SignalShark Vehicle Integration

Concepts for integration of SignalShark and DF antennas into radio monitoring vehicles

Contents

The SignalShark receiver and direction finder from Narda STS is a versatile platform that suits various applications. The remote version SignalShark can be mounted in a 19” rack or directly in a system (e.g. a car), while the outdoor version handles applications in harsh environments and where the receiver and antenna need to be very close together.

Both these SignalShark units can operate with the highly sensitive Automatic Direction-Finding Antennas 1 and 2, which cover a wide frequency range.

Narda STS has successfully demonstrated to customers and partners how the SignalShark system can be integrated in vehicles. Some solutions are straightforward, allowing for flexible use. Other solutions are based on professional vehicle integration, with the SignalShark included with additional payload, such as mast mounting, mobile satcom connectivity, and a personal workspace within the vehicle. This Technical Note gives a clearer view of some of the vehicle solutions where SignalShark has proven to be perfect in providing support for end users not just as a product, but as the solution itself.

SignalShark receivers and form factors

› SignalShark 3310 – Handheld Unit

The SignalShark Handheld Unit is the most advanced real-time handheld Signal and Spectrum Analyzer from Narda STS. Not only is it very sensitive, with a very good dynamic range, it is also based on a transparent, open architecture. The SignalShark handheld unit measurement application can handle multiple tasks and views that can be run in parallel and which provide a highly innovative user interface. The SignalShark Handheld Unit is optimized for size, weight, and power (SWaP), and can be used in a vehicle or on foot with equal ease.

› SignalShark 3320 – Remote Unit

The SignalShark Remote Unit is available as a brick or a rackmount unit. It is the same height as a one unit high 19” rack enclosure, but only half its width. Hence, there is the option to have one or two receivers in a 1U high enclosure. The Remote Unit can operate from a DC voltage of between 10V and 48V and is equipped with many remote operation interfaces.

› SignalShark 3330 – Outdoor Unit

The SignalShark Outdoor Unit is a rugged, IP65-rated version of the SignalShark which is available in two versions for data connectivity: Power-over-Ethernet (PoE) or Modem. It can be attached easily to a mast, close to the antenna, with no need for a long RF cable as it has Power-over-Ethernet capability. The unit can also host a modem for mobile connectivity e.g. via 4G / LTE. As this version has a power consumption of just 45W it can also be operated from battery-buffered solar panels at remote sites.

› SignalShark key features

- Wide frequency range: 8 kHz – 8 GHz
- Low typical noise figure: 12 dB (44 MHz < f ≤ 3 GHz)
- High typical IP2: 40 dBm (42 MHz ≤ f ≤ 8 GHz)
- High typical IP3: 14 dBm (44 MHz ≤ f ≤ 3 GHz)
- High scan speed: 50 GHz/s
- High real time bandwidth: 40 MHz
- Good POI signal duration: 3.125 µs
- Remote display via DisplayPort interface
- Precise timing for TDOA applications
- Remote control via SCPI
- IQ data output: VITA49
- Customization using Python scripting plugin
- Open operating system: Windows 10
- Wide software support: Decodio Red/Rex/Localizer, Comint Consulting Krypto 500, Procitec go2Monitor, VAS ES Skudra, TCI Blackbird, RadioInspector, etc.

SignalShark antennas

› Automatic Direction-Finding Antenna (ADFA) 1/2

Narda STS produces two Automatic Direction-Finding Antennas, ADFA 1 and 2:
ADFA 1 covers frequencies from 200 MHz to 2.7 GHz and is mainly for telecoms applications. It utilizes single-channel correlative interferometer technology and achieves typical DF accuracy of 1° RMS.
ADFA 2 ranges from 10 MHz to 8 GHz and can be used for many more applications than the ADFA 1. It is also even more sensitive than the ADFA 1.
ADFA 2 makes use of the Watson-Watt technique to measure signals at lower frequencies down to 10 MHz.
Both ADFA 1 and 2 have the same form factor: 219 mm high with a diameter of 480 mm. This is much smaller than similar products on the market at time of writing. The ADFA 1 or 2 are therefore both perfectly suited to vehicle integration requirements where space is limited.

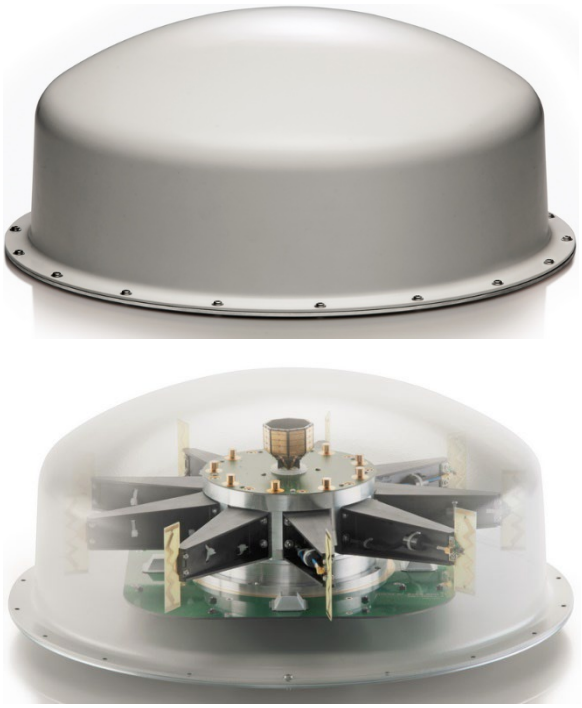

Figure 1: Automatic Direction-Finding Antenna 1/2

› Directional handheld antennas

Narda STS provides four directional handheld antennas that cover frequencies between 8 kHz and 8 GHz. These antennas have excellent receive pattern symmetry, and are also extremely light in weight. This set of antennas, which fits into the same easily transported rugged suitcase as the SignalShark Handheld Unit, is highly appreciated by interference hunters all over the world.

Figure 2: Directional antennas 1 and 3

› Antennas for TDOA and other applications

The SignalShark can, of course, also be operated with any other antenna, e.g. where direction finding is not required but the time difference of arrival (TDOA) technique utilizing multiple, interoperating receivers and omnidirectional antennas is to be used for radio transmitter localization.

SignalShark integration in vehicles

› Non-penetrating magnetic car mount

The SignalShark Handheld Unit is perfect for applications where permanent integration in a vehicle is not desired. When combined with the Narda magnetically mounted Automatic DF Antenna, the complete system can easily be transported and fitted in or on any vehicle. The magnetic mounting plate of the ADFA can withstand speeds of up to 130 km/h (80 mph). Inside the vehicle, the SignalShark unit can be operated directly, or from a separate display / touchscreen, or from a computer through an RDP connection.

Figure 3: ADFA with magnetic mount on a rental car, operated from a SignalShark Handheld Unit to give non-permanent integration

› Mast mounted Outdoor Unit and ADFA

The SignalShark Outdoor Unit plus ADFA can basically be installed on any mast, which can be part of a vehicle or trailer. The Outdoor Unit version 3330/101 incorporates a POE splitter. This means that one LAN cable is sufficient to connect the receiver to other infrastructure, and the RF cable between the receiver and the antenna can be kept short and does not need to be prepared as a moving part. This reduces system complexity and also leads to higher sensitivity due to lower cable losses.

Figure 4: ADFA and SignalShark Outdoor Unit mounted close together on a mast and powered from PoE

› Multi-purpose communication and monitoring vehicle by Teradium

The following use case demonstrates the SignalShark combined with professional vehicle integration by Teradium. The project shows a multi-purpose communication, RF monitoring and direction-finding vehicle based on a Nissan Patrol SUV. The vehicle can carry various payloads, and can send collected data to other vehicles or a data center via secure satcom communications with redundancy (e.g. VSAT or BGAN). The main application these specialized vehicles from Teradium are for out-of-area missions, border patrols and homeland security, where there is a need for the operating systems and communication with other parties in the field to be available on the move.

Figure 5: Teradium SF5 based on a Nissan Patrol SUV

The standard Teradium SF5 vehicle platform is a mechanically modified off-road SUV. Client-specific vehicles can be modified on request, as the vehicle architecture is designed using automotive industry standard CAD design tools. Customization to specific requirements is thus possible.

Depending on the power consumption of the sub-systems installed, the vehicle is fitted with either a basic battery management system or a silent, high-power AC generator. An aircon system is fitted for high ambient temperatures (up to +60 °C); this can be run from the AC generator when the vehicle is stopped with the engine switched off. Electronic equipment that requires an uninterrupted power supply can be run from the in-line UPS fitted in the vehicle. A second 12VDC vehicle battery is installed as backup; this is charged automatically from the generator system, or from an AC line connection, or from the vehicle alternator when the engine is running.

The vehicle can be fitted with up to two 19” rack systems for more electronics. The vehicle on-board power system provides different AC and DC power levels on-the-move, enabling the operation of a wide range of electronic devices. The Narda SignalShark 3330 Outdoor Unit plus Narda DF Antenna are installed on the roof platform of the Teradium SF5 vehicle, either fixed to the roof of the vehicle, or with both units mounted on a silent electromechanical mast system for low noise, higher resolution measurements. This rugged mast is specified for applications on the move, and can be elevated up to 6 m above ground from inside the vehicle, for exceptional spectral measurement results. The mast payload is connected to the equipment and the control PC inside the vehicle by a compact mechanical cable management system, which carries a variety of power and signal cables. With the other equipment on the vehicle, such as a satcom link (with satcom-on-the-move capability) and a 4G/5G node, the vehicle concept means that IP devices can connect to remote networks to enable network-centric operation of the available applications. Thus, data can not only be sent from the vehicle to other stations but also sent back to the vehicle. This makes it possible to perform collective radio transmitter geolocation, and also allows remote operation of the systems on the vehicle, e.g. from the data center.

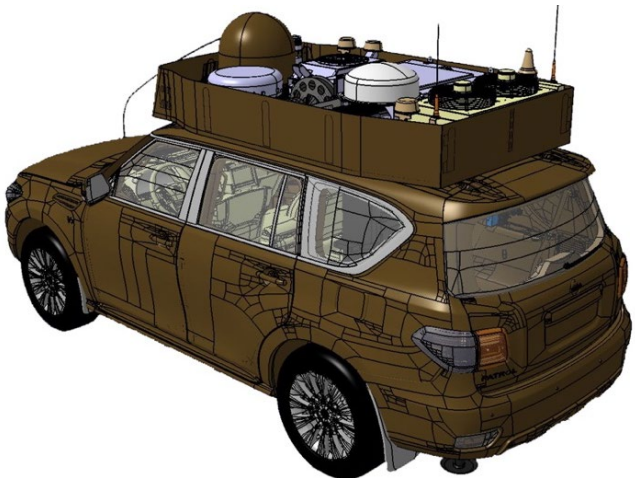

Figure 6: CAD drawing of Teradium SF5, showing SignalShark on elevated mast in the field without sunshield

These options lead to improved situational awareness, flexibility, and automation, and better utilization of human resources.

For more information, see: www.teradium.com

› NASA integration example at Kennedy Space Center, Cape Canaveral, Florida

To ensure that the radio spectrum is kept clear of interference, NASA has equipped one of their radio monitoring vehicles with a 19” rack-mounted SignalShark Remote Unit, with an ADFA 2 mounted on the vehicle roof without an additional mast.

Figure 7: Radio monitoring vehicle at Kennedy Space Center equipped with SignalShark and ADFA 2

› EMF safety evaluation vehicle by Diakar Techniki

The Greek National Electromagnetic Field Observatory contracted Diakar Techniki to redesign and convert a commercial van to meet the requirements of their real time EMF measurement project. The Diakar team reconfigured the vehicle to hold a portable station for measuring electromagnetic fields and rearranged the available space to accommodate the measurement process and provide sufficient secure on-board storage for the valuable electronic equipment.

Figure 8: Diakar EMF safety evaluation vehicle equipped with Narda EMF antenna

The complete redesign of the vehicle interior using high strength coated wood with suitable supporting modules, produced enough workspace for two scientists. Diakar also fitted two auxiliary cabinets inside the vehicle, a metal one for secure storage of measuring equipment and related toolkits, and a wooden one, both equipped with safety locks to ensure safe working conditions when the vehicle is in motion. The interior walls were covered with insulating material and textile lining. Finally, Diakar fitted an auxiliary 220V-1.5 KVA electric generator in the rear of the vehicle in addition to the on board 12V battery supply. The engineering team also installed a UPS system next to the generator to ensure uninterrupted operation of the electrical equipment.

For more information, see: www.diakar.gr

Figure 9: EMF safety vehicle by Diakar with detachable EMF antenna and safe storage compartment

› Multi-role operation support (MUROS) vehicles by Elettronica GmbH (ELT)

The ELT product portfolio comprises a wide range of solutions that provide end users with state-of-the-art surveillance, interception, mission control, and illegal activity detection capabilities. The available capabilities can be combined in a single vehicle, fleet of vehicles, or a trailer, and purpose-built to meet specific operational needs. ELT solutions are based on an open, scalable architecture that is identified by the MUROS (multi-role operations support) brand.

The solution comprises electromechanical and software components developed, fully integrated, and tested by ELT at their premises in Germany, and which ELT has certified with the relevant authorities according to EU standards. All significant aspects, such as safety, security, ergonomics, and electromagnetic compatibility are analyzed, simulated, and tested by ELT.

The end user and ELT together select the commercial vehicle that is to be transformed into a MUROS vehicle, which is validated with the data made available through the **in-place partnership** agreements between ELT and the vehicle manufacturers (e.g. Mercedes, Volkswagen).

The vehicle interior and exterior are redesigned by ELT using **proprietary solutions** and architectures, which cover the complete range of essential elements: side panels, reinforced windows, seats, vehicle roof, retractable masts, antenna interfaces, air conditioning, power supplies, vehicle lights, vehicle control network (CANBUS), sensor network, equipment racks, IT infrastructure, workstations, etc.

ELT successfully manages severe weight constraints through the use of innovative materials such as composites, carbon fiber, laminates, etc. From simple enclosures for electronics to antenna chassis to ISO containers, ELT provides unique multipart solutions that are already in use by their customers.

All sensors and devices are fully integrated in the MUROS vehicle, and monitored and controlled from the on-board workstations or remotely via wireless links. MUROS proprietary command and control covers the endogenous sensors and the vehicle parts themselves (e.g., engine, lights, liquid levels, alarms).

For more information, see: www.elettronica.de

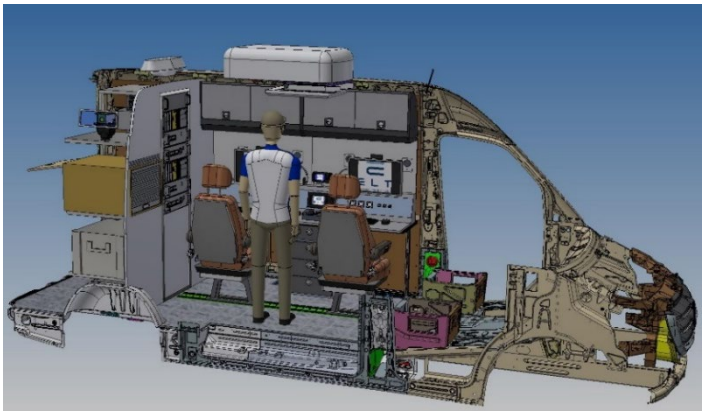

Figure 12: MUROS based on a transporter

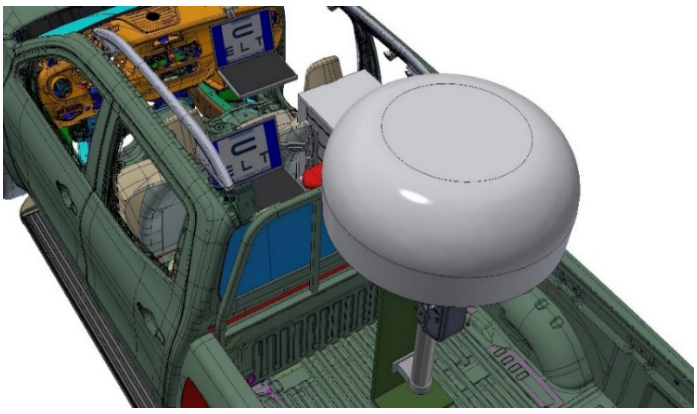

Figure 10: MUROS based on an SUV

Figure 11: MUROS based on an SUV, with elevated mast

General system and design considerations

The various parts and features of a vehicle-based radio monitoring system are outlined in more detail below.

Vehicle type

Usually, customers want a standard or “off-the-shelf” vehicle modified to their individual requirements. Some projects require the use of small, inconspicuous cars, while others require large, rugged trucks with high payload capacity. The following commercial on- and off-road vehicle models have proven themselves in the field:

- SUV / Transporter: Mercedes V Class, Nissan Patrol, VW Caddy, VW Amarok
- Truck: MAN TGS 33.400

Some of these vehicles (e.g. Nissan Patrol) have a rugged chassis designed for off-road driving and heavy payloads. The chassis and suspension system are further modified.

Air conditioning

Depending on the mission area and the expected ambient temperatures, monitoring vehicles are equipped with additional aircon systems. The high-power aircon systems and inverter-based compressors are operated from an AC generator to provide sufficient cooling at ambient temperatures of up to 60 °C.

Battery management

Monitoring vehicles are typically fitted with a secondary on-board battery system which can easily be charged externally. Both battery banks can be electrically coupled for emergencies via a power switch.

If additional electrical equipment such as a high-power aircon system is installed, a silent compact generator that supplies 380 V AC is provided. All circuit lines are fuse-protected, and are switched on and off by means of switch-activated power relays.

Mast and cabling

Many radio monitoring vehicles utilize an integrated mast, which allows the antenna to be raised to a height of 15 meters or more. This facility is helpful as it reduces the effects of noise and increases the radio horizon and the chance of a line of sight (LOS) to the target transmitter. However, as the mast is a moving component, proper consideration must also be given to the cabling for vehicle integration.

Teradium electromechanical mast systems are very rugged and have better resistance to sand and dust. There are two versions of the mast system, one for SUVs and one for trucks. The SUV mast elevates the payload up to 6m above ground level. The version for trucks elevates the payload up to 15 m above ground level. The mast system for SUVs can be operated on the move. The mast systems are electrically operated from a high-power DC source. The compact mechanical cable management system connects the electronics on the mast to the interior vehicle electronics. This compact design allows efficient utilization of the limited roof space on the SUV or truck and avoids cable coils.

RF up or down

As already mentioned, there are two different options for fitting the SignalShark receiver in a vehicle. The classic option is to mount the receiver in a 19” rack inside the vehicle and connect it to the antenna on the roof / mast via RF and control cables. The other option is to use the SignalShark Outdoor Unit 3330 mounted on the mast with the antenna. In this case, the RF cable between the SignalShark and DF antenna is very short, and the only connection from the SignalShark into the vehicle is a LAN cable with power-over-Ethernet (PoE). This setup needs more space on the roof, but the cabling from this RF system to inside the vehicle is extremely simple and does not require any special components.

Additional payload

Customers often require a vehicle that has more than just radio direction finding capability. Further applications, e.g. real time data exchange, may also be needed. Some of the mission-specific systems typically required are:

- Ku/Ka band Satcom on-the-halt (OTH) or on-the-move (OTM) systems
- LTE eNodeB / radio
- HF radio
- IMSI catchers
- Jammers and C-IED devices
- Tactical cameras / imagers
- Directional microphones
- 360° camera surveillance
- Weather stations

With increasing functionality, the power management and cooling requirements also typically increase, and at some

point, the vehicle structure, chassis and suspension system must also be considered. Furthermore, as shown in some of the references mentioned, even the CANBUS system of a vehicle can be included in a system solution to use data from the vehicle sensors such as the current speed.

Rack or brick

Depending on the expansion level, most vehicles come with 19” racks for standard electronics installation. In some cases, it is also feasible to install non-19” electronics as bricks in dedicated spaces on the vehicle.

Covert or exposed

The payload of the vehicle sometimes needs to be kept hidden. That is a problem if a mast is required. Sometimes, a more important role is played by the noise while driving or aerodynamic design for higher speed. All these various aspects need to be considered when the project is defined.

Network or standalone

A direction-finding system can operate as a standalone. TDOA localization of radio transmitters is possible if several monitoring vehicles are teamed up together. However, this requires that the monitoring vehicles are equipped with some means of communication, such as a long-range mobile satellite communication system, or 4G / LTE connectivity. This leads to specific use cases and design criteria.

Conclusion

This Technical Note shows that radio monitoring vehicles can be designed to meet the highly distinct requirements of each different use case. Often, the applications do not simply require a standalone direction finder mounted on a vehicle. They frequently also require a network setup with mobile connectivity to other stations in the field. This would apply, for example, if the task is to monitor a large event using TDOA and merge all the collected data together at headquarters, or in situations where redundancy and flexibility is required to better deal with emergencies.

Additional consideration is needed if the vehicle is to be able to cope with harsh environments.
Further payload, such as a mast plus satcom on-the-move or an imaging system, make additional claims on the space within the vehicle as well as on its power management and generator or battery requirements, and even on its suspension system.

In conclusion it can be said that devices are much more suitable for vehicle integration if they are compact in size, have low power consumption, and provide a high degree of flexibility and interoperability. Narda designed the SignalShark with this in mind.

- The SignalShark is an open architecture design. The background operating system is Windows 10. It can transfer data in VITA49 format, and is compatible with Python and many other commercially available specialized software applications thanks to its wide range of hardware and software interfaces.

- The SignalShark is a platform-based receiver that enables it to be produced in various form factors, i.e. handheld, rack mounted or outdoor / mast mounted. As an example of a very flexible scenario, the SignalShark Handheld Unit can be integrated in the vehicle with the option of quick removal, and connected to an ADFA magnetically mounted on the vehicle roof. If necessary, the handheld unit can be taken out of the vehicle and connected to any handheld antenna to continue the mission on foot. This offers the advantage of a rapid switch from a vehicle-based search to a “last mile” hunt using the corresponding antennas. Furthermore, the bearing results and system settings are retained when switching between these two modes, so that they can be further used without interruption.

- The SignalShark’s RF parameters relative to its size and power consumption are outstanding in comparison with any other product on the market. This is particularly apparent when it is used with the Automatic Direction-Finding Antenna 2 that covers frequencies between 10 MHz and 8 GHz.

- The SignalShark can be combined with Narda’s Automatic Direction-Finding Antennas, and can be part of a TDOA network that includes both fixed and mobile stations, e.g. vehicles.

Nevertheless, with all the features and options that are available, it should not be forgotten that the purpose is to deliver not just a product but a solution that actually helps users in their everyday work. Narda is proud to provide the SignalShark to customers for various applications, and to support a wide network of integrators and specialist vehicle customization companies all over the world.

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