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Application Note | SignalShark

Next generation of Auto-DF Antennas and receivers to make bearing more reliable in urban canyons

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***Abstract* — With more and more communication systems sharing the same frequency range, the probability of conflicts, i.e. interference with each other, becomes higher and higher. On the other hand, however, more and more reliability is demanded of the systems if, for example, industries want to handle their production control via a mobile network such as 5G. Fast and efficient interference elimination is thus becoming a must, because if production comes to a standstill, it becomes really expensive. The following article will describe how this can be raised to a new, consistent level through new approaches such as hybrid direction finding systems, elevation measurements during mobile interference hunting and the use of open platforms.**

***Index Terms* —TDOA, AOA, Interference hunting, Elevation Measurement, open Plattform.**

I. Introduction

There are several reasons and methods for localizing transmitters. For example, network providers search for harmful interferers, regulators look for unlicensed transmitters, the military is interested in the location of potential enemies, the police search for jammers, and intelligence agencies are interested in the location of wireless communication devices used by terrorists or equipment used by eavesdroppers.

The two main methods of localizing transmitters are based on the angle of arrival (AOA) and the time difference of arrival (TDOA) at different receiving locations. Hybrid methods that use more than one property for the localization process also exist. This paper deals with the new developments in this sector and will show, that new tools make this process more efficient and safer.

Three required scenarios for the localization of interferers:

1. The fixed installation of a surveillance network
2. The mobile rapid response unit with the vehicle.
3. The search for interferers in buildings on foot

Each of these scenarios has its importance; all together, they form a symbiotic tool to get a disturbed communication network up and running again. Let us first deal with the fixed installation.

II. Fixed monitoring system

Within a metropolitan area, a network of receivers and antennas is set up to monitor the spectrum and detect and locate unwanted interference. Thereby the question arises: should the localization be realized on TDOA or on AOA? The correct answer is both! Both measurement principles have their advantages and disadvantages. TDOA systems cannot locate CW signals. An oscillating repeater, which radiates a CW signal at 900 MHz on its antenna, is invisible to the TDOA system. However, CW signals are easy prey for the AOA based measurement system. The AOA system has difficulties with very short pulses, e.g. the switching regulator of a solar system on the roof. There again TDOA is in its element. So-called hybrid systems can not only increase their precision by using both principles, but also close physically determined gaps.

A prime example of software that masters all three measurement principles is the Decodio Localizer software.

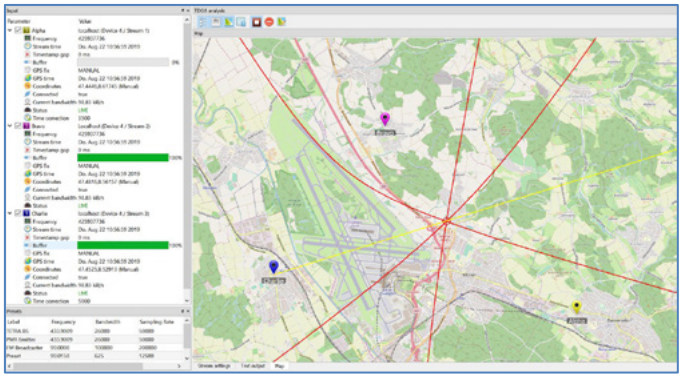

Fig. 1. Example of a localization based on a hybrid system realized by Narda SignalShark Receivers and Decodio Localizer Software.

It can do both AOA and TDOA as well as the hybrid. The appropriate hardware is provided by the company Narda with the SignalShark. This high-performance receiver is available in three versions: as a portable handheld, as 19'' rack-mount version, and now brand new: as an outdoor unit. All three designs have excellent RF performance in common.

Fig. 2. Narda SignalShark high performance Receivers

In addition, they are smart due to their integrated Win10 PC. I.e. the provision of a separate PC is not required, you simply install your own software (e.g. Decodio ReX for the TDoA sensors) on the SignalShark's integrated computer and it then controls itself. Do you need a VPN connection for streaming the IQ data in the monitoring network? It can be installed directly on the analyzer. How about a required cellular connection for communication? Just plug a standard modem into one of its USB ports. The Outdoor Unit, which can be installed directly on the antenna mast is

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powered by solar panel or PoE, you are perfectly equipped for 24/7 monitoring.

Additionally, Narda provides the automatic direction-finding antennas, ADFA. These antennas are capable of both, omnidirectional operation for the TDOA system and AOA in combination with the SignalShark. The frequency range is unique. Covering all services from 10 MHz to 8 GHz with only one antenna is the world's first among automatic DF antennas.

Fig. 3. Narda ADFA DF-antenna. Frequency range 10 MHz to 8 GHz.

If you need another monitoring station in the vicinity of a large event, then simply take the handheld version of SignalShark. With hot-swappable batteries, mains-independent, equipped with an LTE modem and an omnidirectional antenna, you can comfortably take everything with you on your bike and easily follow the demonstration procession. as a mobile sensor for the TDOA system. Perfectly integrated in the Decodio network.

III. Mobile based Localization

In general, radio interference is rarely reported in rural areas. The higher the population density, the higher the chance that the technical equipment used will interfere with the neighbor or their technical equipment.

However, street canyons are an extremely unfavorable place to measure the direction of a signal at street level. Reflections and multipath propagation are much more common than a direct "line of sight" of the DF antenna to the interferer. Powerful algorithms must separate the wheat from the chaff. What helps are intelligent statistical processes and as many good measurement results as possible. This makes it possible to differentiate false localizations by reflections from the correct ones at the line of sight and to display them, for example, as a heat map on the receiver.

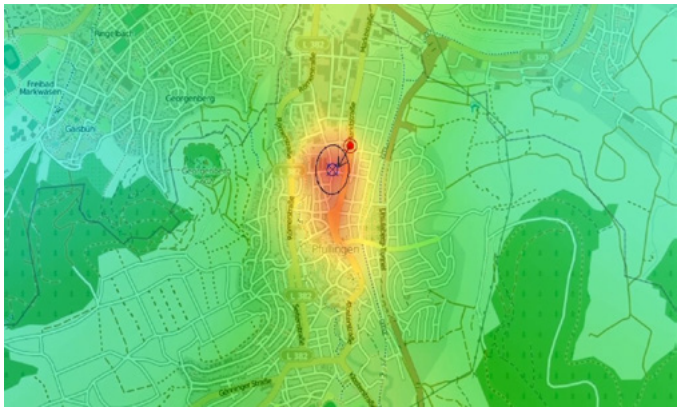

Fig. 4. Representation of a localization with a heatmap

This is again a prime discipline of the Narda SignalShark in combination with the ADFA antennas. The antenna is mounted on the roof of a vehicle and with the help of the receiver, they repeatedly measure the angle of arrival of the signal while driving. In this way, interfering signals can be identified and localized very quickly.

Fig. 5. Localization based on a vehicle

However, it does not just indicate the direction or azimuth, but also the elevation in the frequency range where the principle of correlative interferometry is used. That is not something that would normally be expected of an antenna that is used to determine the direction of a signal.

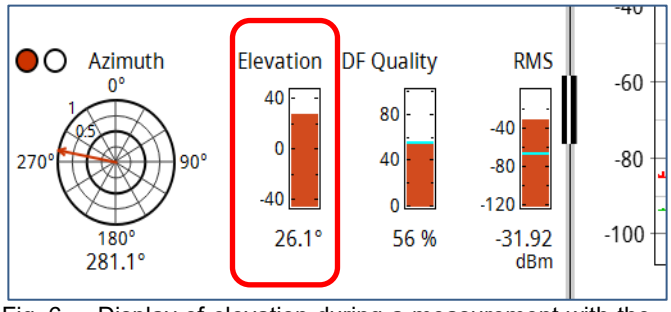

Fig. 6. Display of elevation during a measurement with the SignalShark and ADFA.

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Single channel direction finding measurement is based on the principle of measuring the phase difference of the incoming signal at the dipoles in a circular array in the antenna. This results in a pattern of phase angles between the antenna elements for each angle of incidence. This pattern is compared with a database of patterns to determine the AOA.

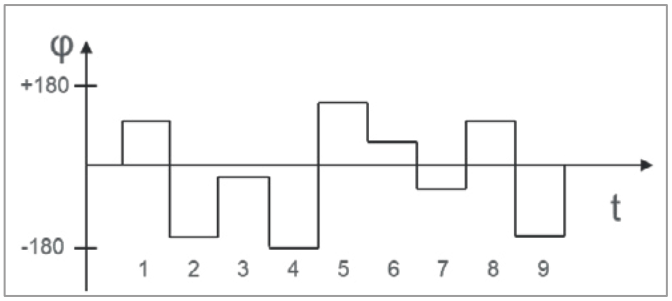

Fig. 7. Example of a phase angle pattern.

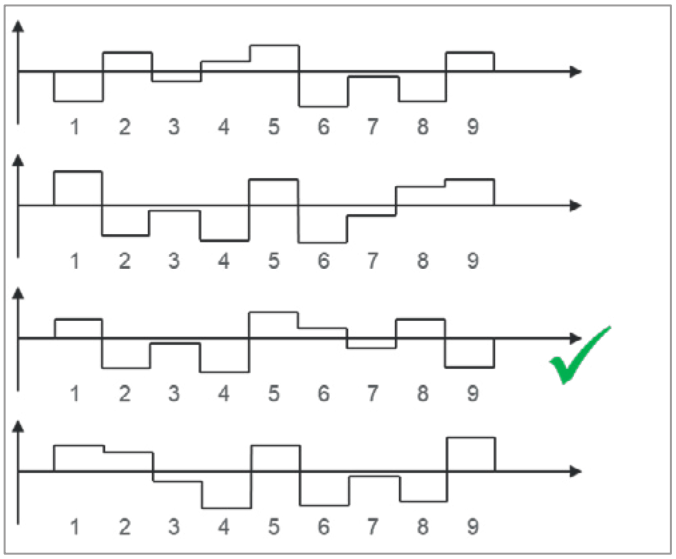

Fig. 8 Database of possible phase angle patterns stored in the SignalShark.

This database is initially determined for each type of antenna in a test field and is then recorded in the SignalShark. This is not just done in the four directions shown in figure 8. Rather, a large number of meaningful directions and frequency points are taken. In fact, the degree to which the actual measurement results correspond to the database values is described by the DF quality parameter.

Advanced measurement capability with Narda's Automatic DF Antennas

Normally, these databases only contain reference values for the horizontal plane since this is the plane in which the AOA is basically determined. At a great distance from the transmitter, this is, of course, correct. But in an urban environment, the signals may not impinge on the antenna only in the horizontal plane. As the source is approached, the signals may be coming from above, i.e. with a certain elevation relative to the antenna. This elevation will also have an effect on the phase differences that are determined. If there are no reference values recorded in the database for such a situation, the DF quality is degraded, and it is even possible that the measurement results will be incorrect.

To avoid this, the ADFA-1 and 2 automatic antennas are also calibrated for elevation and these values are likewise included in the database. This ensures that the Narda direction finding antennas will still deliver stable, precise, and reliable data even when approaching the source, where this is of course particularly important. When purchasing an automatic antenna, it is good to make sure that it can also handle elevation. The ADFA-1 and 2 from Narda both cover an elevation range from +40° to -20°, so that exact direction finding is possible even in hilly terrain.

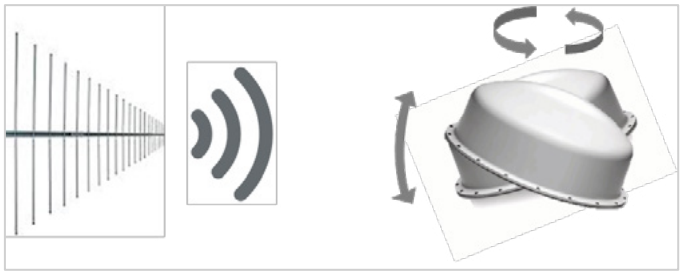

Fig. 9. Narda antennas are both rotated and tilted during the determination of the phase catalog.

IV. Localization by foot

Both fixed installation and mobile deployment with the vehicle can locate the building of the interference source but cannot answer the question in which apartment the interference source is ultimately installed. And here again, Narda offers the perfect solution with the SignalShark handheld and its manual directional antennas.

Fig. 10. Narda SignalShark now equipped with a manual antenna for homing purpose.

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The same handheld device that has just produced heatmaps for localization in the car with the automatic antenna, can now be used for homing with its featherweight directional antennas. Always the same device, always the same operation, so localization becomes fast and efficient.

V. Summary:

The Narda SignalShark family is the ideal companion when hunting for interfering signals. With many thoughtful details, excellent dynamic values, and thanks to their open architecture, they excel in successfully analyzing, identifying and locating RF signals. Housing several frequency bands in an ADFA antenna provides the widest band available is as simple as ingenious. The measurement of elevation, for example, is an innovation that can decisively advance the process of locating interference. Especially on the last few meters, when it gets exciting, the ADFA continues to measure unaffected while other antennas lose track. In addition, when a complete system is required, the SignalSharks are open to all sides, communicate in standard languages and are thus the ideal partner for any integrator. This allows everyone to play to their strengths, Narda for perfect RF performance, the integrator and the user for the system.

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