

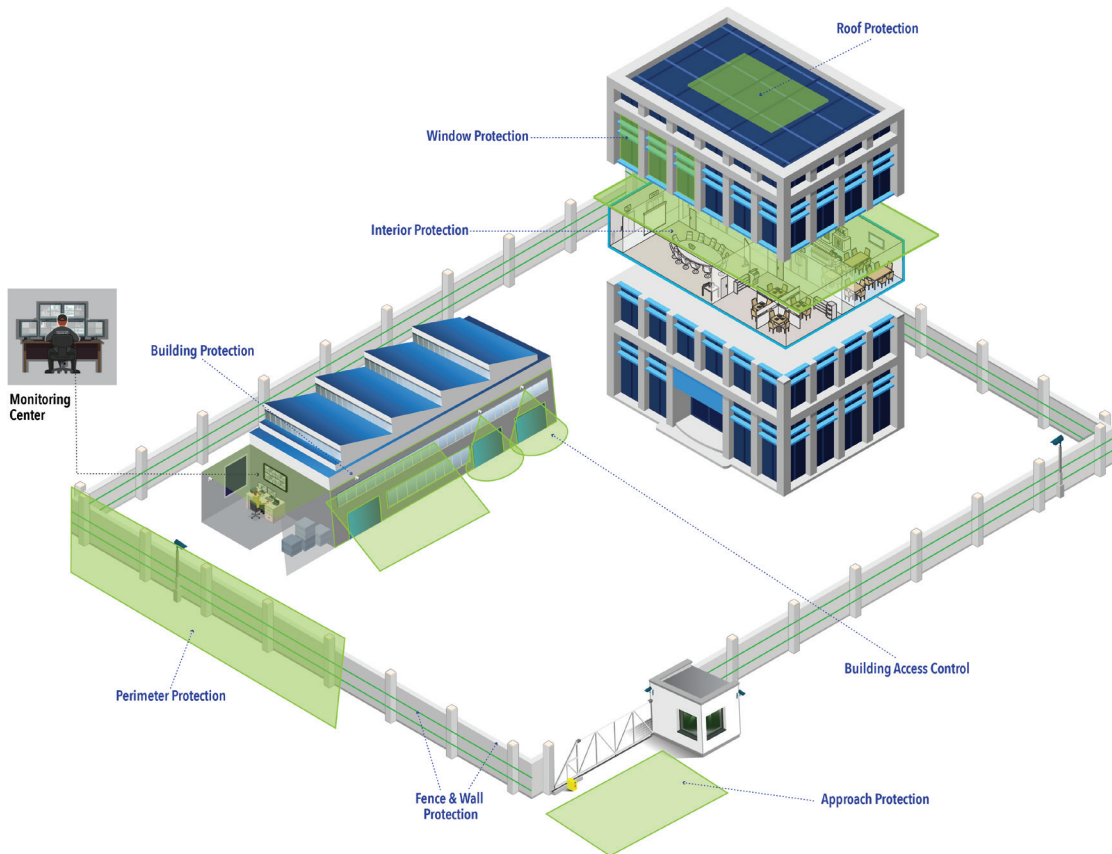
WHITE PAPER

QORTEX ▶ FOR SECURITY SOLUTION

This white paper discusses the superiority of QORTEX DTC™ perception software and LiDAR technology in security applications and compares it with other technologies frequently used in security systems. This paper also provides significant details about the usage and potential of QORTEX for Security.

1. INTRODUCTION

QORTEX for Security is the most innovative and intelligent LiDAR-based, 3D perimeter fencing and intrusion detection system. An integrated hardware and software platform, this security solution combines Quanergy's M8 LiDAR sensor with QORTEX perception software. The M8 LiDAR sensor is a patented and proven LiDAR powerhouse with a 360° field of view. QORTEX incorporates machine learning and 3D perception algorithms to identify, track and classify objects. The solution also adds an accurate and reliable virtual fence with a low false alarm rate, substantially reinforcing perimeter security.



2. WHAT IS LIDAR?

LiDAR technology is the way of the future for security applications, replacing traditional solutions such as radar and microwave sensors. Quanergy's powerful security platform is fully integrated into existing VMS and PSIM infrastructures, offering surveillance automation with real-time people detection, classification and tracking. Quanergy is disrupting the security market by enabling an entirely new level of smart awareness along with reducing total system and labor costs.

3. WHY USE LIDAR IN SECURITY?

In its most primitive form, perimeter security consists of a wall or watchdog. Advancing technology has enhanced perimeter security through innovative ways of perceiving intrusions within a scene of interest. LiDAR technology in particular is impacting how we address perimeter security since it is far superior in enabling more effective and accurate systems at a significantly lower cost. More specifically, LiDAR works in all lighting conditions, has exceedingly longer range, and is not as readily absorbed by non-metallic materials due to the laser's high energy light waves.

Quanergy's LiDAR-based QORTEX DTC solution can replace or dramatically enhance other surveillance systems, which may include security personnel, video monitoring systems (VMS), motion detectors, thermal imaging, and radar. Through reliable hardware and highly intelligent software, Quanergy's solution upgrades all the many inherent benefits of LiDAR and provides a higher level of accuracy in demanding physical and weather environments. QORTEX DTC can accurately trigger an alarm upon detecting an intruder, and then track the person or object breaking the virtual perimeter.

REDUCED FALSE ALARMS

False alarms occur all too frequently in many modern security systems. A false alarm is costly, inefficient and even dangerous if the people involved are on high alert. Repeated false alarms can even cause a reduction in site monitoring. Many third-party monitoring systems have a maximum number of false alarms, and after that number is surpassed, the alarms are ignored for a period of time, such as 24 hours, leaving the site exposed and vulnerable. LiDAR security systems are less likely to fall prey to such problems because they are largely indifferent to the environmental issues of weather, temperature, materials, and lighting that affect other systems.

Precise in Accuracy

The more precise a security solution is, the more effective it will be, with fewer false alarms. With more data comes more accuracy and detail, resulting in a more secure site. Some security systems simply do not have the necessary precision and processing power to interpret the results of what is reported accurately. For example, wildlife such as deer, foxes, birds, spiders and moths can provoke some systems to incorrectly alarm. Such situations are prevented if, for example, the security solution understands the size and shape of a human, and only raises alarms for those shapes. LiDAR systems employ a Time-of-Flight (TOF) calculation that identifies an object's precise location by its X, Y, Z coordinates. Even better, QORTEX DTC processes that point information to determine the entire object's size in three dimensions to safely prevent false alarms from objects that may appear large but are actually just close to the sensor. This solution also determines the shape of an object by the number of points hitting the target and the speed of the object, and it disregards objects that do not fall within specified criteria for the site.

Reliable in Weather

While some security systems have trouble operating reliably in extreme environments, LiDAR performance is unaffected by changes in weather, temperature, and surface material. The QORTEX solution optimizes many hardware and software variables to enhance those inherent characteristics of LiDAR. For example, rain, snow and mist can wreak havoc with camera imaging and cause false positives based on the distorted images, but the laser light of LiDAR fires through such particulates, and Quanergy's M8-Plus LiDAR sensor operates with an IP69K rating of complete ingress protection.

Reliable in Temperature

LiDAR is indifferent to temperature, and the QORTEX hardware is designed for full usage indoors and outdoors in any weather, from the bitter cold of $-20^{\circ}\text{C}/-4^{\circ}\text{F}$ when operating, and $-40^{\circ}\text{C}/-40^{\circ}\text{F}$ when in storage, to the baking sun and heat of $60^{\circ}\text{C}/140^{\circ}\text{F}$ when operating, and $105^{\circ}\text{C}/220^{\circ}\text{F}$ when in storage.

Reliable in Lighting

The image resolution of cameras is affected by low lighting, and high-contrast areas that include both bright sunlight and deep shadows, which can yield false positives. Thermal cameras have three issues. They have trouble capturing sharp, clear, accurate images of objects near sources of heat. Their images blur greatly unless captured from an extremely steady platform. Daylight causes noise in the images, making them hard to decipher. LiDAR, however, is a laser technology that does not require visible light in order to perceive accurately. Operating at the 905 nm wavelength, Quanergy's LiDAR sensor performs in all lighting conditions, including broad daylight, ambient light and complete darkness, with no infrared signature needed, while perceiving objects up to 50 meters away with clarity.

Reliable with Materials

While some sensing systems struggle to detect certain materials and textures in the environment, LiDAR performs well with metallic, non-metallic, and retroreflective materials. For example, radar is based on radio waves, which reflect back in an interference pattern after hitting metal; LiDAR bounces back with no such interference, allowing LiDAR to excel in areas with lots of metallic fencing and plant machinery.

SCALABLE SCOPE

LiDAR sensors can be used together to form a more complete view of an area. When positioned up to 100 meters apart, QORTEX DTC sensors can overlap their views of a scene to form a complete and unified scalable virtual fence that may be as large or small as necessary. Through Quanergy's Q-View software, sensors can be fused together to provide a full overview of large sites or areas combined into a single view, making it much easier to manage.

IMMUNE TO INTERFERENCE

LiDAR technology differs from radar in that laser technology generally encounters no interference. Radar, on the other hand can be subject to interference from living creatures such as large birds, flocks of smaller birds and swarms of insects; natural phenomena such as rain storms, waves and sea spray; and solid structures such as masts, buildings, wind turbines and metallic materials.

UNOBTRUSIVE AESTHETICS

Quanergy's M8 LiDAR sensor is compact in size and dark in color to provide a less intrusive design that can fit into a building or site with a small footprint.

LOWERED COST WITH GREATER ROI

QORTEX DTC is a low-cost overall solution, where each LiDAR sensor provides up to a 50 meter range of detection in 360 degrees. Each sensor rotates at ten hertz, which means the laser array within the sensor rotates ten times per second. This solution covers a lot of ground with fewer sensors and therefore needs fewer spots for installation, less groundwork, less power, less cabling, and less labor for installation.

The following table provides an overview with additional details of how the QORTEX implementation of LiDAR compares favorably with other technologies that have been used in security solutions.

	QORTEX LiDAR-BASED	VIDEO	RADAR	THERMAL	MICROWAVE
Sensing Dimensions	3D	2D	1D	2D	3D
Cost	Medium	Medium	High	High	Low
Calibration	Easy	Difficult	Easy	Medium	Difficult
Light Condition	Day/Night	Day	Day/Night	Day/Night	Day/Night
Range	Wide Area Medium Distance	Wide Area Short Distance	Wide Area Long Distance	Narrow Area Long Distance	Narrow Area Medium Distance
Object Information	Detection Speed Direction Distance Classification Tracking	Detection Identification	Detection Speed Direction Distance Tracking	Detection	Detection
Distance Include/ Exclude Zones	Yes	No	Yes	No	No
Multi-Sensor Fusion	Yes	No	Yes	No	No

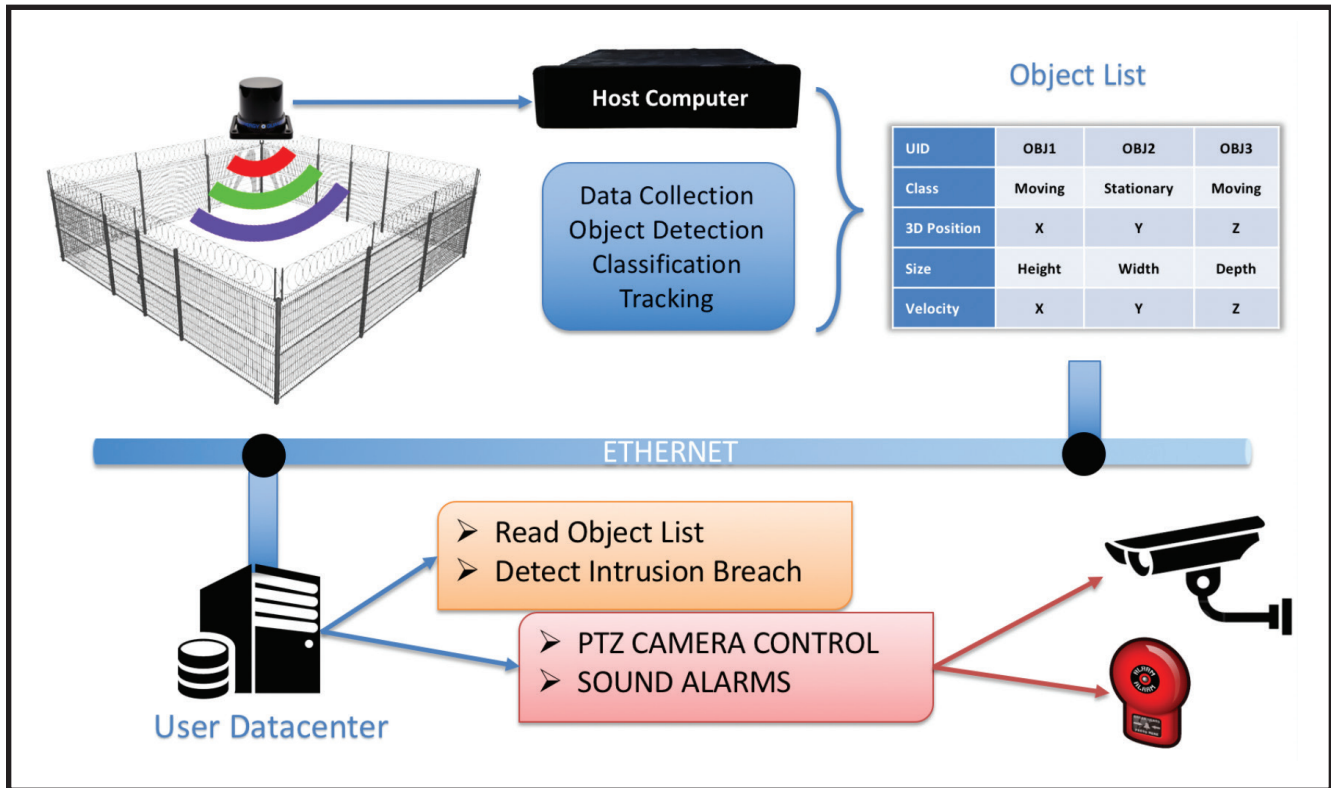
4. TECHNICAL OVERVIEW

QORTEX for Security is a LiDAR-based solution in which Quanergy's M8™ LiDAR sensor and QORTEX DTC software provides three-dimensional perception and volumetric sensing for the detection, tracking, and classification (DTC) of human objects. With data intelligence and centimeter-level accuracy, QORTEX DTC provides a cost-effective solution to enable Internet of Things (IoT) applications in security sectors where human movement is important to monitor such as perimeter security, border security and prisons. QORTEX for Security can also protect critical infrastructure such as airports, data centers, maritime and harbors, military and nuclear facilities, oil refineries and pipelines, gas and power utilities, or any industrial premises holding valuable equipment.

SYSTEM TOPOLOGY AND ARCHITECTURE OVERVIEW

The QORTEX DTC system architecture deploys in a simple distributed scenario where all solution components connect to the installation site's local area network (LAN) via TCP/IP protocol. QORTEX DTC involves several blocks of functionality: M8 LiDAR sensors, QORTEX DTC Server, QORTEX DTC Client (or Video Management Systems (VMS) plug-in), Q-View™ toolkit and PTZ camera control. The M8 LiDAR array produces surveillance data that is collected by the computer hosting the QORTEX DTC server.

The server software analyzes the point cloud to detect moving objects in the surveillance area, tracks the objects as they move around (paying extra attention to those in event zones or ignoring those in exclusion zones, as predefined by the user through the Client software), and formats the surveillance data into an object list. The object list contains details that classify those moving objects and then publishes that object list over local Ethernet. The security infrastructure or data center consumes the object list and determines actions to take, including pointing cameras at intruders and triggering alarms.



Sensor

Quanergy's Time-of-Flight (TOF) M8 LiDAR sensor has a 360° field of view, high accuracy, fine resolution, and high reliability. Operating at the 905 nm wavelength, the sensor was designed to see by day or night, with no IR signature needed, and is operational in mist, rain, snow, and dust. The M8 sensor is certified/compliant with the FDA, FCC, CE, RoHS, WEEE, ISO 9001:2015, EN-61326, IEC-61010, IEC-60079-15 and ASTM G154 organizations and standards.

Up to 100 meter spacing between sensors is recommended. As soon as the M8 LiDAR spins up, objects are detected within a range of 50 meters and can be tracked continuously at up to 40 meters. In real time, each mechanical 8-beam LiDAR rotates at 10 Hz and detects up to 420,000 points per second. These points return from foreground moving objects and background static objects.

The M8 sensor is offered in two versions: the M8-Plus is suitable for use with regular Ethernet networks, and the M8-PoE+ is for networks that support PoE+ for simplified network and power cabling.

M8-Plus



M8-PoE+



Server

The QORTEX DTC server is the backend system hosted on a Linux® Ubuntu® 16.04 certified computer with Gigabit Ethernet, at least 100 MB storage memory (not for recording). If the application uses the recording feature, external storage for up to 20 MB per sensor per minute is recommended for data collection in single return mode.

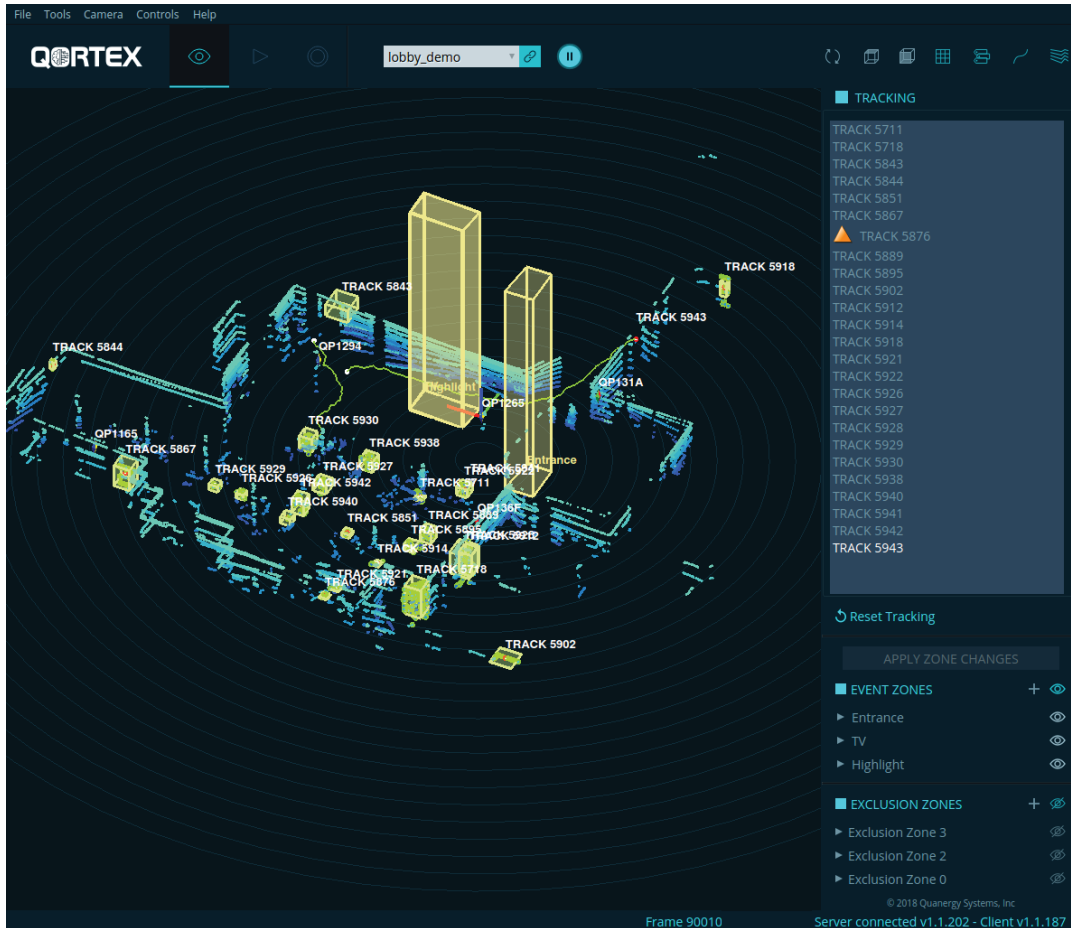
The data flow for the QORTEX system is as follows: The server receives input from multiple M8 LiDARs that have been calibrated through the Q-View toolkit. The server then processes the data to detect, track, measure and classify objects. Finally, the server publishes output in a serialized format to the user's network infrastructure, including VMS systems such as Milestone and Genetec. Any number of potential third-party host infrastructure applications may subscribe to these published data stream outputs for surveillance or visualization.

The QORTEX solution can support two processing architectures, each optimized for target applications requiring specific system and network infrastructures:

- ▶ *A centralized processing model* based on the Quanergy Server Processing Unit (QSPU™) server is suitable for securing large interior and exterior sites such as airport, arena and general building security where many objects may be detected. This solution would include sensors connecting directly to an Ethernet network with raw sensor data collected upstream at a central server. The QSPU chassis could accommodate up to four QORTEX DTC servers in a virtual machine configuration for up to twenty total sensors. For large sensor deployments, multiple QSPUs could be used together. The QSPU is designed for Ethernet networks, with network capacity sufficient to support the raw data stream from sensors.
- ▶ *A decentralized processing model* (edge processing) that is based on the Quanergy Processing Unit-L7 (QPU-L7™) computer or the QPU Mini™ platform is suitable for perimeter fencing or remote location security where network bandwidth is limited. The computing unit functions as the QORTEX DTC server, typically co-located with the sensors. The QPU-L7 can process data for up to six sensors, and the QPU Mini can process data for up to two sensors. Post-processed server data from the computing unit (that is, object information) would be sent upstream for data merger with the output from other servers and visualization at a central command center.

Client

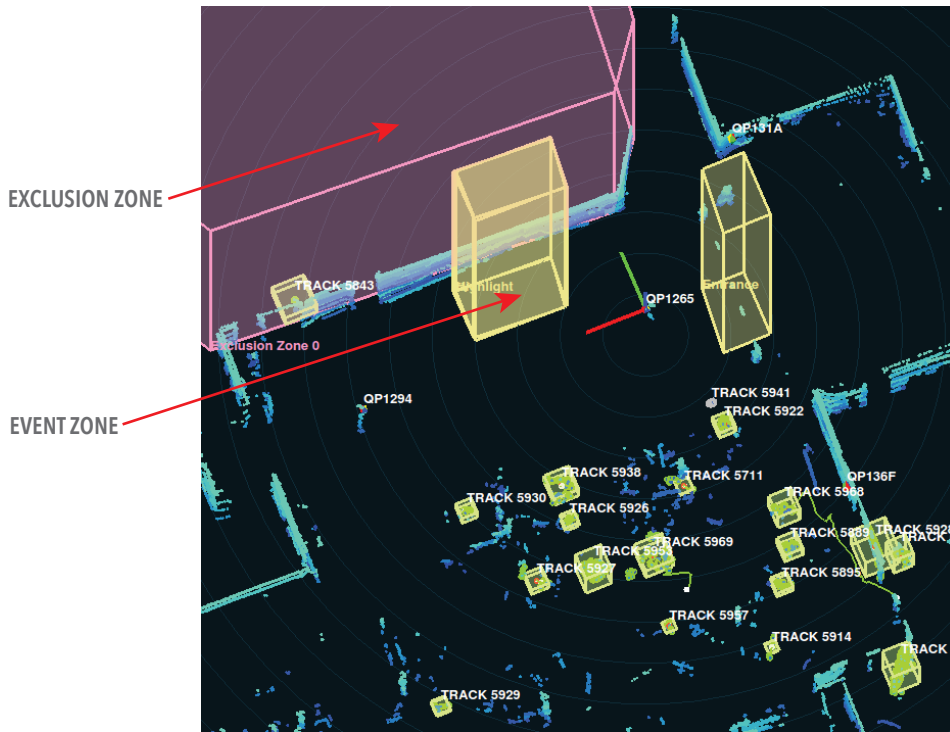
The QORTEX DTC client is a visualization and configuration application that renders a three-dimensional representation of the objects, zones, and point cloud published by the server. The client is responsible for posting command and data messages that control the server's behavior, such as when to start/stop recording and the definition of event zones (to heed) and exclusion zones (to ignore).



3D ZONE SETUP

Zones are important methods of pre-determining which data is most and least significant. In the QORTEX DTC client visualizer, the user can click and drag a mouse to draw the footprint of two types of 3D zones:

- ▶ *Event zones* are defined for areas of heightened interest that are critically important to protect. The user can click through client menus to define automated actions for the software and PTZ cameras to track particular objects and call attention to suspicious activities before problems occur. Automated actions could include highlighting tracked objects in the visualizer or turning devices (lights, alarms, etc.) on and off through a typed HTTP GET network command.
- ▶ *Exclusion zones* are defined for zero-interest areas that pose no threat, but are visually noisy, for example, with flapping flags and swaying branches. To preserve bandwidth, the software does not monitor, collect, visualize, or output points within these zones.

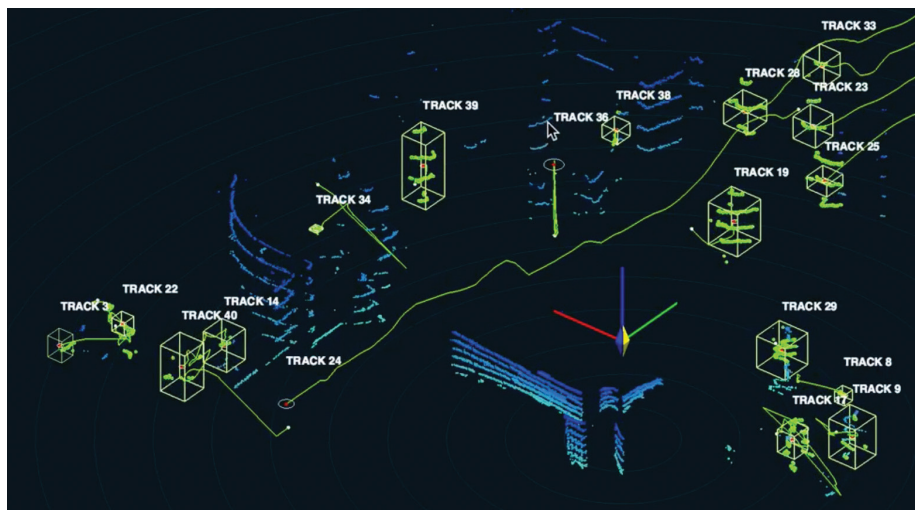


TRACKING AND CLASSIFICATION

QORTEX DTC tracks multiple objects at once and classifies them in real time.

The point cloud is analyzed by AI algorithms, which cluster and group the points into trackable objects. A commercial-grade, static LiDAR visualization system is able to sense and display in real time the movement and trail of human-sized objects (appearing as bounded boxes) over time, persisting even through blockages and crowd gaps. This gives users the ability to track and record the historical movements of potential threats.

QORTEX DTC classifies objects in real time as human based on surveillance data that the host computer collects, analyzes, and outputs into an object list, which serves as the basis for further action, including the notification of external alarm systems via LAN, TCP, and HTTP GET. By measuring and providing exact 3D coordinates of humans, QORTEX DTC reduces or eliminates false positive threats.



FEATURES

QORTEX DTC provides several enhancement features, including Multi-LiDAR Fusion™, control of PTZ cameras, and VMS integration.

Sensor Fusion

Multiple LiDARs acting in concert provide an enriched perspective of a shared area of interest through a calibration tool that allows the user to quickly enable Multi-LiDAR Fusion by aligning connected LiDARs' views. Through Quanergy's user-friendly, software-based LiDAR discovery and management Q-View toolkit, multiple pairs of LiDARs are selected, aligned, and calibrated to each other. When calibration is complete, the resulting calibration file is output. QORTEX DTC ingests that file and aligns the overlapping vision of multiple LiDARs into an enriched fused single view of the same space. As a result of this distributed vision, the visualization may detect points from one LiDAR's point of view that are blocked from another LiDAR's view.

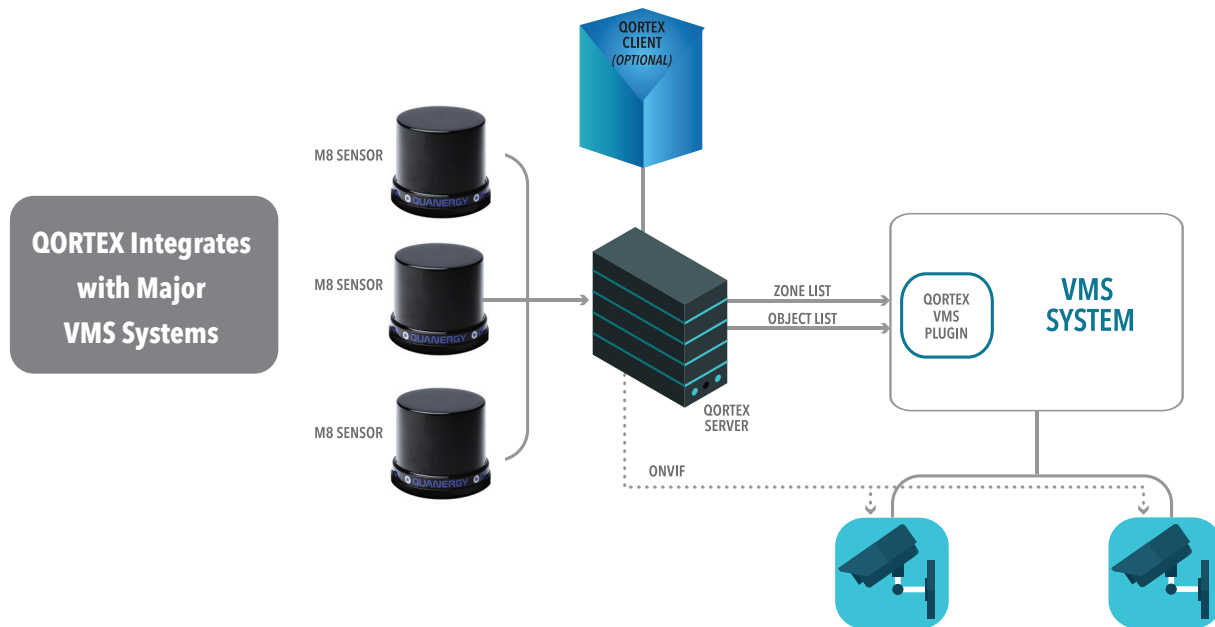
PTZ Camera Control

QORTEX DTC is able to control Pan-Tilt-Zoom (PTZ) cameras that are compliant with the global standards set by the Open Network Video Interface Forum (ONVIF), Profile S (for "streaming video"). Such compliance ensures the effective interoperability of security products operating under the Internet Protocol (IP). QORTEX DTC is a client of ONVIF services and supports Web Services Security (WSS) digest authentication. For example, QORTEX DTC has been tested with the AXIS Q6155-E PTZ Network Camera, HikVision DS-2DF8336IV-AEL IP Dome Camera, and FLIR Systems PT-Series (PT-625E) Thermal Camera. A LiDAR sensor cooperates with cameras by outputting information (including an object's XYZ coordinates, dimensions, direction, and velocity) that enables cameras to focus attention on an area of interest, track and zoom to specific objects observed in the general surveilled area or event zone, and lock to the track of a specific object until it is lost to view. Alternatively, the Genetec or Milestone VMS system can integrate and control the PTZ cameras.

Easy VMS and PSIM Integration through API

The QORTEX DTC server publishes object, zone event, and point cloud information as streams of data output from the server's processing action in a serialized format on the Ethernet network. The QORTEX DTC client consumes and visualizes these streams of published data, but third-party host infrastructure applications may subscribe to them for surveillance or visualization. The streamed object data includes XYZ coordinates, dimensions, direction, and velocity for all objects in the field of view.

Users who hold a premium license for the QORTEX DTC server may prefer to integrate a VMS solution seamlessly with the QORTEX DTC system. QORTEX DTC dramatically boosts surveillance effectiveness when integrated with major Video Management Systems (VMS) solutions. Quanergy offers VMS plug-ins to Milestone XProtect and Genetec Security Center to integrate with existing customer security platforms for security visualization, alarms, PTZ camera control and map overlays for situational awareness. (Camera compatibility requirements are determined by the particular VMS solution.)



QORTEX DTC demos, case studies and data sheets are available upon request from sales@quanergy.com.