APPENDIX B1:
RESIDENT DECISION-MAKING

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Executive summary

This report is in response to **Objective B1: Establish conceptual understanding of expected resident performance during evacuation and influential factors**, as outlined in the original proposal of work. The intention was to review research literature and case studies on human behaviour during emergency evacuations that relates to high-rise residential buildings.

To develop an understanding of relevant evacuee decision-making we have reviewed the following sources:

- General material on evacuation from fire (e.g. research literature, case studies, etc.).

This was used to identify key elements (behavioural statements) and develop a structure using:

- Existing conceptual models of evacuee behaviour.

This was used to produce a structure applied to the resident decision-making process:

- Material on resident evacuation from fire emergencies (e.g. research literature, case studies, etc.).
- Material on resident evacuation from multi-occupancy structures involving fire emergencies (e.g. research literature, case studies, etc.).

This was used to focus the behavioural statements on resident evacuee decision-making and populate the decision-making structure.

This required us to complete the following steps:

- 1: A collection of behavioural statements derived from general research to describe expected elements that affect resident decision-making during an incident. These are calibrated (based on resident evacuation research).
- 2: A mapping of the modelling structures outlined here to the previous matrix structure identified in the report for Objective A1: Establish building design principles underpinning evacuation strategies.
- 3: Compilation of factors and actions specific to resident evacuation in multi-occupancy structures.
- 4: The development of a simple resident decision-making process connecting the compiled factors and behavioural statements, using refs. [1-3].

The elements of the work outlined here (see Figure B1-1) and the survey work to be conducted will be applied to develop scenarios of interest in sufficient detail that they can then be modelled using the selected simulation tool. The information/external conditions will vary according to location – which then determines the cluster of factors present. This also approximates the level at which guidance operates (e.g. different structural components).

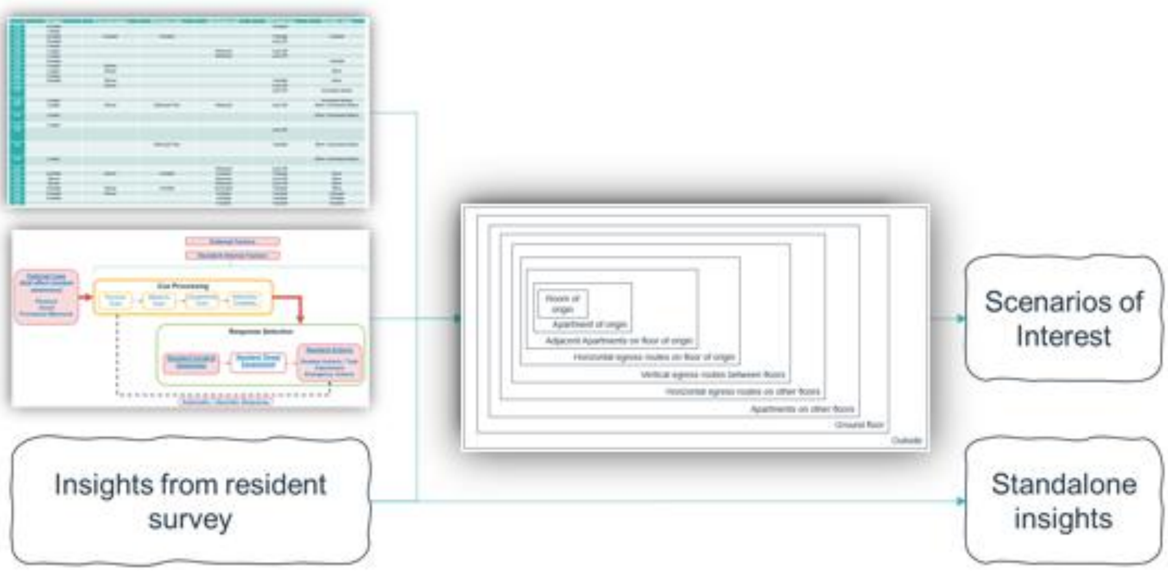

Figure B1-1 Structure of the work described in this report

This work will facilitate several steps:

- Use the tools developed here to inform survey design iterations.
- Develop a provisional description of scenario structure.
- Conduct a provisional examination of simulation tools available to establish which of them have required functionality.

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B1-1 Overview: Resident response

This report is in response to **Objective B1: Establish conceptual understanding of expected resident performance during evacuation and influential factors**, as outlined in the original proposal of work. The intention was to review research literature and case studies on human behaviour during emergency evacuations that relates to high-rise residential buildings.

This review of evacuee decision-making focuses on two aspects of resident evacuation:

- **the process** that an evacuee goes through; and
- the **factors that influence this process**.

Until the 1980s, it was generally assumed that the **overriding evacuee response to an emergency** was **panic**, irrespective of the type of scenario or structure involved. This response, although not clearly defined, typically involved a combination of selfishness, competition, irrationality, hysteria and/or a herd mentality. This notion – **that panic would determine and dominate evacuee response** – **has now largely been discredited**. Response is seen as more complex, sensitive to information, more adaptive, more social and more altruistic than one might expect in a panic-driven response.

A large body of behavioural research has instead shown that **before an evacuee performs an action**, they will **have perceived external cues**, **interpreted the situation, assessed the risk posed based on those external cues combined with prior knowledge and experience, and then decided on what to do based on this assessment** (see [1-273] along with the material presented in response to Objective A1)**.**

Therefore, instead of evacuee response being dominated by an instinctive response to external information in an irrational / selfish / immediate manner (i.e. panicking), they instead process the information available to them in order to assess the situation and determine (a) whether a response is required at all and (b) what that response might be.

This has significant implications for physical and procedural design. For instance, if a panic-based approach is assumed, then notification might be delayed for fear of an uncontrolled evacuee response and little information would be provided, given that the evacuating population would not process it. In contrast, assuming evacuees are sensitive to information, notification will be made promptly (to ensure maximum time) and information would be provided to aid in evacuee decision-making. The availability and accuracy of information is paramount to evacuation safety.

Evacuees are dependent on information [137, 142]. This dependence can be addressed through the residents seeking out information from their surroundings (physical, environmental, social, etc.) or through procedural notification.

Unfortunately, there is no accepted comprehensive theory of evacuee behaviour. We therefore must produce a composite of different insights, structures, and findings. Our main understanding is instead based on piece-meal ‘behavioural statements’ that describe various aspects of evacuee performance [137,146], developed in conjunction with a simple decision-making structure used to house key factors and actions related to these statements and resident-specific evacuation findings.

To develop an understanding of relevant evacuee decision-making we have reviewed the following sources:

- General material on evacuation from fire (e.g. research literature, case studies, etc.). This was used to identify key elements (behavioural statements) and develop a structure.
- Existing conceptual models of evacuee behaviour. For instance, [25, 41, 46, 136, 187,266]. This was used to produce a structure applied to the resident decision-making process.
- Material on resident evacuation from fire emergencies (e.g. research literature, case studies, etc.). For instance, [253, 255].
- Material on resident evacuation from multi-occupancy structures involving fire emergencies (e.g. research literature, case studies, etc.). For instance, [9-11, 27, 28, 45, 86, 108, 114, 135, 160, 171, 176, 206, 215, 229, 231, 232, 253-255, 271].

This was used to focus the behavioural statements on resident evacuee decision-making and populate the decision-making structure.

Throughout, as a source became more relevant to the conditions present in multi-occupancy structures, so its findings were given precedence.

This work is based on series of simple assumptions. We assume that multi-occupancy residential properties have several characteristics:

- A relatively complex spatial layout where residents are separated into compartments (apartments, or flat) which provide privacy ensuring that residents are not all subject to the same cues.
- Each apartment hosts one or more people. If more than one, a social group exists that has social / emotional ties either to each other and / or to the property and its contents in some form.

- The structure does not have all the safety / procedural measures that might be expected in business / public building (e.g. staff, sophisticated notification systems, etc.)

In contrast to analysis conducted in the 1970s and 1980s, we now assume [4,15 ,25, 33, 42, 46, 56, 64, 66, 69, 77, 89, 90, 93, 96, 113, 136, 154, 162-170, 183, 197, 201-217, 224, 234, 240, 243, 248-249, 262, 263]:

- Individuals are subjected to external cues that disturb / interrupt their current situation / behaviour.
- The relationship between the individual and external information is affected by their innate attributes / status / activities, the situation, the environment, and social context.
- This information will likely be a sub-set of the information available.
- The perceived information will be interpreted and may / may not affect the individual's situational awareness.
- The individual will need to make sense of the situation (based on this situational awareness) and determine an action to meet their objective (should this have been updated).
- It is unlikely that the only action in which an individual engages is evacuation.

We do not deny the potential for panic-based or irrational responses. We only suggest that such a response rarely dominates evacuation and that the implications of such a response can be charted. It is more important to address the complex factors that affect evacuee decision-making to ensure that they are addressed in later elements of this work and in the regulatory framework.

As noted by numerous researchers (e.g. 93, 96, 97, 205, 207, 213, 218, 224, 244, 254, 268), single-occupancy domestic environments present a slightly different resident response given:

- Emotional attachment.
- Fire cues likely indicating an event inside the structure.
- Reduction in response delays given the increased attachment and reduced ambiguity in location of cue.
- In contrast to other occupancy types, in single-occupancy housing where a resident is awake, residents are likely to investigate and then perform protective actives.

However, multi-occupancy residential environments introduce many more opportunities for external cues, remote cues, and ambiguous cues – complicating the response of the residents [9, 14, 19, 99, 104, 107, 123, 127, 134, 135, 172, 158, 182, 191, 206, 234].

Here, we assume that the general evacuee decision-making research is applicable to evacuation from multi-occupancy residences, requiring calibration to the specific conditions of multi-occupancy buildings. In essence, the key decision-making steps remain the same, but the situation (i.e. information available, procedural measures, situations and social context) is different. This informs our approach.

This work is based on several objectives:

- Build on the work conducted during Home Office project addressing resident evacuation behaviour (reported in 'Evacuation from fire in UK high-rise residential buildings: A rapid evidence review', 2020):
    - We have deliberately **not** sought to produce another detailed of review of evacuee behaviour. We instead derive several core factors that affect resident actions and a basic structure to connect them.
    - This can then be applied throughout the various spaces within a residential design.
    - Enable model scenarios to be developed and configured according to the findings of the Home Office report, the earlier analysis of the physical impact on resident evacuation and the survey results.
- Building on work conducted in the earlier report in this project (i.e. the work addressing Objective A1: Establish building design principles underpinning evacuation strategies). This ensures that the matrix developed in this earlier report is a consistent with the work conducted here.
- Develop a sufficient understanding of evacuee decision-making to inform the eventual development of evacuation scenarios to be explored using computational simulation tools.
    - Given that simulation tools do not comprehensively represent the nuances of risk perception and situational awareness and their impact on the decision-making process, we focus on external cues and factors that affect resident decision-making, individual attributes that influence performance and the actions that might be selected/performed (see example decision-making process in Figure B1-2.
- Provide input into the development of the resident survey on the perception and understanding of fire emergencies (in response to Objective B2:

Determine occupant understanding of evacuation strategies/fire safety measures, occupant confidence in protection, occupant risk perception and predicted occupant response to emergency).

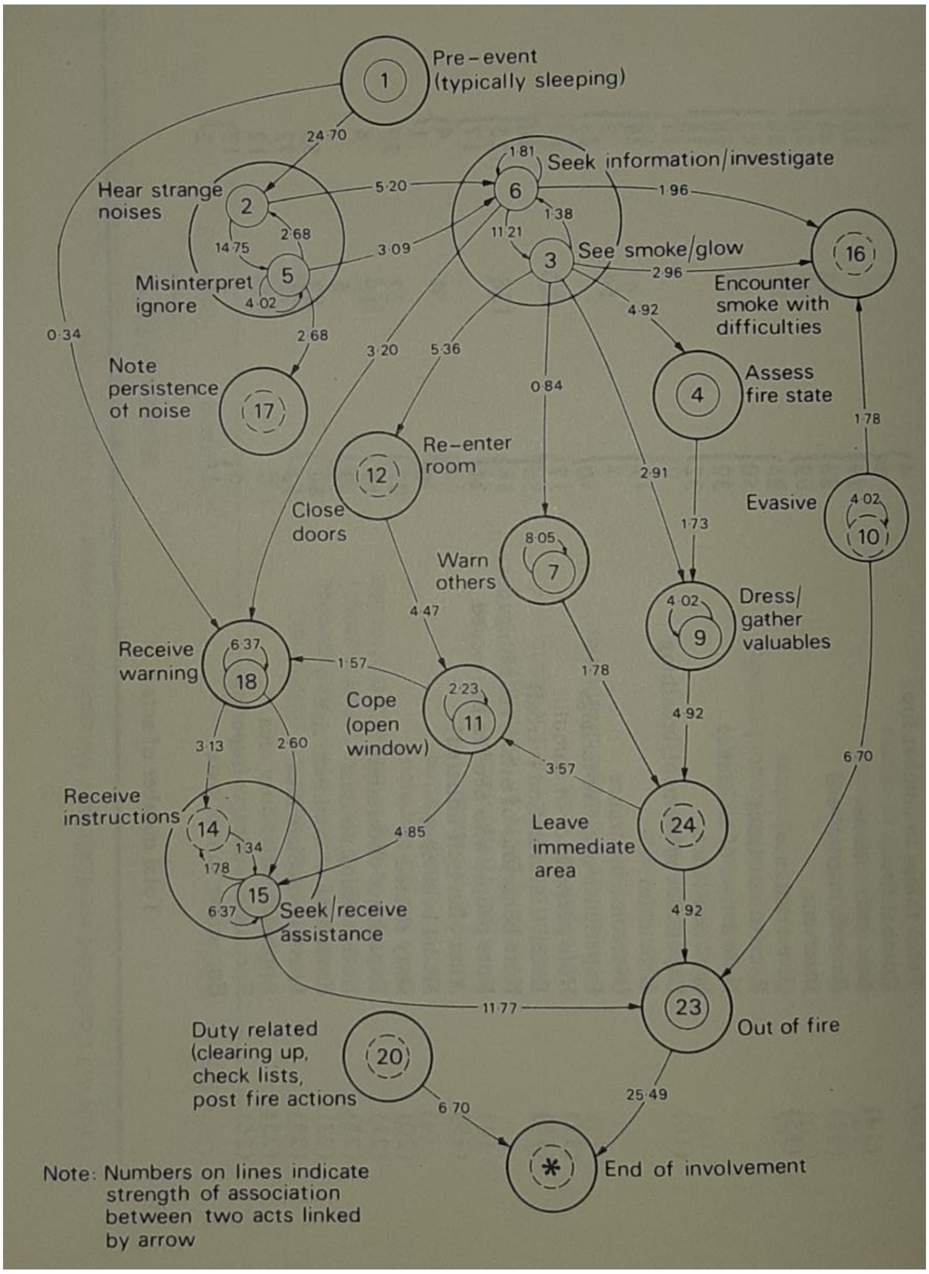

Figure B1-2 Model derived by Canter et al. [46] on evacuee response in fire in multiple occupancy properties

B1-2 Conceptual decision-making models

In this context, *a conceptual decision-making (DM) model is a composite of existing theories and data that has been drawn together to represent some portion of resident performance during emergency conditions*. Several such models exist, for instance, [25, 41, 46, 136].

Existing DM conceptual models tend to focus on

- The overall process providing limited detail regarding the decision-making process. For instance, Breaux et al. [25], three stage model of decision-making: recognition/interpretation, behaviour and outcome (see Figure B1-3) and Canter et al. [46], generated a sequence-based model to identify actions commonly performed (see Figure B1-4).

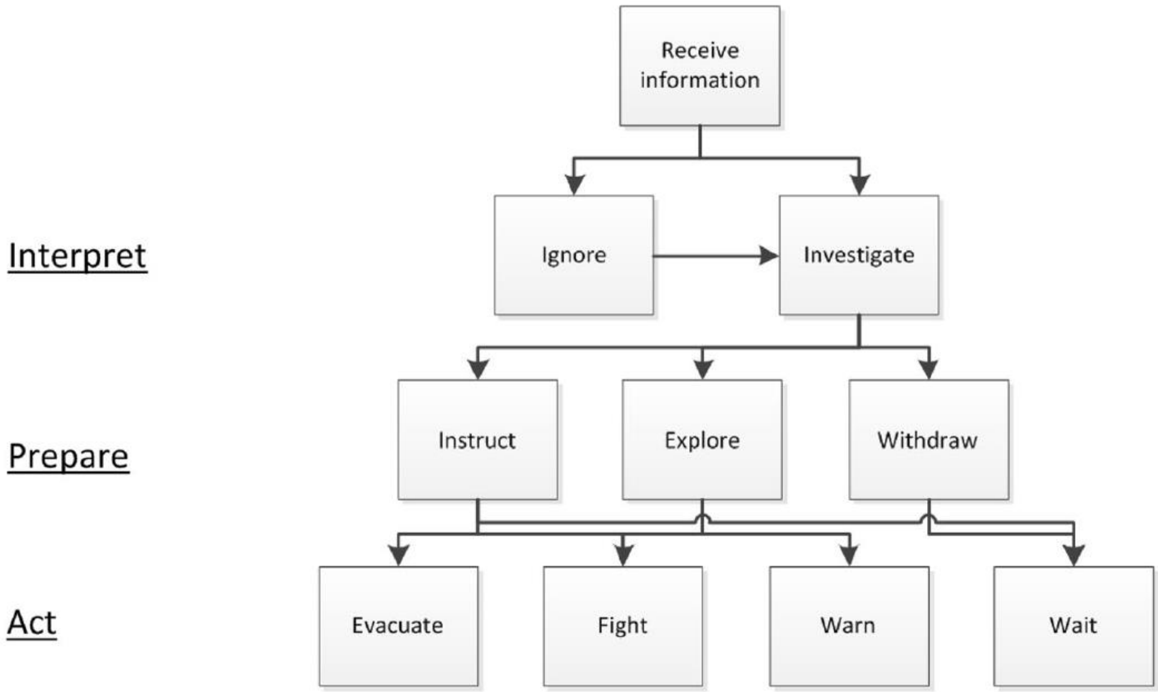

Figure B1-3 PIA model [25]

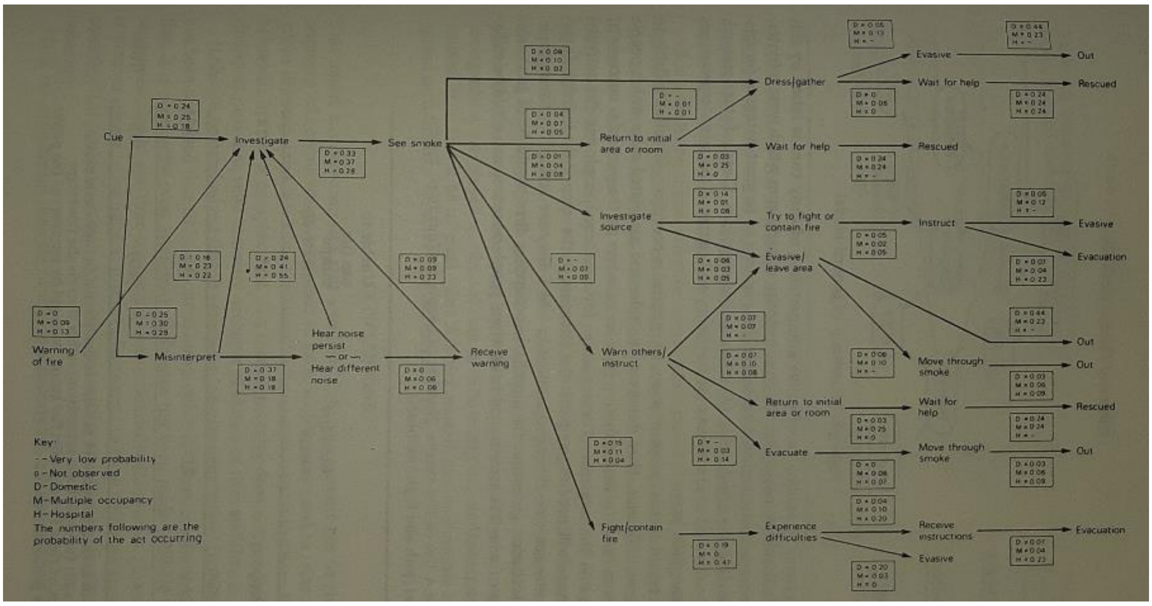

Figure B1-4 Stage-based action sequence [46]

- Response to communication (e.g. derived from large-scale disaster research) [59, 154, 155, 162-170].
- An aspect of the decision-making. For instance, Proulx described the impact of stress [41], where an individual response changes as the degree of stress increases from control to ambiguity, to fear, to worry and eventually to confusion (see Figure B1-5).

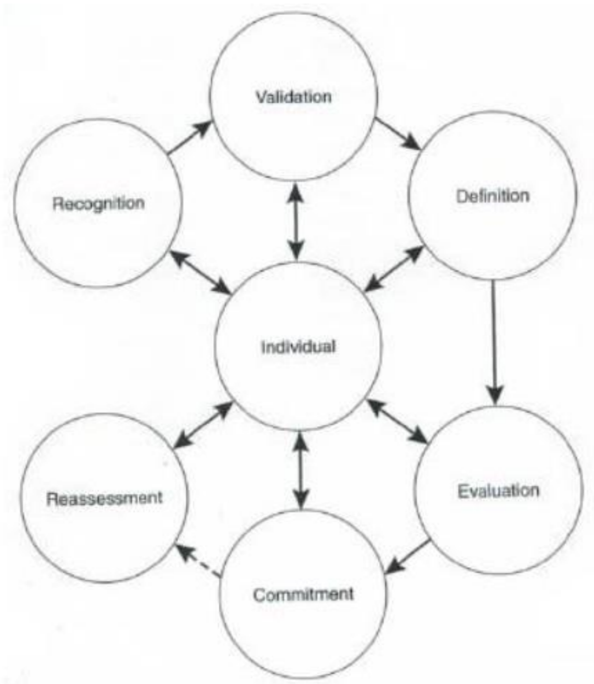

Figure B1-5 Proulx's six stage decision model [41]

- The evacuee decision-making process during a specific incident. For instance, in her seminal work on the analysis of the World Trade Center attacks, Kuligowski developed a simple model outlining how evacuees made sense of their surroundings, processed the information (given the availability of existing experiences and the social setting) and then determined a response [136]. This model involved individuals receiving cues, processing these cues given their existing understanding and role, and given their assessment and perceived risk either taking protective action, continue their current actions or seek more information.

Several examples exist of model developers who have compiled these conceptual models to produce more complex overarching models to enable simulation. For instance, Pan implemented a model where agents perceived numerous cues and prioritises their impact to represent the decision-making process [187]. Wijermans developed a model of crowd behaviour to represent how the agent's physiology, available information and social factors affected their response [266]. Similarly, Gwynne et al. developed a conceptual model of evacuee response (see below) that was explicitly designed for implementation in an agent-based environment (i.e. at the individual level) [93, 97]. These examples (and others) have been reviewed to identify the salient points needed to *structure* our understanding gained from general evacuation literature and evacuation literature addressing residential fire emergencies.

The Kuligowski work is seen as particularly relevant as it focused on sensitivity to surrounding information and a varied response to a complex incident, i.e. that might be sufficiently flexible to address the scenarios in which we are interested. Kuligowski examined survivor accounts of the WTC incident, combining this with several sociological theories, to develop a high-level structure for understanding the evacuee response (see Figure B1-6).

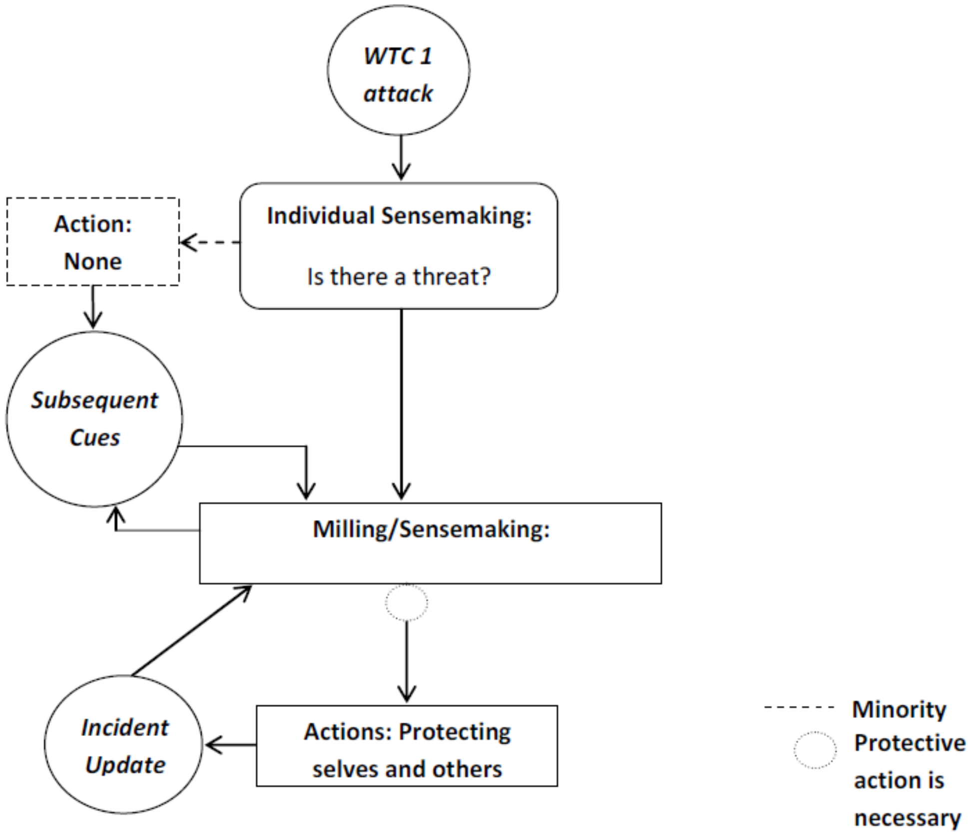

Figure B1-6 Original model produced by Kuligowski describing evacuation behaviour from WTC [143]

This was deliberately general to account for the variability in the responses recorded. Kuligowski's work was reviewed and translated into a format that was suitable for an agent-based model, i.e. suitable for practical application (see Figure B1-7).

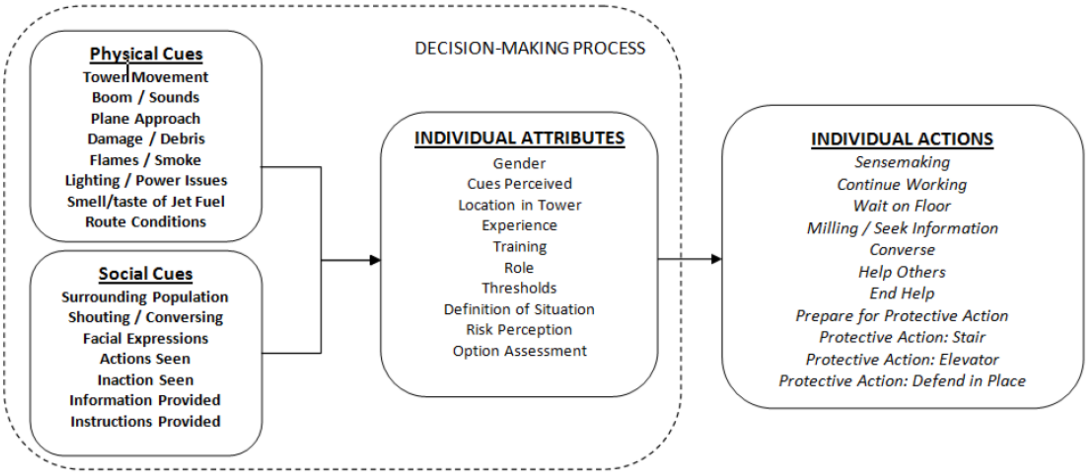

Figure B1-7 Reworking of Kuligowski model for application within ABM [96]

Several sophisticated simulation tools exist to quantify the impact of evacuee response on building evacuation (see [141]). However, none of the current set of simulation tools explicitly represent the evacuee decision-making process described in this document. There are several reasons for this, e.g. general focus on physical conditions, absence of relevant supporting data in a usable format, absence of many external factors within the simulated environment, etc. This is not to say that the current crop of simulation tools cannot be used to examine evacuation scenarios and quantify response – only that the user must manually configure existing simulation tools to reflect the impact of external conditions on the evacuee response.

In the next sections, several different areas of analysis are presented:

- Section B1-3: A collection of behavioural statements derived from general research to describe expected elements that affect resident decision-making during an incident. These are calibrated (based on resident evacuation research).
- Section B1-4: A mapping of the modelling structures outlined here to the previous matrix structure identified in the report for Objective A1: Establish building design principles underpinning evacuation strategies.
- Section B1-5: Compilation of factors and actions specific to resident evacuation in multi-occupancy structures.
- Section B1-6: The development of a simple resident decision-making process connecting the compiled factors and behavioural statements.
- Section B1-7: A brief overview of next steps.

B1-3 Behavioural statements

It is accepted that evacuee response is typically a result of a decision-making process. Evacuees move through a series of phases involving disturbance (i.e. the receipt of external cues), recognition and interpretation, assessment, action selection and performance. The precise path through these phases is heavily influenced by the nature of the cues, the individual involved, their situation and the time/options available. Kuligowski (followed by [93, 97]) compiled the current understanding of evacuee performance into a structure triggered by new information leading to action, via selective interpretation. Although this process might be subverted and constrained by time, it still follows a recognisable series of cognitive stages - especially where the individual is confronted by a wholly new (unfamiliar) situation, i.e. no pre-determined response is available.

Kuligowski identified a four-phase decision-making process (see Figure B1-8). Each phase is subjected to external and internal factors. Her model is directly comparable to the work of Bryan [41], Canter [46]. Following on from the models examined above, a set of statements have been developed and these statements are grouped according to the aspect of the decision-making process that they influence and the factors that affect this process:

- **[Stage 1]** Factors that influence or represent aspects of cue processing.
- **[Stage 2]** Factors that influence the assessment of the situation and/or the risk.
- **[Stage 3]** Factors that influence the selection of a response.
- **[Stage 4]** Factors that influence or represent aspects of taking protective action.
- **[Stage 5]** Factors that influence or represent aspects of the overall process.

We use this structure here to compile key findings from the general literature (i.e. a set of behavioural statements), refined through examining research on residential properties, and then applied to multi-occupancy residential structures. These are now listed according to the stages identified. It should be noted that these statements may have multiple influences throughout the decision-making process and evacuee response. This is addressed later in Table B1-2 where the impact of each statement is charted across the five stages. The groupings are therefore indicative of the primary influence of each statement, rather than indicating that this impact is limited to a particular stage.

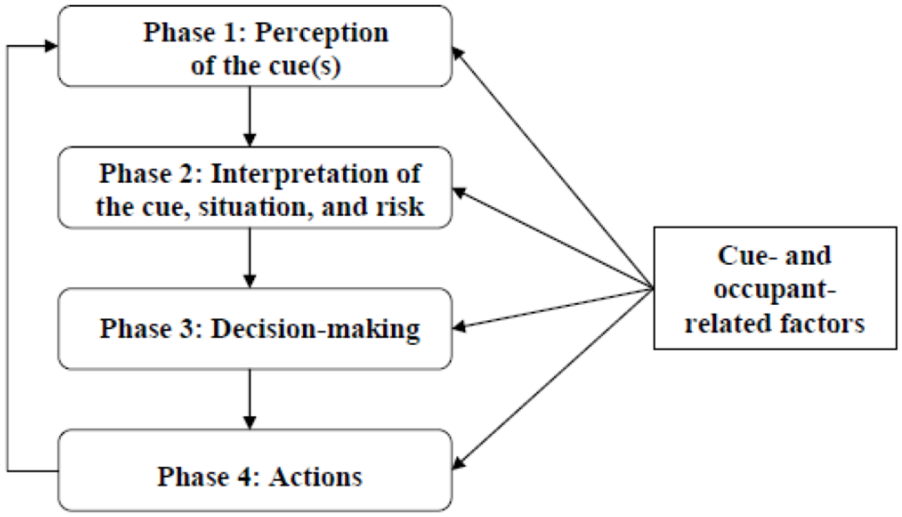

Figure B1-8 Four phase approach developed by Kuligowski [146]

Stage 1 – Resident Sensitivity to Information

A set of statements are provided numbered according the stage and the instance – [stage#.instance#].

[1.1] **The evacuee decision-making process is sensitive to external information.** However, information is not treated equally. The precision, credibility, clarity, comprehensiveness, intensity, and specificity of the information (in the form of external cues) will affect an evacuee's assessment of the information and their use of it in their decision-making process. Evacuating residents are unlikely to have first-hand information regarding the incident unless they were originally located near the incident (e.g. in the room of origin). Otherwise, they will likely have encountered remote cues (e.g. sound, smoke from another apartment), received secondary information from an alarm or other seeing other evacuating residents. Similarly, emergency responders face enormous challenges assessing the conditions given difficulties in collecting and interrogating the information available. For instance, establishing the precise location and severity of the incident, locating the evacuating population and assessing their condition. People actively interpret their surroundings. The perception and interpretation of the information available is coloured by the experiences and capabilities – they are not simply an objective/neutral recipient of the information available.

Resident Impact: Information available is dependent on location, procedural measures in place, status, sensory attributes, and environmental conditions. There is the potential to influence resident response by providing information before and during the incident. This might affect their initial response, the routes adopted, and tasks performed – depending on when the information is available. This is needed to fill the gaps in their understanding of the incident, the procedural measures in place *and the incident that they face. The precise nature of this impact will change according to the location and situation of the recipient residents.*

[1.2] Information will arrive from a source; e.g. the fire, an emergency responder, another resident, an alarm, etc. **The authority of the information's source (or perceived authority [49, 50]) will affect the perceived credibility of the information.** This influences the indicative power of the information – and the resident's perception of the information. It is likely that no staff/wardens are onsite to assist with the evacuation.

Resident Impact: The information shared should clearly identify the source of that material (e.g. emergency responders, local authority, etc.) to ensure that it is deemed authoritative. Where possible, the time/date of the information should be shared to ensure that the resident population know that it is current (or at least recent). This will influence the initial delay to commence evacuation. Given absence of staff and sophisticated notification, sources may vary in credibility.

[1.3] **The actions of other residents can act as external cues [63-65].** For instance, seeing other residents move to a set of stairs may suggest that a response is required and that those stairs appear a more viable and attractive means of egress. Nilsson identified that evacuating individuals particularly relied on the actions of others in the absence of other information from more authoritative sources.

Resident Impact: Precise impact influenced by the identify of, actions of and relationship with the adjacent population. When designing the procedural plan or notification system, it is important to know that when residents are not provided with information, they will seek it out elsewhere. It may be useful to provide opportunities to ensure visual access (e.g. door peepholes normally intended for security or access to security footage of people using the stairs, etc.). This will influence the initial delay to commence evacuation. The actions of other residents can affect the initial response, but also evacuee performance throughout the incident – both as a cue influencing the decision-making process and also through the resident act increasing demand for a resource and changing the conditions faced (e.g. affecting population density on a stair).

[1.4] **Some individuals exhibit hypervigilance that makes them particularly sensitive to certain cues.** This sub-population will be difficult to manage and inform during an evacuation. This might be affected by previous incidents (e.g. negative experience in previous incidents, evacuations, etc.), innate sensitivities, responsibilities and may be amplified by time pressures. It is difficult to know who precisely will be subject to such sensitivity in advance.

Resident Impact: Vulnerable residents (especially those with cognitive issues) may not be able to cope with the situation. Much as PEEPs are developed in public spaces, it may be useful for vulnerable residents to have buddies. This will influence *the initial delay to commence evacuation and may also influence route selection during their response.*

[1.5] **Previous experience of false alarms (for emergencies and general disruptions) can reduce sensitivity to alarm signal and reduce the perception that they imply a threat requiring a response.** The resident population may have experienced false alarms in their building (or in their apartment) depending on the location, connectivity, and maintenance of the system. In addition, the resident population may also have experienced false alarms elsewhere and import this experience to interpret the alarm sounding in the current situation.

Resident Impact: Exposure to repeated false alarms is likely to desensitise an individual to its message and increase the time it takes for them to initiate response. Detection and alarm systems of low standard / maintenance are more likely to activate. Large residential blocks are more likely to experience more false alarms (i.e. where an evacuation is not actually required) – given the larger number of residents present. Given this, alarm tests should be clearly advertised as such. The operational capabilities of local detection and alarm systems affect the safety of the entire building. A building-wide alarm policy provides several advantages, e.g. consistency, capacity to target messaging, etc. This will influence the initial delay to commence evacuation. However, it also makes false alarms building-wide should they occur.

[1.6] **Habituation (where a process or object has become routine in nature), focus and stress can narrow the perceptual field and reduce the information noted by an individual**. Not all available cues will be internalized and then used in the decision-making process. For instance, residents may not notice an emergency sign / exit next to a stairwell that they have walked past every day, given that it is always part of their experienced background and never used.

Resident Impact: May reduce the information perceived affecting the initial time to respond and awareness of route availability during the evacuation. It should not be assumed that residents will automatically be aware of or follow signage. Measures might be taken to ensure signage is more effective at grabbing resident attention (e.g. active / dynamic signage). Local devices might also be exploited if possible. This will affect the routes used.

[1.7] **Sensory impairments can inhibit the perception of cues**. Residents may have an existing impairment. For instance, partial blindness, deafness, etc. This is particularly the case given the social context and the demographic factors that might be present (e.g. the elderly, the very young, carers, etc.). However, sensory impairment may also develop because of the incident. For instance, the presence of smoke may obscure visibility. This will hinder evacuee movement and wayfinding. Such impairments may also be the result of temporary factors (e.g. intoxication, being asleep, etc.) that limit access to external information.

Resident Impact: We can expect a significant number of residents to have limited access to visual / aural cues. This will limit their situational awareness. This may influence the initial decision to evacuate and the resident awareness of (and access to) evacuation routes during the response.

[1.8] **Initial delays will be sensitive to proximity to the incident.** For those in the room/apartment of origin, fire cues will be more apparent and less ambiguous. These will likely lead to investigation – but will reduce the probability of a resident maintaining routine activities (i.e. break them from task attachment). The sense of urgency will be further enhanced through the sounding of an alarm – response is likely to be driven by protective actions rather than risk assessment (see [4.3]). However, away from the apartment of origin, residents will have less interaction with the fire effluent. If the alarm system is local to each apartment, they may also only have remote access to alarm signals. In both instances, these may be ambiguous – requiring investigation, confirmation and assessment of the threat posed. The availability of fire cues will be affected by the complexity of the space. **Content and clarity of the cue matters.** Eventually, the movement of other residents (and communication with them) may also act as a secondary cue (see [1.3]).

Resident Impact: Situational awareness will vary across the structure. This will affect the time for people to initiate evacuation actions and the routes that they choose to use. It is profoundly important that this is recognised – the provision of egress components does not guarantee that they will be used.

[1.9] **The activity and status of an individual at the time of the incident might limit access to the information around them and affect their interpretation of it.** For instance, residents may be asleep, having a meal, in company, etc. Their focus, attention and/or commitment to an activity might affect their ability to notice external information (e.g. alarm signals or smoke) and their willingness to disengage from their current activities.

Resident Impact: This will influence the initial delay to commence evacuation. It places additional weight on the notification system in place – to alert the population of the incident (grab their attention and potentially overcome issues presented by their status). This may need to be intrusive to interrupt routine activities.

[1.10] **The structure may house those from low socio-economic backgrounds**. This might align with lower maintenance and operational standards – affecting the installation and upkeep of alarm / detection systems. Such deprived surroundings may also be correlated with elevated health concerns (see [4.1]) that affect assessment and movement.

Resident Impact: Those living in deprived situations will likely place fire safety at a lower priority given the challenges faced and allocate care and resources accordingly. It is important that provisions provided do not place an additional burden *and that the residents are engaged with the logic and benefits (both to fire safety and beyond) of the provisions provided.*

Stage 2 – Assessing the Situation

A set of statements are provided numbered according the stage and the instance – [stage#.instance#].

[2.1] **Normalcy bias and optimism bias are commonplace**, i.e., people often think that nothing serious is taking place and that nothing bad will happen to them – unless exposed to obvious, credible cues. This means that unless residents are directly exposed to physical cues from the incident (e.g. that they are in the room of origin), they may need to be convinced of the existence, nature, and severity of the incident. Even then, residents will likely underestimate the severity of the incident and overestimate their ability to get to a place of safety. Individuals may then try and continue with their existing objectives (e.g. continue watching a TV programme, finish cooking dinner, etc.), requiring them to play down the significance or perceived risk of the external cues. In reality, evacuating residents may quickly be overcome by the conditions present. This contrasts with the smaller number of people who might be exhibiting hypervigilance and elevated anxiety (see [1.4]).

Resident Impact: This will influence the initial delay to commence evacuation. Residents may delay response in the false belief that the situation is less dangerous or that it is under control when it is not. Where fire cues are not present it will be necessary to convince residents that the fire is a threat to them that requires timely action.

[2.2] **Training / outreach / education will allow evacuees to define the incident more quickly and provide them with pre-determined viable responses.** Residents are likely to be unfamiliar with the safety measures in place and evacuation procedure required of them. Engagement with the resident population (familiarising them with the procedures, the protection measures, and the underlying logic behind them) will help ensure residents can identify when systems are compromised, what actions to take in response, and why these actions are necessary. Such outreach might involve demonstrations / exercises, meetings, media, etc.

Resident Impact: Less chance of a consistent training offer or documented procedure familiar to the resident population. This will influence the initial delay to commence evacuation, the routes selected, and the actions selected. Residents will not know by default when the fire is out of control or has compromised the building design. This may mean that they delay their response, move towards an incident, or move through smoke without full understanding of the significance of these actions. Guidance should be provided on what triggers denote such situations.

Stage 3 – Selecting a Response

A set of statements are provided numbered according the stage and the instance – [stage#.instance#].

[3.1] **People tend to satisfice rather than optimise**. In other words, they are more likely to choose an option that is perceived as "good enough" rather than the best option available. It is therefore important to ensure that the residents' default (first) choice in response to an incident – is sufficient to get them to a place of safety. This will short-cut the decision-making process and ensure that the desired outcome is considered.

Resident Impact: This will affect the response selected and the time to reach that selection. This will be reliant on the individual's capacity to identify a credible response. We want residents to quickly arrive at a good response. If prior outreach / education can provide them with such a response, then it may shortcut initial delays and encourage more informed use of the egress routes out of the structure.

[3.2] **The presence of smoke does not always preclude the use of a route**. Depending on the context, the presence of smoke alone may not indicate a sufficiently severe incident to prevent the use of a route. For instance, smoke in a stairwell may slow an evacuating resident down but may not prevent them using the route – especially if they are unfamiliar with the location of the other stair and of using the lift. The public's interpretation of fire effluent cannot be relied upon to ensure prompt response or expected / desired route use.

Resident Impact: This might affect the routes used. Residents may use smoke-logged routes especially if they are familiar to them – over other available but less familiar routes. It is important that residents are fully aware of the routes available and, ideally, their status to reduce the likelihood of them encountering dangerous and toxic conditions. The presence of smoke may act as an indication of a serious event (reducing initial response), but it may also make preparations more difficult depending on smoke levels at the time.

[3.3] **Training, education and / or experience may increase an individual's familiarity with the use of components / devices and subsequently improve the effectiveness of their use**. It cannot be assumed that residents will be willing or able to employ unfamiliar devices or components without prior instruction. For instance, the use of a fire extinguisher, an automatic awareness that stair doors need to be closed to maintain the conditions on the stair, etc. This follows on from the impact of training / experience on assessing the situation (see [2.2]).

Resident Impact: Training may familiarise people with the equipment available and the use of it. Training provided to residents (or a sub-population) may not necessarily be disruptive but focus on local activities and understanding (e.g. exit operations, *alarm operation, extinguisher locations, etc.). Residents are unlikely to have received detailed training. This will influence the initial delay to commence evacuation and use of egress provisions in place (e.g. the emergency lift, if one is in place).*

[3.4] **Pre-event commitment to a particular activity may cause individuals to decide against taking protective action**. For instance, residents may be having dinner, having a gathering, watching a film, etc. Their commitment to this pre-arranged event may encourage them to (non-consciously) underestimate the severity of the incident or avoid a rational assessment of the situation to reach their existing goal.

Resident Impact: This will influence the initial delay to commence evacuation. In other building types it might be possible to end routine activities (e.g. shutdown computers at work). This will likely not be possible in residential properties. It may also encourage a resident to perform additional non-emergency actions before or during evacuation. This places additional weight on the notification system in place – to alert the population of the incident (grab their attention). This may need to be intrusive to interrupt routine activities.

Stage 4 – Affecting the Response

A set of statements are provided numbered according the stage and the instance – [stage#.instance#].

[4.1] **People have different abilities that influence action selection**. These include differences in sensory (visual, hearing, etc.), cognitive (processing, retention, comprehension, etc.), education levels, language skills and physical (mobility, dexterity, agility, fitness, etc.) abilities. These differences will influence the actions considered by a resident and the final action selection made (see Figure B1-9). For instance, a mobility impaired resident may not feel that they can descend a long staircase; a visually impaired resident may not feel able to navigate their way unaided along an unfamiliar route; someone with limited English may not understand instructions provided to them. In these cases, these residents may avoid (or delay) taking these actions. The potential impact of the impairments present in the population is shown below. It is apparent that different impairments will influence various aspects of the evacuation process. This insight allows us to better account for vulnerable populations in the design process. For instance, vertical evacuation may be challenging for certain populations. We might then determine the expected proportion of the population who suffer from a movement impairment and then ensure that more accessible egress routes are provided. The resident demographic profile will likely include an elderly sub-population (subject to clusters of movement impediments), young children, those with innate movement / sensory impairments, pregnant women, and those with long-term health concerns. This implies that there might be a sizeable sub-population who might take additional time to prepare and the move to a place of safety. This sub-population may also affect those with them (e.g. family, carers) and those evacuating near to them (e.g. behind them on the stairs).

Resident Impact: Residents will have access to different sets of information, process this information differently and act on it differently. These differences may be present at the outset, or evolve during the incident (e.g. injury, fatigue). This variation will increase with project demographic changes. This will affect the time for residents to respond, the actions performed, the routes used and the speed at which people are able to move. It is critical that such variation is accounted for in preparatory and procedural measures – to ensure that the physical measures in place are used effectively.

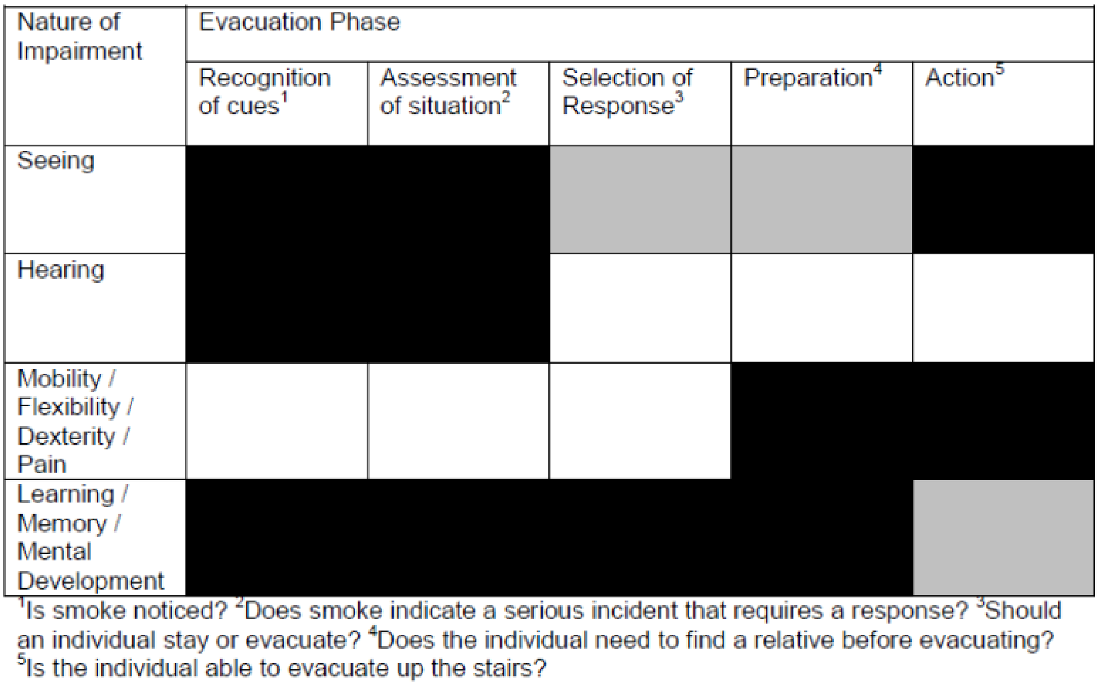

Figure B1-9 Relationship between impairment and evacuation performance [90]

[4.2] **People seek information in situations where information is lacking or incomplete**. Resident response is very unlikely to involve them moving directly to a place of safety – especially if they are not in the room of origin. Instead, they will typically confirm the nature of the incident to assess it and determine the required response. This may involve them looking for additional cues to support their assessment of the situation – potentially leading them towards the seat of the incident. If the resident is not in the room of origin, then they may not have early access to fire effluent – instead relying on secondary cues such as an alarm or the actions of other residents. This space will be compartmentalised, reducing visual access to information (including the original incident). This may then lead to residents seeking out information (e.g. leaving their apartment, looking out the window, etc.), especially in the absence of authoritative notification.

Resident Impact: This will influence the initial delay to commence evacuation. Information seeking is caused by gaps in resident situation awareness. Within an apartment, this will likely take the form of moving to the room of origin. This will be difficult to affect. However, for those elsewhere in the structure, sharing credible/authoritative information with the residents may reduce their need to investigate and seek information by moving towards the apartment of origin. It may also encourage residents to perform additional information seeking actions during their evacuation.

[4.3] **People engage in protective actions before they initiate a movement towards safety.** Residents may not immediately move to a place of safety, even once they are convinced that an incident requires them to go there. They may perform several preparatory tasks prior to this; for instance, securing their property, getting dressed, closing doors / windows, helping to protect others from harm, etc. They may also engage in actions during the response that affects their movement to a place of safety (e.g. filming the events, etc.).

Resident Impact: This will influence the initial delay to initiate evacuation. Residents will prepare themselves for the evacuation (e.g. get dressed), collect others and secure the property. This is a given. It is important that we get them to initiate such activities as quickly as possible and reduce their engagement in less fundamental activities.

[4.4] **People move towards the familiar.** This includes other people, places, and things. Affiliation influences the interaction with other people and the physical environment. It is expected that residents will have an attachment to their apartment, its contents, and fellow occupants. The use of a space and the relationship between those using the space can influence movement during an emergency. Social groupings will typically remain together during an evacuation – or may reform prior to or during it – therefore influencing the routes adopted. In addition, people will seek to use routes with which they are familiar and confident. It typically takes staff intervention or a loss of other options before evacuees engage unfamiliar and untested routes. Should severe smoke block infringe on familiar routes, evacuees might be forced to evacuate along familiar-smoke-logged routes or use new unfamiliar routes. Evacuees can become disoriented in both situations. Residents will likely be familiar with a few well-used routes into the building. This can become more problematic should they typically use lifts to access the structure, and these are not available during the evacuation. It cannot be assumed that residents will know all the stair locations in their building if they do not use them regularly.

Resident Impact: This will influence the routes used during the evacuation and the tasks performed during this movement, including searching for significant others. Residents need to be made confident in the routes available and/or receive authoritative instructions to make use of less familiar routes – otherwise they will default to the familiar.

[4.5] **People may re-enter a structure**, especially if there is an emotional attachment to the structure / contents, role responsibilities and / or the inhabitants. Residents will have a significant attachment to property, contents, and inhabitants. Residents may re-enter the room of origin or the apartment of origin – depending on the precise location and severity of the fire itself. Residents may have become separated from socially significant others during the evacuation and then re-enter the building to locate them.

Resident Impact: Residents may re-enter their apartment or re-enter the building. This makes evacuation conditions more complex; e.g. bidirectional movement on the stairs, etc. affecting the flow of people evacuating.

[4.6] **Residents are more likely to attack the fire or attempt to mitigate conditions than those with a lesser emotional attachment to the space.** This means that (should they wish to fight the fire or conduct other ad hoc measures) individuals will likely have to perform several preparatory tasks (e.g. finding an extinguisher), before moving towards the room of origin and spending time in close proximity of the fire itself.

Resident Impact: Where possible, the local mitigation of fire conditions may prevent fire development (where automatic suppression systems are not in place). However, it is critical that residents can identify conditions that can be addressed – and do not place themselves in undue danger by remaining near a fire that is out of control. At the very least, this activity delays their evacuation movement.

[4.7] **Appearance of a route can affect its use.** The design, upkeep and lighting of a route can influence whether someone sees it as a viable means of egress.

Resident Impact: Where stairwell conditions are not maintained, residents may not be willing to use them during an evacuation.

Stage 5 – Influencing the Overall Decision-Making Process

A set of statements are provided numbered according the stage and the instance – [stage#.instance#].

[5.1] **People will typically behave in a rational AND altruistic manner**; panic is rare. Evacuees will typically try and cope. Evacuees are typically information-dependent. Even if able to reach a place of safety, the individual’s capacity to do so is affected by the information available. This information is used to form their picture of the situation that determines how they assess the current situation. This picture, along with previous experience, governs their response selection. However, the selection of a response is not independent of the status of those around them. Evacuees will very rarely deliberately undermine the efforts of another evacuee in their own interests and are more likely to aid others in need, even if they are not familiar to them. People are action- and goal-oriented; however, these goals often include the well-being of others around them - especially socially significant others.

Resident Impact: Residents will try and deal with the problem faced [241-242]. Their capacity to do so will be affected by their situation and their innate abilities. However, it will also be affected by the information that is available to them. The provision of such information is an opportunity to reduce the time to initiate movement, effectively use the routes available and reduce actions that prolong the time to reach safety.

[5.2] **Uncertainty, time pressure and volume of information can increase stress levels that impede the decision-making process.** At moderate levels, stress can encourage an urgent response. However, as stress levels increase, the likelihood of missing external cues, misinterpreting the significance of cues, or selecting an inappropriate response becomes more likely. The impact of this may become more significant as the volume of information increases with potentially critical information (e.g. the location and severity of the fire) being missed. This becomes more challenging when information is inconsistent or conflicting.

Resident Impact: Information will arrive from multiple sources – both formal (e.g. alarm system) and informal (e.g. social media). It is important that efforts are made to ensure that formal information is concise, simple, available, and authoritative. Incomplete, inaccurate, or inconsistent data might delay response or undermine subsequent decisions (such as route selection).

[5.3] **Pre-incident experience influences how external cues are processed, how the situation is defined and how protective actions are selected.** For instance, if a resident experienced a real incident previously then this might make them more likely to interpret the cues as indicating a real incident. Experience may also be gathered second-hand (e.g. from the media or from other people who have been in a fire). Behaviour has an historical context.

Resident Impact: The history of a building should be considered when designing procedural measures that make use of the physical provisions in place. Resident experience might affect both the assessment of new cues and decision-making before and during an evacuation.

[5.4] **Evacuation (or any protective action) is a social process**. Groups may already exist and are likely to form during an emergency response. This builds on the affiliative behaviours [4.4], the importance of the actions of other evacuees [1.3] and the continual need to acquire information to inform the decision-making process [1.1]. This can have enormous implications on initial response (e.g. families might respond when the person taking the longest time to prepare is ready) and movement (e.g. a social group may move along the stairs at the speed of their slowest member). This may also extend to people seeking refuge together in the form of convergence cluster (i.e. multiple social groups gathering together in a single apartment to seek solace).

Resident Impact: We cannot expect residents to evacuate independently of social groups. Families will evacuate as units, where possible. This fact should be built into any emergency plans in place. The recognition of such social realities may also better engage residents in the development and implementation of any emergency plans. An individual's response might therefore be affected by the identity and capabilities of those nearby.

[5.5] **Social rules and roles in place prior to a fire event form the basis of those employed during the event**. In other words, people's role before the incident will influence their performance during the event. Resident social groups will have their own structure that underlies who influences the group's response [5.4]. People do not automatically adopt a new role during an incident. While the situation can be resolved using the current social norms and roles, it likely will be. Figures of responsibility and credibility (e.g. emergency responders or well-regarded neighbours) will likely exert influence over the resident decision-making process given their perceived expertise and authority (even though they may be unfamiliar as individuals). It is otherwise difficult for strangers to reliably influence the decision-making process of others without perceived expertise or authority. Role-related rules guide behaviour.

[5.6] **Behaviour is affected by setting.** In conjunction with the individual's role, the rules and responsibilities associated with that role in the setting faced will influence the response selected. This might also be affected by the culture norms and practices present. Therefore, a patriarchal family might follow the guidance of the male head of the family irrespective of their competence or capabilities, etc.

Resident Impact: Most social structures have a basic hierarchy within which individuals influence the actions of those around them. This may provide advantages or disadvantages depending on the actions of those influencers. It is important that such 'influencers' are informed – of the procedure and the situation – as they may then have a local role of responsibility that affects those around them.

[5.7] **New norms may emerge where existing normative structure is incapable of addressing the new situation**. For instance, people may break down doors to access routes where no others are available.

Resident Impact: Residents should not feel that prohibitions in place during routine times affect their evacuation. Doors may normally be considered off limits, etc. Residents should be reassured that once an alarm sounds (or some other trigger has been enacted) then they will not be held accountable for newly derived actions. This may otherwise delay their initial movement or affect the routes deemed to be available.

These last stages [5.3-5.7] highlight that the space is a people movement system (see Figure B1-10). This system can be used according to several movement phases: people arrive (ingress), use the space (circulation) and then leave the space (egress). The way in which people enter, use, and leave the space is highly coupled – people become familiar with routes, etc. In addition, the space may be used according to several distinct procedural regimes: safety (e.g. getting people to a place of safety during an emergency), operational procedures (e.g. using communal spaces, services, living areas) and security (e.g. limiting access to certain areas to prevent criminal activities). The uses of space and the various procedures employed can exist in the same space and time - increasing the complexity of resident behaviour (see Figure B1-11). However, understanding the relationship between these various modes of use and procedures can indicate opportunities for procedural intervention.

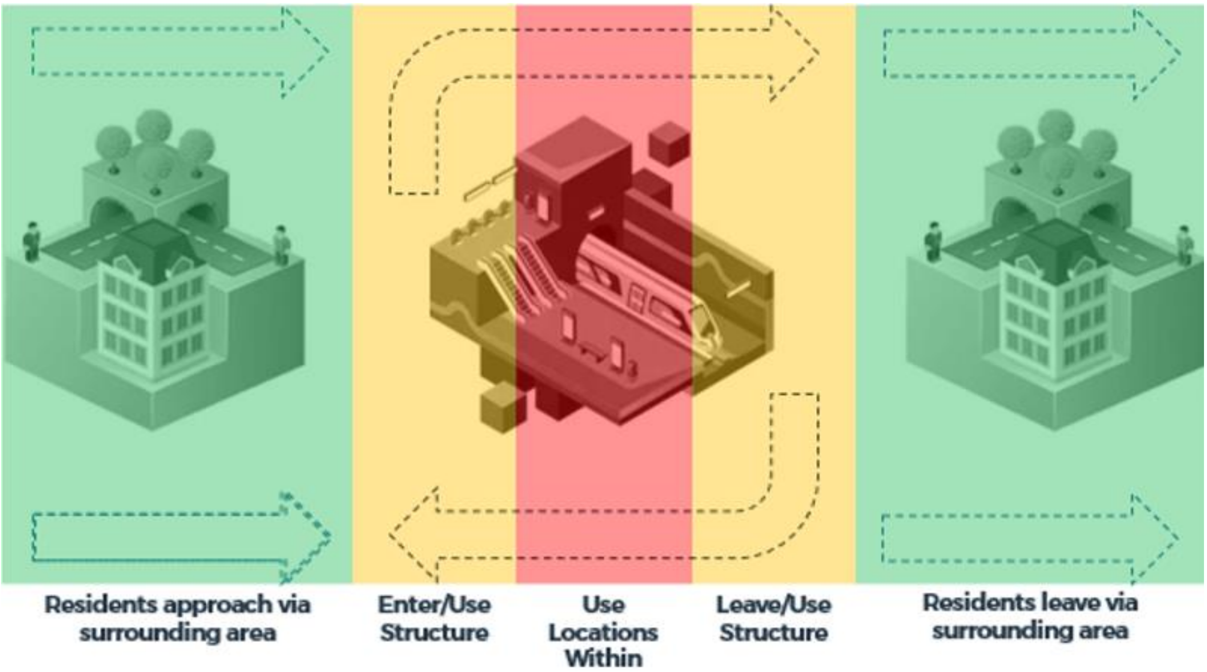

Figure B1-10 Resident use of space

(ICE)		Procedural Activities (SOS)		
		Safety (S)	*Operation (O)*	*Security (S)*
Phase of Movement	*Ingress (I)*	Fire Department Arrival	Ticketed Access	Ensuring appropriate exits are used for ingress
	Circulation (C)	Crowd management	Providing information on facilities and services	Managing Access to areas within the structure
	Egress (E)	Managing emergency evacuation	Leaving the building	Ensuring appropriate exits are used for egress

Figure B1-11 Interaction between type of movement and procedural activities

B1-4 Mapping physical impact to modelling levers

Previously in Appendix A1 we identified a range of physical measures that affect a fire incident and the resident response. This allowed a simple matrix to be developed outlining what aspects of evacuee performance these measures influenced. The matrix is shown in Figure B1-12.

	Active measures							Passive measures			
	Detection	Audible alarm	Visual alarm / beacons	Staff / resident intervention	Emergency lighting	Suppression	Smoke control	Fire separation	Construction materials	Structural design	Signage / wall plans
Report section	4.1.1	4.1.3	4.1.4	4.1.5	4.1.6	4.1.7	4.1.8	4.2.1	4.2.2	4.2.3	4.2.4
Pre-evacuation											
Recognition	√	√	√	√							
Preparatory actions – physical		√	√								
Preparatory actions – awareness		√	√	√	√						√
Evacuation movement											
Wayfinding / route selection		√	√		√					√	√
Physical travel			√							√	

	Horizontal egress					Vertical egress				Firefighting		
	Internal dwelling arrangement	Corridors	Doors	Balconies	Refuge points	Stairs	Evacuation lifts	Movement devices	Other	Fire mains and hydrants	Firefighting lifts	Smoke clearance
Report section	4.3.1	4.3.2	4.3.3	4.3.4	4.3.5	4.4.1	4.4.2	4.4.3	4.4.4	4.5.1	4.5.2	4.5.3
Pre-evacuation												
Recognition												
Preparatory actions – physical												
Preparatory actions – awareness					√							
Evacuation movement												
Wayfinding / route selection	√	√	√	√	√	√	√	√	√			
Physical travel	√	√	√	√	√	√	√	√	√		√	

Figure B1-12 Mapping relationship between physical measures and evacuation performance

This conceptualisation differs slightly from the 'levers' open to modellers when representing evacuee response – a key activity in subsequent tasks of this project. However, these can be mapped. The key modelling 'levers' include:

- [D] Initial delay time – the time to commence movement to another location
- [TS] Travel speed – the maximum unimpeded walking speed,
- [FC] Flow conditions / constraints – the relationship between speed/flow and population density.
- [RA] Route availability –routes available to the evacuees,
- [RU] Route usage/choice –routes selected by evacuees.
- [BT] Behavioural tasks performed after initiating movement that might incur delays and affect the people / objects around them.

The mapping between physical impact and general (modelling) impact is shown in Table B1-1.

Table B1-1 Mapping between physical and modelling measures

Physical impact on performance	General impact on performance
Recognition Preparatory actions	Initial delay time Behavioural tasks
Route selection	Route availability Route use
Physical travel	Travel speed Flow conditions

This mapping is necessary as we will need to map the physical factors on performance and decision-making elements on performance. Effectively, these ‘levers’ will be varied to generate different scenarios – along with variations in the building design, population demographics and the incident itself.

An initial assessment of how these factors might be represented within a simulation tool are described in Table B1-2. Table B1-2 outlines the potential impact of each statement (indicated by the Stage#.Instance number – e.g. 1.1, 2,2, etc.), on each of the five behavioural stages – in essence, how the specific element being described affects evacuee response. This will provide an initial assessment of how these factors, as applied to residential blocks, might be represented in the selected simulation tool and aid in the development of simulation scenarios to be defined later in this work – after the surveys of resident perception have been completed.

Table B1-2 Representation of behavioural statements as model levers

Behavioural stage	Stage / instance	[D] Delay	[TS] Travel speed	[FC] Flow const.	[RA] Route avail.	[RU] Route use	[BT] Beh. tasks
Sensitivity to information	1.1	Variable				Variable	Variable
	1.2	Variable				Variable	Variable
	1.3	Variable	Variable	Variable		Variable	Variable
	1.4	Variable				Less Efficient	
	1.5	Longer					
	1.6	Longer			Reduced	Less Efficient	
	1.7	Longer			Reduced	Less Efficient	
	1.8	Variable					Variable
	1.9	Longer					
	1.10	Longer	Slower				
Assessing the situation	2.1	Longer	Slower				More
	2.2	Variable				Variable	Variable
Selecting a response	3.1	Variable	Slower			Variable	More
	3.2	Variable	Slower			Less Efficient	
	3.3						Reduced delays / More effective actions

Behavioural stage	Stage / instance	[D] Delay	[TS] Travel speed	[FC] Flow const.	[RA] Route avail.	[RU] Route use	[BT] Beh. tasks
	3.4	Longer					Increased delays
Affecting the response	4.1	Longer	Slower	Reduced Flow	Reduced	Less Efficient	More / Increased delays
	4.2	Longer					More / Increased delays
	4.3	Longer					
	4.4					Less Efficient	
	4.5			Reduced Flow		Variable	More / increased delays
	4.6	Longer					More / increased delays
	4.7				Reduced	Less Efficient	
Influencing the overall decision-making process	5.1	Variable	Slower	Variable	Variable	Variable	More
	5.2	Slower			Reduced	Less Efficient	More
	5.3	Slower			Reduced	Less Efficient	More
	5.4	Variable	Slower	Variable	Increased	Variable	More
	5.5	Variable	Slower		Variable	Variable	Variable
	5.6	Variable			Variable	Variable	Variable
	5.7				Variable	Variable	Variable

B1-5 Resident decision-making: Compilation of factors and actions

As noted by several researchers [142, 243, 254], in reality resident response is formed from exposure to external information, the assessment of existing and newly perceived information – based on a formed situational awareness and risk perception, the selection of a response and then the execution of this response.

Here we focus on the most tangible elements of this process (external cues, external factors that affect performance, internal factors that affect action selection, and resident actions). This focus allows us both to characterise scenarios, model the underlying factors (especially given that most current simulation tools do not comprehensively represent the decision-making process) and suggest areas of interest in the surveys to be conducted (see Figure B1-13).

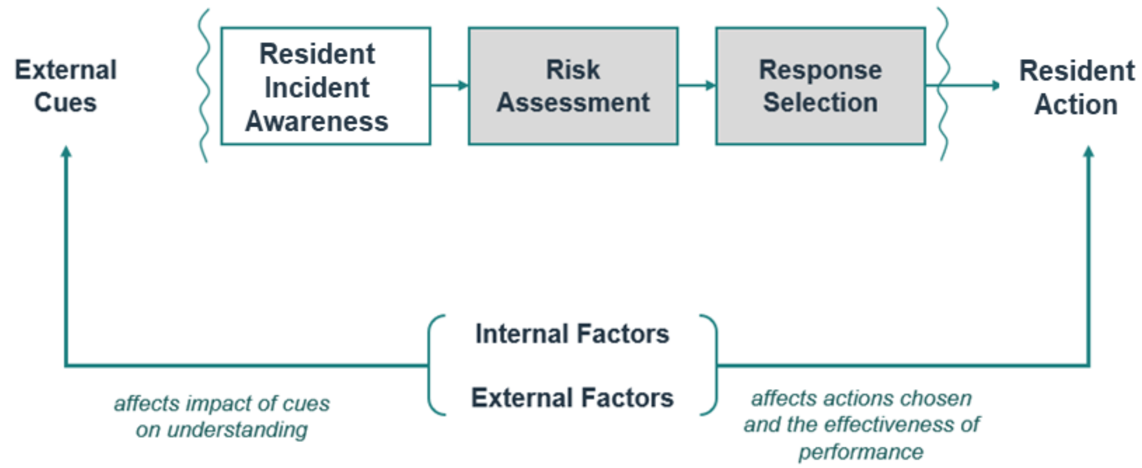

Figure B1-13 Abridged process of evacuee decision-making

In Figure B1-14 and Figure B1-15 is a compiled set of:

- External cues that affect resident awareness
- Elements of resident awareness
- External factors that affect resident performance
- Internal factors that affect resident awareness / performance
- Resident actions deemed possible in fire incidents.

These are derived from general fire sources, sources specific to resident/dwelling fires and sources describing resident evacuation in multi-occupancy structures [1-273].

The intention of this list is to help inform future iterations of the survey design (e.g. prompting the inclusion of external cues or possible actions in questions) and the types of agent actions that might be addressed in the simulated scenarios.

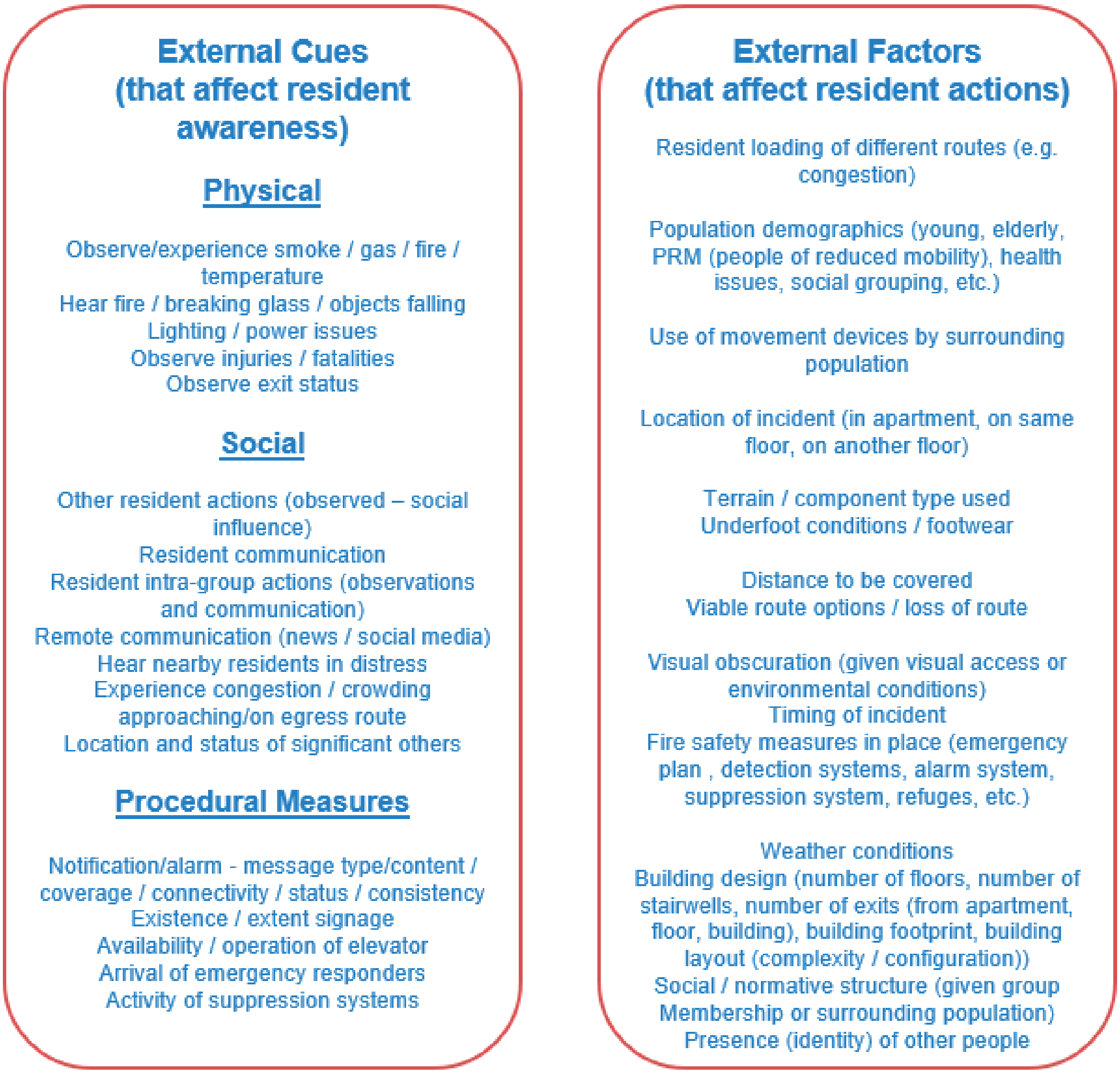

Figure B1-14 Derived external elements that affect resident decision-making during multi-occupancy fire emergencies

Resident Incident Awareness

Incident existence
Incident type
Incident location (absolute / relative)
Incident severity
Incident status (whether it is uncontrollable, being addressed, compromised design)
Threat posed to individual / sig. other
Onsite provisions to address incident/conditions

Residents Internal Factors (that affect resident actions)

Location within building
Visual access to incident given location
Sensory / physical / cognitive existing impairments
New impairments acquired during incident (e.g. injuries, fatigue)
Individual attributes (age, gender, Fitness, existing impairments, etc.)
Previous experience (e.g. false alarms, previous incidents)
Previous fire safety training / outreach
Role (within home / structure, resident / visitor)
Social group membership
Encumbrance (e.g. belongings)
Activity at time of alarm
Status at time of alarm (e.g. awake / asleep, sober / intoxicated / medicated)
Familiarity with building layout (e.g. resident or visitor)
Understanding of required response (according to plan)

Resident Actions

Routine Actions / Task Attachment

Enter building / leave building
Continue routine activities in apartment (e.g. sleep, social activities / gathering, work, bathing, eating, etc.)
Continue routine activities in building (e.g. laundry, refuse, communal activities, etc.)

Emergency Actions

Search/seek (information / location of incident / people / equipment / exit / assistance)
Receive assistance
Wait (for information, rescue)
Personal preparatory actions – (gather belongings, secure room / apartment / environment, locate/gather others, locate FF equipment, close/open windows, close/open doors)
Investigate incident
Make call (public - inside/outside building, emergency services)
Address incident (e.g. fight fire)
Record incident (e.g. phonecam)
Evacuate – to a remote place of safety (inside / outside structure)
Local move – away from immediate danger
Force door / window / climb over debris
Re-enter apartment / re-enter floor / re-enter building
Call/use elevator
Appraise conditions / situation
Deliberately observe fire / deliberately observe others
Warn others (in apartment, on floor, in building)
Raise alarm
Attempt rescue / provide assistance
Communicate (in person / on phone)
Move through smoke

Figure B1-15 Derived resident elements that affect decision-making and response during multi-occupancy fire emergencies

B1-6 Resident decision-making: Development of simple process

A simple decision-making process diagram is derived from the conceptual models discussed earlier and the material presented in the previous sections (see Figure B1-16). It represents an attempt to represent the evacuee sensitivity to the information available; the fact that a process is typically required; that this process is affected by individual, physical and social traits; and this process ends in a set of potential actions.

This is primarily developed to help structure the modelling process and as a companion to the various behavioural statements and the elements identified as influencing resident response.

The intention is then to:

- Help ensure logically coherent (and internally consistent) scenarios to be modelled – given current expectation and proposed changes to the physical / procedural recommendations made.
- Provoke discussion to finalise survey design to ensure that the content can provide (a) standalone insights in resident perceptions of building design and procedural measures in place and (b) inform the model scenarios.
- Enable the behavioural statements and derived factors to be co-located with different areas within the building space.

The impact of the elements discussed will vary according to a range of situational factors. A simple way of compiling such factors is according to resident location and the impact this has on the cues available, situation, proximity to incident, and social units. An example of such a structure is shown below. A version of this will be needed when developing the model scenarios and establishing the response of resident agents in the building design given the conditions faced.

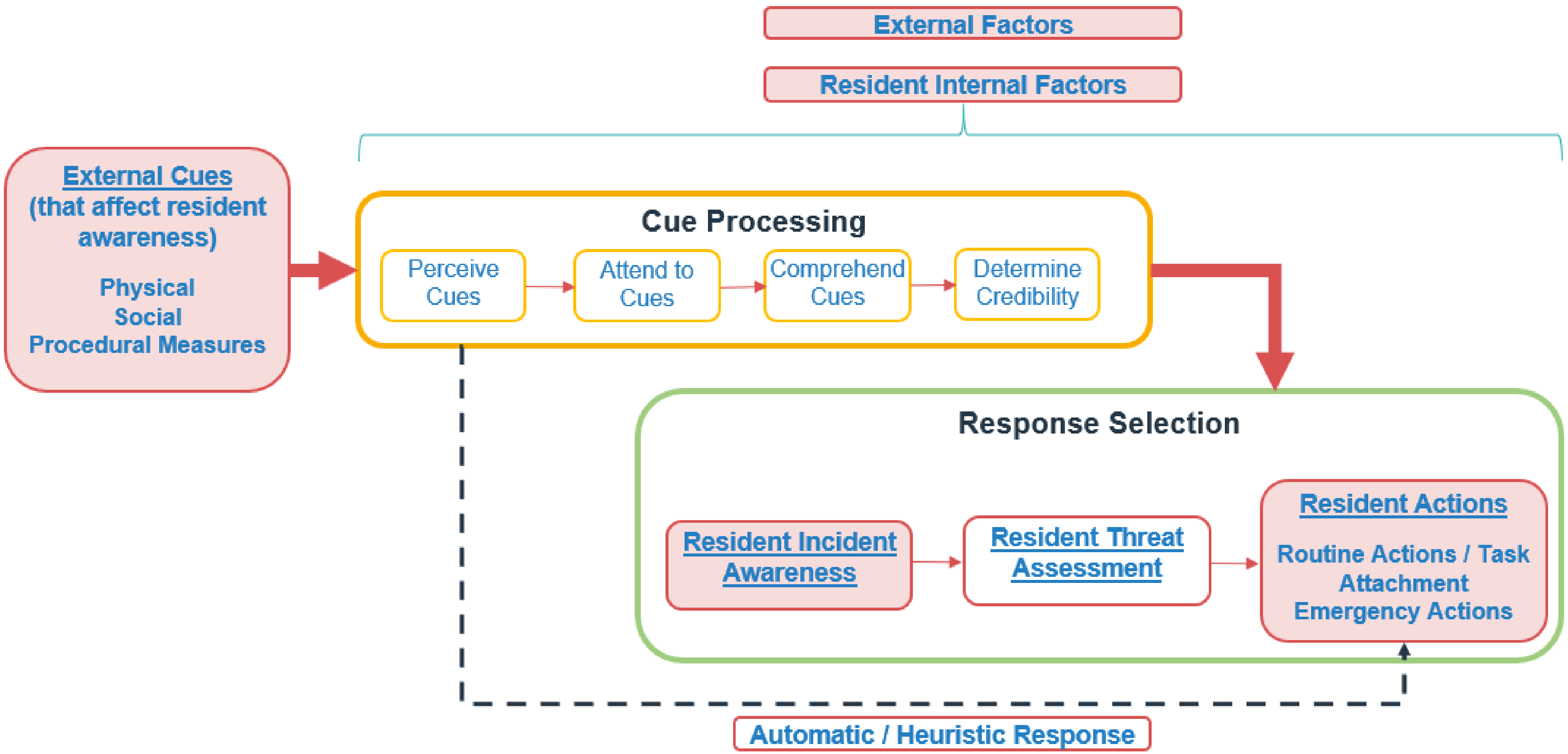

Figure B1-16 Derived resident decision-making process designed to structure elements derived from resident evacuations and cater for general behavioural statements

B1-7 Implications

The goal of this brief report has been to establish a conceptual understanding of expected resident decision-making (and therefore performance) during evacuation and to identify the factors that influence these decisions. The involved reviewing research literature and case studies on human behaviour during emergency evacuations that related to high-rise residential buildings. The conceptual model of evacuee decision-making during residential fires is intended to complement the matrix of physical factors that might influence evacuee performance (outlined in Objective A1: Establish building design principles underpinning evacuation strategies) and survey findings to be developed in Objective B2 – to produce standalone insights into the evacuation process and to inform the design of scenarios to be modelled as part of the performance assessment using evacuation models (see Figure B1-17). It will also provide a benchmark against which evacuation models might be compared to determine their suitability for use in the performance assessment process. This produces insights into the physical environment of the evacuation and the way evacuees cope with this environment – to inform the modelling of representative scenarios.

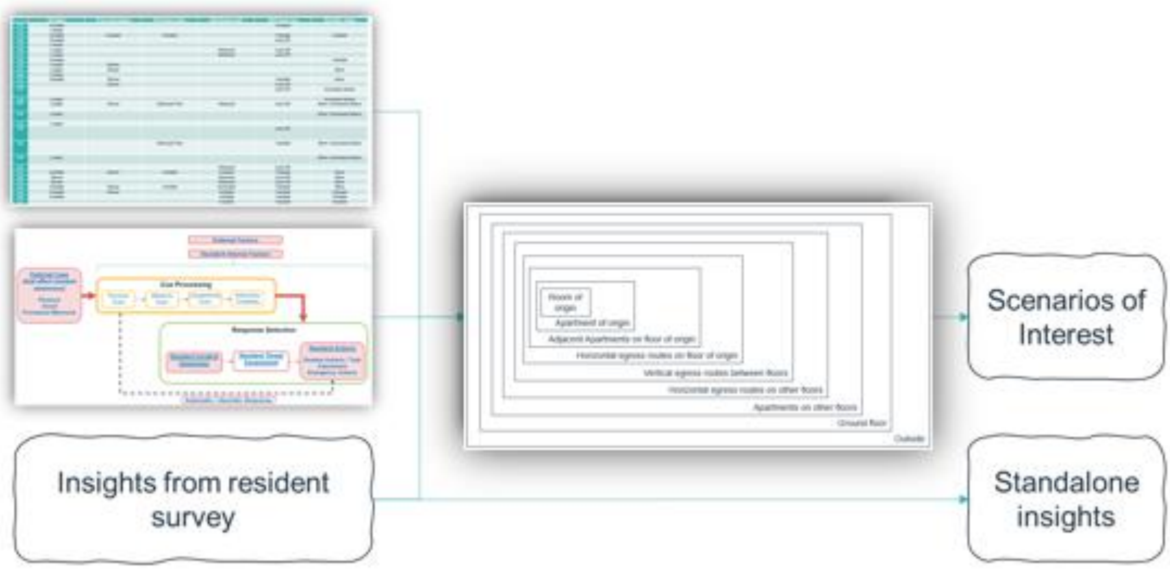

Figure B1-17 Structure of the work described in this report

The conceptual model has several implications for an assessment of evacuee response and its representation within an evacuation model. These are summarised below with modelling implications outlined (derived from Table B1-2):

- **The importance of situation awareness in the decision-making process.** This information might be derived from the emergency (e.g. not part of the procedural response), the local response to it (e.g. the actions of others) or might be managed and disseminated as part of the procedural response (e.g. via notification systems, staff, signage, etc.). The information available will differ between scenarios, across populations and over time. It cannot be assumed that all people initially have the same awareness of what to do in response to emergencies (e.g. prior understanding), the current status (situational awareness), or the appropriate response given this status. This means that simply providing physical infrastructure (e.g. stairwell, fire protection measures, etc.), does not guarantee that they will be used as intended. Procedural measures present an opportunity to fill gaps in situational awareness across the resident population. *This might be represented within a model by varying the response times of individuals and selected response in accordance with the scenario being examined and their location within the building being examined.*

- **This decision-making process is often accompanied by preparatory actions enabling people to disengage from their actions when they first became aware of the incident, confirmation of the new information, or sharing of this new information with others.** *In all instances, there will be a delay between initial cues and purposive response to the new information. This might be represented by initial delays reflecting variation in the time for different resident groups to initiate movement to a position of safety.*

- **A range of responses (protective actions) may be available.** Residents will have access to different sub-sets of these protective actions depending on their capabilities, their location in relation to the incident, the abilities of those in their social group and the time at which they initiate movement*. This variation might be represented in the form of different scenarios or by varying evacuee response within particular scenarios.*

- **Residents will not have the same awareness of the resources available**. At its most basic level this means that residents will not necessarily use the most direct route to a place of safety. *This can be represented by varying the precise routes adopted to reach a target location (either through a sensitivity analysis, or through derived the impact of familiar on route selection).*

- **These actions will be performed to varying degrees of effectiveness** – given the different situations faced by residents, the response selected and their individual capacity to execute this response. *This variation might be represented by applying a coefficient to expected performance levels (e.g. a factor that reduces stair movement rates to reflect a movement impairment, etc.).*

- **The decision-making process is not a one-off activity** but reflects a highly iterative and adaptive process of evacuees to cope with the new situation faced. As such, it may be that actions evolve during the evacuation or that their performance level changes during the evacuation. This might be represented by changing performance levels (e.g. travel speeds reducing given fatigue) or actions changing (e.g. evacuee direction of movement changing given the loss of a route). *This might be represented by performance levels changing during a scenario or delays being incurred at certain points during the evacuation process.*

The key finding from this brief review is this: it cannot be taken for granted that physical infrastructure is used, is used effectively and efficiently evacuating residents. These evacuees negotiate the environment based on partial information and limited resources. Procedural measures have a critical role in aiding the use of the available fire protection measures within the physical infrastructure. To adequately model the resident evacuation from representative building designs it is important to capture the sensitivity of response to information, the impact of this decision-making process on resident response and the support provided by the procedural measures in place.

B1-8 Next steps

The work outlined here and the survey work to be conducted can be applied to develop scenarios of interest in sufficient detail that they can then be modelled using the selected simulation tool (see Figure B1-18). The information/external conditions will vary according to location – which then determines the cluster of factors present. The scenarios will be formed from these factors. These factors (and the values that they adopt for each scenario) will deliberately reflect the level at which guidance operates so that the results produced provide actionable insights.

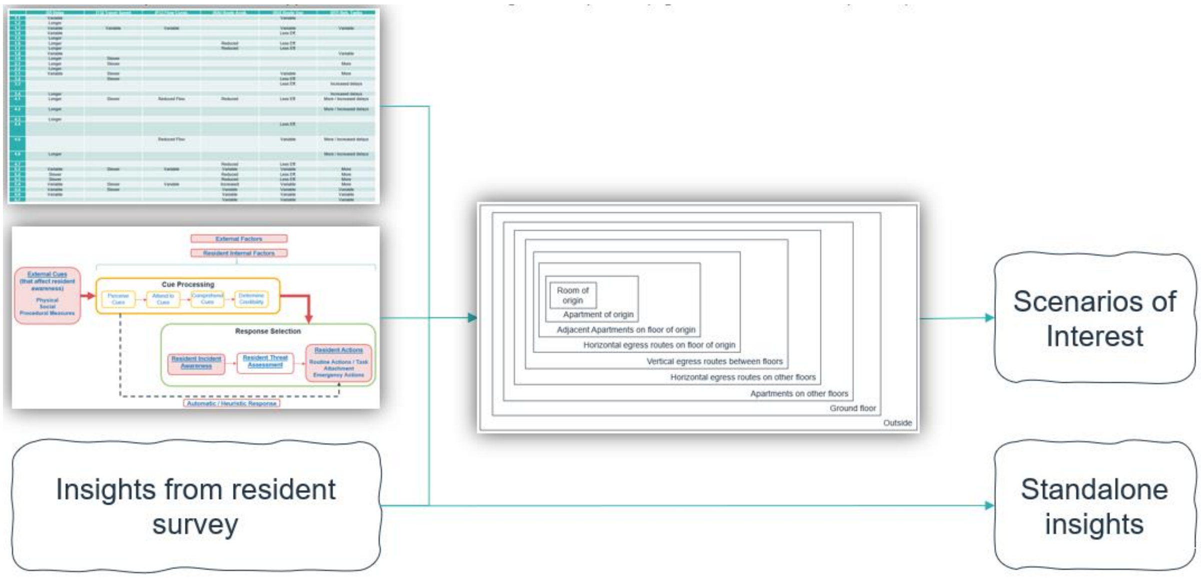

Figure B1-18 Scenario generation

- The model developed here will feed into subsequent tasks in this project. These include:
- Apply the tools developed here to example case studies to demonstrate their effectiveness at capturing key factors. This will enhance our confidence in their use in later tasks.
- Use the tools developed here to inform survey design iterations. We will hold an internal discussion with the project consortium to derive implications of the findings – gaps, factors that need to be further developed. This discussion will feed into the survey design and into our interpretation of the results produced.
- Develop a provisional description of the scenarios to be examined using the simulation tools. This description will be expanded after the survey is completed and additional insights are produced. The representation of the scenarios will reflect the key findings of the analysis (mapped onto the model

levers). This representation will account for differences in the conditions throughout a structure and how these might evolve over time (see Figure B1-19).

- Conduct a provisional examination of simulation tools available to establish which of them can represent necessary ‘levers’, resident performance and expected conditions, given the findings here.

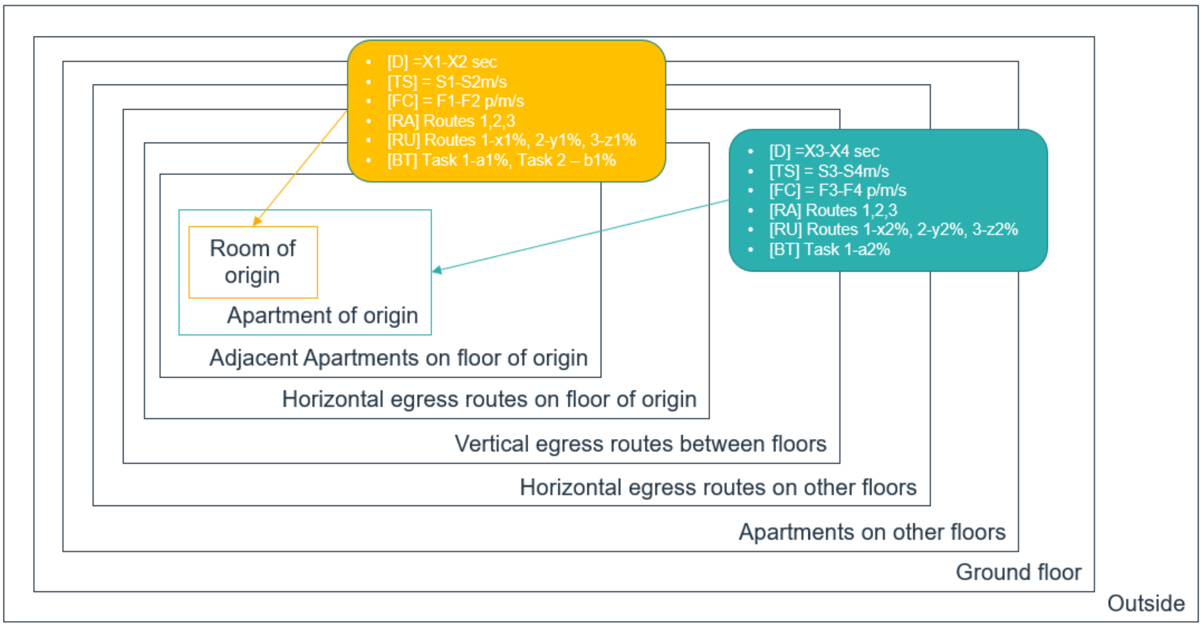

Figure B1-19 Representation of the conditions across time / space within each scenario

B1-9 References

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