# The Unintended Consequences of Ignoring Evacuee Response

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# The Unintended Consequences of Ignoring Evacuee Response

#### (Un)Healthy Skepticism

- Conceptual Behavioural Models (CBM)
- The impact of CBM:
  - Deductive / Inductive / Abductive Approaches
- Cascading Impact of Evacuee Behaviour

### **MODEL VARIETY**

- Evacuation models adopt different approaches all of which are simplifications.
- These approaches determine the credibility and granularity of the results generated.
- It is important to be skeptical with all models / domains:
  - Computer Simulation
  - Engineering Hand Calculations
  - Evacuation Drill
  - Prescriptive Regulation
  - Individual Conceptual Understanding
- Many discussions here about local physical factors.
- Discuss impact of employing a representation of evacuee behaviour in different modes – non-local/ non-physical factors (NLNP).



## CONCEPTUAL BEHAVIOURAL MODELS

UNPOLLUTED THROUGH IMPLEMENTATION



#### CONCEPTUAL REPRESENTATION: CODE-FREE ASSESSMENT

- Panic Model
- Indication of an incident may lead to rapid, simultaneous response – potentially overloading exits
- Response will be uncontrolled and competitive – 'stampede'
- Process will contaminate observers.
- Information provided may
- not have desired impact...

• Process Model (PADM)



#### Kuligowski et al [2011]. Derived from Lindell and Perry [2004]



## **CONCEPTUAL REPRESENTATION: PANIC-BASED DESIGN**

- Procedural Impact given assumed evacuee panic:
  - Delay notification.
  - Quietly inform some people.
  - Content is irrelevant, provide a bell. Coverage should still be checked.
  - Deploy staff to control evacuees.
  - No basis for further analysis evacuees insensitive to guidance.



#### **CONCEPTUAL REPRESENTATION: PADM-BASED DESIGN**



Derived from Lindell and Perry [2004]

Different behavioural models produced different physical designs.

# **DEDUCTIVE APPLICATIONS**

STATE INITIAL ASSUMPTIONS AND DERIVE LOGICAL CONSEQUENCES



### **DEDUCTION: INDIVIDUALS AND GROUPS**

- *'The crowd is big enough to ignore social groups.'* Very difficult to know in advance.
- Not saying always include grouping; need to acknowledge when it is not included.
- Flow of individuals vs flow of groups



#### DEDUCTION: SPEED MODIFICATION AND GROUP MAINTENANCE

- Group Maintenance
- Range of speeds and opportunity to disperse (all other things being equal)



#### DEDUCTION: SIMILAR EMERGING CONDITIONS MASKING UNDERLYING DYNAMICS

- Potential for strata formation relationship between speed and density. Potential to misread underlying dynamics
- Derived influence of social factor on physical conditions. Different social assumptions produces different outcomes.





# INDUCTIVE APPLICATIONS

IMPERFECT PROJECTIONS FROM THEORETICAL AND EMPIRICAL BASELINE



#### **INDUCTION: AGENT-BASED MODELS**

- Potentially able to simulate individual agent responses
  - Autonomous decision-making and action selection
  - Locally stored attributes and information
  - Capacity to share information between agents
  - Agent mobility enabling agent interaction
  - Agent actions can affect other agents, objects and generate aggregate conditions
- Capacity to represent agent internal processes, agent interaction and agent responses.
- Sensitive to local (e.g. physical) and NLNP factors.
- Different from fire conditions. Evacuees are biographical not just biological. [Singer]



https://www.anylogic.com/use-of-simulation/agent-based-modeling/

#### **INDUCTION: BASIC APPLICATIONS**

- Evacuee decision-making logic is the engine of agent actions. Connection between external factors and agent actions.
- Agent actions (and interactions) are the engine of emergent conditions.
  - Identify a scenario (i.e. set of initial conditions) that is representative of domain.
  - Examine how they evolve given (behavioural) model applied.
- Where model representation is lacking, user may drive response. However, critical to differentiate between prediction and specification.
- We are not just interested in final outcomes. Chain of events in decision-making is of interest and affects where, when and what actions are performed and how they are performed.



Component Level	Questions Addressed if Represented
↑ L6.Summary Outcomes	How long does it take to clear the building?
↑ L5.Aggregate Conditions	What is the flow rate achieved on the route given the new agents making use of the route?
↑ L4. Acent Action	How quickly is the agent able to move given the adoption of a new route?
↑ L3.Decision- Making Logic	What is the impact of the information in a sign on route selection given that it has been perceived, understood and the agent's existing information?
↑ L2.Internal Agent Attributes	What information is available to an agent via exposure to a sign given relative location and sensory attributes?
↑ L1.External Objects	What is the catchment area of a sign given its location and type? How many people see the sign given its location/design?

- Without levels (e.g. why not a single probability):
  - Fewer output levels less access to underlying dynamics
  - Fewer means of comparison
  - Reduced number of scenarios
  - Less sensitivity to the agent attributes and environmental artifacts.
- Less likely to capture when, where and what is performed.

# **ABDUCTIVE APPLICATIONS**

IMPERFECT BY DEFINITION – 'AFFIRMING THE CONSEQUENT'. CAPACITY TO ASSESS CREDIBILITY OF *CANDIDATE* BEHAVIOURAL EXPLANATIONS BY SETTING BOUNDING CONDITIONS.





#### **ABDUCTION: CANDIDATE EXPLANATIONS**





Fair use

### **ABDUCTION: EXAMPLE BUILDING**



Door<sub>2</sub>: 3m

### **ABDUCTION : CANDIDATE EXPLANATIONS**

- [A] Panic Model
  - Move on sound of alarm (delayed until 90s by safety officer through fear of causing panic)
  - Move at maximum individual travel speed
  - Use nearest exit
- [B] Prescriptive Model
  - Move immediately
  - Move at maximum uniform speed (1.35m/s)
  - Use exits according to capacity

#### **ABDUCTION: CANDIDATE EXPLANATIONS**

- [C] Social-Adaptive Model
  - Evacuees communicate (affects response) to group members and attempt to maintain group structure (affects travel speed)
  - Access to initial information differs according to location – reflected in initial response times
  - Individuals can redirect to secondary exit, if caught in severe congestion



#### **ABDUCTION: PANIC-BASED RESULTS**

- Evacuation Time: 180s
- Exit Use
  - Door 1: 116 (161s)
  - Door 2: 32 (118s)
  - Door 3: 152 (180s)
- Experience
  - Congestion: 25s
  - Distance: 15m
  - Avg. Individual Travel: 128s



#### **ABDUCTION: PRESCRIPTIVE RESULTS**

- Evacuation Time: 92s
- Exit Use
  - Door 1: 75 (45s)
  - Door 2: 151 (92s)
  - Door 3: 74 (45s)
- Experience
  - Congestion: 20s
  - Distance: 18m
  - Avg. Individual Travel: 36s



#### **ABDUCTION: SOCIAL-ADAPTIVE RESULTS**

- Evacuation Time: 205s
- Exit Use
  - Door 1: 104 (196s)
  - Door 2: 67(191s)
  - Door 3: 129 (205s)
- Experience
  - Congestion: 24s
  - Distance: 18m
  - Avg. Individual Travel: 124s



### CASCADING IMPACT OF EVACUEE BEHAVIOUR



#### **COUPLED EFFECTS**



Local physical / NLNP conditions

Local physical conditions

### **CONCLUDING REMARKS**

- Agent decisions are the means by which experien emergent conditions.
- Decision-making process has stages; there is prac individual attributes to processing to response se
- Conditions are not just based on local physical co NPNL information influences local physical condit
- The impact of non-physical factors cannot be limi influence evacuation conditions and possibly the



- Critical to recognize the physical / NLNP elements addressed and the user-driven aspects of the model – to assess outcomes.
- When are your actions entirely divorced from who you are and what you are thinking?

#### Fair use