Crowd Analysis Technologies

Market Survey Report

April 2024

Science and Technology

NUSTL®
NATIONAL URBAN SECURITY TECHNOLOGY LABORATORY

Approved for Public Release

SAVER-T-MSR-47

The Crowd Analysis Technologies Market Survey Report was prepared by the National Urban Security Technology Laboratory—in conjunction with the US Army Combat Capabilities Development Command (DEVCOM) Armament Center's Tactical Behavior Research Laboratory (TBRL)—for the U.S. Department of Homeland Security, Science and Technology Directorate under terms set forth under Financial Transaction (FT) FTLF-21-FT020.

FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate. Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of federal, state, local, tribal, and territorial responders to address the homeland security mission. The laboratory assists responders with the use of technology to prevent, protect against, mitigate, respond to, and recover from homeland security threats and incidents. NUSTL provides expertise on a wide range of subject areas, including chemical, biological, radiological, nuclear, and explosive detection, personal protective equipment, and tools for emergency response and recovery.

NUSTL manages the System Assessment and Validation for Emergency Responders (SAVER) program, which provides information on commercially available equipment to assist response organizations in equipment selection and procurement. SAVER knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: "What equipment is available?" and "How does it perform?" The SAVER program works with responders to conduct objective, practitioner-relevant, operationally-oriented assessments and validations of commercially available emergency response equipment. Having the right tools provides a safer work environment for responders and a safer community for those they serve.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, and coordinating with other organizations to leverage appropriate subject matter expertise. In conjunction with the U.S. Army Combat Capabilities Development Command (DEVCOM) Armament Center's Tactical Behavior Research Laboratory (TBRL), NUSTL conducted a market survey of commercially available crowd analysis technologies. This equipment falls under the AEL reference numbers 04AP-05-CDSS, titled Systems and Tools, ICS, 04AP-05-SVIS, titled Software, Operational Space Visualization, and 04AP-06-TRAF, titled Software, Traffic Modeling.

SAVER reports are available at www.dhs.gov/science-and-technology/saver-documents-library.

Visit the NUSTL website at www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory or contact the lab at NUSTL@hq.dhs.gov.

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

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EXECUTIVE SUMMARY

Emergency responder agencies are interested in crowd analysis technology to determine how to address emergencies and effectively manage large crowds during planned events and unplanned incidents to prevent delayed, inadequate, or misplaced responses across the first responder community. Without these technologies, responders use experience, communication, and knowledge of public spaces, city blocks, barricades, and other items to gain situational awareness of crowds and estimate crowd sizes and other crowd characteristics. Responders may be unable to count crowds more accurately because of distance, lighting and weather conditions, inherent bias [1], personal safety, and other factors.

Between July 2021 and August 2022, the System Assessment and Validation for Emergency Responders (SAVER) program conducted a market survey of commercially available crowd analysis technologies. As part of this research, the SAVER program interviewed first responder participants with experience in crowd management at large scale events. This market survey report is based on information gathered from these interviews with first responders, manufacturer and vendor websites, internet research, industry publications, and a government-issued request for information that was posted on the System of Award Management website. This research identified 15 products whose prices typically depend on deployment size.

The following are key product features of interest:

- Must analyze video data during (i.e., in real time) and after events
- Must monitor and determine counts, location, movement, and density of crowds
- Must work with existing hardware (e.g., CCTV) and software (e.g., video management systems)
- Must operate in all environments (i.e., indoor and outdoor)
- Should identify and track potential hazards, threats, and bad actors
- Should determine the motivation of the crowd
- Should have data processing and storage flexibility

This market survey provides emergency responders information they can use to guide emergency response agency operational and procurement decisions. Emergency responder agencies should consider the overall capabilities, technical specifications, and limitations of crowd analysis technologies in relation to their agency's operational needs when making technology selections. The SAVER program has not independently verified the performance of these products or the information included in this report.

Agencies should also consider the impacts associated with integrating equipment into their power and information technology infrastructure including data management, cybersecurity, concept of operations, and required maintenance.

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1.0 INTRODUCTION

Crowd Analysis devices and systems were identified as technologies of interest by the First Responder Resource Group (FRRG), an all-volunteer working group convened by DHS. First responder agencies, particularly in law enforcement, are interested in technologies that can help effectively manage large crowds during planned events and unplanned incidents to prevent delayed, inadequate, or misplaced responses across the first responder community. This interest is driven by elevated challenges or threats stemming from a lack of situational awareness during large-scale events.

Crowd analysis technologies use artificial intelligence (AI) and machine learning (ML) to determine crowd characteristics in real time using video, images, and other information. During our research, NUSTL interviewed several first responders who reported that they were not using crowd analysis technology. However, they expressed a desire for access to crowd analysis information, including crowd count, density, location, movement, and motivation, as well as assistance identifying potential hazards, threats, and bad actors. The first responders described their existing surveillance systems, which typically consist of an operations center with a station commander and team, video cameras, facial recognition software, and license plate readers to help identify vehicle owners.

Based on first responder interviews, a response during large-scale planned or unplanned events typically uses the following concept of operations (CONOPS):

1. First responders ("front line" and "boots on the ground" personnel) relay information to leadership (a station commander) at an operations center where a team is ready to assist them.
2. This team observes video camera feeds and relays relevant crowd information including their own visual observations of crowd characteristics, potential hazards, threats, and bad actors to their station commander.
3. This station commander determines how to respond to the situation, then disseminates this information to other leadership within the operations center or at other locations to establish a larger plan to address the situation.
4. Leadership then deploys this strategy to the relevant first responders in the field.

Crowd analysis technologies could improve this CONOPS in several ways. First, crowd analysis technologies can relay information in real time or near real time[1] to leadership before first responders can physically reach and assess an area of interest. This could potentially eliminate steps 1 and 2, resulting in significantly shorter response times and more accurate and appropriate responses.

Between July 2021 and August 2022, the System Assessment and Validation for Emergency Responders (SAVER) program conducted a market survey of commercially available crowd analysis technologies. As part of this research, the SAVER program interviewed first responder participants with experience in crowd management at large scale events. This market survey report is based on information gathered from these interviews with first responders, manufacturer and vendor websites, internet research, industry publications, and a government-issued request for information (RFI) that

[1] Near real time is "a designation that pertains to the timeliness of data or information that has been delayed by the time required for electronic communication and automatic data processing. This implies that there are no significant delays." See Oxford Reference. "Near real time," 2024.

was posted on the System of Award Management website. The U.S. Department of Homeland Security (DHS) Science and Technology Directorate's (S&T's) Technology Scouting Group also contributed to the market research used to develop this report.

For inclusion in this report, the crowd analysis technology had to meet most of the following criteria:

- Must analyze video data during (i.e., real time) and after events
- Must monitor and determine counts, location, movement, and density of crowds
- Must work with existing hardware (e.g., CCTV) and software (e.g., video management systems)
- Must operate in all environments (i.e., indoor and outdoor)
- Should identify and track potential hazards, threats, and bad actors[2]
- Should determine the motivation of the crowd[3]
- Should have data processing and storage flexibility

Crowd analysis technologies have been increasingly driven by AI and ML; research indicates that the market for crowd analysis tools has grown in recent years and that the market for software solutions is more robust than the market for integrated solutions. The overall increase in solutions, especially software solutions, has included an increase in indoor monitoring applications (e.g., retail locations) in addition to existing outdoor crowd management solutions. This report is representative of products in the marketplace but is not intended to give a comprehensive overview of the market. It provides information on several solutions that provide capabilities for this particular use case. Additional solutions may be available in the market, including custom software, that meet similar requirements.

The focus of this report is on technologies that do not rely on facial recognition to conduct crowd analysis. Agencies interested in the technologies in the report should verify with the vendors whether facial recognition capabilities can be disabled in the system if that is a point of concern.

[2] Hazards, threats, and activities of bad actors encompass a range of issues, including overcrowding, dangerous behavior, unauthorized access, the presence of suspicious objects, fire, smoke, and other related concerns.
[3] Determining the motivation of the crowd refers to the analysis of behavior and intent of individuals and groups in a crowd.

2.0 CROWD ANALYSIS TECHNOLOGY OVERVIEW

When dealing with large crowds, situational awareness is essential to an emergency response. Emergency response operations need information on crowd characteristics like size, density, location, and direction of movement. Emergency responders must identify potential and existing hazards in a crowd in a timely manner to mitigate any unsafe conditions or potential consequences, so first responder, and particularly law enforcement agencies, are interested in technologies that enhance real-time situational awareness and promptly alert both command and field personnel.

These sought-after technologies should help uncover potential threats and concealed aspects of crowds. They should also support analysis of past incidents to assist with effective planning for future events. The solutions described in this report are primarily analysis software tools that deliver crowd information in real time or near real time. These solutions are generally scalable and adaptable to various camera setups.

2.1 Current Technologies

First responders described their existing surveillance technologies as standard fixed and pan-tilt-zoom (PTZ) video systems with live feeds that can focus on certain areas of interest. Both static and PTZ cameras can be set up to automatically start recording, zoom in, and alert a person to monitor the recording if the system detects motion or a change in the scene. Personnel either monitor live feeds or begin watching when they receive an alert to monitor a feed more closely.

First responders also described exposure to other AI enabled technologies such as license plate readers that can help identify vehicle owners and facial recognition software, which is not a focus of this report. For planned events and unplanned incidents, first responders reported an absence of any crowd analysis technology that could help them with situational awareness.

2.2 Key Components

Figure 2-1 shows that the key components of crowd analysis technologies typically include data sources, analysis software, and a visual display. Video-based surveillance systems are usually mounted in an existing environment or on a vehicle, deployable mast, or drone. Analysis software often uses ML and AI to determine crowd analysis information. Several of the technologies provide a visual display on a computer screen or smart phone screen and work with existing systems.

Figure 2-1 Key Components of Typical Crowd Analysis System

2.2.1 Data Sources

Systems used to observe and monitor an area during large-scale events can employ various sensors that connect to a recording device or network to be watched by law enforcement or security personnel and analyzed by automated software. Data sources for this purpose can include fixed or deployable video cameras, aerial surveillance, wireless tracking, etc.

Video monitoring systems typically comprise standard and high-definition video cameras, including static cameras, PTZ cameras, existing CCTV cameras, deployable cameras, and body cameras. Some video systems use fisheye lenses on ceiling-mounted video cameras to allow for a wide angle (180˚) field of vision. Higher quality video and image sources increase the effectiveness of crowd analysis software.

Aerial monitoring captures images or video from airborne vehicles like drones, helicopters, or planes. It offers high-resolution images from long distances, potentially aided by radar and infrared devices that detect body heat [2].

Detecting wireless signals such as Wi-Fi and Bluetooth, and more specifically counting the individual number of wireless emitting devices, can serve as a reasonably proxy for estimating the number of individuals in an area. While simple Bluetooth detection only requires a typical smartphone to detect devices within the smartphone's Bluetooth range (about 16.5 feet away), detecting signals in a larger area requires placing several Bluetooth-enabled receivers within that area. These receivers can detect individuals and their movement within the area and send that information to a single device [3]. Legal considerations for this type of tracking include laws related to wireless tracking without an individual's consent that vary in different states.

Other data sources that could potentially be input into crowd analysis software include radar and LiDAR, which can be used to obtain information like the distance between individuals and objects in a crowd.

2.2.2 Analysis Software

Surveillance system information has typically been monitored manually by personnel, but such monitoring can now be performed automatically in real time and sources can be reviewed by analysis software after the fact. Analysis software often uses AI, usually based on ML, to summarize and organize surveillance content, make it searchable, mark objects of interest, and sort it by density, speed and direction to hasten the review process.

For real time analysis, some software can provide:

- Crowd information (e.g., size and density)
- Perimeter security alerts
- Highlight crowd congestion
- Detection of potential hazards within a crowd

The limitations of most analysis software stem from the quality and quantity of the data inputs. For example, the quality of the data from a video camera depends on the specifications and quality of the camera. Poor lighting conditions or sensor quality can limit the performance of most analysis software.

2.2.3 Visual Display/Output

Visual displays of surveillance systems aim to provide highly informative content to help emergency personnel make decisions. To avoid overwhelming them with excessive information, certain visual displays are customizable. They can condense, arrange, and categorize surveillance data while highlighting specific individuals or objects of interest on 2D or 3D maps or within a designated area. Depending on the system, the data analysis output can be viewed on various types of visual displays including a cell phone screen, tablet, or computer monitor using desktop software, an application, or a website and send alerts based on customizable pre-defined rules. Alert customization can help prevent alert fatigue, where operators become desensitized to alerts and, as a result, ignore or fail to respond to alerts appropriately [4].

First responders that were interviewed strongly desired visual displays to overlay on existing command and control displays so they would not have to look at another dedicated screen.

2.2.4 Additional Considerations

It is important for agencies to understand the infrastructure and capabilities of their existing systems when considering crowd analysis software. The location and method of data analysis may depend on the capabilities of the data capture devices, storage, and processing methods they currently deploy or plan to acquire. Newer devices may use edge analytics, which is the process of collecting, analyzing, and creating actionable insights directly from local devices with lower latency compared to a cloud computing. In non-edge analytics, data streams are sent to and processed on a centralized server (e.g., cloud servers) independent from the sensor. Crowd analysis solutions might also use "hybrid" analytics, a combination of edge and non-edge analytics with varying system architectures and associated costs.

Agencies should consider whether software can integrate with existing software systems, the limitations of the video or image quality and deployment size, display technologies (cell phone, tablet, computer screen), and the backend capabilities. Backend considerations may include storage capacity and scalability, graphics and central processing abilities, bandwidth, network connections (Wi-Fi, ethernet, internet), and the ability integrate with cloud-based web services or run locally. Agencies may employ a video management system (VMS) to integrate and manage data from various sources; the platforms typically allow for live video monitoring and recording. Agencies that already have a VMS in place should contact their providers to check the types of data with which their VMS is compatible and its compatibility with external analytics software.

2.3 Applications

Crowd analysis technology allows first responders to effectively manage large crowds during planned events and unplanned incidents. It can help bring emergencies under control and save lives by providing information related to the following:

- Resource allocation, especially when resources are scarce. Map overlays can display the current location, speed, and direction of one or more targets or issues to possibly address.
- Hazard alerts can keep areas secure from threats, suspicious objects, bad actors, or unauthorized access; detect overcrowding; and help responders evacuate an area quickly if safety concerns arise.

- **Pre-event planning** based on crowd size, density, location, type of gathering, and other characteristics can help determine the amount and type of personnel needed for planned and unplanned events and ensure adequate staffing for planned events.
- **Post-event analysis** can be helpful to develop after-action reviews and debriefs. Analysis of videos, screenshots, investigations, and real-time reports provided by crowd analysis technology can help provide factual information regarding operations, timing, and benchmarks for improvement over time.
- **Developing lessons learned**:
  - Determining what worked and did not work.
  - Planning a more consistent and efficient response using generated reports. This may involve scheduling emergency personnel and their activities and the required resources for those activities.
  - Learning new use-cases and improving data accuracy using active learning, situational awareness, and communication between emergency personnel.

2.4 Use of Grant Funds for Certain Telecommunications and Video Surveillance Equipment or Services

The John S. McCain National Defense Authorization Act for Fiscal Year 2019 (NDAA), Pub. L. 115-232, Section 889 (NDAA) prohibits the use of federal funds, including loan and grant[4] funds, to obtain or acquire certain telecommunications technologies manufactured by certain entities or to enter into contracts with entities that use those technologies. The Office of Management and Budget (OMB) published regulations at 2 C.F.R. § 200.216 to clarify the application of the NDAA to the use of federal grant funds to procure or obtain certain telecommunications equipment or services.

Effective August 13, 2020, federal grant recipients and subrecipients (i.e., **non-federal entities**) are prohibited from obligating or expending loan or grant funds to procure or obtain[5] the following "covered telecommunications equipment or services":

- Telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities)

For the purpose of public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by:

- Hytera Communications Corporation
- Hangzhou Hikvision Digital Technology Company
- Dahua Technology Company
- or any subsidiary or affiliate of such entities
- Other entities identified by the Secretary of Defense

[4] This also includes cooperative agreement funds.
[5] Nor may they extend or renew a contract to procure or obtain, or enter into a contract to procure or obtain the covered equipment or services.

The restriction also applies to systems that use the covered equipment or services as a substantial or essential component, and to subsidiaries or affiliates of those listed above[6]. See www.federalregister.gov/d/2020-17468/p-877.

Costs associated with covered equipment and services are "unallowable" for grant funding. Grant recipients are responsible for ensuring funds are used only for allowable costs, and would be obligated to refund the government for unallowable costs. The Federal Emergency Management Agency (FEMA) issued FEMA Policy #405-143-1, Prohibitions on Expending FEMA Award Funds for Covered Telecommunications Equipment or Services (Interim) for further guidance on the Section 889 prohibitions. Additionally, OMB issued frequently asked questions (FAQs) on the topic.

For **federal** entities, FEMA published interim rules amending the Federal Acquisition Regulation[7].

2.5 Standards/Certification Programs

Several standards that may be applicable to crowd analysis technologies are detailed in Table 2-1.

Table 2-1 Standards Applicable to Crowd Analysis Technology

Standard Organization & Number	Standard Title	Relevance to Crowd Analysis Technologies, Crowd Management, Event Security, or Incident Command
ANSI ES1.9-2020	American National Standards Institute (ANSI) Event Safety - Crowd Management	This standard identifies minimum requirements and provides questions and suggestions to help event organizers make reasonable decisions under the conditions of their event. [5] This standard distinguishes "crowd management" from "crowd control" and provides an overview of crowd management theory and terminology for use during foreseeable risks that arise during live events.
ISO 9000	International standard on quality management [6]	This certification assures product or service quality for crowd analysis technologies procured by a customer [7].

[6] As well as telecommunications or video surveillance services provided by entities or using equipment described above.
[7] www.federalregister.gov/documents/2019/12/13/2019-26579/federal-acquisition-regulation-prohibition-on-contracting-for-certain-telecommunications-and-video and www.federalregister.gov/documents/2019/08/13/2019-17201/federal-acquisition-regulation-prohibition-on-contracting-for-certain-telecommunications-and-video

Standard Organization & Number	Standard Title	Relevance to Crowd Analysis Technologies, Crowd Management, Event Security, or Incident Command
FAR 52.204-24	Federal Acquisition Regulation (FAR) on Representation Regarding Certain Telecommunications and Video Surveillance Services or Equipment [8]	This amendment to the FAR prohibits contractors and subcontractors of the federal government who provide services related to "public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes" from using select telecommunications and video surveillance equipment that has been manufactured by specified Chinese firms and their subsidiaries. Any contractor reporting that it will supply such equipment must provide additional detailed disclosures about the equipment [9].
IEEE 802	Institute of Electrical and Electronics Engineers (IEEE) standards for local, metropolitan, and other area networks [10]	This family of standards helps ensure that internet services and technologies follow a set of recommended practices so that network devices can work together smoothly [11].
ONVIF Profile S	Open Network Video Interface Forum (ONVIF) Profile S for Basic Video Streaming	The Profile S Standard is designed for IP-based video systems. A Profile S device (e.g., an IP network camera or video encoder) is one that can send video data over an IP network to a Profile S client. A Profile S client (e.g., a video management software) is one that can configure, request, and control video streaming over an IP network from a Profile S device. Profile S also covers ONVIF specifications for PTZ control, audio in, multicasting and relay outputs for conformant devices and clients that support such features.
STANAG 4609	North Atlantic Treaty Organization (NATO) digital motion imagery standard [12]	This standard encourages interoperability of present and future motion imagery systems in a NATO Combined/Joint Service Environment. Interoperability is required because it will significantly enhance the warfighting capability of the forces and increase flexibility and efficiency to meet mission objectives through sharing of assets and common usage of information generated from motion imagery [12].

3.0 PRODUCT INFORMATION

This section provides information on 15 crowd analysis technologies. Most systems require custom quotes specific to the scope, so most cost information is not provided here. These products are listed alphabetically by manufacturer in Table 3-1, which provides general product characteristics and specifications. Product information presented in this report was obtained directly from manufacturers, vendors, and their websites from July 2021 to August 2022.

The information has not been independently verified by the SAVER Program.

This report is representative of products in the marketplace but is not intended to give a comprehensive overview of the market. It provides information on several solutions that provide capabilities for this particular use case. Additional solutions may be available in the market, including custom software, that meet similar requirements.

Information in the Product Comparison Matrix in Table 3-1 includes key performance parameters and key system attributes, defined as follows and listed in column order.

- Requirements refers to key performance parameters (KPPs) specified for inclusion:
    - It must analyze video data during (i.e., real-time) and after events
    - It must monitor and determine the counts, location, movement, and density of crowds
    - It must work with existing hardware (e.g., CCTV) and software (e.g., video management systems) systems
    - It must operate in all environments (i.e., indoor and outdoor)
- System Capabilities refers to key system attributes (KSAs) that are desirable for end users:
    - It should identify and/or track potential hazards, threats, and/or bad actors
    - It should determine the motivation of the crowd
    - It should have data processing and storage flexibility

The technologies in this section use AI-based software to provide crowd analysis information. They can interface with existing data sources and software systems. This feature was identified as important to first responders who were interviewed because their organizations need to consider budget limitations and thus favor using existing infrastructures.

Table 3-1 Product Comparison Matrix of Key Performance Parameters and Key System Attributes

Manufacturer and Product	Analyzes video data during (real time) and after events	Determines count, location, movement, and density of crowds	Works with existing hardware systems	Works with existing software systems	Identifies and/or tracks potential hazards, threats, or bad actors	Determines motivation of the crowd	Data processing and storage flexibility
ACES Group Dynamic Crowd Measurement	✓	✓	✓	✓	–	✓	✓
Actuate Actuate AI	✓	✓	✓	*	✓	–	–
AFRY Flowity	✓	✓	✓	✓	✓	–	*
AT&T IoT Video Analytics System	✓	✓	✓	✓	✓	–	✓
BriefCam Video Analytics Video Analytics Platforms	✓	✓	✓	✓	–	–	✓
CrowdVision CrowdVision Analytics Software	✓	✓	✓	✓	✓	*	✓
Deep Solutions Deep Crowd	✓	✓	✓	*	–	–	✓
iOmniscient Inc. iOmniscient Video Analytics	✓	✓	✓	✓	✓	*	*
Lauretta AI LLC B-Sight Depth Perception	✓	✓	✓	✓	✓	*	*
Oxagile Video Analytics Solutions	✓	✓	✓	✓	✓	–	✓
Rank One Computing Corporation ROC Watch	✓	✓	✓	*	✓	–	–

Manufacturer and Product	Analyzes video data during (real time) and after events	Determines count, location, movement, and density of crowds	Works with existing hardware systems	Works with existing software systems	Identifies and/or tracks potential hazards, threats, or bad actors	Determines motivation of the crowd	Data processing and storage flexibility
Scannera Smart Real-Time Video Analytics	✓	✓	✓	*	✓	—	✓
Senstar Senstar Video Analytics	✓	✓	✓	*	—	—	—
Viisights Wise	✓	✓	✓	✓	—	✓	✓
Zensors Inc. Zensors AI	✓	✓	✓	✓	—	*	✓

✓ system is equipped with corresponding feature

— system is not equipped with corresponding feature

* information unknown/not available

3.1 ACES Group Dynamic Crowd Measurement (DCM)

The ACES Group's Dynamic Crowd Measurement (DCM) is an AI-based software solution that provides autonomous real-time data and intelligence for informed decision-making with crowds. Their software analyzes the data, then provides visual results including heatmaps to end users in real time and for post event analysis.

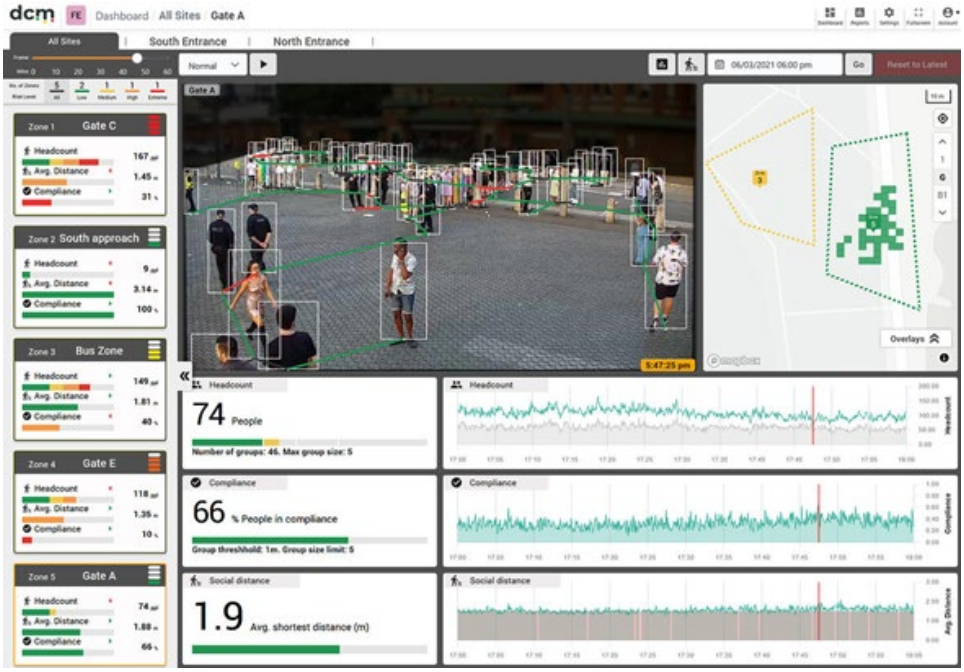

Figure 3-1 ACES DCM

Image Credit: ACES Group

The software can determine crowd count, density, location and movement and the distance between individuals. It also can determine the mood of a crowd by analyzing facial expressions and counting smiles to measure and categorize mood as positive, negative, or neutral and plot this on a map for different locations. The software can also deliver hazard alerts based on the above characteristics. In the event of enforcement requirements, such as social distancing during the pandemic, the software can determine the level of compliance to rules and government regulations. In addition to real time analysis, the software also has a feature to play back data to provide retrospective analysis like changes in crowd mood, density, and speed. Another feature of the software is a visual validator that enables a comparison of data against a live image or heatmap to increase situational awareness at a given location. The DCM dashboard can be accessed via a web browser on a phone, tablet, or computer with login credentials.

This solution works with existing PTZ cameras that are compliant with the ONVIF Profile S Standard and CCTV systems and can be deployed via cloud, on-premises, or hybrid solutions. It is hosted by Amazon via Amazon Web Services and clients can specify where their data is stored.

3.2 Actuate AI Video Analytics

Actuate's AI Video Analytics (Actuate AI) is a software-based solution that integrates with existing indoor and outdoor security cameras. The software uses computer vision and AI to detect guns, intruders, crowds, abandoned objects, and vehicles. Actuate AI can help manage crowds with self-reported low false positive threat detection, historical heat maps of where crowds usually occur, and post-event analysis.

Figure 3-2 AI Video Analytics

Image Credit: Actuate

In real time, Actuate AI detects and provides crowd count, density, location, and speed. The analysis is conducted with anonymized data to protect the identity of individuals. The software also provides heat maps of the number of individuals within a given location down to the square foot. To reduce false positives, the software monitors user defined spaces for intruders based on the detection of objects and actions and produces alerts for unauthorized entries and bad actors. The software also has an abandoned object detection feature that monitors public areas to detect objects that have been left behind for a given period and possibly in different light environments. This could reduce the possibility of human error and improve response time for abandoned object threats.

The software requires either on-premises processing or cloud processing through Amazon Web Services (AWS) and Microsoft Azure with minimal bandwidth usage to reduce IT burden. This solution does not require any on-site hardware. Actuate AI is compliant with CCTV, IP video cameras, and most VMSs. A complete compatibility list of VMS, camera, and security automation platform integrations can be found on the company's website.

3.3 AFRY Flowity Crowd Management

Flowity is a crowd management platform that uses data-driven AI to analyze large, open areas to provide object detection and tracking as well as real time and predictive crowd analytics. Flowity also allows users to review previously collected data to make future predictions.

Flowity provides crowd count, density, location, and movement. The software enables the detection of people anonymously and complies with the General Data Protection Regulation, a European Union regulation that protects data and the privacy of individuals. The software can detect objects, including bicycles and vehicles, in indoor and outdoor environments at varying distances and track and analyze objects in real time. According to AFRY, the system can provide insight into an individual's walking trajectories and behaviors. The vendor states that continuous tracking over long periods without full camera coverage is possible and that the system can detect partially obscured or assembled objects, which could help with weapons detection.

Figure 3-3 Flowity Crowd Management System

Image Credit: AFRY

This product works with existing video cameras on non-proprietary drones and sensors that can be placed anywhere where people or traffic need to be monitored. Users can access the data through existing systems with a graphical user interface or connect to their software application. Flowity also offers a flexible web user interface that can work on most mobile devices. This solution can process data on the edge or in the cloud.

3.4 AT&T IoT Video Intelligence System

AT&T's Internet of Things (IoT) Video Intelligence System uses network-connected sensors to collect relevant information on operations and crowd activity. The software applies computer vision to near real-time or existing video camera footage to generate actionable data and alerts through their configurable mobile and desktop dashboards. Alerts could be sent through email and text as well. This product also provides post-event analysis.

Figure 3-4 IoT Video Intelligence System

Image Source: AT&T

This solution provides customizable near-real time alerts and analysis of crowd characteristics like crowd count, density, location, and movement. It can also count and identify objects, including abandoned objects.

Other solution capabilities include perimeter and intrusion detection, license plate recognition, and thermal analytics. The object detection capability includes counting objects and identifying anomalies, such as objects in restricted areas or near structural supports. The solution includes a privacy protector that pixelates human bodies or vehicles in video footage to remove identifiable attributes for privacy reasons.

The software works with edge, cloud, and hybrid data; new or existing Internet-enabled cameras; and most major VMSs. It is modular so that it can integrate with existing command and control systems.

3.5 BriefCam Video Analytics Platforms

The BriefCam Video Analytics Platform supports situational awareness by providing real time alerts and data insights. Analysis includes object detection and classification, behavior analysis, and face and license plate recognition. The software uses AI, ML, and deep learning to detect and extract objects in video, then identify and classify each object. Video analysis capabilities include search and filtering, alerting, data aggregation, and visualization. For post-event analysis, the software can review hours of video within minutes.

Figure 3-5 BriefCam Video Analytics Platform

Image Credit: BriefCam

BriefCam can provide software-based analytics for crowd attributes like crowd count, density location, and movement. The software enables the configuration of count-based rules for monitoring occupancy in a pre-defined range of view or area. The software will trigger real-time, rule-based alerts for analysis such as people counting, line crossing, and object counting. The vendor states that alerts can be integrated with a VMS, physical security information management (PSIM) alerting module, or other messaging systems and that the solution's architecture can be adjusted to meet the desired use case.

BriefCam is a scalable solution that works with existing VMS, and its open API enables integration between third party applications and alerting infrastructures. A full list of BriefCam's supported VMS integrations is available on their website. BriefCam supports standalone or multisite, all-in-one or distributed large scale, on-premises or cloud, and edge or hybrid deployments.

3.6 CrowdVision Analytics Software

CrowdVision Analytics software provides automated crowd analytics and insights in real time. The software uses ML and AI algorithms to provide real time analysis of video, LiDAR, Wi-Fi and Bluetooth detection, and infrared sensors. The software can generate pre-formatted or customized historical reports for post-event analysis.

The software can track crowd count, location, movement, and density. The company reports that it can identify and track potential hazards, threats, and bad actors.

Figure 3-6 CrowdVision Analytics

Image Credit: CrowdVision

CrowdVision works with existing COTS cameras but is best configured using fisheye cameras mounted on the ceiling or on pillars to provide 360-degree coverage of the areas and accountability for the individuals in the area. This result is based on median, best-, and worst-case performance. The product's real time dashboards and alerts provide actionable insights to improve situational awareness. CrowdVision states that the software can interface with existing VMSs.

The solution's infrastructure can be a private cloud or an on-premises customizable data center. To reduce storage requirements, video is not retained once it has been analyzed. The solution is designed to be easily scalable. To measure additional analytics in an area with sensor coverage, only software configuration changes are required. The product's security protocols conform with US government best-practices, and its settings can be customized to meet a range of scenarios across global regions.

3.7 Deep Solutions, Deep Crowd

Deep Solutions' crowd analysis software platform, Deep Crowd, provides real-time crowd analytics and post-event analysis. This platform is capable of reporting crowd density in large open spaces and can detect abnormalities and contact authorities immediately.

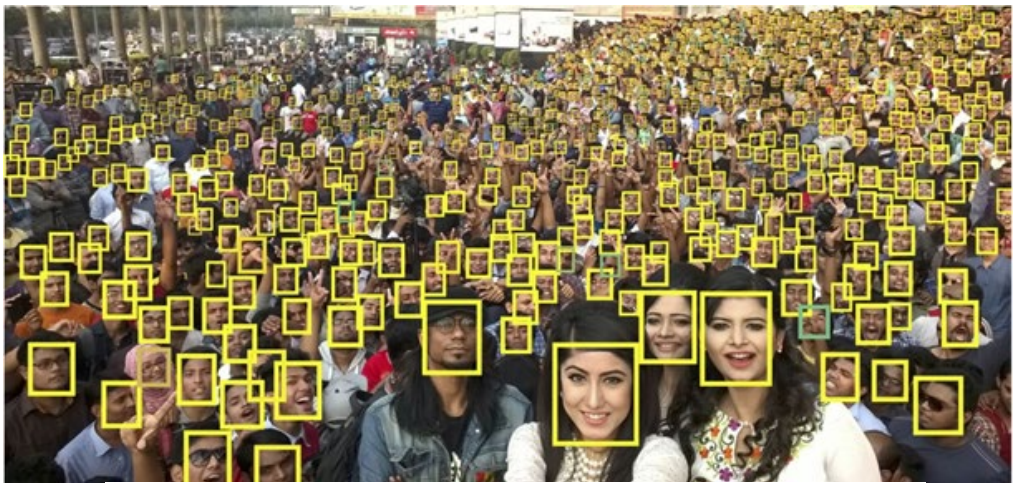

Figure 3-7 Deep Crowd, Crowd Analysis Platform

Image Credit: Deep Solutions

The software detects and tracks crowd count, density location, and movement and identifies faces and clothing patterns, and traces paths and threshold crossings. Their customizable control panel can show all system cameras in one view.

Indicators and alerts can be configured to include people count, identification, behavior classification (including fights, burglars, and drowning people), and action prediction. The software performs action prediction by pose estimation and classification. The pose estimation feature classifies activities (e.g., people lying on the ground) by tracking the specific 3-dimensional (3D) pose of someone and comparing it with previous postures or movements.

The cameras integrated into the software can operate autonomously without a constant internet connection. The vendor states that in the case of anomaly activities (e.g., accident, injury, assault, or burglary), the system can automatically detect abnormal behavior and generate an alarm.

3.8 iOmniscient Video Analytics

iOmniscient offers an AI platform to conduct video analytics that is capable of object counting and crowd management. Their software-based system can analyze crowds in varying environments with real time information. In addition to real-time analysis, the system can be used in "forensic mode" to verify results and for post-event analysis. The software can detect and track objects and people indoors and outdoors during the day and night and allows for customizable settings and alerts. This solution has a counting algorithm that is used to determine traffic flow and to count individuals entering and leaving a given area to determine when an occupancy limit has been reached.

Figure 3-8 Object Counting & Crowd Management

Image Credit: iOmniscient

iOmniscient's solution for crowd analysis provides the number of individuals overall or in a defined area, the location of individuals, the movement of individuals or masses, and crowd density. The solution can detect abandoned objects in a crowd and can alert when a crowd suddenly forms or disperses. The software can also perform crowd behavior analysis including theft detection, slip and fall detection, fighting, loitering, and running.

The video analytics performed by iOmniscient can leverage existing cameras and network infrastructure (distributed/edge, centralized or hybrid). The solution can be provided as an independent system or integrate with an existing VMS.

iOmniscient's software licenses require an annual subscription that includes new updates, training, and maintenance support. Their support centers provide 24/7 support in various languages, including English. iOmniscient's software products are available through GSA and overall cost is dependent on license volume.

3.9 Lauretta AI, B-Sight Depth Perception

Lauretta AI's B-Sight Depth Perception is a cloud-hosted AI package that provides a means to translate human positions to a top-down map view. Lauretta AI can use existing CCTV cameras to automatically detect and notify security personnel of ongoing threats. It uses processed behavioral data for predictions and post-event analysis.

The solution provides near real-time crowd count, density location, and movement, including the velocity and flow of individuals. The system uses monocular depth perception to identify individuals relative to the camera and places trackers on them while in view of a given camera position to identify absolute position. It also automatically detects threats like presence in banned spaces and vehicle collisions. The system has three add-on modules for bag abandonment, weapon detection, and high energy activity.

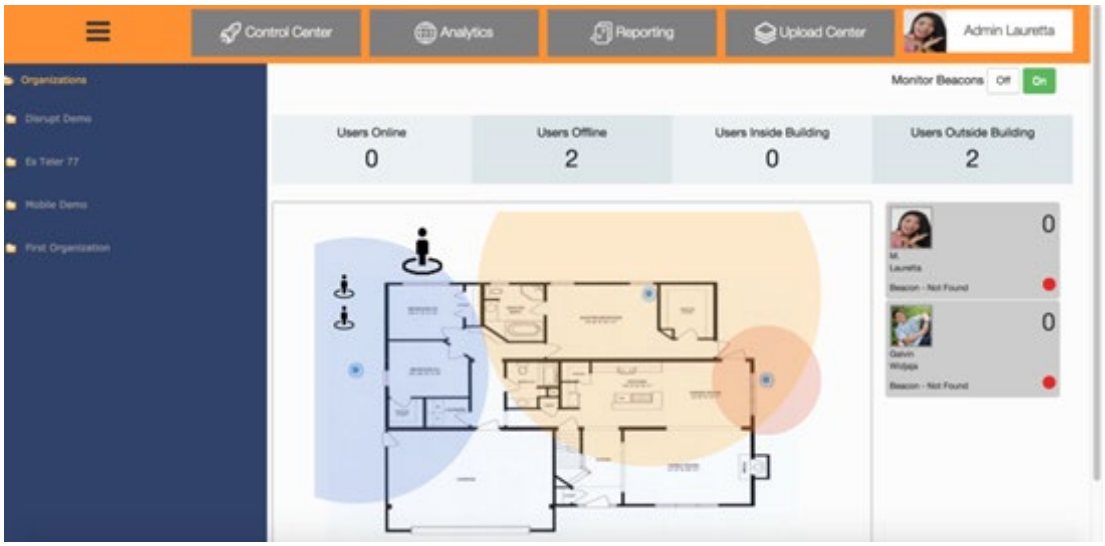

Figure 3-9 Lauretta AI's Software Package

Image Credit: Lauretta AI

Lauretta AI is a scalable system and is offered as a software package or standalone server that can be connected directly to six cameras. Lauretta AI details a five-step integration process into a client's existing infrastructure. This first includes a site visit to determine site layout and camera placement, then integration by connecting to a client's existing CCTV system. Installation occurs where areas of interest are defined within the CCTV coverage, then behavioral analytics are installed and tested. Live deployment involves providing support and insights using their dashboard, API, Telegram alerts, and prediction systems. The software servers require protection from rain and cannot operate in temperatures greater than 100°F.

Lauretta AI provides onboarding and regular training and offers 24-hour remote tech support. The system can be purchased by subscription or as a one-off contract.

3.10 Oxagile Video Analytics Solutions

Oxagile offers custom computer vision video analytics solutions. The video analysis system provides real-time crowd analysis to detect, classify, and report anomalies, objects, and threats. The system also is also capable of behavior analysis and action detection. It also provides video annotation and post event analysis.

This software tracks crowd metrics like crowd count, density, location, and movement. The People Tracking system can detect and track one or more individuals that are standing or moving. The software also has a system that can perform facial recognition. Oxagile offers systems that perform pattern recognition, vehicle detection and identification, and license plate recognition.

Figure 3-10 Oxagile Abnormal Behavior Detection

Image Credit: Oxagile

Oxagile reports that its software can identify violent behavior of individuals like pushing, hitting, kicking, and gun violence. The system can classify objects and can compensate for moving camera footage, occlusions, poor lighting, and adverse weather conditions. This system optimizes image analysis accuracy with system performance.

Oxagile solutions support on-premises, in the cloud, and edge deployments devised for desktop, tablet, and mobile devices. The system uses Google Cloud AI, Amazon Machine Learning, and Azure Machine Learning services. The system is scalable and can integrate with existing video cameras and user interfaces.

3.11 Rank One Computing, ROC Watch

Rank One Computing's (ROC) Watch is a browser-based software solution that provides real-time and post-event crowd analysis, facial recognition, and object detection capabilities for existing camera infrastructures. It can manage multiple video feeds, control PTZ cameras, provide robust search and archiving, and perform object and face detection.

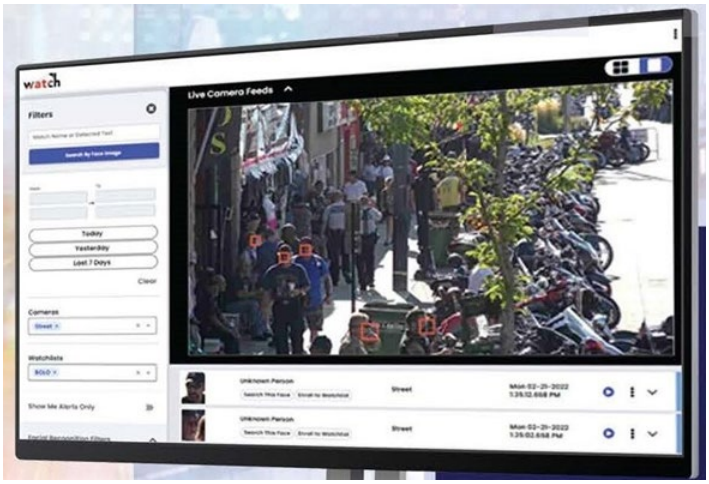

Figure 3-11 ROC Watch

Image Credit: Rank One Computing

For crowd analysis, it can detect crowd count, density, location, and movement. The object detection feature detects weapons, vehicles, text (i.e., license plate numbers), and other objects of interest and detects people within a camera frame and possibly across multiple cameras. The software can provide alerts within their desktop or mobile application, SMS, or WhatsApp. The software can determine identity, age, and gender, but users must comply with all state and local privacy laws. Their face recognition algorithms are routinely evaluated by NIST for accuracy. Face detection can be turned off by the user via licensing or application settings. If it is disabled, ROC Watch can still provide other alerts.

Data connectivity is required for server-side analysis. Storage requirements depend on the video quality and the number of cameras. Data capacity policies can be customized to address user requirements. The company states that ROC Watch integrates with existing VMSs.

Perpetual and annual licensing support models are available.

3.12 Scannera Smart Real-Time Video Analytics

Scannera's Smart Real-Time Video Analytics provides live monitoring, object detection and recognition, classification, intrusion detection, theft and accident detection, and face detection. It also offers crowd metrics including a count of people and objects and provides statistics within an entire scene or a specific zone.

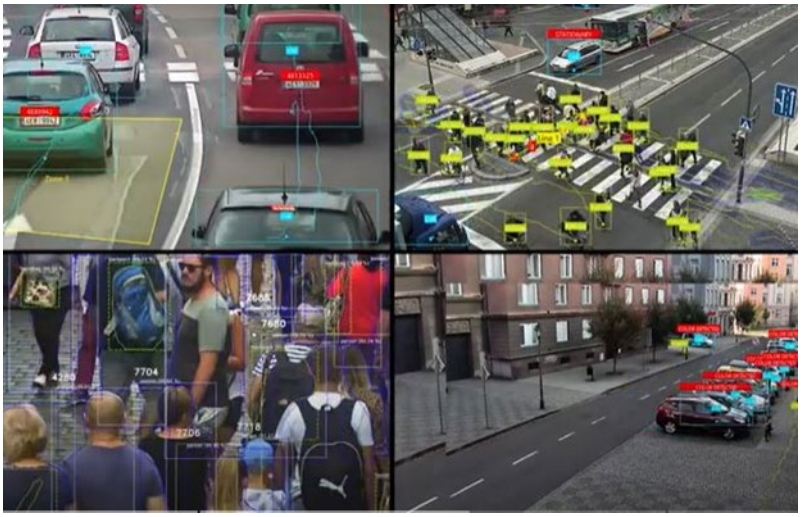

Figure 3-12 Smart Real-Time Video Analytics

Image Credit: Scannera

Scannera conducts behavior analysis by detecting behavior patterns such as loitering, sudden direction changes, and aggressive behavior. In addition to face detection, Scannera can perform biometric analyses of voice, gait, pose estimation, and weapon detection and description.

Post-event analysis allows for advanced searches and video processing. Scannera can analyze hours of video in just a couple minutes. The analytic features of this use case include object detection and classification, resistance to weather conditions, behavioral analysis, and more. The traffic analysis option provides video analysis and data management on traffic and vehicle-related logistics or violations.

For crowd metrics, this solution can detect crowd count, density, location, and movement. Scannera can use real-time video analysis to automatically alert users of abnormal or suspicious behavior. The configurable user interface allows users to set notification rules for each camera. In the event of an alert, users can be notified via text message, email, or mobile push notifications. Alert events can also be used to sound on-site alarms or notify third party security personnel.

This scalable system can be purchased as standalone software or a bundle of software and hardware. Scannera can be a component of a cloud or on-premises solution and connect to IP cameras, CCTV systems, and other existing infrastructures. The vendor states that additional capabilities are coming soon, including extended behavior analysis and biometrics, software development kit (SDK) integration, and synoptic and forensic analysis for extended monitoring times.

3.13 Senstar Video Analytics

Senstar developed a video analytics solution that uses existing video surveillance infrastructure to provide real time situational awareness and post event video analytics. The solution offers eight modules, including crowd detection, indoor people tracking, and outdoor people and vehicle tracking.

Figure 3-13 Senstar Video Analytics

Senstar Video Analytics

The Crowd Detection module estimates crowd count, density, and location in real time and enables occupancy-based alarms. The vendor states that the solution is intended for use in public areas such as subways, entertainment facilities, convention centers and shopping malls. When used with the Indoor People Tracking and Outdoor People and Vehicle Tracking modules, the solution can track crowd movement indoors and outdoors. However, the software is only able to analyze behavior indoors.

The manufacturer reports that their product can integrate seamlessly with existing VMSs, including verified integration with Milestone VMS. Their video analytics software solution is scalable and can be run locally, centrally on a video server, or in a hybrid model with edge equipment.

Other crowd management related modules and capabilities offered by the vendor include automatic license plate recognition, object detection, unattended object detection (for use indoors only), and facial recognition. The facial recognition feature can be enabled by an administrator, and a dynamic privacy mask can be turned on to scramble faces and provide anonymity to people in the image.

3.14 Viisights Wise

Viisights Wise is an AI-based software solution that provides real-time video analytics and post event analysis. The solution analyzes large amounts of video content captured by widespread existing video surveillance cameras for large-scale crowd management. The system is camera agnostic and processes video streams in real-time or offline to provide insights and real-time alerting for various actions, events, and scenes of interest.

Figure 3-14 Viisights Wise

Image Credit: Viisights

The Wise software features behavioral recognition capabilities for violent activity, suspicious activity, person and crowd behavior, perimeter protection and control, traffic monitoring, and environmental and personal safety. The software identifies actions such as fighting, rioting, vandalism, loitering, running, abandoning an object, or getting out of a vehicle. The person and crowd behavior solution classifies crowds by size, determines crowd density, identifies crowds moving/gathering/dispersing, runs occupancy analytics, and measures person-to-person proximity. It also monitors crowd metrics like behavior, perimeter control, traffic accidents, hazards, and safety issues.

This software can provide configurable alarms with API or Viisights' alarm console and can send hazard alerts as an email containing a web link to the camera capturing the hazard. In a command center, the camera view will automatically display the video to determine if a response is required. Wise offers a scalable solution that can be deployed on-premises or in a private cloud. The Wise software can integrate with various VMSs, including Milestone, Genetec, Qognify, Cognyte, and Immix. The software requires a yearly subscription and software licenses are offered with one-, three-, and five-year support packages. The price is dependent on the number of video channels and features.

3.15 Zensors AI

Zensors AI is a real time cloud-based AI software solution that provides video analytics using existing camera systems, including IP cameras, CCTV, and mobile device cameras. The system is designed to learn new use cases and continue to improve the accuracy of the data using active learning.

The software provides the location and count of crowds, crowd density, and the location and count of objects. It can also detect overcrowding based on predefined custom threshold values and can produce alerts in real time. Zensors does not perform any facial recognition and keeps data anonymous by design. Facial blurring can be enabled to prevent the capture of PII.

Figure 3-15 Zensors AI

Image Credit: Zensors

This software solution can be rapidly deployed by registering new or existing cameras. The live camera feeds are piped into the Zensors AI edge or cloud platforms, which report the state of an environment. The solution can send reports via text message, email, or to a TV or monitor or they can be viewed within the software and web platform. Users can access the situational awareness information from the Zensors AI dashboard, visualization, and reporting tools or data can be programmatically shown for use in other applications with their API. Zensors provides data security with end-to-end encryption and granular access control logs.

4.0 COMPANY CONTACT INFORMATION

Additional information on the crowd analysis technologies included in this market survey report can be obtained from the companies listed in Table 4-1.

Table 4-1 Company Contact Information

Company	Website	Address	Phone Number	Contact Information
ACES Group	www.acesgroup.com	225 Church St. NW Huntsville, AL	660-441-1691	www.acesgroup.com/contact
Actuate	www.actuate.ai	1216 Broadway, 3rd Floor New York, NY 10001	646-389-4872	info@actuate.ai
AFRY	afry.com	295 Madison Avenue Suite 300 New York, NY 10017	46 10 505 00 00	info@afry.com
AT&T	www.business.att.com/products/att-iot-video-intelligence.html		855-614-6566	information request form
BriefCam	www.briefcam.com	275 Grove St. Suite 2-400 Newton, MA 02466	860-269-4400	info-us@BriefCam.com
CrowdVision	www.crowdvision.com	3090 Bristol St. Costa Mesa, CA 91626	714-685-9776	info@crowdvision.com
Deep Solutions	deepsolutions.io	Barcelona, Spain	34 659 418 105	bcn@deepsolutions.io
Lauretta	lauretta.io	80A Oxford St, Arlington, MA 02474	65 9793 9937	hello@lauretta.io

Company	Website	Address	Phone Number	Contact Information
iOmniscient	www.iomni.ai	854 Mariners Pt Drive St Louis, MO 63141	646-583-3222	iomni.ai/contact-us
Oxagile	www.oxagile.com/competence/computer-vision/video-analysis-solutions/	165 Broadway, 23rd Floor New York, NY 10006	855-466-9244	usa@oxagile.com
Rank One Computing	roc.ai	1290 Broadway Denver, CO 80203	303-317-6118	hi@roc.ai
Scannera	scannera.ai	Brezinova 1608/42, 616 00 Brno–Zabovresky, Czech Republic	+420 515 917 917	info@scanlock.cz
Senstar	senstar.com/products/video-analytics	119 John Cavanaugh Dr. Ottawa, ON, Canada K0A 1L0	800-390-5796	senstar.com/contact/contact-sales
Viisights	www.viisights.com/products/wise	1740 Broadway 15th floor New York, NY 10019		infousa@viisights.com
Zensors	www.zensors.com	1355 Market St. #488 San Francisco, CA		www.zensors.com/company/contact-zensors-ai-team

5.0 CONCLUSIONS

Emergency responders need crowd analysis technology to effectively manage emergencies and ensure safe gatherings during planned events like celebrations, parades, or concerts and unplanned incidents like civil unrest, disasters, or other emergencies. This technology can prevent delayed, inadequate, or misplaced responses across the first responder community.

This market survey report provides information on 15 software-based crowd analysis technologies that use computer vision and AI to perform data and video analysis, including two that have reported the ability to determine crowd motivation.

Most of the crowd analysis technologies included in this report claim to provide real-time information on the counts, location, movement, and density of crowds; visuals, visual control, and alerts during major events; and adaptive learning and analysis to plan more effectively for future threats. While several technologies reported the ability to identify and track potential hazards, threats and bad actors, only two reported the ability to determine the motivation of the crowd. These technologies can provide accurate information on operational events, timing, and benchmarks to assist with post-event analysis and improvements.

All the products in this report work with existing surveillance systems, with live feeds, and in most environments and all provide data processing and storage flexibility. The products in this report range in price, with many crowd analysis vendors allowing for custom packages to accommodate the agency's needs. Emergency responders should carefully research the overall capabilities and limitations of crowd analysis technologies in relation to their agency's operational needs when making procurement or acquisition decisions.

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