

Integrating *Fire Safety and Security* into **Movement Management**

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Introduction

This article discusses the issues related to managing the movement of people within and around occupied structures. Traditionally this movement has been segregated into distinct processes, such as managing access and emergency egress, and then managed accordingly. The procedures implemented and the staff roles allocated have then reflected this thinking. This approach poses a number of problems. In the next sections, the problems posed by such an approach are discussed. Given that the necessary expertise and computational tools are now available to examine these problems, some general suggestions are then made as to how this situation may be improved.

Changing times

Traditionally the management of certain types of structures has required a concerted effort to address issues posed by fire safety and security – both of which relate to the management of people movement. Previously these structures would have included airports, prisons, places of entertainment (especially nightclubs), etc. Given the current climate [1], a more diverse set of structures are now deemed to be at threat from a wider array of incident scenarios and require increased levels of security. These structures now include high-rise structures, structures of historical value, famous residencies, sports stadia, etc. Therefore, the importance of security and its possible interaction with other aspects of people movement has increased.

In each of these cases a variety of incident scenarios are now considered as representing credible threats. Whereas previously the primary threats would have included malicious and accidental fire, criminal access and acts of vandalism, they now also include more exotic terrorist scenarios. The manner in which these new scenarios are addressed is vital in terms of assuring a successful procedural response to the scenarios in question.

Unintended consequences

The recent change in the 'safety' climate has occurred over a relatively short period of time; certainly within the lifetime of a structure. As a consequence, the modification and development of security procedures has been required. This has especially been the case immediately after a serious incident has occurred, such as the London bombings [2], and the threat to air travel posed in 2006. Both of these incidents saw short-term increases in the security measures applied. A more sustained solution has been required in response to catastrophic, high-profile incidents such as that involving the World Trade Centre, or the war in Iraq.

These security developments are understandable and often necessary; however, the impact that these changes have on other types of people movement needs to be understood, and a coherent approach developed to manage them. For instance, hastily expanded security measures are often introduced without an accompanying assessment or modification in the fire safety procedures in place. Therefore the impact of the security changes upon the effectiveness of the fire safety measures is rarely assessed or understood. Several critical questions are rarely if ever posed regarding these developments:

- How do the changes in security measures influence the effectiveness of the evacuation procedure?
- How do the changes in security influence the normal circulation movement about the structure?
- How do the security procedures and the evacuation procedures interact?
- How clearly defined are the fire and security scenarios?
- When does a fire scenario become a security issue and vice versa?
- Does this lack of integration introduce weaknesses and loopholes in the security of the structure?



This last question is particularly important, as it might be the case that if new security measures are introduced in the absence of an integrated procedural approach, they may simply alter the perceived security problem rather than eradicate it. An example will further illustrate the problems posed.

Let us assume that security measures are enhanced in a high-rise office block due to an increase in the perceived threat. These enhancements are introduced at the point of entries to the building, bolstering perimeter control. Additional members of security staff are introduced on the ground floor where bags are searched, identities checked, etc., along with additional security technologies. This is introduced in response to heightened fear of a terrorist attack. However, the unintended consequences of this are numerous and rarely quantified:

- (1) Significant delays are produced when members of staff are entering the building. This will delay them reaching their place of work and may increase the level of discomfort experienced.
- (2) Additional security staff will be needed in order to implement and manage the expanded security systems, possibly with the provision of extra training. Although these may be funded from 'new money' dedicated to dealing with the new security situation, they may also be funded by diverting money from other areas of the building operations.
- (3) Congestion will build up on the ground floor around the security access points, due to the increased time to service each of the arriving members of staff. Whereas previously the population would have been more distributed on their arrival, due to them passing through the entrance more quickly, queues will now develop. These queues may now present a more attractive target to any potential attackers: a high-density population that exists outside of the protective cordon that will be present for a fairly predictable amount of time. Therefore, the very act of increasing security in order to protect the building and its inhabitants, may well have exposed the inhabitants to a different type (although equally high-profile) risk of attack.
- (4) The distribution of people around the structure at certain times will have changed. This may have an impact on the effectiveness of the current emergency egress procedure. For instance, if a traditional fire scenario developed during the morning rush hour, what impact would the congestion at the entrance foyer have upon the effectiveness of the evacuation procedures?

Therefore, well-intended developments in improving security will not only have an impact on the access to the structure, but will also have an important impact on both using the structure and leaving the structure – both during normal use and in times of emergency.

Two of the fundamental functions related to people movement (fire safety management and general security) will often be modified over the life-time of the structure, given its changing uses, resident populations and the regulations governing both functions. It is often the case that these functions are modified independently of each other. The problems that this can cause have manifested themselves during a number of fire incidents, where the security measures taken have directly hindered the movement of the evacuees. Examples include the Triangle Waistshirt Fire in the United States (locked doors to prevent staff from leaving during normal operations); the StarDust NightClub fire in Eire (presence of security operatives and the perceived barring of certain exits, both in order to manage ticketed entry); and the Gothenburg Night Club Fire in Sweden (where windows were barred) [3-6]. These are prime examples of where the interaction between procedures relating to people movement had unexpected and destructive consequences. However, this impact need not be limited to high-profile tragedies, but may also leak into other areas of people movement.

Continuing with our example of security developments in a high-rise office block will be illustrative. In general, access to a high-rise office structure will be via an access-controlled foyer. Security in this area will limit access to the upper floors via the elevators. During an emergency evacuation, some proportion of staff will usually descend via staircases either directly out of the building or through the same foyer and then on out of the structure. Even during an evacuation, security will normally be maintained to some degree; this is especially the case now, given the possibility for malicious actions. This increases the possibility of the two procedures directly interacting. As we will see in the next sections, the likelihood of different types of movement co-existing is inevitable, especially in large, complex structures such as tall buildings. A more comprehensive and less segregated understanding of the manner in which occupants move around the structure (termed people movement) is required. The discussion of a general approach is presented here, accompanied by specific references to the problems posed by high-rise structures.

Coming or going

Structures are designed and constructed to serve, house, and be used by people in one form or another. There are three basic phases of population movement during the lifetime of a structure: ingress (people entering the structure); circulation (people moving about and making use of the structure); and egress (people leaving the structure). All occupants will find themselves in one of these three phases at any one time when using the structure (see Figure 1).

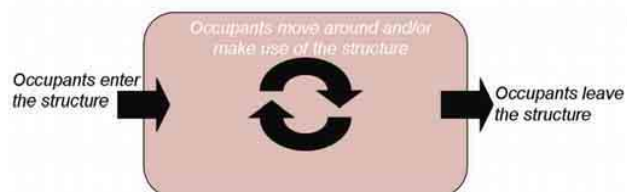


Figure 1: The three phases of people movement.

		Scenario	
		Emergency	Non-Emergency
Phase of Movement	Ingress	Crowd management, Fire Department Emergency	Security, Ticketed Access
	Circulation	Ensuring initiation of response, disengagement of population from their pre-event activities	Providing information on facilities and services
	Egress	Managing emergency evacuation	Leaving the building, crowd management

Table 1: The interaction between Movement and Scenarios

In addition to these phases, the building can be utilised under two different types of scenario: non-emergency (e.g. standard, daily usage, etc.), or in some type of emergency scenario (e.g. a breach of security, a fire, a natural hazard, etc.). Over the past few decades, expertise has developed in the phases of people movement and the various incident scenarios that may develop [7]; unfortunately the interface between these phases of movement and between the various procedural responses to them is less well understood. This is reflected in the procedures that are designed and employed.

Six degrees of ambulation

In order to understand the interaction and co-existence of different types of people movement, sophisticated tools are required. The potential for examining these situations has evolved over the past few decades. Whereas previously, real exercises (e.g. fire drills, time and motion studies, etc.) would be the only mechanism by which to understand the outcome of people movement, two recent developments have occurred enabling us to better understand these processes:

- (1) There have been significant advances in our theoretical understanding of people movement [7]. This enables experts to analyse a situation and formulate possible outcomes to a greater degree of accuracy.
- (2) The development of simulation techniques to apply this understanding computationally [8]. This has extended the analytical approach in several ways: by embodying expertise into a stand-alone tool; by allowing an array of situations to be examined relatively quickly; by allowing results to be produced on a number of levels, and reflecting a variety of different situations and conditions; by enabling the user to support any recommendations made by the computational results produced.

As such, not only are the processes at work better understood, but the various procedural responses to the situations can be designed and tested prior to their implementation. This increases the potential for examining new and potentially drastic procedural changes before they are implemented and demonstrating their effectiveness. This is vital in establishing confidence in any changes that are made, and is especially important when these changes are unfamiliar or wide-ranging.

Two factors, type of population movement and scenario, interact to define the situations that can be expected and the procedures required to address the resultant incidents and conditions. These two factors interact to define the manner in which the movement manifests itself. Examples of this are shown in Table 1.

Broadly speaking, building management develop procedures and practices to cope with each of the six types of movement shown or a sub-set of them. Unfortunately, each of the procedures developed typically addresses only one of these six types of movement; e.g. managing normal access (security), ensuring efficient use of the facilities within the structure (general services), optimising route usage during an emergency (fire safety management), etc.

These procedures require staff in order to carry them out. This is enabled by staff training, which is then reinforced by the experience gained during the work of the member of staff; therefore, the specialisation of the individual's understanding is started during training and reinforced during their work-life where they are applied to a sub-set of the procedures employed. Staff are trained and allocated according to the requirements of these separate procedural responses; i.e. individual staff members would then only have expertise or experience in a small number of the six situations. *The way in which the system of people is seen has a direct impact upon the training and experience of staff.* The current absence of an integrated procedural approach has the potential of posing several problems:

- (1) In any one of the six situations, many of the members of staff will either be incapable of contributing to or will not be directly involved in the procedure(s) employed. For instance, those members of staff specifically trained in fire safety may not have a detailed understanding of the facilities and services available within a structure; therefore, during normal usage of the structure they may not be able to provide appropriate advice when asked. This represents a highly inefficient use of the available staff resources. The current approach almost ensures that some staff is then under-utilised.
- (2) Conversely, there are often not enough members of staff available for the successful implementation of a procedure. In times of emergency, there is nearly always a need for more experienced and well-trained staff to provide assistance. The

absence of sufficient numbers of appropriately trained and sufficiently experienced staff can have severe consequences [9]. The presence of under-trained staff, irrespective of their willingness to help, can also be problematic [10].

- (3) The early segregation of staff into specialised roles encourages the separate design, development and testing of the procedures themselves. Given this is the case, there is the potential for procedures contradicting each other, not complementing each other and/or having conflicting objectives.
- (4) If the procedures are developed independently of each other then they may not have clearly defined jurisdiction; therefore, it may not be clear when a certain procedure needs to be employed and, critically, who has authority in any given situation. This may lead to conflicting advice being provided, information being overruled, and general confusion. In an emergency, this conflicting advice can have catastrophic consequences [9].

All of these problems can lead to confusion, delay and an inadequate response to any of the six situations highlighted in Table 1. This can lead to frustration and discomfort, but becomes particularly important during emergency conditions when the implementation of the procedures may be critical to the safety of the inhabitants. The way in which people movement is theoretically viewed will directly influence the procedures that are developed and how they are employed and supported by staff. In the following sections, the manner in which procedures are designed and implemented is discussed. By doing so, the relationship between the management of fire and security is addressed with several suggestions made as to how we can better marry the management of the two types of movement.

Coping with non-uniform conditions

For management purposes, it would be ideal if people were all doing the same thing at the same time. This would then enable a procedure to be employed with a greater degree of confidence. Unfortunately, this is not how buildings are used, especially large, complex structures. During the use of the structure it is possible (likely), that a sub-set of the six highlighted situations (see Table 1) will co-exist. For instance, in a large structure, irrespective of whether there is an emergency or non-emergency scenario, there is likely to be ingress, circulation and egress happening simultaneously – at least for a period of time. In complex environments (such as high-rise structures), these situations may interact and may therefore require the simultaneous application of procedures managing different aspects of people movement. Even in serious fires, where sophisticated notification systems are in place such that the entire resident population is informed of the incident, it is possible that people may still enter the structure or continue on with their normal activity, either not understanding the information provided, not interpreting it as being relevant or not believing it [9-13]. This fact will have a direct impact on the effectiveness of any procedures that are applied.

An example of how such a situation might develop is shown in Figure 2. In this figure (let us assume that it is

the ground floor of a high-rise structure), a space is shown that is separated into a number of compartments. These spaces are visually separated. In the situation shown (see Figure 2 (a)), occupants are entering the structure in a 'typical' way (e.g. to go to work). Occupants are also shown to be using the structure and leaving it in the normal course of the daily operations of the structure (Figure 2 (b and c)). For instance, they may be performing their normal daily activities and then leaving the building to go home. These groups are either unaware that there is an incident or are unwilling to disengage from their 'normal' activities. However, an incident has developed in one part of the building that has led to a response by the local population that has experienced the incident first hand. These groups are moving around within the area (performing operational shutdowns, collecting belongings, finding colleagues, confirming cues, etc.), while others are leaving the structure more quickly as part of an emergency evacuation (see Figure 2 (d and e)). In addition, emergency personnel are attempting to enter the structure (Figure 2(f)). The simultaneous occurrence of these events is further impacted by a number of factors:

- technological factors (notification coverage, false alarms, lack of familiarity with systems, etc.);
- physical/structural factors (e.g. physical separation of spaces, etc.);
- environmental factors (e.g. presence of confounding environmental conditions, absence of clear indicators of an incident, etc.);
- sociological factors (e.g. peer pressure to remain, an individual's role within structure, etc.);
- procedural factors (e.g. ambiguous instructions, non-uniform procedures throughout the space, etc.);
- psychological factors (e.g. tendency to believe the best, etc.);
- cultural and language considerations (e.g. inability to understand the instructions provided).

These types of movement are likely during an incident. It is not credible to assume that people will respond uniformly either to non-emergency or emergency procedures. Therefore the procedural responses need to be flexible enough to address the potential for several types of movement co-existing and also their transition from one type of movement to another.

This situation is compounded when several organisations or tenants occupy different locations within the same structure and apply different procedures [1], as would likely be the case in a high-rise structure: different messages could be received; different behaviours observed; different objectives presented. Therefore, a fluctuating situation can exist where priorities change, and where the allocation of staff needs to change in accordance with these priorities. The process of switching staff between different situations to match their training with the required procedural actions is made more difficult if they have not been sufficiently trained or if they have only been trained regarding a limited number of scenarios. For instance, if staff only has training in providing information on the amenities within a building, then even if they are on hand, they may be of no real help during a fire emergency. Indeed, even with good intentions, they may be a hindrance.

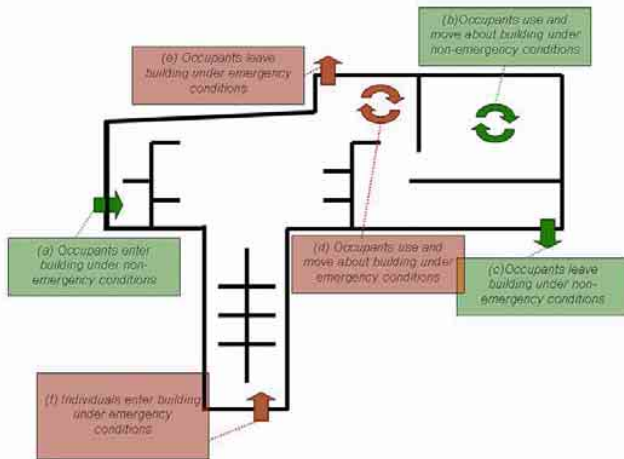


Figure 2: Existence of different modes of movement and scenarios.

Given the potential for these different conditions to exist simultaneously and to quickly evolve, the need for an integrated procedural approach becomes apparent. When employing the more traditional procedural approach, a segment of the staff would be summoned in order to address pre-determined situations. This may lead to delays (e.g. the time to be contacted, to move to the location of the incident, etc.) and also to staff, already present, being redundant given their inability to deal with the situation at hand. With the adoption of a more integrated approach, the staff present would have sufficient training and experience to assess and begin to deal with the situation. The two approaches are now compared.

Interface and jurisdiction: 'Fire people look after the fire; security people look after the security'

Staff members are usually structured (i.e. allotted, trained and gain experience) according to the different phases and types of movement (see Table 1). For instance, separate sections of staff will be responsible for managing security, evacuation activities, providing general information during circulation, etc. This may be further refined so that staff deal with only emergency or non-emergency situations. However, given the ambiguities in the scenarios that may arise (as shown in Figure 2) and the fact that the situation will certainly be dynamic, this may not be the most logical or efficient approach.

The traditional segregation of staff into these distinct roles encourages redundancy. In this approach, staff members are allocated to specific roles early on in their employment and they then receive training and responsibilities appropriate to this role (see Figure 3). This role is associated with a sub-set of the six situations indicated earlier. They are then trained for these particular situations, but are not necessarily trained or able to respond to other situations.

The allocation of staff to these roles is performed in advance of any type of situation developing (usually well in advance of an emergency situation). Therefore, it will be determined that X number of staff are required for security,

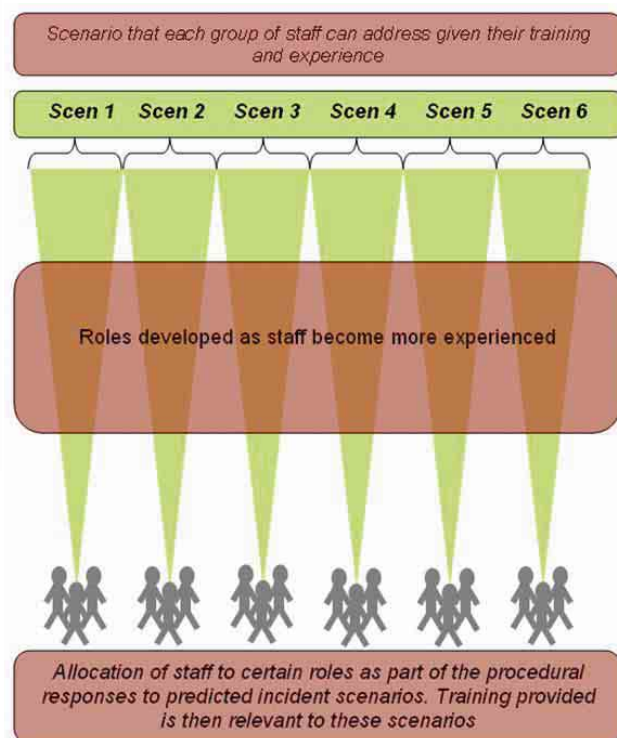


Figure 3: Traditional method of allocating and training staff.

Y for fire safety, etc. The number of staff allocated will be based on an estimate of the staffing levels required to cope with the situation in question. However, this estimate may not be appropriate for more complex scenarios or those that had not been anticipated. Problems may arise when the number of trained staff available is not sufficient to cope with the situation at hand. When these circumstances are not apparent, the skills of these staff members are effectively redundant. It is therefore contended that a different categorisation of the skill-sets available should be applied. The current approach is premised on the limited specialist knowledge of a sub-set of the people movement situations; the suggested method requires that each person has a broader range of skills relating to the management of people movement. Under such an approach, people movement is seen as a single integrated system. Staff would then be trained in people movement with the different types of situations shown in Table 1 seen as examples of it. These events have distinct qualities, but also share elements in common, and are assumed to be able to co-exist or evolve into each other quickly. The staff on-hand should be suitably prepared to address these situations.

The integrated approach suggested here makes fewer assumptions earlier on in the design of the procedure; staff would then be provided with a broader training curriculum in order for them to cope with a wider array of situations (see Figure 4). This would be based on the assumption that all of these situations fall under the broad category of people movement and were not distinct areas in and of themselves. Staff would be applied to the various situations throughout their employment, gaining understanding and experience throughout. The staff could then be allocated at the time of the situation developing, according to the need of the situation. The benefits of this are numerous: staff would be applied to variety of different tasks in the

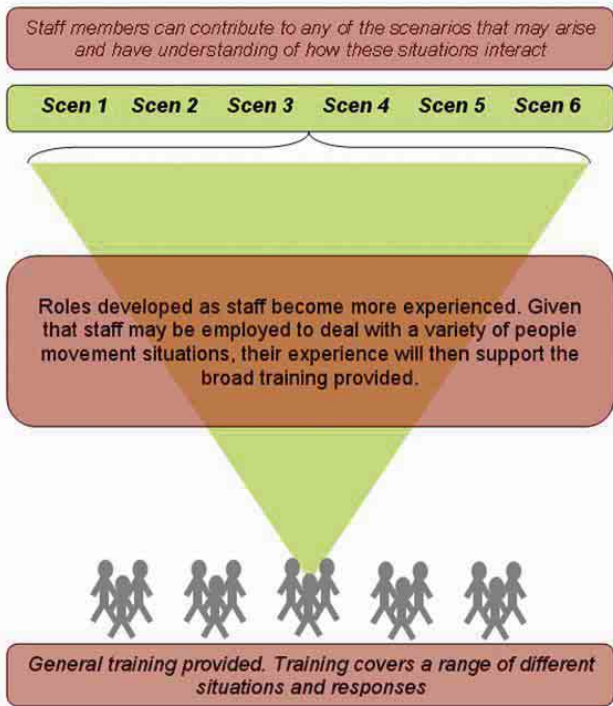


Figure 4: Integrated approach to managing people movement.

course of their work; there would be a larger reservoir of staff available to address any situation that arose; future procedural changes can be tried without necessarily having to continually search and employ new staff.

The traditional approach is shown in Figure 3. Here, members of staff are partitioned early and allocated to a specific role. Training is provided for this role. This is then reinforced over the course of their working lives, as scenarios arise, the staff members are then only able to deal with a small sub-set of them. The suggested integrated approach is shown in Figure 4. Here, members of staff are trained in people movement, which includes the full range of situations and procedural responses that might arise. Throughout their working life, they will then be able and expected to address these different situations as and when they arise, reinforcing their broader training. Although during this period each member of staff may not adopt

all of the possible roles, they would have a much wider range of experience than would otherwise have been the case. Given this, they would be better armed to deal with the various scenarios (emergency or non-emergency) with which they may be faced.

Turning the procedural table

Just as the procedures need to be integrated in order to better complement each other, so the individual roles associated with each member of staff need to be broadened; indeed, the two developments support each other. By appreciating people movement as a single system that may be in a number of states and producing staff that can address these states, the ability to react to simultaneous, but predicted, movement scenarios is improved, along with the provision of a more solid base to address unpredicted or more complex events. In addition, by rotating staff and having an integrated procedure, the knowledge normally only applied exclusively to each of these states (e.g. the principles of security, expertise in evacuation procedures, etc.) will be more widely shared. These principles could then be of general benefit, with the principles and knowledge of one area (e.g. security, circulation movement), benefiting and influencing another (e.g. fire safety). Rather than seeing a real world resource (members of staff) being subject to an organisational resource (different people movement procedures), the emphasis is completely changed: the procedures are designed as tools provided to staff through training and experience so that they can cope with the situations that they may face (see Figure 5).

Although they may have a primary area of expertise, staff members would have sufficient expertise in the range of different procedural activities to suitably identify, assess and cope with the situations identified. This would have a number of advantages:

- (1) More appropriately trained staff would be available for any situation that might arise. Management could then allocate them as required, without having to rely on untrained staff at the scene to employ ad hoc 'expertise' or quickly learn the relevant procedure in place, or wait for trained to staff to arrive. This would benefit non-emergency and emergency scenarios alike.

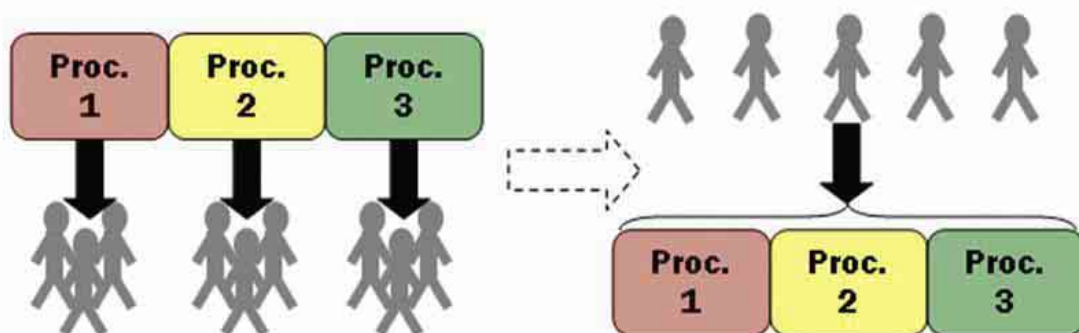


Figure 5: Movement from (a) the staff being the tools of each procedure to (b) each staff seeing the available procedures as tools and having access to them when deemed necessary.

- (2) Through staff having a more comprehensive understanding of the procedures employed, they may then be engaged in a greater variety of tasks (i.e. have a less monotonous job), and also provide management greater flexibility in how the staff are employed at any one time. Staff would also be more active, in that they will be generally employing some aspect of their expertise during their work, rather than waiting for certain conditions to arise. Their more varied experience would support their comprehensive training.
- (3) Given that staff would need to be intimate with the procedures applied in a wider range of areas, it would further encourage the integration of these procedures. Given this, possible conflicts could be identified and eliminated. It will also allow staff to be able to place the procedural response to a situation in context with the other operations employed within the building. This will allow them to have a deeper understanding of the system as a whole and be able to better predict the consequences of their actions.
- (4) With their broader understanding of people movement and the use of the structure in general, staff would be better able to understand a situation, determine appropriate responses and assess the consequences of these responses.

Although the implementation of such a system would have overheads (e.g. increased levels of training) and may require a cultural change in how training is seen within an organisation (e.g. from a one-off task to an ongoing process), these costs may be off-set by the many benefits (e.g. better performance, staff that is more interested in their work, fewer procedural loopholes, the more efficient use of staff, etc.).

Conclusion

It is possible that for much of the lifetime of a structure, the traditional approach to movement management is sufficient. This is to be hoped for, given the fact that this is the standard approach to movement management and is almost universally applied. This approach is supported with appropriately distinct training and movement exercises. Whether it is able to cope in the most efficient manner is likely not to be assessed in most circumstances, unless dedicated analysis is performed. The means to perform these analyses are now available, either through the use of current expert analytical or simulation technique. Unfortunately, if this analysis is not performed, it is then more likely that the inadequacies of the overall management strategy could be exposed should a serious incident occur.

Applying the expertise of consultants skilled in understanding people movement and human behaviour and using a variety of tools including modelling, will allow for integrated procedures to be developed that improve life safety and security. It is suggested here that by treating people movement as a single system, and then training staff appropriately to respond to such a system, that the associated people movement will be safer and more efficient during both emergency and non-emergency scenarios. The benefits of such a system would increase, along with the complexity and size of the structure. Such a system would be ideally suited for high-rise structures (along with airports, shopping malls, etc.) that are particularly subject to the new security concerns.

It is recognised that administrative, technical and organisational issues may mean that only a compromised integrated system could be implemented. However, even if this system represents an idealised goal, the evolution of the management of people movement in that direction should still provide a number of important advances and improvements to the experience and safety of the resident population.

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