

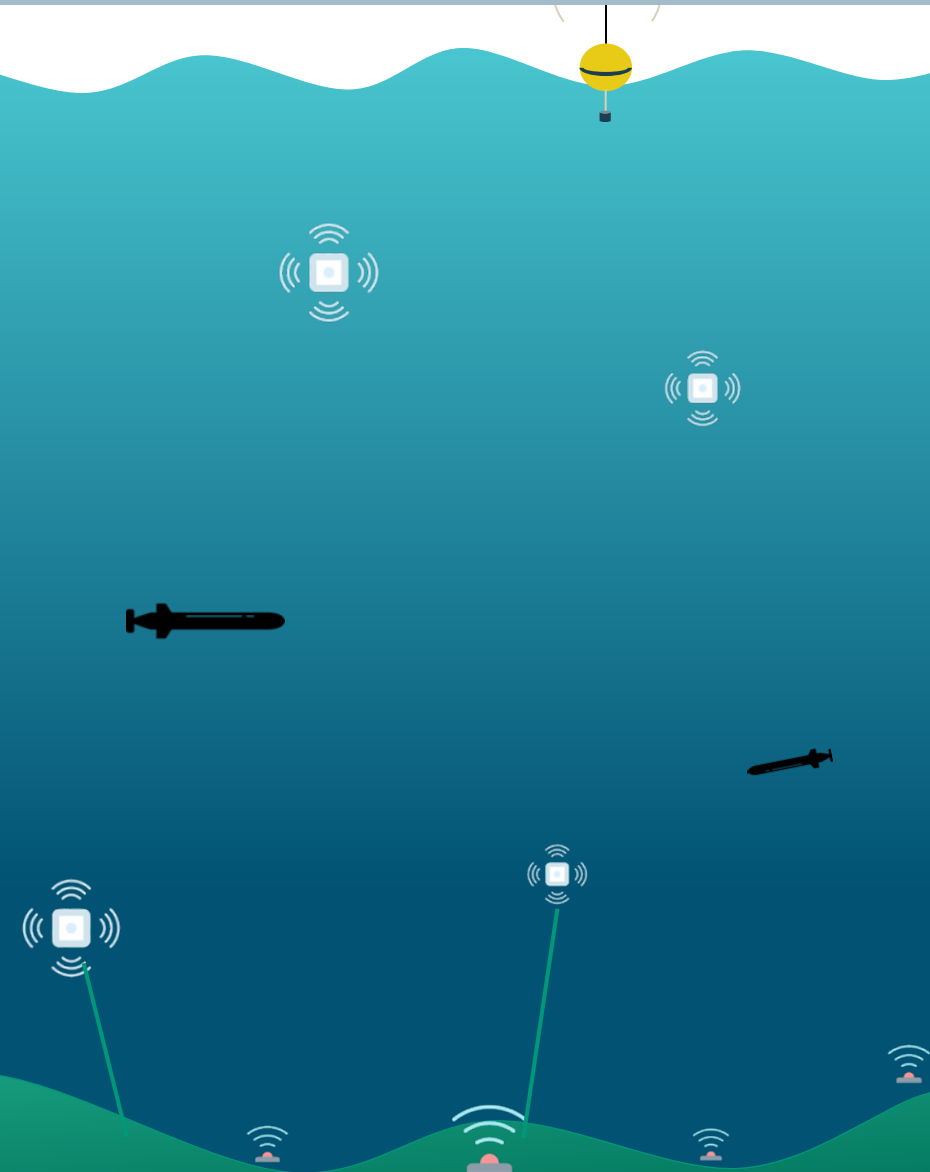
07.10.2026, MARCAS@LCN 2026

Luisa Lux, Eric Wagner, Ulrike Meyer, Jan Bauer

Murphy Also Loves Fish: Lessons Learned from Practical Underwater Communication Trials

Who is communicating? – Underwater Acoustic Networks (UANs)

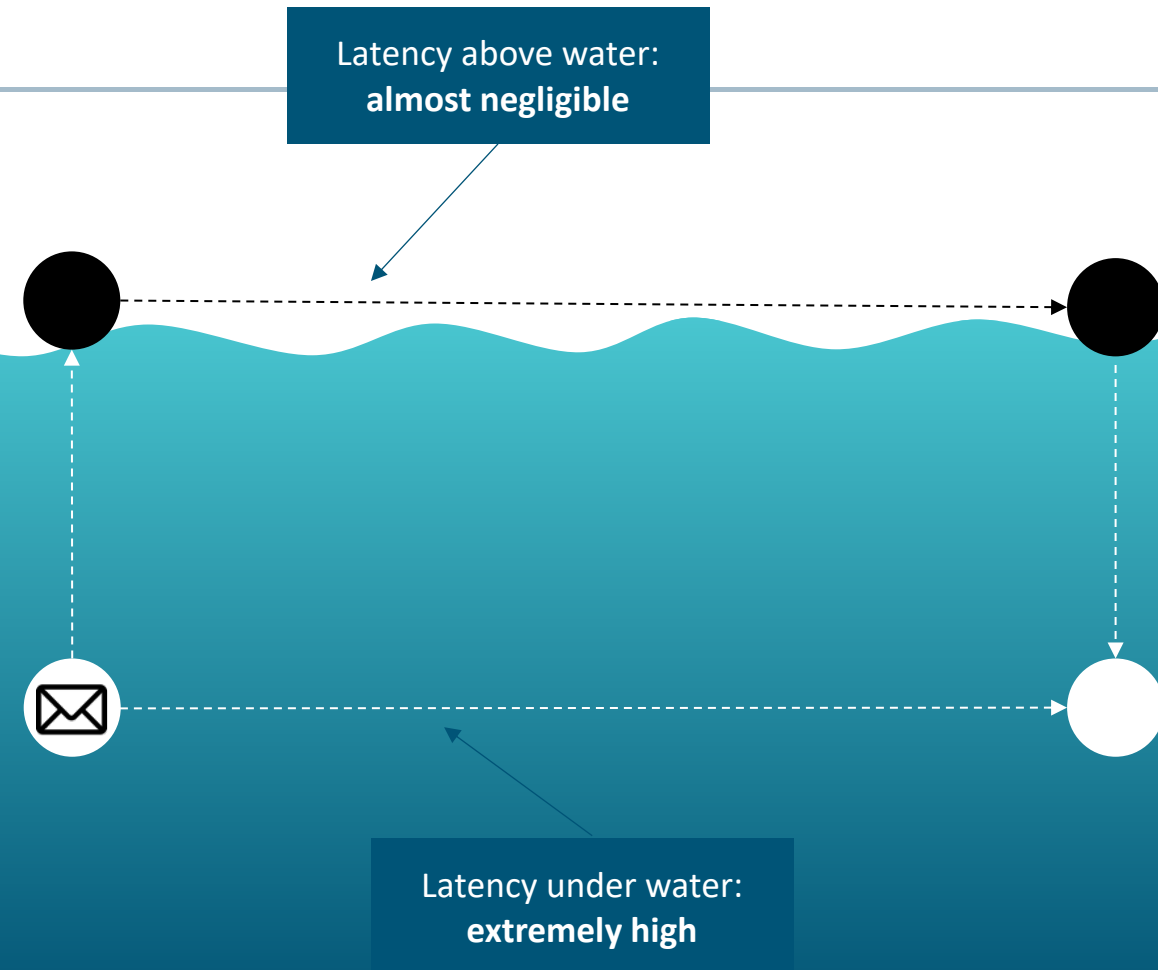
- Communication via the acoustic channel
- Challenges
 - low datarates
 - interference, noise
 - High latency



A research idea leading to season full of lake trials: Overtaking messages

Speed of sound under water: $\approx 1500 \text{ m/s}$
Speed of light over water: $\approx 300.000.000 \text{ m/s}$

= Difference of 5 magnitudes



A Deep Dive into Wormhole Attacks in Underwater Acoustic Communication: From Theory to Practice



<https://dl.acm.org/doi/abs/10.1145/3765613.3811672>

Focus of this talk



- Experienced groups have tacit knowledge, but **newcomers lack it**
- However, rising demand for underwater research

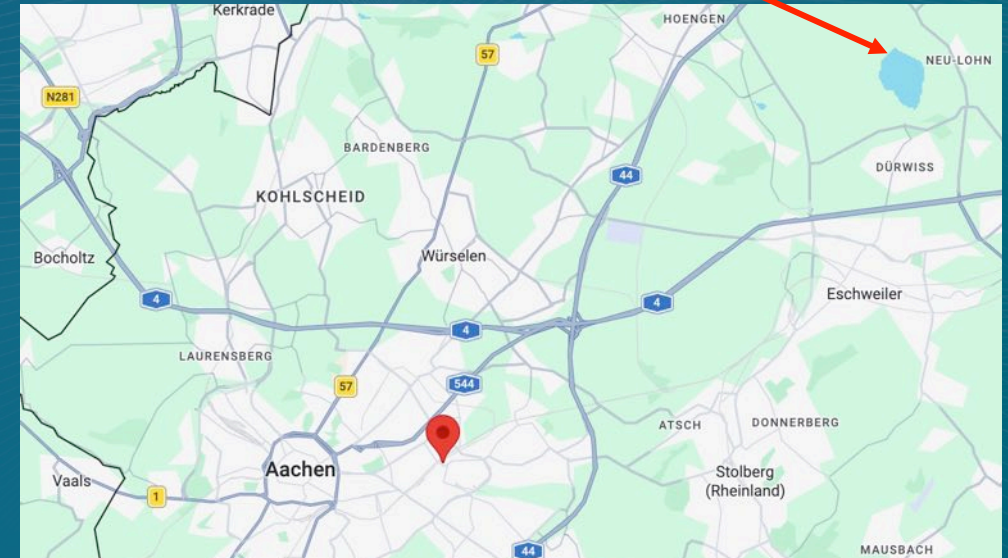
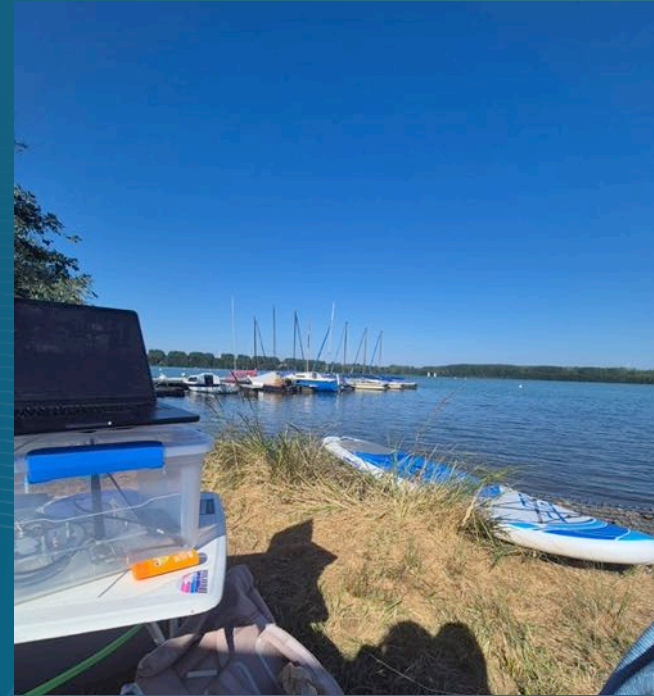
Missing:

Honest detailed account of practical pitfalls in underwater testing for newcomers

Lessons Learned

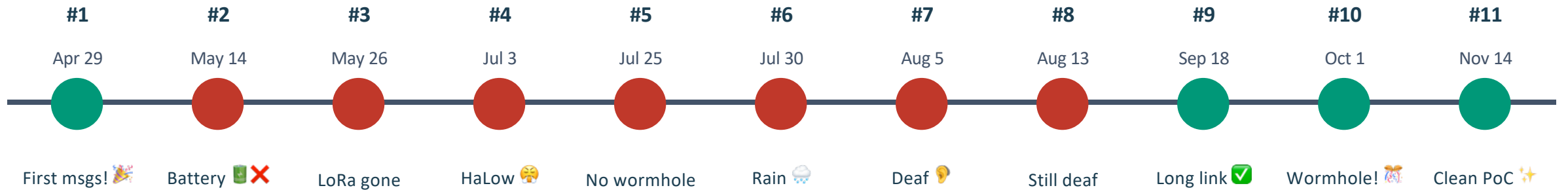
11 Trials. 8 Months. What Could Go Wrong?

A chronological tour of (mostly avoidable) disasters



The Emotional Rollercoaster – 2025 Season Overview

"We were sometimes so frustrated that we did not even know if there would ever be a next lake trial."



The Testbed Setup

Underwater Modems: Ahoi Modem!

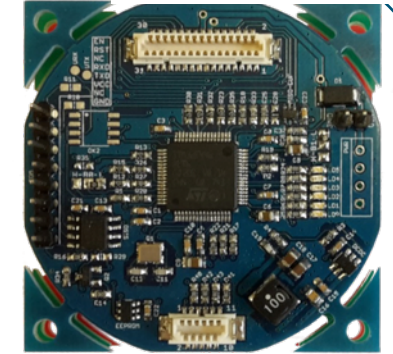
- Open-source
- Research Modems
- **Data Rate:** 250 - 4,500 bit per second
- **Range:** 300 m shown in experiments

Surface-communication: LoRA

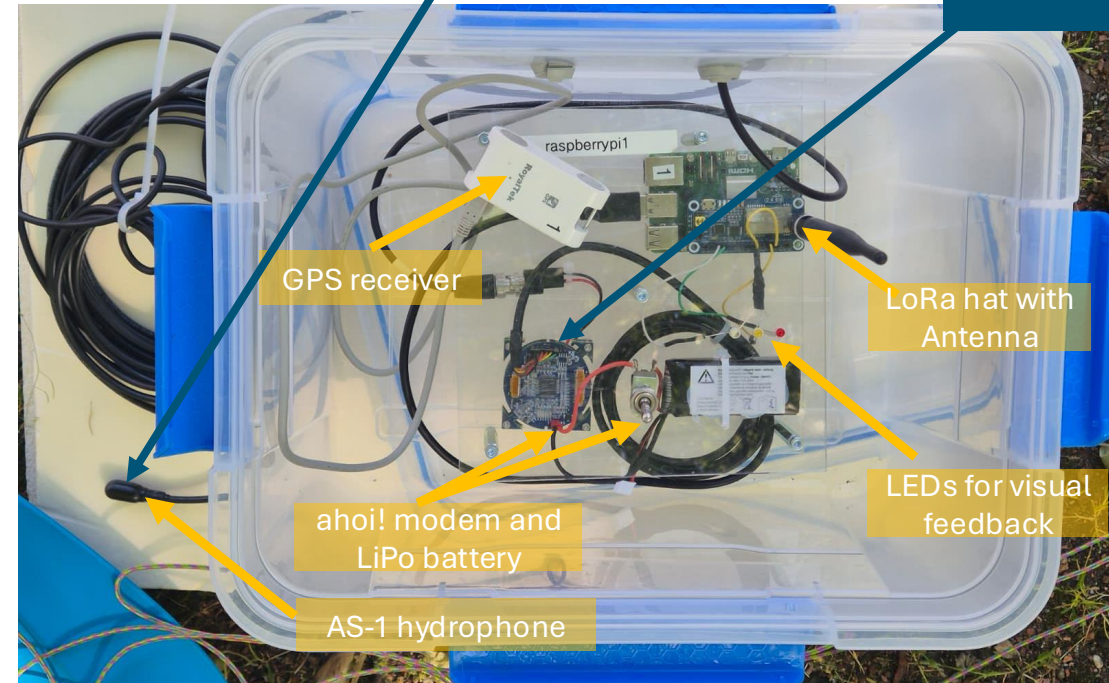
- Point-to-point
- Robust
- Often used in maritime networks



AS1 Hydrophone



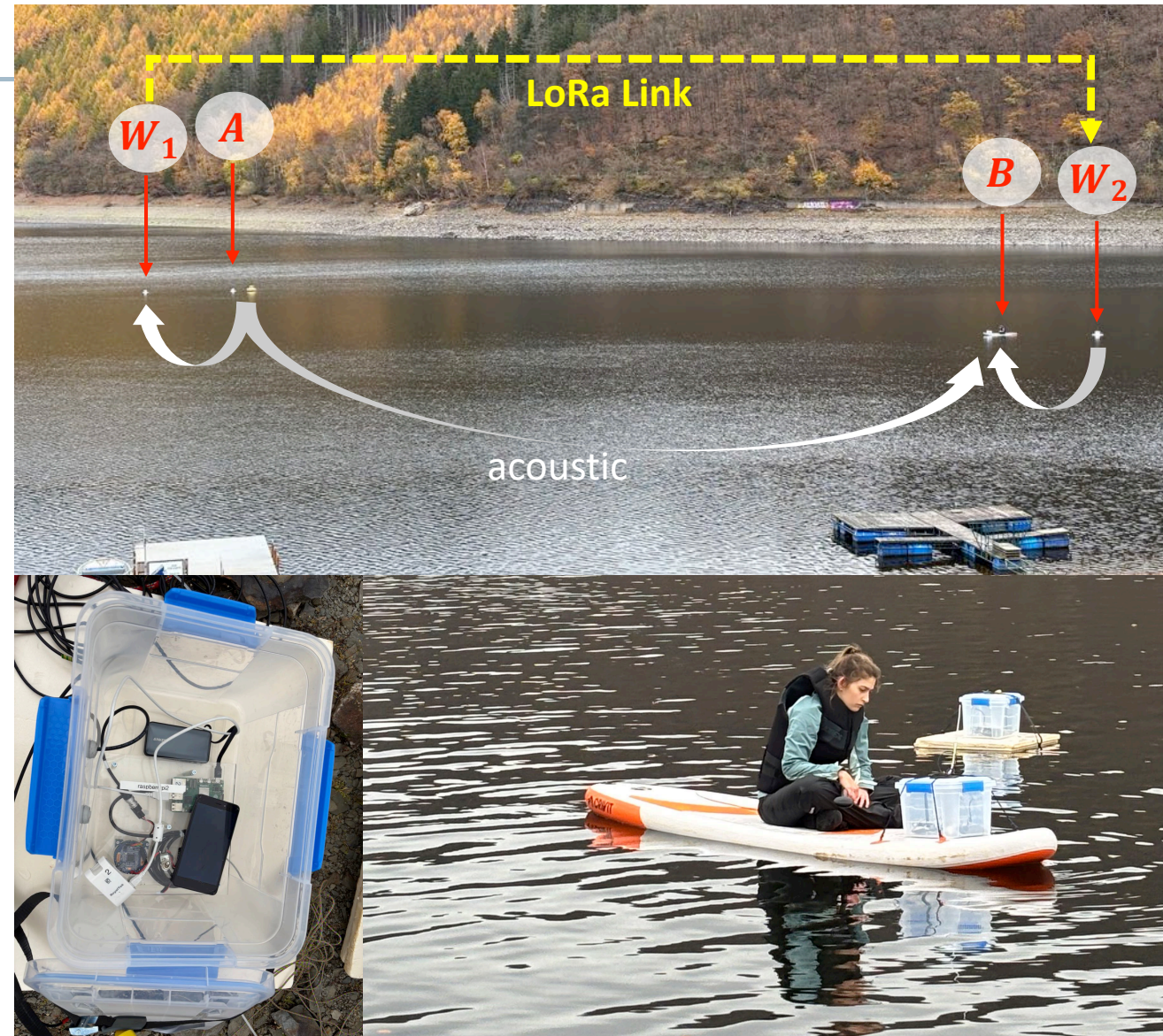
Ahoi! Modem



From the Field – Lake Trial Impressions

Procedure:

- **A** : broadcasts packet with every 10s
- W_1 : eavesdrops, forwards packet over LoRa to W_2
- W_2 : forwards packet to B
- **B** : receives packets from A and W_2 , compares reception events of both packets





Flying Blind Is Not an Option

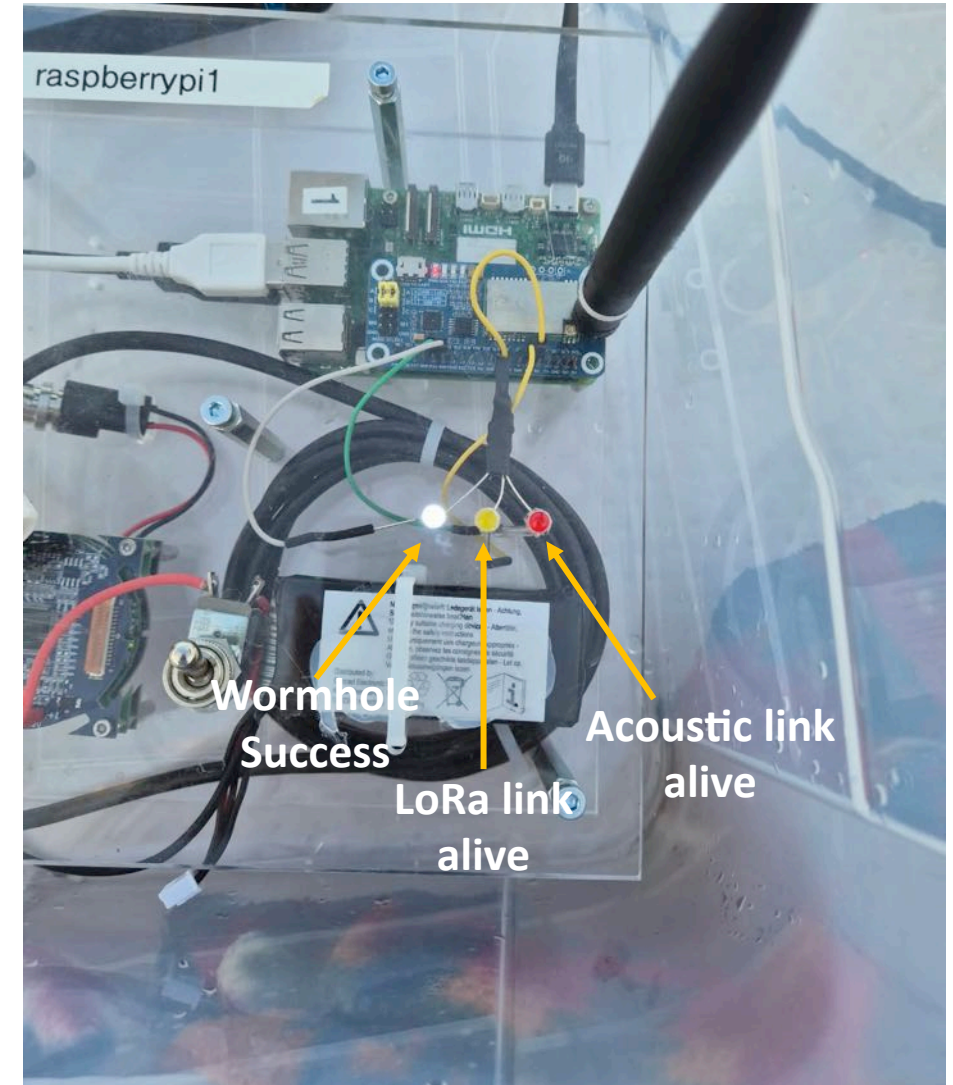
LoRa keepalives to shore → range too short, often lost

HaLow for SSH → USB jacks fell off, buggy boot

Solution: 3 LEDs on node B:

- ▶ LoRa link alive?
- ▶ Acoustic link alive?
- ▶ Wormhole succeeded?

→ Simple feedback beats complex infrastructure that adds instability.



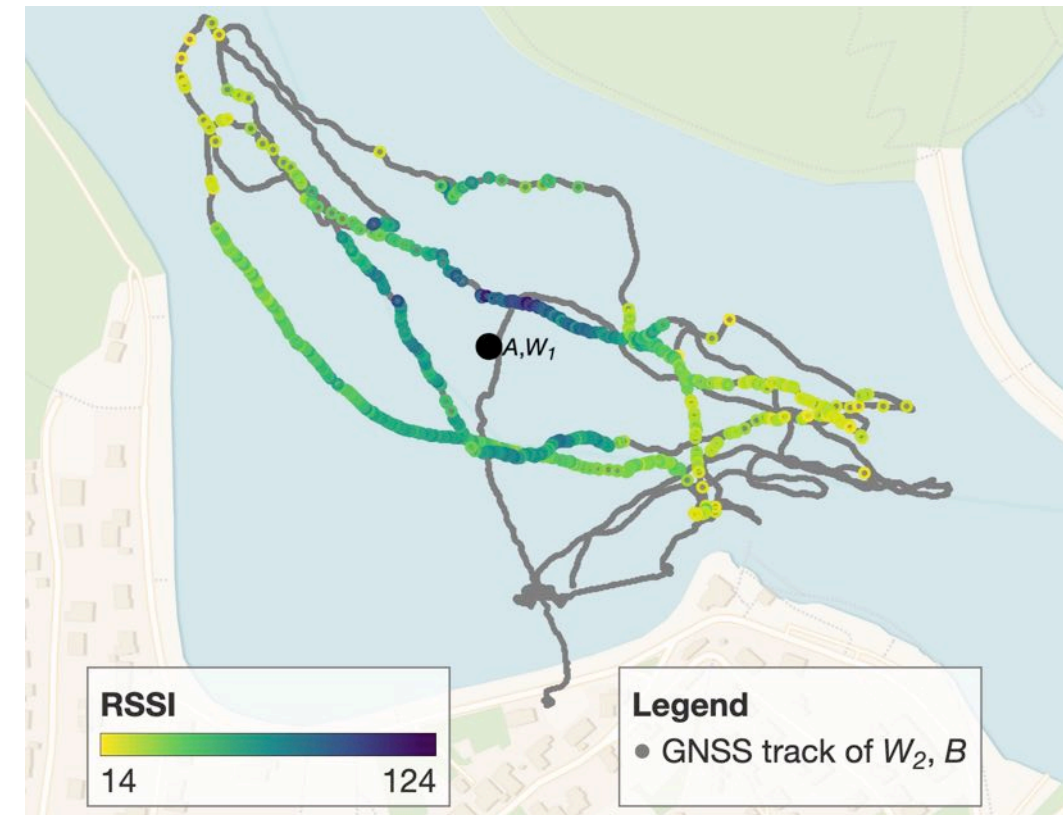


Lost in Transmission

Signal quality varies drastically within same lake

Solution: **Measure in deep waters**

- ▶ Mount node box on swimming styrodor island
- ▶ Hold fixed position with lake buoy
- ▶ Setup with a low-cost vehicle such as a SUP



→ Avoid extremely shallow waters as much as possible.



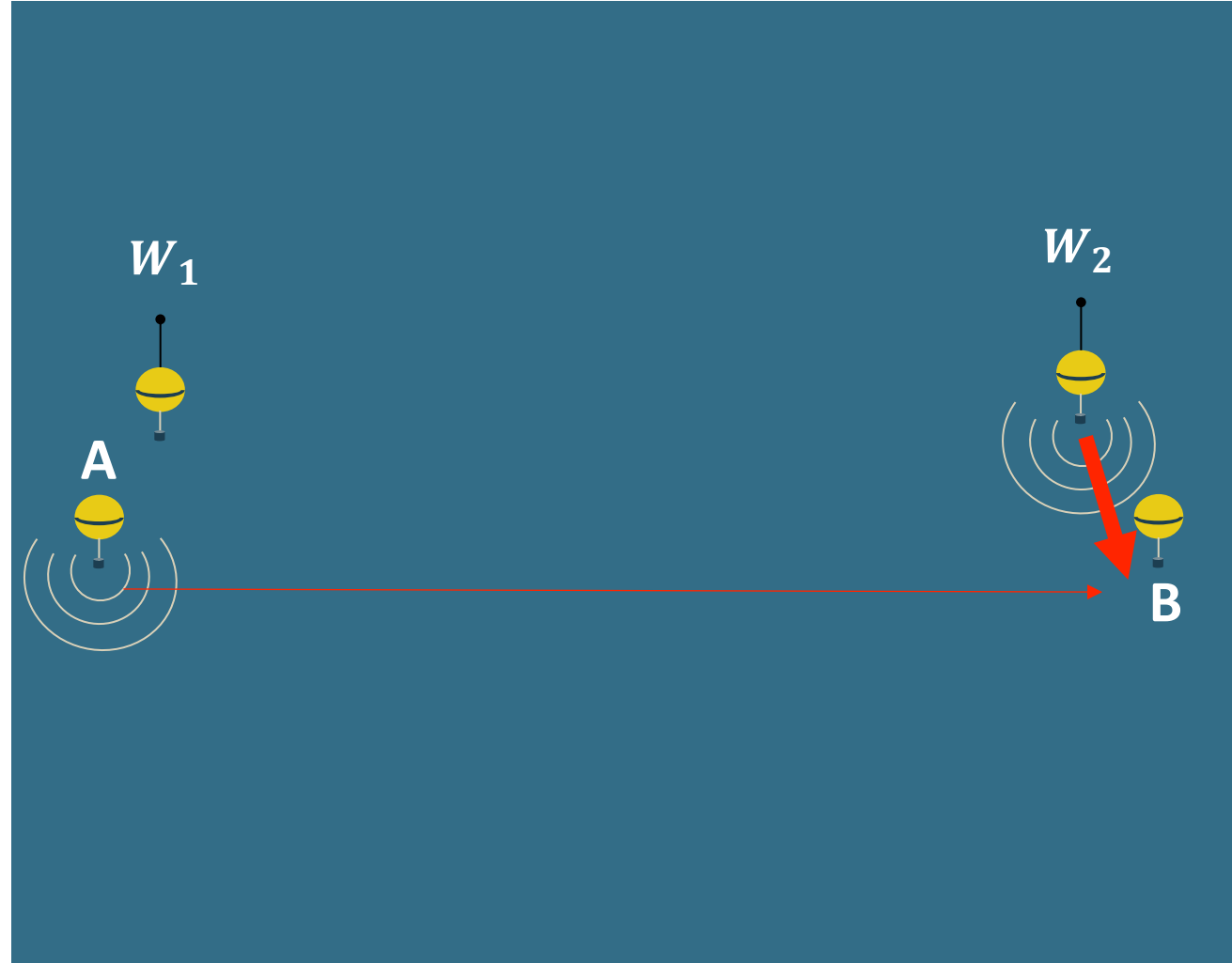
Why did our nodes go deaf?



Gain Balancing – too much, too little, just right:
Automatic Gain Control (AGC) going rogue

→ Disable default AGC, set static RX gain.

→ Reread the manuals after some time.





Murphy Also Loves Questions!

Thank you.

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