburg

Table 1

Measurement Route

- Table 2 shows the final route for TPN

- 2 parts are nearly the same with TTN/TTI (Frankfurt – Nuremberg, and Nuremberg – Halle)

Date	Start	Over	Destination
08/01/22	Berlin	Wolfsburg – Kassel – Fulda	Frankfurt/Main
08/04/22	Frankfurt/Main	Wuerzburg	Nuremberg
08/07/22	Nuremberg	Erfurt – Halle	Berlin

Table 2

Results

- ## After validation:

  - ### 509 valid measurement points in TTN/TTI

  - ### 154 valid measurement points in TPN

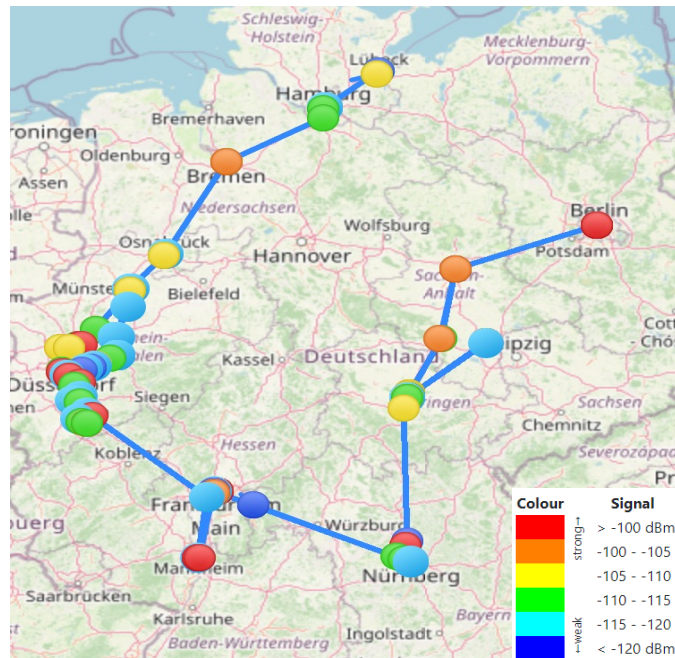 - ### Each point is displayed on a map with a corresponding RSSI (see Fig. 2 a/b)
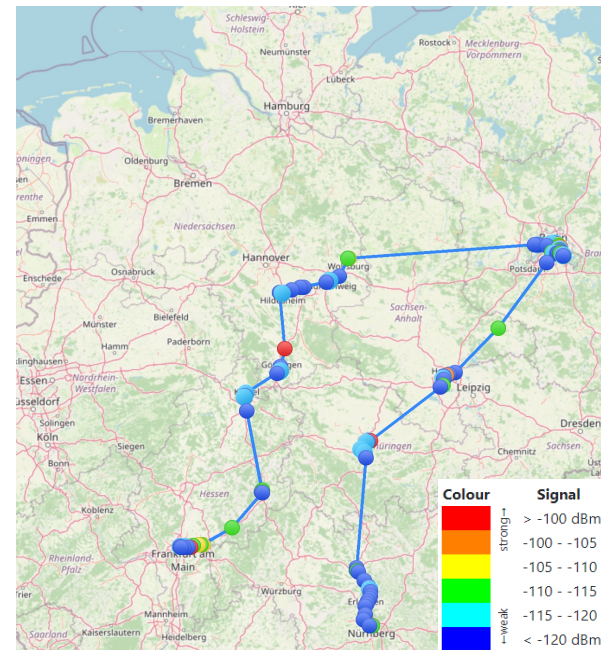

Figure 2 (a): TTN/TTI Coverage

Figure 2 (b): TPN Coverage

Results

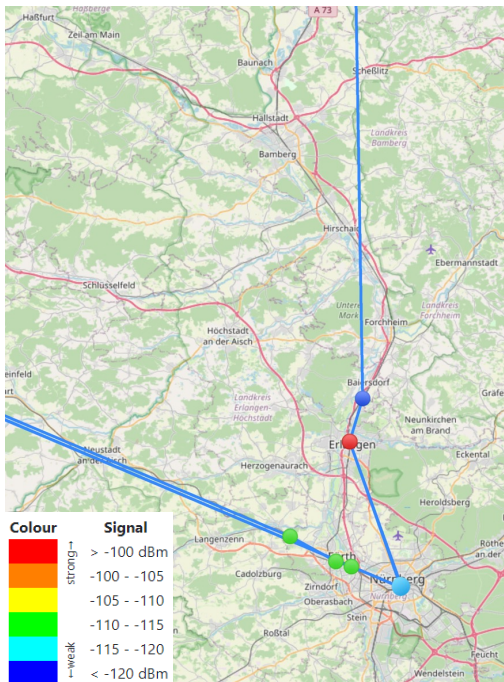- Better coverage in TPN in some regions (Figure 3 a/b)

Figure 3 (a): TTN/TTI Coverage

Figure 3 (b): TPN Coverage

Results

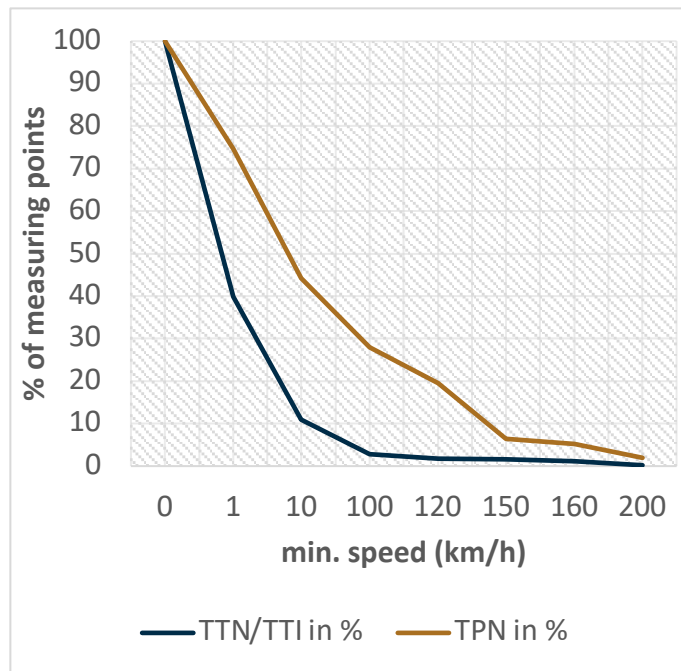- The drop in measurement points by speed is also greater in TTN/TTI (Figure 4 a/b)

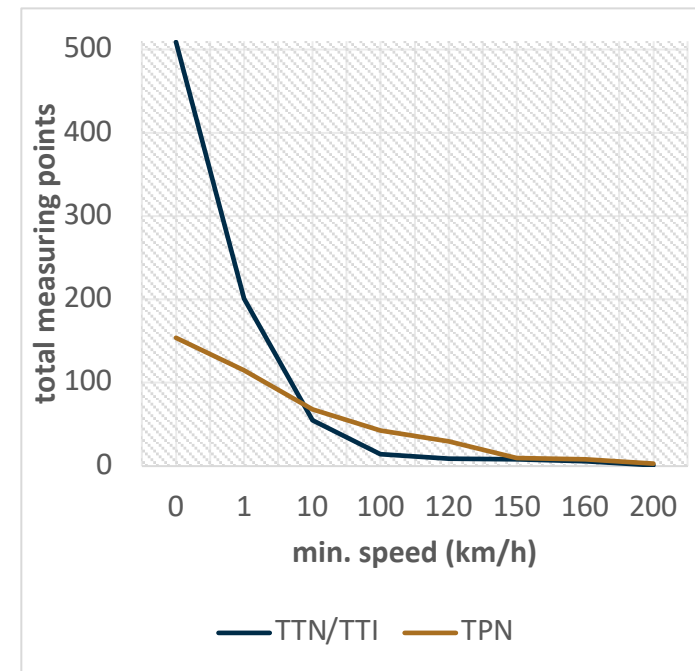Figure 4 (a): TTN/TTI and TPN (in %) measuring points by min. speed

Figure 4 (b): TTN/TTI and TPN (in total) measuring points by min. speed

Discussion

- LoRaWAN for live monitoring (eg. 5-minute updates) e.g. trucks or trains is not applicable

- Geofencing would be a solution

  - Transmition would be limited to covered areas

  - Transmit attempts in uncovered areas would be avoided

- Another option would be campus supply (delinated, regional area) for uncovered regions

  - In combination with geofencing, it could provide a low-cost LoRaWAN connectivity solution

Limitations

- Only the spreading factor (SF) 10 was used and sent with the highest possible power

- Maybe in some situations with a bad signal, SF12 would perhaps bring better results

- Problems with the measurement module occurred in both networks

  - In TTN/TTI some transmitted data was not received despite coverage after startup, a firmware reinstall fixed the problem

  - In TPN, there was a total failure between Frankfurt/Main and Nuremberg

Conclusion

- LoRaWAN coverage appears mostly in urban areas

- Live monitoring from long-distance transportation is not applicable

- Geofencing and/or campus coverage could be a solution

- For a specific use case, the measurements should be repeated with parameters adapted to the use case

Thank you.