TECHNICAL SOLUTION PROPOSAL **Reference: B2017-011**

Title: Sensor network for terrain monitoring

Corporate entity: **Diehl Defence GmbH & Co. KG**

Introduction

The present proposed technical solution concerns a sensor network comprising a plurality of self-crosslinking sensors for monitoring-relevant parameters that can be deployed in a terrain.

Problem

Current events show that cost-effective, simple and, in particular, large-scale monitoring of camps, thoroughfares or restricted areas against unauthorised intrusion, such as entry by persons, vehicles or aircraft of any kind, is necessary in order to be able to avert imminent dangers in good time. In order to be able to detect possible threats at an early stage, 24-hour surveillance is desirable, especially in crisis areas. However, such monitoring should neither place excessive / additional demands on the personnel available there nor put them in danger themselves. Common sensor systems, e.g. stationary radar stations or camera systems, quickly reach their potential limits of use: highly fragmented areas or terrain such as forests, hilly or mountainous areas are difficult to monitor comprehensively and permanently. Surveillance options that are more suitable for such areas - for example, by drone or satellite - are not designed for permanent surveillance and are often not available for reasons of cost and/or personnel. If an area behind enemy lines is to be monitored, this can usually only be done by means of small-scale, easy to attach/detach and
/easily deployable and difficult for third parties to detect; large-scale sensor systems are unsuitable for this purpose.

Previous approaches to a solution

Until now, surveillance of areas behind enemy lines has mostly been carried out by personnel deployed in the vicinity, who are forced to continuously observe the area to be monitored in order to become aware of any threats. Alternatively or additionally, in such cases, surveillance is also carried out with stationary sensor systems, such as radar systems and/or cameras, which are, - however, as already mentioned, this quickly reaches the limits of feasibility in highly fragmented and/or difficult-to-access areas, or cannot be used at all or only to a limited extent in hostile territory. In many cases, the aforementioned monitoring systems are stationary and expensive solutions in which a maximum of a dozen sensors are interconnected via a command and control system or a central unit. In order to network the sensors used there, a defined installation with regard to position/alignment/position is also required. Furthermore, the structure of such a network is usually fixed, which makes installation in highly fragmented areas even more difficult.

From DE 10 2005 048 269 B4 a sensor network for monitoring a terrain is known, in which a number of self-networking sensors for monitoring-relevant parameters, which can be deployed in a terrain, are used. The sensors are each equipped with a communication means for communicating with each other. It is intended that the sensors network with the neighbouring sensor to which the strongest communication connection can be achieved. Among the sensors there are also several master modules which allow to establish a radio contact to a central unit located further away. The master modules serve as interfaces between the sensors and the central unit.

Task

The task of the proposed technical solution is to specify a sensor network for monitoring a site/area that is robust and allows simple and reliable querying of the status of the entire sensor network.

Solution

For this purpose, the proposed technical solution provides for a sensor network comprising a plurality of sensor modules for monitoring-relevant parameters that can be deployed in a terrain and are designed to network themselves, which have a) a communication means for the independent exchange of their information with each other, b) a storage means for storing incoming information and c) an interface that allows an evaluation unit to be latched in.

The technical approach is based on the realisation that if a master module in a network fails, no more information can be transmitted to the master module and thus to a central unit and, in the worst case, monitoring is no longer possible. Since the sensor modules have a communication medium for exchanging information and a storage medium for saving information, all information of the sensor modules in the network can be retrieved via a sensor module.

The proposed technical solution is further based on the consideration that, for example, due to terrain movements, intrusion of third parties etc. into the area monitored by the sensor network, it may not be possible to get within range of a master module in order to be able to retrieve information of the network by means of the master module, in particular without attracting attention. Since, according to the proposed technical solution, all sensor modules are equipped with an interface that allows an evaluation unit to be latched on, the status of the network can be queried via this sensor module by means of an evaluation unit at any suitable or arbitrary location where a sensor module of the sensor network is located.

In a preferred variant of the proposed solution, the sensor modules are mini-sensor modules, in particular low-cost mini-sensor modules. These sensor modules can respond, for example, to movement, vibration or noise. Mini-sensor modules have the advantage that they are difficult to detect by third parties, and if one of the mini-sensor modules is found behind an enemy line by an enemy unit, for example, the enemy unit is usually already exposed by the sensor module, since it generates corresponding information based on movement/vibration/noise and/or other measured variables to which the sensor module responds, and sends this information to other sensor modules.

Conveniently, the sensor modules exchange their information using RF technology via their communication means, as this allows a range of several kilometres. The sensor modules that communicate with each other via radio integrate themselves into the network. Since each

sensor module has a means of communication, they also serve as transmission support points for the other sensor modules. In this way, a network can be created that allows large-scale monitoring of a site.

Because the sensor modules are designed to be deployable, they can be scattered. Such scattering makes it possible to monitor fragmented terrain and terrain that is difficult to access. In areas of the terrain to be monitored, more or fewer sensor modules can be deployed as needed to ensure reliable monitoring. Cleverly, the sensor modules are designed to be air-droppable, such as by an unmanned drone. The deployability of the sensor modules also means that no on-site installation is required. This avoids the risk to personnel when deploying the sensor modules in hostile territory.

As the sensor modules independently establish a network with the modules located in the reception area, a very high robustness of the network is achieved, as in the event of a failure of a sensor module, the network is autonomously updated by the remaining sensor modules.

Since each sensor module has an interface that allows an evaluation unit to be latched in, it is possible for not only one but also several evaluation units to latch into the network ("mesh network") - independently of the detection of a measured variable by a sensor module - and to query the current status of the entire network and accumulated events from the storage means of a sensor module.

Preferably, the sensor modules are equipped with very simple electronics in order to have low energy consumption. This means that 24-hour monitoring can be guaranteed. Preferably, blockchain technology is used to protect the sensor network from intruders / the infiltration of false information.

Design example

Surveillance of a site can be carried out as described below:

After the sensor modules have been deployed by an aircraft, an unmanned drone or the like over the area to be monitored, the respective sensor module is briefly woken up when noise, vibration etc. is detected and sends this information to all other sensor modules within range, which store this information in their memory and send it on. This creates a network of information about where in the network something was detected. Each sensor module in turn stores an incoming signal for later evaluation, whereby such a signal can be either a signal that the sensor module itself receives via its own sensor system or generates from a measured variable or a signal received from another sensor module via the communication medium. Since the sensor modules are loosely and directly networked with each other via RF technology, no central unit is required. Even if a single sensor module fails, the network reorganises itself because the sensor modules autonomously establish connections to nearby sensor modules. One or more evaluation units, which are located at least within range of a sensor module, can be used to evaluate the information or the signals or the measured variables recorded by the sensor modules of all sensor modules attached to the network. By using the blockchain method, the network of sensor modules can be protected against intruders or the feeding in of false information.

The sensor network according to the proposed solution and its described implementation variants can be used in particular for field camp protection, for the control of thoroughfares / restricted areas or for the observation of hostile areas.