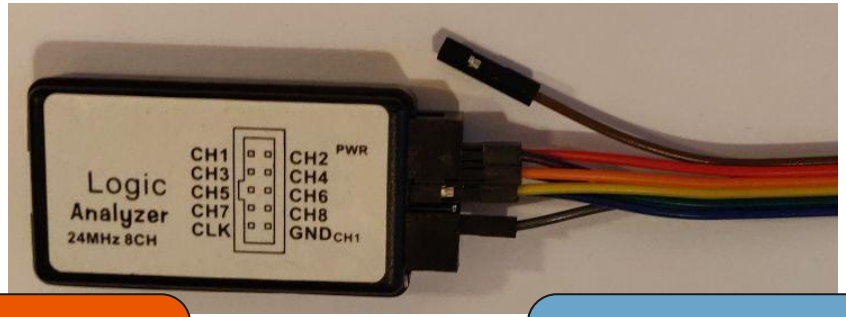
LASAGNA [development]

Low power Autonomous System for Adaptive Generalised Naval Assistance

Alessio Cappellini, Dario Petrillo
May 3rd, 2022

Brought to you by

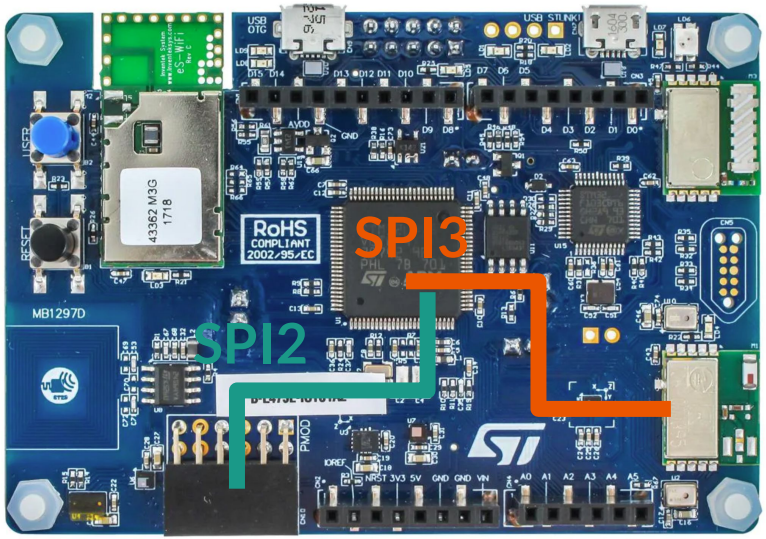


Call NOW! And get your very own 1-800-LOGIC

Buy one, we'll send another one for free!

Perfect for household problems!

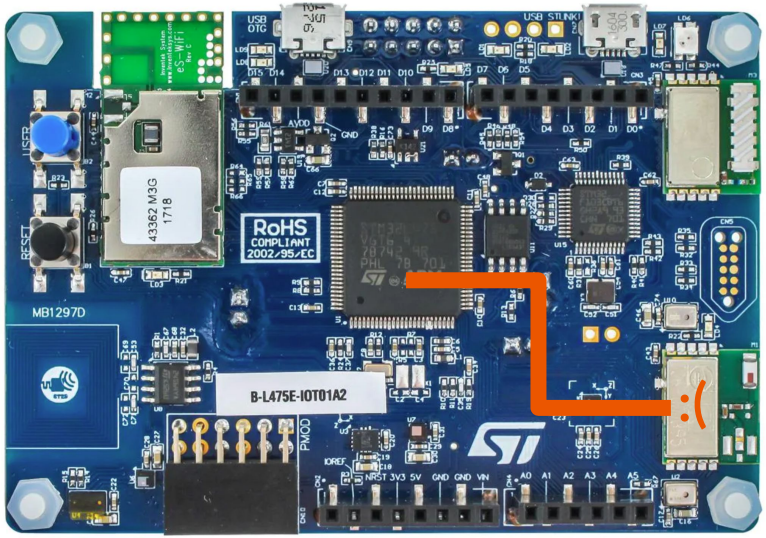
BLE Support



Step 1: add support to RIOT for the missing SPI buses

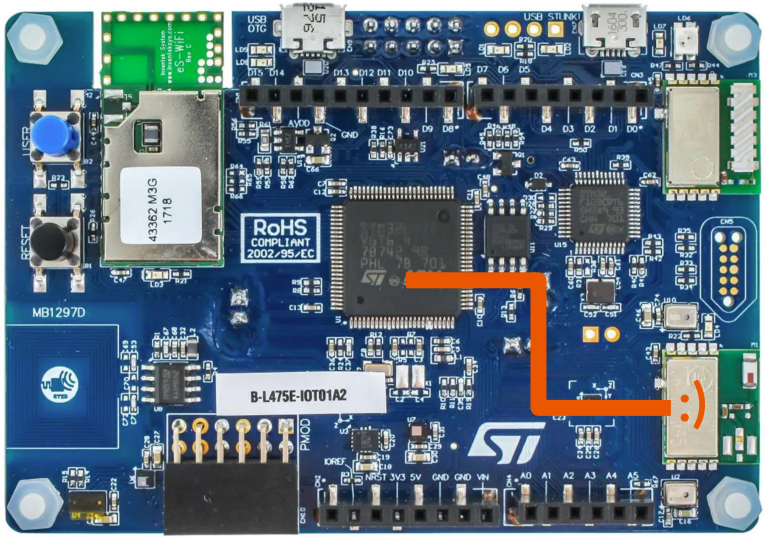
=> We need to use SPI3 to talk to our chip

BLE Support



Step 2: Try (and fail) to use the chip with NimBLE

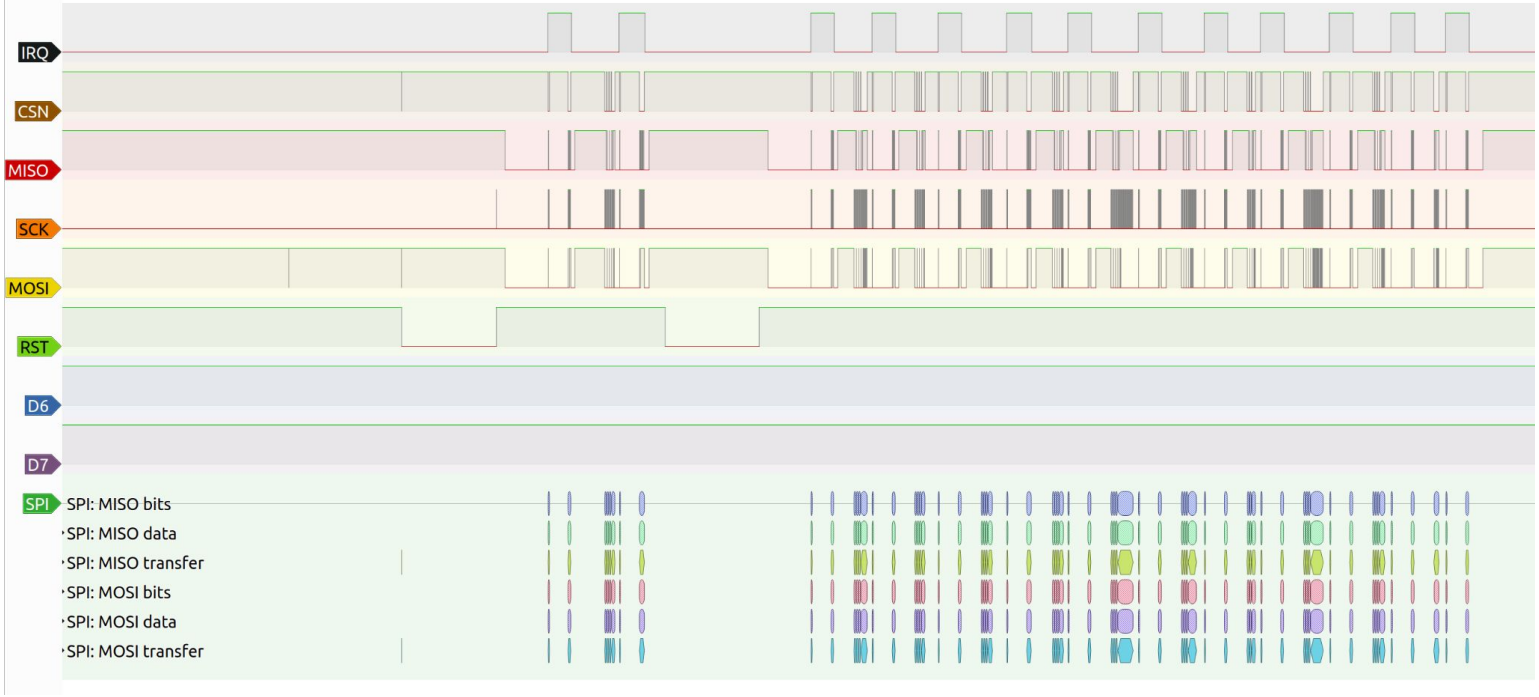
BLE Support



Step 3: Backtrack to a simpler solution

We ported the stm32duino/SPBTLE-RF library to RIOT

BLE Support - our first communication



BLE Support - receiver

Step 4: The stm32duino library can only work as a beacon :/

=> We implemented the observer role in our fork to receive packets

LoRa Support

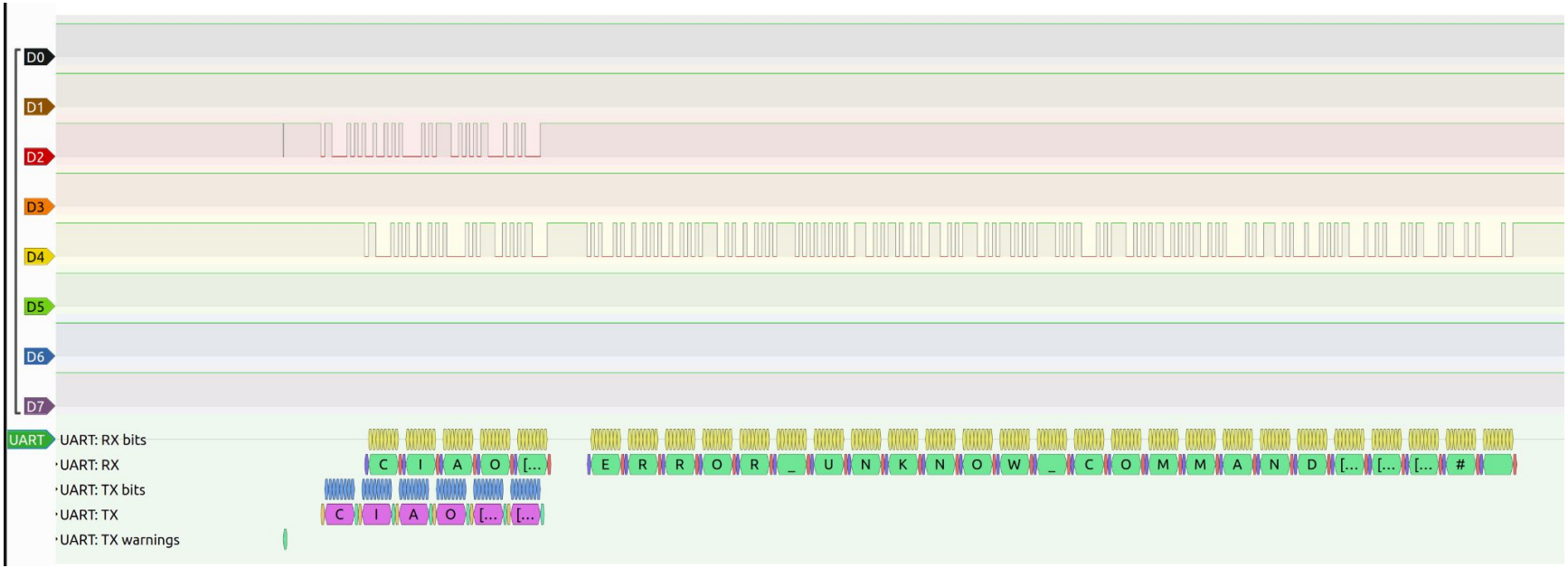
Step 1: Try to make the LoRa shield work

=> It uses a variant of AT with custom commands

=> The only documentation we found describes the last firmware version

=> But of course ours is older

LoRa Support - AT Commands



LoRa Support

Step 1: Try to make the LoRa shield work

=> By modifying the RIOT AT driver, we managed to communicate with the shield

=> And could even start a LoRa join procedure!

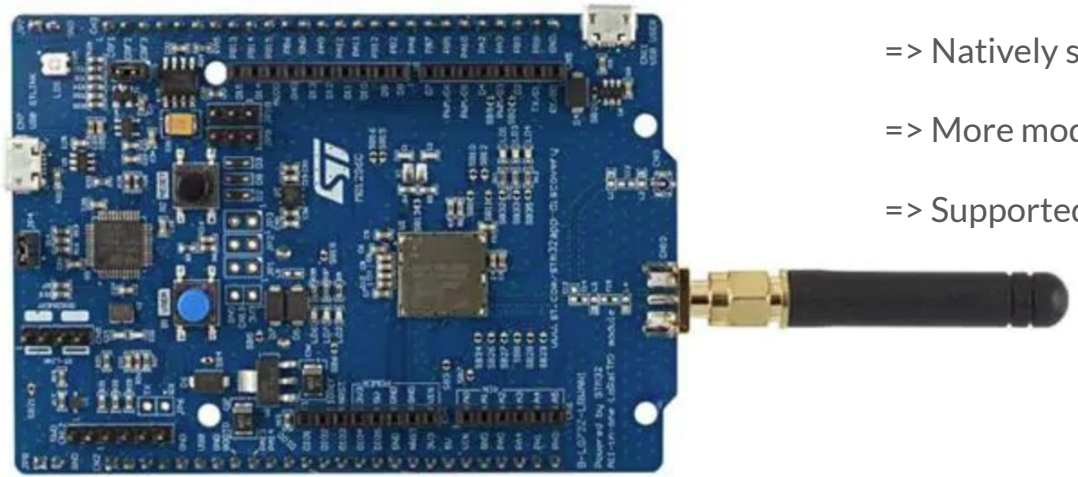
LoRa Support

Step 1: Try to make the LoRa shield work

=> But after TTN forwarded the join-accept we didn't receive any packet from it


THIS IS MADNESS
NO, THIS IS LORA
imgflip.com

LoRa Support



Step 2: Try a different board

=> Natively supported by RIOT

=> More modern LoRa version (1.0.2)

=> Supported by IoT-Lab

LASAGNA [demo]

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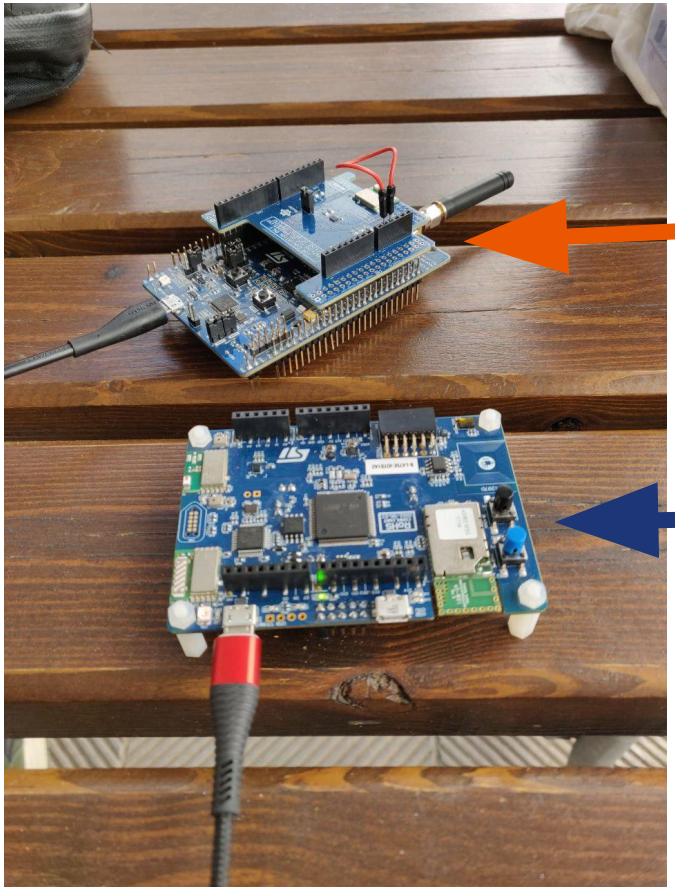


Receiver

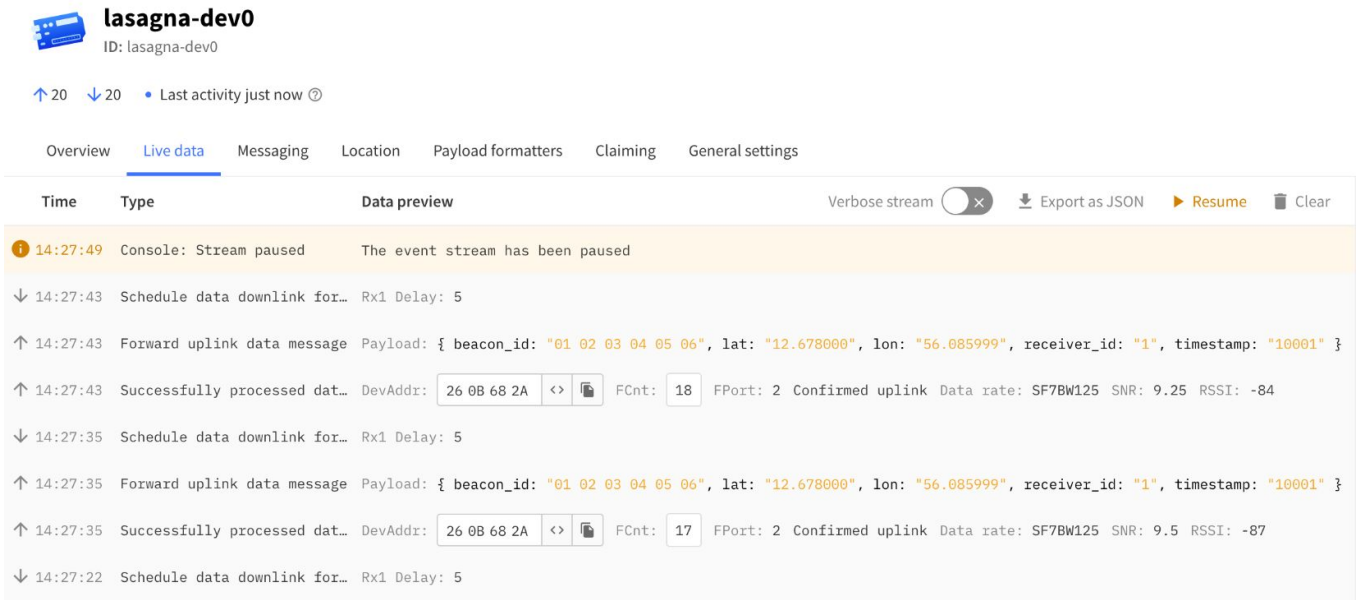
Beacon

Receiver serial

```
verified 74412 bytes in 3.082072s (23.578 KiB/s)

Info : Unable to match requested speed 300 kHz, using 240 kHz
Info : Unable to match requested speed 300 kHz, using 240 kHz
shutdown command invoked
Done flashing
/home/riot/Desktop/dev/LASAGNA/code/RIOT/dist/tools/pyterm/pyterm -p "/dev/ttyACM0" -b "115200"
Twisted not available, please install it if you want to use pyterm's JSON capabilities
2022-05-02 05:22:09,490 # Connect to serial port /dev/ttyACM0
Welcome to pyterm!
Type '/exit' to exit.
2022-05-02 05:22:10,496 # 00 12 02 00 03 B6 AA FE 00 EA 4C 41 53 41 47 4E 41 00 12 34 01 02 03 04 05
 06 00 00
2022-05-02 05:22:10,496 # [=] beacon id:  01 02 03 04 05 06
2022-05-02 05:22:13,133 # Sending: {"beacon_id":"01 02 03 00main(): This is RIOT! (Version: 2022.04-
devel-1138-g1abc0-HEAD)
2022-05-02 05:22:13,136 # [+] Starting LoRa connection
2022-05-02 05:22:13,213 # [+] deveui: 70 b3 d5 7e d0 4 f3 19
2022-05-02 05:22:13,216 # [+] appeui: 0 0 0 0 0 0 0 a2
2022-05-02 05:22:13,222 # [+] appeui: 3c 95 97 1b fc c9 c2 4f d8 99 d3 76 74 95 d4 d9
2022-05-02 05:22:13,224 # Starting join procedure
2022-05-02 05:22:18,409 # Join procedure succeeded
2022-05-02 05:22:18,413 # LoRa initialization completed successfully
2022-05-02 05:22:18,413 #
2022-05-02 05:22:18,415 # [+] Starting BLE
2022-05-02 05:22:18,426 # [+] BLE started
2022-05-02 05:22:18,445 # Observer started
2022-05-02 05:22:18,446 # [+] Initialized
2022-05-02 05:22:20,204 # [=] data parsed:  1F 02 01 06 03 03 AA FE 17 16 AA FE 00 EA 4C 41 53 41 47
 4E 41 00 12 34 01 02 03 04 05 06 00 00
2022-05-02 05:22:20,208 # [=] beacon id:  01 02 03 04 05 06
2022-05-02 05:22:20,221 # Sending: {"beacon_id":"01 02 03 04 05 06", "receiver_id":"1", "lat":"12.67
8000", "lon":"56.085999", "timestamp":"10001"}
2022-05-02 05:22:25,478 # --------------
2022-05-02 05:22:30,214 # [=] data parsed:  1F 02 01 06 03 03 AA FE 17 16 AA FE 00 EA 4C 41 53 41 47
 4E 41 00 12 34 01 02 03 04 05 06 00 00
2022-05-02 05:22:30,217 # [=] beacon id:  01 02 03 04 05 06
2022-05-02 05:22:30,230 # Sending: {"beacon_id":"01 02 03 04 05 06", "receiver_id":"1", "lat":"12.67
8000", "lon":"56.085999", "timestamp":"10001"}
2022-05-02 05:22:35,487 # --------------
```

TTN console


lasagna-dev0
ID: lasagna-dev0
20 20 Last activity just now
Overview
Live data
Messaging
Location
Payload formatters
Claiming
General settings
Time
Type
Data preview
Verbose stream
Export as JSON
Resume
Clear
14:27:49 Console: Stream paused The event stream has been paused
14:27:43 Schedule data downlink for… Rx1 Delay: 5
14:27:43 Forward uplink data message Payload: { beacon_id: "01 02 03 04 05 06", lat: "12.678000", lon: "56.085999", receiver_id: "1", timestamp: "10001" }
14:27:43 Successfully processed dat… DevAddr: 26 0B 68 2A FCnt: 18 FPort: 2 Confirmed uplink Data rate: SF7BW125 SNR: 9.25 RSSI: -84
14:27:35 Schedule data downlink for… Rx1 Delay: 5
14:27:35 Forward uplink data message Payload: { beacon_id: "01 02 03 04 05 06", lat: "12.678000", lon: "56.085999", receiver_id: "1", timestamp: "10001" }
14:27:35 Successfully processed dat… DevAddr: 26 0B 68 2A FCnt: 17 FPort: 2 Confirmed uplink Data rate: SF7BW125 SNR: 9.5 RSSI: -87
14:27:22 Schedule data downlink for… Rx1 Delay: 5

LASAGNA [evaluation]

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Clock drift

- Receivers need to be synchronized with each other for localization to work
- The RTC crystal can drift by up to ±20ppm, or 50s per month

Frequency Tolerance @+25℃	-20	-----	+20	ppm	32.768kHz
	-30	-----	+30		Other frequencies

- We need a better time source for long term stability
    - GPS!

Beacon lifetime

Table 2: Average dwell times at major European container terminals (in days)

Characteristics	**Bremen**	**Hamburg**	**Rotterdam**	**Antwerp**	**La Spezia**	**Gioia Tauro**
Import dwell vessel – truck	6,4	6,4	6,4	6,4	7,4	7,4
Export dwell truck – vessel	4,6	4,6	4,6	4,6	5,6	5,6
Import dwell vessel – train	6,5	6,5	6,5	6,5	7,5	7,5
Export dwell train – vessel	4,7	4,7	4,7	4,7	5,7	5,7
Import dwell vessel – barge	4,1	4,1	4,1	4,1	5,1	5,1
Export dwell barge – vessel	4,3	4,3	4,3	4,3	5,3	5,3
Transshipment dwell	-	-	-	-	-	5,3

Beacon lifetime

Table 4.1: Comparison of Cargo Dwell Time in Major African Ports

Type of dwell time	Durban	Mombassa	Douala	Lagos	Port said
	No. of days	No. of days	No. of days	No. of days	No. of days
Operational	2	5	5	5	1
Transactional	1	3	5	4	1
Storage	1	3	9	7	3
Total	**4**	**11**	**19**	**16**	**5**

Source: Extracted from the World Bank study on cargo dwell time in African ports.

Beacon lifetime

- Given these results, we target a lifetime of 20-30 days to handle most situations

LASAGNA [future plans]

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Development

- Data processing to extract locations and paths
- Evaluation of localization algorithms
- Integration of the GPS module in the receiver
- Finalization of the packet formats

Evaluation

- Beacon power consumption
- Bluetooth network usage
- LoRa usage and duty cycle monitoring