IoT-polje

LoRaWAN Parameters Optimization for Efficient Communication (in Agriculture)

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How LoRaWAN Can Make Agriculture More Sustainable?

Long Range

- Deep indoor coverage (including multi-floor buildings)
- Star topology network design

Long Battery Life

- Low-power optimized
- Up to 10-year lifetime
- Up to 10x versus Cellular M2M

High Capacity

- High capacity – millions of messages per base station / gateway
- Multi-tenant interoperability
- Public or private network deployments

Low Cost

- Minimal infrastructure
- Low cost end-node
- Open source software

Geolocation

- Indoor/outdoor
- Accurate without the need for GPS
- No battery life impact

FUOTA

- Firmware Updates Over-the-Air for applications and the LoRaWAN stack

Roaming

- Roaming: Seamless handovers from one network to another

Security

- Embedded end-to-end AES-128 encryption
- Unique ID
- Application
- Network

Izvor: https://lora-developers.semtech.com/documentation/tech-papers-and-guides/lora-and-lorawan/

Received Signal Strength Indicator

- RSSI is a relative measurement that helps determine if the received signal is strong enough to get a **good wireless connection** from the transmitter.
- LoRaWAN supports bi-directional communication, RSSI is an important measurement for both gateways and end devices.
- RSSI is measured in dBm and its value is a negative form. The closer the RSSI value is to zero, the received signal is stronger.
- Apart from the output power of the transmitter, the following factors mainly influence the RSSI:
  - **Path loss**
  - **Antenna gain**
  - **Cable/connector loss**

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Signal-to-Noise Ratio

- SNR is the ratio of the **received signal power** to the **noise floor**. SNR is commonly used to determine **the quality of the received signal**.
- SNR can be calculated using the following formula and is often expressed in decibels (dB):

$$\textbf{SNR (dB)} = \mathbf{P_{received\_signal}\ (dBm) - P_{noise}\ (dBm)}$$

- If the RSSI is above the noise floor the receiver can easily demodulate the signal.

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Spreading Factor

- The spreading factor controls the chirp rate, and thus controls the speed of data transmission. **Lower spreading factors** mean **faster chirps** and therefore a **higher data transmission rate**. For every increase in spreading factor, the chirp sweep rate is halved, and so the data transmission rate is halved.
- Lower spreading factors reduce the range of LoRa transmissions, because they reduce the processing gain and increase the bit rate. Changing spreading factor allows the network to increase or decrease data rate for each end device at the cost of range.

Noise Floor for LoRaWAN

Normally the noise floor is the physical limit of sensitivity, however LoRa works below the noise level.

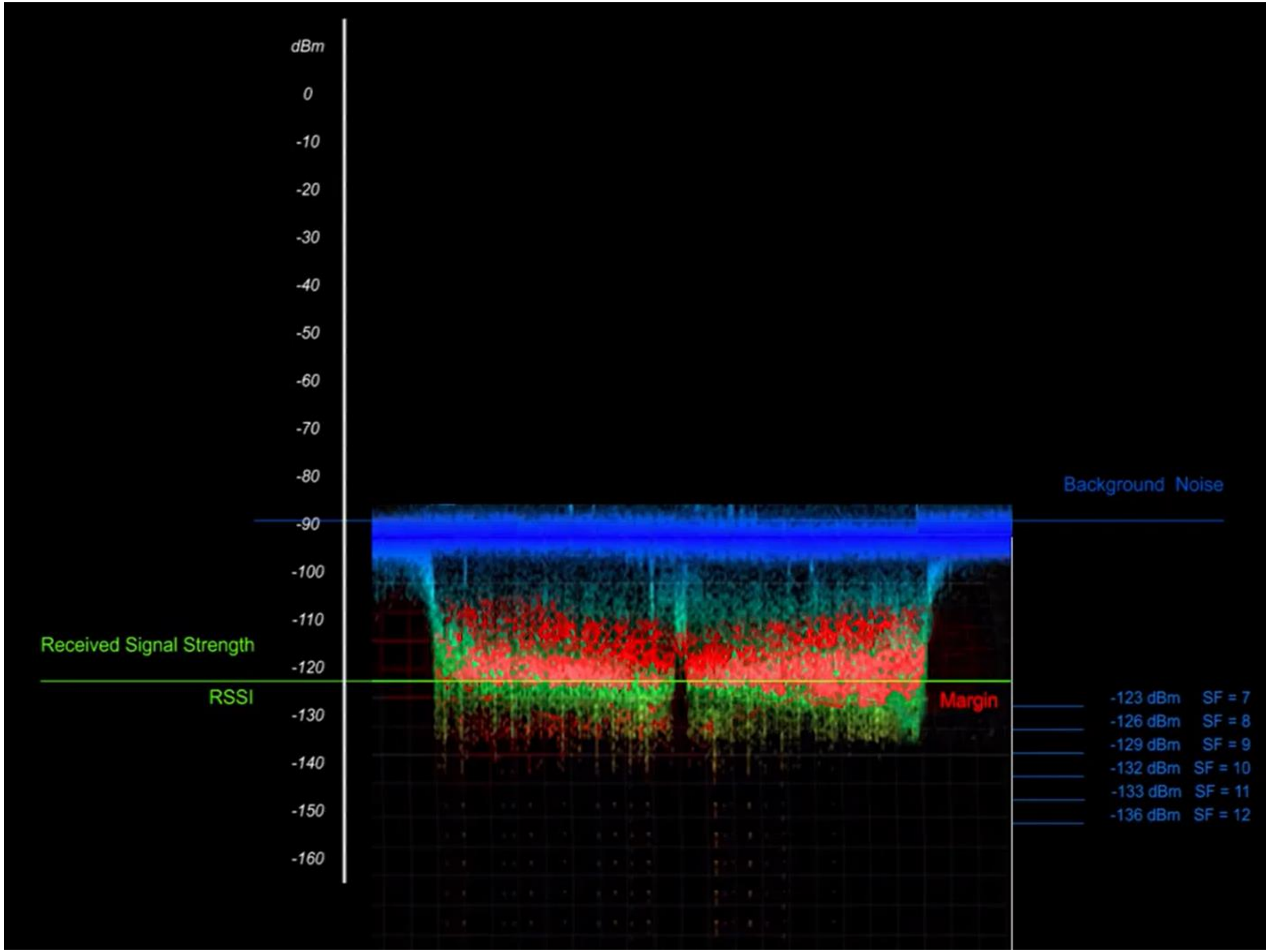
Typical LoRa SNR values are between: -20dB and +10dB

A value closer to +10dB means the received signal is less corrupted.

LoRa can demodulate signals which are -7.5 dB to -20 dB below the noise floor.

SNR (dB) = $P_{received\_signal}$ (dBm) - P_{noise} (dBm)

SNR (dB) = -120 dBm -(-90 dBm) = -30 dB



Izvor: https://www.thethingsnetwork.org/docs/lorawan/rssi-and-snr/

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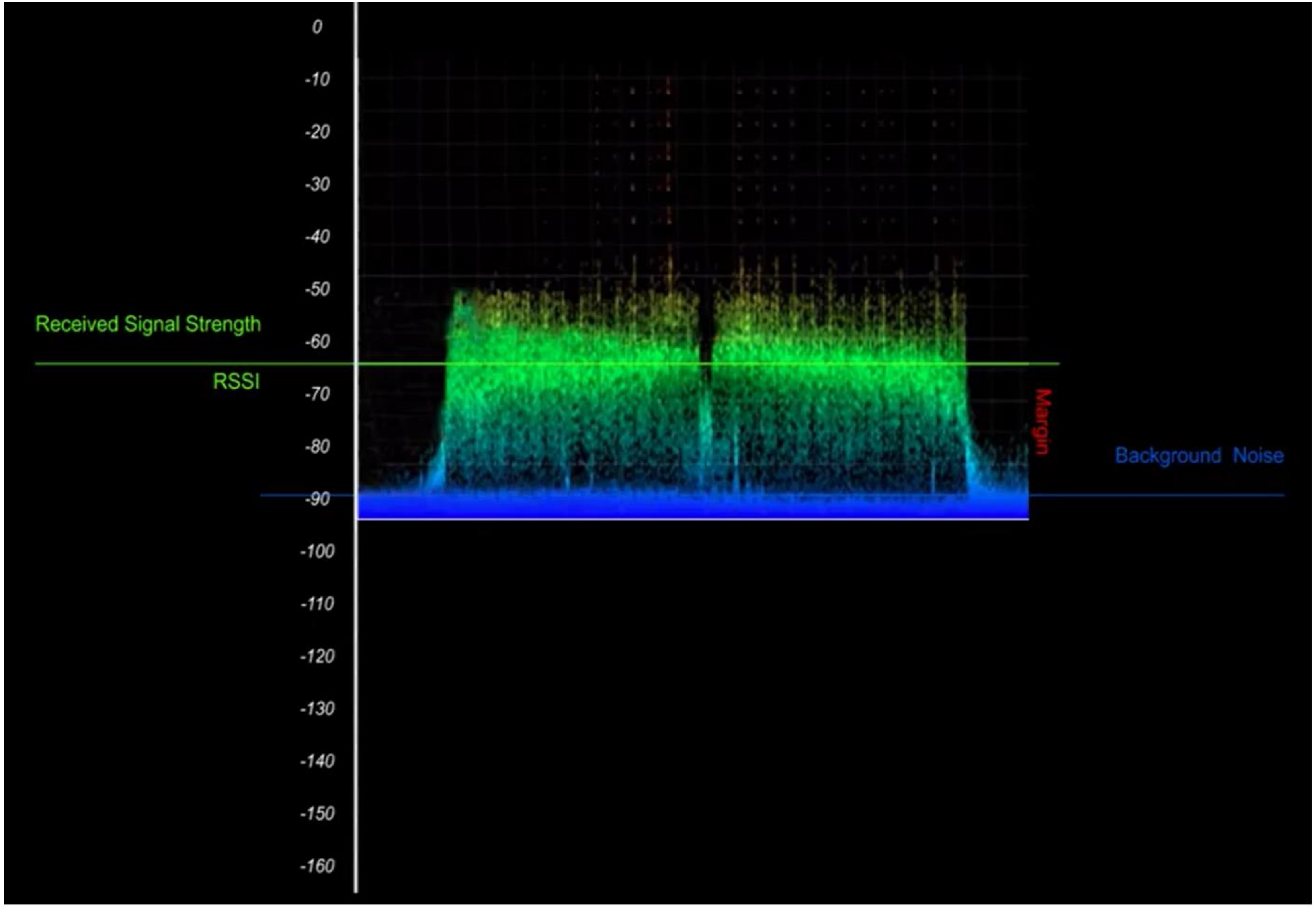
Noise Floor for LoRaWAN

SNR as follows:

SNR (dB) = $P_{received\_signal}$ (dBm) - P_{noise} (dBm)

SNR (dB) = -65 dBm -(-90 dBm) = 25 dB



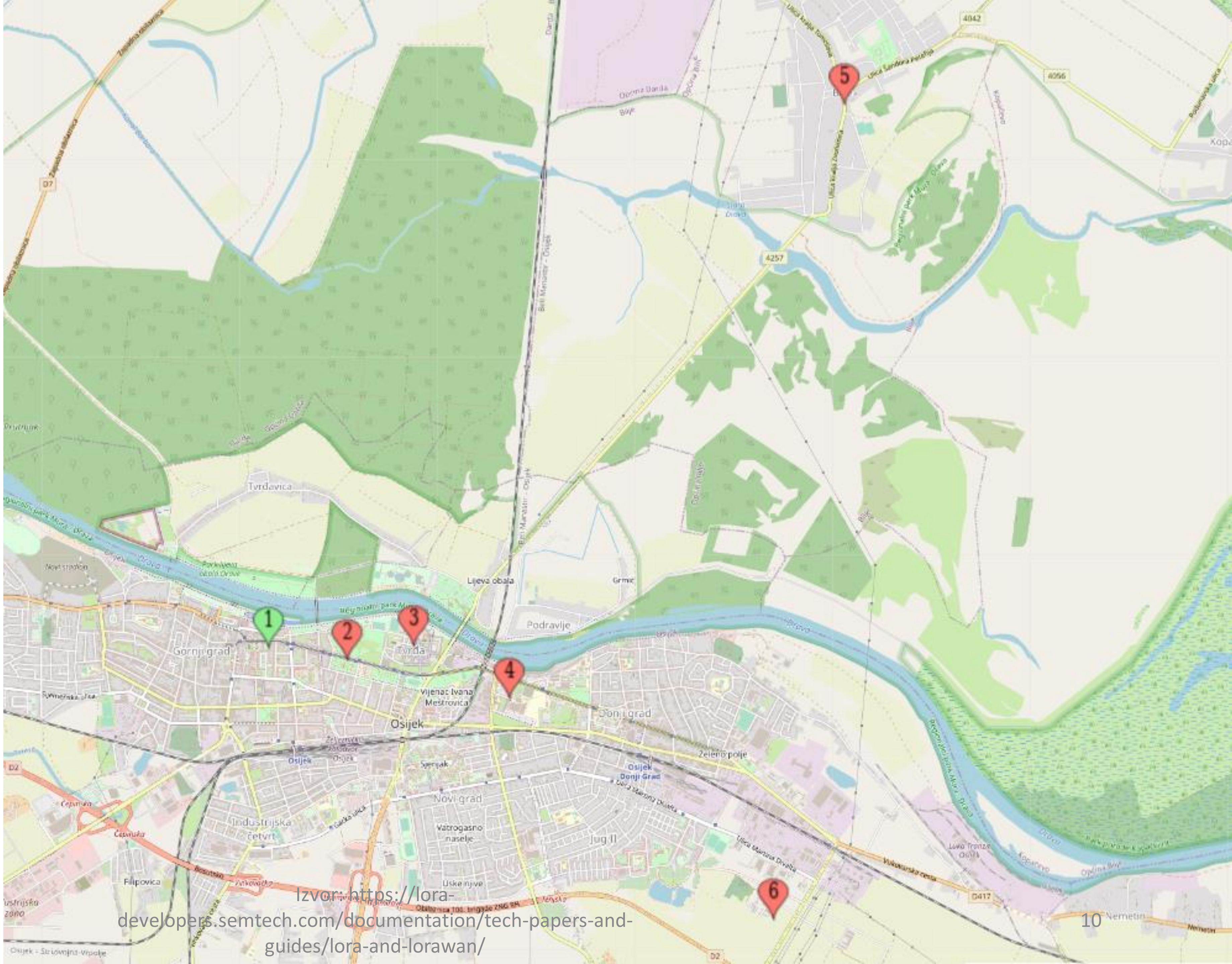
Izvor: https://www.thethingsnetwork.org/docs/lorawan/rssi-and-snr/

Experiment Setup

- Measurements of RSSI and SNR were made using an RFM95 LoRa module.
- Each measurement is the result of a different combination of LoRa parameters. (e.g. SF7 CR4/5 +14dBm).
- Each combination was tested as five packages (10 bytes) were sent to the receiver, which reported the RSSI and SNR of the transmission
- An average of all five transmissions was calculated for the RSSI and SNR, and several unsuccessful transmissions were noted

Experiment Locations

- Experiments for this research were conducted in Osijek and Bilje.
- The gateway position and the reference point for measurements was Hotel Osijek (1).
- Measurements were conducted at six different locations.



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Results

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Combination	1	2	3	4	5	6	7	8
50 m reference point								
Gain (dBm)	14	14	14	14	20	20	20	20
SF	7	7	10	10	7	7	10	10
CR	5	8	5	8	5	8	5	8
Average RSSI	-82,6	-81	-79,8	-80,6	-82,24	-82,6	-82,6	-82,6
Average SNR	9,44	9,76	9,46	9,86	9,3742	9,06	9,18	10,2
Unsucessful transmissions	0	0	0	0	0	0	0	0
680 m urban area								
Gain (dBm)	14	14	14	14	20	20	20	20
SF	7	7	10	10	7	7	10	10
CR	5	8	5	8	5	8	5	8
Average RSSI	-108,8	-102,8	-102,2	-105,4	-106,8	-104,4	-105,2	-108
Average SNR	3,4	7,68	6,5	7,52	6,16	7,88	5,9	5
Unsucessful transmissions	0	0	0	0	0	0	0	0
1,3 km urban area								
Gain (dBm)	14	14	14	14	20	20	20	20
SF	7	7	10	10	7	7	10	10
CR	5	8	5	8	5	8	5	8
Average RSSI	-108,5	-109,6	-109,8	-111,4	-108	-107,6	-106	-104,8
Average SNR	0,45	4,4	1,48	3,46	4,58	5,96	2,94	6,46
Unsucessful transmissions	1	0	0	0	0	0	0	0
2 km urban area								
Gain (dBm)	14	14	14	14	20	20	20	20
SF	7	7	10	10	7	7	10	10
CR	5	8	5	8	5	8	5	8
Average RSSI	-116,5	-117	-116	-113,6	-117,3	-117,3	-115,6	-116,6
Average SNR	-8	-4,8	-9,7	-9,7	-5,4	-5,4	-8,5	-8,38
Unsucessful transmissions	3	4	2	0	2	2	2	0
5 km suburban area								
Gain (dBm)	14	14	14	14	20	20	20	20
SF	7	7	10	10	7	7	10	10
CR	5	8	5	8	5	8	5	8
Average RSSI	-118,5	-115	-119	-117,5	-117	-118,2	-117	-117
Average SNR	-8	-9,5	-11,8	-8,15	-7,2	-6,875	-11,6	-11,85
Unsucessful transmissions	3	4	2	1	3	1	3	1
5 km rural area								
Gain (dBm)	14	14	14	14	20	20	20	20
SF	7	7	10	10	7	7	10	10
CR	5	8	5	8	5	8	5	8
Average RSSI	-117	-114,5	-116,2	-110	-115,7	-115,2	-113	-115
Average SNR	-5	-2,95	-2,75	-5,62	-4,65	-2,9	-2,7	-3,44
Unsucessful transmissions	4	1	1	0	1	0	2	0

Results

Combination 1 of parameters results in low signal strength on all distances.

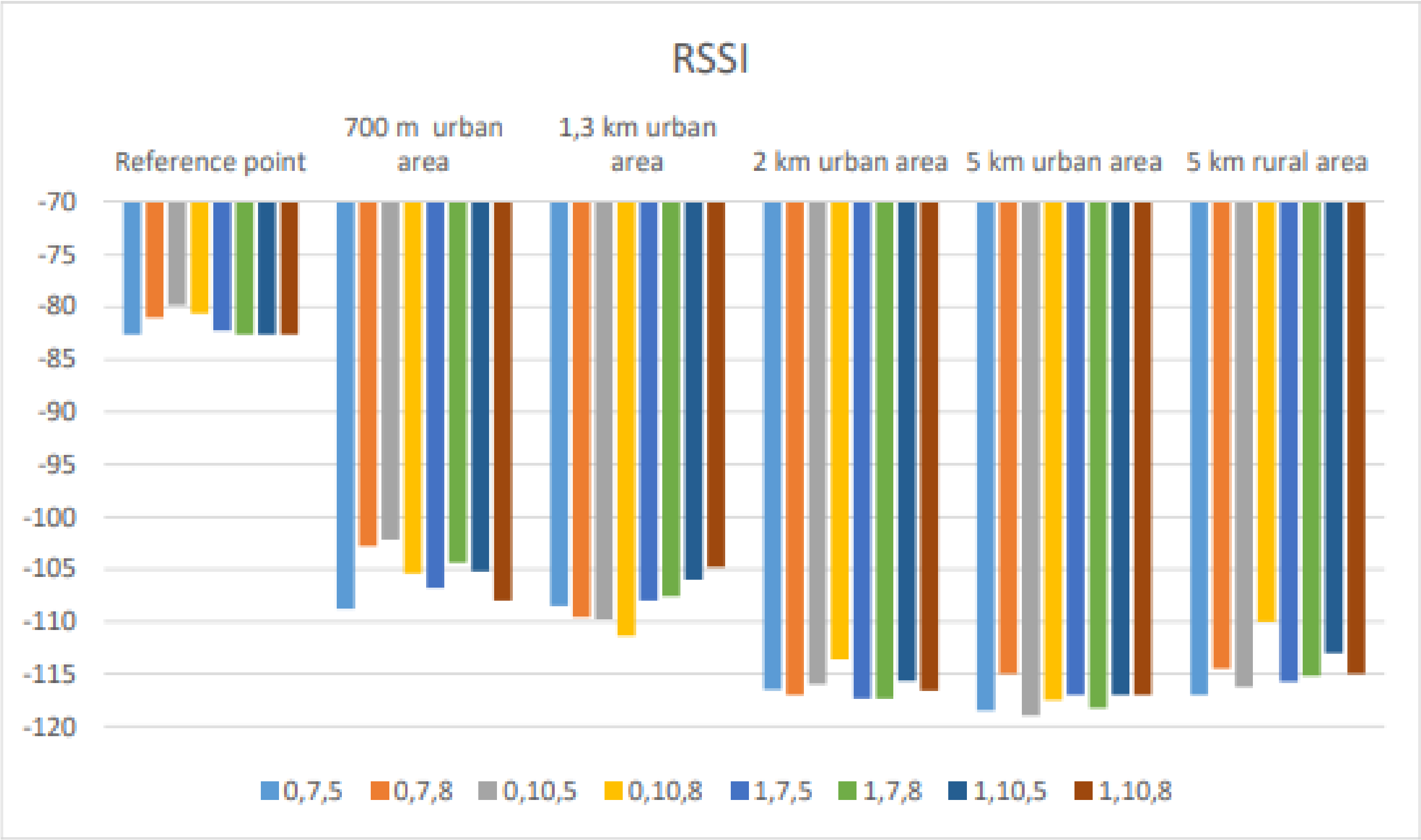
Combination 2, while similar to the first combination, results in higher RSSI on shorter distances.

Combination 3 shows the best signal strength on low distances, while longer distances are similar to the first two combinations.

Combination 4 is variable but results in the best RSSI in long-distance rural areas.

Combinations 5 and 6 result in similar values of RSSI.

Combinations 7 and 8, while not having high RSSI on low distances, give better results over larger distances.



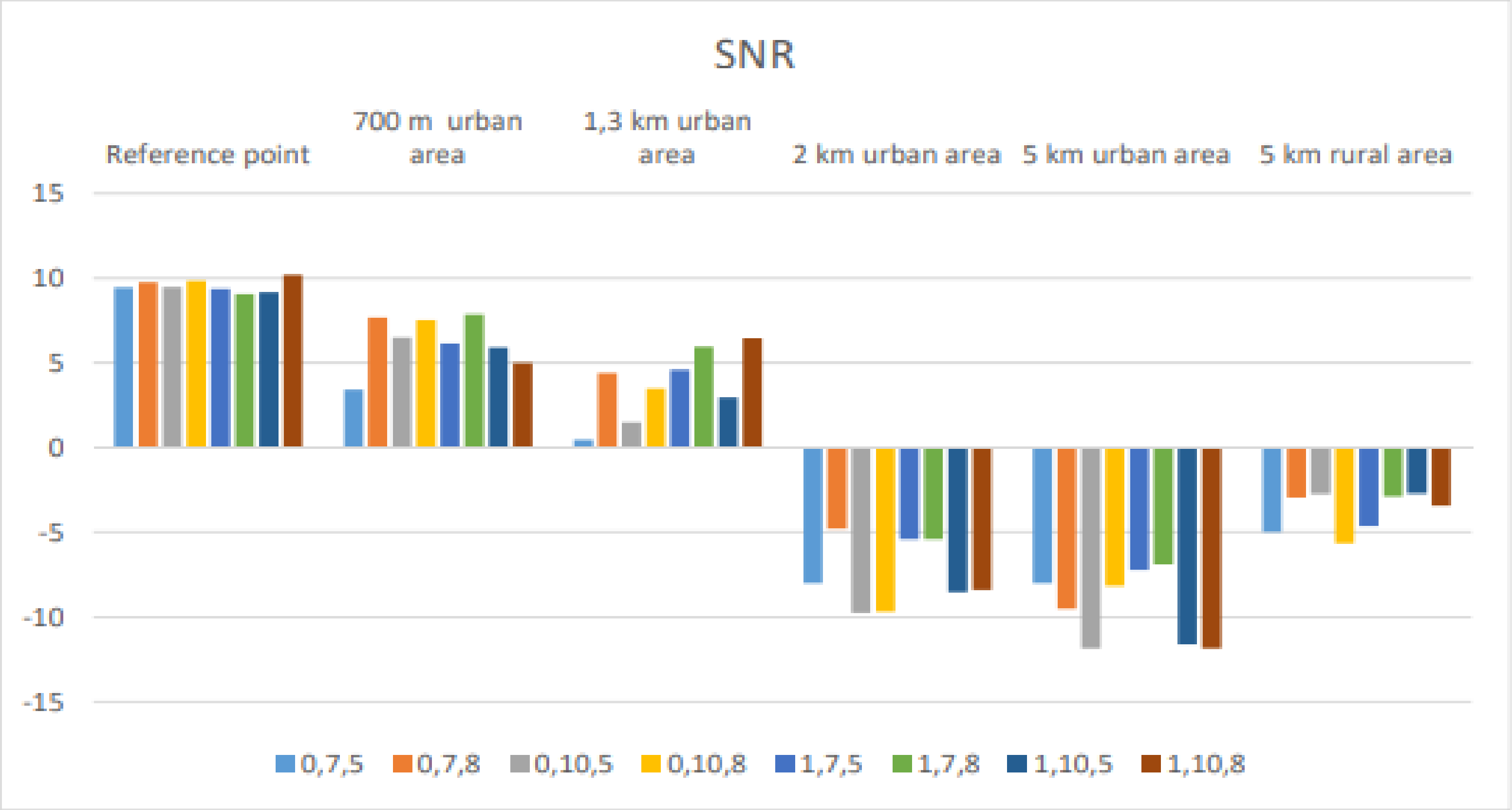
Results

Considering SNR, it is expected to have significantly lower values in urban areas than in rural areas, as seen in Figure 2. SNR values for all combinations at a distance of 700 m have lower values then at a reference point where it can be seen how objects influence the SNR.

At a distance of 1.3 km in urban areas, SNR values drop as expected.

Combinations 6 and 8 show the best noise resistance, while it can be seen that combinations

At distances of 2 and 5 km in urban areas, SNR values drop in negative regions, which show significant noise interference at longer distances in urban areas.



Conclusion

- For longer distances and objects interfering with the signal, LoRa communication is highly prone to unsuccessful transmissions
- In urban areas, RSSI is variable and at a distance of 5 km it can be seen that RSSI is close to -120 dBm which means that 5 km is the edge of range in urban and suburban areas.
- Unlike urban areas, RSSI measured in rural area of 5 km is slightly better which means that communication is possible on longer distances.
- It can be concluded that higher values of SF and higher values of CR are crucial for successful LoRa communication on longer distances.
- Future work - During the vegetation season of 2022. we collected more than 50k data points about LoRa RSSI and SNR, next step is to process data and find new conclusions about the optimization of LoRaWAN communication.

To Sum Up – Why LoRaWAN in Agriculture?

- **COST REDUCTION**
- **ABILITY TO COLLECT DATA OVER A LONG DISTANCE**
- **EASE OF DEPLOYMENT**
- **REDUCTION OF POSSIBLE DANGER FOR CROPS AND FARMERS**
- **INCREASED CONNECTIVITY**
- **POSSIBILITIES FOR PREDICTIVE ANALYTICS**
- **INCORPORATION OF ARTIFICIAL INTELLIGENCE**

Izvor: https://www.tektelic.com/expertise/smart-agriculture-devises-and-solutions/

Thanks for Your Attention