7º Congreso Internacional de Ingeniería de Seguridad contra Incendios
7th International Congress on Fire Safety Engineering

Performance-Based Fire Safety Engineering: Current Situation and Future Trends

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Organizadores / Organizers

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Acknowledgements and Disclaimer

Acknowledgements

I would like to sincerely thank APICI and the conference organizers for the invitation to present at this important international conference and for their generous support.

Disclaimer

This talk reflects my observations and opinions. I do not claim to include all data on the current situation or the ability to predict the future. I offer my perspectives with the hopes of challenging ourselves to continue to develop our profession and to seek the support we need to do so.

Overview

- Current situation with PBFSE
  - Level of development of FSE as a discipline
  - Current PBS and PBFSE framework and guidelines
  - Current issues, shortcomings and gaps
  - Recent responses
- Future trends
  - In short term, more detailed guidance is needed
  - Codes and designers moving to holistic building performance – PBFSE needs to as well if FSE want to maintain relevancy
  - In the long term, codes will embrace probabilistic nature of fire – PBFSE needs to as well if PBFSE is to advance

Maturity of FSE as an Engineering Discipline

- Infancy
  - Uncoordinated relationships between practice & research; needs & solutions
  - Developments reflect personal tastes, ease of solution and simple chance
  - Applications tend to be small parts of larger problems isolated and resolved without reference to a broader framework, as no framework exits
- Adolescence
  - Foundations for a framework and a viable set of solutions for some areas exists
  - Development is still largely incomplete: some topics are virtually untouched, limits of effectiveness of the parts or the whole are not well understood, some applications are rather naively formulated
  - Applications exist, but often without confidence or the wisdom of experience
- Maturity
  - A framework exists and the capabilities and limitations are widely appreciated
  - Most practitioners have received education in the area, recognize situations in which the approach is applicable, and speak the language of the area
  - Smooth interaction between research and practice, with most research being conducted in response to obvious needs of practice

Emergence of FSE & PBD

Fire Research: 1950s-1980s

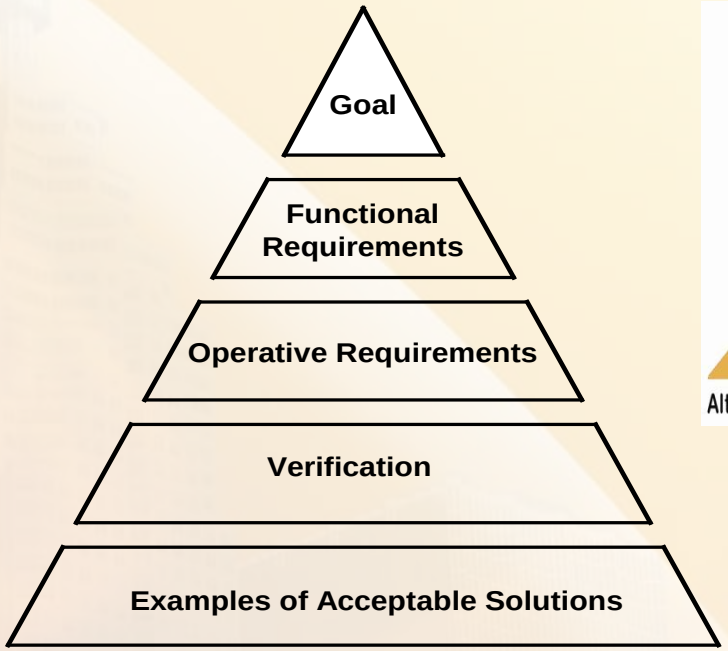
- 'Critical mass' of research
  - BRE/FRS, BRI, NBS, TNO, VTT, FM, etc.
- Key data and relationships
  - Plume theory, flashover, fire dynamics, etc.
  - Fire test data collection and publication
  - Analytical tools
- Technological advances
  - Computational models

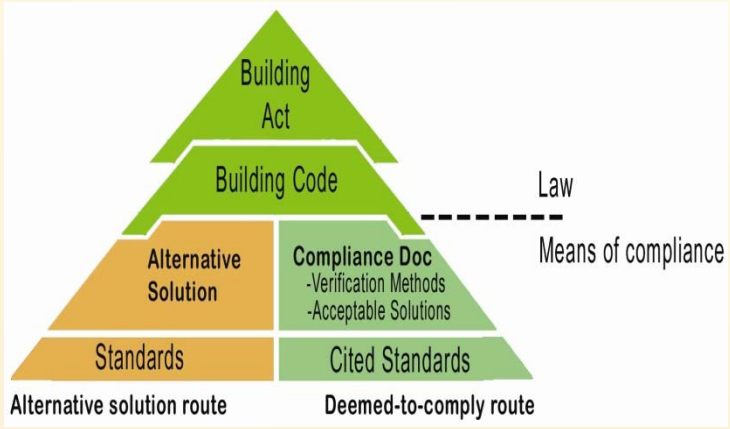
Guides and Guidelines

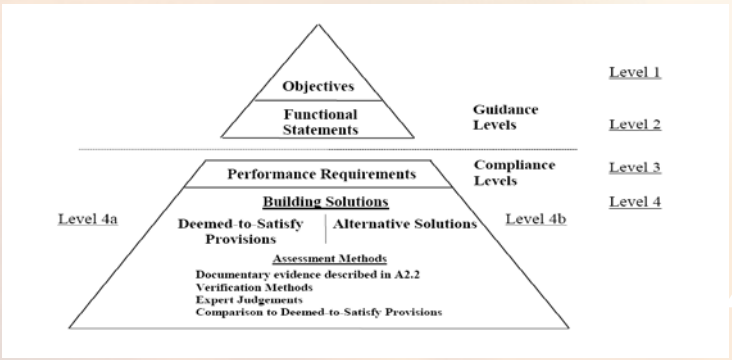
- GSA Appendix D, 1972
- NKB, 1976 & 1978
- CIB, 1980s
- SFPE Handbook, 1988
- Warren Centre, 1989
- NKB, 1994
- SOPRO, 1995-2000
- FCRC, 1996
- BSI DD240, 1997

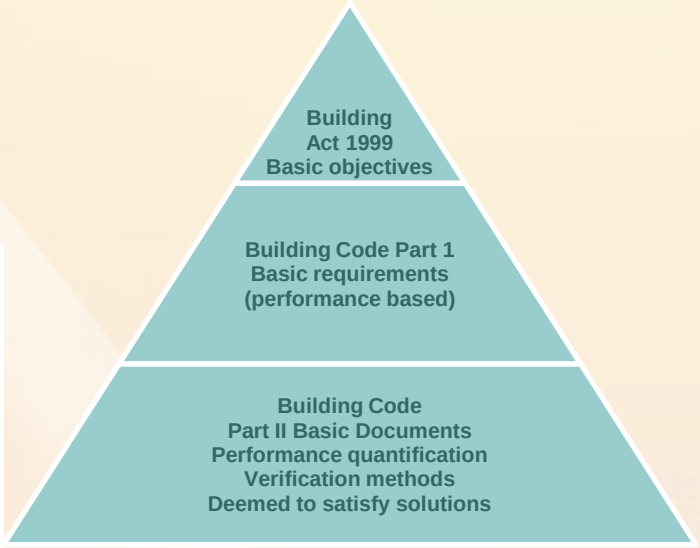
Emergence of Performance-Based Codes

Australia
Austria
Canada
Denmark
England
Finland
Japan
Netherlands
New Zealand
Norway
Scotland
Singapore
South Africa
Spain
Sweden
(United States)









Formulation of Framework and Guidelines

- NKB, 1994 (Nordic countries)
- FEG, 1996 (FCRC, Australia)
- ISO TR 13387, 1999 (International)
- SFPE, 2000 (USA)
- BSI 7974, 2001 (UK)
- IFEG, 2005 (Australia, Canada, New Zealand, USA)
- Engineering Methods for Fire Protection, 2009 (vfdb, Germany)
- Ongoing updates and activities of above groups

BS7974 Code of Practice – Application of fire safety engineering principles to the design of buildings							
BSPD7974-0	BSPD7974-1	BSPD7974-2	BSPD7974-3	BSPD7974-4	BSPD7974-5	BSPD7974-6	BSPD7974-7
Guide to design framework and fire safety engineering procedures	Initiation and development of fire within enclosure of origin	Spread of smoke and toxic gases within and beyond the enclosure of origin	Structural response and fire spread beyond the enclosure of origin	Detection of fire and activation of fire protection systems	Fire service intervention	Evacuation	Probabilistic risk assessment

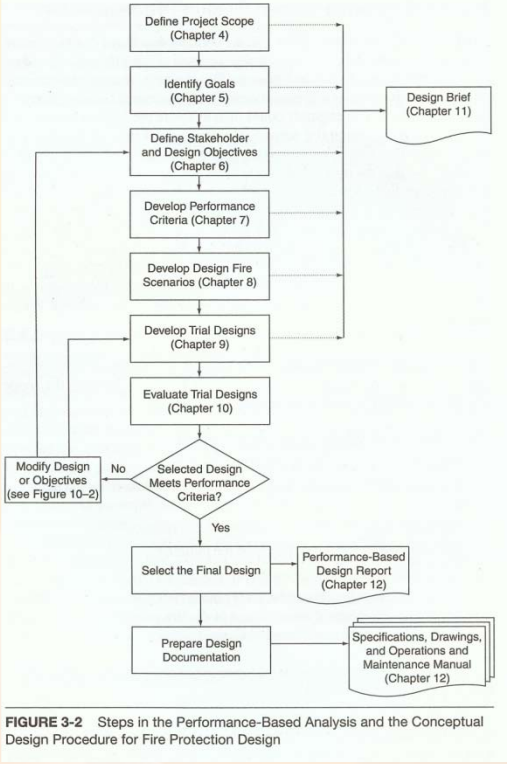


FIGURE 3-2 Steps in the Performance-Based Analysis and the Conceptual Design Procedure for Fire Protection Design

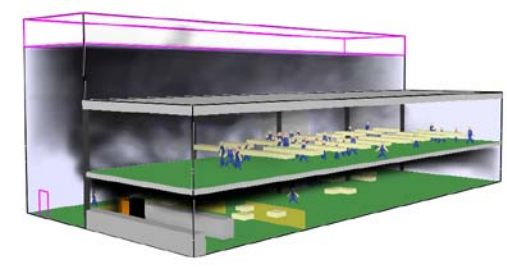
Recent/Current Research, Data & Technology

FSE Related

- Increasing data on fire performance of materials
- Increasing data on human behavior in fire
- Increasing number and complexity of computational tools
- Increasing number of university FSE programs
- Decreasing research funding

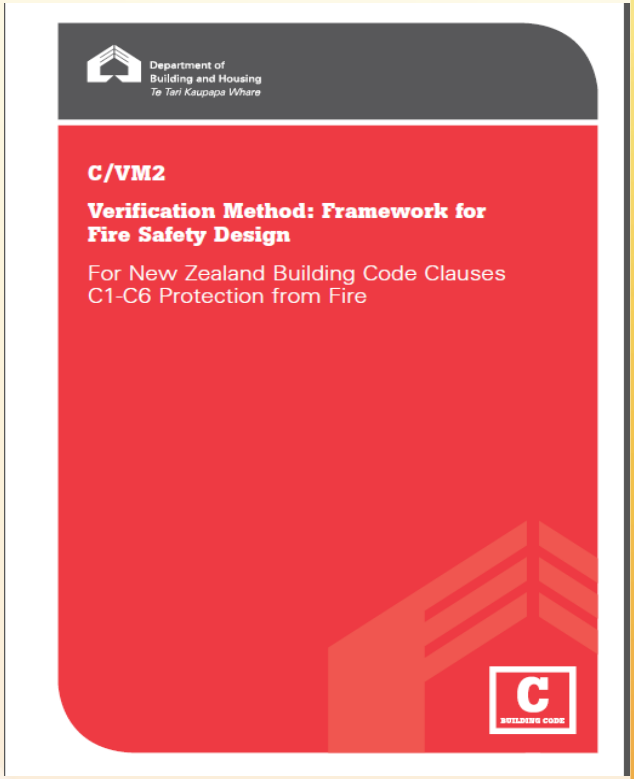
Other

- Increased use of BIM in design profession
- Increased use of new materials and building technologies – sustainability focused
- Increasing complexity of building design
- Increasing height of buildings



Recent/Current Frameworks & Guidance

- SFPE Guide on Substantiating Fire Model for Given Application
- New Zealand Verification Method
- INSTA 950 - Verification of Fire Safety Design in Buildings (NKB)
- SFPE Engineering Guide – Fire Safety in Tall Buildings
- SFPE Task Group on Design Fire Scenarios
- CEN effort on FSE
- ISO update to design fire scenarios and design fires, and many others



Recent/Current Issues

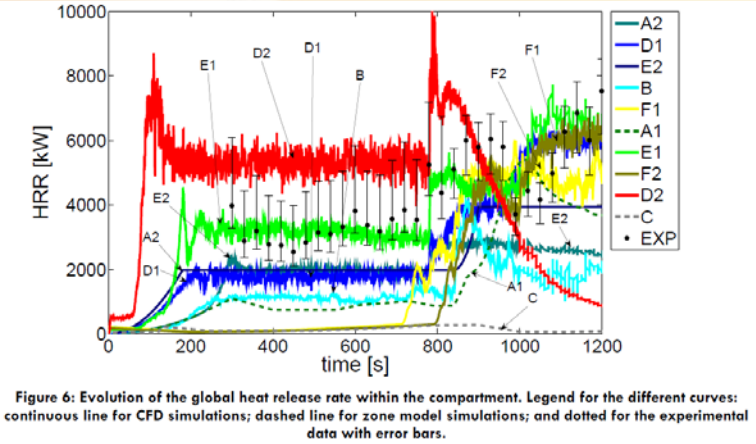
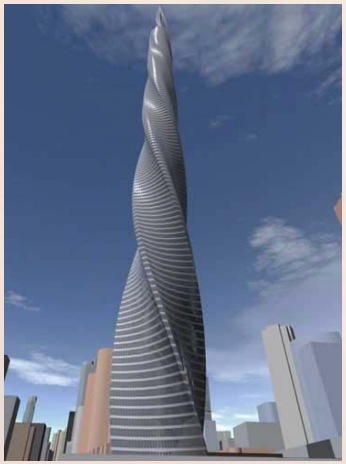
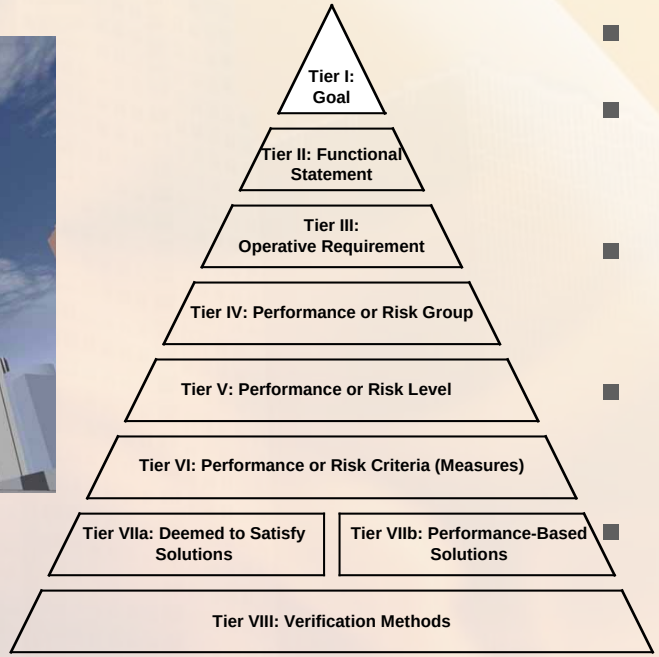


Figure 6: Evolution of the global heat release rate within the compartment. Legend for the different curves: continuous line for CFD simulations; dashed line for zone model simulations; and dotted for the experimental data with error bars.



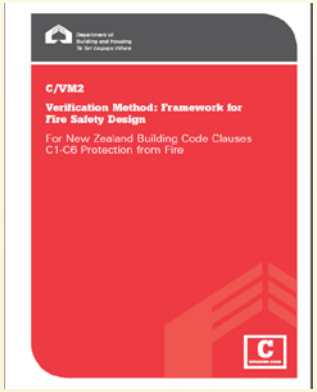


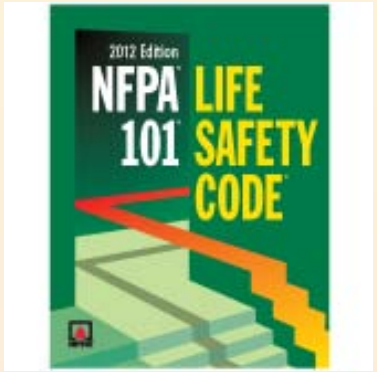
- Wide variation in practice, especially in applying tools
- Wide range of education – engineers and authorities
- Challenges with ethics
- Buildings more complex
- People less able
- Uncertainty and variability not being addressed
- Recognition that performance / risk level and criteria need to be explicit
- Recognition that risk should be part of engineering analysis
- Recognition that holistic approach is needed

Trends and Implications

In the short term, more parameters may be prescribed in codes

- Japan has prescribed design fires, evacuation factors, and engineering relationships for years – now not sure they want to relax this
- NZ Verification Method defines scenarios, fires (including model input parameters), tenability criteria, delay times – fewer PB options
- Swedish building code includes scenarios and criteria, and guidance outlines acceptable verification (will be INSTA 950)
- NFPA 101 and NFPA 5000 define 8 fire scenarios which have to be applied to every analysis
- Many NFPA standards including engineering guidance for PBD (e.g., NFPA 72, 92, …)





Trends and Implications

Regulatory responses driven by lack of confidence in analyses and decisions – a function of a lack of specific guidance on adequate scenario development, appropriate fire and occupant characterization, appropriate use of models, treatment of uncertainty

- Telling someone to develop scenarios is not the same as describing how to develop them and determine if they are appropriate/adequate
- Telling someone to quantify fires is not the same as describing how to develop them and determine if they are appropriate/adequate
- Telling someone to characterize occupants is not the same as describing how to develop them and determine if they are appropriate/adequate
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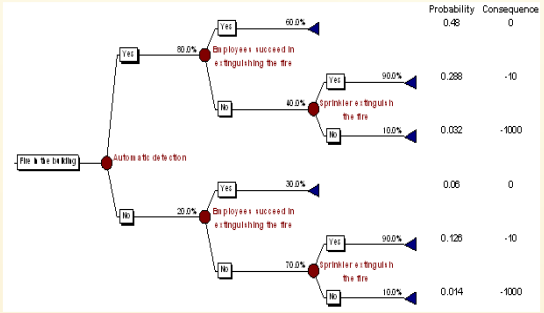

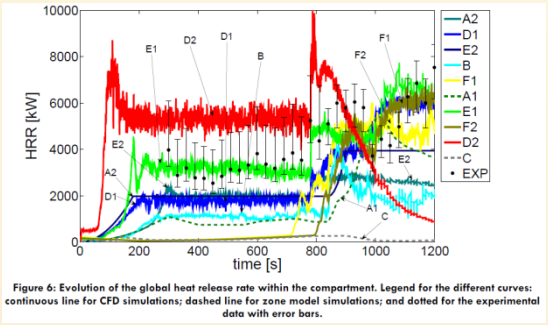

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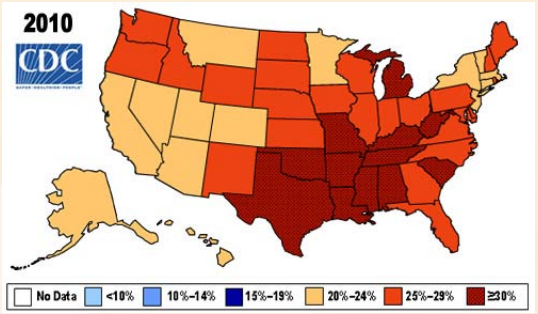


Trends and Implications

Increasing acceptance of probabilistic nature of hazards by regulators and benefit of risk-informed design – PBFSE needs to move in that direction as well, and has started

- PS7974, Part 7 (2003) - Probabilistic risk assessment
- Eurocodes (reliability based approach)
- Risk/reliability approaches in structural fire engineering
- INSTA 950 (2012) - Verification of Fire Safety Design in Buildings (NKB)
- Requirements for risk assessment of fire in construction works (NS 3901:2012)
- TNO project on probabilistic approaches to fire safety design
- Increasing use of probability distributions for model input parameters

We need a framework for risk-informed performance-based FSE that provides guidelines and details

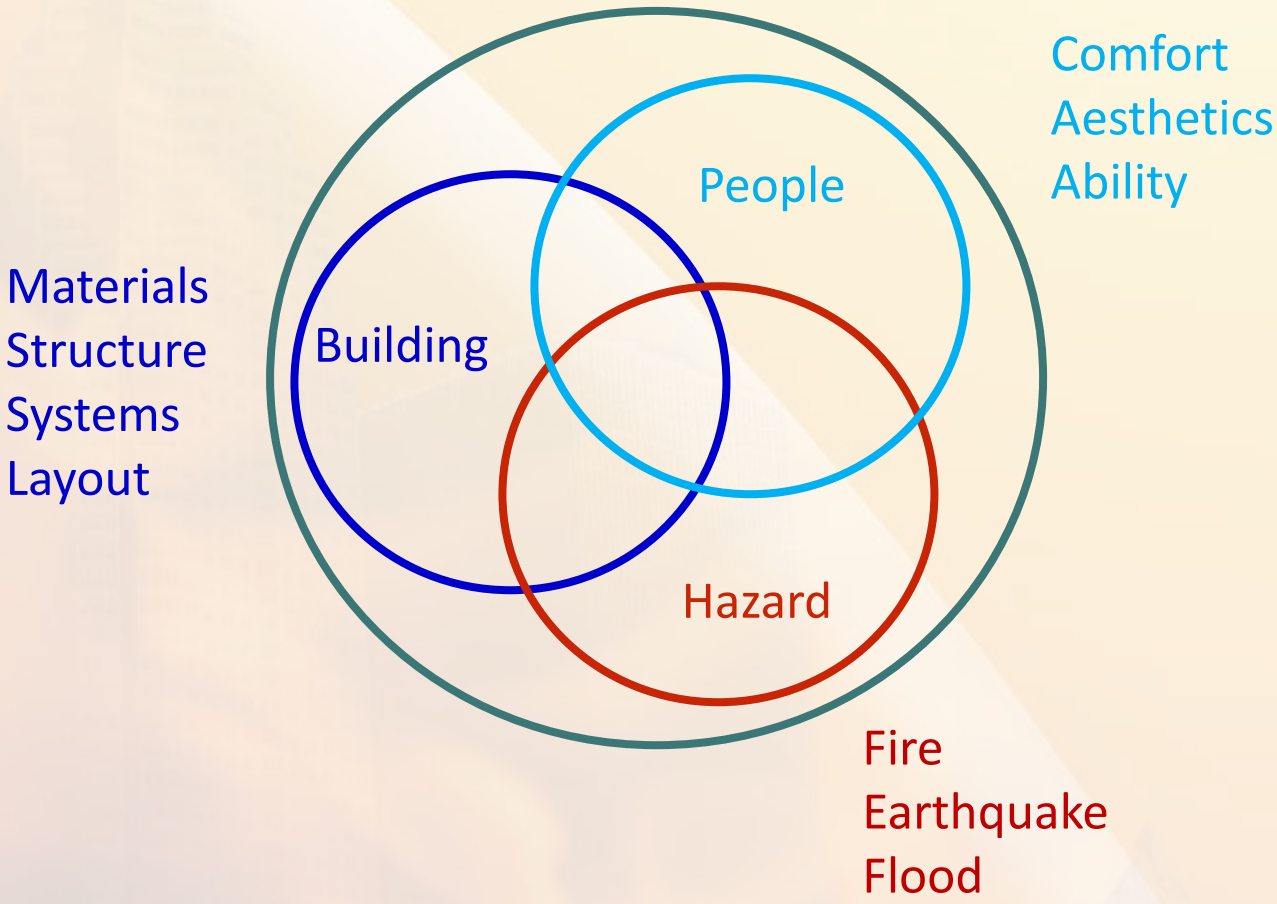
Trends and Implications

- Buildings becoming more complex.
- People are aging, becoming obese and increasingly less abled.
- Sustainability trends are creating unforeseen impacts on building fire performance.
- Climate change is impacting imposed hazard loads and occupant use.
- Other engineering disciplines are embracing holistic building performance more readily than FSE, led in many instances by energy and resource performance.
- FSE need to look at all aspects of a building – throughout its intended life – and design fire safety that is appropriate to future expectations as well as current ones.






More Holistic Framework is Needed



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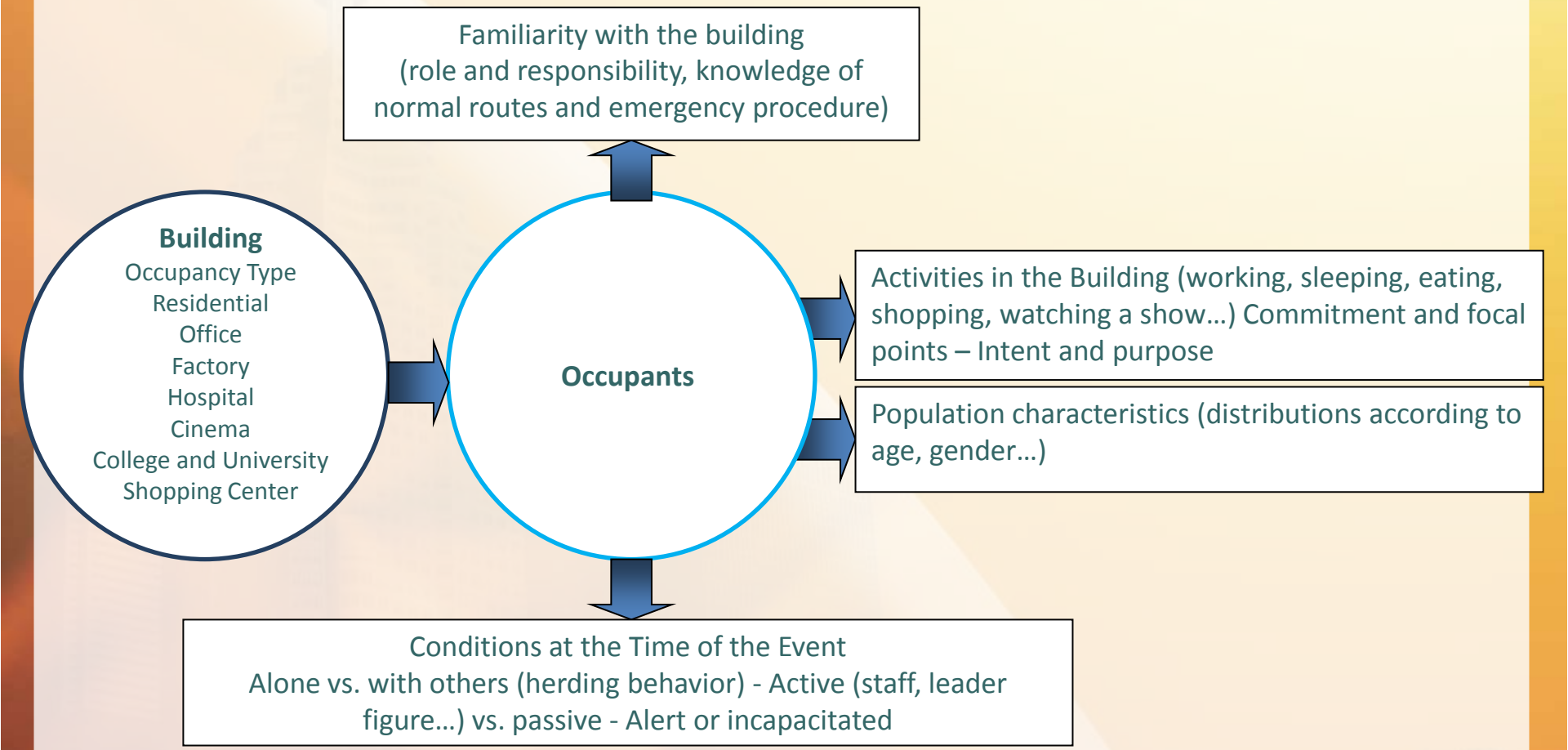
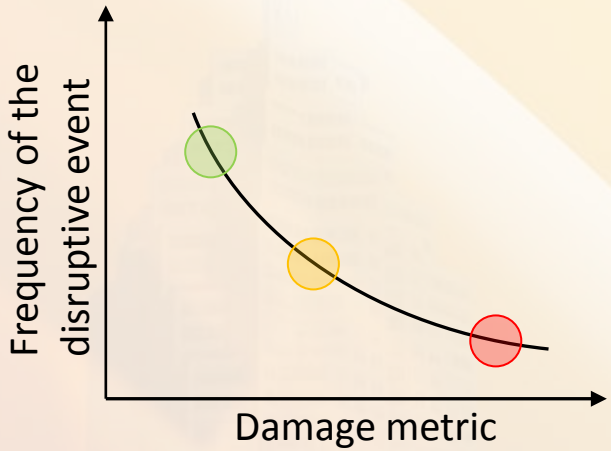
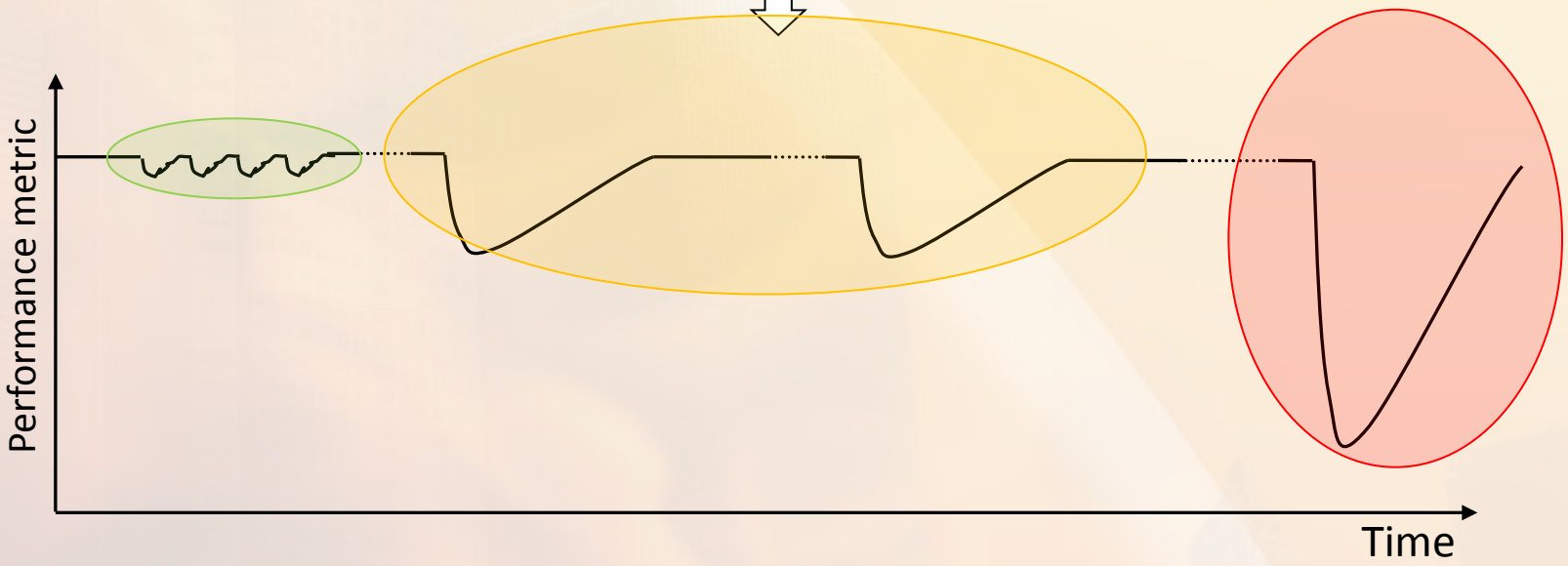


People do not think about fire in the daily use of the building: fire is a disruptive event during the otherwise normal building use.

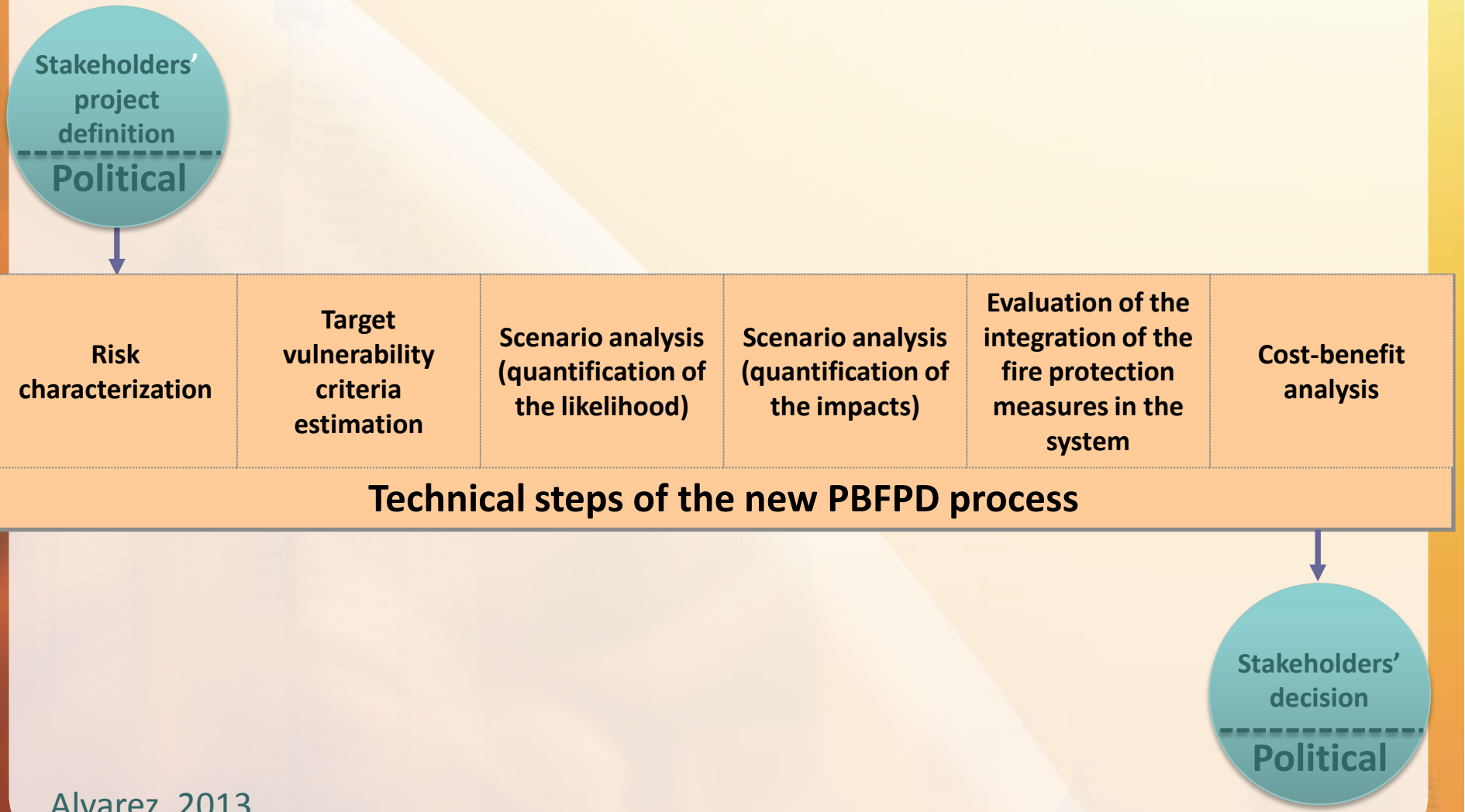
More Holistic Framework is Needed



Gravity	Probability				
	Class 1	Class 2	Class 3	Class 4	Class 5
Level 5					
Level 4					
Level 3					
Level 2					
Level 1					



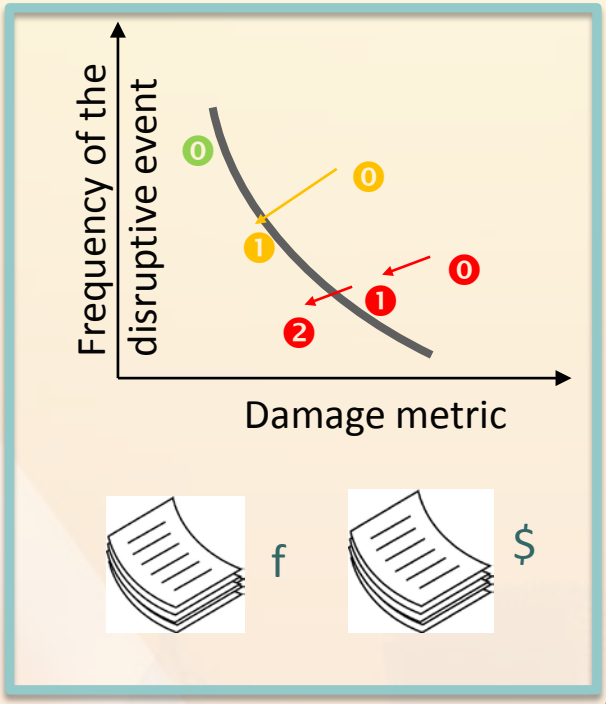
Risk-Informed PB Approach is Needed



Alvarez, 2013

Risk-Informed PB Approach is Needed

Risk characterization	Translation of the stakeholders' concerns in FPE terms: List of system targets
Target Vulnerability criteria estimation	How the targets are affected by the fire
Scenario analysis (quantification of the likelihood) / **Scenario analysis (quantification of the impacts)**	Quantification of the fire risk and proposition of fire protection measures
Evaluation of the integration of the fire protection measures in the system	Documents for the stakeholders to make their decisions
Cost-benefit analysis	



Risk-Informed Performance-Based Approach

Risk characterization	Damage criteria estimation	Scenario analysis (quantification of the likelihood)	Scenario analysis (quantification of the impacts)	Evaluation of the integration of the fire protection measures in the system	Cost-benefit analysis

Going through the PBFPD process

Guideline or standard related to the Process Step

- Standards, guides and guidelines already published or in progress

Research related to the Process Step

- Input from other parties (e.g., census data)
- Input from other experts (toxicologists, economists…)

Input from stakeholders, by building occupancy types and building-occupant systems

Possible output for other steps

Concluding Thoughts

- Fire safety engineering continues to mature – we have made significant advances, but we have more to do
- Regulators have lost some faith in FSE given the wide variation in implementation (for 'regular' buildings, not just unique ones)
- Architects are designing more complex buildings, with new materials, which have a significant sustainability component
- In the short term, regulations will 'prescribe' performance to increase confidence
- Codes and designers moving to holistic building performance – PBFSE needs to as well if FSE want to maintain relevancy
- In the long term, codes will embrace probabilistic nature of fire – PBFSE needs to as well if PBFSE is to advance

Gracias por su atención
Thanks for your attention

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