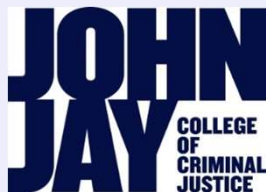


Designing and Managing the Movement of Occupants during Fire Emergencies in Tall Buildings

A Simple Decision Model

Tall Building Fire Safety Network
4th International Tall Building Fire Safety Conference
London, 20 – 22nd June 2017

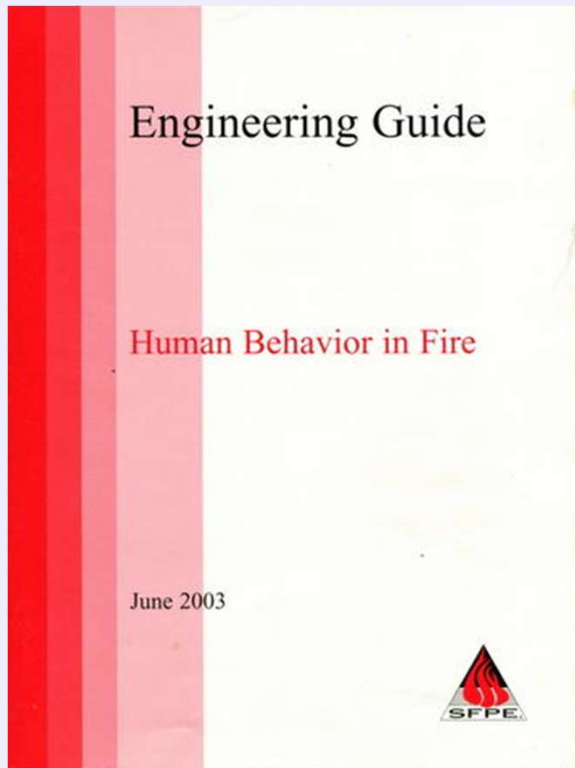
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Existing guidance is too general

- Typically lists of planning considerations, but little help in deciding what occupants movement strategies are appropriate for specific buildings and scenarios
- How to actually plan people movement during fire emergency that is tailored to specific buildings and scenarios

*New Chapter in the forthcoming SFPE
Engineering Guide to Human Behavior in Fire*



More detailed information than in this presentation.

How to actually plan people movement during fire emergency that is tailored to specific buildings and scenarios

For an earlier version, download 2016 Fire Journal paper at:

<http://www.sciencedirect.com/science/article/pii/S0379711215300412>

NYC requires that: “The Emergency Action Plan shall set forth the circumstances and procedures for the sheltering in place, in-building relocation, partial evacuation and/or evacuation of building occupants in response to an emergency.”

But the requirements are silent about how to accomplish this requirement.

Standard strategies for whole buildings are much too general

- sheltering in place
- in-building relocation
- partial evacuation
- evacuation of building

Which "standard strategies" apply to which occupants depends on the scenario

Instead, decision model helps designers decide who goes where given a specific scenario

“Required safe egress time” (RSET) is an incomplete measure of human performance

- Difficult to include are (1) remaining in place and relocation strategies; (2) considerations of decision making in response to a specific scenario.
- ***In the occupant movement decision model, the goal to keep occupants separated from the hazard.***
- Decision model is appropriate to minimizing RSET by selecting appropriate movement strategies

Two versions of the model to decide who goes where, when

1. For building designers

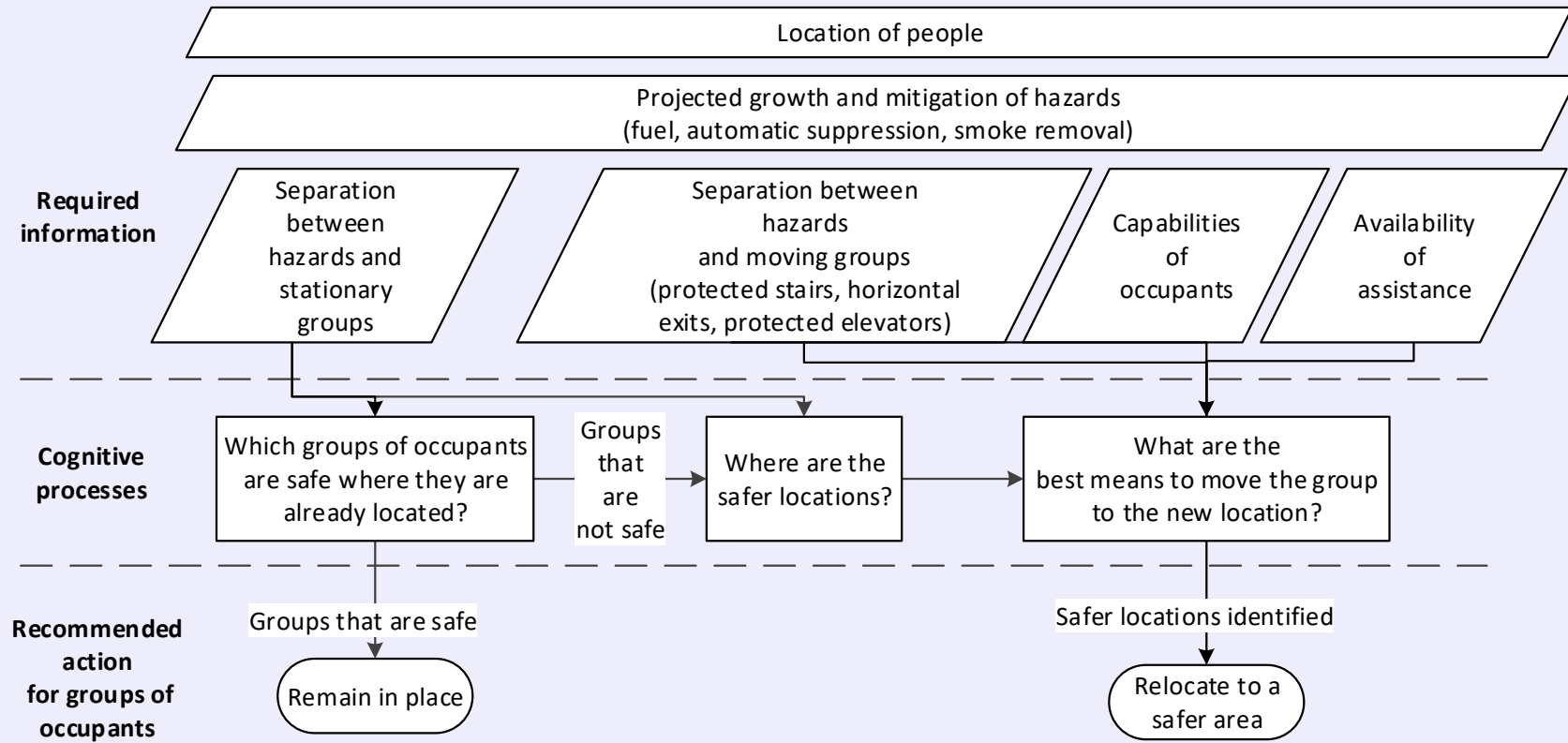
Designers include architects, fire protection engineers, owners, developers and management

2. For operational managers

Guidance on emergency occupant movement planning, both before and during a fire emergency

Operational managers include both building/tenant safety directors and first responders.

Decision Model for Designing Buildings that Optimize the Movement of Occupants



Three intuitively valid decision processes

1. Which groups of occupants are safe where they are already located?
2. If not, where are the safer locations?
3. What are the means to move the group to the new location?

The decision model divides occupants into groups using the following ***scenario-specific*** information

- Locations of building occupants
- Anticipated growth and mitigation of hazards
- Separations between hazards and groups of occupants both while stationary and moving to safer locations.
- Limitations in abilities of building occupants to move to new locations
- The availability of assistance to compensate for those limitations.

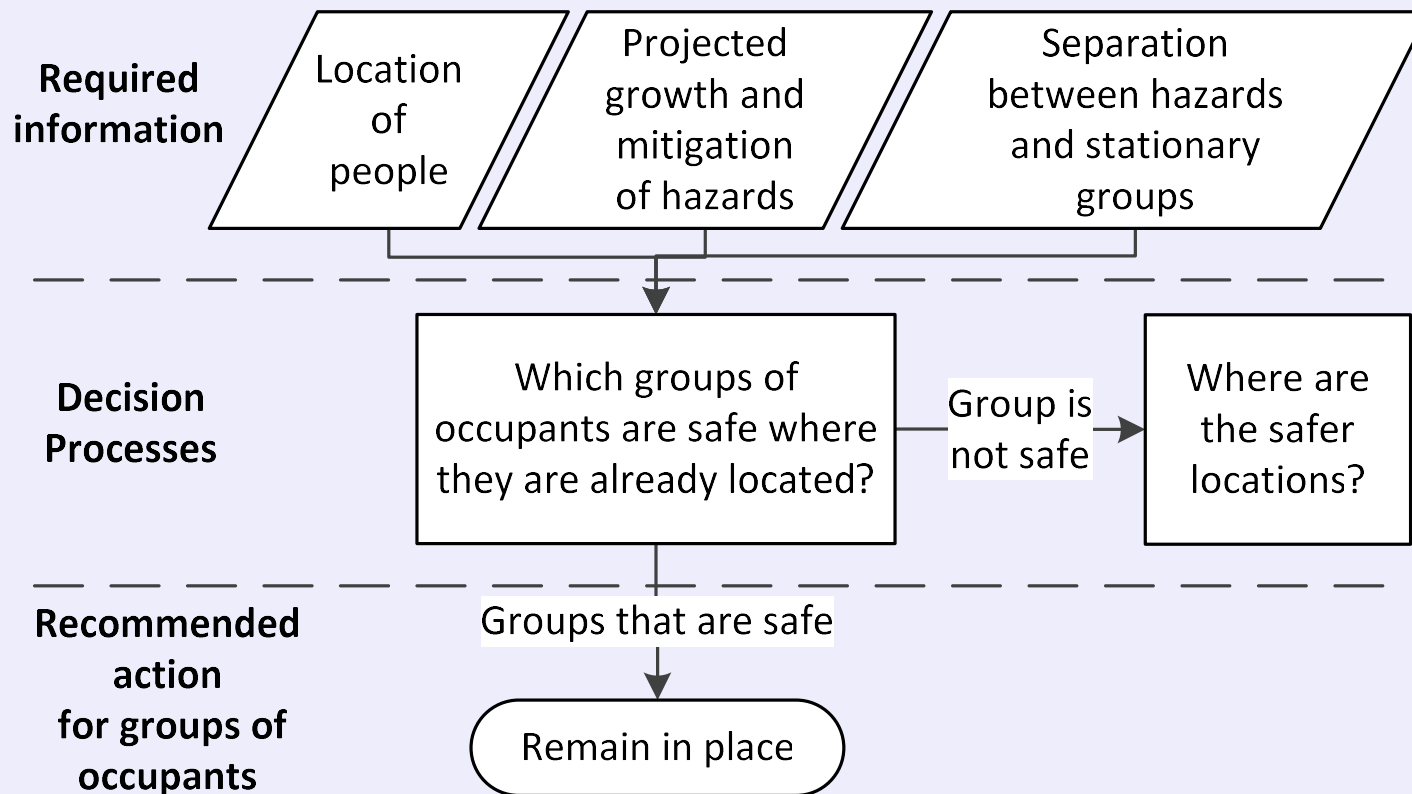
For any given group, there are only two possible recommendations

- Move to a specific safer location
or
- Stay where you are already located

The communicate recommend actions even when people are not asked to move

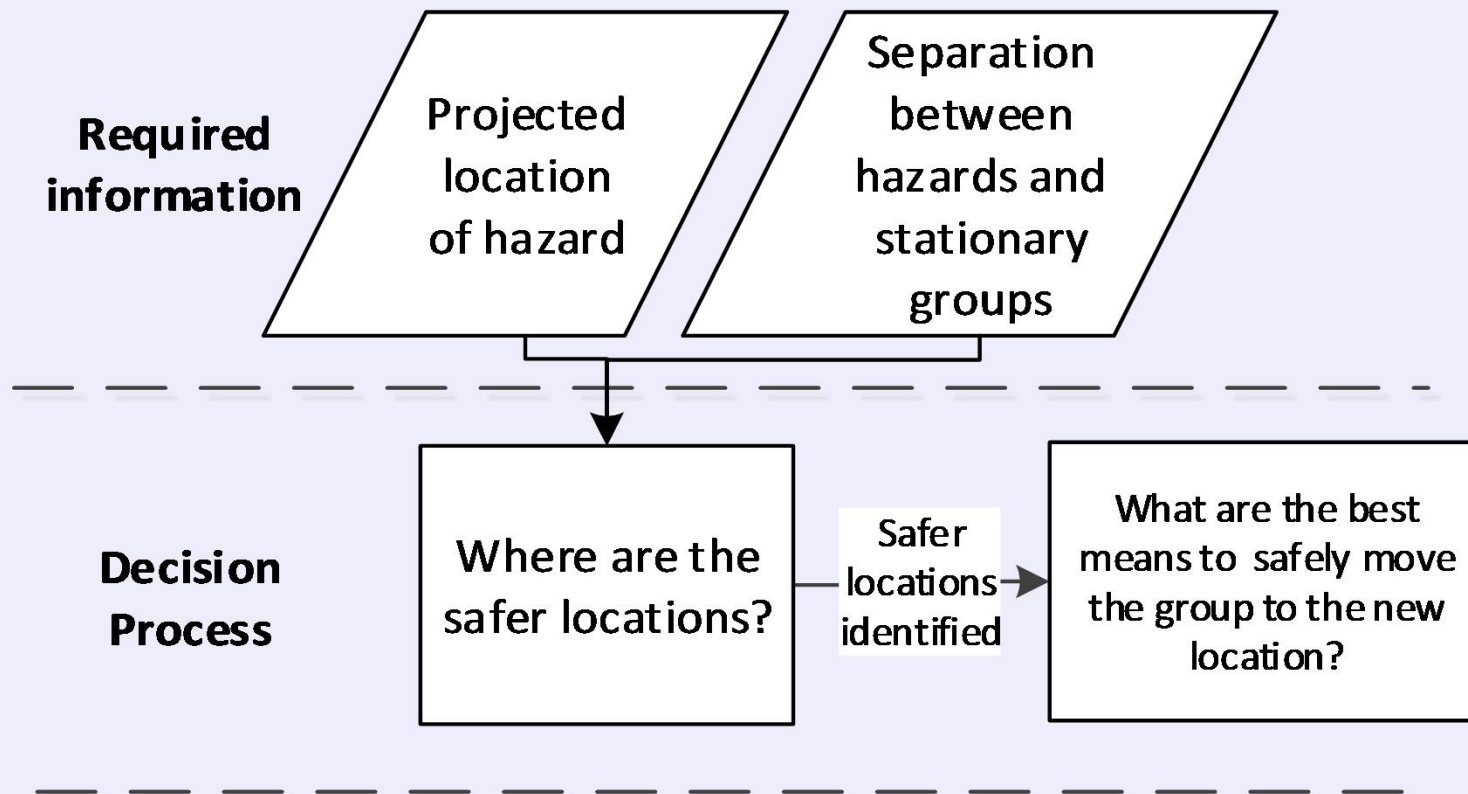
- People may be motivated to leave a safe area when they
 - Observe cues (e.g., smell smoke)
 - See emergency responders (e.g., arriving fire fighters)
 - Communicate with others (e.g., cell phones, social media).
- Tell them ***why*** they are safe

Decision 1. Which groups are safe where they are already located?



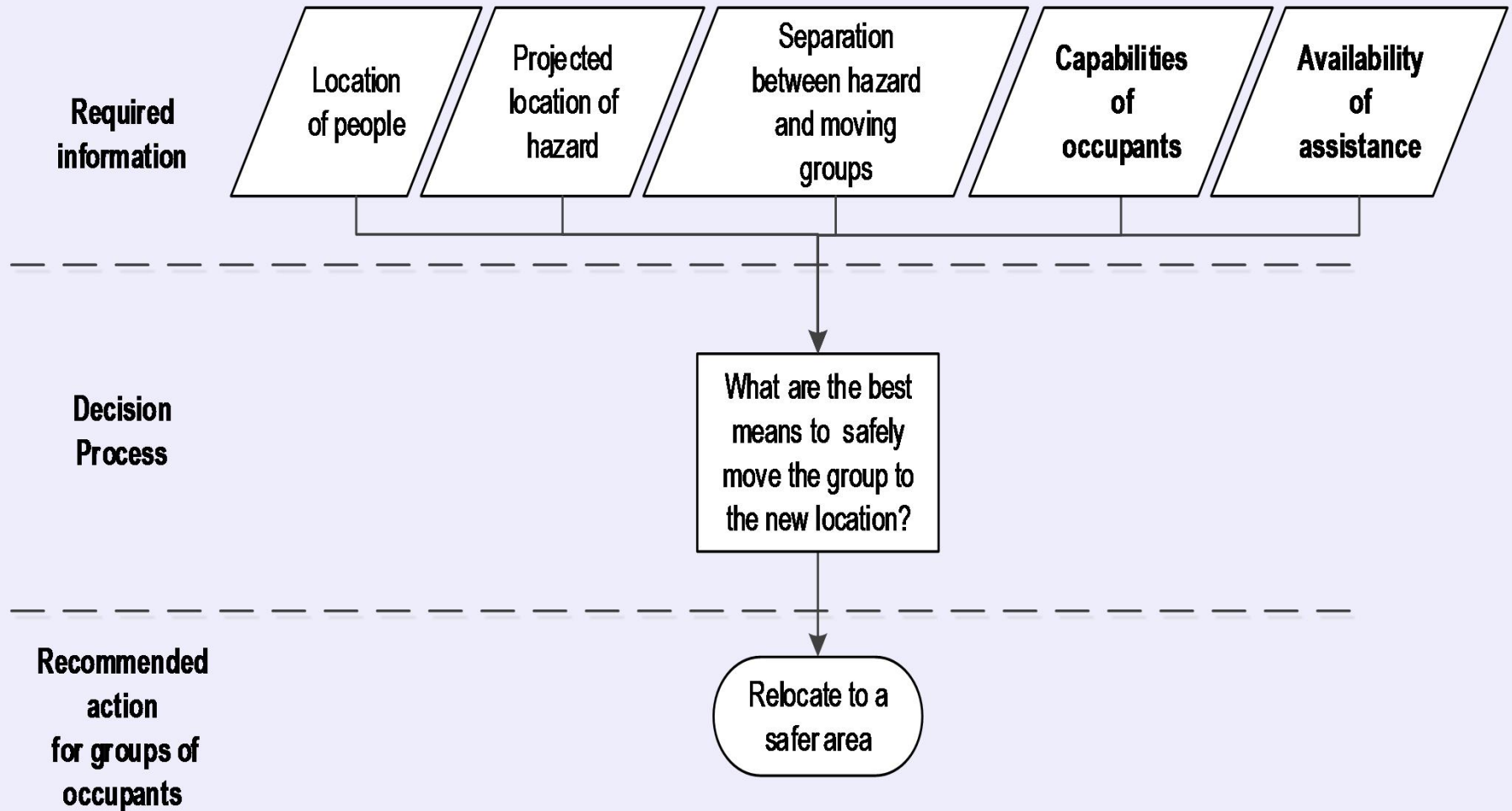
Decision 2.

Where are the safer locations?



Decision 3.

What are the best means to move the group to the new location?



Information inputs movement performance of occupants

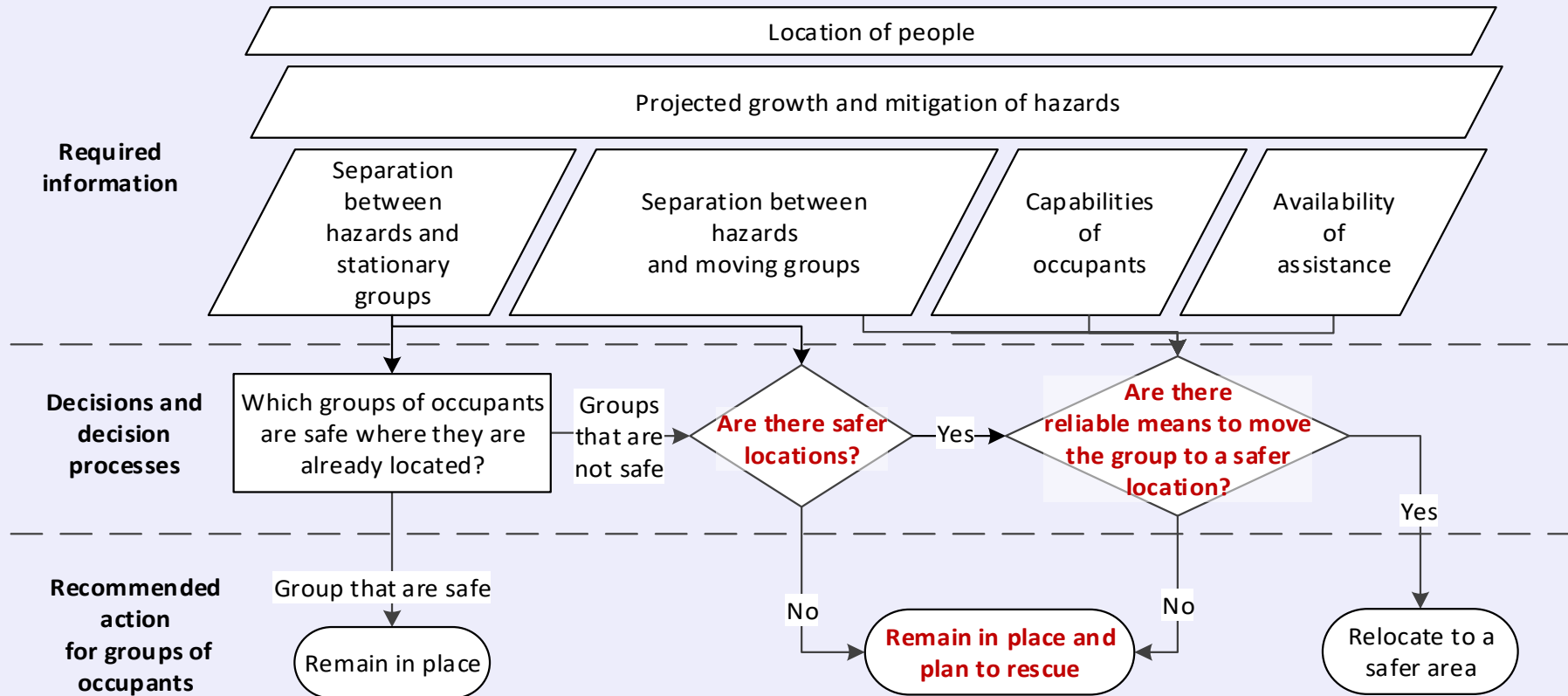
- **Mobility impairments**
 - Hidden disabilities
 - Temporary impairments
- **Sensory disabilities**
 - Sight
 - Hearing
- **Cognitive impairments**
 - Age-related
 - Drugs and alcohol
 - Sleep

How can designers use the decision model?

Designers are architects, fire protection engineers, building owners and managers

- Clarify the occupants movement strategies
- Design the building to support the selected strategies (e.g., situation awareness, communications)
- Discuss occupant movement strategies among the entire design team
- Provide a “users’ manual” that will harmonize building features and operational strategies

Decision model for operational managers



Operational managers can inherit buildings with problems and fires can develop in unexpected ways

- Scenarios not considered during design
- Outdated or lenient code requirements
- Fire protection features that have not been maintained and fail to function as designed
- Inaccurate understanding of building occupants' limitations or inadequate resources allocated to assist occupants
- Complex subsystems can interact with each other and environments in ways that cannot be anticipated (black swans and “normal accidents”)

During fire emergencies, circumstances can disrupt good plans

- *Scenarios have not been considered during the design phase*
- *Building protection features fail because of retrofits*
- *Organization fails (e.g., training not supported)*
- *No assessments building occupants capabilities*
- *The building was designed using code provisions that do not meet current standards.*

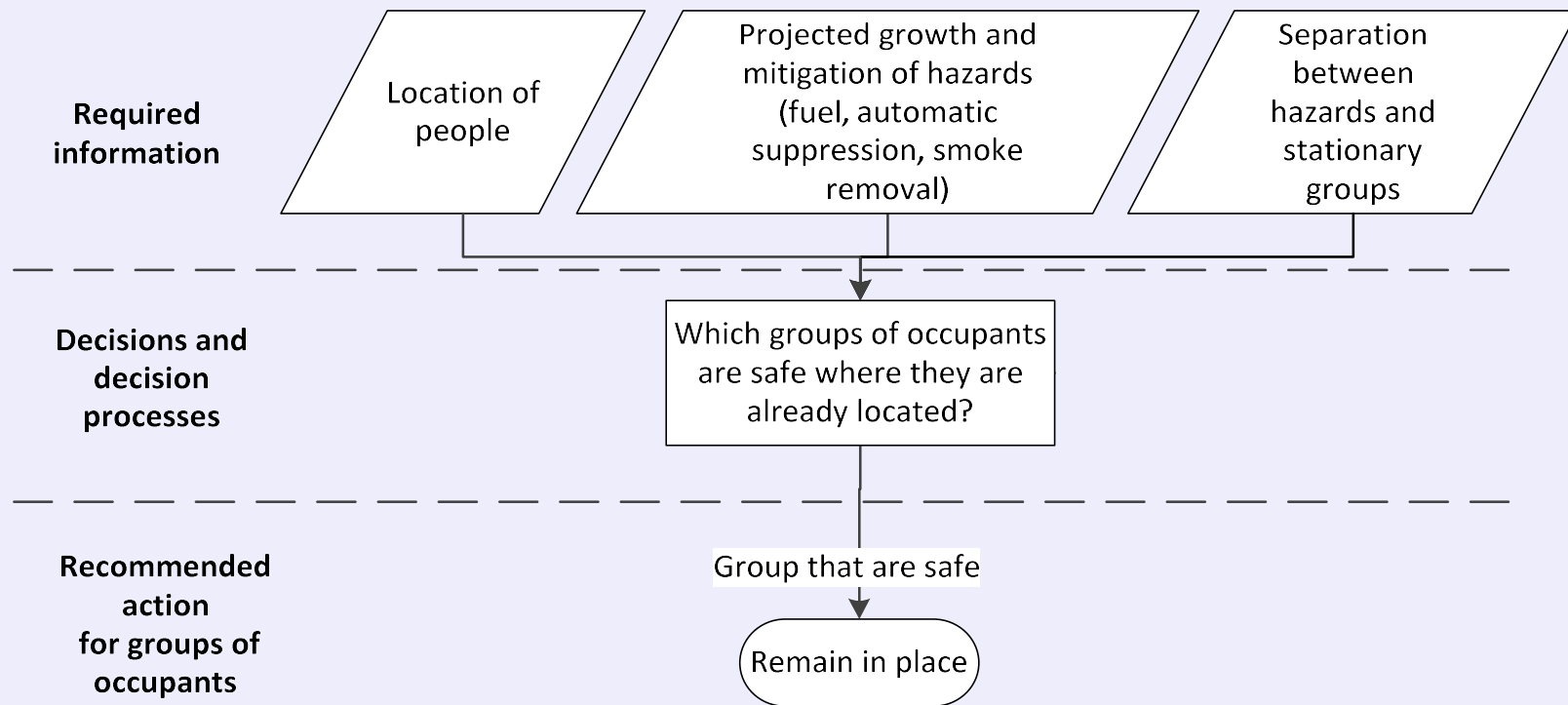
Using the occupant movement model to adapt occupant movement strategies as an emergency develops

- Backup strategies

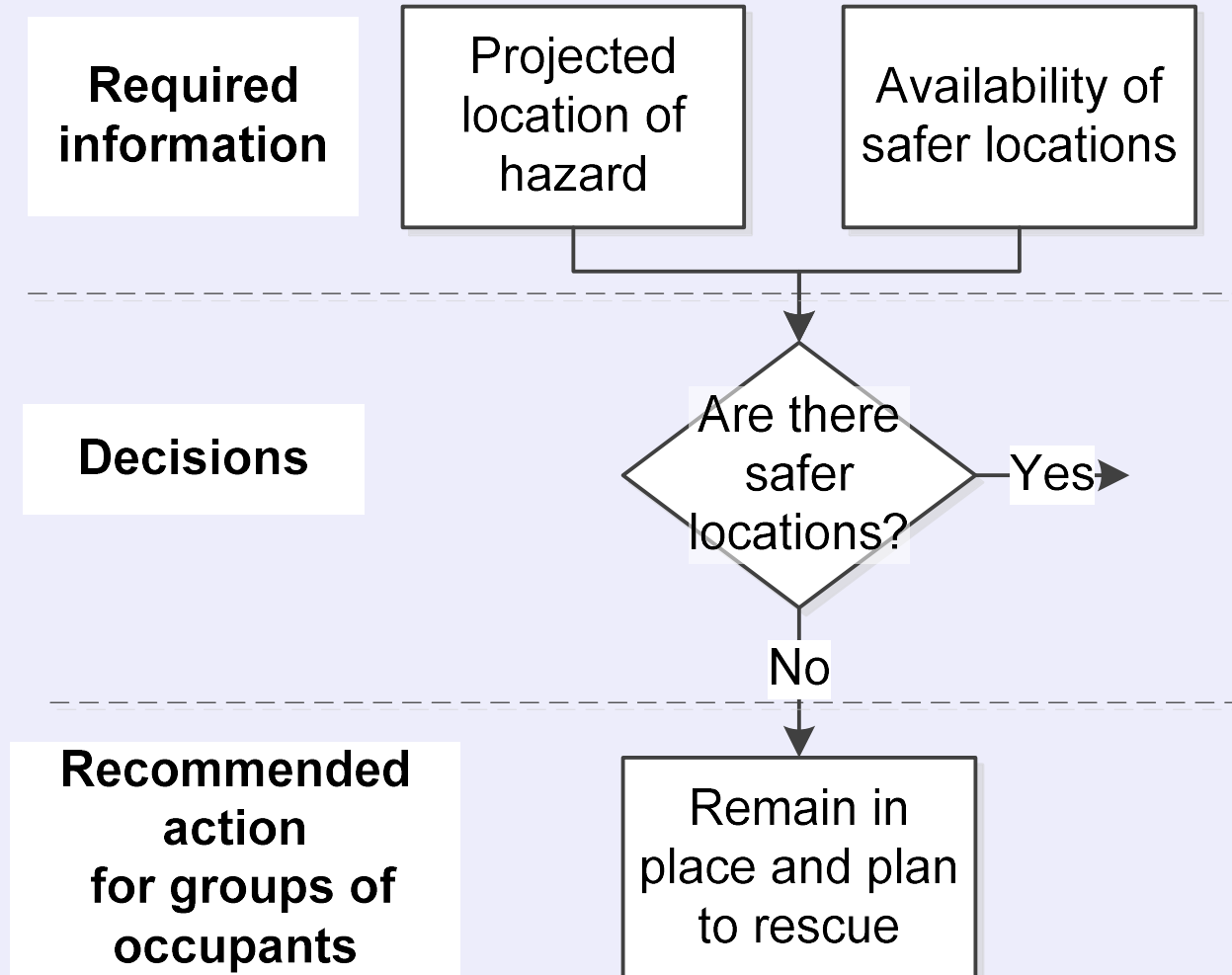
Remain in place and
plan to rescue

- Maintaining good situation awareness
 - Interpersonal communications
 - Sensors and annunciators
 - CCTV

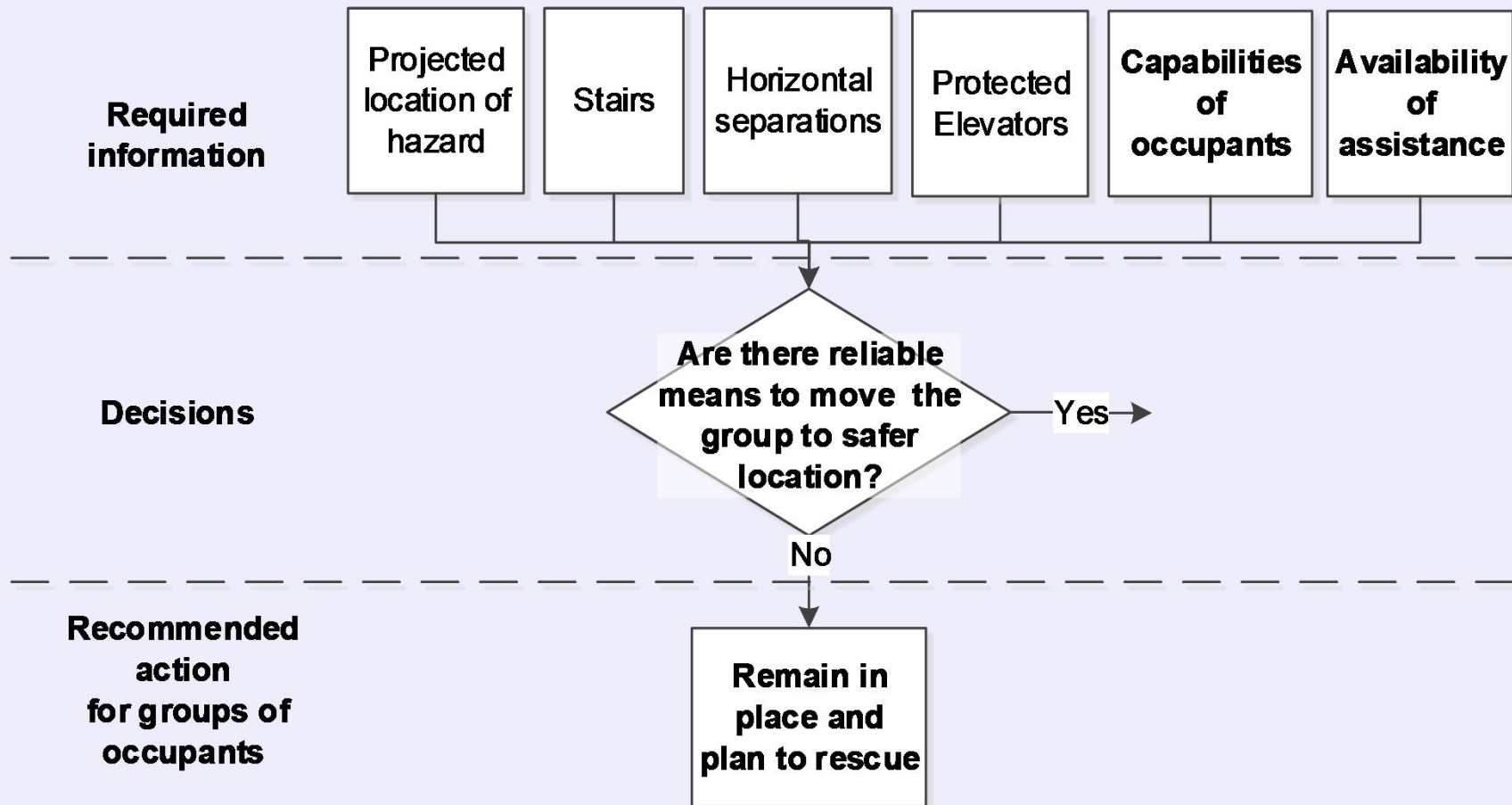
Decision process number 1 is the same as the model for building designers



Decision number 2: Are there safer locations?



Decision 3. Are there reliable means to move the group to a safer location?



Example: office versus residential tall buildings

Which groups are safe where already located?

Informational inputs		
	Residential	Office
Location of people	Mostly in living units, especially non-working hours	Dispersed. Relatively few occupants after working hours
Projected growth and mitigation of hazard	Relatively lower fuel loads, but smaller spaces. Sprinklers?	Uncertain fuel loads, large spaces Smoke removal? Sprinklers?
Separation between hazards and occupants	Good vertical and horizontal separation	Poor horizontal separation Good vertical separation

Example: office versus residential tall buildings

Are there safe means to move occupants to a safer location?

Informational inputs		
	Residential	Office
Location of people, hazard growth/ mitigation, separation hazards from occupants	Same as before	
Capability of occupants	Asleep, potentially intoxicated, age and other related limitations very likely	Mobility, sensory limited likely among some occupants
Availability of assistance	Limited staff, family members may be available	Coworkers, emergency response team, security

Example: office versus residential tall buildings

For any “unsafe” group, where are there safer areas?

Informational inputs		
	Residential	Office
Projected growth and mitigation of hazard	Relatively lower fuel loads, but smaller spaces. Sprinklers?	Uncertain fuel loads, large spaces Smoke removal? Sprinklers?
Separation between hazards and stationary groups	Good vertical and horizontal separation	Poor horizontal separation Good vertical separation

Example: office versus residential tall buildings

Summary and recommended actions		
	Residential	Office
Location of people, Projected growth/ mitigation, separation hazards and occupants	Good horizontal separation	Poor horizontal separation
Capability of occupants	Delayed, may not move without assistance	Good with some exceptions
Availability of assistance	Notification problems Very limited	Likely with assignments and training
Recommended action	Evacuate unit where fire, remain in other apartments, plan rescue as needed	Evacuate a fire zone, remain in place below, plan rescue as needed for floors above fire zone.

Model can be used for any situation where occupants must be kept separate from hazards

- Explosions (intentional and unintentional)
- Biological, chemical, and radiological releases, both inside and outside the building
- Natural disaster (flooding, wind, falling debris during earthquakes)
- Active shooters and other workplace assaults

CONCLUSION: USING THE MODEL

- The models are simple and intuitive
- For designers
 - ✓ Communicate with design team
 - ✓ Provide a “users’ manual”
 - ✓ Incorporate features that improve situation awareness
- For operational managers
 - ✓ Plan and organize planning workshops
 - ✓ Train/educate to occupants
 - ✓ Collaborate on EAPs (planning and response)
 - ✓ Argue for upgrades
 - ✓ Use to document the rationale for plans