

# Using PIFA Technology to secure stable connectivity in mobile IoT units

A technical review and comparative measurements



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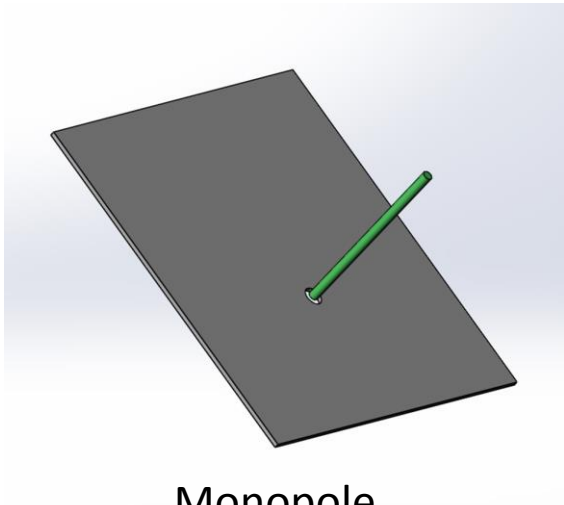
# Background

- The total number of Connected devices in the world is staggering already (16 billion devices in 2016). According to a forecast made by Ericsson there will be **29 billion by 2022** of which **18 billion will be related to IoT**. **Wide area IoT** and **Short range IoT** will account for the bulk of growth, according to the said forecast. The annual growth will be 30% and 20% respectively.
- **Many of the connected IoT devices are/will be mobile.** Quality of connectivity will be an ever-increasing demand of users. The overall acceptance of poor connectivity is decreasing along with mobile devices become a natural part of everybody's professional and private living. A vital part of mobile connected devices' functionality is the performance of the antennas. *"A chain is only as strong as its weakest link"*
- **Embedded antennas of Mobile devices face different performance challenges than fixed/immobile ditto.** Factors like polarity of the RF, frequency stability and omnidirectionality play major roles in establishing robust and safe connectivity due to the ever-changing spatial location of the transmitting/receiving counterparts.

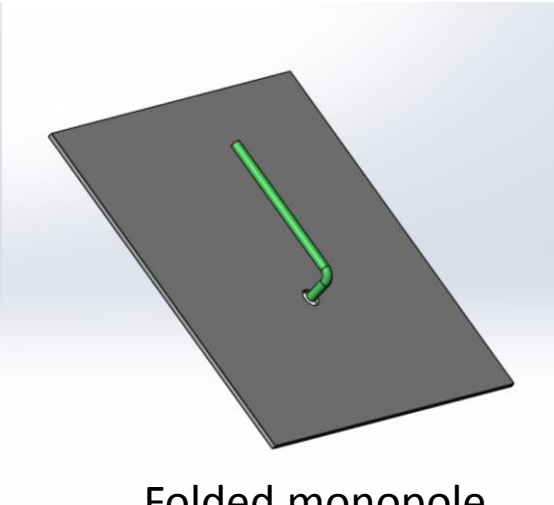
# What features of the embedded antenna are crucial with respect to mobility?

- The antenna should keep on radiating within the "right" frequency range no matter whether the wireless device is close to dense matter (wood, concrete, metal etc.) or the human body. **Frequency stability.**
- The antenna should radiate in all directions. Since mobile devices move around, the antenna's directionality affects the connectivity. The antenna should be as **omnidirectional** as possible.
- Since the antennas angle relative the receiving or transmitting counterpart changes, the polarity of the antenna affects the connectivity. **Mixed polarity** is beneficial.

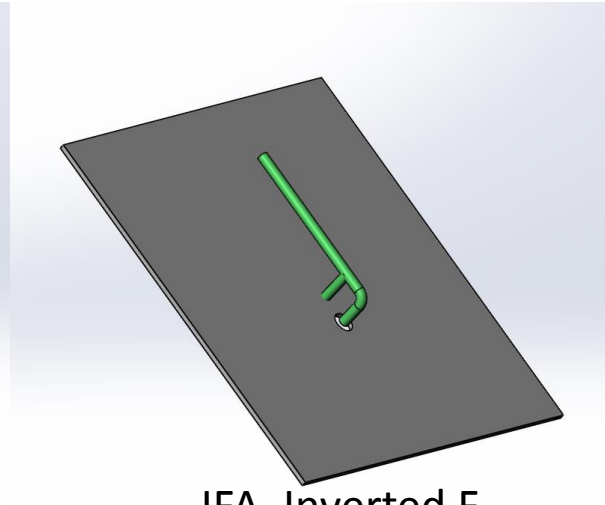
# PIFA (Planar Inverted F Antenna) – Schematics



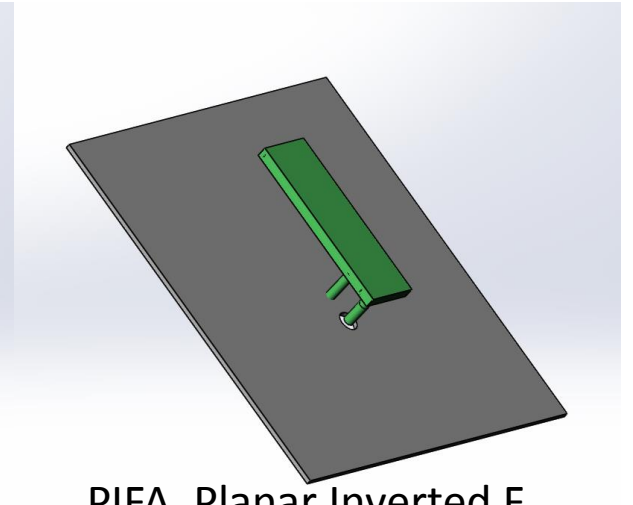
Monopole



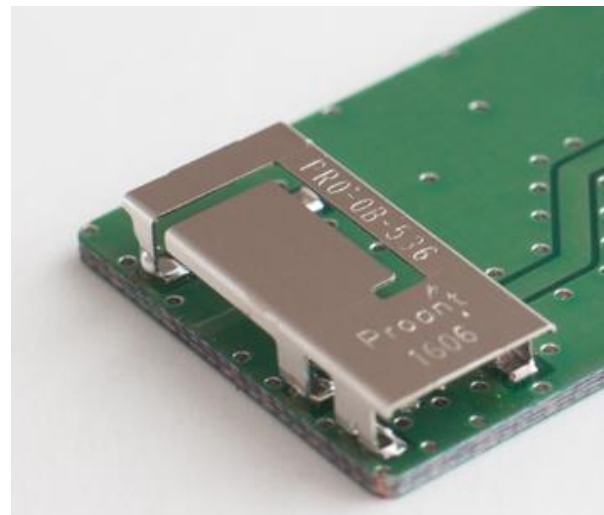
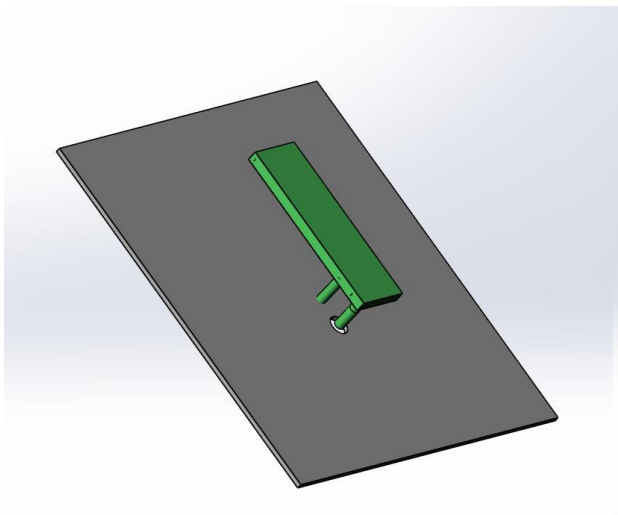
Folded monopole



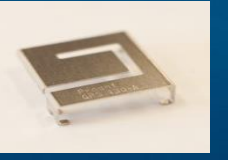
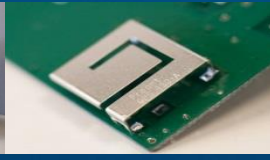
IFA, Inverted F



PIFA, Planar Inverted F



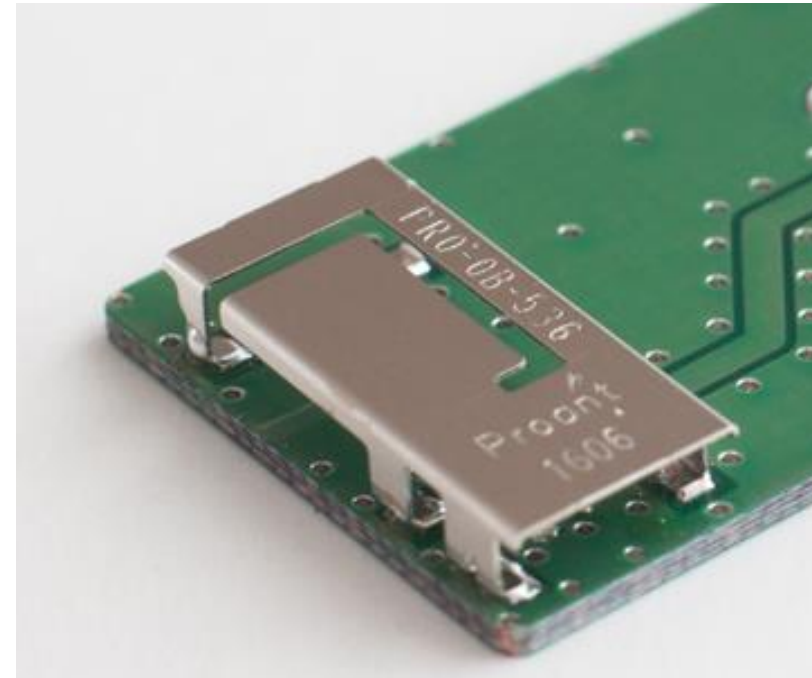
Adding a slot to the PIFA can result in multiple resonances that can be used for further expansion of bandwidth or create a dual band antenna.



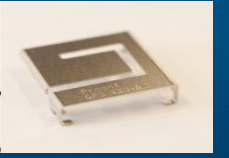
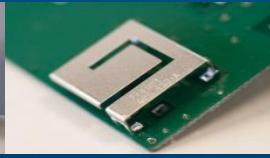
# PIFA Technology

Proant's planar inverted F antennas (PIFAs)

- Made of sheet metal
- Mounted directly on PCB
- Frequency optimization by matching components
- Components can be placed under the antenna
- No ground cut out
- Frequency stable
- Relatively omnidirectional radiation pattern
- Mixed polarization
- High radiation efficiency
- Tape and reel delivery



Proant OnBoard SMD series are PIFAs

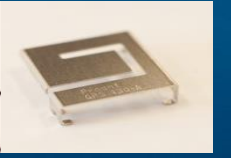
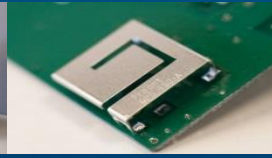


# Focus on frequency stability in mobile units

This study will focus on connectivity of mobile units. The **variety of use cases** differs mobile units from units that are designed for fixed positions/fixed mounting. When exposed to different environments, it is vital that the units' antennas still radiate in the desired frequency band(-s). The most common environment, detuning the antenna, is proximity to dense materials.

The antenna may of course be tuned to manage proximity to dense materials, but then it may detune in other environments. Stability is desired!

In real life situations, for wireless mobile units, this translates to proximity to, for example, metal or the human body.



# Three commonly used antenna types



PIFA



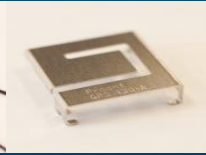
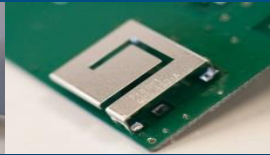
Chip antenna



PCB printed antenna

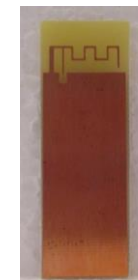
The antenna types of this study are:

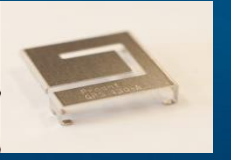
- PCB printed antenna
  - Chip antenna
  - Planar Inverted F-antenna, PIFA
- These three types are very commonly used for embedded implementations.
  - All three types are well suited for efficient mass production processes.



# Preconditions

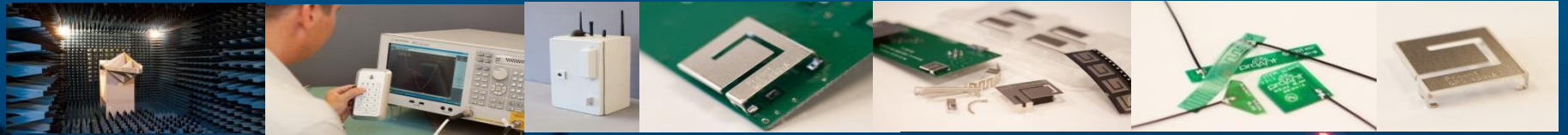
- **The PCB Printed antenna** – Manufactured according to appnote AN043 from Texas Instrument. 2,4 GHz. PCB GND size 17 x 41mm, total PCB size 17 x 50mm. GND cutout 9 x 17 = 153mm<sup>2</sup>.
- **The Chip antenna** – Off the shelf standard antenna from a well renowned manufacturer, 2,4 GHz. PCB GND size 30 x 30mm, total PCB Size 30 x 50mm. GND cutout 20 x 30 = 600mm<sup>2</sup>. (The manufacturer's evaluation board)
- **The PIFA** - The Proant, off the shelf, OnBoard SMD WLAN antenna. Requires 13.8mm<sup>2</sup> GND cutout (only the free floating pads). PCB size 17 x 47mm (The Proant evaluation board)



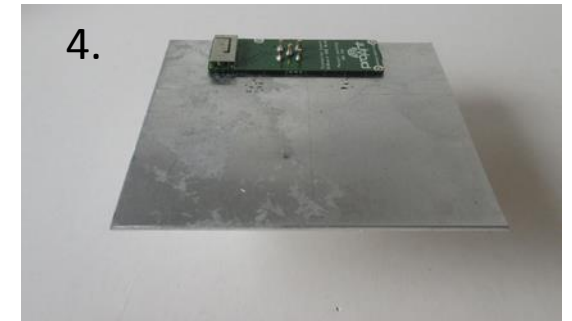
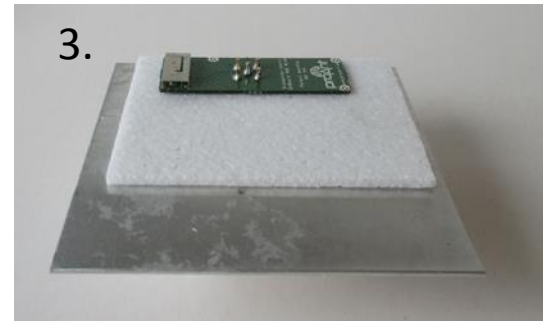
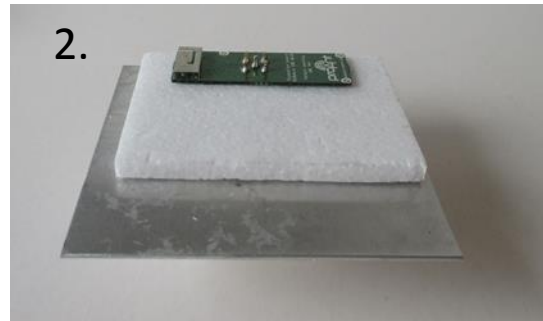
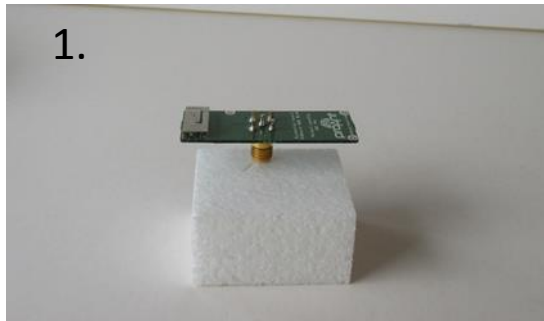


## Use cases of the study

- **Free space** represents an environment that affects the antenna performance at a minimum.
- **Hand held** represents a very common use case. Many mobile units are designed to be hand held or placed close to the body (wearables).
- **Close to metal** – represents the most aggressive environment for the antenna, yet it is common.

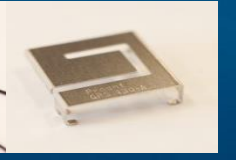
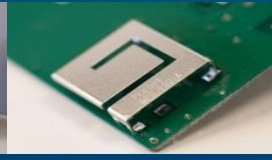


# Measured setups



## Five different setups:

1. Free Space
2. 5mm from metal (Styrofoam spacer)
3. 2.5mm from metal (Styrofoam spacer)
4. On Metal
5. Handheld (Using a phantom hand with the same electrical properties as a human hand.)

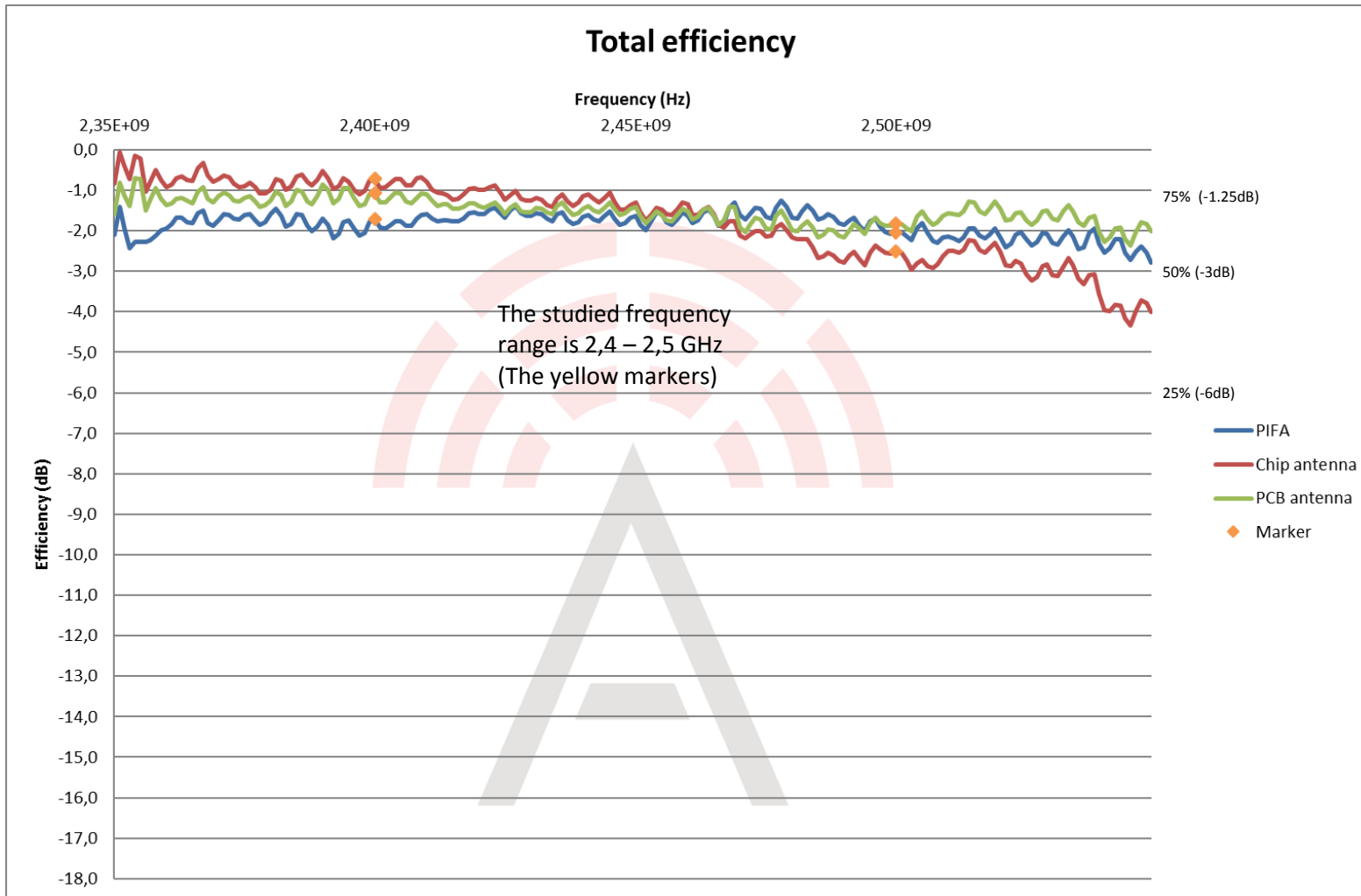


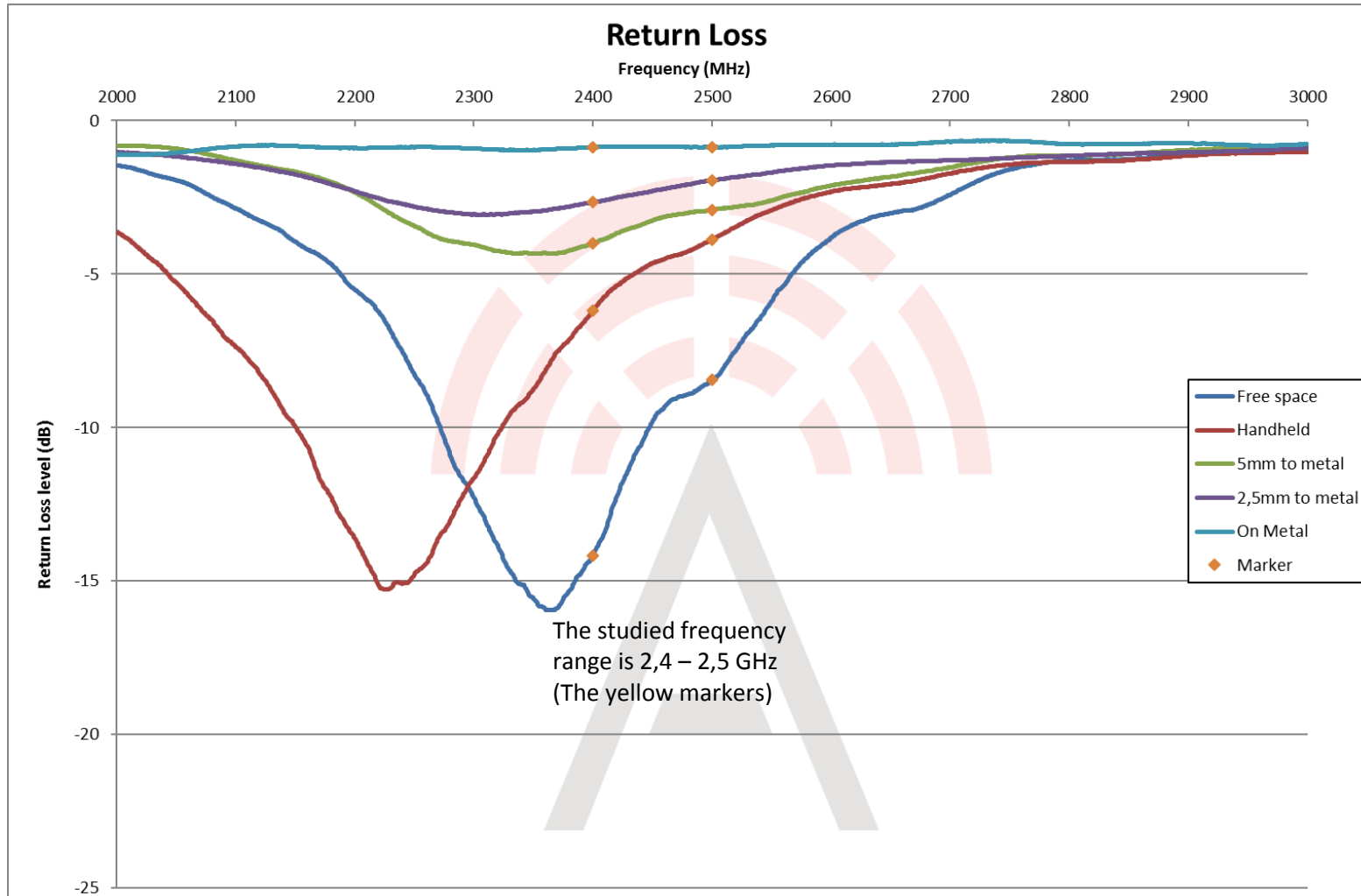
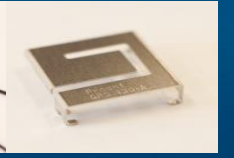
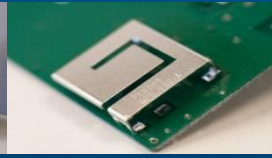
# Total efficiency in free space

The chart shows the three different antennas' total efficiency measured in free space. All three antennas perform well – they are all better than approximately 65% total efficiency.

Antenna datasheets often only state the antenna performance in 'free space' setup.

Are these three antennas equally good? The following will show that it depends on the use case.

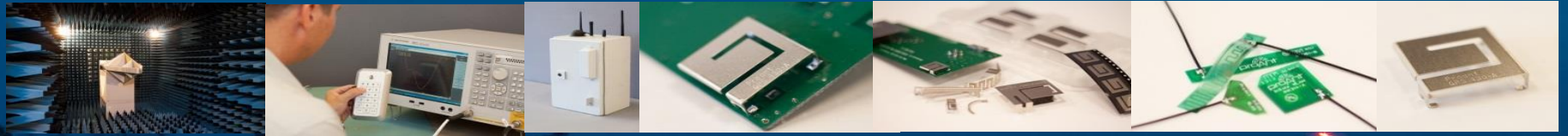




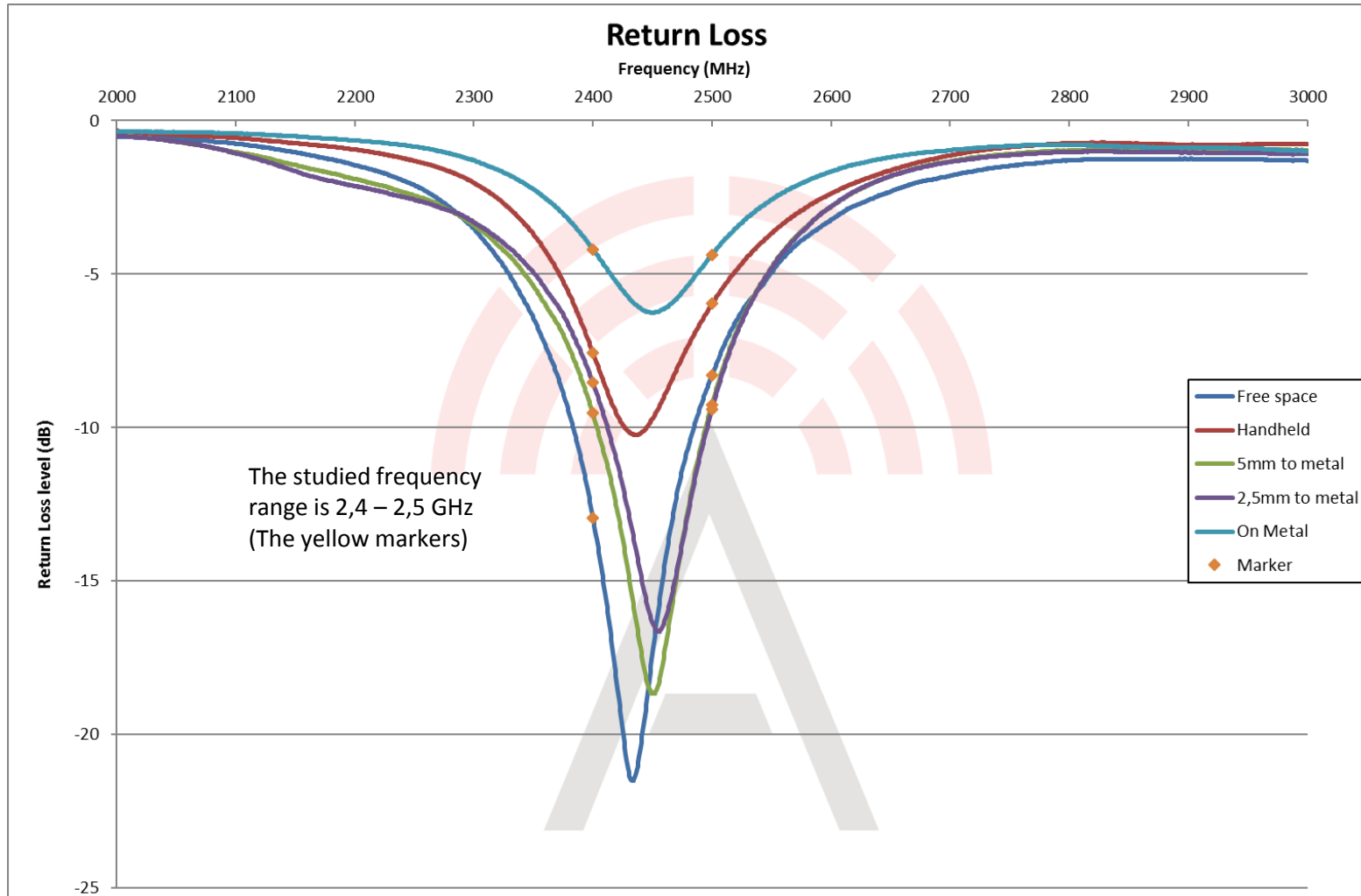
## Chip antenna return loss in different setups

The chart shows the chip antenna return loss.

- A significant detuning in the hand held setup
- Proximity to metal strongly affects the antenna return loss.

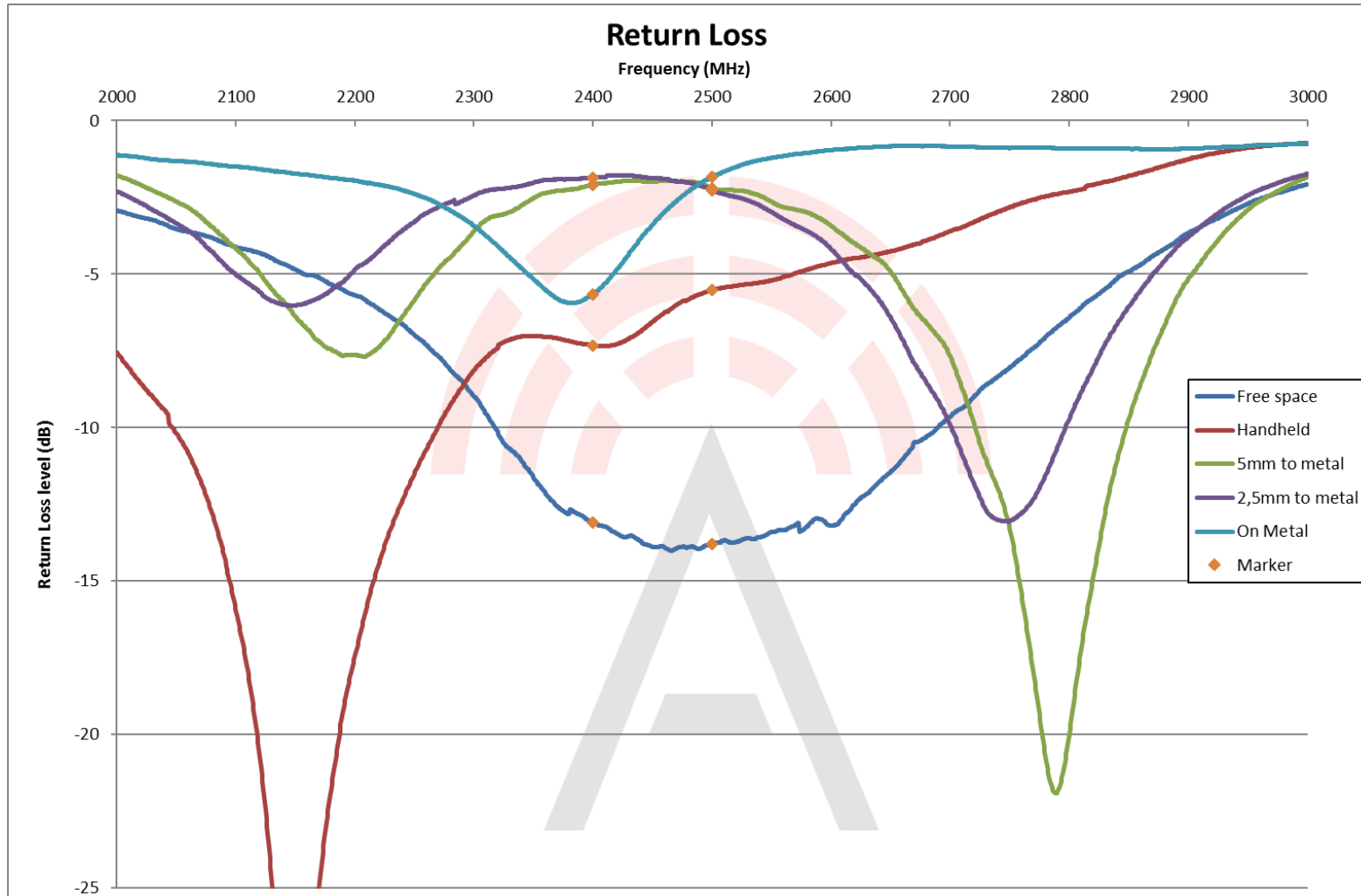
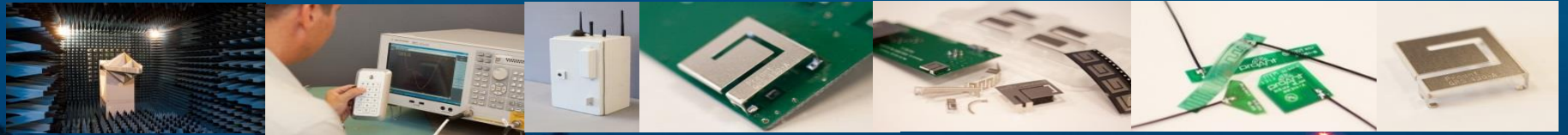


## PIFA return loss in different setups



The chart shows the PIFA return loss.

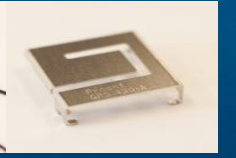
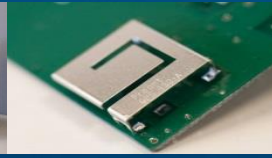
- Resonant frequency remains stable in all setups.
- Proximity to metal affects the antenna return loss but the antenna still radiates in the desired frequency band.



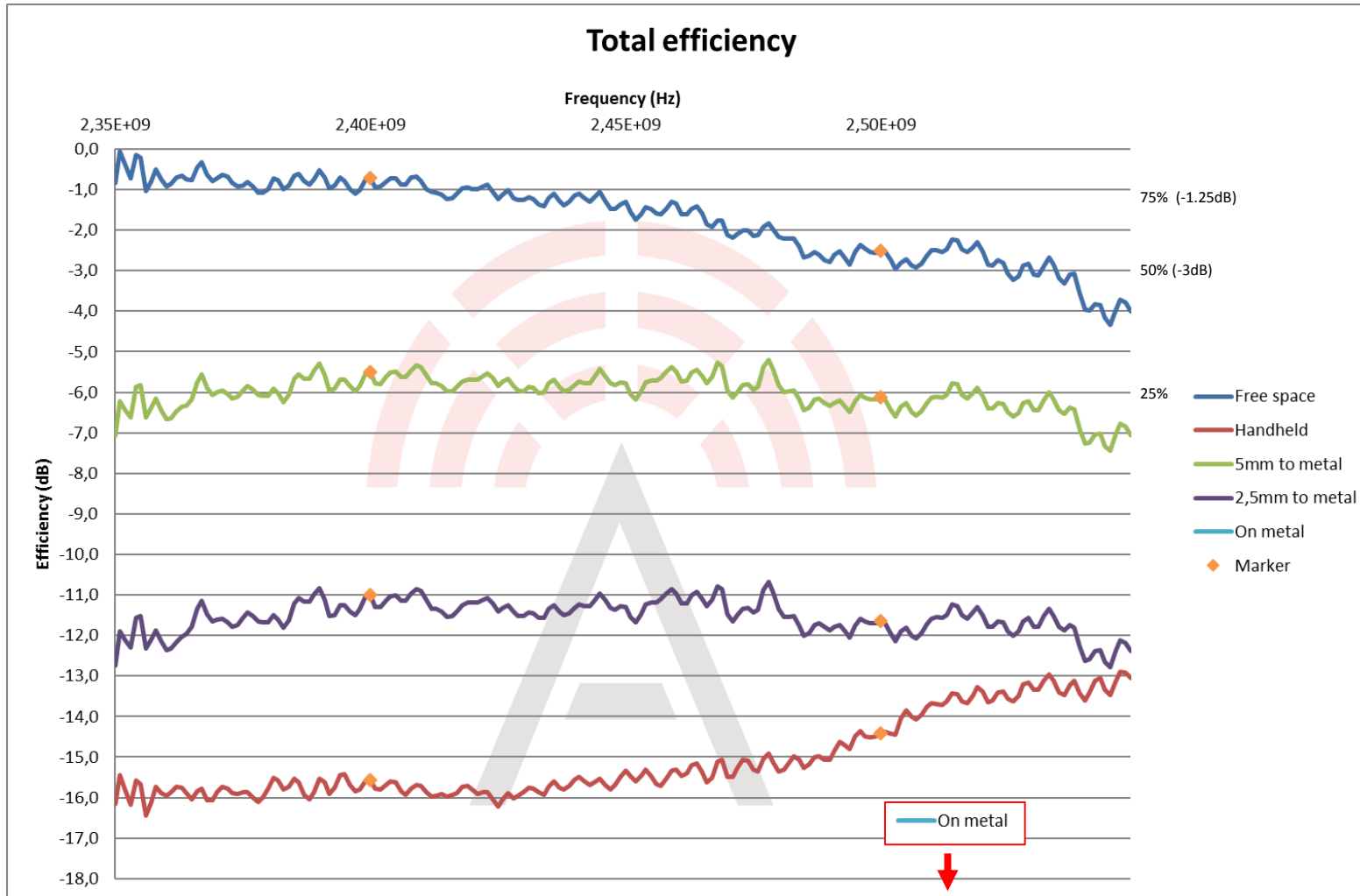
## PCB antenna return loss in different setups

The chart shows the PCB antenna return loss.

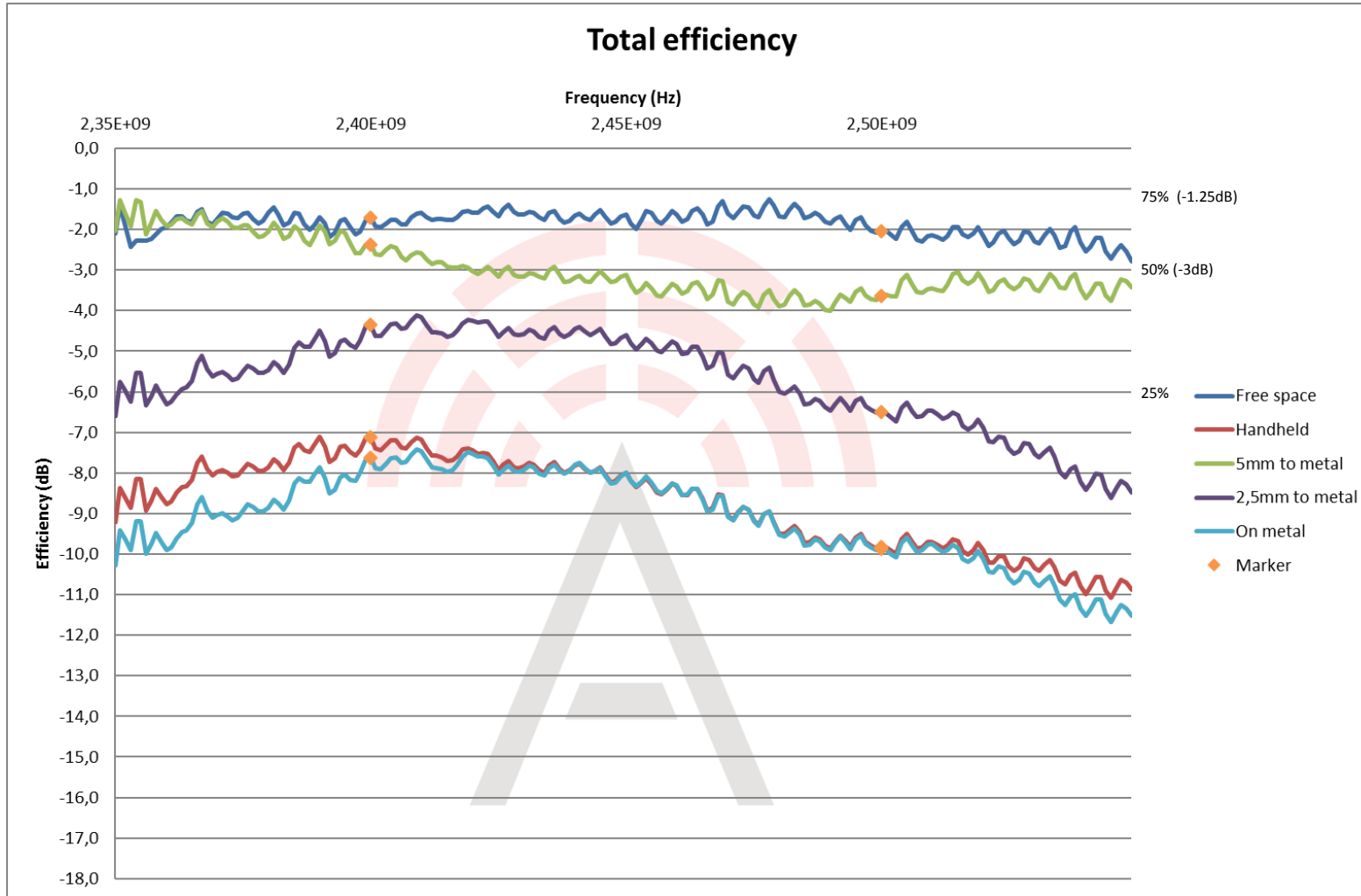
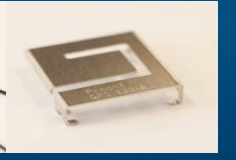
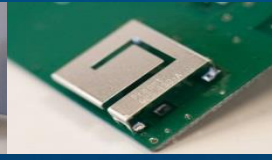
- A significant detuning in all setups, except free space.
- Shows great sensitivity to different use cases.



# The chip antenna total efficiency

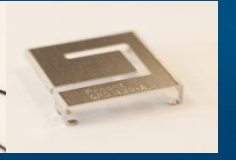
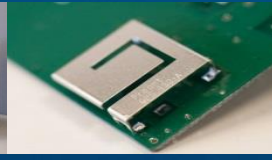


- The chart shows the chip antenna total efficiency in the different setups.
- The closer to metal, the worse the efficiency. Does barely not radiate at all 'on metal'.
  - Reading in the hand held setup is worse than 4%.

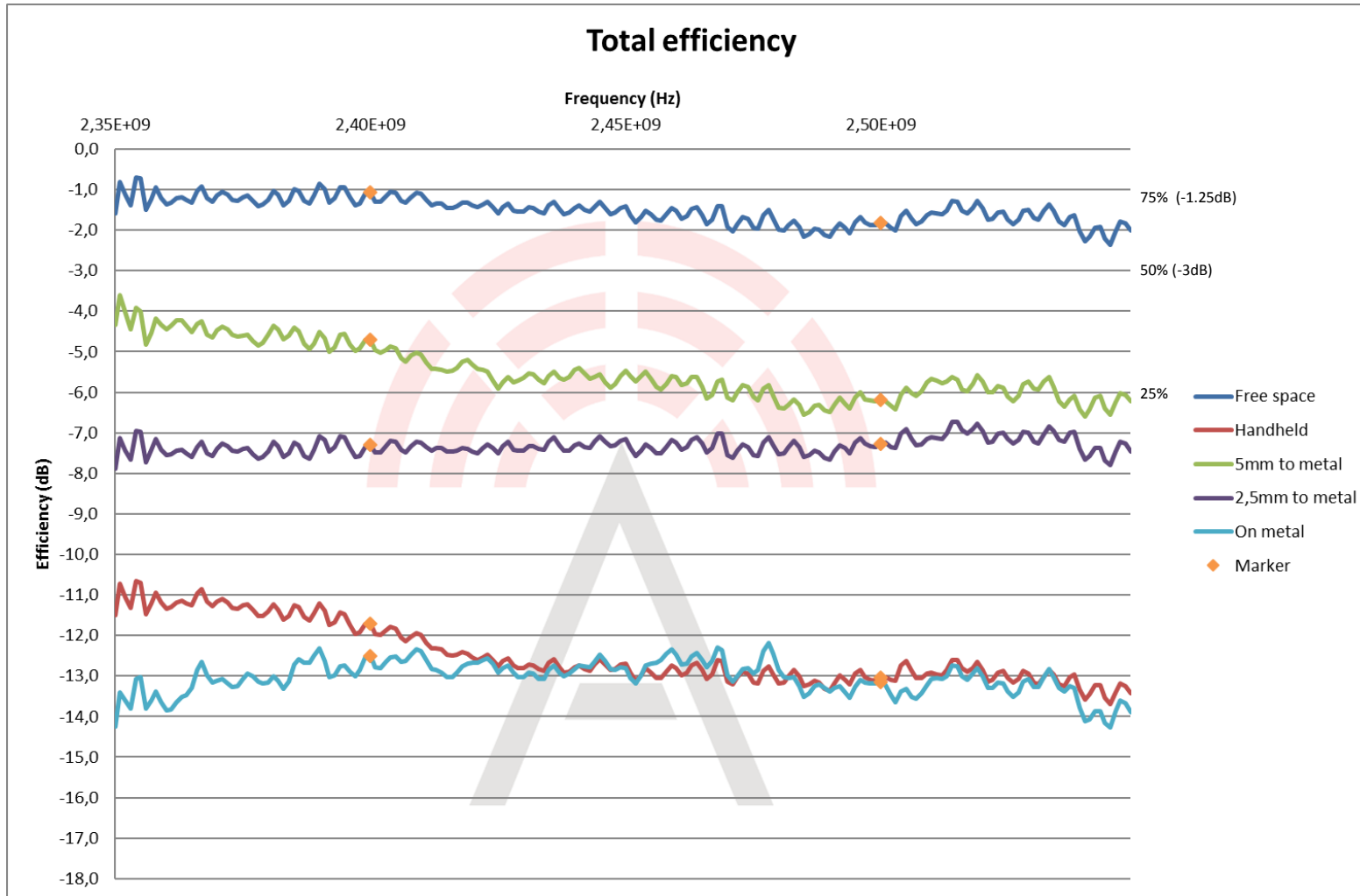


## The PIFA total efficiency

- The chart shows the PIFA total efficiency in the different setups.
- Shows the least sensitivity to proximity to metal/human body of the antennas in the study.
  - Still radiates when placed 'on metal'

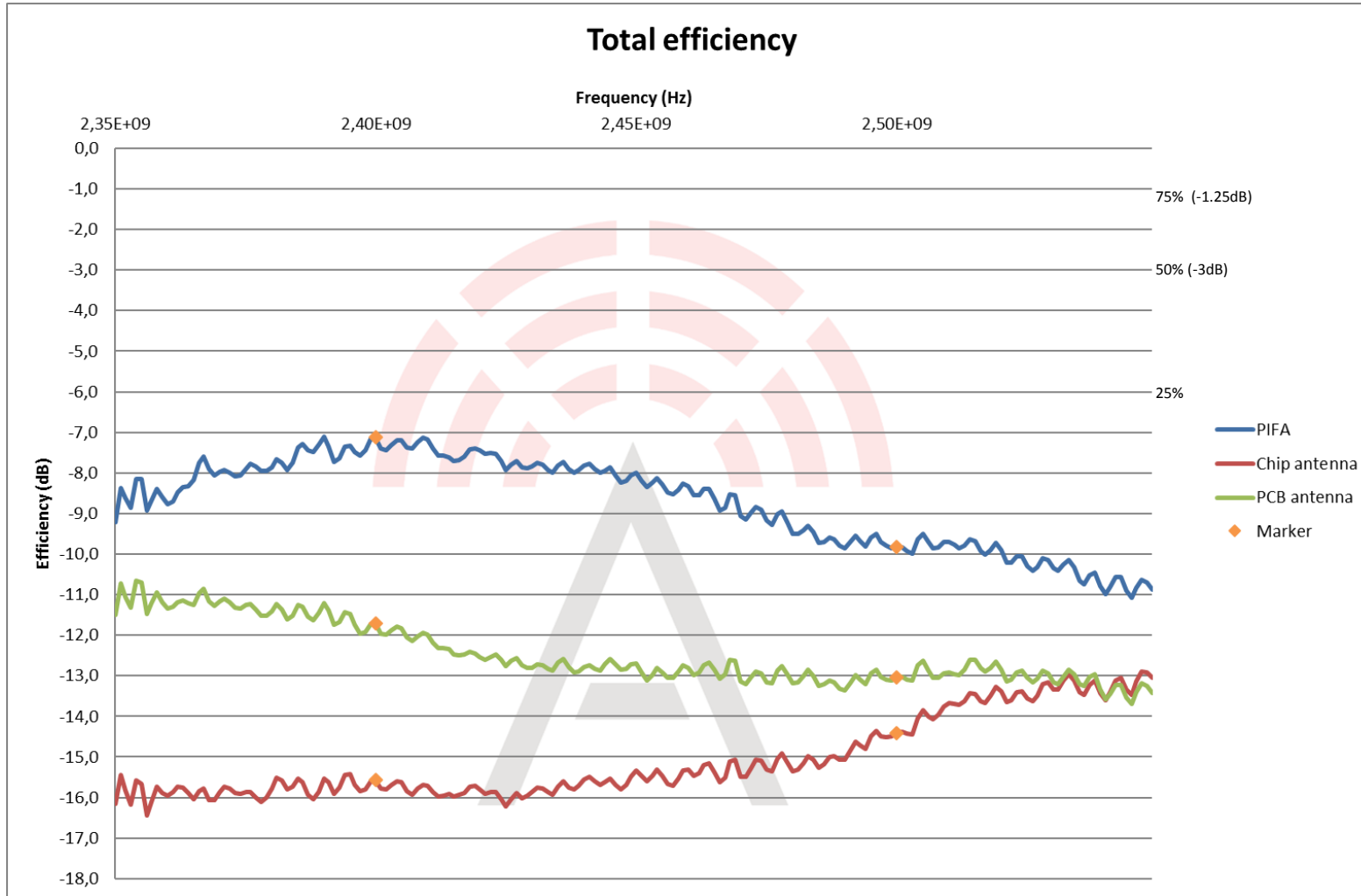
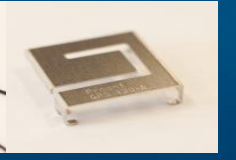
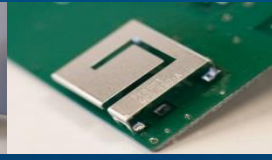


# The PCB antenna total efficiency



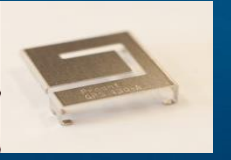
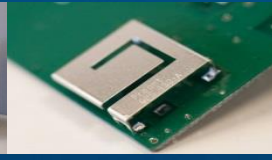
The chart shows the PCB antenna total efficiency in the different setups.

- The closer to metal, the worse the efficiency. Reading in the hand held and on metal setup is worse than 6%.



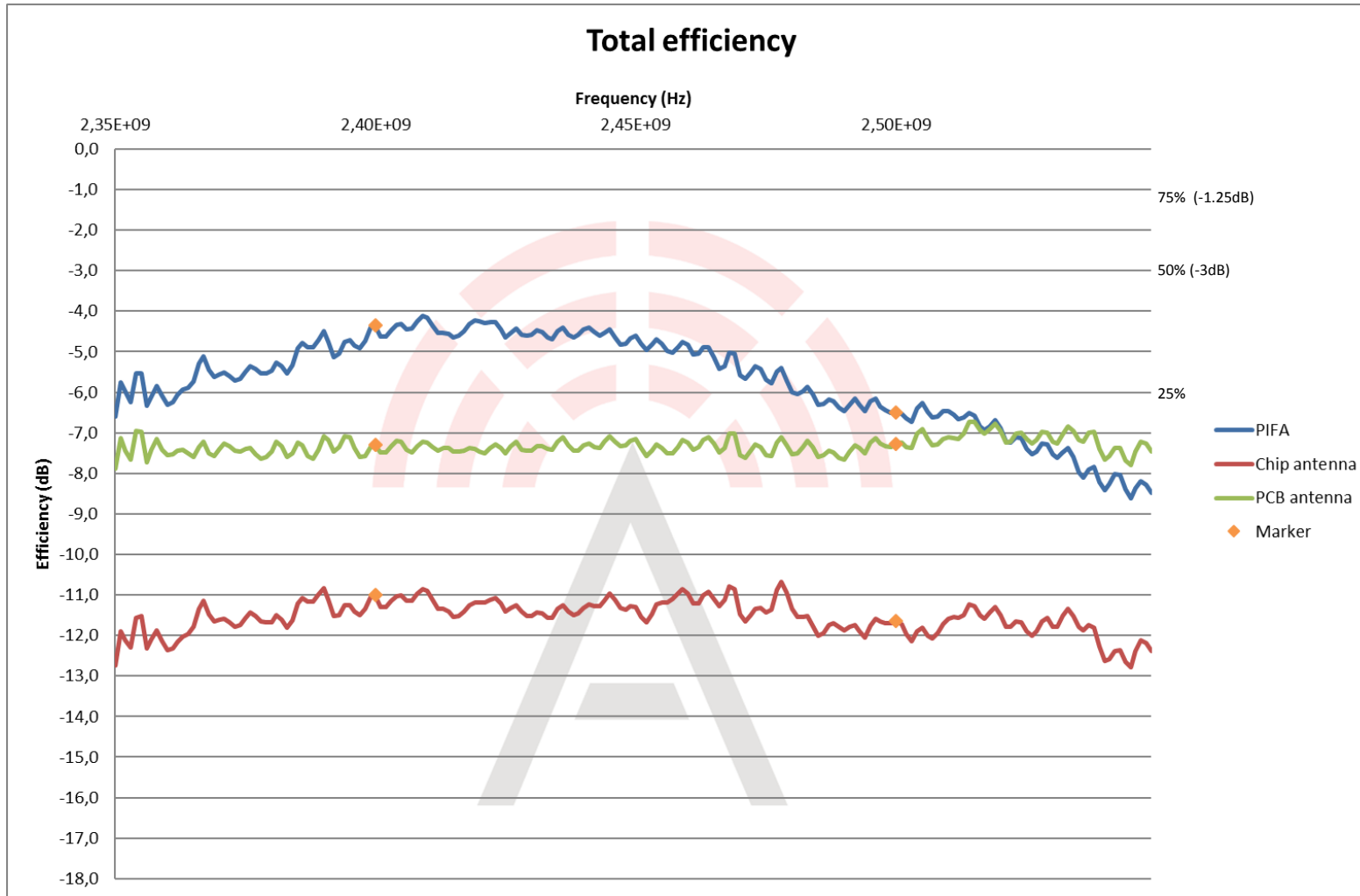
## Antenna comparison in the hand held setup

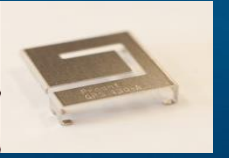
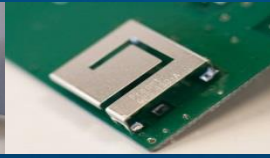
The chart shows the three different antennas' total efficiency in the hand held setup.



# Antenna comparison in the 2.5mm from metal setup

The chart shows the three different antennas' total efficiency in the 2.5mm from metal setup.





# Conclusions

- The choice of antenna technology for your mobile device may be crucial to the quality of connectivity achieved.
- Datasheets often only state the antenna performance in 'free space' setup.
- It is vital to investigate and test how the antenna performance is affected by the device's most common use cases.
- The PIFA technology proves to be a suitable choice if...
  - The common use cases of the device is unknown.
  - The common use cases involve proximity to the human body and/or metal.