White Paper

Impact of Perfect Information on Effective Incident Management Decision Making

Ronald Dubois, Ph.D.
Director/Secretary/Treasurer
rdubois@nettalon.com
Tel: 540-368-5290 Ext 113
NetTalon Security Systems
Fredericksburg, VA 22408

James T. Byrne, Jr.
Chief Technology Officer
jbyrne@nettalon.com
Tel: 540-368-5290 Ext 120
NetTalon Security Systems
Fredericksburg, VA 22408

Introduction

This paper addresses the impact of "perfect" information on effective incident management decision making by fire department personnel who work as on-scene incident commanders. Unfortunately, "perfect" information does not exist in a dynamically changing emergency situation. The best one can hope for is a continuously updated flow of real-time information displayed in an easily understandable format. If such an information system existed, the incident commander would be evaluating the situation in a condition that could be described as "near-perfect".

The ultimate goal of an emergency information system is to provide incident commanders access to the critical changes occurring in real-time at a fire emergency. This information includes the exact location of the fire, the temperature of the fire, the spread of smoke and carbon dioxide within the facility, the location of trapped victims and the current status of the facility not currently involved with the fire. Ideally, this "real-time" information is updated within three (3) seconds rather than two (2) minutes of a change and simultaneously available to the on-scene incident commander and to all other key personnel in the chain of command.

Look at this futuristic portrayal of a fire in progress. Three men would have probably died when a fire quickly erupted where a flammable substance engulfed the room. They are cornered with no way out. The local fire department receives the alarm within seconds, localized the source of the fire and knows immediately where the victims are trapped. Using his laptop, the incident commander located on-site quickly develops an efficient plan to isolate and extinguish the fire and evacuate the victims. In addition, his supervisor within the chain of command has simultaneous access to the same real-time information describing the dynamically changing incident.

In such a scenario, the incident commander develops a plan to isolate and extinguish the fire and evacuate the victims **prior to arriving on the scene**. Any decisions made and the results of those decisions are immediately available through the chain of command by monitoring the course of the incident in "real-time" using the emergency information system. In this way, critical information about the incident is simultaneously provided to the chain of command. Monitoring such "real-time" information allows for decisions to be made as the complex scene dynamically changes. This case is an example of providing incident commanders with "near-perfect" information that drastically improves their decision making and improves the odds of saving the lives of both incident victims and responding fire personnel. Finally, consider the opportunities for improving training if all incidents were recorded and can be replayed to evaluate current and improve fire fighting procedures.

The purpose of this paper is to review the processes associated with effective decision making in complex, dynamic, time-pressured emergency situations and analyze the impact of adding "near-perfect" information to the on-scene and off-scene commander's arsenal of decision tools. In addition, the authors will discuss the impact of such technology on the future training of fire personnel which incorporated the use of emergency management information systems in the training curriculum. Such changes will fundamentally change the way incident managers do their jobs now and in the future.

Today's Technology

While significant advances in communication and fire suppression technologies over the past decades have fundamentally changed the nature of firefighting operations, the human component, namely local command activity has remained a "human" endeavor. Today, on-scene commanders work as leaders of a team of trained individuals, using specialized equipment, whose efforts are coordinated via command, control, and communication processes to achieve specified objectives under conditions of threat, uncertainty, and limited resources. The command and control function exercised on-scene is crucial to successful management of emergency situations.

Several studies have focused on those decision processes associated with more versus less effective incident management. Effective incident management requires technical knowledge, knowledge of standard operating procedures and the ability to process information under conditions of high-stress and limited time. Table 1 details the Behavioral Markers of Effective Incident Command as stated by McLennan, Pavlou & Omodei in 2003.

Table 1 - Behavioral Markers of Effective Incident Command

Anticipation and Planning	• Used 'dead time' to study plans and diagrams • Prepared for 'worst case' scenario early, took precautions, called for additional resources • Warned crews of likely developments and tasks
Communication	• Used site maps and diagrams to explain intention to subordinates • Clear, controlled speech to subordinates • Maintained eye contact when speaking/listening to subordinates face-to-face • Radio: paused after subordinate acknowledged call before giving orders/asking questions
Leadership & Assertiveness	• Spoke clearly, firmly, decisively (radio, face-to-face) • Greeted key 'players" (facility managers) warmly but decisively
Management of Workload	• Use white board to record incoming information and to write 'reminder notes' • Incoming radio traffic: asked sender to "wait" until current task is completed • Requested new arrivals at the control center to wait outside until ready to speak with them • Gave 'closed' rather than 'open' orders so not required to remember short-term crew assignments
Re-evaluation of Situation	• On first indication of deterioration of the situation raised the alarm 'level' so as to call-out more resources
Use of Available Information	• Used multiple sources: subordinates, local 'experts', site plans, diagrams

Let's examine the potential impact of a "near-perfect" emergency information system available to an incident commander responding to a serious fire emergency. Such a decision support system would satisfy five out of the six behavioral markers listed by McLennan, Pavlou & Omodei:

- anticipation and planning,
- communication,
- workload management,
- re-evaluation of the situation,
- use of all available information resources.

Emergency Information System

Let's define the nature of the emergency information system. It is important to emphasize the distinction between the emergency information system and a classical "*alarm*" system; the classic alarm system simply alerts upon detection. In contrast, the emergency information system continuously reports the changing site conditions. The emergency information system provides the first responders and incident commander the real-time information they need to efficiently manage the scene.

The incident commander needs to have as much information as possible to gain a situational awareness of the changing events at the scene. However simply having more information is not necessarily better; the information must be presented in a format that creates focus rather than confusion. Using visual tools to organize the information into a relevant format (floor plans, alarming icons) is an ideal method of reducing the complexity of the information and would relieve the incident commander of the task of envisioning the site conditions.

Icons would represent the current state of individual sensors which change dynamically as individual sensors change state during the emergency. Individual sensor icons depend on the type of sensor being displayed (i.e. security, fire, temperature, pressure etc.) and upon its current state. The changing icons provide the ability for the incident commander to observe simultaneous alarm events, being able to differentiate isolated alarm events from those collaborated by multiple co-located alarming sensors (smoke, temperature, CO) or to discern if there are multiple intruders within a facility (motion detectors).

The icons not only identify where the alarms are, but should also identify those recently in alarm (non-fire). As a non-acknowledged sensor returns to a normal condition, the recently-in-alarm icon would maintain the visual integrity of the recent non-acknowledged alarm state while also demonstrating its current condition. This provides the incident commander a visual "footprint" of where recent alarm activity has taken place.

Finally, the system specification should require all sensor changes are displayed on **all** monitoring screens within seconds of occurring.

Anticipation and Planning

In such a system, the incident commander has the floor plan of the facility and the relative location of all sensors. Sensor status changes are displayed in real-time providing the incident commander with knowledge of the status of each sensor. For example, the incident commander can monitor the extent of smoke disbursement within the facility, the exact temperature at each temperature sensor, the exact concentration of carbon monoxide at each CO sensor and how these values change relative to the location of the fire within the facility.

This information provides the incident commander with the current status of the fire and allows remote viewers the opportunity to plan alternative methods for addressing the fire in case a worst case scenario should develop unexpectedly.

Communication and Re-evaluation

Having this information available not only to on-scene incident commanders but to the entire chain of command can significantly improve communications between the incident commander, his subordinates and with the chain of command. Once the incident commander makes a decision he can communicate that decision to his subordinates with clear, concise instructions. This is likely because the stress on the decision maker is lower when a decision is made with the benefit of "near-perfect" information.

Furthermore, the entire chain of command has access to the current status of the facility. Whenever the emergency situation warrants a change, the incident commander and his chain of command can discuss the change to the plan prior to its implementation. This use of multiple information sources minimizes the chance that the incident commander will make incorrect decisions since he has based it on the best available information.

In this way, the entire emergency decision process improves because all decision makers access the same information and can evaluate how well recent decisions have impacted the status of the emergency.

Good Incident Commanders

In general, good incident commanders know what to look for and they know what to do when they find it. Rasmussen in 1983 stated that this ability does not come from a simple years on the job but rather the ability of the incident commander to reflect at length on the effectiveness of their past performance and develop a mastery of their craft in the form of extensive rule-based decision making ability. These learned rules allowed the incident commanders to utilize a recognitional decision processes rather than slow, vulnerable analytical problem-solving processes. McLennan in 2003 noted that networks of learned rules enabling the use of recognitional decision processes form the basis of what Adams and Erickson in 2000 characterized as procedural expertise.

Unfortunately, many emergency situations are sufficiently complex to preclude the use of simple recognitional decision processes. These situations are characterized by one or more of the following: **novelty –** the officer never encountered such a situation before, **opacity –** needed information was not available, **resource inadequacy –** the resources currently available were not sufficient to permit an optimal response.

In such situations, “good” incident commanders are able to transcend their limited range of specific past experiences and use fast, robust analogical decision processes to apply previous learning to novel situations. In other situations characterized by high levels of uncertainty incident commanders were forced to use analytical knowledge-based problem solving processes in order to choose an option from among a set of alternatives.

Under such circumstances good commanders used a small number of simple and robust heuristics to guide rapid decision making about what actions to take. Adams & Erickson concluded that analogical decision processes and simple heuristics may well form the basis for adaptive expertise.

In each instance the incident commander is forced to depend upon his experience base and his ability to develop procedural processes from those experiences to successfully manage each “novel” incident. How much better would it be if incident commanders were given sufficient “real-time” information about the fire to allow them to be trained on developing procedural expertise based on the analysis of actual case studies derived from a database of actual fires where detailed archived information about the incident was available for review, replay and analysis? Such a database would include a time stamp for each alarm event as well as the type and state/value of each sensor during the incident. These data are replayed on a graphical screen detailing the layout of the facility to replicate real-time emergency situations.

Incident commander training could be expanded to support the development of procedural expertise based on the deliberate analysis of all available information. Over time the archival database would become the basis of developing an "expert system" available on-line to all incident commanders and their chain of command. A simple search of this database would result in a series of "what-if" scenarios that could be used in support of novel incidents thus satisfying the anticipation and planning criteria stated by McLennan et. al. as representative for effective incident command. The incorporation of this technology in the incident commander training curricula brings each trainee a procedural expertise that is analogous to the simulation systems now used by both government and private training academies.

Finally, this information could be incorporated in a DVD based training curriculum designed to provide incident commanders with an on-hands, cost-effective training tool for the development of procedural expertise. In effect, this training tool could be developed for use at both training academies as well as local fire departments. In this way, the benefits of "near-perfect" information would be available to all fire commands for use in developing and maintaining firefighter's incident management decision making capabilities.

Tomorrows Technology Today

Over the past five years, a "near-perfect" emergency information system has been developed and patented by NetTalon Security Systems located in Northern Virginia. The NetTalon System 3000 has been installed at several facilities in West Virginia and at beta test sites in Virginia. A recent installation at the Louisiana State University Fire & Emergency Training Institute in Baton Rouge, LA demonstrated its efficacy in action to the fire community.

The System 3000 reports alarm conditions to all authorized monitoring stations within three (3) seconds of a sensor or smoke detector going into alarm. Sensor and detector conditions depicting the nature of the evolving emergency are reported virtually immediately on a graphic representation of the building's floor plan. Icons that represent the various sensors (heat sensors, duress buttons and smoke detectors) are overlaid on the floor plan and change color to indicate alarm conditions. The icons representing the heat sensors display the changing temperature in real-time. The smoke detectors inform the first responders the amount of restricted visibility and potential breathing difficulty; the duress buttons display the locations of personnel trapped by the fire emergency and the temperature sensors report the source of measured heat leading the responders to the source of the fire.

The outstanding advantage of the new system is its ability to network the local fire department with the building being protected. Firefighters can examine details of a fire and begin to form their strategies before they ever leave the firehouse. The speed of the system and the ability to visualize the fire-involvement situation should greatly increase speed of deployment and efficacy of response.

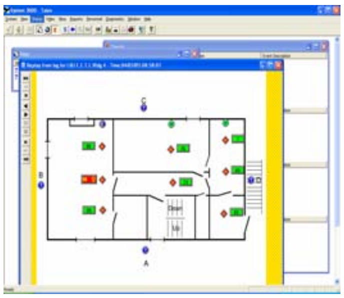
A national study recently concluded that the average arrival time for a fire company is in excess of six (6) minutes following validation of alarm. The System 3000 utilizes this time by providing the responding units with information about the incident. Firefighters arrive at the scene already understanding where the fire is, where it's spreading to, where the victims are, and with a deployment plan already formed and understood. Hence the fire departments can now envision a day when they respond to emergency situation with "near-perfect" information about the incident they are responding too.

Testing: the LSU story

In a preliminary real-time test series at Louisiana State University's Fire & Emergency Training Institute in Baton Rouge, LA, a preliminary test series of six fires was started and monitored.

The fire department from St. George, a suburb of Baton Rouge, responded to the test fires in the conventional manner, while LSU fire institute personnel and senior commanders from the St. George company monitored the fire scene remotely using the System 3000.

From the time each fire was started, LSU control personnel allowed two (2) minutes to pass to simulate the time it takes



to process an alarm signal. Meanwhile, System 3000 monitoring stations were viewing smoke activity at multiple points in the building within a few seconds of the fire starting. Within the next 30 seconds, monitoring personnel could view actual fire activity and the location of a dummy victim. All information was received a full 90 seconds before the staged fire company received the dispatch.

After dispatch it was another 4-1/2 minutes before the real-time firefighters located the test fire and victim dummies. Control personnel watching via System 3000 knew the fire's intensity, location, involvement in the building, spread of smoke, victim location and victim danger long before the fire responders even arrived. This speed of notification and remote real-time intelligence clearly demonstrated to the LSU staff and participating fire department the important advantage System 3000 can give in fire control, victim rescue, personnel safety, and speed and efficiency of the firefighting operation.

On the operations side of the equation, the System 3000 can make important fire data available to the commander and the responding crews before they even leave the fire station, theoretically allowing the commander to develop his strategy and tactics, make key, critical decisions, and be farther ahead when he arrives at the fire scene.

Conclusion

The ideal of fighting fires with perfect information is a vision that many fire professional view as not attainable since the essence of fire is chaos. Chaotic situations are difficult to quantify and define by their nature. However, the possibility of fighting fire with "near perfect" information changes everything. Fortunately, the vision of such an emergency information system is close to reality today.

We are now approaching the time where the fire industry has the opportunity to redefine the way it serves the public and emergency services by providing state-of-the-art technology designed to not only alert the first responders of an emergency but provide first responders with sufficient "real-time" information about the emergency to allow for the efficient planning and response to the emergency prior to arriving on-scene.

Add to this, the ability to develop an archived database of actual fire emergencies and we enter a time when the training paradigm shifts to embrace the technology of emergency information systems.

References

McLennan, J., Omodei, M. M., Holgate, A., and Wearing, A.J. paper entitled "Human Information Processing aspects of Effective Emergency Incident Management Decision Making" presented at the Human Factors Decision Making in Complex Systems Conference, Dunblane, Scotland, September 2003.

Holgate, A. (2003). *Decision making processes in effective fireground command and control.* Melbourne, CFA.

McLennan, J., Pavlou, O., & Omodei M.M. (2003). Cognitive control processes distinguish between better versus poorer decision making by fireground commanders. In H. Montgomery, R. Lipshitz, & B. Brehmer (Eds.). *How professionals make decisions.* Erlbaum.

McLennan, J., Omodei, M. M., and Wearing, A.J. (2001). Cognitive control processes of first-on-scene fire officers in command at emergency incidents as an analogue of small-unit command in peace support operations.

Adams, R.J. & Ericsson, A.E., (2000). Introduction to the cognitive processes of expert pilots. *Journal of Human Performance in Extreme Environments*, 5(1), 44-62.

Rasmussen, J. (1983). Skills, rules, and knowledge: Signal, signs, and symbols, and other distinctions in human performance. IEEE Transactions on Systems, Man, & Cybernetics, 15, 234-243.