

Air, Fire and ICE: Fire & Security Challenges Unique to Airports

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Image of Singapore Changi Airport courtesy of the Civil Aviation Authority of Singapore.

Airports have always posed unique challenges for security and fire safety. However, the events of 9/11 have raised significant concerns for effectively managing fire and other emergency events – without compromising security. Security concerns are now the highest priority for airport management, irrespective of the likelihood of such an event occurring, and the implications of a lapse in security extend far beyond the facility and its occupants. It is fair to say that airport security has become synonymous with national security.

The cover story of the January/February 2007 edition of *Fire & Security Today*¹ discussed the importance of integrating fire and security protocols within the overall framework of managing people movement. This overall managed approach is particularly important in airports, with their inherent transient population, and overriding concerns for security.

In reality, several modes of people movement occur at the same time within an airport: managed ingress; circulation movement; and egress. This movement is further complicated during an emergency – whether it involves a breach of security or not. Given this, airport managers and designer/consultants to the industry need to pay particular attention to the integration of the facility fire alarm and other emergency systems with public address/paging systems, and security/access control systems. Most important of all, they need to develop and implement a plan to manage the movement of people in both emergency and non-emergency conditions.

Ingress Circulation Egress (ICE)

All structures involve three basic modes of people movement. For the structure to be used people have to arrive and enter the structure; during its use, people circulate around the structure; and eventually people

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leave the structure (see Figure 1). In an airport this process is further complicated by security requirements which restrict all three modes of movement: ingress is closely managed; access is limited; egress is controlled, especially at international terminals.

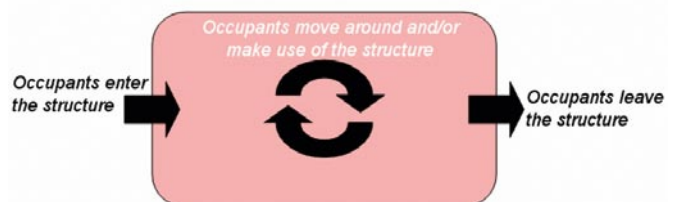


Figure 1: ICE: the three modes of people movement.

Given these modes, and the fact that they are highly coupled (i.e. they co-exist and interact), it is beneficial to treat people movement as a single system that can exist in a number of modes, rather than as a number of disparate entities. The acronym ICE (ingress, circulation and egress) is introduced to describe the system of people movement. This coupling implies that the design of procedures addressing any of the three modes should be sensitive to the procedures in place for the others; e.g. emergency fire procedures should be sensitive to the procedures in place for security, etc. Ideally they should be part of the same overarching approach to people movement. In the next section, the practical implication of the coexistence of these modes is discussed.

Balancing security & fire safety

Traditionally, fire and security have been viewed as competing issues, particularly when it comes to egress doors: security limits access, while fire evacuation requires access be unrestricted. The interconnection of fire alarm systems with security doors has been occurring for decades, with the emergency egress function being considered primary over the security function. However, in the current high-security environment, these two functions are considered equally important. This has important consequences for the management of both modes of people movement.

Aside from the security considerations, an unmanaged evacuation also poses a potential safety issue for occupants for other reasons: exiting into unfamiliar areas with aircraft transport, baggage handling, vehicle traffic and other hazards. As the occupants would be unfamiliar with these areas, their exposure to the inherent safety concerns of these areas is more significant compared to airport workers familiar with the areas. There is also a well-documented tendency for people to prefer familiar routes and avoid entering completely unfamiliar spaces during an emergency². This is made worse in an environment where security is such a high priority and where (in non-emergency scenarios) such behaviour would be strongly sanctioned. Managed evacuation would require additional coordination and personnel, but would reduce associated exposures to hazards and dependency on the unfamiliar.

Persons wanting to do harm to airport patrons and employees, airport property or aircraft could use the fire detection and alarm system as a means to opening security doors and gain access to various areas, to cause persons to gather in particular areas or to force responders to enter specific areas. In any of these cases, the scenario could be prearranged such that the fire alarm system is the means to obtain access or gather personnel to a particular location so that maximum harm can be achieved. Not only is this a viable means of exploiting fire safety systems, but security management are aware of this potential and treat fire incidents accordingly; i.e. that they may not necessarily be authentic, but instead malicious. It therefore becomes imperative in an airport environment, that an intentionally activated malicious

alarm or even a genuine alarm event, not cause a breach in security. Apart from the inconvenience that this may have for patrons, it may identify loopholes in airport security that can be exploited.

The need for security checkpoints poses an obvious barrier to people movement and the bottleneck they create might even be exploited as a target for terrorist activity. These areas of convergence pose a problem to managers under normal airport operations, and consideration must be given to their impact under emergency conditions.

All of these concerns have driven airport managers to develop non-traditional approaches to fire alarm notification within airport structures. Unlike most public occupancies, where a fire alarm signal typically results in the partial or total evacuation of the facility, airports are beginning to migrate to what can best be described as a 'Managed Response' to alarms. Typical features of a 'Managed Response' are:

- No automatic notification of public area on a single fire alarm event

Fire alarm systems are configured to notify only staff on the first alarm event.

- Investigation of all alarm events by airport staff in accordance with a rigorous response plan

A comprehensive management plan needs to be in place that anticipates, to the extent possible, all possible emergency scenarios and their potential impact on the movement of people.

- Use of video surveillance

Because video surveillance is ubiquitous in the airport environ, integrating the information provided by cameras into the response plan is logical and necessary.

- Integration of overhead paging/public address systems

Airport public address systems typically are capable of providing high quality, intelligible messaging, and should be an integral part of the managed response plan.

This managed approach reduces the potential for unnecessary notification and evacuation, explicitly recognising the ICE system and the potential for hazards from numerous sources. The final point explicitly mentions the integration of the notification and paging systems; i.e. the emergency and non-emergency means of communication. Similar integration should be considered for staff: fire marshals, security personnel etc., should be cognizant of each other's procedures and the potential scenarios that might arise. The principles highlighted in this managed approach should be extended to include and involve security and facilities personnel. Ideally this inclusion would not only occur in response to an incident, but would also involve them in the design of the procedural response; the same approach would apply for security and circulation procedures.



Photo by Arne V. Petersen, Copenhagen Airports A/S.

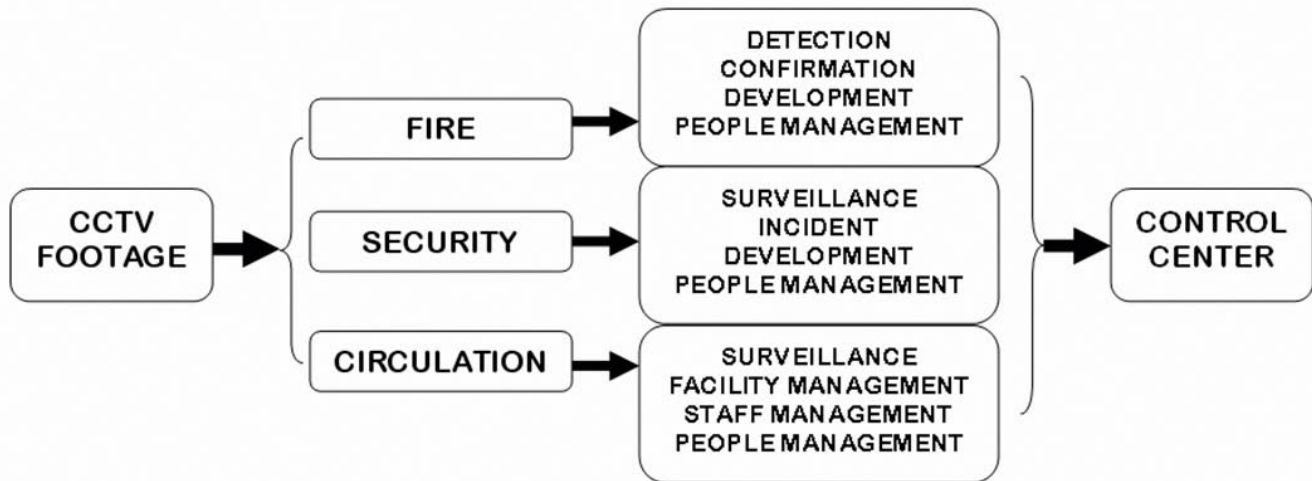


Figure 2: Benefits of CCTV.

Seeing is believing

A significant benefit of airport security systems is the coverage of cameras and the ability of emergency responders to use them for a variety of situations (see Figure 2). This allows responders to coordinate with security personnel and view areas where fires might be reported or where exiting occupants may be travelling. When a managed evacuation methodology using manual messaging is implemented, the security camera system can be used to assist responders in verifying the fire location and the stage of its development. Additionally, this verification could be used to facilitate the management plan for relocating and evacuating occupants.

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Video surveillance also aids in the general management of facilities and circulation, allowing comfort levels to be assured and efficient use of commercial spaces. Supporting this idea is the fact that camera coverage is usually extensive, and fires can be viewed within seconds by airport personnel or emergency responders. Technologies exist to integrate the fire alarm system and the security cameras. However, the benefit obtained from the technology is highly dependent on the emergency planning scheme implemented, the maturity of the incident command structure, and the capabilities of dispatchers in both security and fire.

Video surveillance can also provide data on the use of the airport, such as where people gather, what facilities they use, what routes they adopt, etc. This data can then be used to hone the procedures employed; ensuring that they are appropriately designed. This approach is labour intensive as it requires staff to analyse the data (it is not suggested

that this is a continuous task, only periodic). However, this type of analysis will allow procedures to be kept current, ensuring that their design and implementation will be based on the latest (and most relevant) data available.

Managing people movement in a secured environment

For most of the 20th century, it was widely assumed that an evacuating population should be deprived of information regarding an emergency incident (e.g. a fire), as it would have instilled panic^{2,3}. This view is not unique to this area of safety, but is also prevalent in other areas of emergency and security management. This point of view has been replaced, through advances in our understanding of human behaviour in fire, by the view that the population needs to be informed of the event necessitating their evacuation as early and comprehensively as possible, in order to increase their acceptance of the emergency procedures and inform their decision-making process⁴. In fact, it is now widely accepted that depriving evacuees of information increases their probability of performing irrational or sub-optimal actions⁵. This approach has similar merit both for circulation movement (allowing people to utilise the facilities available) and for security management (explaining staff actions to gain cooperation). People are more likely to respond when they understand the nature of the event (e.g. a threat), how it affects them (e.g. the threat posed to them), and what they should do in response (e.g. move to a place of safety, defend in place, etc.). This will not only make the population more receptive, but also provide a safety net to the procedures in place; should they fail, at least the population will be informed and better able to cope independently (although this is certainly not desirable).

There is an admitted difference between the response that fire alarm and other emergency alarm systems are intended to evoke and the response that actually occurs. Although there is a range of reasons why occupants do not immediately begin movement out of a fire area, a common thread within the reasons is a lack of information regarding the location and/or severity of the event. In many cases this lack of input causes occupants to make judgments regarding their level of safety that

may be incorrect. The judgments of occupants can impact security in addition to security features affecting the actions taken by occupants. For instance, evacuees being simply told to leave may adopt routes counter to security requirements, placing additional pressure on security personnel. More likely, the evacuees may all choose similar routes, leading to significant congestion, and requiring security personnel to provide assistance, thus exposing previously secure areas.

Additionally, directives regarding security within a given locale, as well as the known consequences of violating security features, can further affect response to emergency situations. The presence and normal operation of security personnel will influence the selection of egress routes, especially where information is limited.

People present in airport spaces generally have a reason for being there; i.e. they are not simply passing through, but wish to make use of one of the services offered by the airport. For instance, they may be departing, or waiting for the arrival of someone. Visitors may expect to encounter security measures during their visit; encountering fire safety procedures, however, would not be expected. In most instances the individual will be committed to remaining in the space especially if they have moved into a secure area (commonly referred to as "sterile areas" in current security jargon); e.g. if they have checked in and gone through security. Responding to a fire at an airport terminal therefore presents several key problems, given this level of engagement:

- People will not want to leave, given their commitment to an activity⁶.
- If people are asked to leave unnecessarily, their removal from the terminal may cause serious disruption (e.g. people missing their flights)⁷.
- People will be reluctant to believe that there is a real incident, especially when there is no physical evidence of an incident (e.g. the presence of smoke).
- Once people have begun movement, they move in a managed way rather than purely according to familiarity with the routes available⁸.

This situation is complicated in the airport setting due to the barrage of non-emergency information provided to the population (i.e. information pollution) as well as the transient nature of the population. The design of the emergency response procedure is therefore critical in ensuring that occupants respond quickly and evacuate in the prescribed manner. In such situations, there will be little if any opportunity to prepare the population. The management and implementation of an emergency procedure will be enabled by the notification system in place and the staff at hand.

In response to any emergency condition it is imperative that evacuees respond in a timely fashion and their response is dependent upon the information available^{5,9,10,11,12}; any factor that delays or confuses this response can have a serious impact on the safety of the population. People are generally reluctant to respond unless confronted by

unambiguous cues. Issues of security and circulation can influence evacuee response, both delaying their initial movement (e.g. people are engaged), or influencing their movement (e.g. the presence of security barriers affects the routes available).

It is necessary that once the population initiates their response, given that they are required to evacuate, they are aware of the routes available, use them efficiently, and do not waste time attempting to find exits; this includes an awareness of security restrictions. It is critical that occupants perform in a coordinated manner to ensure that the protection afforded by the structure and the safety systems are efficiently exploited.

The process of managing people, be it during ingress, circulation or egress is aided by the population knowing what they should be doing and why. The instructions provided (by members of staff or technological systems) can then be better understood and better received. This type of response can be compared to attempts at crowd control where a population is coerced into acting in a specific manner without explanation^{5,13}. This is particularly important in unfamiliar environments where individuals may only be familiar with their entrance route; high-density populations, where routes may quickly become overloaded; and complex structures, where wayfinding may be an issue. All of these attributes can be associated with an airport setting.

Notifying the population of an emergency

The notification process represents an attempt to fill an information gap. This may occur in non-emergency and emergency scenarios, and in any of the three people movement modes. However, during an emergency incident it may be time critical. Ideally, as much preparation as possible would be performed prior to any event so that there is sufficient residual knowledge in the population; the notification process would only then represent a top-up of this knowledge. Unfortunately, in a transient population, such as that present in an airport, this would not be possible.

Initially, notification requires that the population diverts their attention away from the (non-emergency) activities in which they are engaged. The success of this is initially associated with the clarity of the reception of the notification signal (i.e. whether the population is physically able to receive the message). Members of the population who do not clearly receive information, may misinterpret or ignore the message entirely^{5,14}. Success also depends on comprehension of the significance of the message provided. Occupants must receive the message and then accept that it represents an actual event, be it emergency ('there is a fire') or non-emergency ('flight BA217 to New York is about to board'). To attract the attention of the population, the message needs to clearly denote the occurrence of an event - this is particularly important during an emergency incident. The population must be able to differentiate between the emergency message and other signals from adjacent sound systems or background noises¹⁵. Any difficulty in doing this might significantly hinder their safe progress.

Although the emergency procedure should be implemented once notification has taken place, there will inevitably be an associated, and often significant, delay^{14,16,17}. The delay may be due to a variety of factors and will be dependent on the incident scenario. For example, it may involve the population:

- Processing notification; e.g. differentiating the message from other emergency and non-emergency announcements.
- Confirming the nature of the event; e.g. seeking further information, confirming information with colleagues and safety personnel.
- Performing activities that are not part of the procedure; e.g. collecting bags, finishing meal, etc.
- Performing role-based activities as part of the procedures; e.g. shut-down activities.
- Confirming what is required of them.
- Preparing to perform the actions required of them; e.g. determining their first action.

Notification systems that provide no additional information (e.g. a horn or a flashing light) are most likely to be ignored. They are also the most likely to be associated with false alarms or nuisance sounds - probably due to their use when detection systems were less sophisticated and their prevalence in many environments. In addition, they provide no information regarding the required response. Notification systems that provide pre-recorded information are at least able to provide some information relating to an event or an incident. However, if the population detects a 'canned' message then it may be deemed to be susceptible to false alarms, or that the message is significant, possibly representing a 'drill' situation. This type of system will also be limited in the scenarios that it can describe and the responses that it can suggest. Given the approach suggested in this article, it is important that clear information is provided regarding the nature of the incident, whether it is an emergency, and the required response.

A notification system that is able to accurately reflect the current situation, and is perceived to do so, is the most likely system to be effective in initiating and managing a response: getting people's attention, informing them what to do and eliciting the appropriate response. However, it is difficult to ensure that these systems are current; there is then the possibility that guidance can be provided (guidance on which the emergency procedure is predicated) that is out of date. During the Dusseldorf Airport fire of 1997 which claimed 17 lives, one of the contributing factors was the provision of inaccurate information via an automated voice notification system¹⁸. It is stated in the NFPA report on the incident that a significant impact to the loss of life and damage of property was:

'The transmission of erroneous information over the voice announcement system during the first 10 minutes of alarm activation.'¹⁸

Given the reluctance of people to leave and their

reluctance to believe the information provided, it is critical not to produce unnecessary evacuation movement causing disruption, further distrust of the notification system in place, potential loss of revenue, and breach of security. This will only lead to further delays in the future. An egress procedure involving the automatic full evacuation of a space, especially a secure space such as an airport, may therefore be counter-productive. Apart from the impact that such incidents have on the future response to alarms, the evacuation process would become much more complex when a full evacuation is performed. Where it is safe to do so, where the appropriate safety measures are in place, a managed (i.e. zoned/phased) evacuation is preferable. However it is debatable, given recent events¹⁹, that evacuees will necessarily remain in place when told to do so without the presence of staff to assure them.

It is then critical that an evacuation procedure is initiated if, and only if, an incident has been confirmed. Of course, a balance has to be achieved. Extensive delays to the commencement of a needed evacuation would have serious consequences. Therefore, the investigation into the veracity of incident reports (using technology and trained staff) should be both efficient and definitive. It is also important that such an evacuation response be based on the latest information available, such that the event can be confirmed, the potential for its development ascertained, and a procedural response determined; this can then be relayed in sufficient detail to the staff and the population.

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From the research literature¹⁶, it appears that the most effective means of informing an individual of an event or incident is through the presence of a well-informed, well-trained, assertive²⁰, and respected member of staff instructing occupants of the incident. If a member of staff is not present then other means of influencing the evacuation needs to be provided. In their absence, it is critical that an information vacuum be avoided. In an emergency, the worst-case scenario would be that in this information vacuum the occupants respond after an extended period of time and then evacuate in a disorganised manner, overloading some egress routes whilst underutilising others. In contrast, with sufficient information and management, the evacuation can be managed in order to reduce the likelihood of conditions deteriorating.

Given the previous discussion, there are some basic requirements regarding the notification technology irrespective of whether it is visual, audible, tactile or mobile:

- It must have the maximum coverage possible. It should be recognised that there will be a proportion of the population that will not be able to receive the

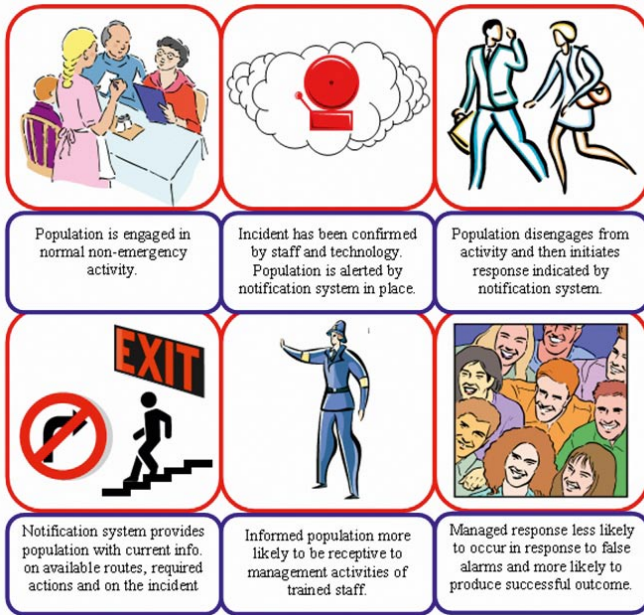


Figure 3: Managed evacuation scenario.

information provided (e.g. the impaired). Alternative measures will need to be taken for these individuals (e.g. the intervention of staff, vibrating devices, mobile devices, etc.).

- The social context of the information should be understood and managed if possible; e.g. will people recognise the information as actually representing a real incident. Technical issues that lead to false alarms, or the misinterpretation of the message as non-emergency, should be addressed.
- The information provided should not only indicate the need to respond but the required response. This may be targeted to certain populations according to location or proximity to the incident.
- Irrespective of whether the required response is uniform or not, the information provided should be based on the most current data available and should reflect the emergency procedures in place.

Ideally, a notification system should be formed from technological and human solutions. Not only will these two sources of information act to reinforce the reality of the incident, they will increase coverage and introduce much needed redundancy into the system (see Figure 3).

Notification systems are obviously a vital tool; they have the potential for providing detailed information to the occupant population, both indicating that an event has occurred and the desired response to it. As such, they support the implementation of the procedures in place - be they addressing fire, security or circulation. However, just as it would be irresponsible to design a system that was totally reliant upon the presence of staff and their actions, given the possibility of their injury or absence, it would also be overly optimistic to assume that a purely technological solution would be sufficient on its own. In an ideal situation, the technological and human resources would be employed in support of each other to ensure coverage, detail and accuracy. Therefore, when designing an emergency notification procedure several questions need to be addressed:

- Who is alerted? A potential problem with the airport environment is the massive disruption of services that can lead from a full evacuation or a false alarm, along with the potential for security breaches. For the zoned approach to be adopted, safety management need to be confident that the incident is contained; i.e. that the systems in place (e.g. separation, sprinklers, pressurisation, etc.) are sufficient to limit the spread of the incident. This would depend on the nature of the scenario.
- How much information is provided? Sufficient information needs to be provided to the population in order to inform them of the nature of the incident, the threat posed, and reduce their need to seek further information.
- How the information is provided?

These procedures need to be employed both before and during the event. The designer has to answer several key questions to appropriately design an emergency procedure (see Figure 4).

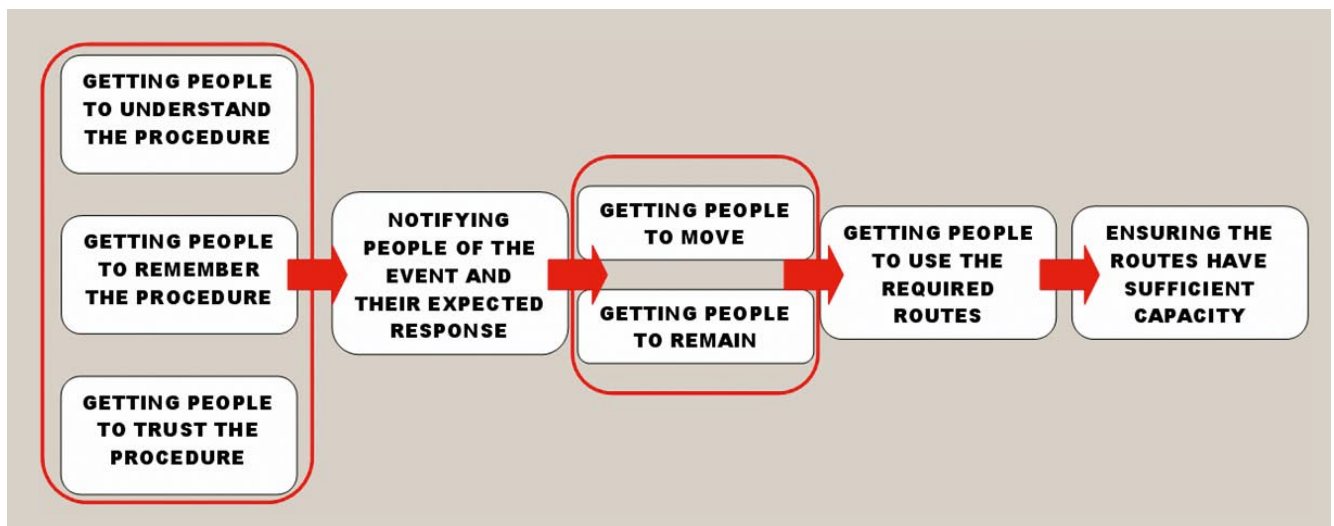


Figure 4: Simplified schematic of key procedural design questions.

This schematic can equally apply to all three modes of people movement. Irrespective of the mode in operation, the provision of information is critical for the population to respond in the anticipated manner. Ideally, the notification system should inform the population of the response required of them, irrespective of the mode of people movement in place. Therefore, a single integrated notification system, trusted by the population as being the authoritative source of information, would be ideal. This would also ensure that the information provided was consistent and coordinated between different sections of the management community and also ensure that information provided did not have to compete with other notification systems in place.

Some systems employ pre-recorded voice messages that can be automatically or manually delivered to the public should an actual evacuation or relocation become necessary; these messages notify occupants of a potential situation and provide instructions accordingly. They can be arranged to direct occupants to relocate to safe zones until the emergency is verified and airport personnel are in place to escort occupants to another location, whether interior or exterior to the building, in a controlled manner. These systems could equally be used for emergency, or non-emergency situations; fire and security scenarios. By aligning the notification and response procedures there is less likelihood of loopholes and also less likelihood that the procedures employed might contradict each other.

Technical implications of a managed response and an integrated notification system

Moving to a fully managed response that incorporates manual voice notification would typically mean the fire alarm system would operate in private mode as defined by NFPA 72. Private mode operation allows for notification of "those persons directly concerned with the implementation and direction of emergency action", and allows for the reduction or elimination of audible notification within public spaces. The means by which audible notification is made becomes far more flexible since it is generally accepted that private mode operation can use reliable sound systems, such as the public address system, to provide emergency messaging.

Traditionally, there is a bias in the fire protection community against using public address and paging systems, for reasons of reliability and integrity of the system. Based on this, voice messages for fire alarm systems have been required to utilise speakers listed for fire alarm service. NFPA 72 requires fire alarm speakers to be listed through UL 1480, *Standard for Speakers for Fire Alarm, Emergency, and Commercial and Professional Use* (other UL listings might also apply, depending on the application). Listing to UL 1480 does not necessarily provide for a high quality of sound, and it is generally recognised that quality paging speakers produce better sound output than fire alarm speakers. Consideration of this is important when designing a system for intelligibility of voice messages, which

is currently required by NFPA 72. Not to be confused with audibility, intelligibility means the message is understood as opposed to just being heard.

Because of the crucial role the public address system plays in the ongoing operation of an airport, it is typically more intelligible than a dedicated fire alarm voice system and provides more flexibility with respect to selectivity of paging zones.

Other means of notification might also be utilised. Textual messaging displayed on the flight information video screens located throughout the facility can provide information to the public and staff alike.

As part of the evaluation of melding security and fire response, thought must be given to the means of notification.

Concluding remarks

People movement cannot easily be compartmentalised. In reality, people enter, use and leave a structure at the same time. They do this with access to different levels of information and for different reasons. When developing procedures to deal with this movement, it is important to be aware of this and to keep the population adequately informed. An integrated approach is needed, both to manage and inform the population. As has been identified above, this has managerial and technological requirements: additional training will be needed for staff; a more coordinated procedural system will be needed; notification technology will need to be developed and better exploited. However, the benefits of such an approach are numerous: a more reliable response to emergencies, with a better informed population; an integrated security operation, that is less exposed to unexpected breaches and that is informed of the status of other operations; a more efficient and less interrupted use of commercial/circulation facilities. This improvement can be brought about by coordinating the management of the three modes of people movement (ICE) and by integrating the staff and technological response to an event. This will allow the type of managed response suggested in this article: where disruption is only caused where needed; where incidents are investigated and ascertained for what they are; where an informed population is managed and guided to a new location if need be.

As part of the evaluation of melding security and fire response, thought must be given to the means of notification. This is true not only for occupant notification, but for fire department and internal notification as well.

Utilising a managed evacuation methodology allows airport management to address evacuation based on the specific fire scenario, while concurrently addressing

other issues, such as security operations, airline traffic control, and incident command functions. This methodology allows airport incident commanders to be far more adaptive in their response, permitting control of occupants and use of non-traditional evacuation means when necessary.

Employing a fully integrated managed evacuation methodology also allows airport management to address emergency conditions that cannot be addressed by direct signalling methods. The current fire alarm systems cannot distinguish multiple-emergency situations, such as a terrorist incident that involves fire as a weapon, or a fire emergency occurring during severe weather, from "typical" fire conditions. The fire alarm system can only provide information to occupants based on available initiating devices. Using a managed evacuation methodology would allow airport personnel to better assist occupants in moving to safe locations and minimising their interaction with emergency response personnel.

The primary drawback to any managed evacuation is that it is personnel intensive and can be procedurally complex. Training of personnel is time consuming and can be expensive, depending on the scale and complexity of the evacuation procedure. However, it should be recognised that management of incidents is already occurring in other facets of emergency, security and weather response. Integrating fire emergencies into this existing structure would be less impactful

than generally perceived, since much of the foundation for incident command is already in place. As noted, it would also benefit non-emergency movement, both in terms of ensuring a more efficient use of facilities and by leading to fewer disruptions.

The public address/paging system supports this function, as does the digital paging system and radio network. With these various notification systems in place, management has multiple methods of transferring non-emergency/emergency information to employees and allowing them to implement developed procedures for response.

This article was conceived, written and submitted prior to the incident at Glasgow Airport that occurred on 30th June 2007.

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Hughes Associates, Inc. is a global provider of fire protection and security consulting services. For further information on the company, visit www.haifire.com.

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