

# Risk Assessment tool for fire safety in Existing Buildings

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1. Drivers for upgrading existing buildings
2. What are the obstacles?
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# Case for refurbishment

Building stock - large % total energy consumption

Embodied energy significant

Motivation for re-use

Heritage buildings – obvious preservation motives

Commercial buildings – case needs to be made

- Pleasant environment, fit for use
- Energy efficient
- Fire safety



# Sustainable design

## Typical measures

Atria and light wells for natural light

- Fire and Smoke spread, Evacuation

Plenums for natural ventilation

- Fire spread in concealed spaces

Interconnected spaces, increased use of glazing

- Compartmentation

# How do we address the dichotomy

## Performance based design

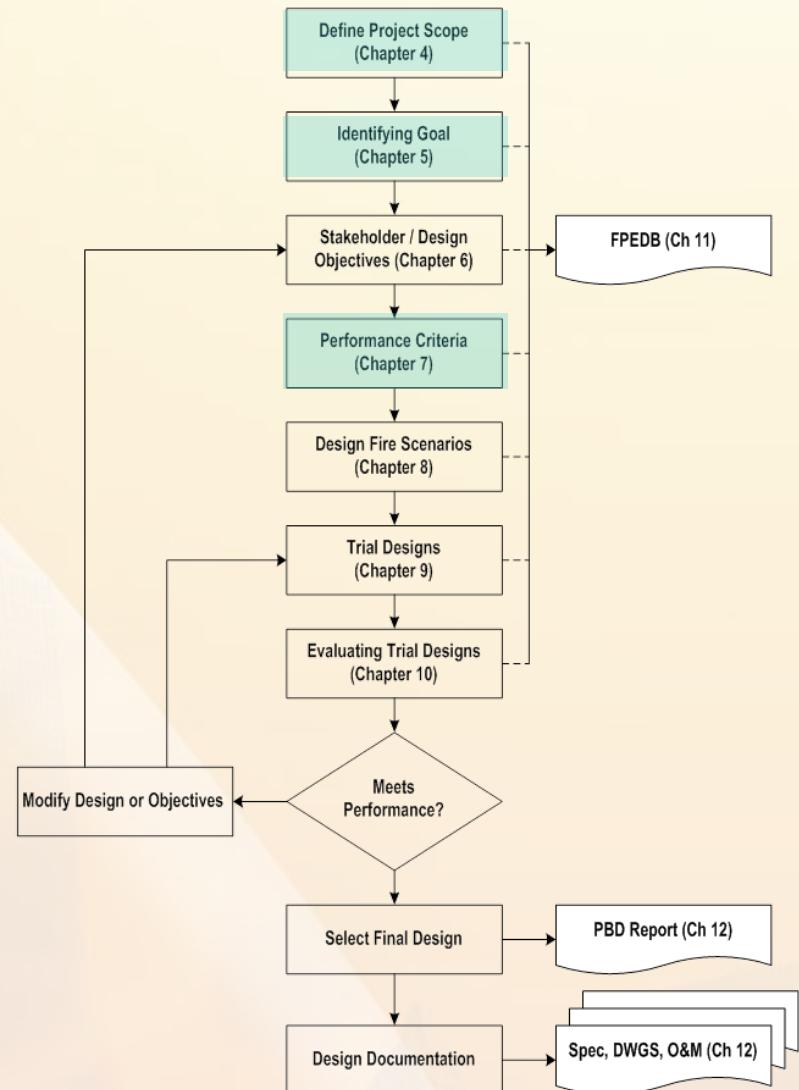
### Identify objectives

- Life safety
- Property protection
- Sustainable design measures

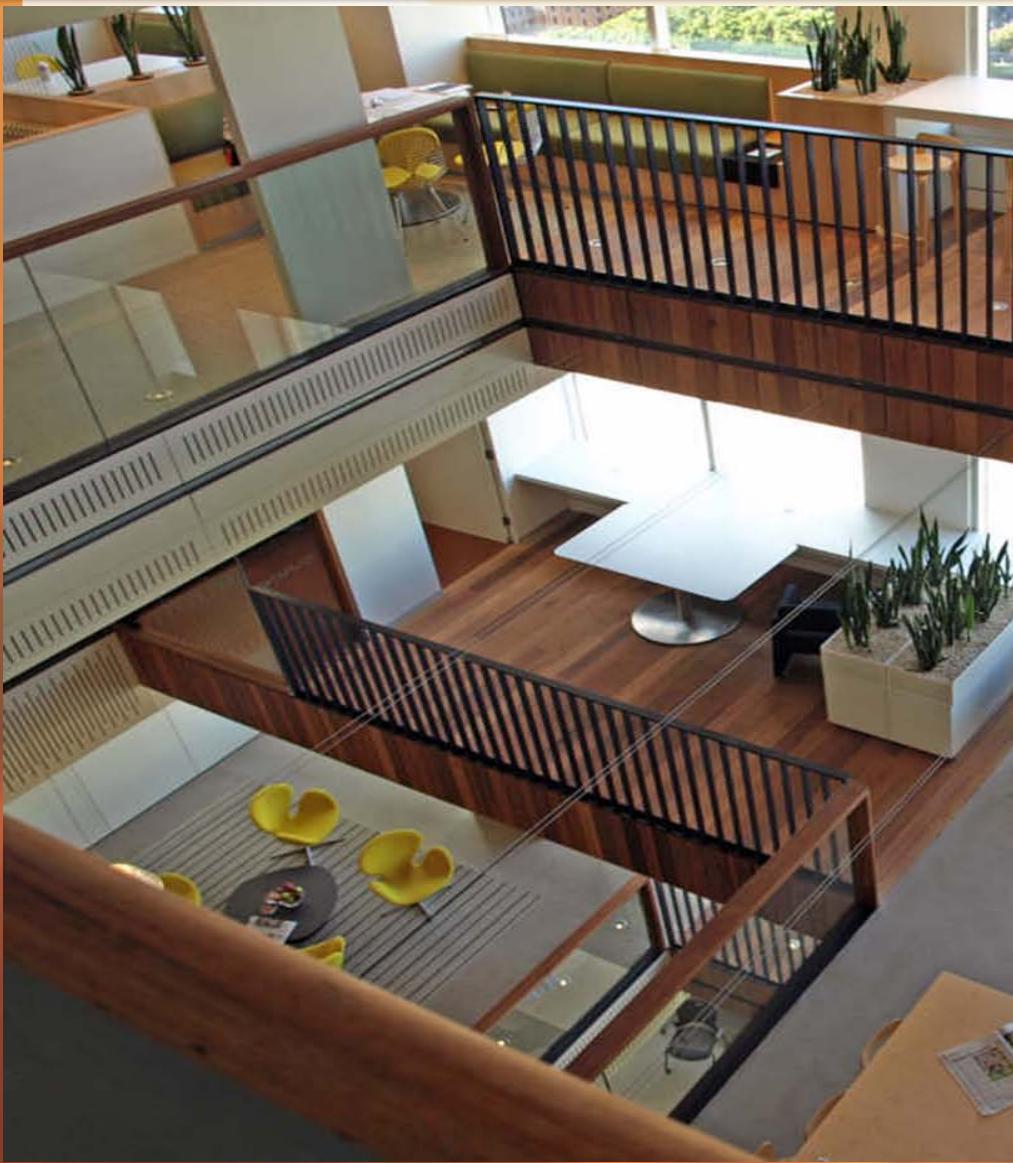
### Establish performance criteria

### Find and evaluate sustainable design measures

### Balance sustainability and fire safety



# Examples



Existing 8 storey office building  
Floors opened up for natural  
lighting of interior spaces

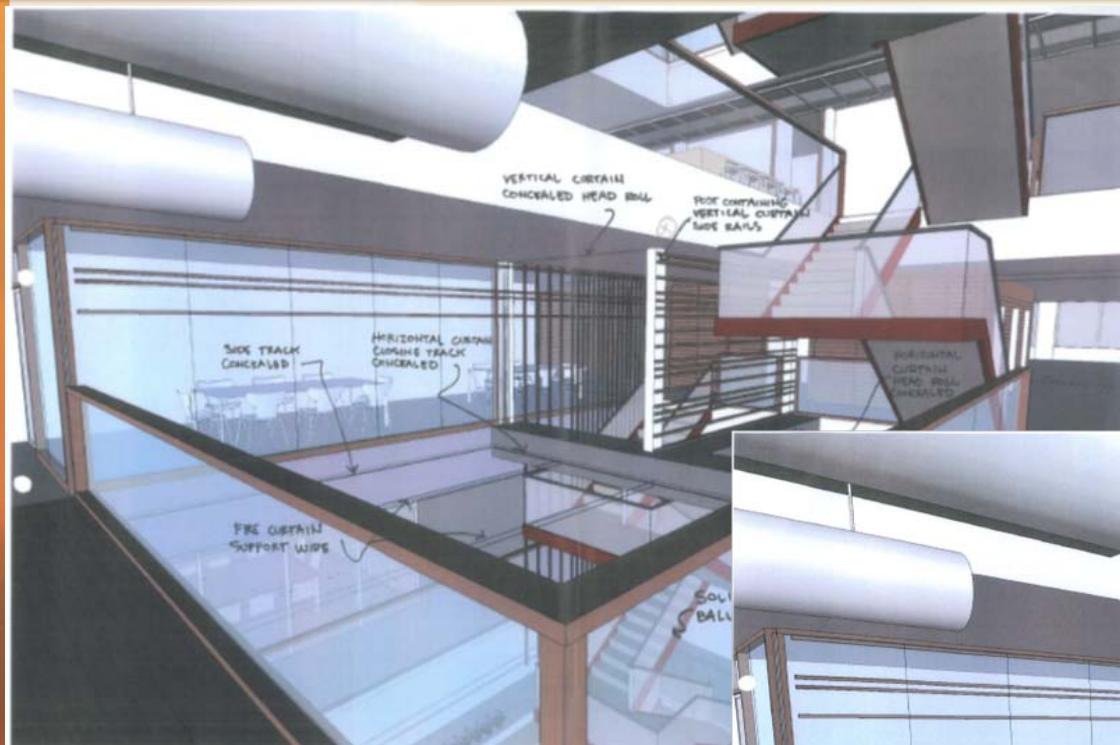
Design strategy consisted of

- Active compartmentation
- Vertical and horizontal fire curtains
- 2-storey compartments upon activation of alarm

Economic and energy efficient

- Minor increase in costs
- Enhanced rental demand

# Practical case

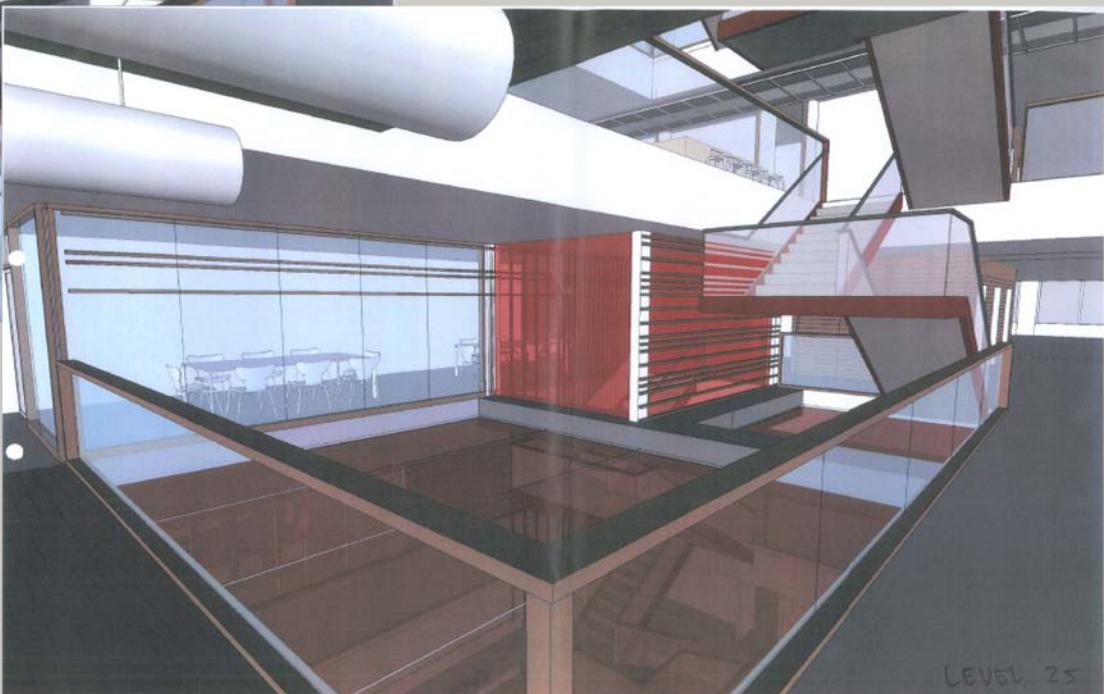


## Performance based design for

- Energy efficient measures
- Fire safety

## Commercial buildings

- Deteriorating before refurbishment
- New lease of life

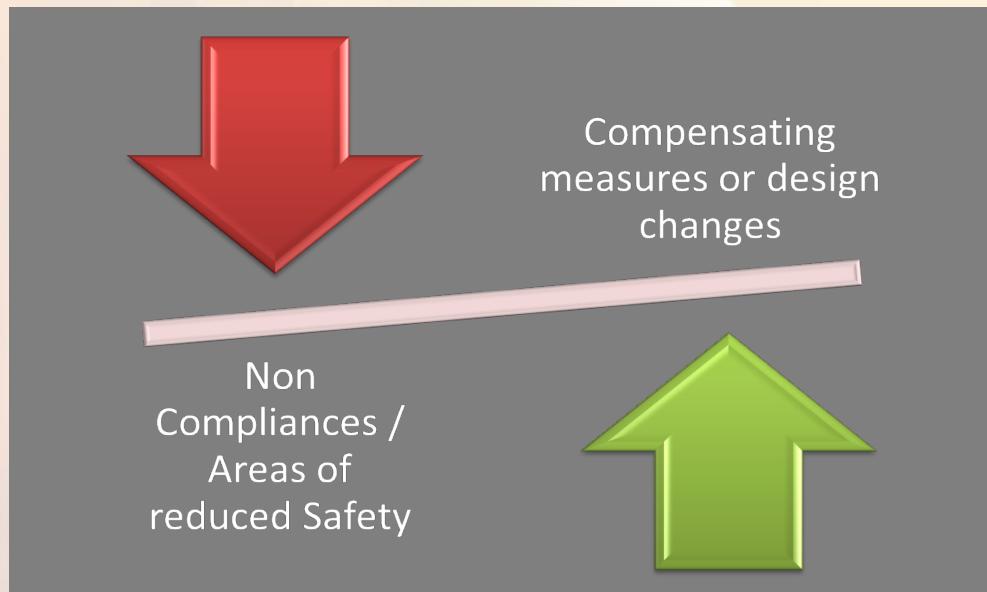


# Decision to upgrade or not

Developers need to be able to evaluate alternatives

Sometimes the performance requirements just can't be met

What then ?



*Let's not fool ourselves into thinking that with PBD we'll always find a fully compliant solution*

Need method to balance fire safety with other considerations

# Alternative to 'do nothing'



Can case be made for improvement, without full compliance ?

Do nothing → energy consumer, low level of fire safety

Refurbish → energy efficient, improved fire safety, but maybe not full compliance

Use Risk Assessment tools to measure fire safety performance against a quantified acceptance threshold

# Risk assessment example

Risk ranking tool developed, based on an internationally recognised methodology for quantifying risk

- (NFPA 101A: Guide on Alternative Approaches to Life Safety)

Tool can be applied to building as a whole or by zone

Methodology:

- Identify key performance indicators for fire safety
- Performance score is calculated against each KPI
- Mandatory values calculated for each of the KPIs
- Performance compared with Mandatory values for each KPI
- Scorecard for each KPI to assess adequacy of the proposed package of measures

# KPI's and Safety Parameters

7 KPI's to assess risk against life safety or property protection

- General Life Safety KPI
- Fire containment KPI
- Extinguishment KPI
- People movement KPI
- General property protection KPI
- Fire propagation KPI
- Smoke spread KPI

Safety Parameters	Life Safety KPIs			
	General	Containment	Extinguishment	Egress
1. Construction / Level of BCA Compliance and Combustibility	✓	✓	✓	✗
2. Level of Compartmentation	✓	✓	✓	✓
3. Unprotected Voids/Vertical Openings	✓	✓	✓	✓
4. Segregation of Hazardous Areas	✓	✓	✓	✗
5. Smoke Control	✓	✗	✗	✓
6. Emergency Movement Routes	✓	✗	✗	✓
7. Occupant Warning	✓	✗	✓	✓
8. Smoke Detection	✓	✗	✓	✓
9. Automatic Sprinklers	✓	✓	✓	✓
10. Emergency Lighting and Illumination	✓	✗	✗	✓
11. Emergency Procedure and Staff Training	✓	✗	✓	✓
12. Fire Hose Reels	✓	✓	✓	✗
13. Fire Hydrants	✓	✓	✓	✗
14. Fire Extinguishers	✓	✓	✓	✗

14 Safety Parameters are used to assess zone performance

S3 (People Movement)

= Sum of (Safety Parameter Scores 2\*,3,5,6,7,8,9\*,10,11)

(Safety Parameter Scores 1 – Construction /Level of BCA Compliance, 4 – Segregation of Hazardous Areas, 12 – Fire Hose Reels, 13 – Fire Hydrants, 14 – Fire Extinguishers are omitted)

# Safety parameter weighting

1. Type of Construction / Level of BCA Compliance	BCA Deficient	Complies with BCA	Higher Level Than BCA	Combustible	
	-2	1	2	4	
2. Level of Compartmentation	No fire compartmentation	Floor by floor compartmentation	Compartmentation within the Floor		
	-3	1	Different use areas compartmented	Individual floors compartmented + different use areas	
3. Vertical Openings (a) (Stairs, shafts)	Unprotected Opening 4 Floors (without sprinklers), BCA non-compliant	Unprotected Openings 3 (without sprinklers) or 4 (with sprinklers) Floors, BCA non-compliant	Openings 2 (without sprinklers) or 3 (with sprinklers) floors to BCA requirement, or no vertical openings	Enclosed with Indicated Fire Resistance	
	-4	-2	1	Smoke Isolated (e) 1 hr or less (f) 2 > 1 hr 3	
4. Hazardous Areas	Double Deficiency		Single Deficiency		
	In Zone	In Adjacent Zone	In Zone	In Adjacent Zone	
	-4	-3	-3	-2 1	
5. Smoke Control	No Control/ BCA Requirement	No or Partial Control/ No BCA Requirement	Passive/Natural and BCA does not require smoke control (h)	Mech. Assisted Systems by Zone	
	-2	1	2	4	
6. Emergency Movement Routes	Single Exit		Multiple Exits		
	Extended Travel (i) or non-compliant width	Extended Travel (d), or non compliant width	BCA DTS Compliant	Horizontal Exits	Direct Exits
	-5	-2	1	1	3
7. Occupant warning	No Warning System Installed & required by BCA	No Warning System, Not Required by BCA	Bell Only	EWS	EWIS (c)
	-4	0	-0.5	2	4
8. Smoke Detection (n) (o)	None (j), required by	Manual call Points	Thermals Only	Smoke Detection	Incomplete System
	-3	1	3	5	2
9. Automatic Suppression (l)	None, not required by BCA	None, required by BCA	Partial and (if sprinklers are provided) compliant separation	Partial and (if sprinklers are provided) non-compliant separation	Entire Building
	1	-3	5	3	10
10. Emergency Lighting and Illumination	No Emerg. Lighting or Exit Signage	Exit signage only	Emergency Lighting only	Emergency Lighting and Exit Signage	
	-3	-1	-2	2	
11. Emergency Procedure and Staff Training	No Procedures or Training (b)	Procedures and no training	Training and no procedures	Comprehensive Plan and Training	
	-3	1	3	5	
12. Fire Hose Reels	Not Installed	Installed, Not compliant (m)	BCA Compliant (m)		
	-4	-2	1		
13. Fire Hydrants (p)	Not Installed	Installed, Not compliant	coverage from external hydrants		
	-5	-2	2		
14. Fire Extinguishers	Not Installed	Installed, Not compliant(m)	BCA Compliant (m)	Installed within each smoke/fire compartment (m)	Installed adjacent each exit. (m)
	-4	-1	1	2	4

# Mandatory values for KPI's

Risk factor values used to calculate Mandatory values for Life Safety and Property Protection KPI's

Ignition Sources (A)	
No Sources	1
One Source not naked flame	1.6
Multiple sources of same type or different type	2
Single Naked flame source	2.5
Multiple flame sources	3
Electrical Protection (B)	
Residual Current Device	1
Circuit Breakers	1.2
Wired Fuses	1.5
Occupant Density (C), number of people / m <sup>2</sup> floor area	
<1	1
1-3	1.2
3-5	1.5
>5	2
Zone Location (D), Floor	
Ground floor	1
1st or 2nd	1.2
Roof	1.4
Basement	1.6
Annual inspection finding a Priority 1 fault (>100oC)	
Annual inspection finding a Priority 2 fault (75 to 100oC)	
Annual inspection finding only Priority 3 or 4 faults (<75oC)	
No fault found or fault rectified	

Number of Floors in whole building	Mandatory Values for Key Performance Indicator		
	Containment (Sa)	Extinguishment (Sb)	People Movement (Sc)
One Storey	2	5	5
2 or 3 Stories	4	8	8
4 Stories or more	5	8	10

blic to staff member ratio	Mandatory Values for Key Performance Indicator	
	Fire Spread (Sd)	Smoke Spread (Se)
1	0	0
2	6	6
3	8	8

Heritage Value of Building and Contents	Mandatory Values for Key Performance Indicator	
	Fire Spread (Sd)	Smoke Spread (Se)
Low or medium heritage value of contents or building fabric within Zone	0	0
High heritage value of contents or building fabric within Zone	6	6
Exceptional heritage value of contents or building fabric within Zone	8	8

Open to public doors/Security controls	Mandatory Values for Key Performance Indicator	
	Fire Spread (Sd)	Smoke Spread (Se)
Open to public doors/Security controls	0	0
Open to public doors/Security controls	6	6
Open to public doors/Security controls	8	8

Risk of switchboards and distribution reloading and faults (G)	Mandatory Values for Key Performance Indicator	
	Fire Spread (Sd)	Smoke Spread (Se)
Low risk	1.1	1
Medium risk	1	1
High risk	1.2	1.2

Annual inspection finding a Priority 1 fault (>100oC)	Mandatory Values for Key Performance Indicator	
	Fire Spread (Sd)	Smoke Spread (Se)
Annual inspection finding a Priority 1 fault (>100oC)	1.0	0.8
Annual inspection finding a Priority 2 fault (75 to 100oC)	0.8	0.6
Annual inspection finding only Priority 3 or 4 faults (<75oC)	0.6	0.5
No fault found or fault rectified	0.5	0.5

# Measurement of performance

Performance measures against Mandatory values for each KPI for zone or building

KPI	Zone Performance	Mandatory Value	Risk Level Result Z(L)
Fire Containment	S1	Sa	S1-Sa
Fire Extinguishment	S2	Sb	S2-Sb
People Movement	S3	Sc	S3-Sc
General Safety	S4	R(L)	S4-R(L)

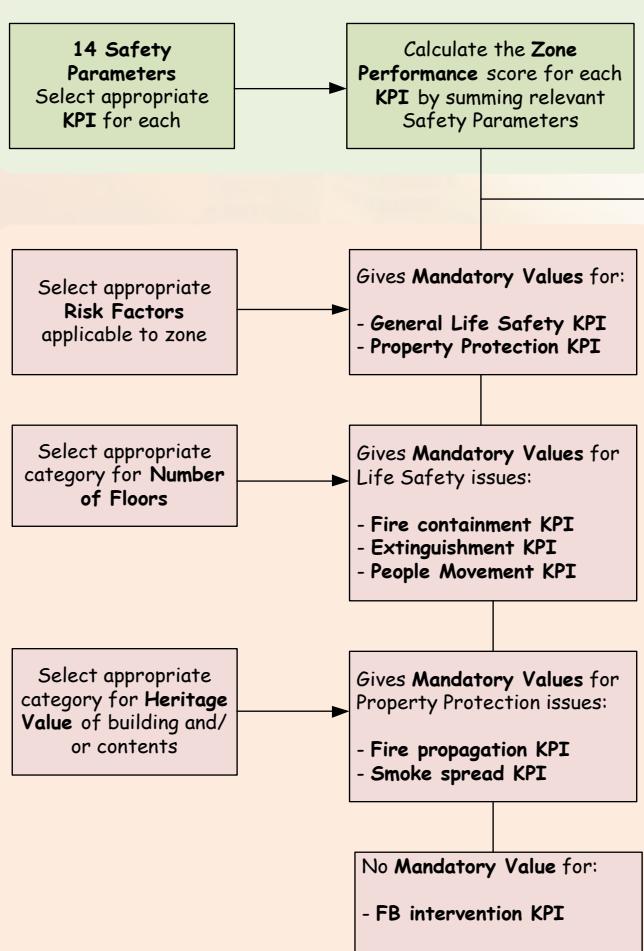
KPI	Building / Zone Performance	Mandatory Value	Risk Level Result Z(L)
Fire Spread	S5	Sd	S5-Sd
Smoke Spread	S6	Se	S6-Se
General Property Protection	S7	R(P)	S7-R(L)

KPI	Level of Fire Risk			
	Red	Orange	Yellow	Green
Fire Containment	Z(L) < -5	-5 ≤ Z(L) < 0	0 ≤ Z(L) < 5	5 ≤ Z(L)
Fire Extinguishment	Z(L) < -5	-5 ≤ Z(L) < 0	0 ≤ Z(L) < 5	5 ≤ Z(L)
People Movement	Z(L) < -5	-5 ≤ Z(L) < 0	0 ≤ Z(L) < 5	5 ≤ Z(L)
General Safety	Z(L) < -5	-5 ≤ Z(L) < 0	0 ≤ Z(L) < 5	5 ≤ Z(L)

Red, Orange, Yellow and Green scoring for convenience

# Overview - Risk Assessment methodology

## Performance -existing state and for options considered



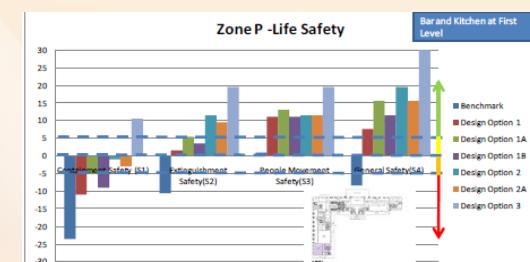
## Measure of Mandatory Performance

### Assessment of Performance vs Mandatory measures

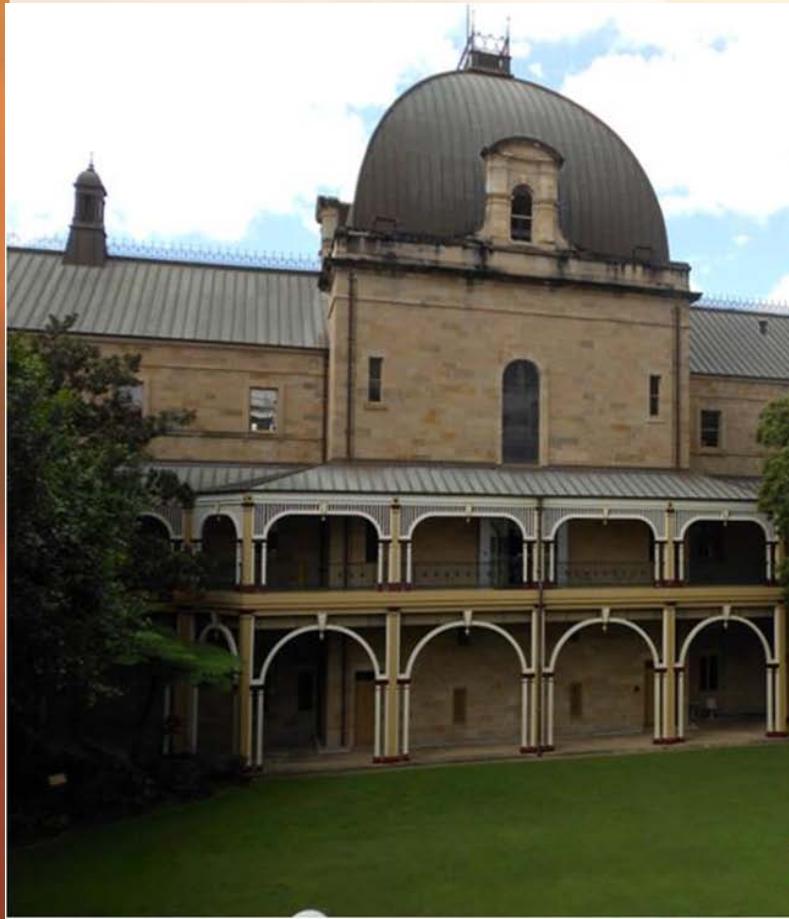


KPI	Zone Performance	Mandatory Value	Risk Level Result Z(L)
Fire Containment	S1	Sa	S1-Sa
Fire Extinguishment	S2	Sb	S2-Sb
People Movement	S3	Sc	S3-Sc
General Safety	S4	R(L)	S4-R(L)

Zone	KPI No.1	KPI No.2	KPI No.2 Score	KPI No.3	KPI No.3 Score	
Major tenancy 1	High	-9.5	Extreme	-10.65	Low	11.1
Major tenancy 2	Extreme	-14.0	Extreme	-14.35	Extreme	-17.1
Specialty 1	Medium	9.5	Medium	3.15	Low	20.9
Specialty 2	Low	11.5	Low	10.5	Low	36.1
Mall 1	Extreme	-17	High	-9.85	High	-5.6



# Existing Parliament House building



# Aim of the risk assessment tool

Identify fire safety hazards and risks in an existing building

Better understand the possible risk reduction measures and their effectiveness

Quickly compare different options

In this case, some of the fire safety issues were

- Common roof void
- Timber construction and open stairs
- Generally good egress but no protected stairs
- Use of areas beneath stairs
- Hydrant performance and locations
- Potential for significant loss before brigade control

# Zone by zone application

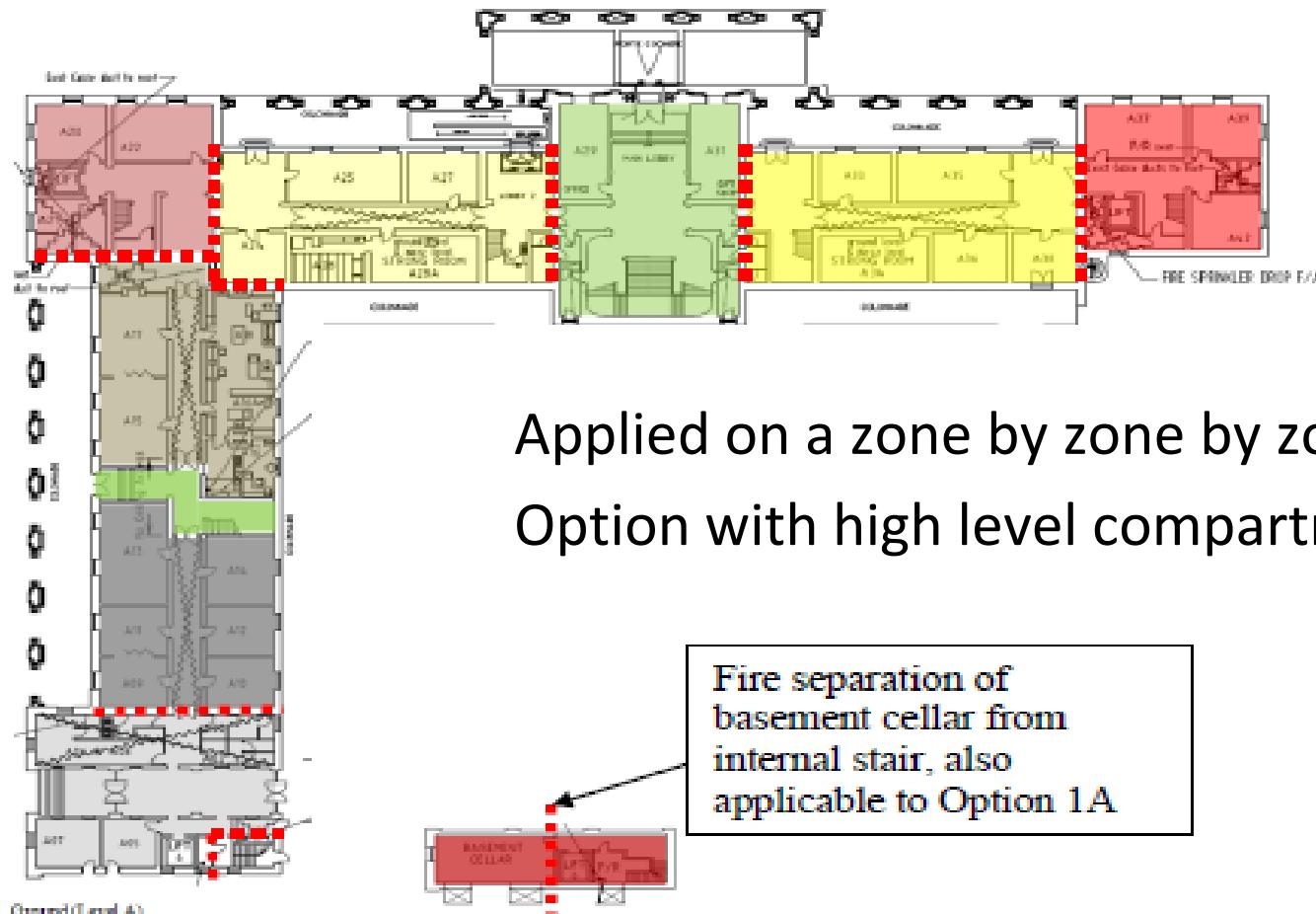
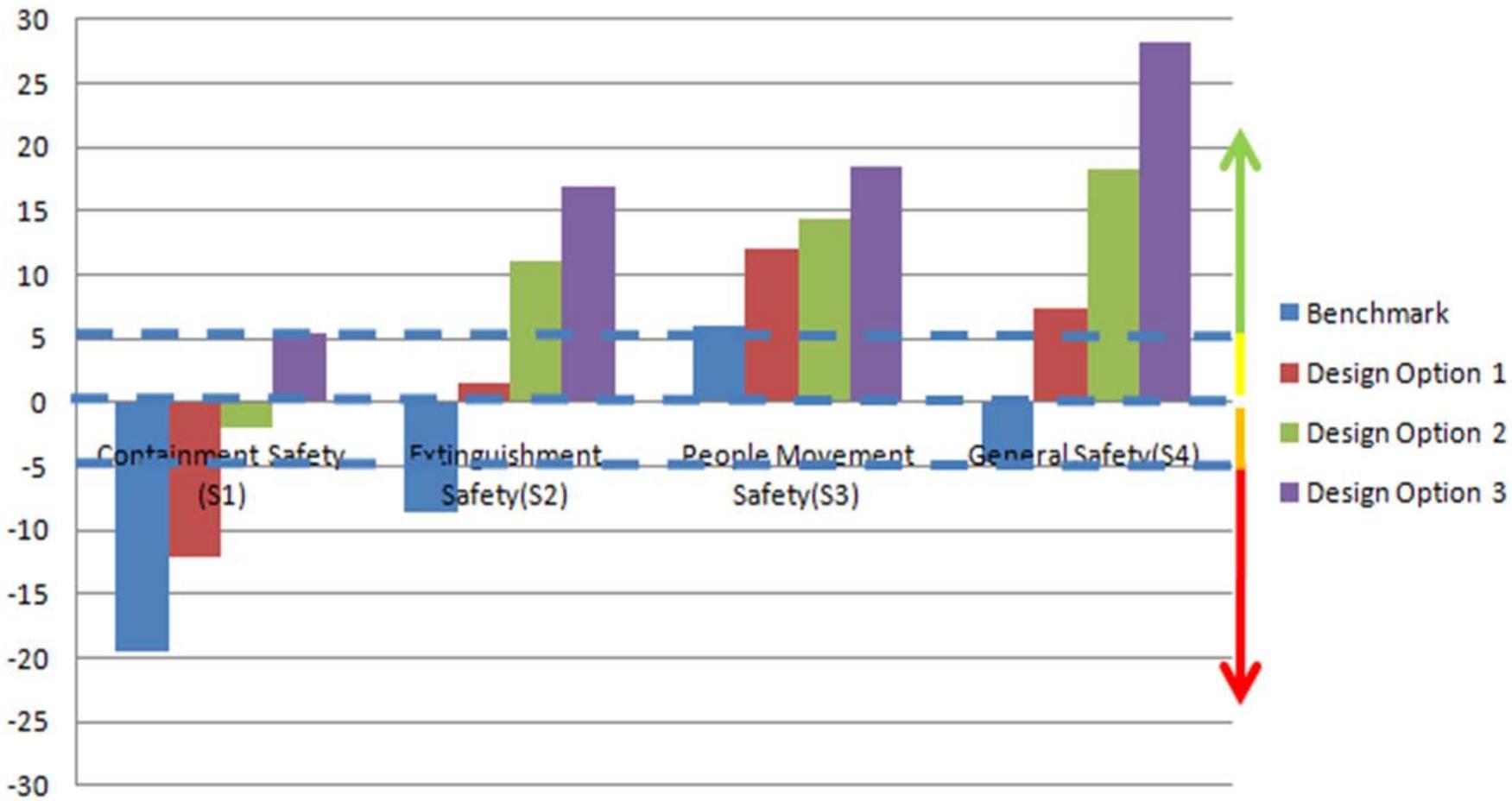


Figure 5 Concept Design Strategy Option 3 – Fire compartmentation lines at ground level

# Risk levels vs Benchmark

## Zone T -Life Safety

O'Donovan Library at  
Second Level



# Summing up on RA Tool

## Advantages of the use of the risk assessment tool

- Identify and rank the fire safety hazards and risks in an existing building
- Enable better decision making based the risk reduction achieved and related to cost
- Allows the Authorities to be involved in setting an appropriate level of risk for a particular building
- Provides means to balance cost, disruption to activities, heritage and sustainability considerations with fire life safety requirements

## Limitations of the risk assessment tool

- A positive score in the assessment does indicate code compliance
- The assessments does not provide a measurement of absolute risk
- The method is not intended to replace a detailed fire engineering analysis (e.g. smoke analysis, egress analysis, structural fire engineering analysis) of future works

# Conclusion

Identify adequate level of Fire Safety - within constraints

- Improvements over a base case (existing or code equivalent)

Performance objectives of all issues need to be considered

- Energy consumption, comfort, fire safety, ...

Quantify a base case and show how proposals affect that

Balance fire safety with other considerations

Can the project afford to proceed?

Need a Legislative environment

to support this approach !



Gracias por su atención  
Thanks for your attention

ARUP

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