NON-IMAGING POLARIMETRIC 76 GHZ RADAR

ELVA-1
Millimeter Wave Division

AI-DRIVEN RADAR SENSOR FOR CONCEALED WEAPONS DETECTION

ELVA-1 OU, ESTONIA

AI-DRIVEN MM-WAVE RADAR SENSOR FOR SECURITY SCREENING OF PEOPLE

ELVA-1 has developed millimeter wave radar with artificial intelligence (AI) analyzing engine for standoff detection of concealed weapons. Operating at 4 mm wavelength, it could recognize on-body guns, hand grenades and massive of small metal particles which are typical for explosive belts.

We believe that effective security screening has to be a layered multi-technology defense with millimeter wave radars working on the far perimeter. Other technologies which work at their best at short distances have to be combined with mm-wave sensors for high overall level of detecting accuracy.

KEY FEATURES

- Low-power polarimetric radar system for standoff detection of on-body concealed weapons
- up to 20 m max range
- 4° antenna beamwidth
- Non-imaging principle of analysis, based on polarization pattern of reflected on-body objects
- Operating frequency band 76.5 GHz (E-band)
- Radar is compact and portable, easy to install
- AI engine is trained to recognize explosive belt components before deployment
- AI engine continues to “learn” after deployment and adapts to specific environment

PRODUCT OVERVIEW

Traditionally, weapons detection has involved just metal detectors. Later, detection technologies list was greatly expanded including molecular spectrometry, X-rays, microwave and millimeter wave scanners.

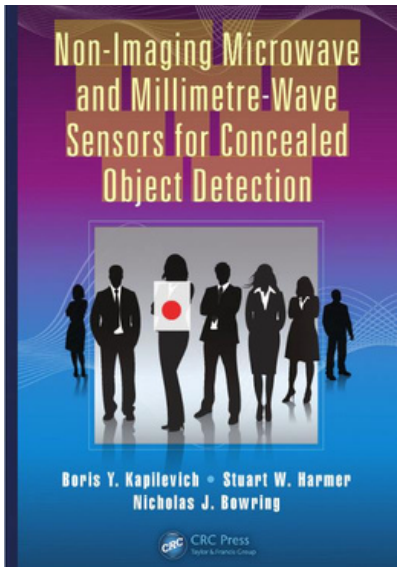
ELVA-1 system works by using non-imaging millimeter wave radar to scan individuals as they walk within the spot of radar beam. The results of the scans are analyzed in real time by AI engine and compared to a database of known patterns. The system is constantly learning and adapting at its place of deployment to new patterns.

The drawback of the majority of new weapon detection technologies is the requirement of very short or even zero distance to the suspected object. These technologies are good enough for scanning luggage in airports, postal deliveries or other goods at customs check-points, but fails to scan moving people, especially on the standoff distance.

At the current stage of science, active millimeter wave detection is promised to be the most long-range people screening technology compared to all other ones which currently exist as many as about a dozen.

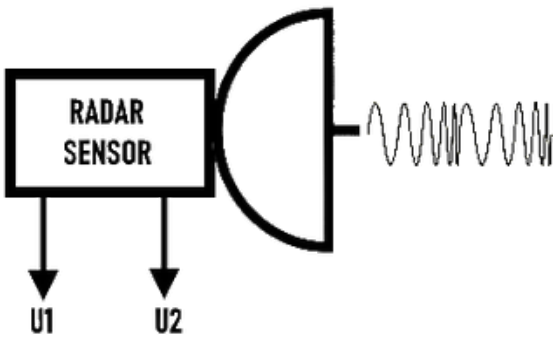
OPERATING PRINCIPLE

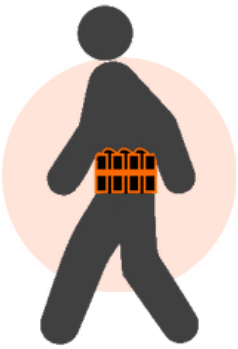
The principle of ELVA-1 radar sensor operation has its origin on the materials of this book -
«Non-Imaging Microwave and Millimetre - Wave Sensors for Concealed Object Detection».



The idea is based on radar polarimetry. The electromagnetic field reflected from the natural human body enters the receiver input without changing the polarization. Foreign objects on the human body affect the polarization properties of the wave. This is why a screened person with on-body objects begins to "shine" on the cross-polarization channel of the receiver.

An each on-body object, even small enough and non-metal, reflects back to the polarimetric radar. This returning signal could be registered by using main (U1) and cross (U2) reception channels.





U1 – voltage proportional to the power level in the main reception channel (the polarization of the receiver coincides with the polarization of the transmitter)

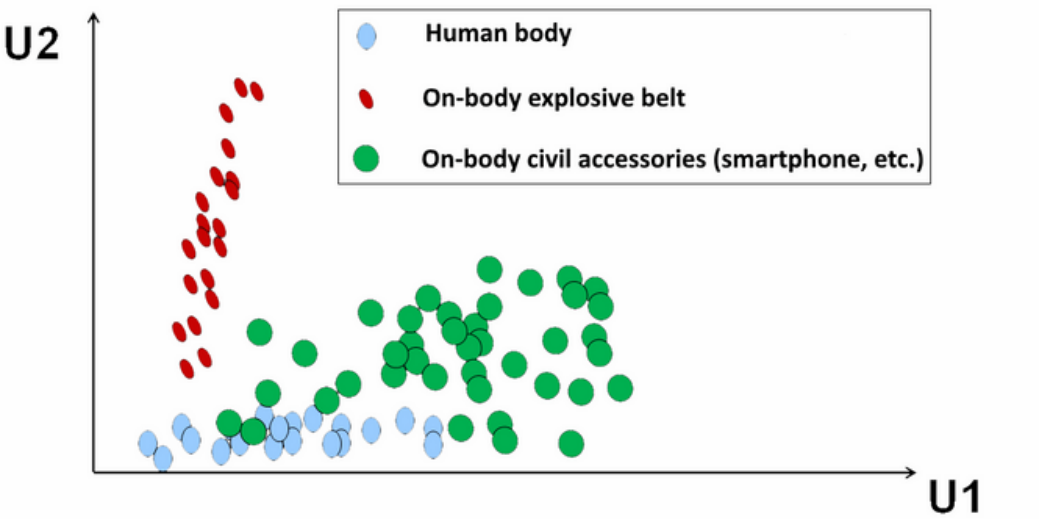
U2 – voltage proportional to the power level in the cross-polarization receiving channel (the polarization of the receiver is orthogonal to the polarization of the transmitter)

Early ideas to build radar–based cameras with enough resolution for distance view of any concealed things on the human body currently are considered as not practicable because of a bunch of reasons.

- **First, such camera is huge of its size and extremely expensive.**
- **Second is the fear that a screened person will receive a significant exposure because of emission from a matrix of radars (even small ones) as each pixel means a separate radar.**
- **Third reason is privacy concern, as radar camera delivers image of a person as a "naked" body.**

The way to resolve these issues brought the idea of using non–imaging radar which delivers just simple ON/OFF alarm signal of concealed weapon detection without displaying any part of the human body.

HOW RADAR SENSOR WORKS



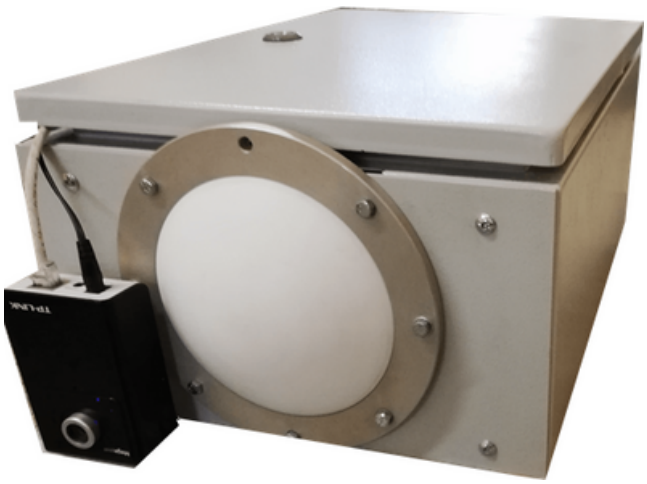
Analysis of typical reflected signals has allowed ELVA's researchers to identify patterns that are reflected from ordinary objects on the human body and hidden weapons.

The current implementation of ELVA-1 radar sensor uses statistical threshold detector, studies are being conducted on the recognition of various dangerous objects using AI engine based on neural network, and statistics are being collected.

The advantage of AI-driven recognition engine is that it continues to “learn” after deployment and self-adapts to specific environment at the place of installation.

Currently, the radar sensor is made in a simple laboratory box.

The commercial version of the radar will be placed in the case in accordance with the specifications from the customer.

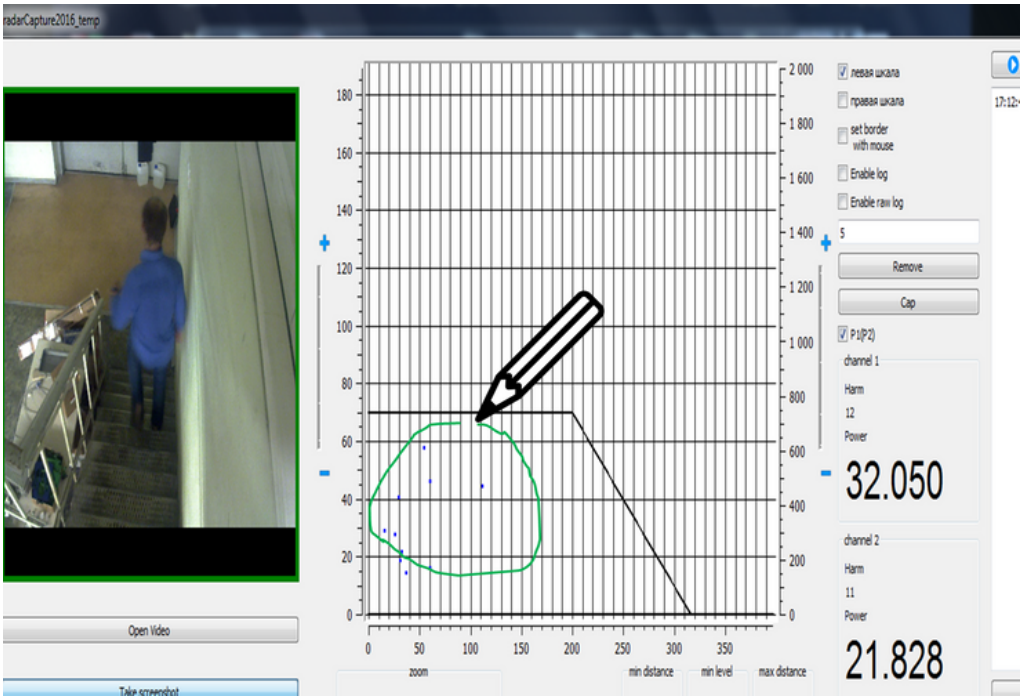


76 GHz band for this radar has been chosen because of sharp recognition any objects that are large than its wavelength of 4 mm.

This frequency band is lightly licensing as belongs to the class of low-power automotive radar sensors.

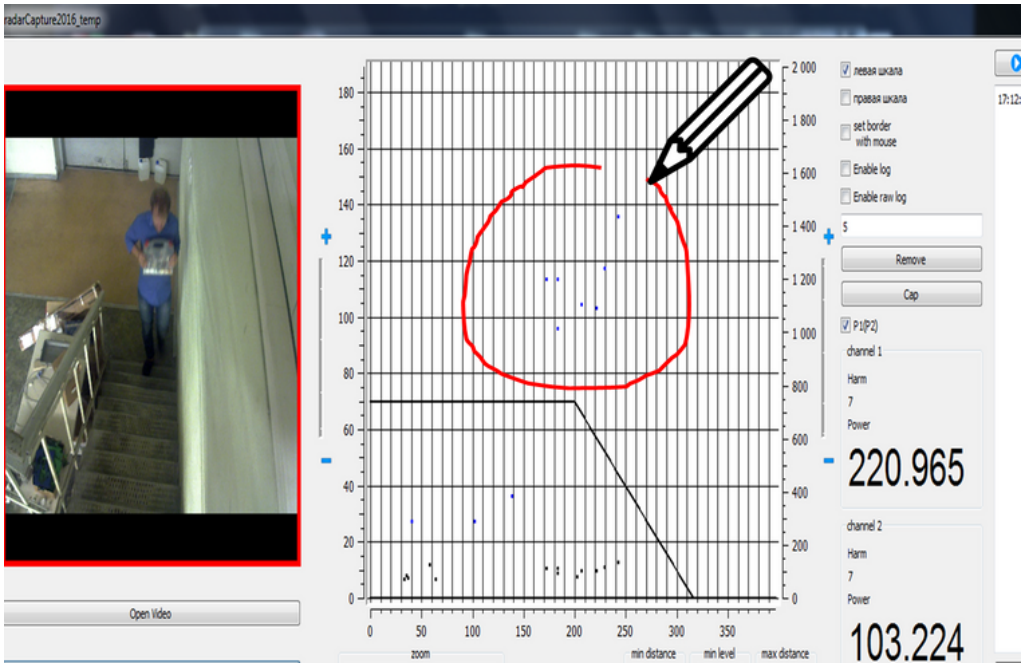
EXAMPLE OF EXPLOSIVE BELT RECOGNITION

This example shows how ELVA-1 radar sensor uses statistical threshold detector when it is detecting the pattern of small metal particles massive which is typical for explosive belt.



A person who has no hidden metal particles, so the threshold is not exceeded, the green light is ON.

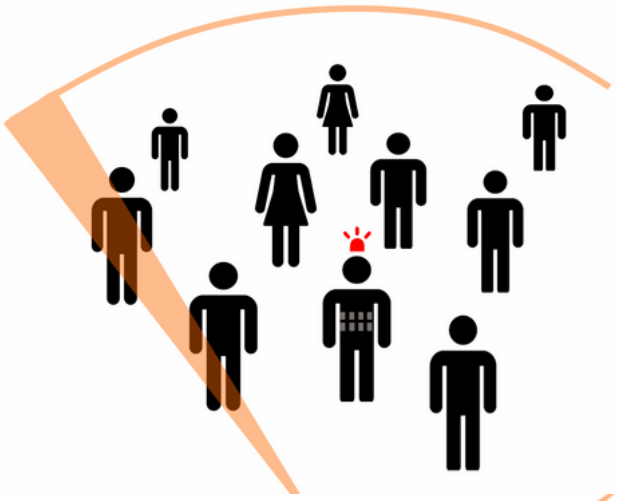
A person with a fake bomb activates the threshold detector, the red signal lights ON.



At the real conditions the radar sensor would be to scan people from a standoff distance. Then security guards could watch flagged individuals more closely or make scans with more sensitive devices.

TYPICAL APPLICATIONS FOR RADAR SENSOR

Mechanical or electronic scan would be needed in case of screening a group of people located in a wide space. Direct visibility to an each person is essential for reliable detection if the concealed weapons by radar sensor.



The millimeter-wave radar system could flag weapons on their way in to busy places to prevent active shooting and suicide bombing.

Entrances to schools, airports, stadiums or shopping malls or wherever there is a large number of people have to be protected with millimeter-wave radar system working on stand-off distance.

LOW-RANGE TECHNOLOGIES TO USE WITH MM-WAVE RADAR SENSOR FOR UP TO 100% CONCEALED OBJECTS DETECTION

- **Ion mobility spectrometry** (IMS) is a sensitive analytical technique that is used for detection, identification and monitoring of chemicals, mainly explosives, highly toxic gases and drug interdiction. Vapours of these compounds are ionized according to atmospheric pressure chemical ionization processes and then the ions are separated on the basis of their mobility in an electric field.
- **Chemiluminescence** (CL) works on detection of nitrogen-containing compounds by measuring the light emitted from excited states.
- **The electron capture detector** (ECD) is a counter suitable for good electron acceptors, such as are present in many explosives. Nitrogen-containing explosives (EGDN, DMDB, NG, PETN, RDX, HMX, NT, DNT, and TNT) can be confirmed at extremely low amounts.
- **Surface acoustic wave** (SAW) devices are based on piezo-electric crystals which resonant frequency is changed when molecules from explosive sample are adsorbed onto the crystal surface.

For more information about this 76 GHz radar sensor and latest development in concealed weapons detection, please contact ELVA-1 team at **sales@elva-1.com** or tel. **+372 6 888 905**.