Field experiments with multiple "Smart Village" applications over the private LoRa Mesh network in Sri Lanka

APAN 59 IoT Working Group

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Telecom for Basic Human Needs

1. Back Ground

Impact of Flash Floods in Sri Lanka

“Flash floods are responsible for most of the deaths caused by Flooding. Floods arrive with little warning and do not permit people to reach high ground away from the path of the oncoming flood. They sometimes tend to overestimate the time taken for the flood to arrive and underestimate the magnitude of the flood, to their peril.”

UNDP BOOK CHAP 04

Problem Statement No. 1

Urban Migration in Sri Lanka

A big challenge is to manage emergencies faced by the parents/elderly, when the children are working in the cities.

Role of Midwives in Rural Areas

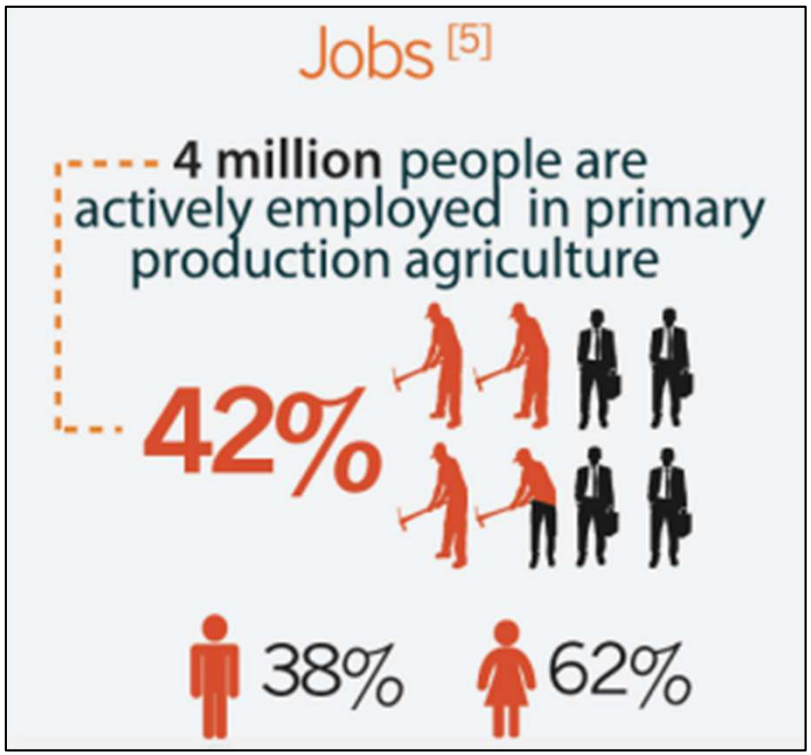
Therefore, ensuring contact between the pregnant mother and midwives is vital.

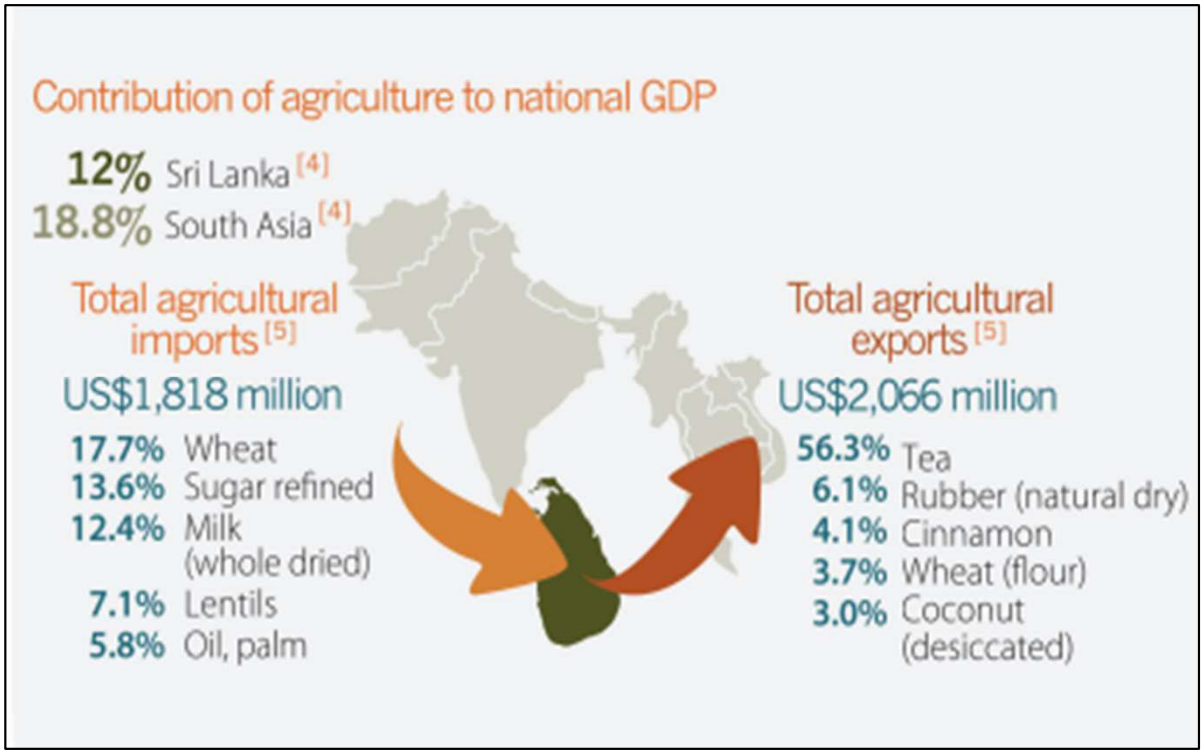
Problem Statement No. 2

Transformation to smart agriculture

The food systems of Sri Lanka require transformation. Emerging technological innovations have the potential to overcome the structural weaknesses of current agricultural systems and deliver a more productive, competitive, and sustainable outcome, using a more precise and resource-efficient approach.

DEVELOPMENT ASIA
An initiative of Asian Development Bank





Problem Statement No. 3

2. Project Over View

Demonstration project of a sensor based system for disaster mitigation, supporting the safety and security of the community and smart agriculture using general-purpose equipment.

1) **The system to be realized must be able to function in the event of a disaster, and be usable by residents in normal times.**

2) **Special feature: No custom-designed equipment.** The core control unit is a commercially available Raspberry 3B with Sensor NerveNet and sensor data acquisition stored within the unit.

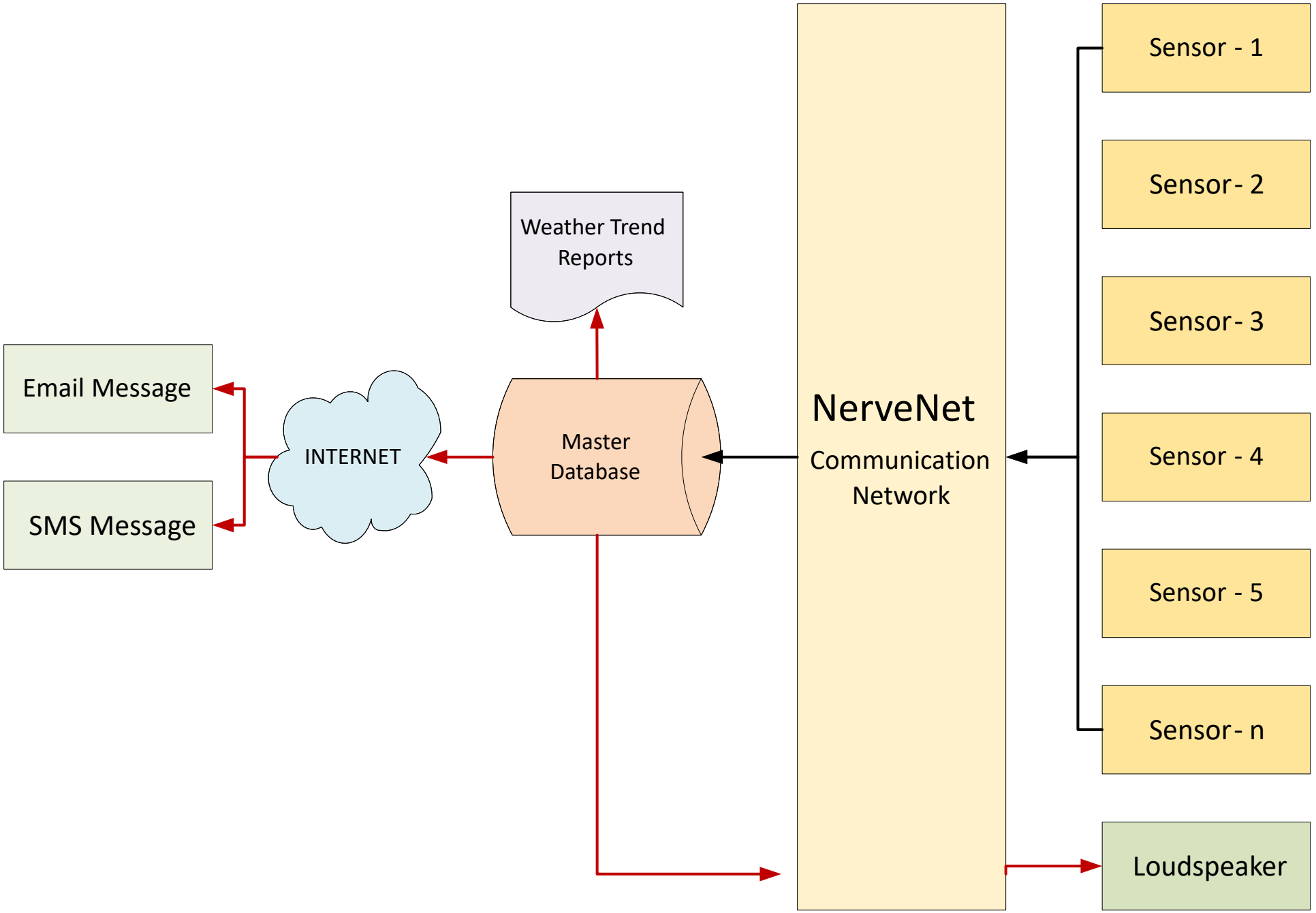
3) The system consists of 10 radio stations controlled by the Sensor NerveNet System and connected by a mesh structure. Each radio station is connected to a sensor for data acquisition.

4) The system uses data obtained from various sensors such as alert, rainfall, sunlight, temperature, humidity, water level of river and oxygen monitoring.

5) A commercially available 920 MHz band LoRa wireless module is used for wireless communication, and the system is designed to include a combination of general-purpose components.

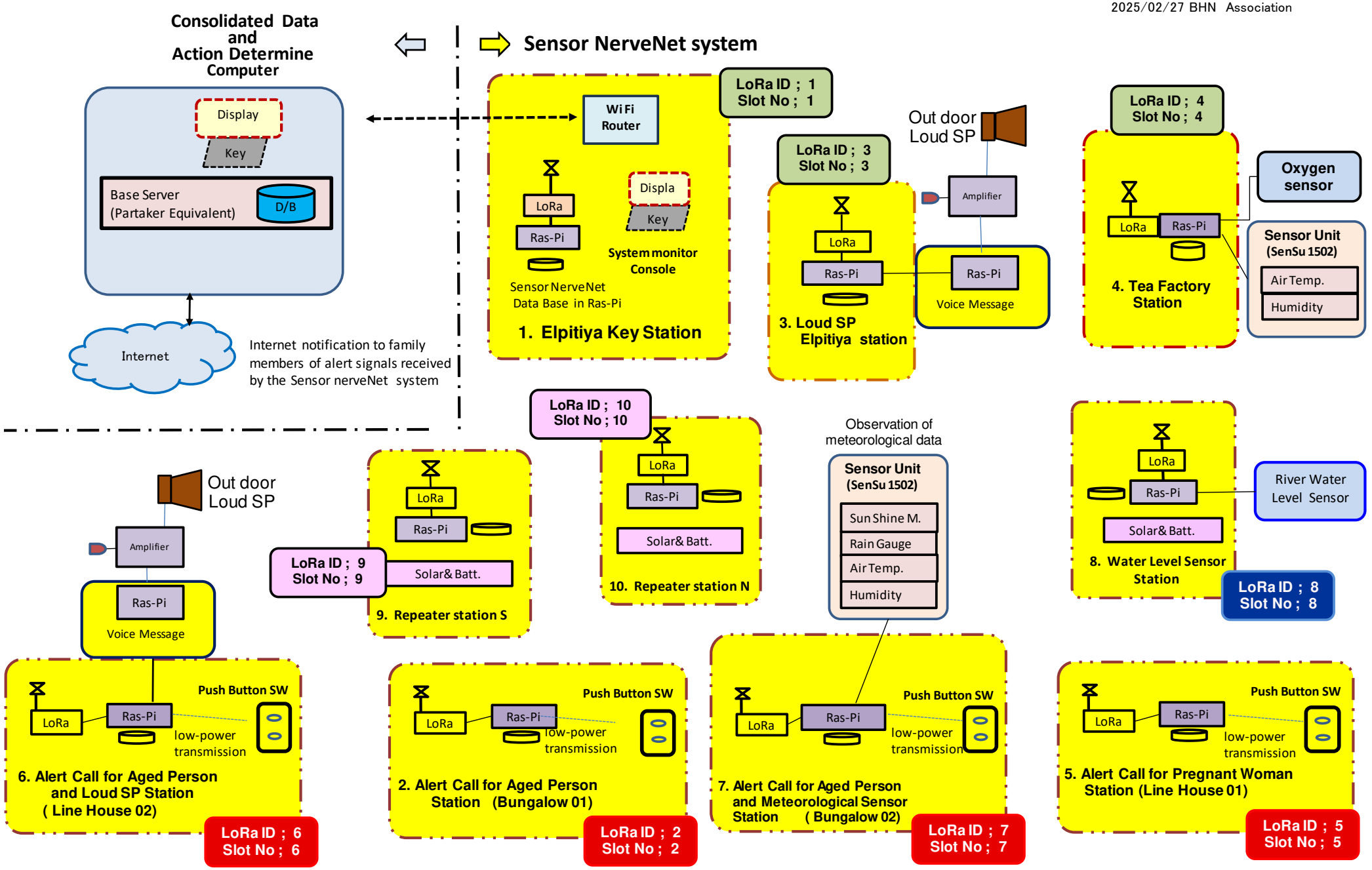
Location Elpitiya, a suburb of Kandy, Sri Lanka.

Overview of the IoT Solution



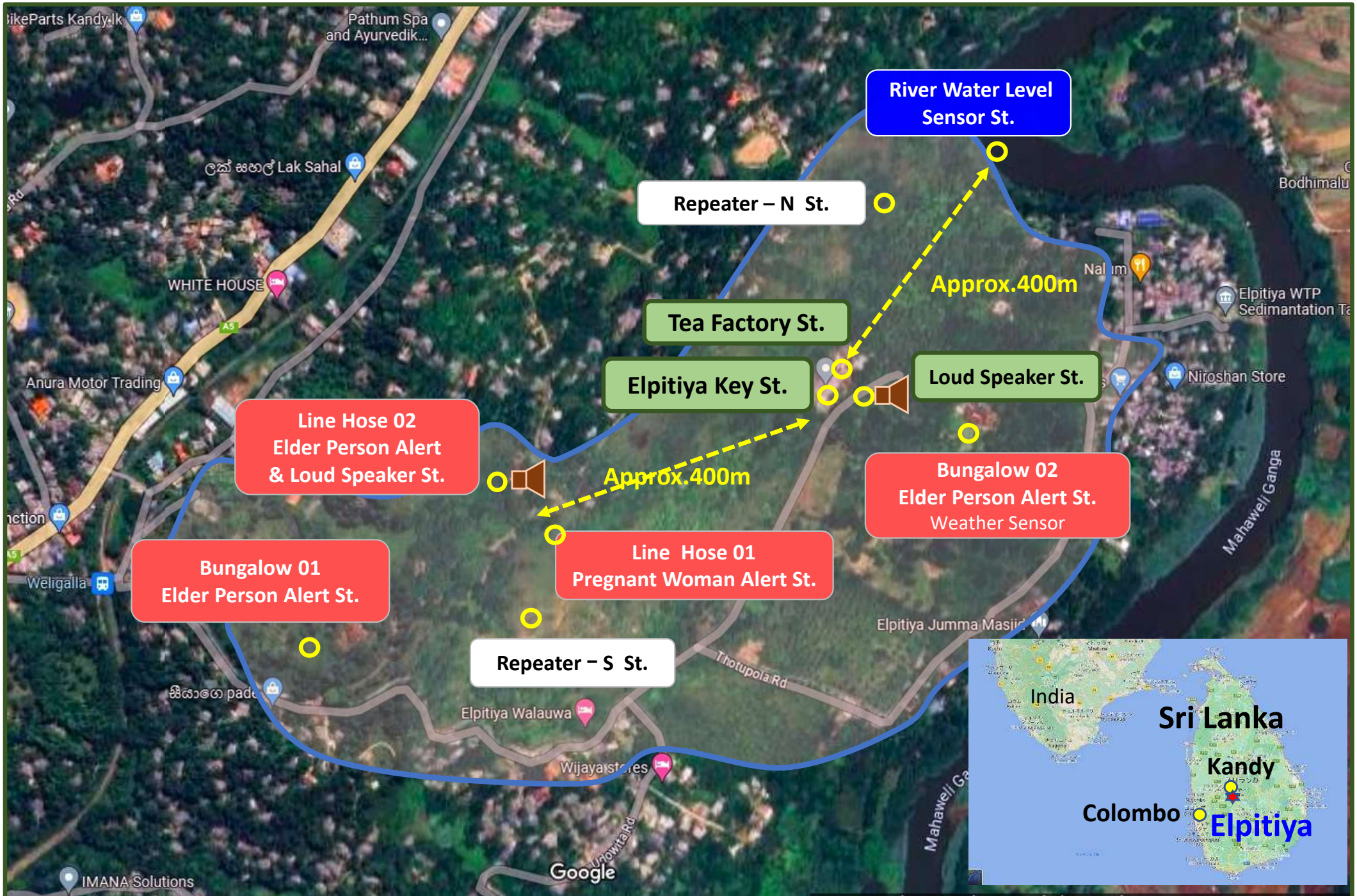
System Configuration

2025/02/27 BHN Association

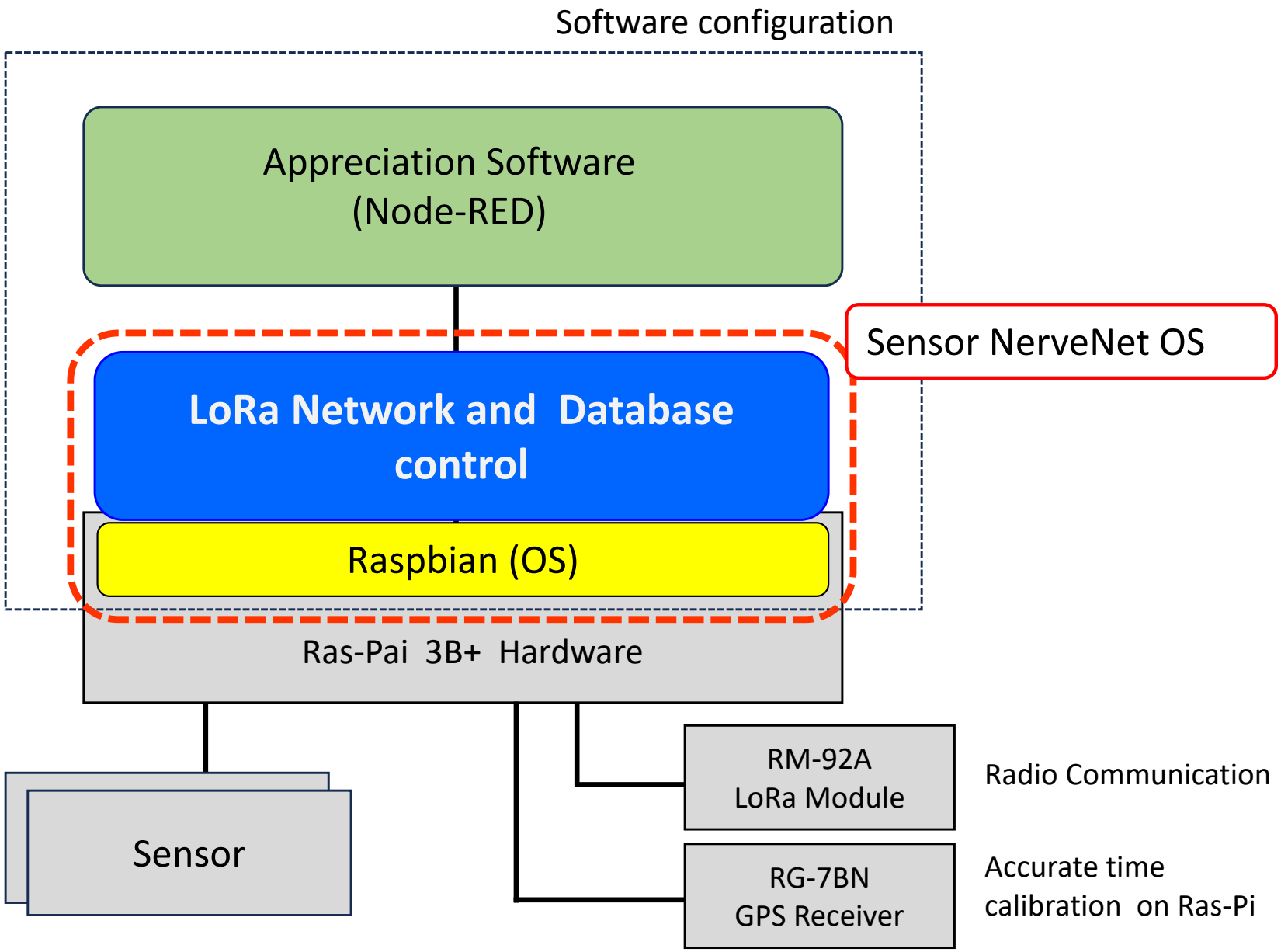


3. System details

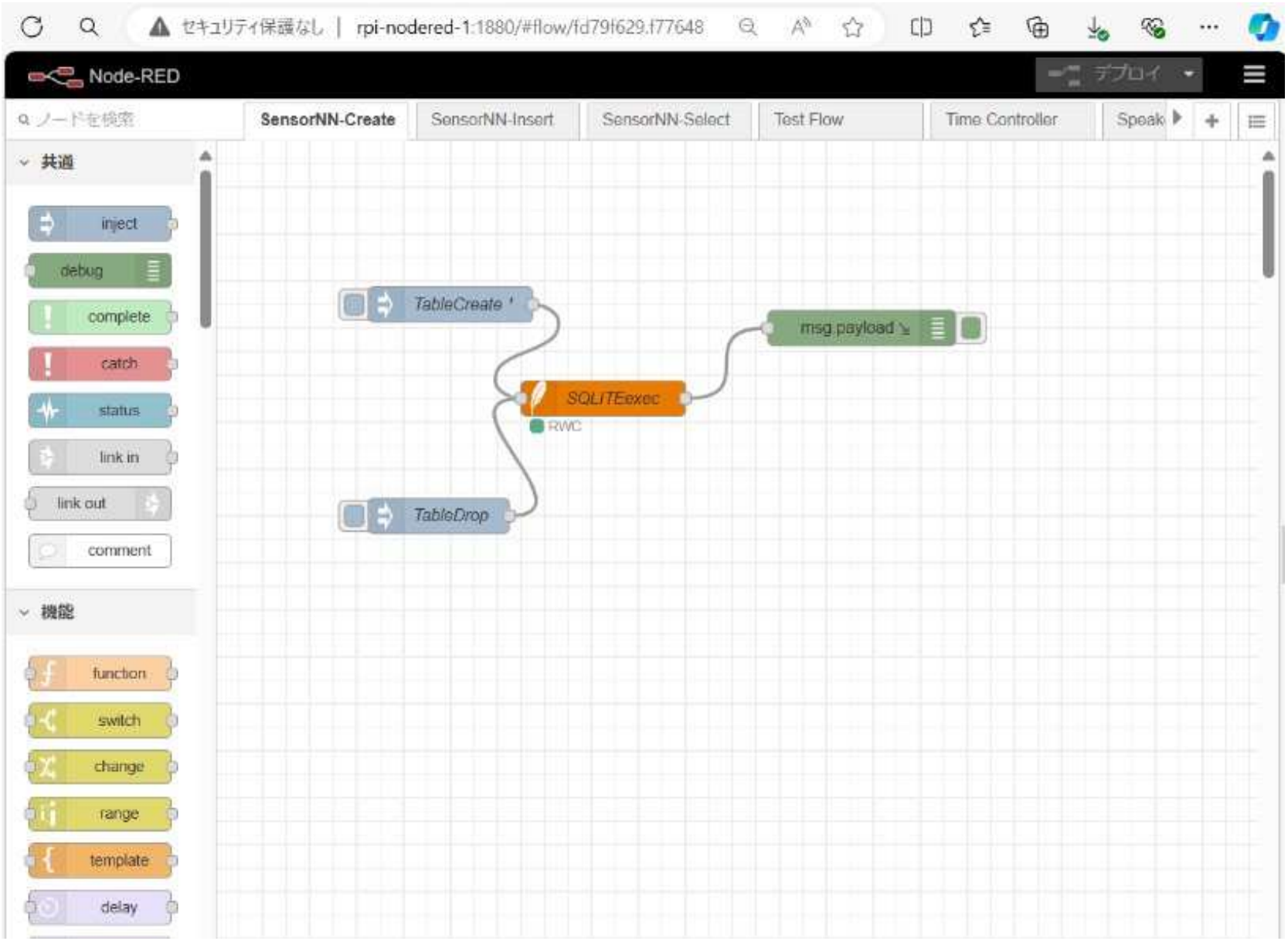
system Layout map



Software configuration of Sensor NerveNet Terminal



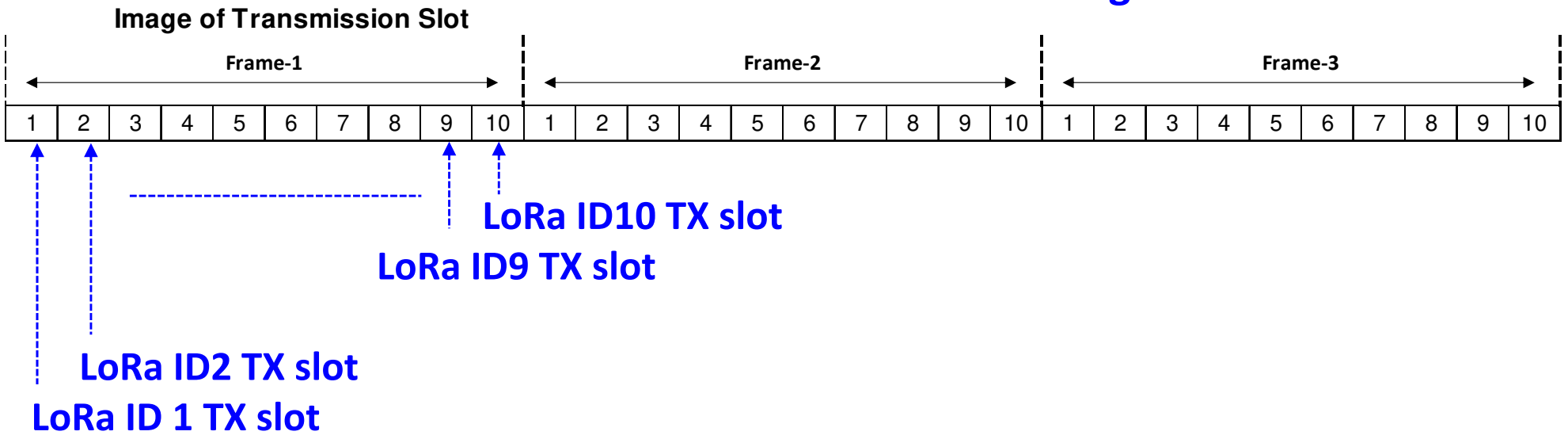
Application software design using Node-Red



Radio Communication Method

This system uses the low-speed **Time Division Multi Access system** as the radio communication method, adopting a mesh structure, which enhances resilience in the event of a disaster.

One Frame time length : 60 seconds
One Slot time length : 6 seconds



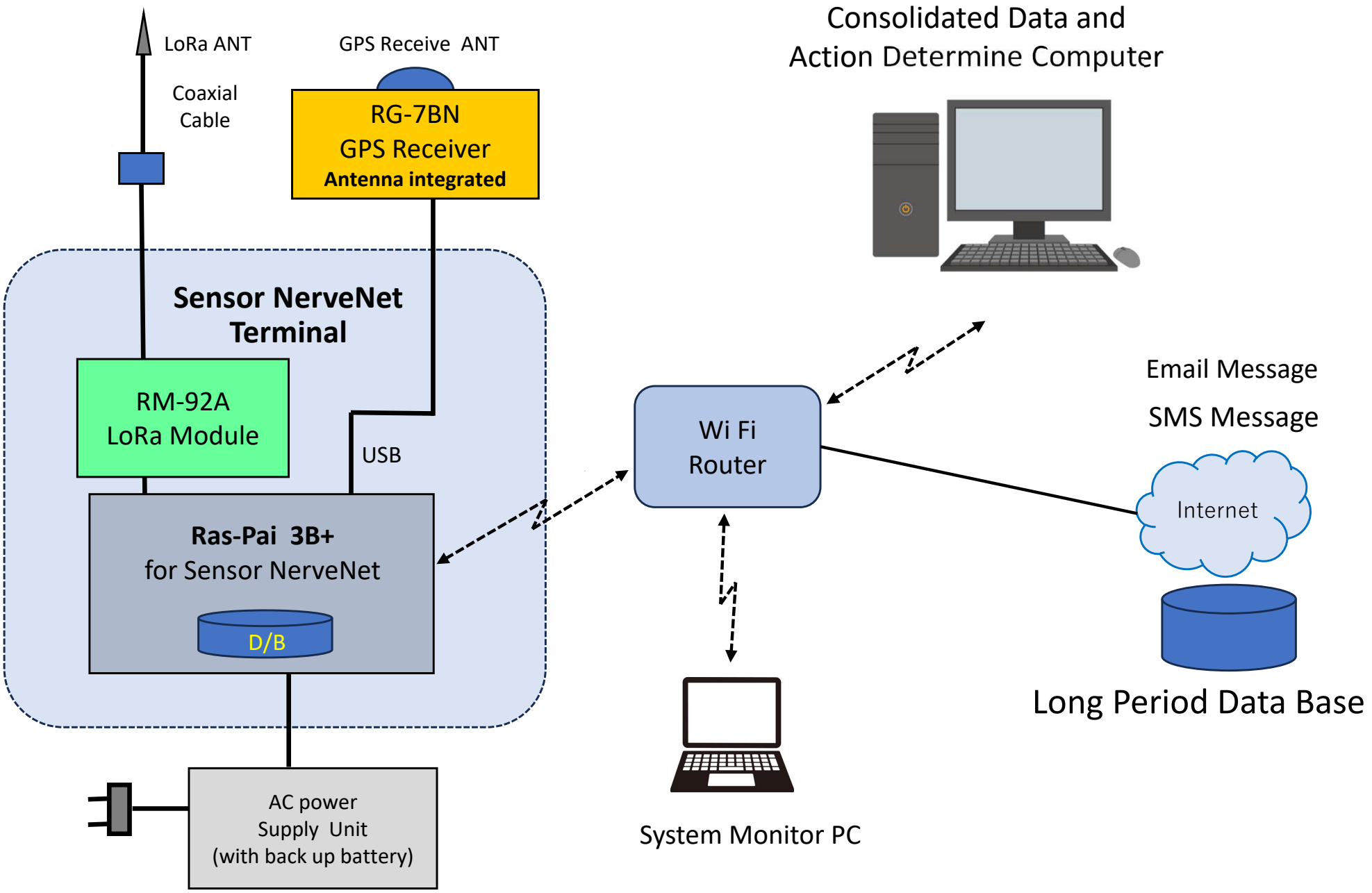
Each radio station assigned LoRa ID 1 to 10 is allowed to transmit only to its own ID number slot. This avoids transmission collisions and realizes reliable radio communication.
To control the time of this TDMA, the Ras-Pi clock is calibrated with the accurate time obtained from GPS.

Communication Speed of LoRa (Bandwidth 125KHz)

The LoRa parameters adopted in this project are intended as follows.

SF (Spread Factor)	項目	(BW)BandWidth=125KHz								Receiver Sensitivity
	Coding Rate	CDR=1		CDR=2		CDR=3		CDR=4		
	Optimise	ON	OFF	ON	OFF	ON	OFF	ON	OFF	
SF12	通信速度(bps)	292.97		244.14		209.26		183.11		-137dBm
	転送時間(10byte)ms	2072.58	1908.74	2301.95	2105.34	2531.33	2301.95	2760.7	2498.56	
	転送時間(100byte)ms	5021.7	4366.34	5840.9	5054.46	6660.1	5742.59	7479.3	6430.72	
	転送時間(228byte)ms	9117.7	7809.98	10756.1	9183.23	12934.5	10559.49	14032.9	11935.74	
SF11	通信速度(bps)	537.11		447.59		383.65		335.69		-134.5dBm
	転送時間(10byte)ms	1036.29	954.37	1150.98	1052.67	1256.66	1150.98	1380.35	1249.28	
	転送時間(100byte)ms	2674.69	2347.01	3117.06	2723.84	3559.42	3100.67	4001.79	3477.5	
	転送時間(228byte)ms	5050.37	4231.17	5967.87	4984.93	6885.38	5738.5	7802.88	6492.16	
SF10	通信速度(bps)	976.56		813.8		697.54		610.35		-132dBm
	転送時間(10byte)ms	559.1	518.14	624.64	575.49	690.18	632.83	755.71	690.18	
	転送時間(100byte)ms	1501.18	1255.42	1755.14	1460.22	2009.09	1665.02	2263.04	1869.82	
	転送時間(228byte)ms	2811.9	2279.42	3328.0	2689.02	3844.1	3098.62	4360.19	3508.22	
SF9	通信速度(bps)	1757.81		1464.84		1255.58		1098.63		-129dBm
	転送時間(10byte)ms	320.51	279.55	361.47	312.32	402.43	345.09	443.39	377.86	
	転送時間(100byte)ms	832.51	689.15	975.87	803.84	1119.23	918.53	1262.59	1033.22	
	転送時間(228byte)ms	1590.27	1262.59	1885.18	1491.97	2180.1	1721.34	2475.01	1950.72	
SF8	通信速度(bps)	3125.00		2604.17		2232.14		1953.13		-126dBm
	転送時間(10byte)ms	170.5	150.02	193.02	168.45	215.55	186.88	233.08	205.31	
	転送時間(100byte)ms	477.7	375.3	561.66	438.78	645.63	502.27	729.6	565.76	
	転送時間(228byte)ms	918.02	702.98	1090.05	832.0	1262.08	961.02	1434.11	1090.05	
SF7	通信速度(bps)	5468.75		4557.29		3906.25		3417.97		-123dBm
	転送時間(10byte)ms	100.61	80.13	114.94	90.37	129.28	100.61	143.62	110.85	
	転送時間(100byte)ms	284.93	216.25	336.13	250.1	387.33	286.98	438.53	323.84	
	転送時間(228byte)ms	546.05	397.57	649.47	471.3	752.9	545.02	856.32	618.75	
SF6	通信速度(bps)	9375.00		7812.50		6696.43		5859.38		-118dBm
	転送時間(10byte)ms	57.98	45.18	66.69	51.33	75.39	57.47	84.1	63.62	
	転送時間(100byte)ms	173.18	121.98	204.93	143.49	236.67	164.99	266.42	186.5	
	転送時間(228byte)ms	337.02	229.5	401.54	272.51	466.05	315.52	530.56	358.53	

Elpitiya Key Station

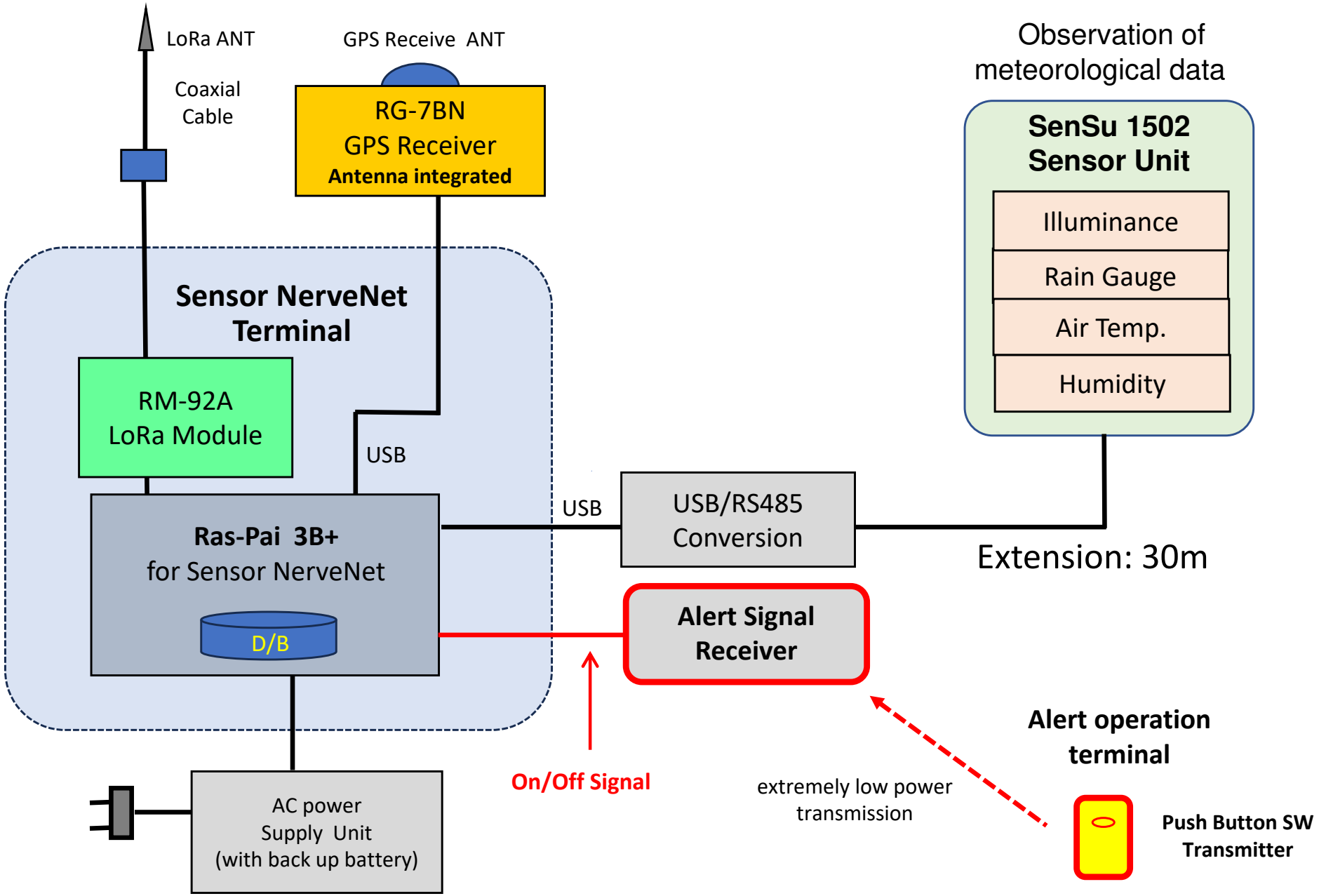


LoRa Radio Module

Specifications

Radio Frequency	920MHz Band
RF output power	20mw
Modification Method	Chirp spread spectrum
	(Frequency Spread Factor FS6 to FS12)
Power consumption	Transmission : 350mA
(5V DC)	Receiving : 20.5mA
	Standby : 0.1 mA

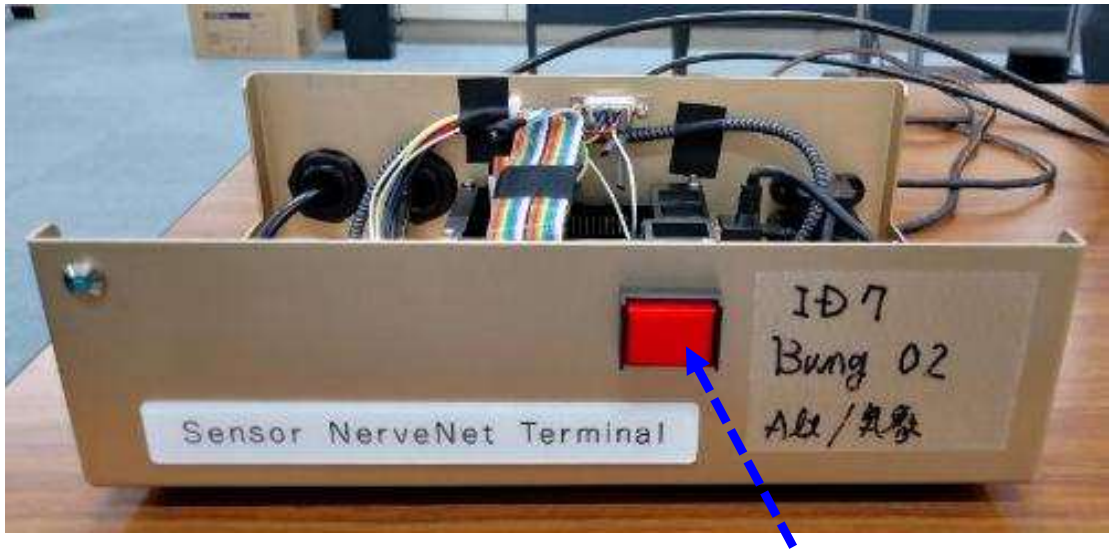
Alert Call for Aged Person and weather Sensor Station 1/2



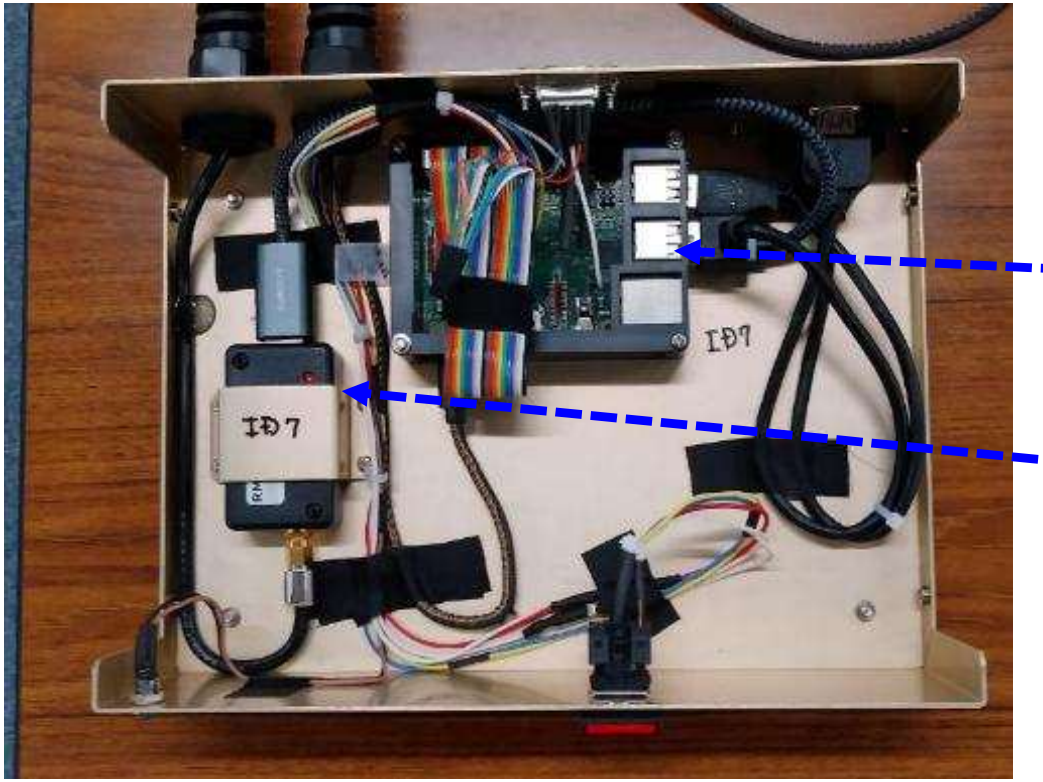
Alert Call for Aged Person and Weather Sensor Station 2/2

Sensor NerveNet Terminal inside

Front View



Alert Transmission SW
and
LED indicator



Ras-Pi 3B+
Control unit

RM-92A
LoRa Module

Main components

SenSu 1502 Weather Sensor

<Sensing function to operate>

Rain gauge

Illuminometer

(sun shine monitor)

Air temperature

Humidity

Digital Communications : RS485

Remote operation Unit for Alert

Remote Controller

Wireless Remote Control Relay Switch

Frequency: 315MHz 1CH

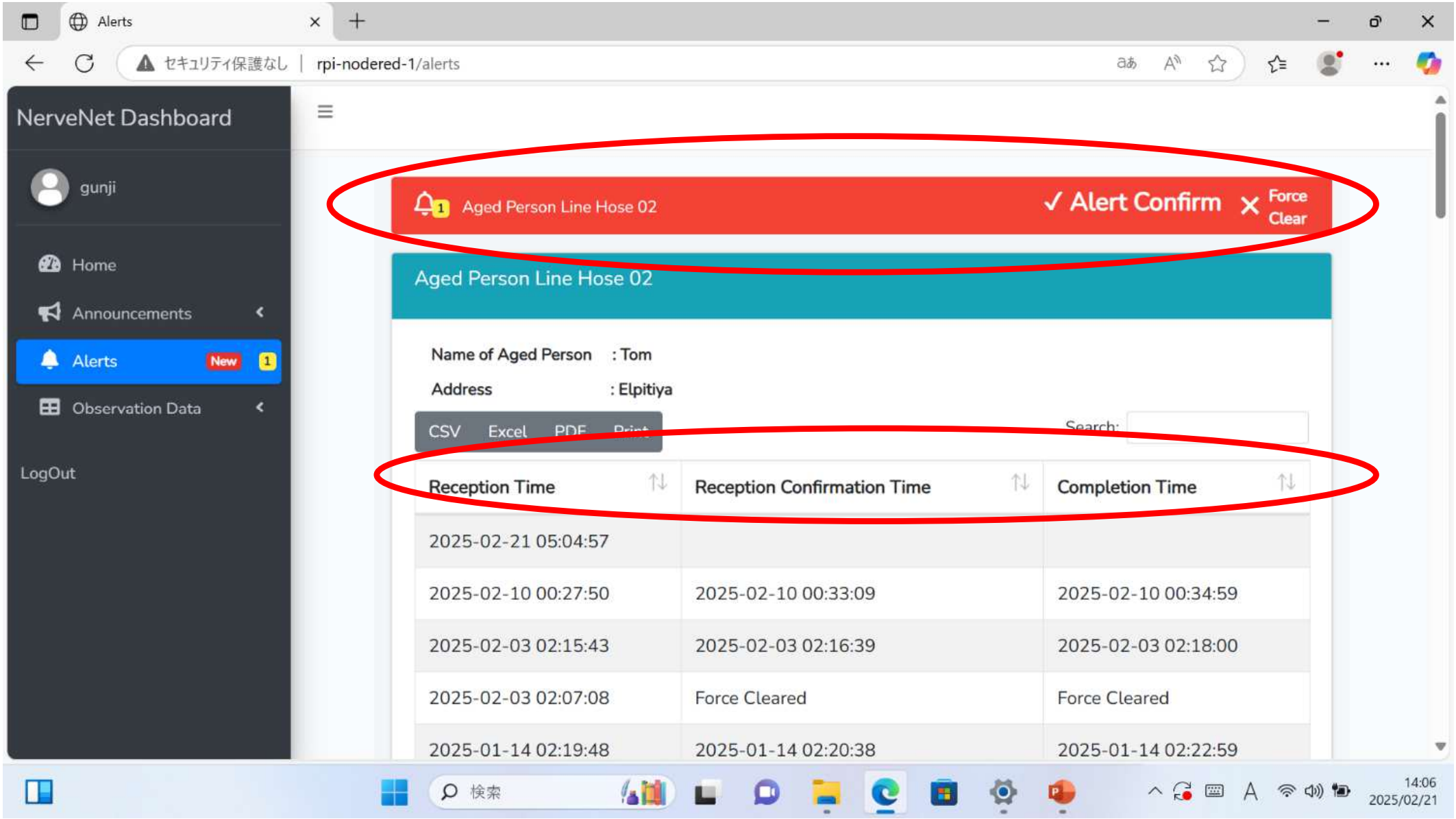
Alert Signal Receiver

Operation terminal

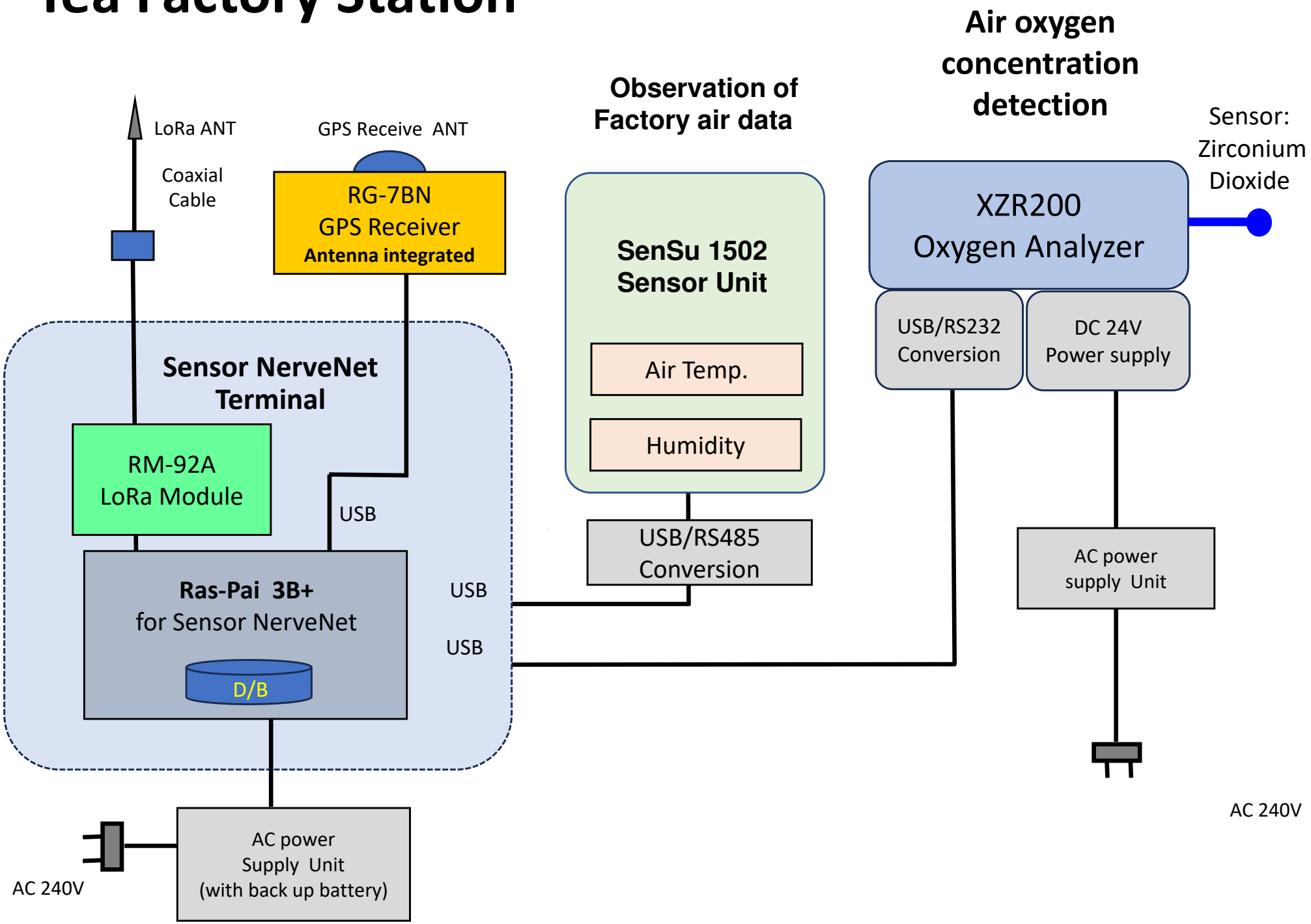
Push Button SW

Transmitter

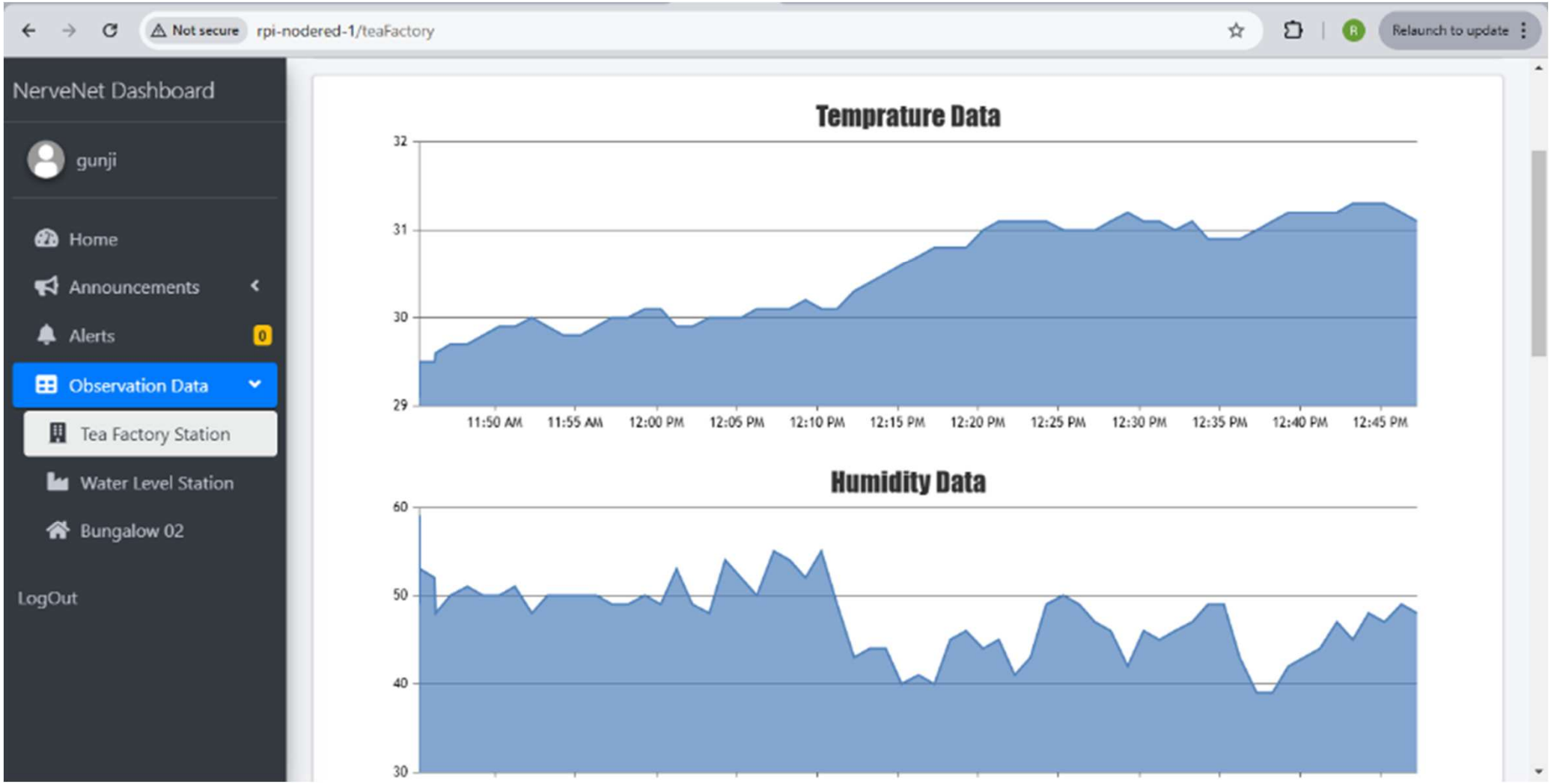
Receiving Alert call 1/2



Tea Factory Station

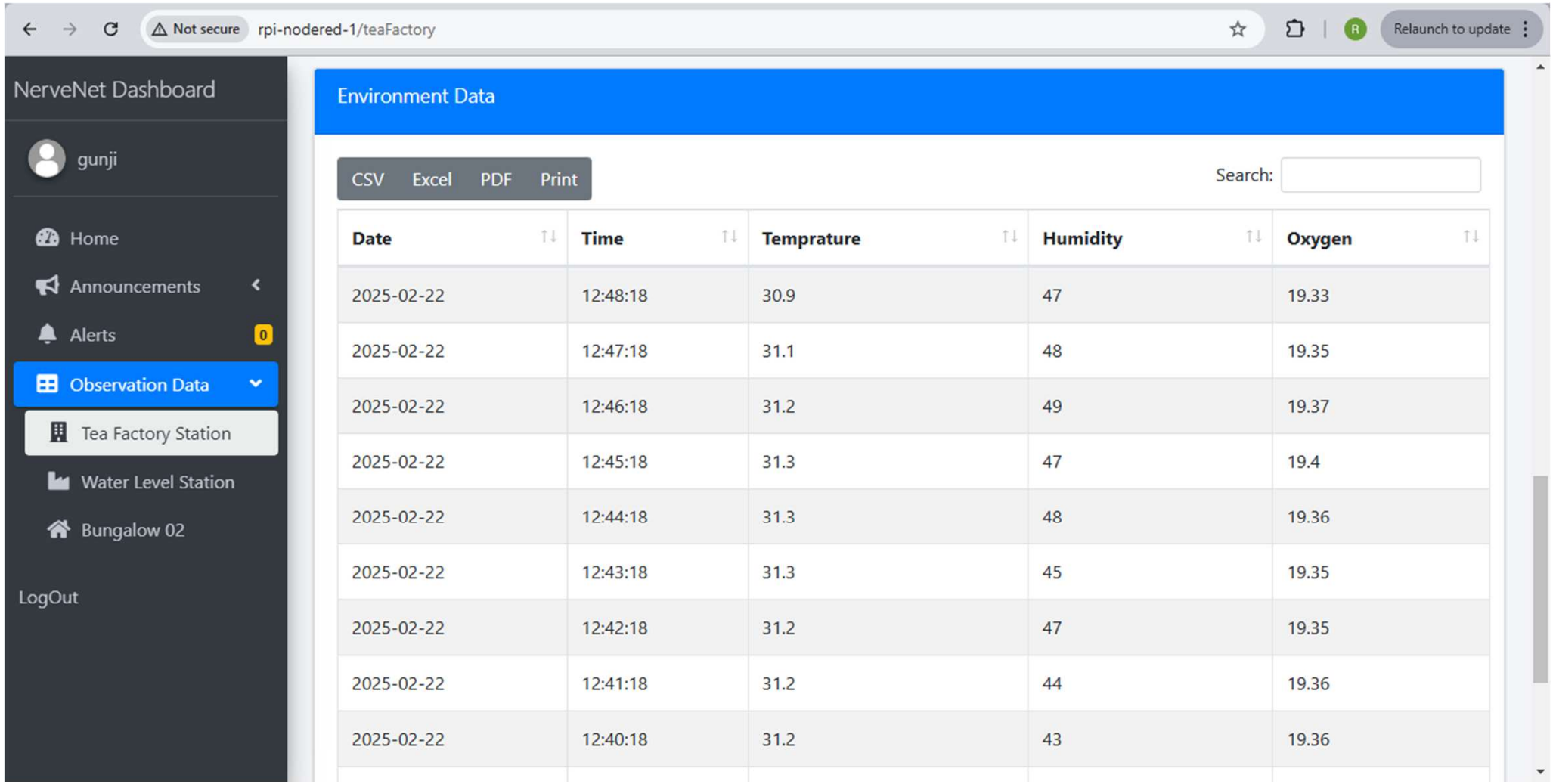


Display of data obtained from Oxygen & Weather Sensor 1/3



Display of data obtained from Oxygen & Weather Sensor 1/2

Display of data obtained from Oxygen & Weather Sensor 2/2



Main components

XZR200 Oxygen Analyzer

<Performance>

Gas : Oxygen

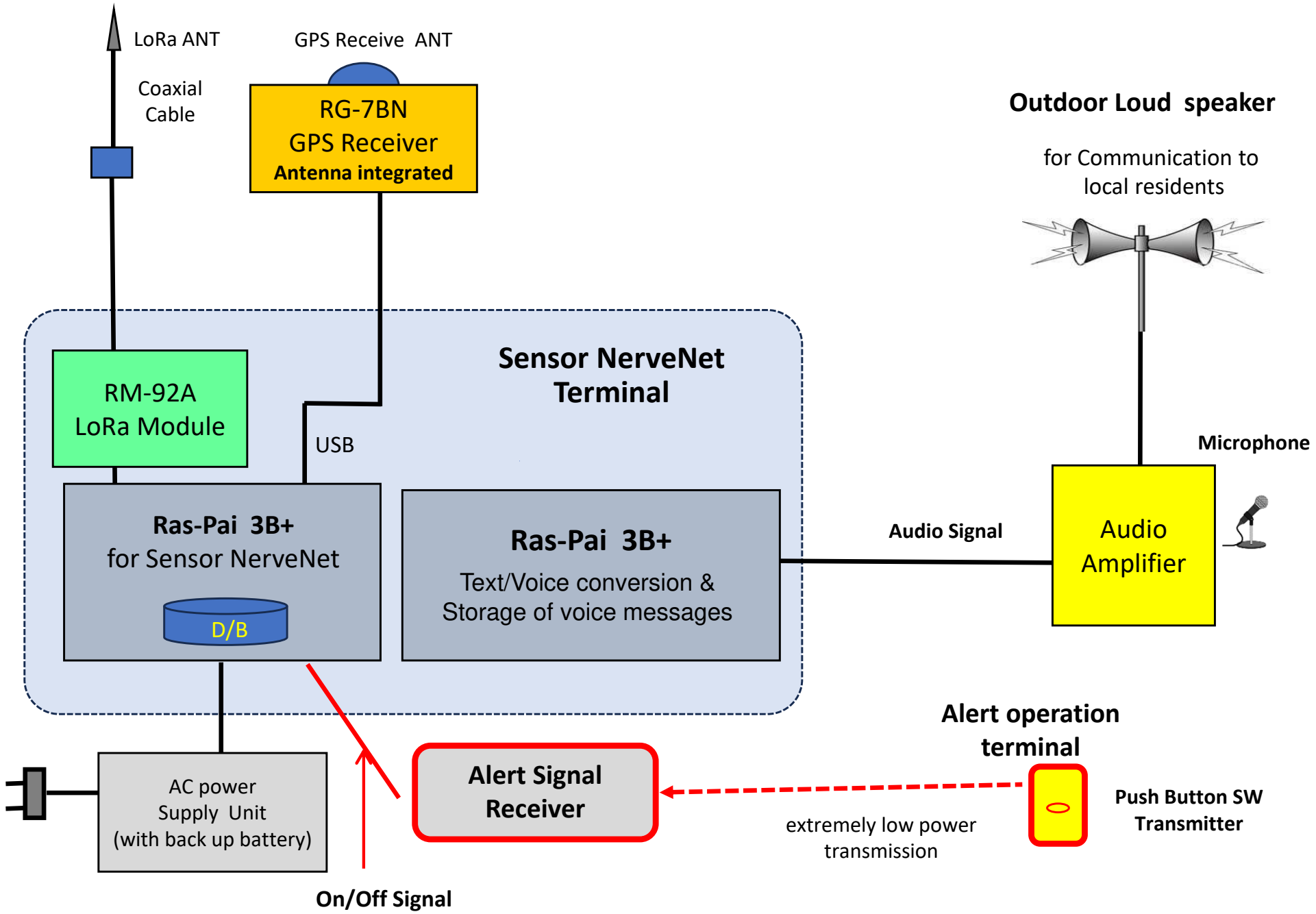
Measurement Range: 0 to 100%

Power supply: 24V 500mA

Digital Communications : RS232C

Sensor device ; Zirconium Dioxide

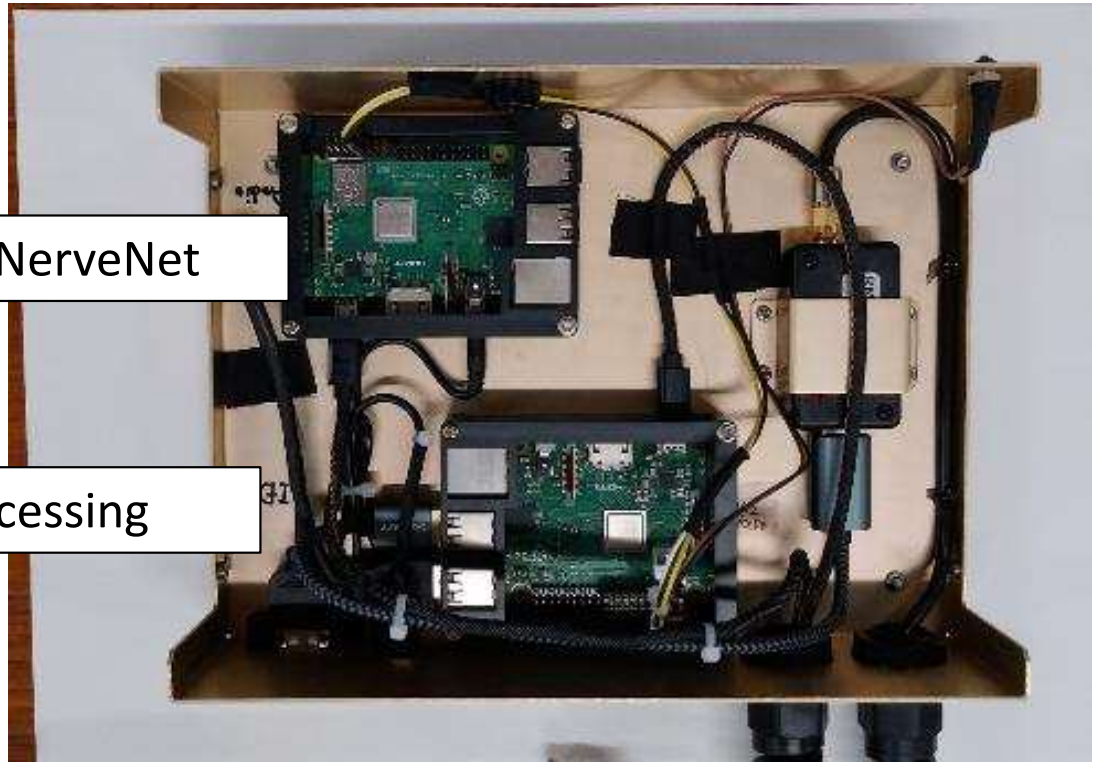
Alert Call and Loud Speaker Station

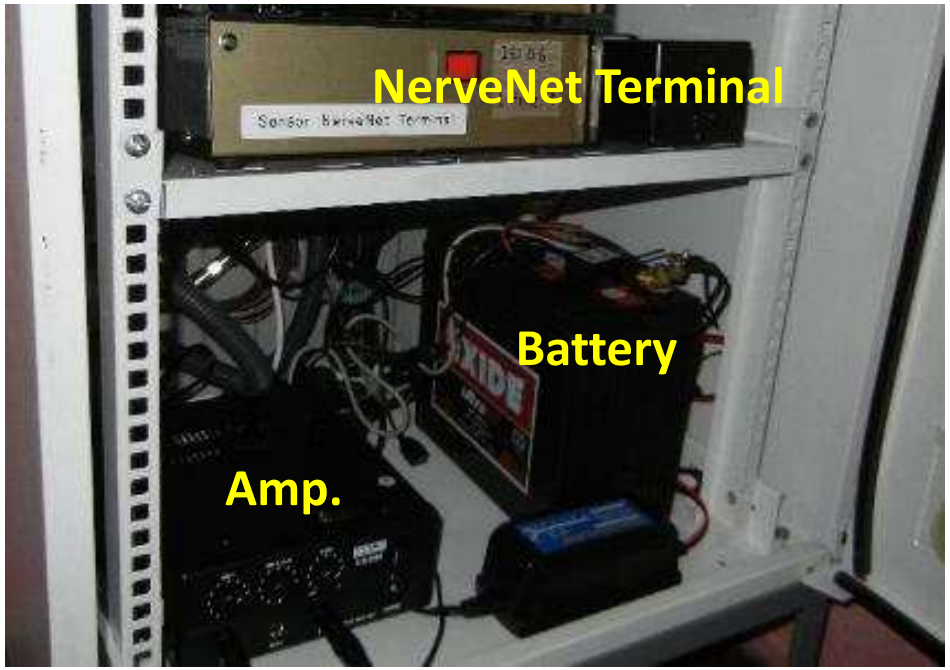


Alert Call and Loud Speaker Station

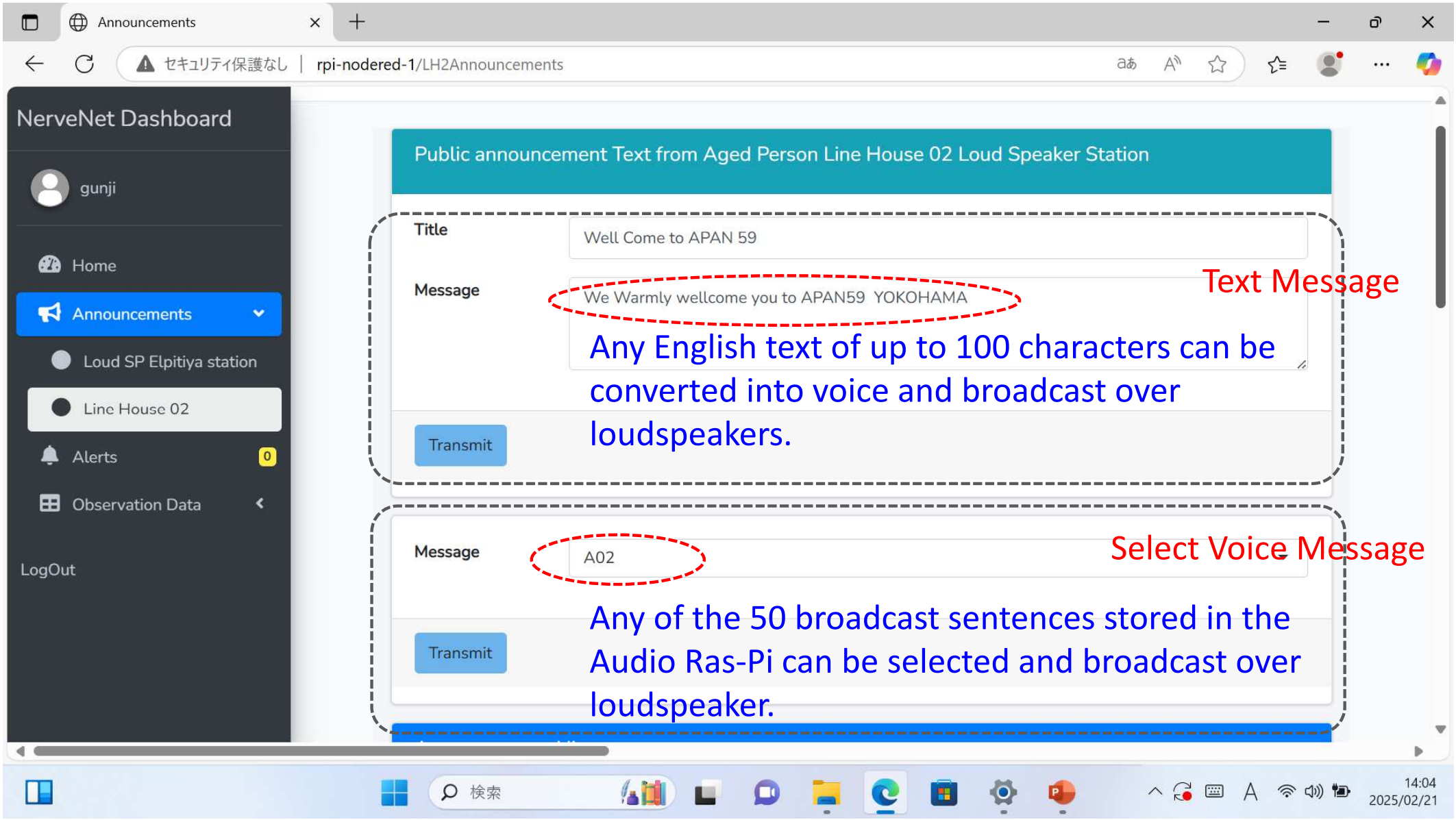
Ras-Pi for Control of Sensor NerveNet

Ras-Pi for Audio Processing

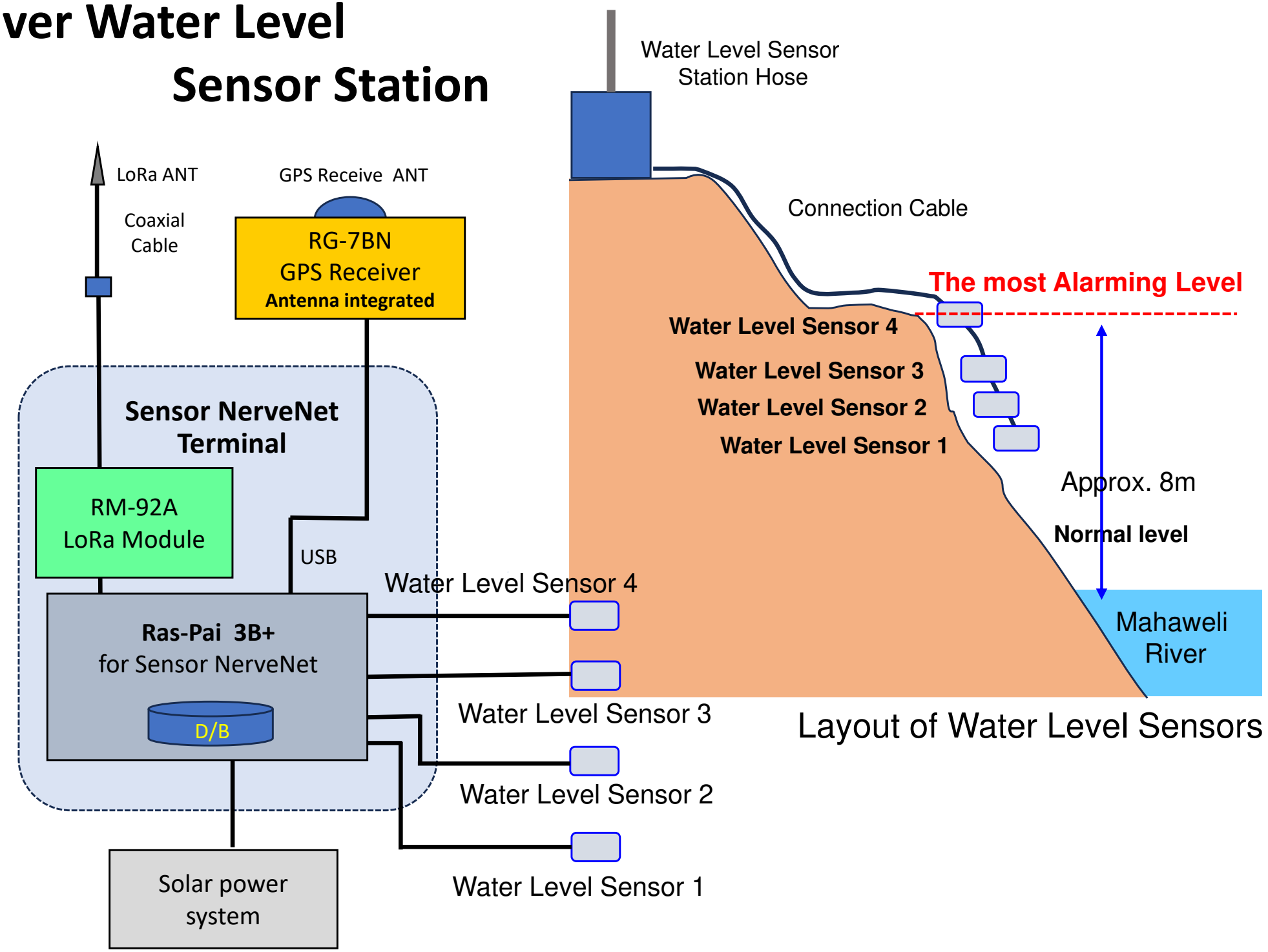




Message Announcement
from Elpitiya Key St. to Loud Speaker St.



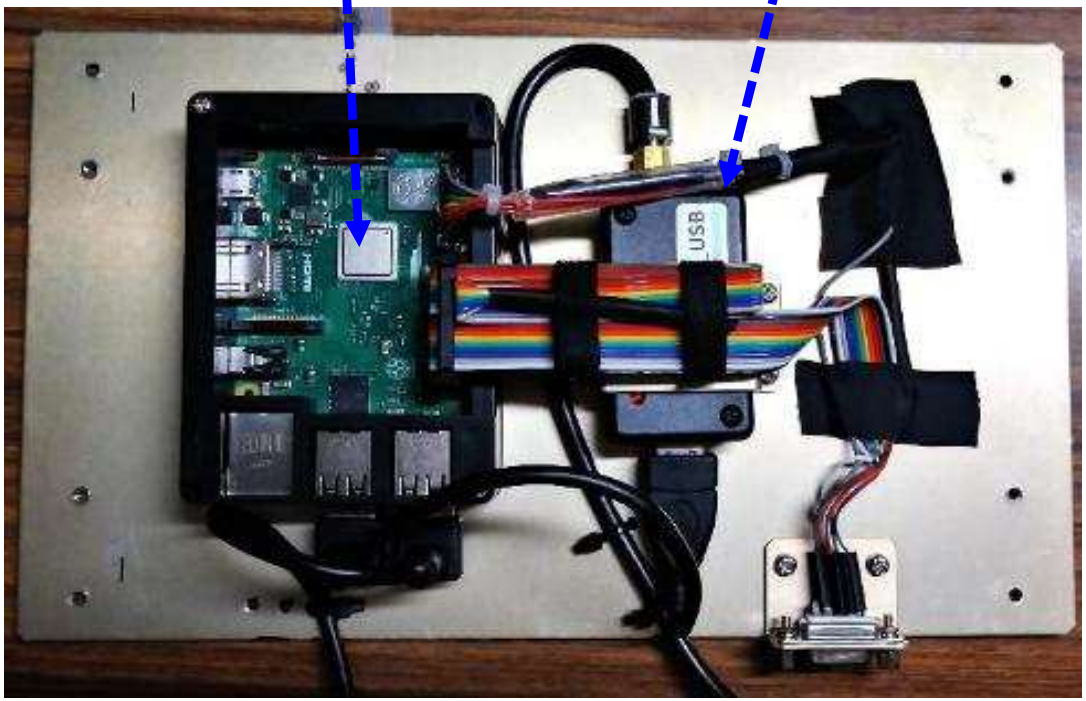
River Water Level Sensor Station



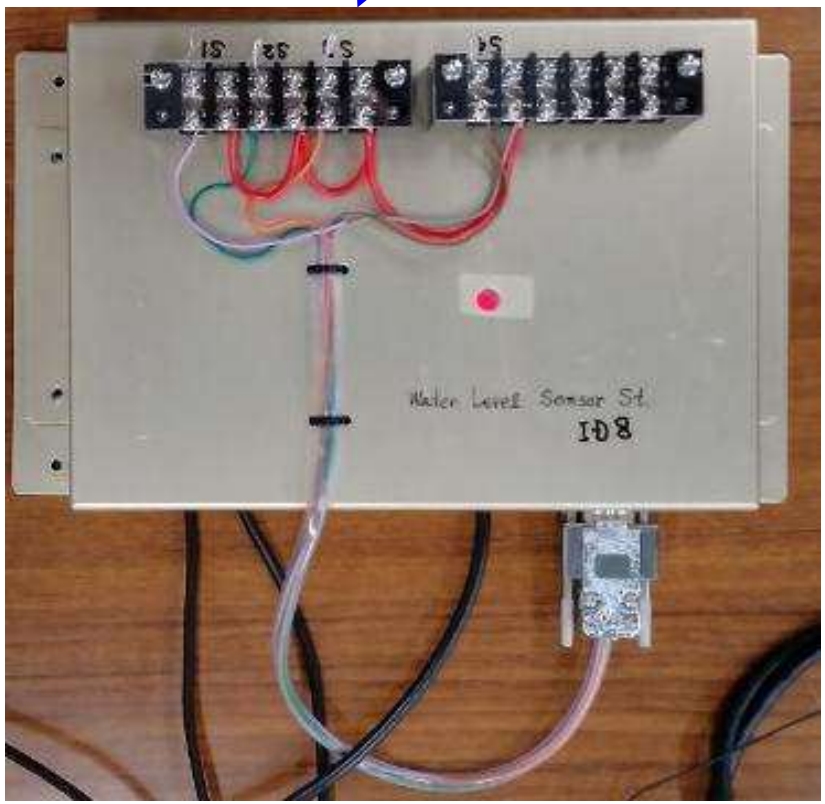
River Water Level Sensor NerveNet Terminal

Ras-Pi 3B+
Control unit

RM-92A
LoRa Module

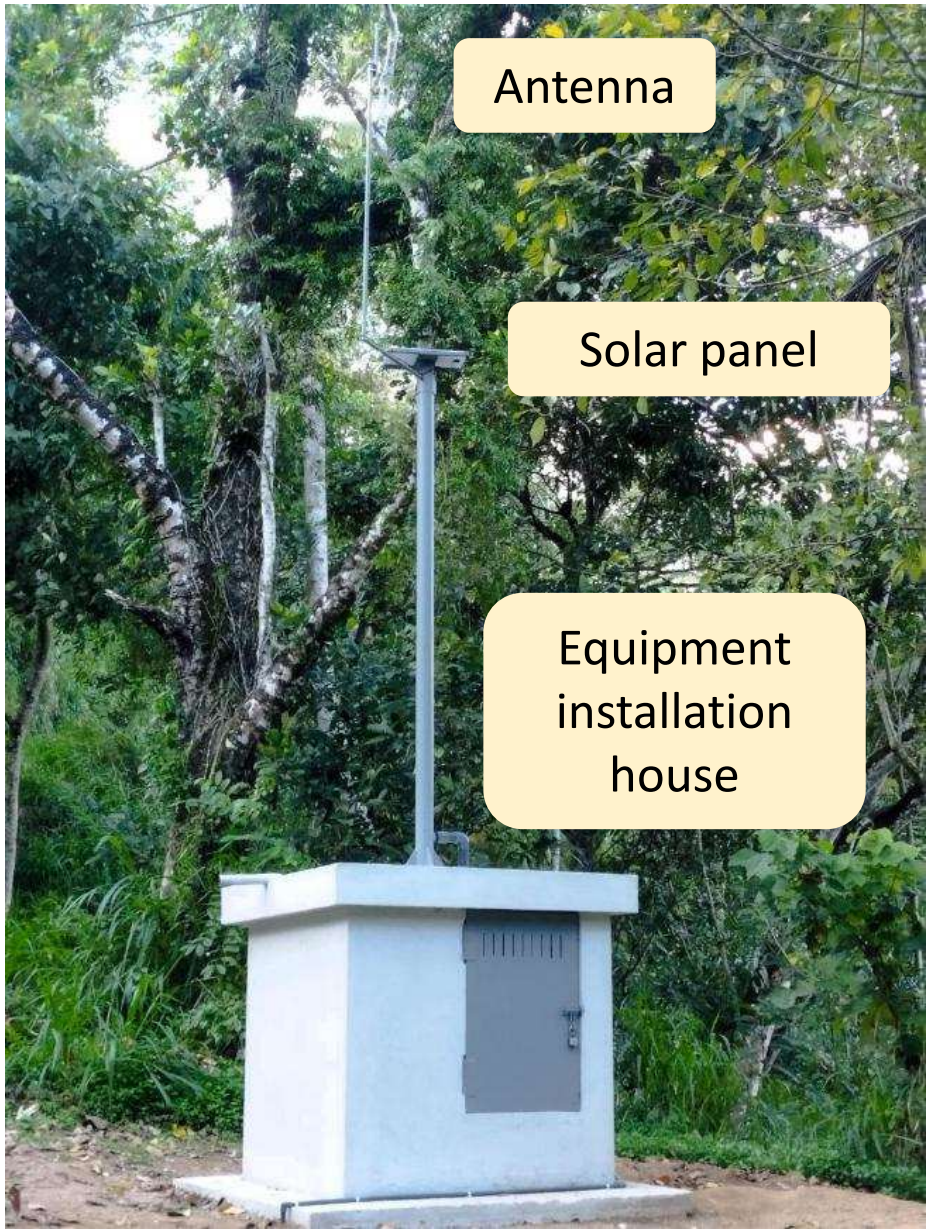


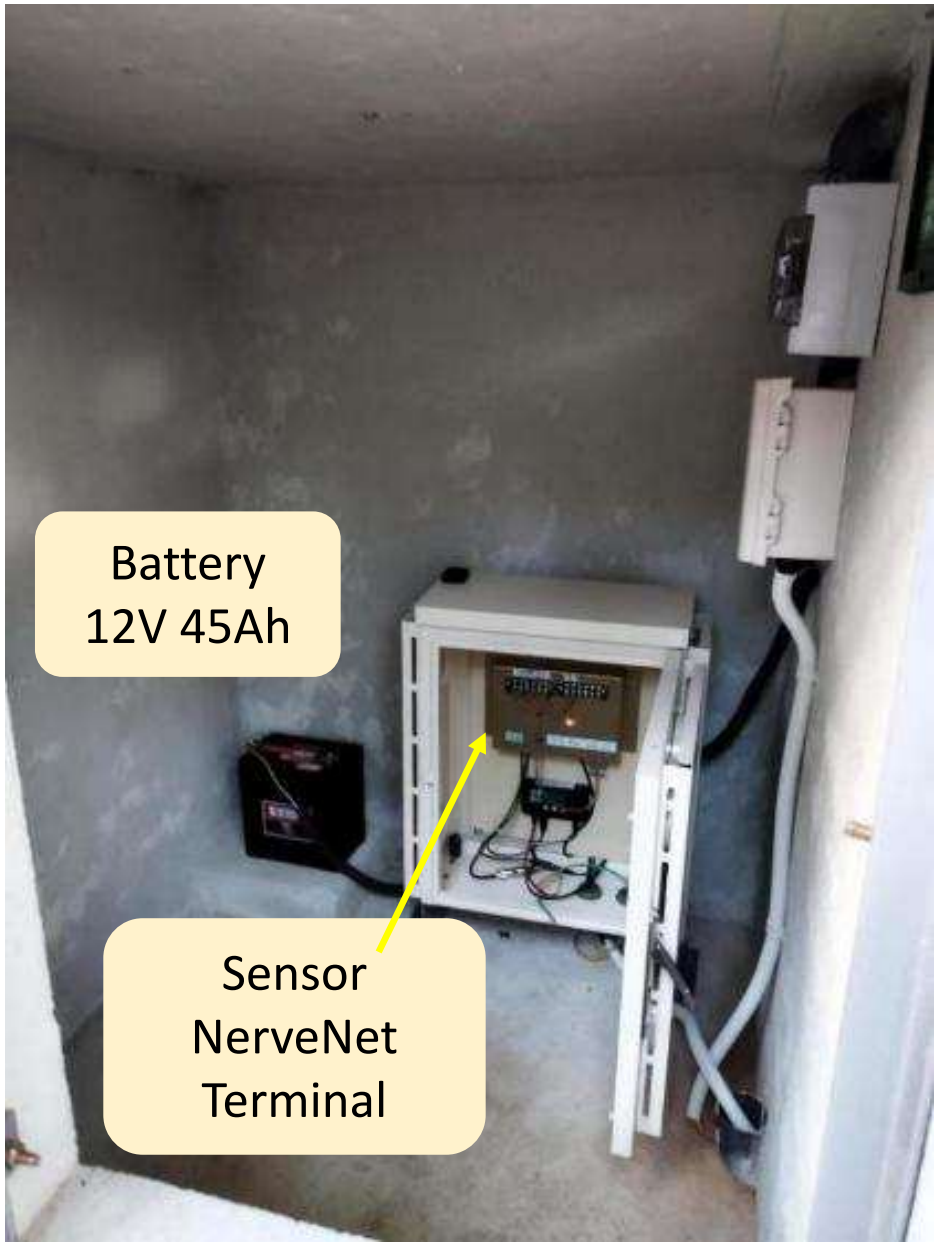
Connection terminal for
water level sensors



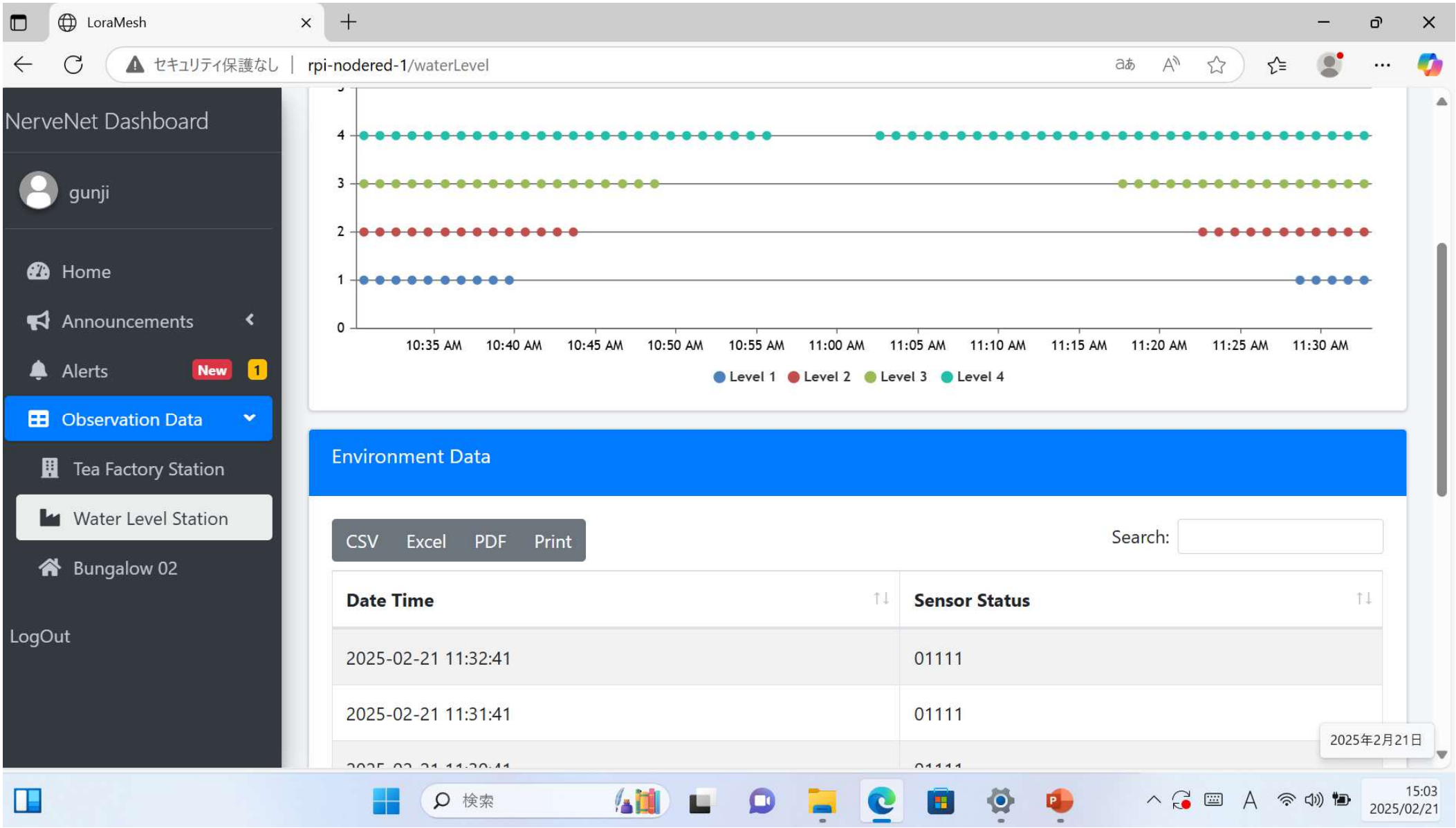
Water Level Sensor Station 1/2

Equipment installation house





Display of Data Acquired from River Water Level Sensors

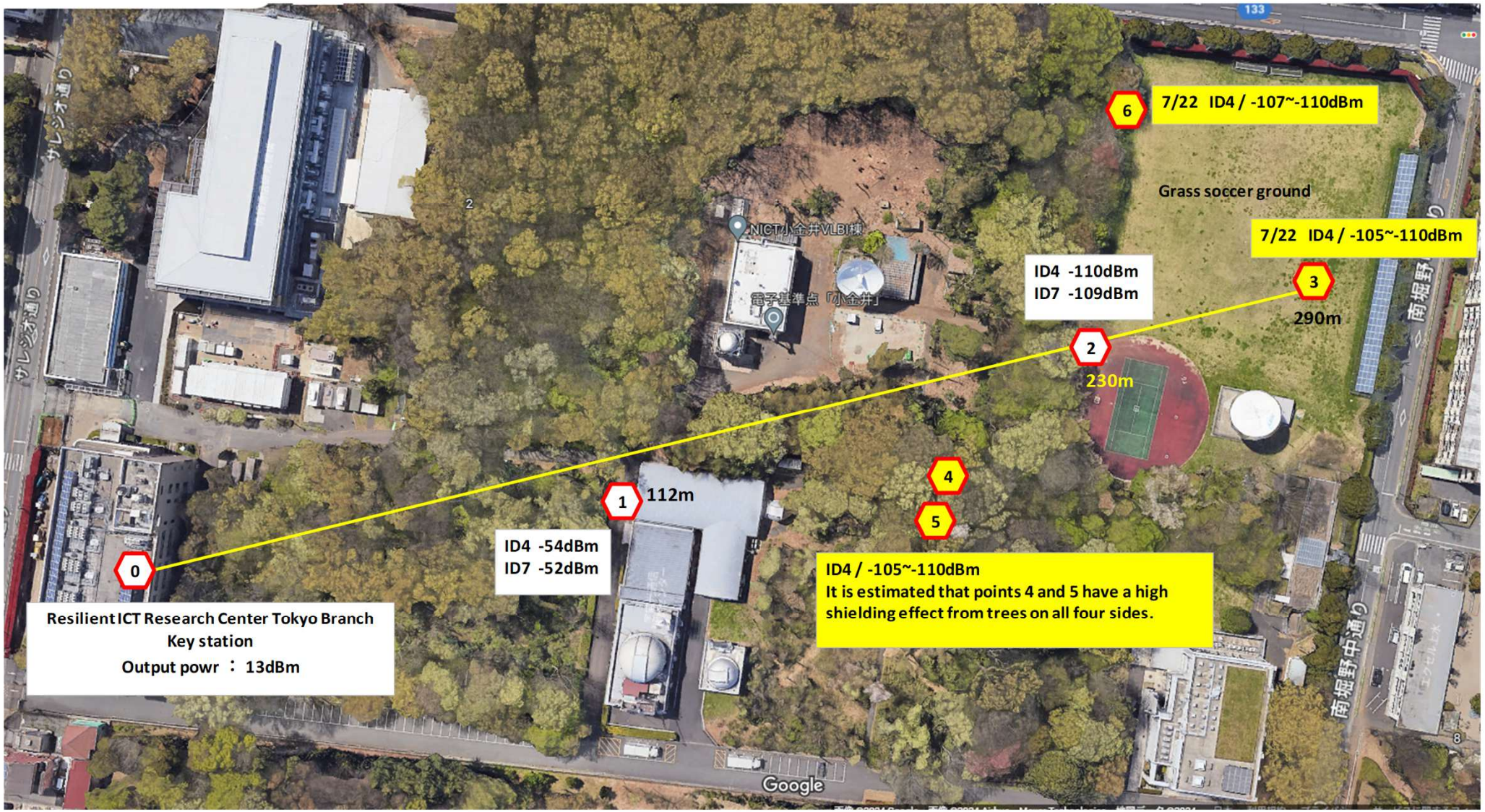


Verification test at NICT

Experiment scene at
The Resilient ICT Research Center Tokyo Branch

Propagation test at NICT

Radio communication tests were conducted in an environment thought to be similar to that in Sri Lanka.



Acknowledgments

Express our gratitude to APT and TRC (Sri Lanka) for promoting and supporting this project.

We would like to take this opportunity to express our deepest gratitude to many parties that are involved with this project including the Technical support from NICT (Japan).

We would also like to gratitude the organizers of this conference for providing us the opportunity to make this presentation.

Finally, we express our deepest gratitude to Dr. Owada, the Chairman of this session and an active technical partner of this project.

Thank you very much for your attention!