A tiered mesh network testbed in rural Scotland

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joint work with
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Rural broadband

- Broadband in rural areas:
  - The **“everyone has the right to have a phone”** policy.
  - Distances far beyond DSL coverage.
  - **Low population density** make "Fibre to the Home/Curb/Building" techniques economically unfeasible.
  - Satellite (**VSAT**) expensive and unsuited for interactive applications
- We are building a testbed to enable research on **Low Cost Broadband Wireless Access** (BWA) in remote and rural areas.

Related work

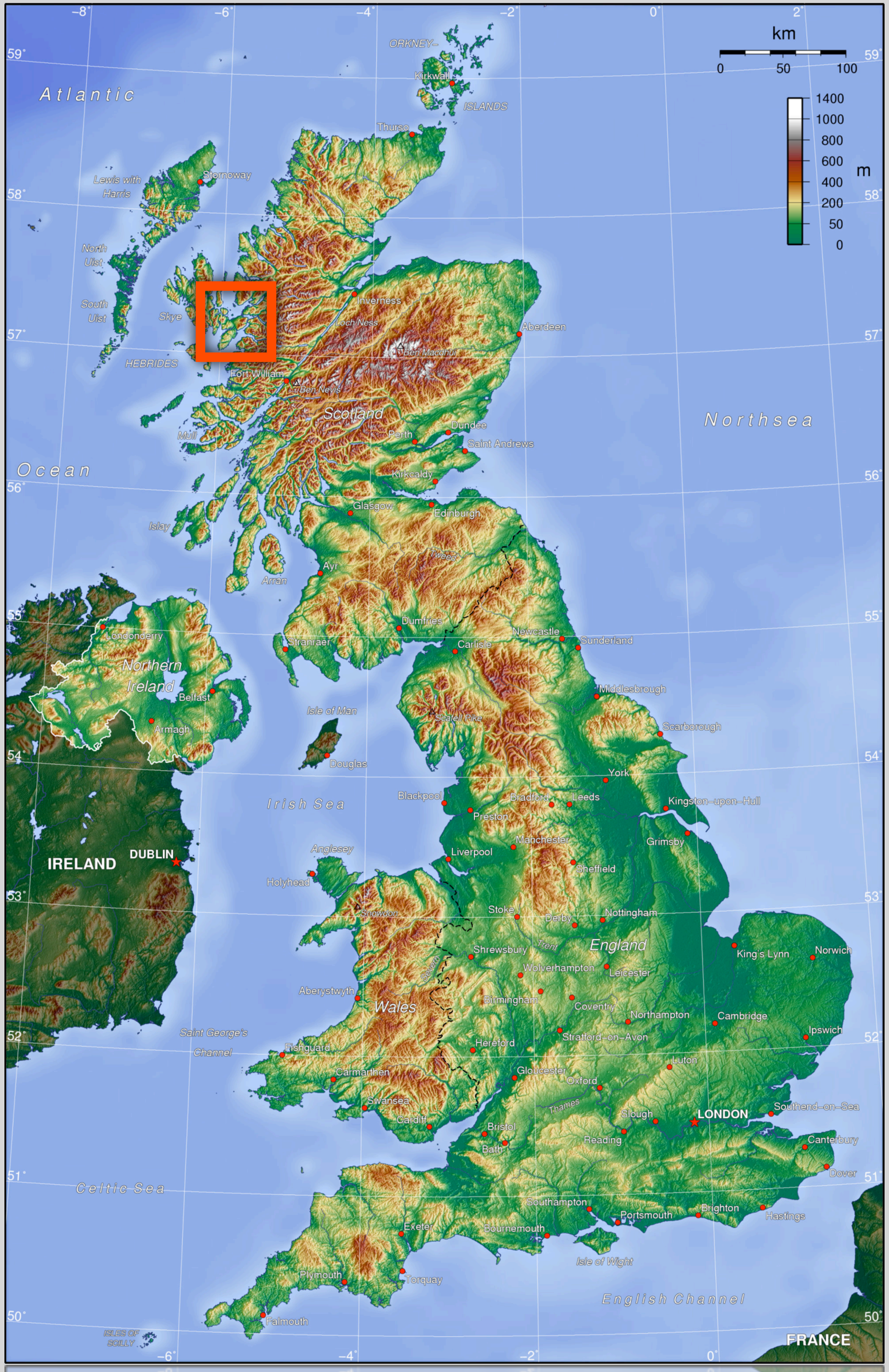
- **Outdoor urban mesh network** testbeds, such as:
  - MIT Roofnet
  - TFA Houston

- **Outdoor rural mesh networks** testbeds, such as:
  - **research** testbeds
    - DGP-India
    - TIER-Berkeley
    - QualRidge-UCDavis

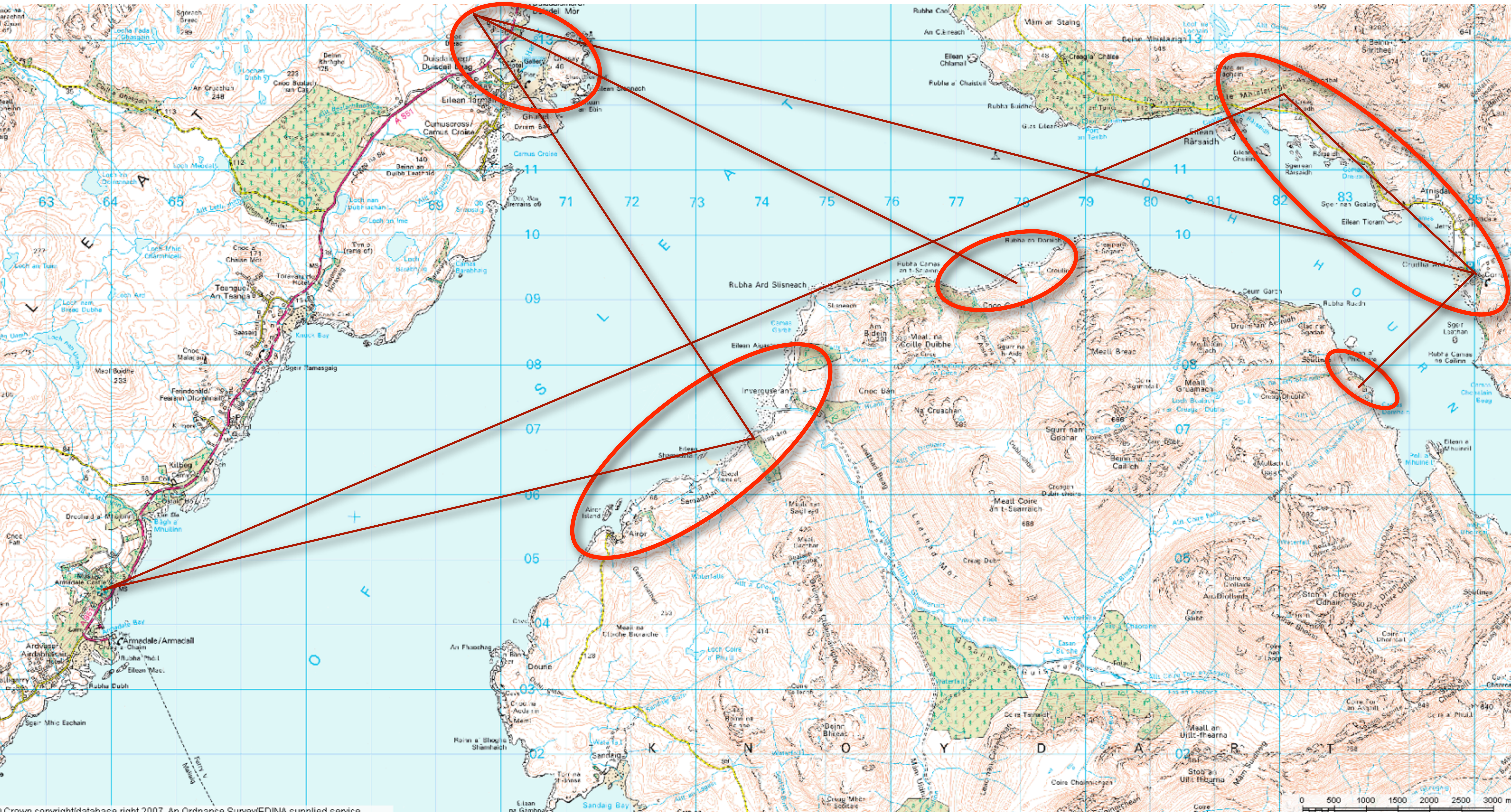
  - **community** deployments
    - Wray village mesh

Unique characteristics

- **Unique aspects** of our testbed:
  - long distance links **over sea**
  - **self-powered masts** with diverse power sources (wind and solar)
  - **weather** conditions
  - active **community** participation



The “tegola” testbed



The art of building Masts

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Modular approach (to get home dry...)

- **Highlands weather**, transportation and limited daylight constrain operations
- Some installations are self-powered, other are not.
- Some installations offer "wireless local loops", other are backbone-only.

Modular approach

- Most of the building materials are **recycled** (donated by locals).
- **Aluminum frame** that can be assembled in minutes.
- The masts are facing the sea: the setup must survive to high **wind loads**.

Waterproofing

- Silicone rubber and fiberglass to provide **additional waterproofing**.
- Sea salt and "upside-down rain" are interesting phenomena.

Hardware

The backhaul platform

- **Board:** Gateworks Avila GW2348-4
- **Equipped with:** Intel IXP425, 64MB RAM and 16MB Flash, 4x miniPCI slots, 2x Ethernet, 1x CompactFlash slot, temperature/voltage sensor.
- **Radio cards:** Ubiquiti Network XtremeRange5.

Antennae

- All the links are **dual-polarized** (Horizontal and Vertical).
- **29dBi dishes** from Pacific Wireless: HDDA5W-32-DP
- Chosen because:
  - Very rugged.
  - Very directional beamwidth (6°), negligible cross-polarization.
  - Radome to decrease the wind load by 30-40%

Self-powered masts

- Two of our installations “self-powered” by a combination of solar panels and wind generator.
- **Solar panel:**
  Kyocera KC130GH T-2: maximum 130W
- **Wind turbine:**
  Rutland Furlmatic 910
  90W@21mph, 24W@11mph
- **Battery:**
  Elecsol 125Ah 12V

The result

Mast at Isle Ornsay

The CPE (Customer Premises Equipment)

- **Board:** PCengines alix.3c2 with AMD Geode and 1GB of solid-state storage. 12V PoE.
- **Radios:** 2x 802.11abg hi-power miniPCI radios.

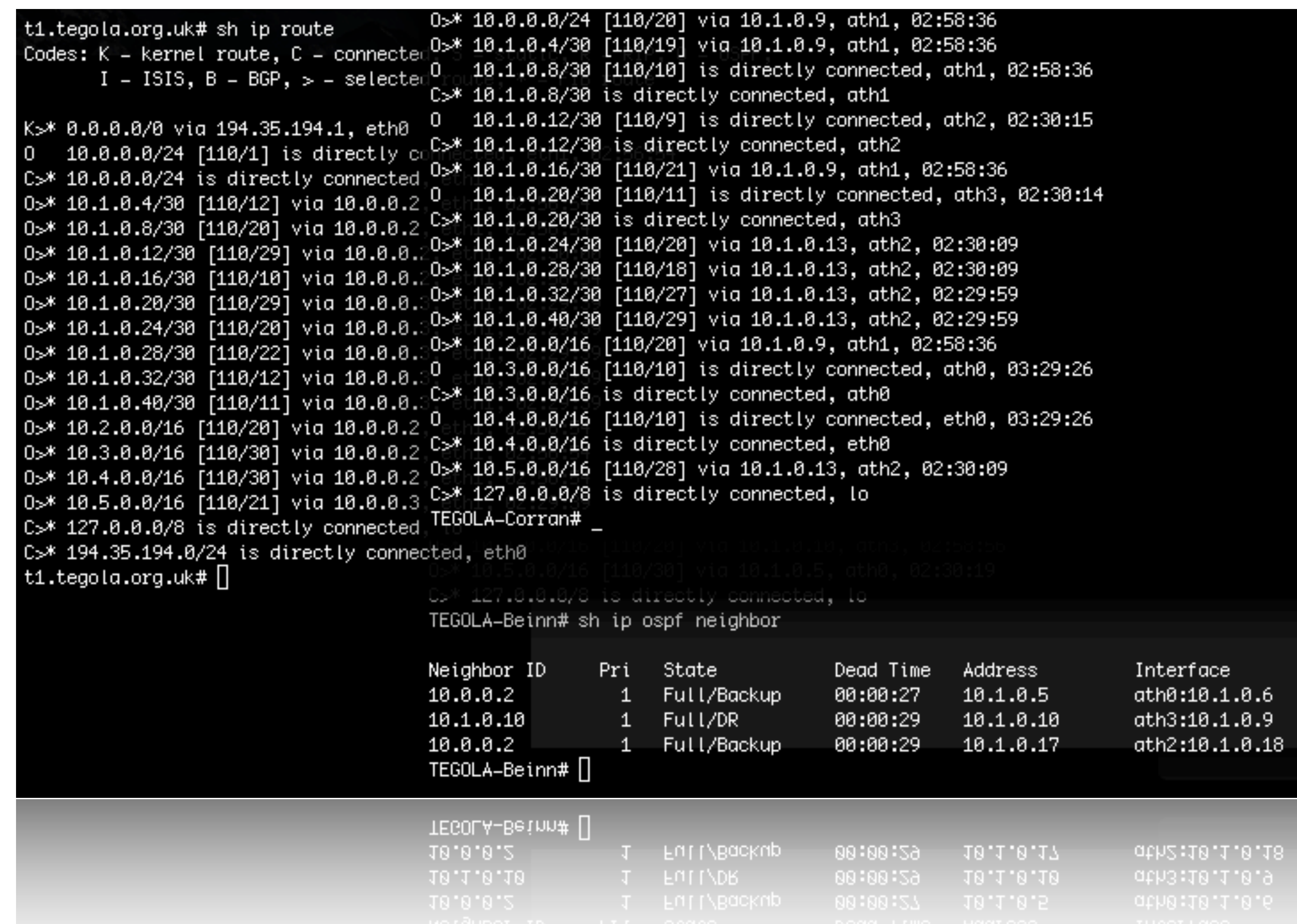
Software and Routing

Software running on the nodes

- **Linux 2.6**, based on the OpenWRT distribution.
- **MadWifi** as wireless driver.
- **Quagga** for routing.
- Custom-made software for data gathering and **statistics**.

Routing

- **Ring topology** optimizes simultaneously redundancy and deployment cost.
- Each link is “**doubled**” by using two orthogonal polarizations.
- IP addressing scheme on private network:
    - **/30** nets for point-to-point
    - **/16** nets for local loops
    - The CPEs do **NAT** of the home network
- **OSPF** to redistribute the local subnets.
    - per-destination load-balancing.

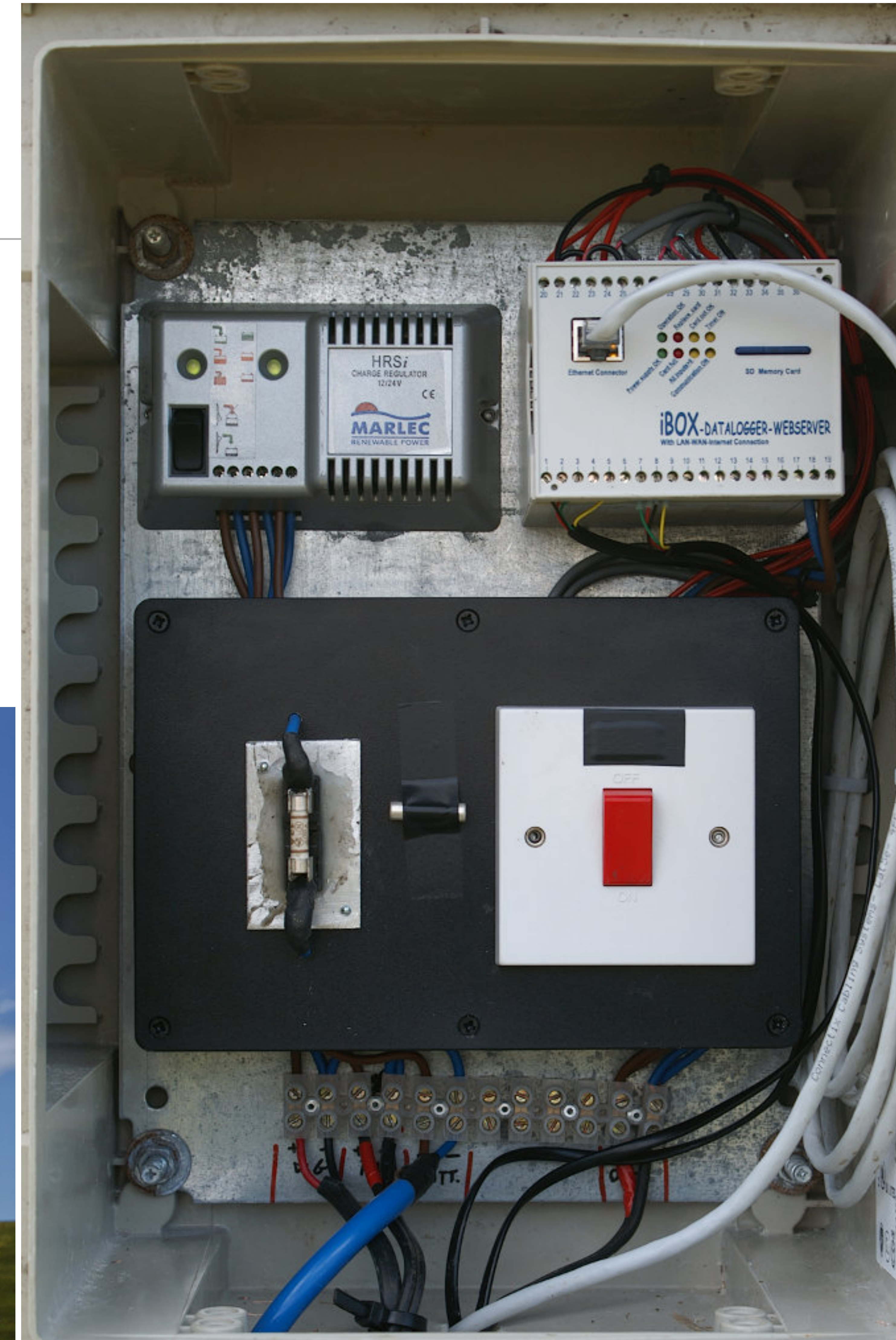


Ongoing and Future Research

Direction #1: power studies

- Using solar and wind reduces the cost by a fourth but power sizing issue is still **unclear**:
  How does power consumption of the hardware vary?
  Are the “solar/wind” models and data realistic?

- We equipped one of our masts with an **IP-enabled datalogger** to allow data post-processing.



Direction #1: power studies

- In building a self-powered mast, the cost of the power subsystem is much higher than the electronics and the antennae.

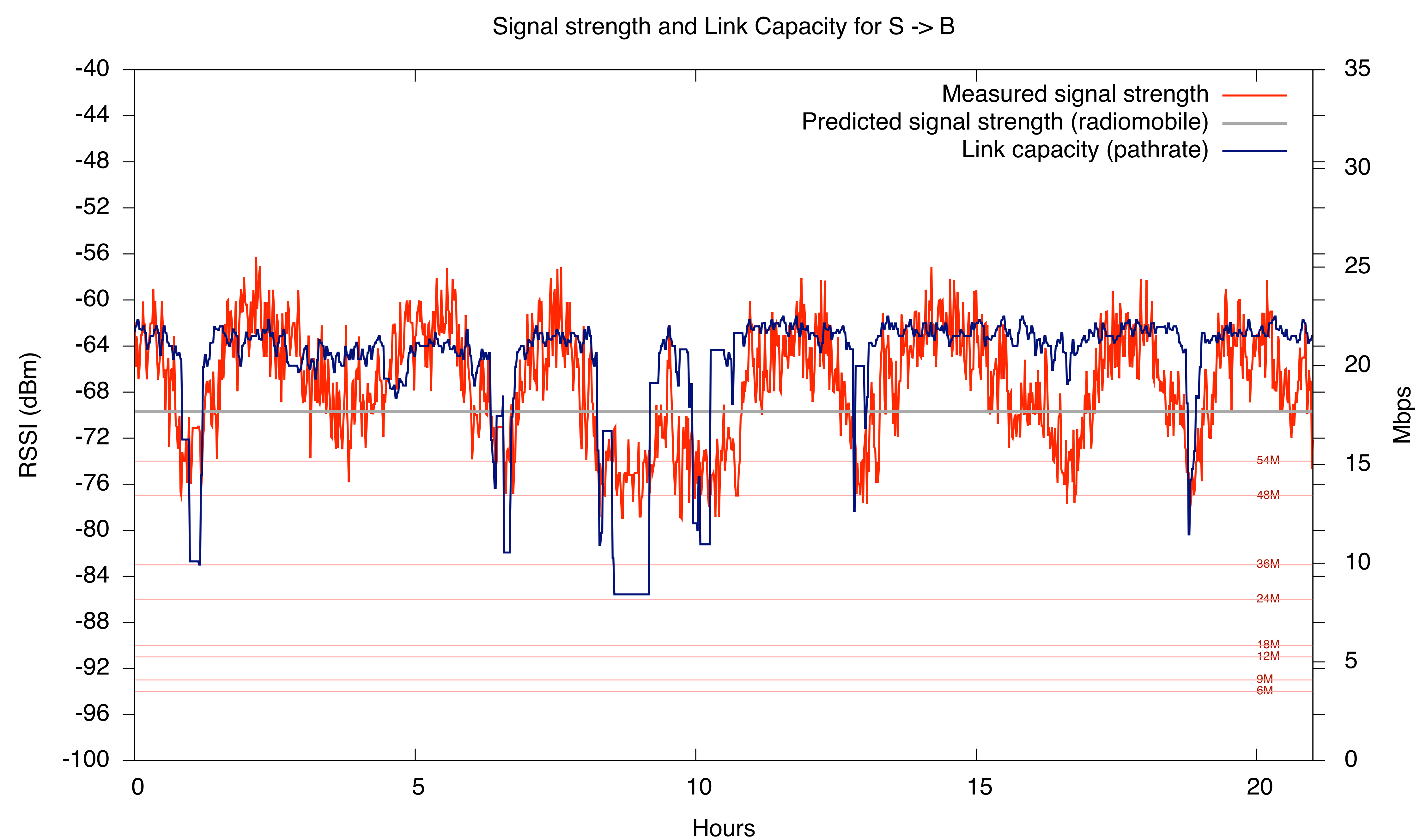
- **Our board requires:**
  - 5-6W for the Gateworks Avila board
  - 4-5W for each of the miniPCI interfaces, if operated at “close to maximum” power levels.

- **Open questions:**
  - Is it possible to reduce these requirements without affecting the user?
  - What’s the cheapest way to provide an uninterruptible power source?

Direction #2: propagation over sea water

- Most of our links travel **over the sea** for long distances (max: 19km) at low altitudes (40-100m)

- Noticed **severe periodic fluctuations** in the signal strength.



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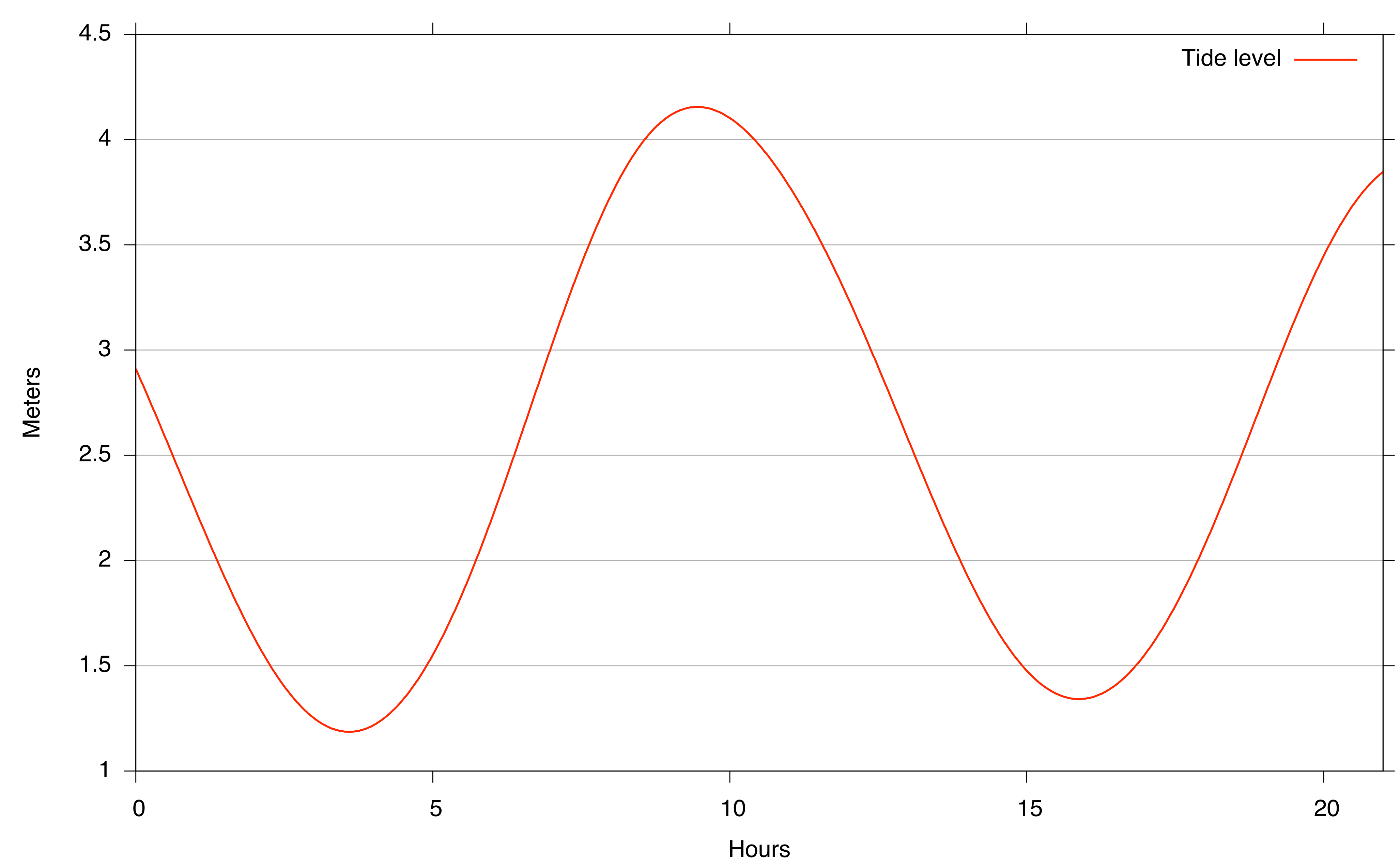
- The UK west coast has important tides, **ranging up to 7 meters**.



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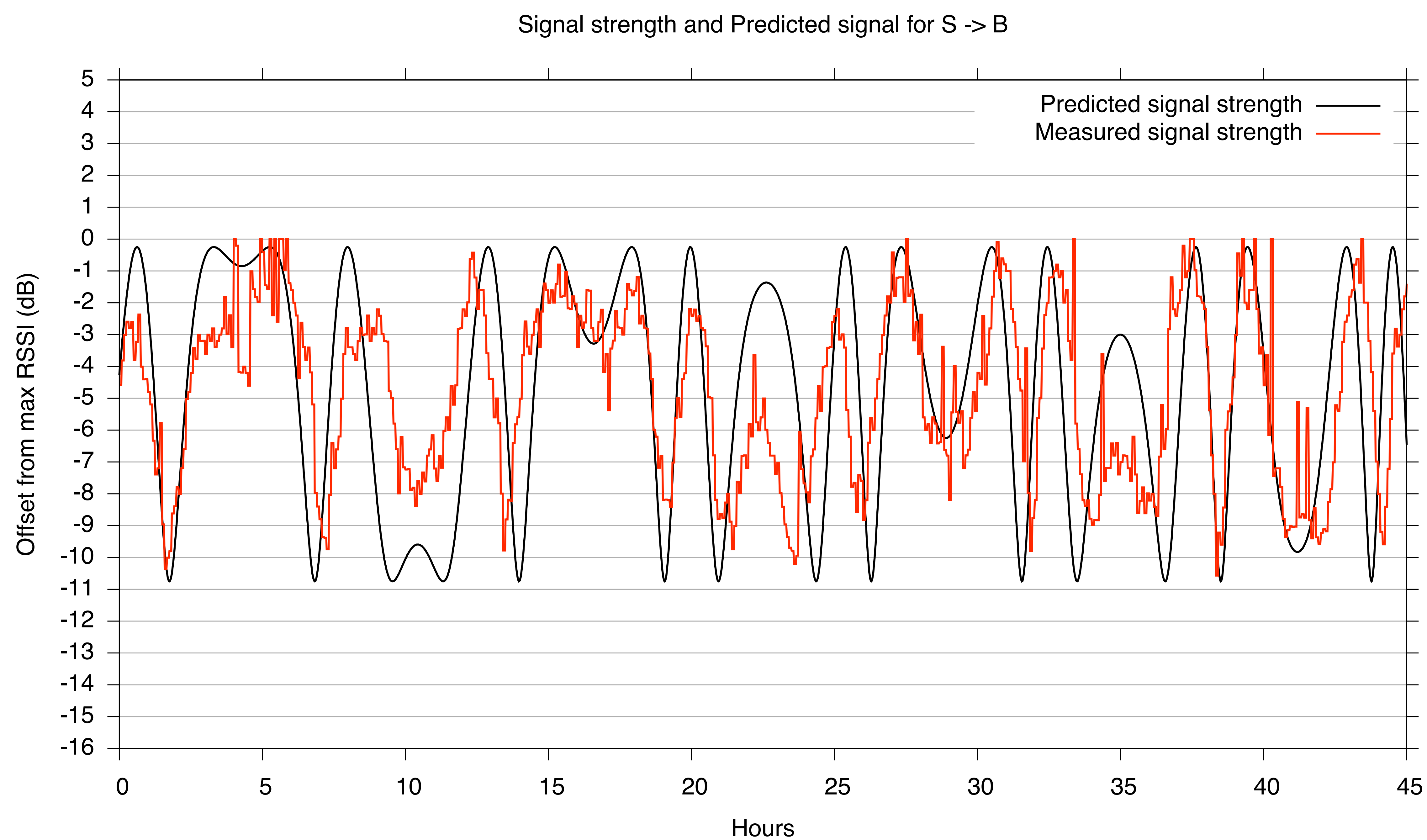
- **Modelling** the impact of tides on propagation over sea water.



Direction #3: management of large WISP networks

- The whole process of deploying a backhauling network for BWA is **complex**:
  1. Planning
  2. Configuration
  3. Monitoring

- We would like to develop a **framework** and a **tool suite** to:
  - identify the **best masts locations** and suggest an optimal topology
  - **automate** frequency planning, router configuration, routing balancing
  - **gather statistics** and present a minimal set of alarms to the network administration

- Additionally: in rural areas, each single link is inherently unreliable. We propose to study **Network-Embedded Applications (NEAs)** as a way to move applications from datacenters to the network routers improving reliability.

Further details

- Project website:
  www.tegola.org.uk

- **Paper to appear** in MOBICOM 2008 workshop on "Wireless Networks and Systems for Developing Regions" (WiNS-DR).

Questions?

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