



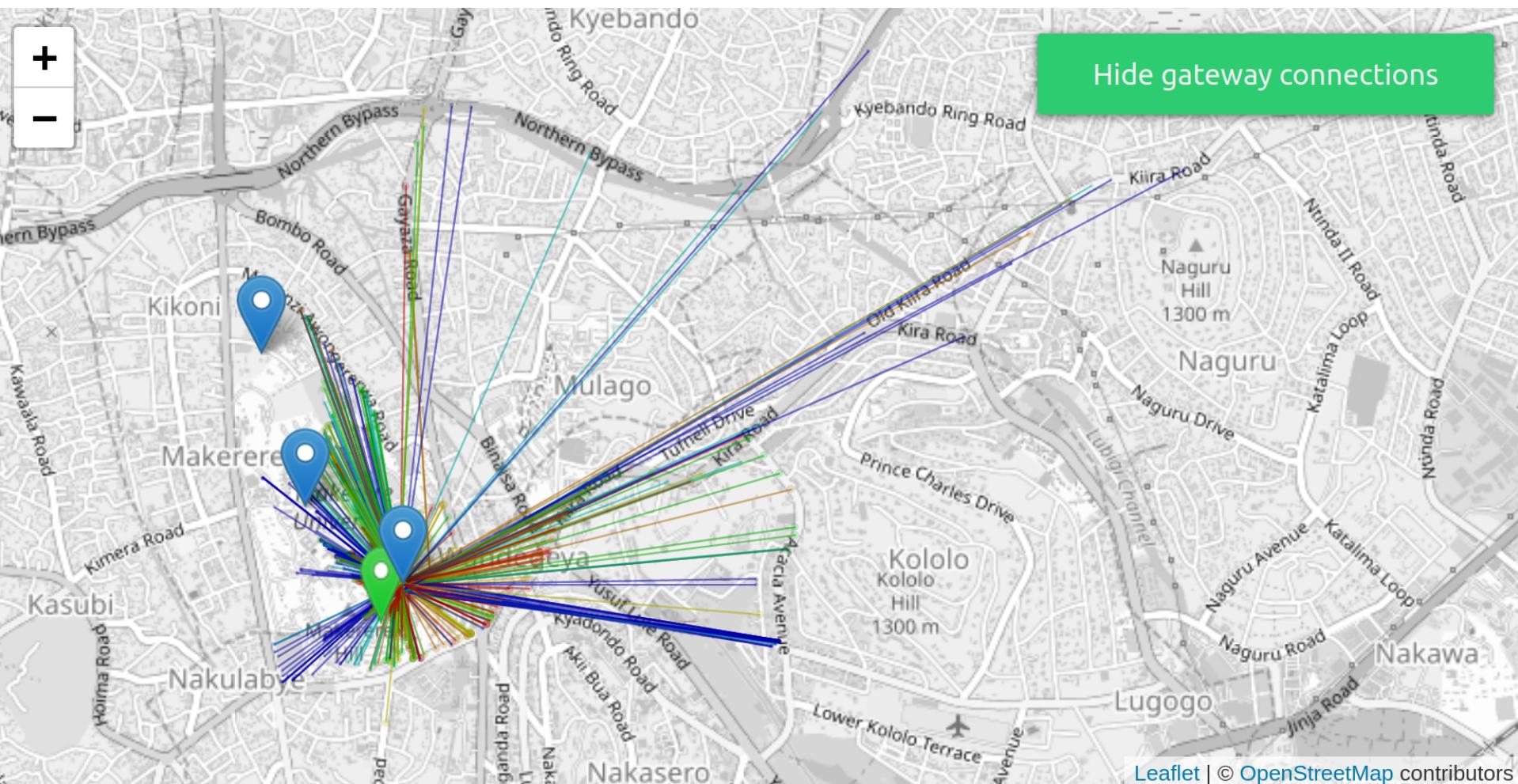
# Advanced LoRaWAN

Workshop on LPWAN Solutions for the Internet of Things  
February 17-21 Makerere University, Kampala, Uganda  
Sebastian Büttrich (IT University of Copenhagen / NSRC)

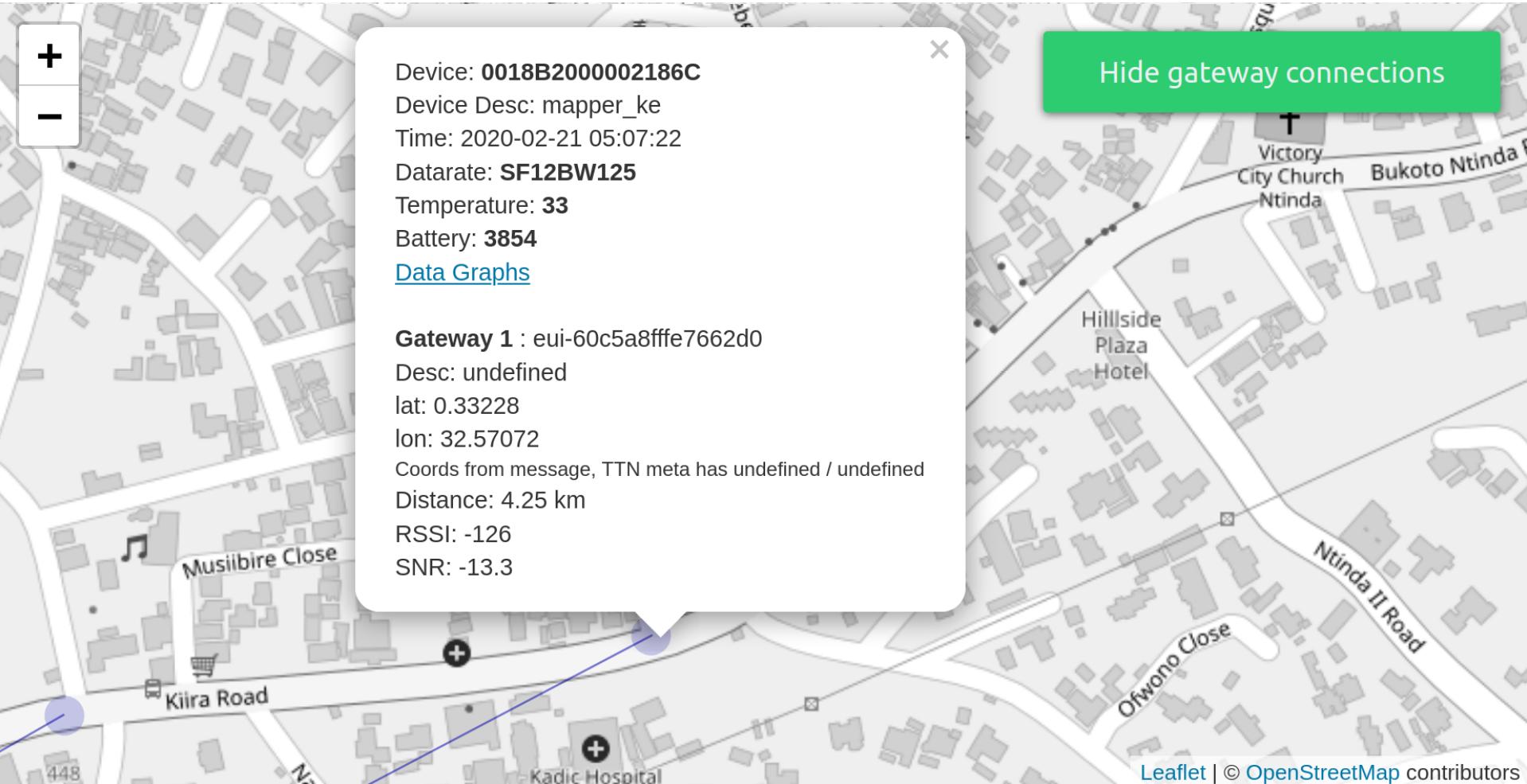
# This talk

- Status of our work here
- Beyond terrestrial LoRaWAN
- 2.4 Ghz LoRaWAN
- Geolocation





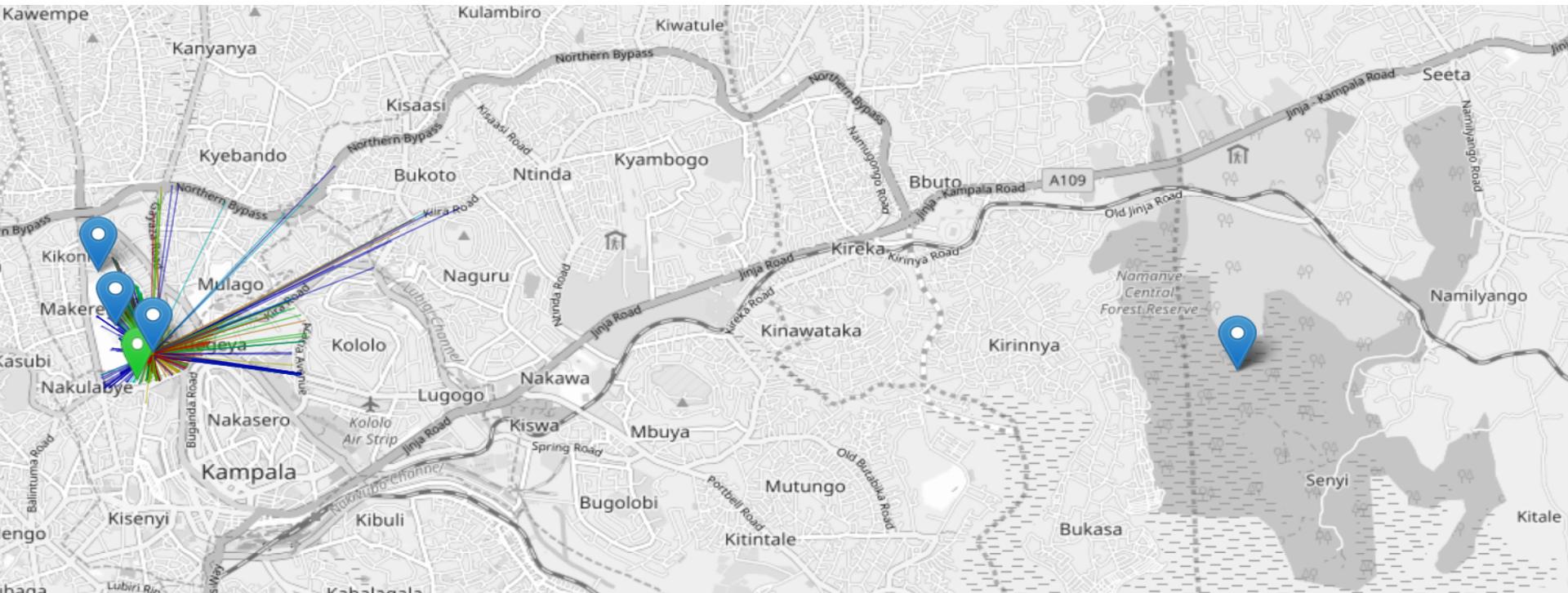
Leaflet | © OpenStreetMap contributors





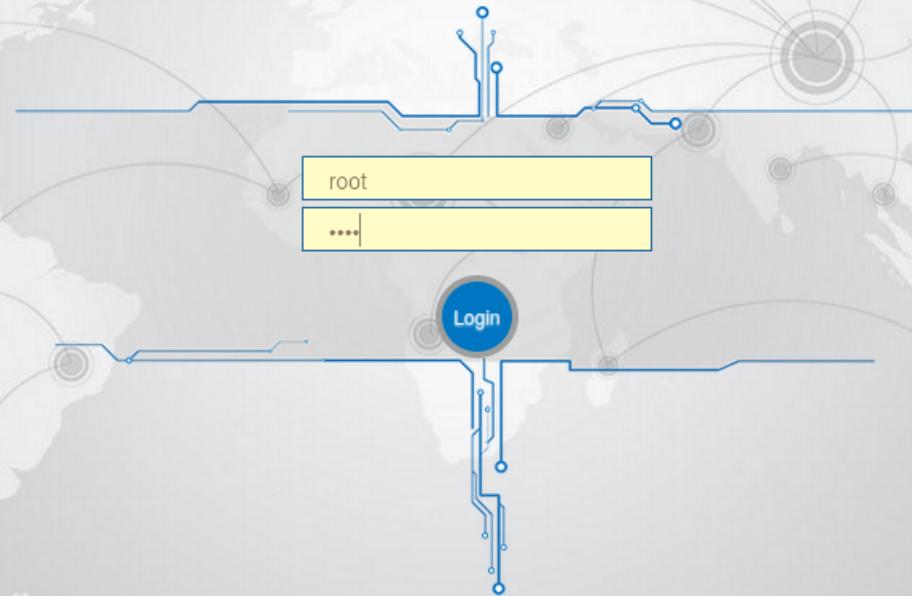
# 4 Countries, 8 Gateways

- Please stay in touch!
- The work only starts here

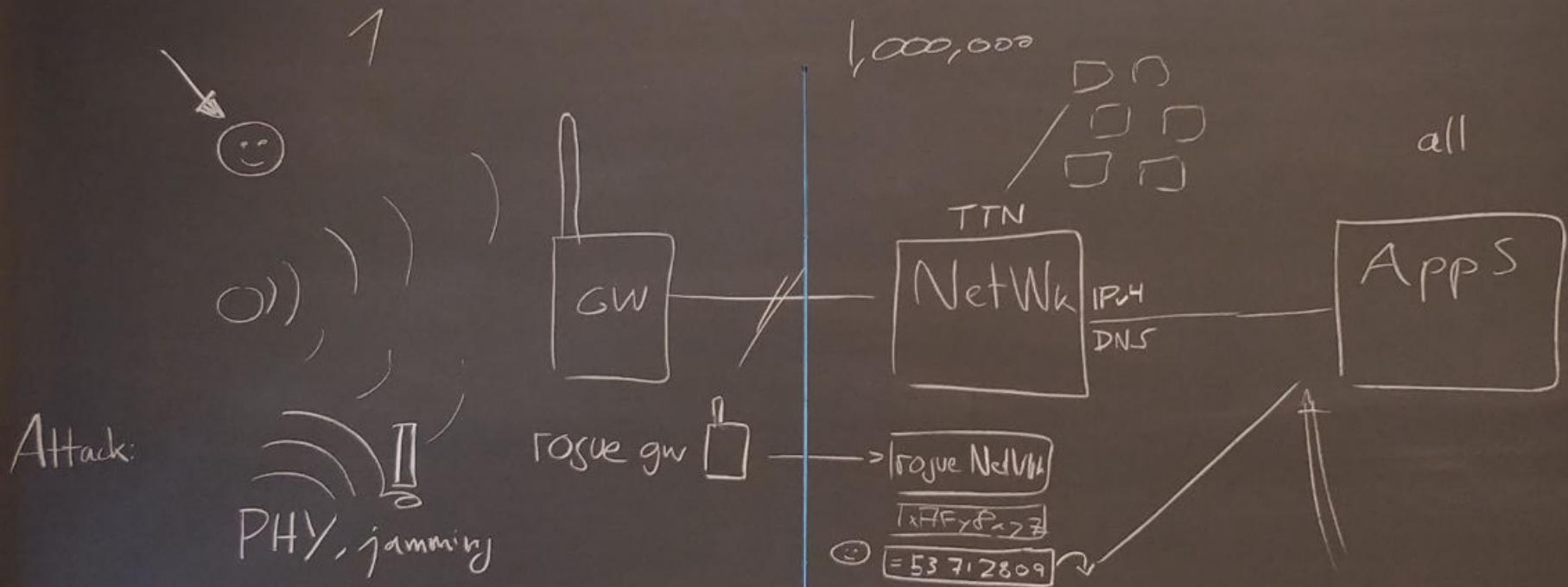




**RAK**  
IoT Made Easy



and Connect







space  
**Lacuna**





**SIGFOX Foundation**  
@SigfoxNation

Yes, rhinos can speak for years ! #IoT #sensors  
#OGNetwork @sigfox



**Institute IRNAS** @institute\_irnas · Feb 19

Rhinos are our hardcore testers. We built a super small #LoRaWAN based GPS tracker to make sure they are alive, healthy and don't get poached. More stories at The Things Conference on Tour Maribor >> [lnkd.in/g2R984Y](https://lnkd.in/g2R984Y)

#smartparks @thethingsntwrk #animalconservation #iot





space  
**lacuna**



# Lacuna.space LoRaWAN - how it works

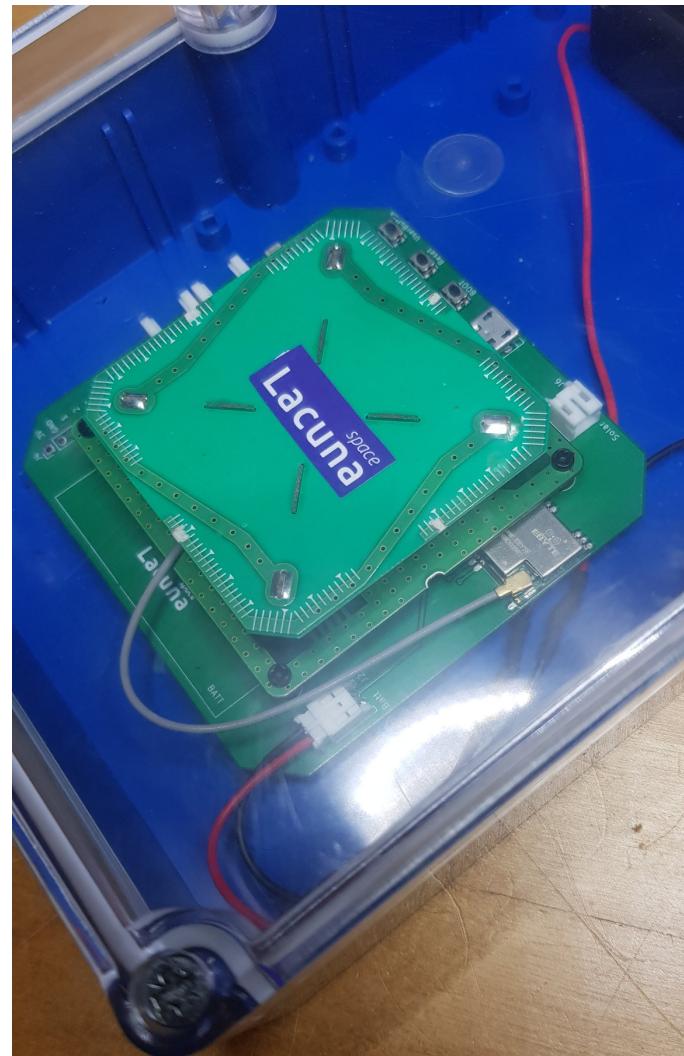
- Gateway in Satellite, LEO, 500 km
- Ground device – a small Arduino type board
- Special antenna – circular polarization
- Ground device programmed to download TLE (Two Line Elements)
- Calculates next passes and wakes up to send
- Sensors: Temperature, Pressure, Accel  
+ every sensor you want!

# Lacuna.space LoRaWAN - how it works

## TLE

M6P

```
1 44109U 19018AF 20051.80584361 .00001804 00000-0 61026-4 0 9992
2 44109 97.4794 120.3670 0057834 268.5777 186.8492 15.30455845 49582
```



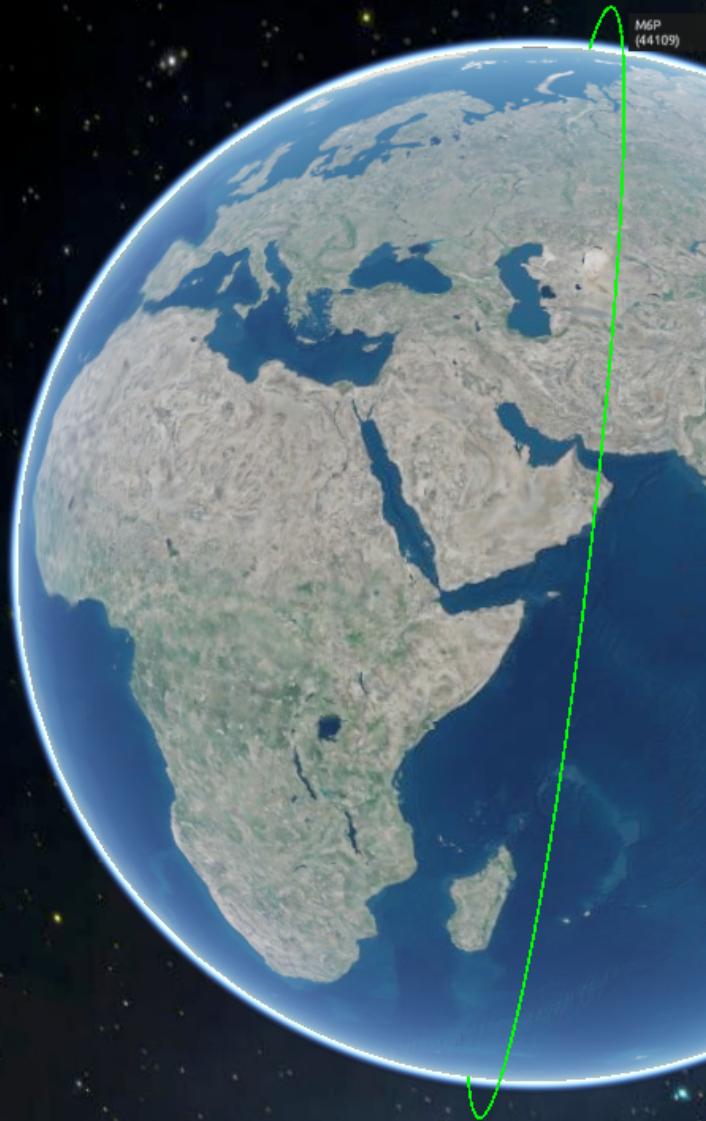
- Satellite:

M6P

(NORAD ID 44109U/19018AF)



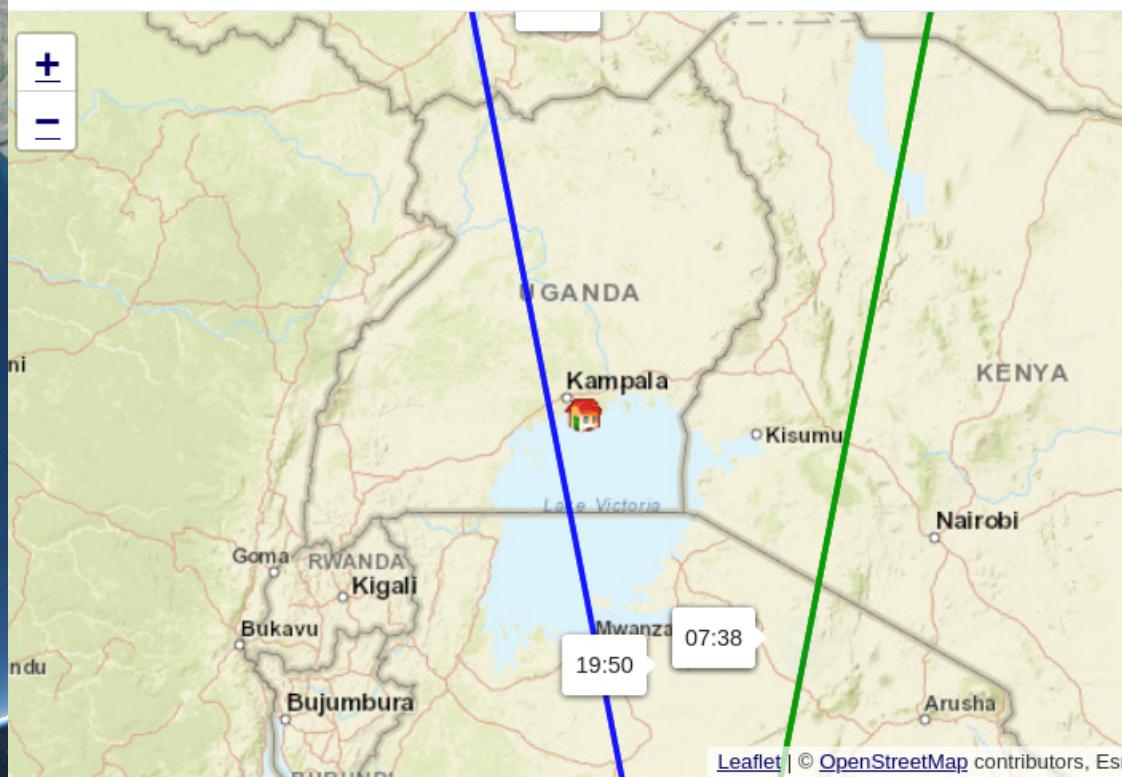


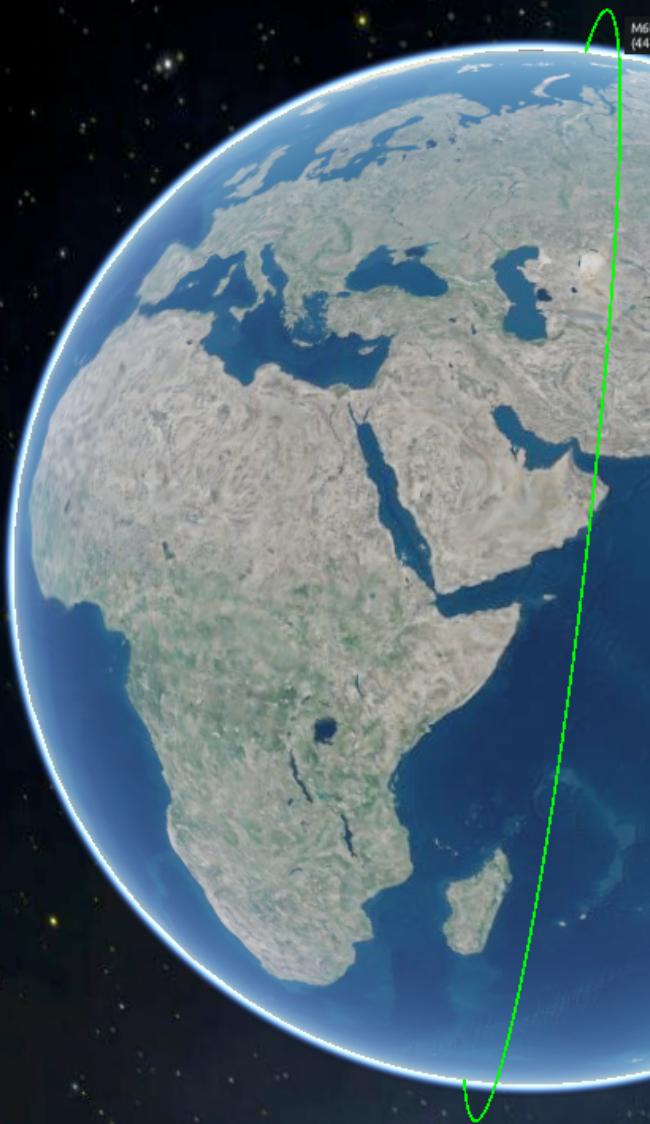


Pass beginning	Max altitude	Pass ending
Date: 18-Feb 19:45:30	Date: 18-Feb 19:50:50	Date: 18-Feb 19:56:10
Az: 169.54° (S)	Az: 226.78° (SW)	Az: 348.46° (N)
EI (alt): 0.39°	EI (alt): 86.55°	EI (alt): 1.22°
Mag: -	Mag: -	Mag: -
Dist to sat: 2435.9 km	Dist to sat: 474.5 km	Dist to sat: 2394.1 km
Eclipsed?: YES	Eclipsed? YES	Eclipsed? YES

Invisible pass

Add this pass on your notifications list

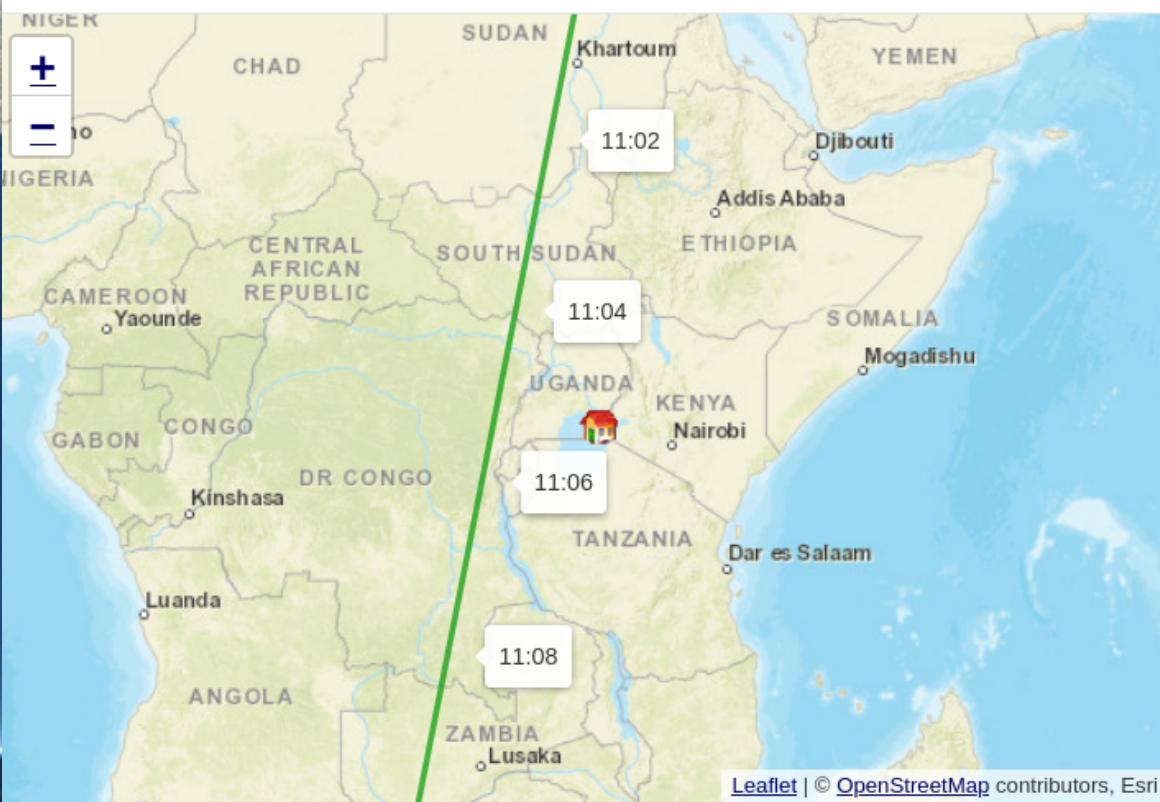




Pass beginning	Max altitude	Pass ending
Date: 18-Feb 10:59:10	Date: 18-Feb 11:04:40	Date: 18-Feb 11:09:50
Az: 1.94° (N)	Az: 281.39° (W)	Az: 200.78° (SSW)
EI (alt): 0.37°	EI (alt): 47.85°	EI (alt): 1.17°
Mag: -	Mag: -	Mag: -
Dist to sat: 2524.6 km	Dist to sat: 634.5 km	Dist to sat: 2364.4 km
Eclipsed?: NO	Eclipsed?: NO	Eclipsed?: NO

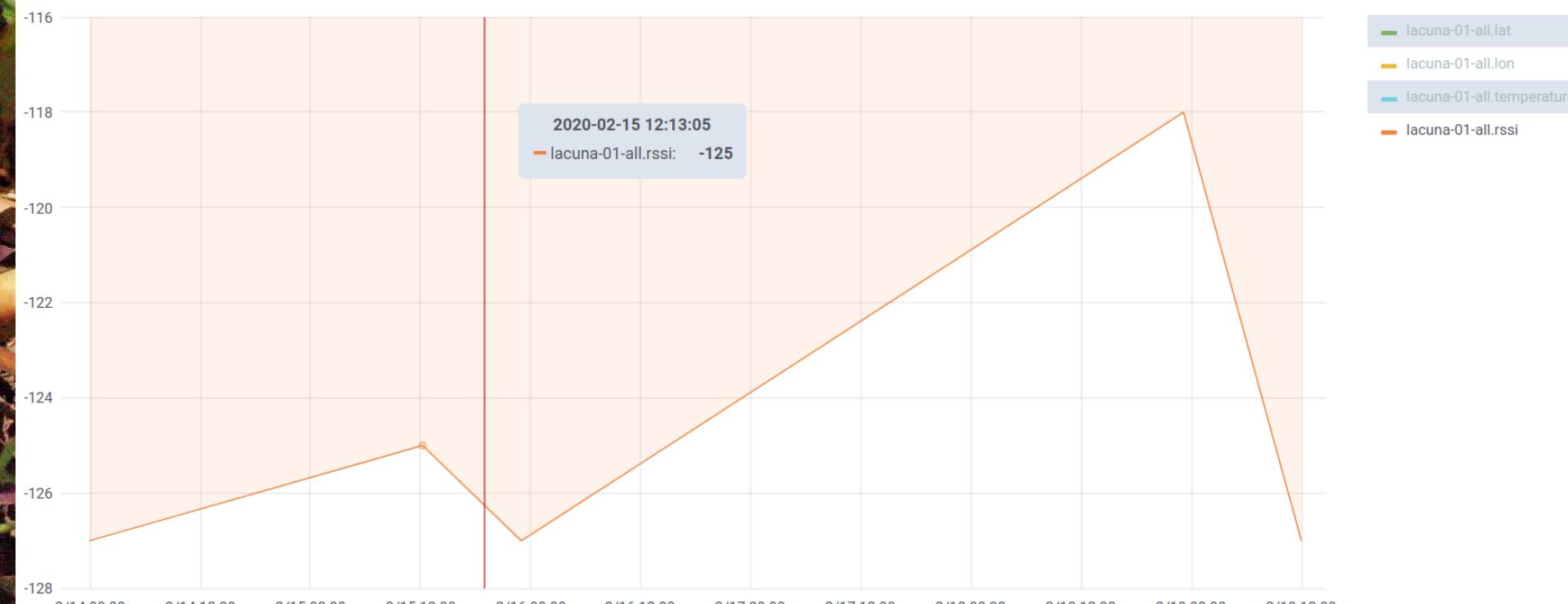
Invisible pass

Add this pass on your notifications list





lacuna-01-satONLY ▾



# Back to earth ... or sea

- Status of our work here
- Beyond terrestrial LoRaWAN
- 2.4 Ghz LoRaWAN
- Geolocation

# Maritime logistics, using 2.4 Ghz LoRa

Transforming  
Maritimes with  
LoRa-based  
Connectivity



# Exchange between many actors

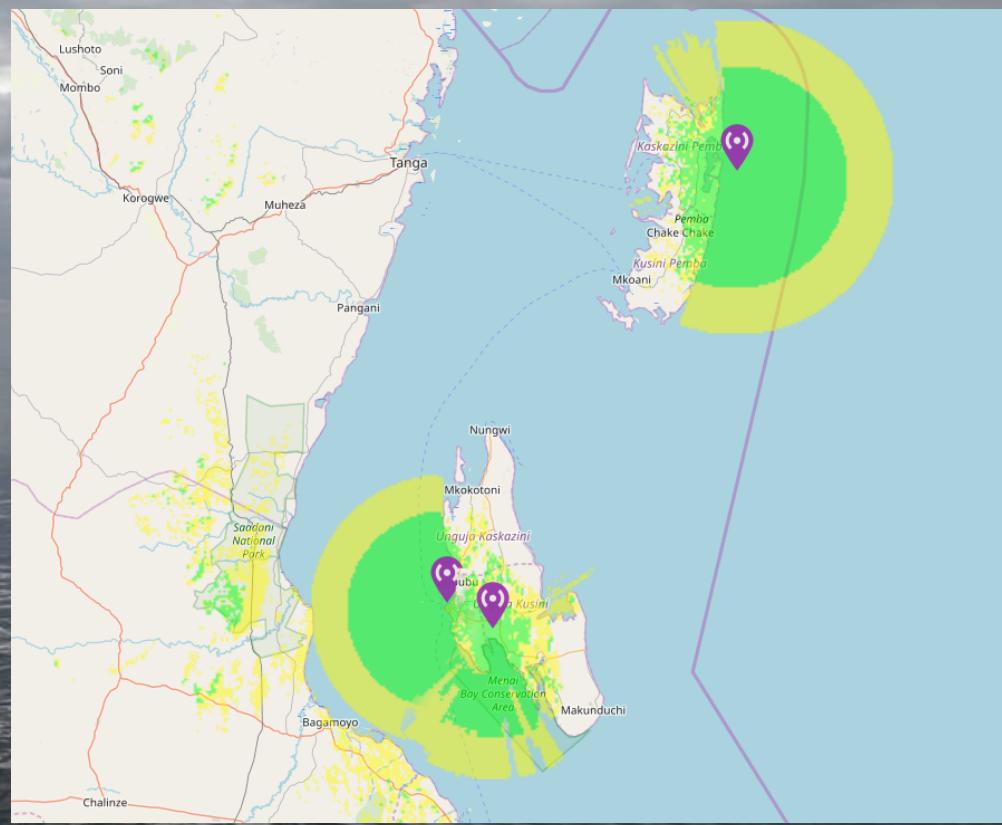


**Packet  
Broker**

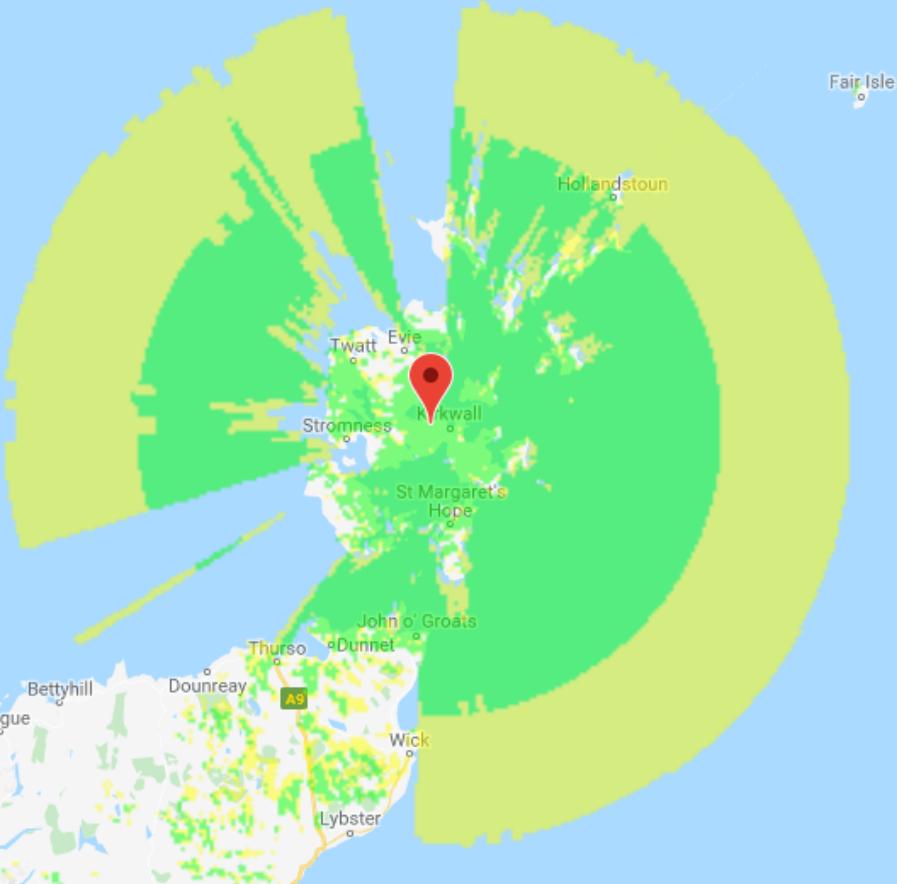
A **neutral** and **open** Internet of Things packet broker allowing IoT operators to interoperate according to the open principles of the internet.



# Coastal networks

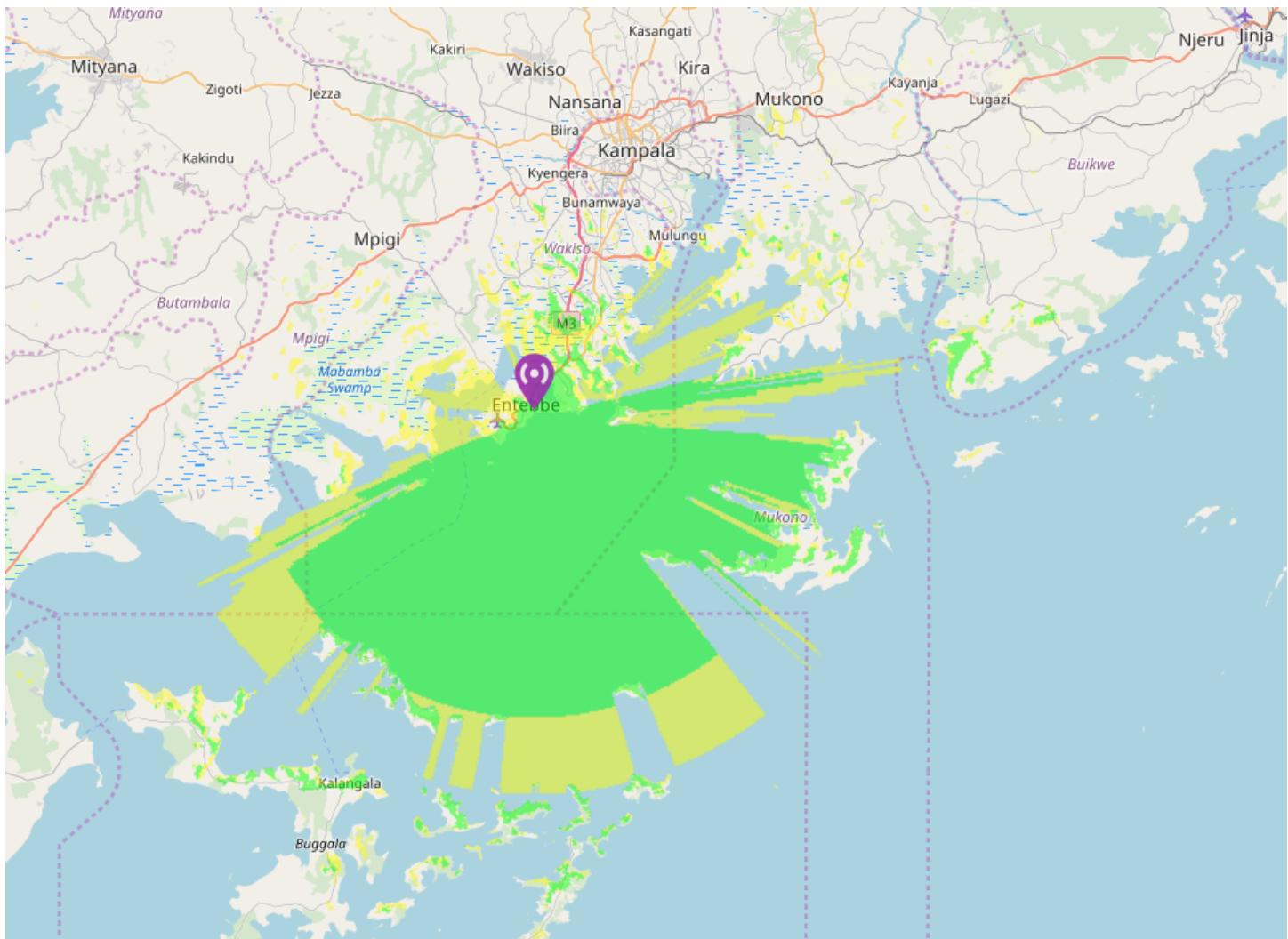


# Island networks

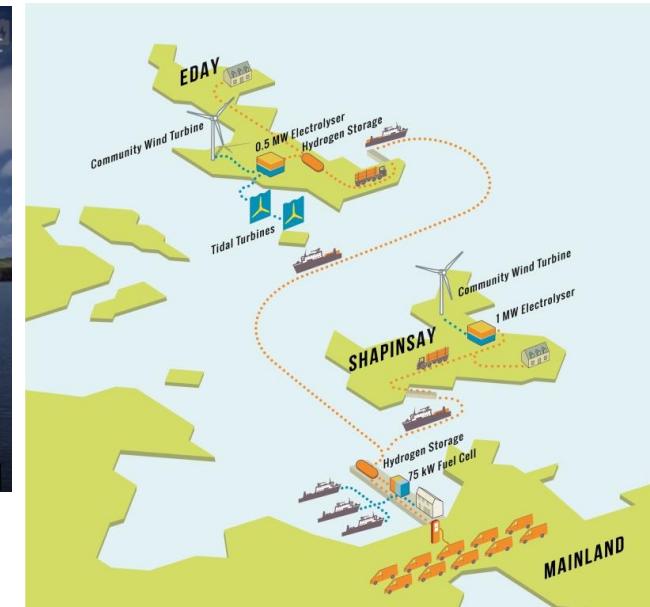
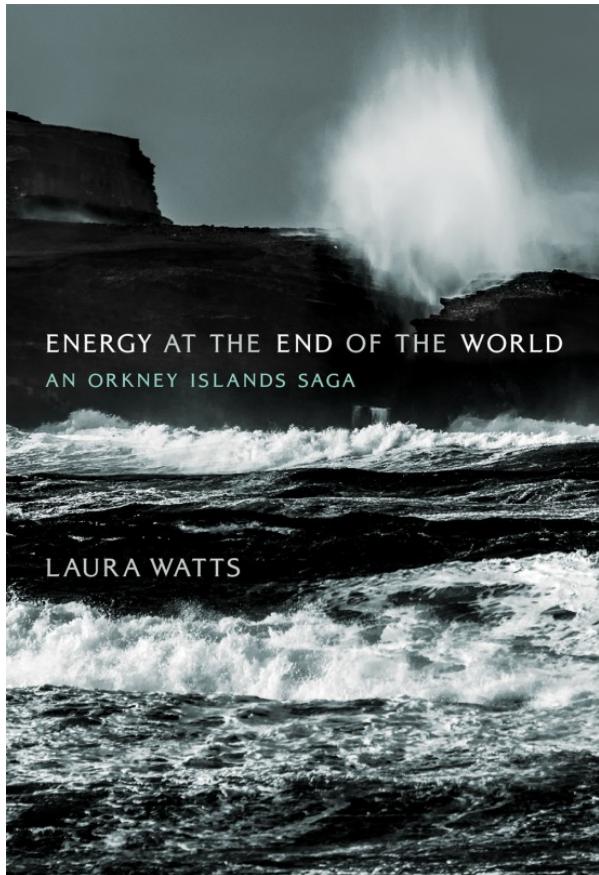


**Orkney  
Scotland, UK**

<https://orkneycloud.org>



# Marine Energy in Orkney



# fish farm in thailand



# IoT & Agriculture



# IoT & Agriculture



## Geolocation / TDOA location i LPWAN



## Geolocation inside a LoRaWAN network

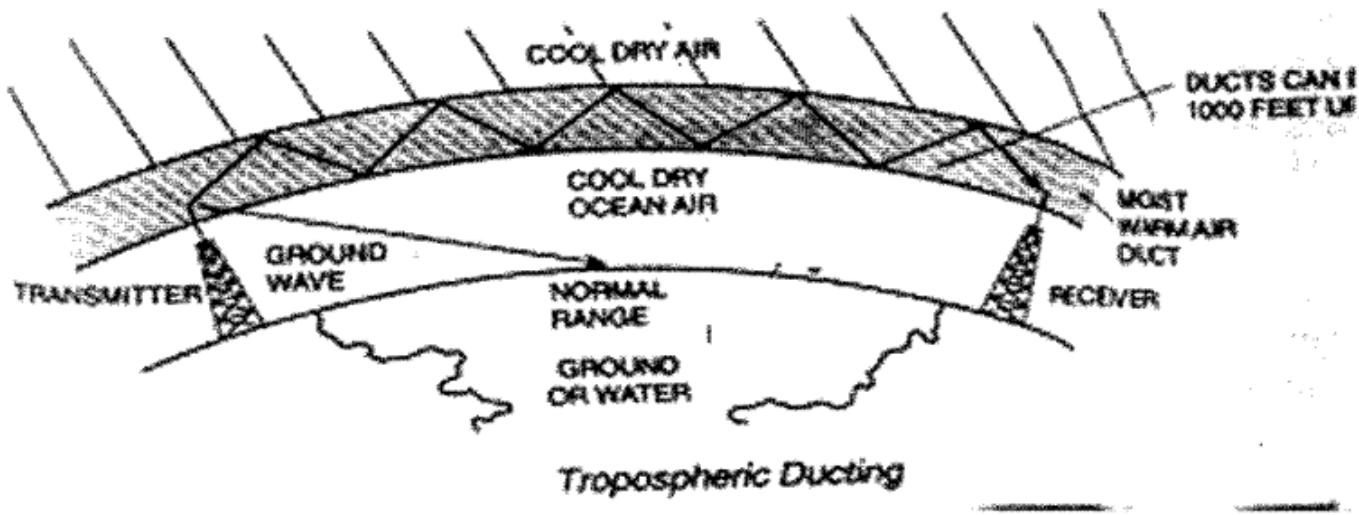
- Measuring distances can be done 2 ways:
  - RSSI (Received Signal Strength) = imprecise
  - Time-of-Flight of the radio wave = precise
- LoRa, given its spectral/time properties, makes it possible to measure a time of flight with a precision of 200ns-1 $\mu$ s under good receive conditions
  - $200\text{ns} \cdot c (3\text{e}8 \text{ m/s}) = 60\text{m}$
- Nodes and network are NOT time synchronized
  - Not possible to measure distance to 1 BS only
- If BS are time-synchronized, they can time-stamp the same message they receive (almost) simultaneously
  - These tiny time-of-arrival differences can be used to compute the relative distance of a node between 2 BS: locus = hyperbola
  - 3 BS required to compute a location in DTOA (Differential Time of Arrival)
  - Dense network needed!!



# Tropospheric propagation

## Tropospheric Ducting

Is when radio waves, normally blocked by the curvature of the earth, are carried in a "duct" between two different areas, beyond normal line-of-sight, which would normally not be carried said distance.





# Inspiration: NRENs & IoT

Evaluating the performance of NRENs in deploying IoT in Africa: the case for TTN

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STF Porto 12 october 2018

# What about a LoRaWAN academic network ?

afnic

Dashboard / GEANT APM / Service and Technology Forum

15th STF - Lisbon, October 2018



Workshop on LPWAN Solutions for the Internet of Things

17 - 21 February 2020  
Makerere University, Kampala, Uganda

Further information:  
Activity URL: <http://indico.ictp.it/event/9033/sm3437@ictp.it>

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## Description:

The growth of the Internet of Things will depend crucially on the establishment of a low cost infrastructure to handle traffic generated by IoT nodes.

Low Power Wide Area Network (LPWAN) solutions based on open standards that address the requirements of mobility, reliability, security and connectivity will be presented.

in the workshop. We will focus on the Things Network (TTN), an initiative to build a world-wide open source platform to support the Internet of Things. TTN operates by allowing users to share the access to gateways. We think NRENs in the region should play a leading role in this initiative. Playing a role for low-bandwidth communications over long distances, it can facilitate the deployment of applications relevant to East African countries.

## Topics:

- Wireless solutions for IoT

- LoRa and LoRaWAN protocols

- Prototyping of sensor boards

- Planning and deployment of a LPWAN network;

- Collection and visualization of the data.

A trusted academic IoT network



# Why NRENs could/should provide IoT/LPWAN infrastructure



(a kind of

- own connectivity backbones on national/regional scale
- can provide bandwidths that can easily accommodate the (small) amounts of additional traffic
- have points of presence in universities and other research institutions
- Cooperate internationally/globally
- are organisationally and culturally close to the R&E sector
- can foster entrepreneurship
- create ecosystems for innovation, startups and business well beyond the limits of the campus