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The need for a Verification and Validation protocol for evacuation models

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Outline

- Current state of V&V Tests
- Why a V&V protocol ?
- Testing emergent behaviours
- Behavioural uncertainty
- Acceptance criteria

Current state of V&V tests

- IMO tests (IMO, 2007)
- RIMEA tests (Meyer-König et al., 2007)
- Tests run by model developers
- Tests and case studies by third parties (mostly research groups)

Tests and methods are different

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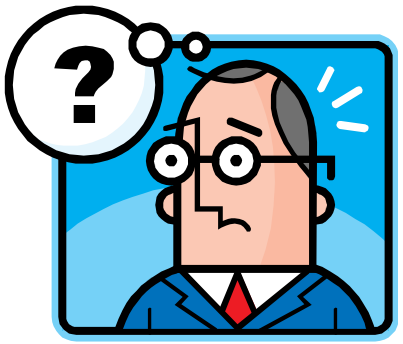
Why a V&V protocol?

The lost users



60+ models

www.Evacmod.net

List of models

1. AENEAS
2. ALLSAFE
3. ASERI
4. BFires V1 / BFires-II
5. BGRAF
6. BuildGEM
7. BUMMPEE
8. Cube Avenue
9. CRISP
10. DBES (Distributed Building Evacuation Simulat
11. EARM
12. EESCAPE
13. EGRESS
14. Egress Complexity Model
15. EgressPro
16. ENTROPY
17. EPT (Evacuation Planning Tool)
18. E-Scape
19. ESM
20. EVACNET4 / EVACNET+
21. EVACSIM
22. EvacuationNZ
23. Evi
24. EXIT89
25. EXITT
26. Exodus
27. F.A.S.T
28. FDS+Evac
29. FIRECAM
30. Firescap
31. FlowTech
32. FPETool
33. GridFlow
34. Helios
35. Legion
36. MA&D (Micro Analysis & Design)
37. Magnetic Model
38. MASCM
39. MASSEgress
40. MASSIVE Software
41. MASSMotion
42. Myriad II
43. Nomad
44. PathFinder
45. PEDFLOW
46. Pedestrian Dynamics
47. PedGo
48. PedRoute / Paxport
49. PedSim
50. S-Cape (external PDF)
51. SGEM
52. SimPed
53. Simulex
54. SimWalk
55. SMART Move
56. SpaceSensor
57. STEPS
58. Takahashi's Fluid Model
59. TIMTEX
60. TSEA: Transient Simplified Egress Analysis
61. UAF (Urban Analytical Framework)
62. VISSIM
63. WayOut
64. ZET

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Why a V&V protocol?

No Standardized tests

Inconsistencies among testing methods

Are all features tested?

Is the model really predictive?

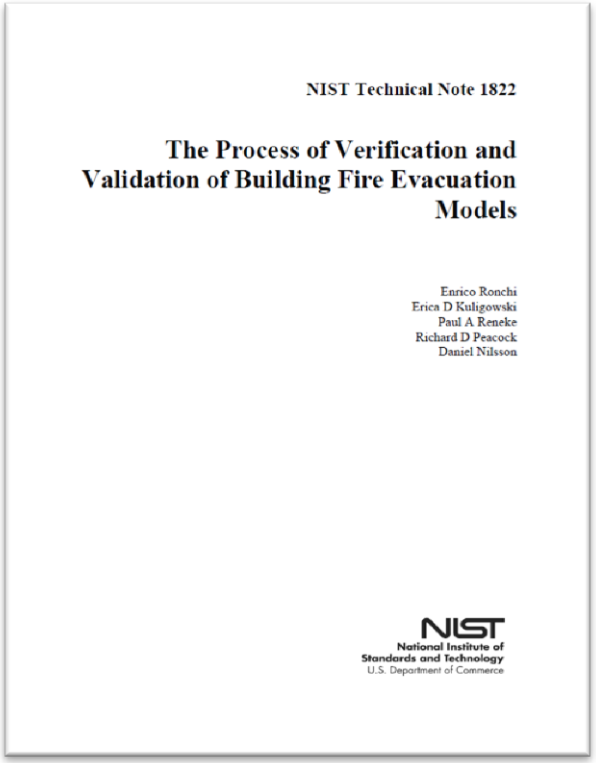
Need for acceptance criteria

Users want V&V!

Why a V&V protocol?

Joint effort between NIST and LU

Ronchi, E., Kuligowski, E.D., Reneke, P.A., Peacock, R.D., Nilsson, D., (2013). *The process of Verification and Validation of building fire evacuation models*. National Institute of Standards and Technology. Technical Note 1822.



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Why a V&V protocol?

Tech Note 1822

WHAT IT IS NOT

It is **NOT** a definitive guidance on the performance of V&V for building evacuation models

WHAT IT IS

- IMO tests review and discussion on their application for buildings
- Model features to be tested (Kuligowski et al., 2010)
- Categorization of tests with core components (Gwynne et al., 2013)
- It suggests verification tests and data-sets for validation
- It proposes a method for behavioural uncertainty

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Why a V&V protocol?

Tech Note 1822

Recommendations on verification tests

Categorization with five core components

1) pre-evacuation time
2) movement and navigation
3) exit usage
4) route availability
5) flow conditions/constraints

Why a V&V protocol?

Tech Note 1822

Recommendations on verification tests

Common structure for verification tests

1) Geometry
2) Scenario(s)
3) Expected Result
4) Test method
5) User's actions

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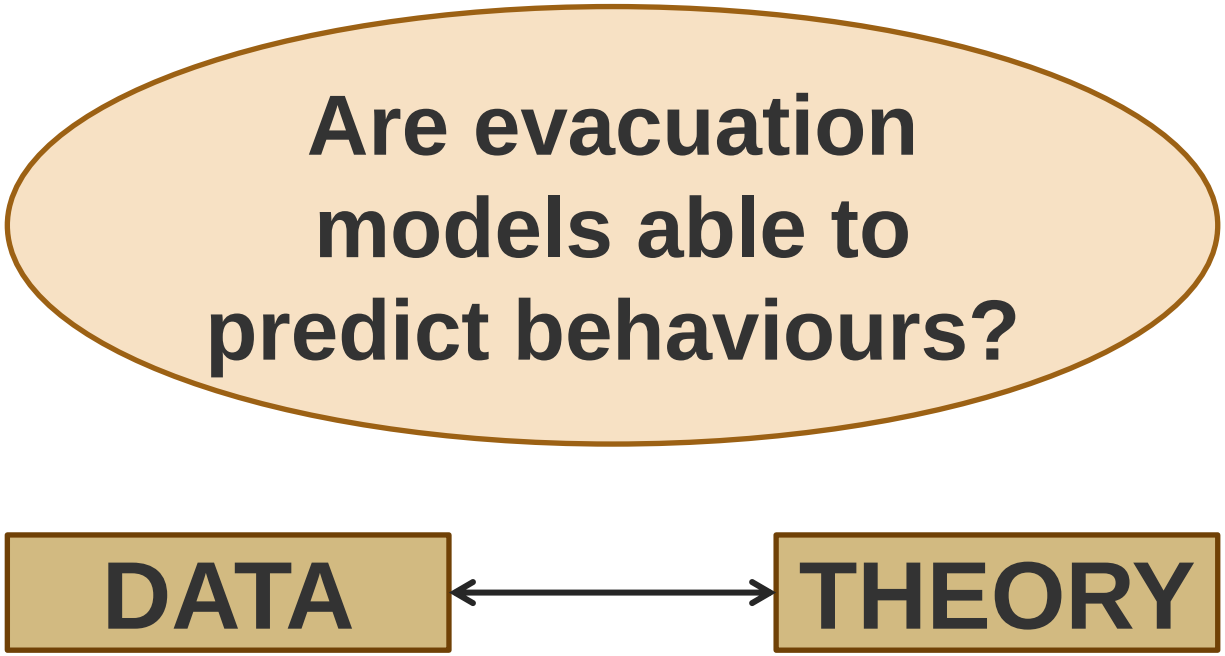
Testing emergent behaviours



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Testing emergent behaviours

Verification of emergent behaviours

"Ability of evacuation models to qualitatively produce results which reflect the current knowledge on human behaviour in fire" (Ronchi et al, 2013)

- Different theories to explain the same behaviour
- What are the *accepted* theories?
- Different modelling approaches

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Testing emergent behaviours

Experimental data

vs

Ideal cases

Ideal cases are simple evacuation scenarios for which expected results can be obtained by evidence or simple mathematical equations

Testing emergent behaviours

- Use of ideal cases for verification of emergent behaviours

Examples in the **Tech Note 1822** are:

Counter-flows, Group behaviours, People with movement disabilities, Social Influence, Affiliation, Congestion, Maximum Flow rates

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Behavioural uncertainty

*1) Measurement uncertainty**

*2) Model input uncertainty**

*3) Intrinsic uncertainty**

*4) **Behavioural uncertainty*****

**Hamins & McGrattan, 2007*
*** Ronchi, Reneke and Peacock, (2013)*

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Behavioural uncertainty

EXAMPLE

1. Experimental measurements

(e.g., pedestrian tracking techniques)

Frantzich et al, 2007

2. Assumptions for walking speed distributions

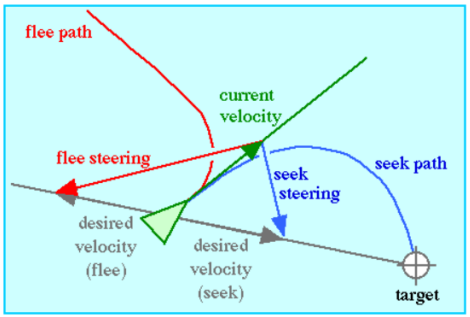
Korhonen & Hostikka, 2009

Body type	R_d (m)	R_t/R_d (-)	R_s/R_d (-)	d_s/R_d (-)	Speed (m/s)
Adult	0.255±0.035	0.5882	0.3725	0.6275	1.25±0.30
Male	0.270±0.020	0.5926	0.3704	0.6296	1.35±0.20
Female	0.240±0.020	0.5833	0.3750	0.6250	1.15±0.20
Child	0.210±0.015	0.5714	0.3333	0.6667	0.90±0.30
Elderly	0.250±0.020	0.6000	0.3600	0.6400	0.80±0.30

3. Calculation methods

(CA, social force, steering, etc.)

Reynolds, 1999



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Behavioural uncertainty

"Evacuate the same building with the same people starting in the same places on consecutive days and the answers could vary significantly" [Averill, 2011]

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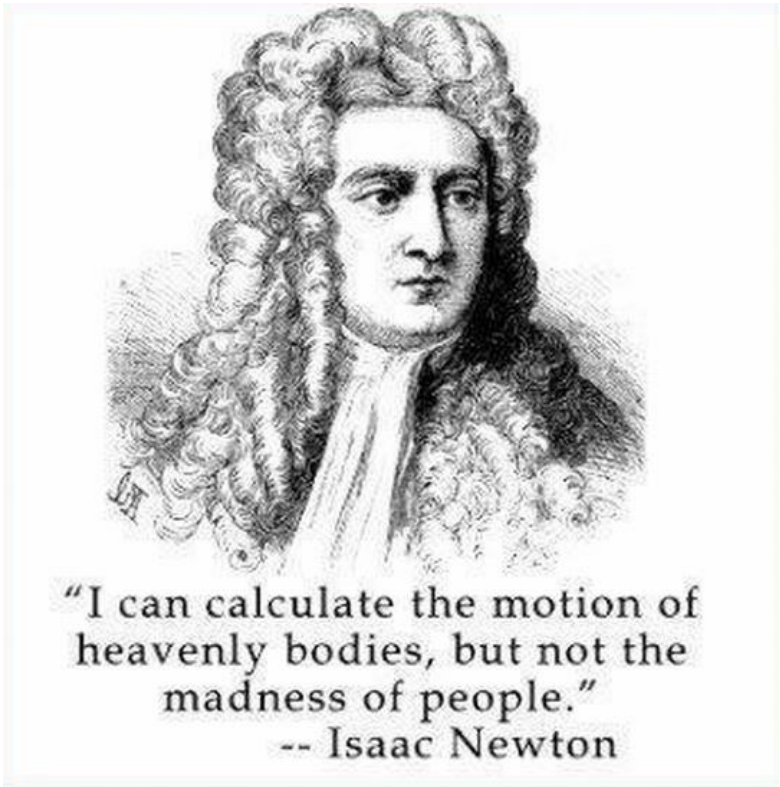
Behavioural uncertainty

Newton



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Behavioural uncertainty

*Do evacuation model **users** account for "people madness" in producing results?*

*Most of the models are **NOT** deterministic → Distributions for inputs and results*

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Behavioural uncertainty

***Why** do model developers use distributions (or stochastic variables) for model inputs?*

Inability to confidently represent all cues and factors affecting human behaviour → **Dual interpretation**

1

The "human element" introduces factors that are not entirely predictable (we will **NEVER** completely assess experimental behavioural uncertainty)

2

The current knowledge on human behaviour is limited and there is not enough information to predict human response with any degree of certainty (we can not assess experimental behavioural uncertainty **NOW**).

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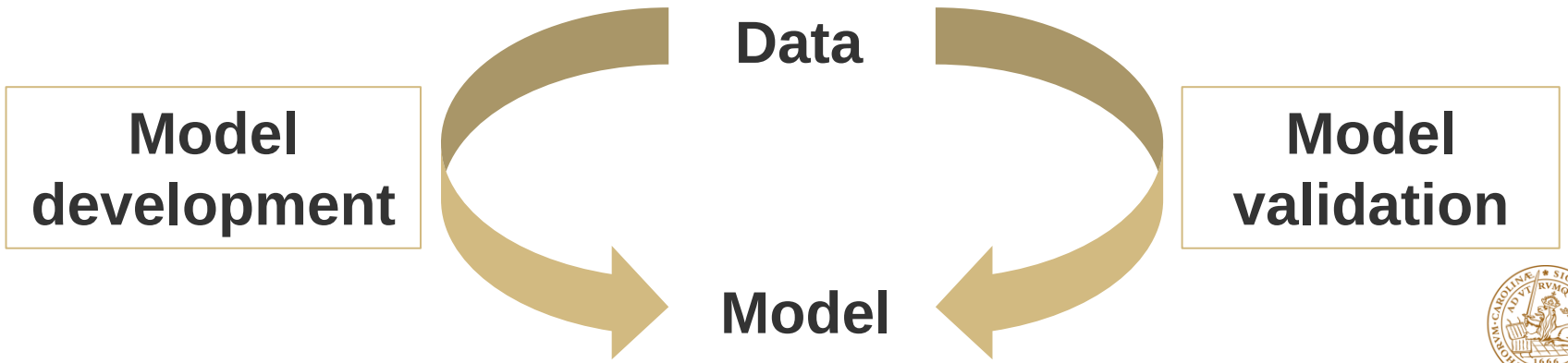
Behavioural uncertainty

*Do evacuation model **testers** account for "people madness" in Validation?*

Can we perform validation studies with a single experiment?

Behavioural uncertainty

- Scarce data on repeated experiments (often a single data-set is the only available reference)
- **Circular Validation Issue**



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Behavioural uncertainty

How many runs for each scenario?

How do we study convergence of results?

What are our results?

- Evacuation times
- Occupant-evacuation time curves
- Emergent behaviours

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Behavioural uncertainty

Different methods to study BU

1) Average total evacuation time (TET) and standard deviation for **arbitrary number of runs** (IMO, 2007)

2) Simple convergence study based on **errors and acceptance criteria** about evacuation times, standard deviation, etc (Ronchi and Nilsson, 2014)

3) Use of **functional analysis** operators (Ronchi, Reneke, Peacock, 2013)

4) Combined use of **functional analysis** operators and **inferential statistics** (Lovreglio et al, 2014)

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Acceptance criteria

- They should be defined in relation to the **intended use** of the models
- Need to assess **uncertainty** to define criteria
- What results should be taken into consideration (best/worst estimation), average, etc.?
- **WHO** should set the criteria (model developers, users, international organizations, regulators)?
- **Minimum** criteria or model **certification**?

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Conclusions

- This presentation includes **21 question marks**! Different parties (model developers, users, researchers, etc.) may have **different views** on the answers to those questions.
- There is a need for a **broad debate** within the evacuation modelling community on the need for a V&V protocol for evacuation models as well as the tests and procedures that it should include

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