***BLueAngel*® "Virometer" Demonstration**

1. Executive Summary

BLueAngel® (Fig 1) serves as an exposure monitor to Coronavirus carriers like a radiation dosimeter that monitors exposure to radiation. The tag measures the proximity to neighboring tags and logs the proximity as a function of time. The tag is meant for all individuals in a facility and once a person is identified as a carrier of the Coronavirus, all individuals that are suspected of having contracted the virus are alerted that they should self-quarantine and be checked if they are Covid-19 positive. See reference 2.1. **The current document summarizes the preparations for a demo.**

Figure 1 - *BLueAngel*® "Virometer"

2. Applicable Documents

2.1. Our proposal - Identification of Medical Staff Exposed to Coronavirus Carriers Preventing Overall Quarantining of Teams 20/3/2020

3. Expected Performance

RF Tests were performed in various scenarios Figure 2 demonstrates a typical detection envelope. Best results are obtained while the individuals are facing one another. In the case that they are not facing each other, the detection range between the two tags is smaller.

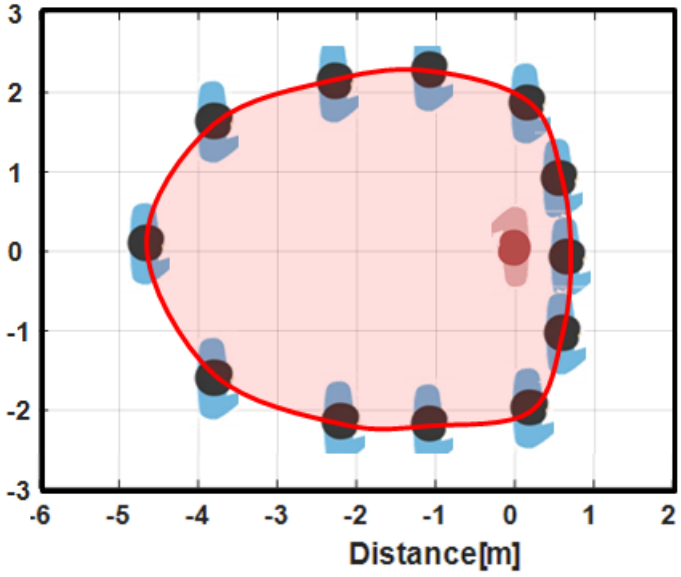


Figure 2 – Proximity Detection Envelope with Tags carried on the chest

4. Data Handling

4.1. BLE Tag

Each tag continuously transmits packet advertising including the network name "*BLueAngel*" and its unique address (MAC Address). In addition, each tag also listens (Observer) to other *BLueAngel*® tags, every X seconds as requested. In addition, it can listen to other defined tags.

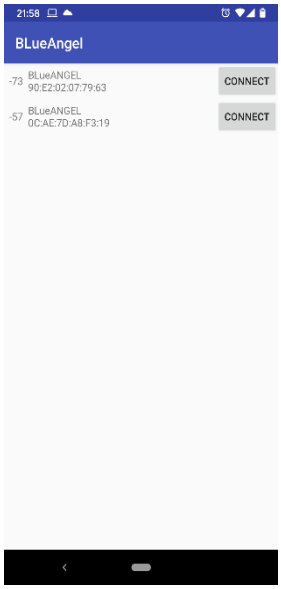


Figure 3

When an interaction occurs with another tag with an RSSI-level greater than a predefined X value, the remote tag address and the exposure time are recorded in the local tag. The exposure time can be set in seconds, minutes, etc.

The data is stored in FLASH memory so that even after the battery is turned off or the battery is replaced, all interactions are maintained. The free memory size is about 64K, which allows you to save interaction history with about 5000 different tags.

The tag data can be unloaded to any peripheral device such as smartphone or dedicated hotspot. Unpacking the data takes now about 20 seconds per 100 interactions.

4.2. SQL Server

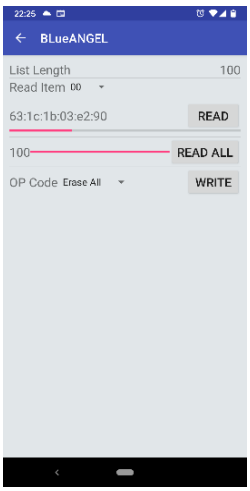
The server holds the information about the tags and the tag holders and associates between them with a unique MAC address for each tag and a unique ID for each person. Subgroups may be set within the list to define different zones of interest. Tag status of Coronavirus carriers will be updated and all possible infected individuals will be marked as potential carriers.

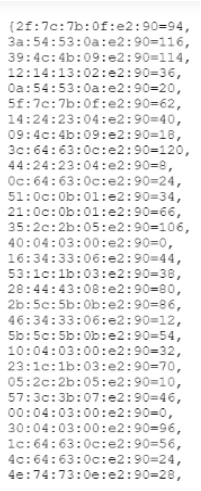
One can add interaction tables for each tag to the server in the future, and further analyze the data.

dx	time added	name	id	Mac	group	positive	suspect	Disregard
1	2020-03-24			0C:AE:7D:A8:F3:19	0	0	0	0
2	0000-00-00			90:E2:02:07:79:63	0	1	0	0
4	0000-00-00			0C:AD:2D:A8:F3:19	0	0	0	0
5	0000-00-00			1C:AE:7D:A3:F3:13	1	0	0	1
6	2020-03-24			90:E2:02:07:7A:85	1	0	1	0
7	2020-03-24			90:E2:02:07:7A:A2	1	1	0	0
8	2020-03-24			90:E2:02:07:7A:6B	1	0	0	0

Figure 4 – Typical Server Report

4.3. *BLueAngel*® (Android/iOS) Application





The app is the pivot between the SQL server and the BLE tags.
While running the application, it contacts the SQL server on the Internet to obtain the latest list of infected tags, and compares them to the local tag interactions after unloading its FLASH memory.
The user may be alerted to significant exposure for tags with an interaction longer than X seconds combined with RSSI greater than Y.
After downloading data from a Coronavirus tag, the SQL server application, synchronizes and updates all tags holders that were in contact with the Coronavirus carrier.
The entire list of interactions can also be uploaded back to the SQL server for further data analysis.

Figure 5

The application shows the exposure level of a tag to tags of Coronavirus carriers. Figure 6 demonstrates that increasing the exposure time increases the exposure level which means that the tag carrier is at a higher risk of having contracted the virus.

Figure 6 – Application Screenshots

5. Required Battery Capacity

Power consumption was tested in hibernation mode and in scan mode. In hibernation mode it consumed 1.5 mA and in scan mode it consumed 18.5 mA. Each scan takes about 1 second and selecting the time interval in between scans affects the average power consumption as shown in Figure 6. For now, we assume the tags will be set to scan every 5 seconds. For this, with batteries of 150 mAh the tags will require recharging every 24 hours. With 500 mAh batteries, the tags will require recharging every 4 days. Tables 1 & 2 show various required batteries for long scan intervals.

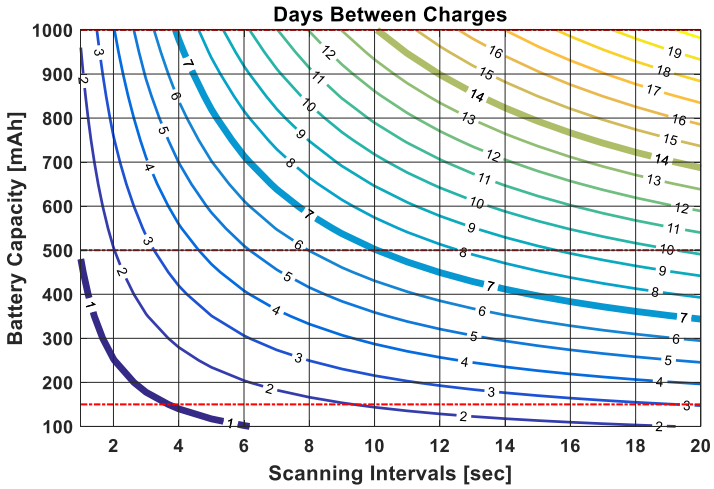


Figure 7 – Days Between Charges for Various Battery Capacities & Scan Intervals

Scan Intervals [sec]	1	5	10	15	20
1Day	480	117	-	-	-
1Week	-	820	502	397	344
2Weeks	-	-	1004	793	687

Table 1 – Batt. Capacity mAh for Days Between Charges & Scan Interval
(Batteries Capacity 100-1000mAh)

Scan Intervals	1min	5min	10min	15min
1 Week	237	195	190	188
2 Weeks	475	391	380	377
3 Weeks	713	586	570	565
4 Weeks	-	782	565	753

Table 2 – Batt. Capacity mAh for Weeks Between Charges & Scan Intervals
(**about 180mAh/week for long scan intervals**)

6. RF Tests Setup

The tags are configured with a low transmission power. The current scan period is 700 milliseconds with a user selectable scan intervals between 1 to 250 seconds. The detection threshold is selectable and was set to detect other tags at a distance up to 5 meters. Part of the tags that were used in the tests are shown in figure 8. Figure 8 also shows the marking on the tags, allowing automated identification even while they are not operational.

Figure 8 – BLueAngle® Tags Prepared for tests

6.1. Preliminary tests

Preliminary tests were performed to get general understanding of system limitations as shown in figures 9-10. This tests were followed by detection envelope tests with the proposed enclosure.

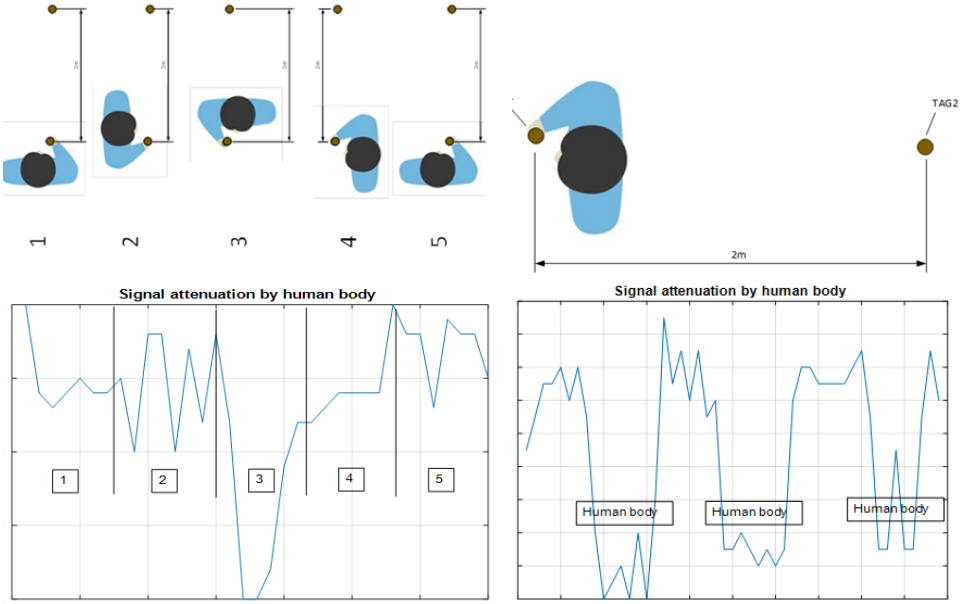


Figure 9 – Various Obstruction Tests

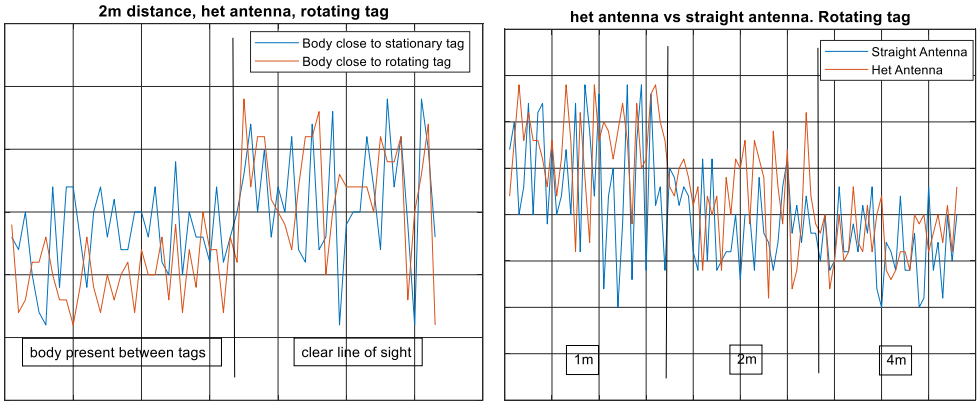


Figure 10 – Various Antenna Direction Tests

6.2. Enclosed Tags RSSI Tests

These tests were performed with 4 BlueAngel units transmitting to a cellular phone while performing the following trajectories:

- Linear translation – Walking away from the receiver from 1 to 7 meters while the BlueAngel tags were mounted on the chest then turning around and moving from 7 to 1 meters. This was done twice. The average results are shown in the following figures. The noise level was less than 5 dB and adding the position versus time gives us the RSSI versus distance for two cases. With the body interference while moving forward (away from the cellphone), and without body

interference while returning toward the cellphone. See Figures 11-12 – Figure 11 show raw data, figure 12 show the processed data vs range.

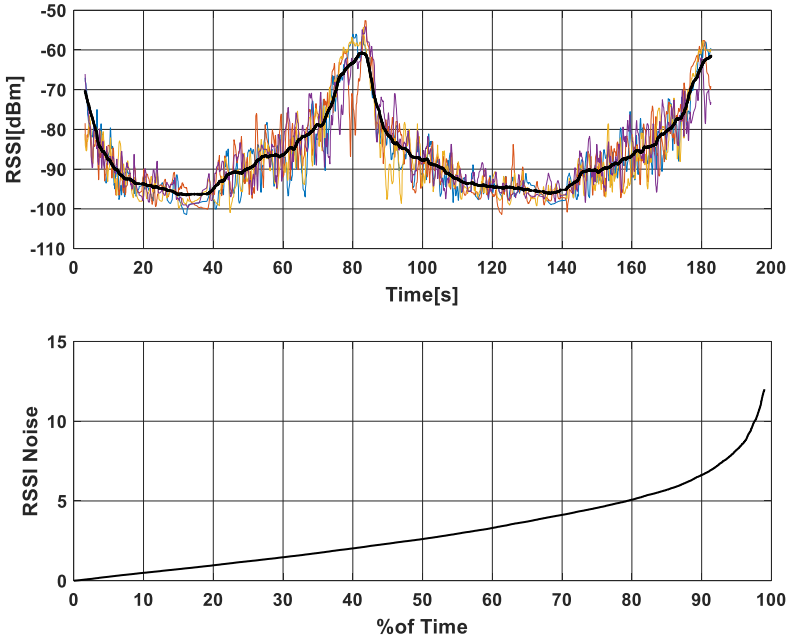


Figure 11 – Linear translation 1 – 7 meters results

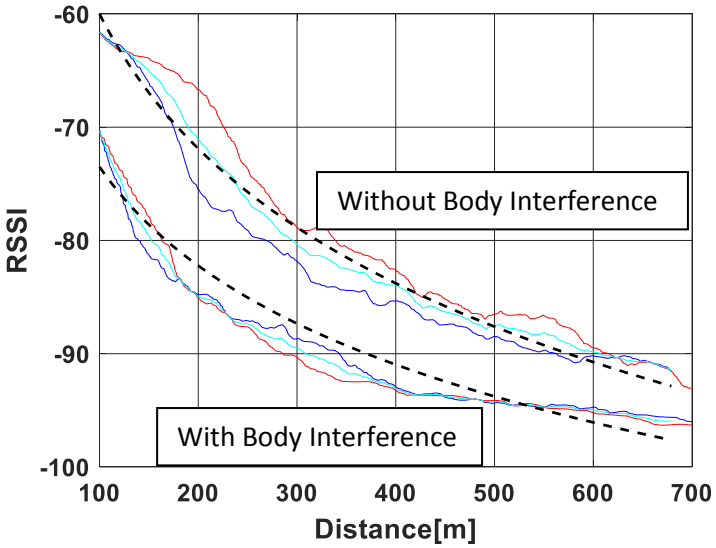


Figure 12 – Linear translation 1 – 7 meters results

- Angular measurements – Rotating in place for four rotations, with each rotation taking about 18 seconds. The rotation rate was about 20 degrees per second. The conversion of the time to angles allows to plot the RSSI as a function of angle and it shows that the RSSI measurements can be approximated as ~5*cos(heading). Figure 13 Shows the raw data and figure 14 shows the processed data vs heading.

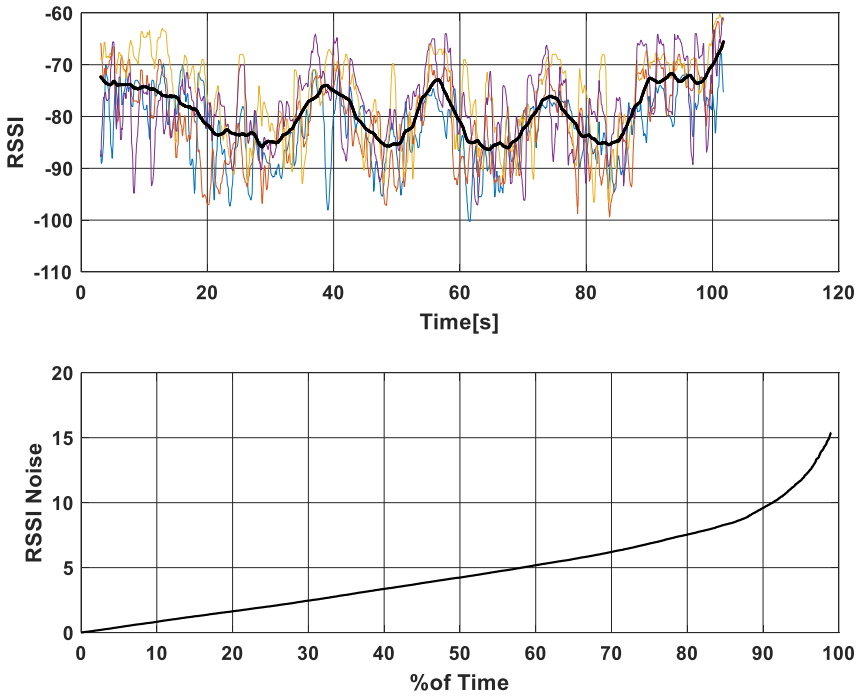


Figure 13 – Rotation tests results

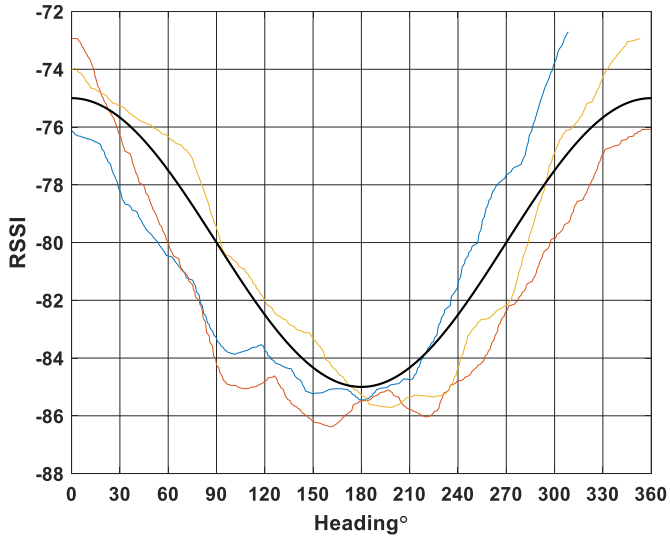


Figure 14 – Rotation tests results RSSI vs Heading

Figures 15 & 16 show calculated & measured constant RSSI envelopes. We see that the measured envelop show similar behavior to the calculated envelope (the threshold at the tests was -83dB.

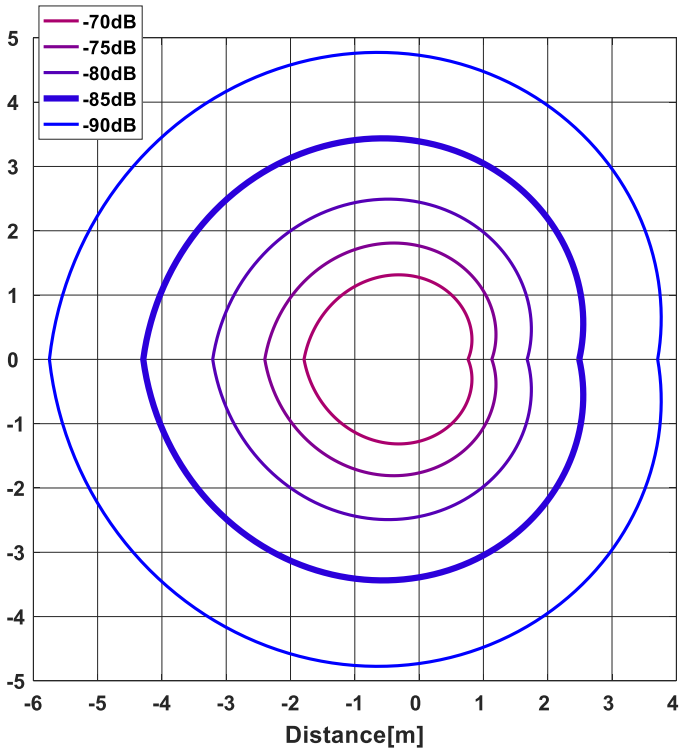


Figure 15 – Calculated constant RSSI Envelope

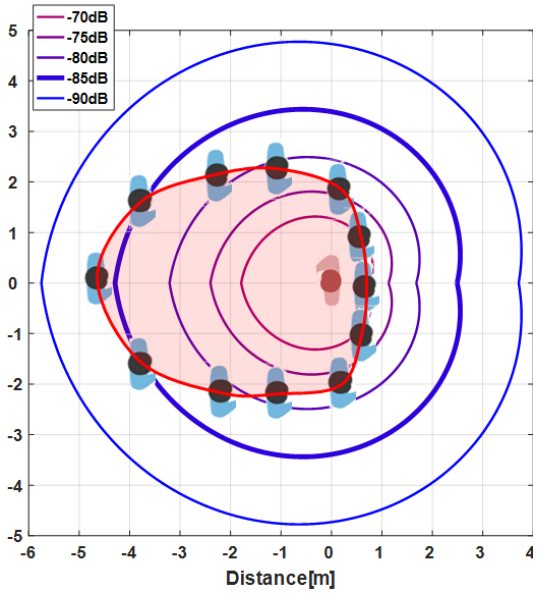


Figure 16 – Measured RSSI envelope (red) & Calculated RSSI envelope