



Enhancing a City's Ability to Plan, Protect and Manage with Intelligent Video Analytics



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...these images of two individuals walking on Boylston Street, that was the turning point of the investigation. When they put these photos out, many people came forward with the information about these two individuals...they helped the FBI, the Boston Police, the State Police, all of whom were working together to come to a conclusion in this case and really find out who these individuals were..

—Thomas Menino, Mayor of Boston

URBANIZATION CHALLENGES TO PUBLIC SAFETY AND TRANSPORTATION

At some time around mid-May 2007, our world became urbanized,² with more people living in cities than in rural areas. With rising population levels and shifting demographics, public safety agencies are increasingly challenged to meet their mandates of protecting lives, property and infrastructure. At the same time, the accelerating pace of globalization and the rising impact of technological developments are increasing the economic and commercial impacts from increased risks to public safety. In many jurisdictions these challenges are compounded by budgetary constraints. Pressure on law enforcement agencies to use public resources more efficiently is being felt in large cities such as London³ and Toronto⁴, which can overextend police resources and decrease an agency's ability to detect and deter crime⁵.

Rapid urbanization can cause a city's transportation system to become overwhelmed, resulting in traffic congestion.⁶ This congestion dampens prosperity by slowing citizens' movement and wasting their time and resources, and by obstructing municipal services such as public safety and maintenance.

In response to these challenges, city managers, law enforcement agencies and traffic operators are taking advantage of advances in video capture and analysis to improve situational awareness for public safety officers and enhance transit officials' ability to manage transportation infrastructure more efficiently. Video cameras aren't ubiquitous, but there are a lot of them, particularly in cities. A 2011 systematic audit in the United Kingdom, for instance, put the number of cameras—both publicly funded and privately owned—at more

than 1.85 million.⁷ Elsewhere, the innovative use of body-worn video cameras by police officers⁸ is driving up the number of devices capable of capturing video.

Although video cameras themselves (e.g., Closed Circuit Television Systems—CCTV—and privately owned systems) are associated with moderate levels of crime deterrence,⁹ the real promise of video systems is the amount and richness of data gathered. Video data can be a valuable aid to help solve crimes and to provide real-time tactical information for other public safety and urban protection purposes. Urban traffic planners and transportation system operators can use information from video cameras to alleviate congestion and improve traffic flow by identifying and responding to incidents. Moreover, these same video cameras can help public safety agencies identify vehicles posing roadway threats or wanted by law enforcement. In a smart city, one camera can have many uses.

However, to be truly useful, cities have to move from merely capturing video footage to organizing, analyzing, and sharing the insight from data within and across municipal agencies. This can make public safety and urban protection "smarter" and enable enhanced coordination for police and response teams to protect the public. The statement by Boston Mayor Thomas Menino noted above highlights the utility of applying analytic tools to video data, and then sharing the intelligence and insight that result from it. But, it is a challenge for agencies to staff enough operators to watch, review and analyze all the data that cameras can capture. How, then, does a city go from simple video capture to valuable insights and actions based on visual data? What would an effective security solution look like, and what could it provide?

Highlights of this paper

- Cities are using intelligent video solutions to help them face the challenges of increasing urbanization.
- These solutions can extend the capabilities of a city's existing video assets, and enhance the effectiveness of safety and traffic management personnel.
- The IBM Intelligent Video Analytics solution is one way cities can enhance their situational awareness and bring more contextual insight and evidence to their management capabilities.
- Intelligent video, coupled with a robust command and control platform, can improve a city's ability to deliver higher levels of service in public safety, event management, and traffic supervision applications.

ENHANCING SAFETY AND TRANSPORTATION MANAGEMENT WITH INTELLIGENT VIDEO

An effective security solution that uses video could add intelligence through computer systems that can recognize and analyze events that humans may miss. Adding this capability, plus collaboration technology, to traditional policing and urban protection skills can deliver more targeted intelligence and improved situational awareness. Moreover, such a solution could not only help personnel to identify threats in real time, but also detect patterns that can help predict crimes.

Using intelligent video to improve public safety is part of the smart public safety concept.¹⁰ A fundamental premise of the concept is that applying data management, analysis, and communication processes to multiple types of data can result in deeper insight into all manner of things impacting public safety. This insight can be used to speed response time and to support officials' decision-making. Video, because of the richness of information that it contains, is an important component of enhancing situational awareness in a public safety environment.

Intelligent video can also enhance transportation management by providing system managers with city-wide visibility across an entire transportation network to improve incident response. It can also help personnel evaluate traffic patterns, dynamically manage public transit, help alleviate congestion and ultimately improve commuter satisfaction. When integrated with a centralized command and control platform, intelligent video becomes a key element in an intelligent urban transportation system.¹¹ Video cameras are non-intrusive and can also enhance or substitute for other traffic monitoring technologies, such as road sensors or radar systems. Video can improve traffic flow and support event management in event route planning, traffic and transit management, and traffic prediction to understand the impact of an event on a city's traffic environment, as well as to help event managers plan event scheduling to minimize traffic system disruption.

Municipal agencies can draw upon intelligent video to augment their ability to identify patterns in video data, draw meaning from it, and take actions based on the resulting insight. The intelligent video solution would consist of four key steps to turn video data into insight, which is illustrated in Figure 1 on page 5.

Figure 1: Turning Video into Insight and Action

CAPTURE	INGEST, ANALYZE & MANAGE	CONSIDER & DECIDE	ACT
SENSORS	ANALYTIC AND DATA MANAGEMENT ENGINES	COMMAND AND CONTROL CENTER	RESPONDERS AND ACTUATORS
<ul style="list-style-type: none"> Capture digital video from cameras, sensors, etc. 	<ul style="list-style-type: none"> Apply analysis to streaming data Tag and catalog data, and create a searchable database Store the data in a high-availability repository Apply analytic tools for forensic analysis 	<ul style="list-style-type: none"> Examine analysis results to glean insight Collaborate with others on interpreting intelligence Consider scenarios Decide on possible actions 	<ul style="list-style-type: none"> Communicate action plans with field personnel and responders Enable actuators and response systems Share insight with investigative personnel

Source: IBM and Frost & Sullivan analysis

As Figure 1 depicts, intelligent video begins by capturing digital video from a variety of optical sources. These could include sensors, fixed or pan-tilt-zoom (PTZ) cameras, mobile cameras or even body-worn cameras, which could be integrated with other sensors such as glass breakage or gunshot detectors. Recording and retaining video data from a multitude of sources creates a vast source of important information that can boost the return on a city's video assets. Cities cannot afford to employ personnel to monitor all these video sources, but capturing the data enables cities to apply powerful analytic and management engines to the data and draw meaning from it.

Once captured, information management systems process the video data. At this point, analytic tools can be applied as the data streams into the system to perform real-time analysis on the video feeds. The data can be tagged and cataloged in a searchable database, available for forensic or predictive analysis by multiple agencies. Because the stored video data from any one camera is organized and accessible, it can be useful to many departments. This is a key value proposition of an intelligent video solution.

City managers and executives can retrieve the video analysis results through operational dashboards in a centralized command and control center and glean insight from them. In real-time contexts, the insight

can become superior situational awareness. In forensic contexts, the insight into why or how or how long an event happened helps to understand root causes. In a predictive context, the insight can help officials project what might happen in the future and plan for it. Armed with insight into the past, present, and future, city officials can use the richness of video to make better, insight-driven decisions.

Intelligent video becomes more valuable when the insight derived is combined with tools like operational dashboards that help manage resources and organizations to facilitate decisions and action among various stakeholders. This can involve field personnel who take action and respond or managers who activate mechanisms in the field (e.g., traffic lights). In other situations, personnel can be consulted or directed to perform additional forensic investigation of the video data.

Applying information management techniques and analytic tools to digital video can help improve the effectiveness of public safety and transportation management. Intelligent video solutions can also increase the efficiency of existing resources, benefitting agencies under pressure to deliver services while their budgets are contracting. The promise of intelligent video is compelling and has the potential to vastly improve the way cities maintain situational awareness and achieve higher levels of operational effectiveness.

SMARTER SAFETY AND SECURITY MANAGEMENT

The IBM Intelligent Video Analytics solution is one way city managers and planners can add intelligent video to enhance their situational awareness and bring more contextual insight and evidence to their management capabilities. The solution is used to amplify the value of a video surveillance network, transforming it into a real-time detection and response tool, as well as supporting advanced investigation techniques. Forensic video investigation can be as broad or narrow as required to rapidly identify the person, object or vehicle of interest, and predictive analysis can produce heat maps and histograms. The solution is designed to work with existing security systems to take video data and apply analytics that can output real-time alerts, as well as specialized search and review analysis for investigations. The application can also capture real-time events from video feeds, and applies analytics for behavior analysis, license plate identification via an integrated license plate recognition solution, facial analysis and recognition via an integrated facial recognition solution and access control. The system creates metadata for all objects in camera views, enabling forensic search capabilities for all scene activity. The forensic search could be done using either default settings or user-defined queries with multiple, detailed attributes (hair color, clothing combinations, object speed, etc.).

Four Steps to Benefit from Intelligent Video Analytics

1. Capture Video Data for a more effective solution
2. Ingest, Analyze, and Manage to identify, predict and prevent
3. Consider and Decide to optimize efficiency
4. Act on contextual insight and evidence

A key point of the IBM Intelligent Video Analytics solution is that it is intended to integrate with existing video surveillance networks and work with products from

multiple vendors. This enables a city's video capabilities to be much broader, to encompass user and system management capabilities, metadata indexing and search services, and extensibility services to incorporate new data sources and add communications and collaboration capabilities. Cities can expand the utility of and gain new benefits from their existing video systems by using Intelligent Video Analytics.

Capture Video Data for a More Effective System

The process of integrating an Intelligent Video Analytics solution can begin by connecting it to a third-party video management system that takes the video data from cameras or network video recorder. In a traditional digital video surveillance configuration, human operators are tasked with monitoring feeds from multiple video cameras and reacting to events that they notice. However, human operators can be highly ineffective at capturing and processing video data during extended periods, a phenomenon known as "inattentional blindness,"¹² and there are high labor costs associated with staffing to monitor CCTV feeds, and retrieve, manage, and store video content. By automating video data capture, and integrating it with a data management and analytics application, cities can greatly increase the efficacy and efficiency of their video assets.

Ingest, Analyze and Manage to Identify, Predict and Prevent

The core of the Intelligent Video Analytics solution revolves around the application of analytic and information management tools to the video data. Once the live video data is captured from a video management system or network video recorder, the Intelligent Video Analytics solution generates metadata and can evaluate the feed for user-defined alerts. Additionally, Intelligent Video Analytics can process the video data in real time to extract events (activities in the camera's field of view) and classify the events or objects in them in multiple ways, including generating metadata on them. Analytics can then be applied to the classification data and metadata, such as type, size, speed, duration in view, etc., and assesses if the event falls within a predefined condition of interest (e.g., a person in a prohibited location, an object is left behind or removed, a crowd is forming, or a post-event face match with a suspect's database is made). If so, then the Intelligent Video Analytics solution can trigger an alert that is sent to a system user.

In addition to ingesting and analyzing the video data, the Intelligent Video Analytics solution can consolidate and store all the data and metadata. The solution will create and manage an index of all the attributes of the ingested video data, which enables users to perform forensic and predictive analysis to define complex events and behaviors. When it is integrated into a city's existing video system, an Intelligent Video Analytics solution can enable users to identify specific events or patterns of events, predict the likelihood of future events, and set the stage for decision-makers to take preventative actions if warranted.

Consider and Decide to Optimize Efficiency

The core capture and analysis capabilities of IBM's Intelligent Video Analytics solution are substantial, but intelligent response is as important as event identification. The solution gains power when it is integrated into a centralized command and control platform, such as IBM's Intelligent Operations Center. The Intelligent Operations Center is a platform that aggregates, correlates, and visualizes data from multiple sources, including video data. It also enables integrated data visualization, real-time collaboration, and deep analytics capabilities that can be used in complex environments, including many urban settings, to help officials consider situations and decide on actions to prevent problems before they occur or mitigate the impacts of them when they do happen. Intelligent Operations Center can also help coordinate activities through standard operating procedures (SOPs) and key performance indicators (KPIs) to help manage situations and boost the efficiency of resources deployed to address them. The platform also gives a city the ability to share information across departments and domains to accelerate consideration, decision and response, and improve interagency coordination. The platform has executive dashboard capabilities that can give managers visibility into the resources available to address situations, as well as facilitate coordination of response teams to send the right resources to the right place at the right time.

Integrating Intelligent Video Analytics with Intelligent Operations Center command and control platform can add deeper, contextual insight to city managers' and planners' holistic view of their city. City executives can focus multiple agencies, their personnel and assets on a specific incident that is triggered by a video-generated

alert. When the powerful video analytics capabilities are married to the visualization and collaboration capabilities of Intelligent Operations Center, executives can coordinate efforts around a common body of video evidence and insight, and share a single, integrated view of a situation. The integration of Intelligent Video Analytics and Intelligent Operations Center gives a city the power to greatly improve its ability to manage traffic and public events, and can boost its capabilities to protect the public.

Act on Contextual Insight and Evidence

At the end of the intelligent video solution chain, alerts and response directions can be transmitted to field personnel. The contextual insight generated from Intelligent Video Analytics and distributed through Intelligent Operations Center can give valuable, real-time information about incidents in progress to first responders or police, increasing their effectiveness in the field. Investigative personnel can access archived rich sources of video evidence and apply other analytics to conduct deeper, more-informed investigations of crime scenes and incident sites. The integrated solution can also help city officials develop contingency plans that can be selected and enacted based on the significance of alerts or specific criteria. By communicating and collaborating over the insight delivered by the system, users can gain a holistic perspective of events in a city.

The key capabilities and points of the IBM Intelligent Video Analytics solution are:

- **Behavior analytics:** The data management and analysis capabilities of the solution enable a range of behaviors to be classified (size, speed, trajectory, duration, etc.) and identified, such as tripwires and directional motion, regions of interest and uninterest, objects removed or abandoned, face capture and facial search, crowd behavior and counting, loitering and speed detection.
- **Scalability:** The solution is able to accommodate thousands of cameras and sensor devices, as well as being able to interoperate with a wide variety of vendor's cameras, video management software, and network video recorder equipment. This gives the solution a very wide scope of operation.

- **Detail:** By being highly scalable, and by being able to accommodate very large volumes of data in various formats, streaming in a high velocity, the solution can deliver a wealth of raw data that can be analyzed, and from those analyses valuable results can emerge.
- **Metadata tagging:** By giving users high degrees of flexibility to define cataloging variables and options, the solution's metadata capability enables a large number and variety of analytics to be applied to activities.

The integration of the Intelligent Video Analytics with Intelligent Operations Center creates a combination that can greatly enhance a city's situational awareness and traffic and event management capabilities. In combination, the solutions can add additional features and capabilities, including a full event index, compound alerting, crowded scene analysis, attribute search, and color recognition.

USING INTELLIGENT VIDEO ANALYTICS FOR PUBLIC SAFETY, EVENT AND TRAFFIC MANAGEMENT

The concrete benefits of using the solution include increasing the efficiency and effectiveness of a city's video monitoring systems and the personnel who are assigned to monitor them. The solution can also help improve the ability of first responders and field investigators to manage and understand incidents. Because it can interoperate with existing systems and equipment, the solution can save cities money that would have otherwise been needed for new equipment. These benefits can be illustrated in the conceptual use cases below. These cases are written to inspire thinking about potential applications for intelligent video analytics.

Public Safety

Intelligent video can be highly useful to city police forces to not only monitor specific areas in real time, but also as a forensic tool to link suspects to crimes committed during public disturbances such as riots. Intelligent video analytics could be used, for instance, as a real-time crime detection and response tool. Working with existing

video security systems, an intelligent video analytics solution could take video data from an intersection and conduct behavior analysis, facial analysis and recognition or access control to the data streams. The solution could then output real-time alerts if a crowd begins to form and crimes are committed. After the crowd is dispersed, officers can conduct specialized search and review analyses as part of their investigations to identify suspects and accumulate video evidence linking them to the crime.

Other applications for an intelligent video analytics solution could involve public infrastructure, such as pipelines, treatment plants, buildings, or railways. Maintenance on this infrastructure is often expensive, and governments spend valuable time and money repairing and recovering assets if they are subject to vandalism or theft. An intelligent video analytics solution could be used to capture and analyze video data in real time from specific sites on the infrastructure and send alerts when it identifies suspicious activity. Such an application would provide a city a deeper level of surveillance and protection with fewer personnel assigned to monitor live feeds.

Event Management

In anticipation of events in a city, an intelligent video analytics solution could be used to help organizers assess the condition of streets along a planned event route for a parade, for instance. When it is used in conjunction with an intelligent traffic management system, the contextual video images of certain streets could help transit managers get large numbers of attendees to and from an event, such as a sports contest, by directing traffic to use secondary routes to prevent congestion on main streets. The predictive capabilities of an intelligent transportation solution could also use the video data captured by an intelligent video analytics solution to traffic prediction to understand the impact of the event on other transportation routes, which could suggest times that an event would run to minimize adverse impacts on traffic in the city.

During the event itself, an intelligent video analytics solution could function to ensure safety at a venue by monitoring crowds, as well as increasing effectiveness of security measures in controlled access zones.

Congestion at entrance or exit points at a venue could be identified and personnel dispatched to maintain order, or the intelligent video analytics solution could help event staff predict when and where congestion could occur and enable them to minimize it.

Traffic Management

In other applications, such as daily traffic management, intelligent video can be an important element of an intelligent traffic system to help manage chronic congestion. Combined with a command and control system, video from cameras deployed across a city's transportation network can generate a consolidated view of existing traffic conditions. System managers can attend to alerts from the system to identify traffic volume, accidents or construction situations, and they can direct other operators to adjust the timing on traffic lights, dispatch incident response teams, or reroute traffic to ease congestion.

Beyond daily traffic management, however, an intelligent video analytics solution combined with a command and control platform could play a critical role in helping emergency officials route traffic in response to unexpected events, which could close roadways and critical arteries. Using a solution that combines rich video information with a robust command and control platform, a city could harmonize emergency management and incident response teams during an evacuation, for instance. In addition, the solution would enable the managers to coordinate city services and operations more broadly across various city agencies during such emergency events.

OPTIMIZING VIDEO TO DELIVER VALUABLE INSIGHTS AND GUIDE ACTION

Video surveillance can be useful as a reactionary tool to detect crime events, but without analysis of video data, the technology by itself has limits to ensuring public safety, managing events, and controlling traffic and easing congestion. Adding the data management and analytic engines to networks of surveillance cameras can be the crucial difference that improves the effectiveness and efficiency of a city's installed video infrastructure.

By capturing video data, and adding analytics and data management to it, a city can evaluate the data and alerts generated by the system and gain deeper contextual insight not possible with traditional video surveillance systems. When this insight is shared through a robust platform, different people and departments can collaborate and take informed actions, and provide higher levels of service to citizens.

The capabilities of IBM's Intelligent Video Analytics solution complement and optimize an existing video infrastructure to provide defense against and a proactive understanding of security vulnerabilities. The IBM Intelligent Video Analytics solution is designed to deliver advanced environmental and behavioral analysis of deeply detailed event records, which enable highly accurate depictions of events. Users can develop complex metadata sets ready for a wide variety of predictive and forensic analysis models. City CIOs can elect to integrate Intelligent Video Analytics with the Intelligent Operations Center platform and greatly enhance a city's holistic situational awareness.

Implementing a video analytics solution, such as IBM's Intelligent Video Analytics, can boost a city's capabilities to identify, predict, and prevent events. With these stronger capabilities, cities are better able to deliver higher levels of service to their citizens.

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