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Identify | Evaluate | Solve

A Strategic Approach to the Application of Occupied Building Risk Assessment

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EPSC Webinar ¦ 20th March 2020

BakerRisk – Who Are We?

- Employee Owned
- Over 100 Engineers and Scientists
- Over 30-years Experience “Providing Solutions to Manage Hazards and Risks”

San Antonio, Houston, Chicago, Los Angeles, Canada, United Kingdom

Webinar Presenters

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BakerRisk (UK)

Agenda

1. Introductions

BakerRisk & presenters

2. Risk Management Programmes

Objectives, drivers, scope, key considerations

3. Assessment

Brief outline of building risk assessments

4. Optioneering

Investigation & evaluation of risk mitigation options

5. Implementation

Basis-of-design, development, implementation & validation

6. Q&A

Let us fill in any knowledge gaps!

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Risk Management Programmes

Programme Objective

PRINCIPAL OBJECTIVE: Provide solutions to prevent or mitigate potential risk exposures and demonstrate risk is *As Low As Reasonably Practicable (ALARP)*

1 Identify & Evaluate

- Identify hazard scenarios (release cases and other applicable hazards)
- Evaluate the consequences and associated risk of fire, toxic, explosion and other potential hazards to onsite personnel

2 Examine

- Examine the risk profile computed
- Identify and develop potential options to mitigate risk exposure
- Implement decision making criteria to identify balanced risk reduction strategy

3 Implement

- Implement and commission selected risk mitigation measures

4 Review

- Review for additional low-cost risk reduction solutions and demonstrate risk tolerability

Guidance for Compliance

Guidance prevalent in the UK/Europe

- COMAH & Seveso II Regulations
  - Legislation that requires hazards and risk be assessed
- Guidance for the Location and Design of Occupied Buildings… (CIA, 2020)
  - 4th Edition good practice standard for the siting and design of occupied buildings at chemical and major hazard sites

Guidance prevalent in the U.S.A.

- Process Safety Management of Highly Hazardous Chemicals (OSHA - U.S. 29CFR1910.119)
  - Legislation that requires hazards and risk be assessed
- API RP 752/753/756
  - Deal with locating onsite populations (permanent and temporary buildings as well as tents; respectively)

3 Key Ways to Reduce Site Risk

Address the Process

- Learn from previous incidents
- Switch to inherently safe design
- Enhance detection and isolation capabilities
- Focus on PSM of high-risk processes
- Reduce likelihood of failure

Address the People

- Move non-essential personnel offsite
- Move essential personnel to low risk buildings
- Enhance PPE and train for emergency response

Address the Buildings

- Upgrade existing buildings
- Design / build for hazard or risk profile
- Portable Buildings (Trailers, BRMs, etc.)
- FORTRESS

Factors & Constraints

1 Multiple drivers

Often multiple local stakeholders with differing priorities and constraints.

2 Forecasting

Must align with long-term strategic programmes and initiatives, I.E. master planning.

3 Differing complexity

Decision making for the simplest to the most complex and difficult of operational cases.

4 Emotion quotient

Criteria need to overcome emotionally charged challenges and decision making.

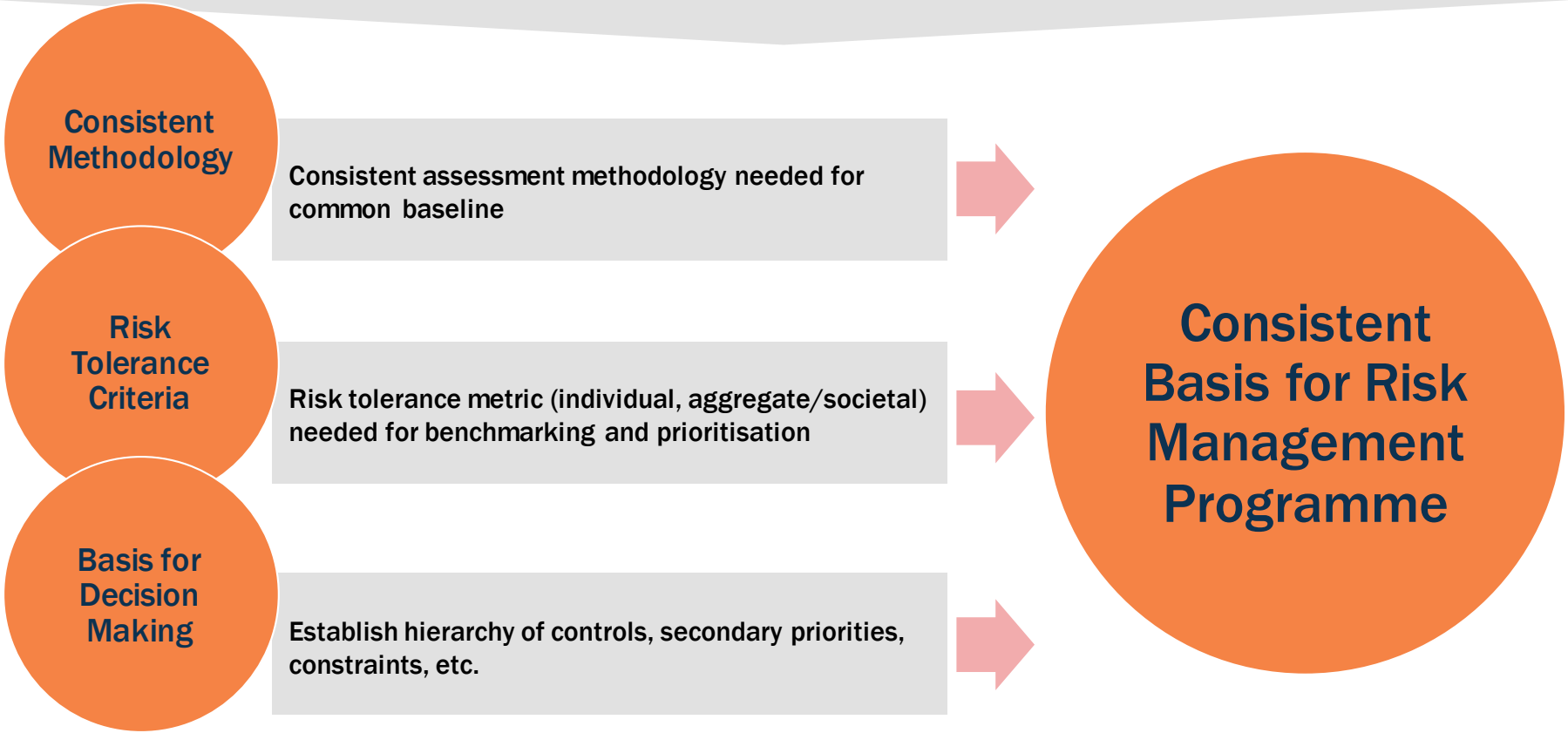
5 Tangible vs. intangible

Overcome bias toward tangible benefits.

››› Basic constraints

Ensure risk is adequately and effectively controlled within funding and time constraints.

Corporate Standards and Criteria



Objective Achieved…?

Before:

After:

Intolerable risk *Risk is ALARP* *Negligible risk*

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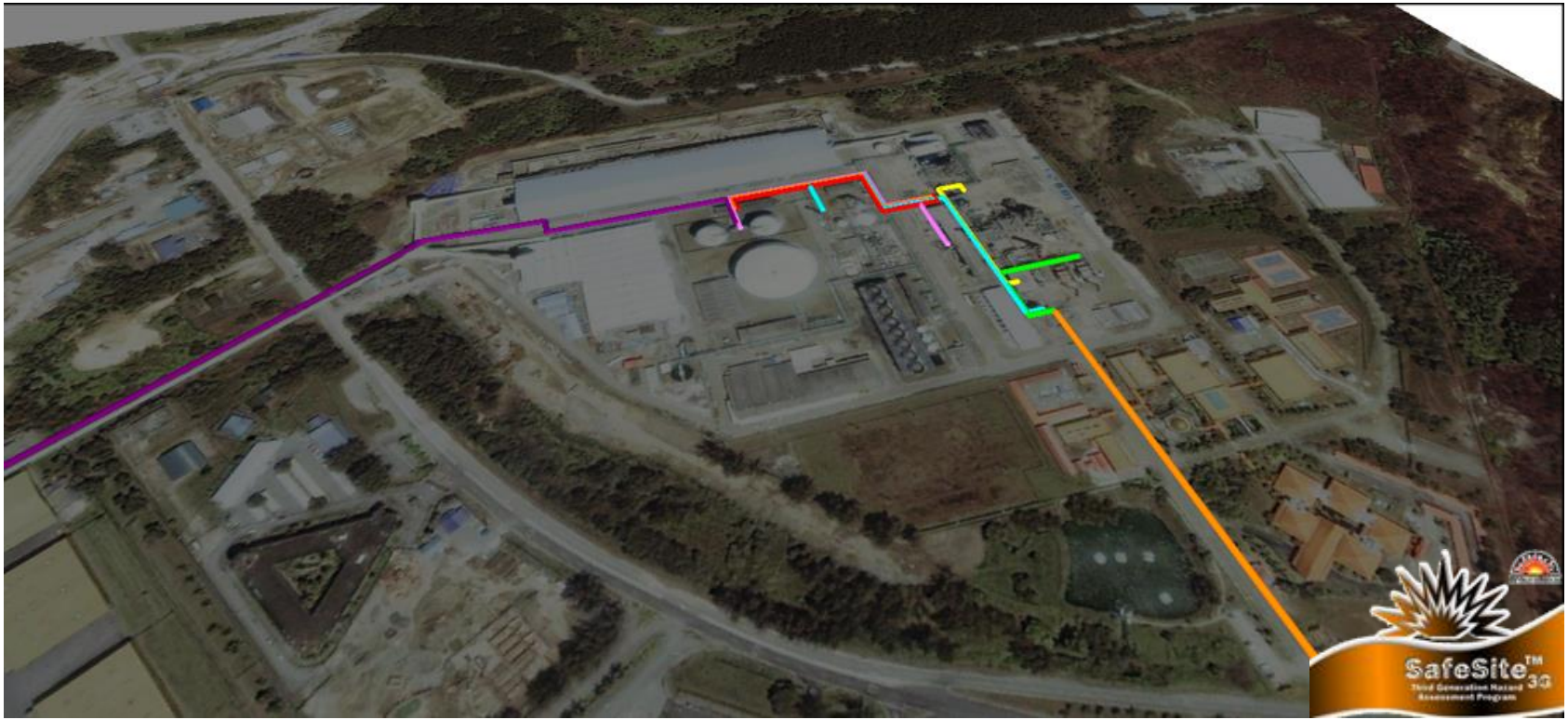
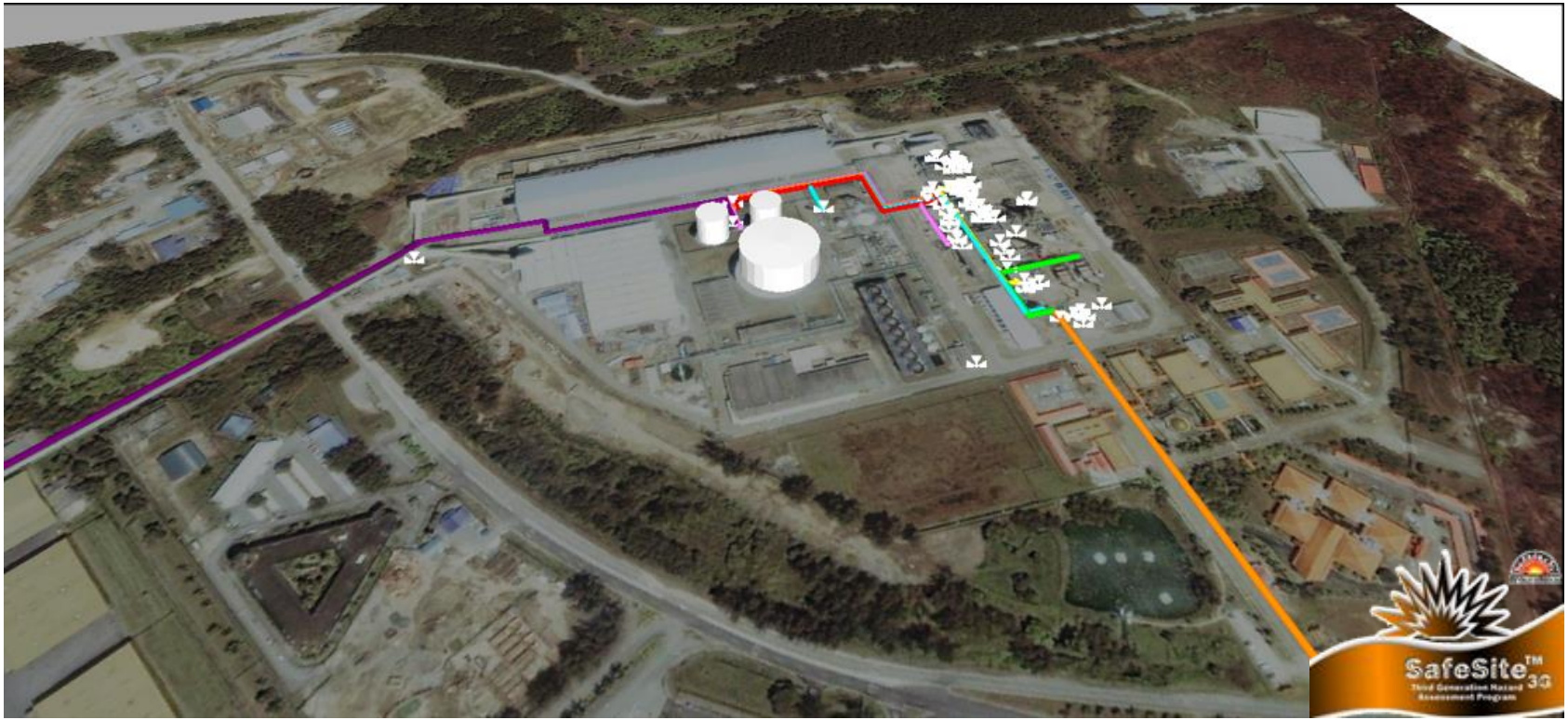
Building Risk Assessment

Hazard Identification & Evaluation

Hazard Identification & Evaluation



Hazard Identification & Evaluation



Hazard Identification & Evaluation

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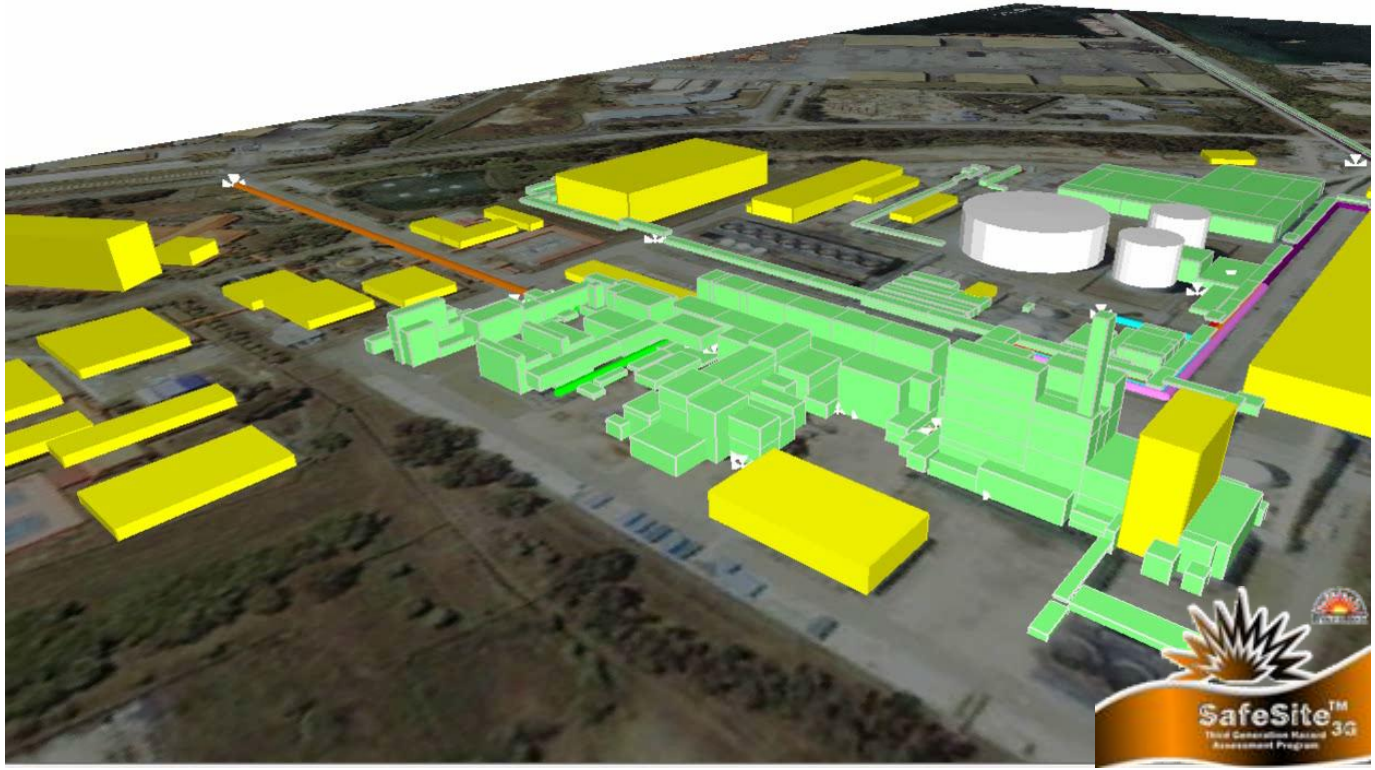
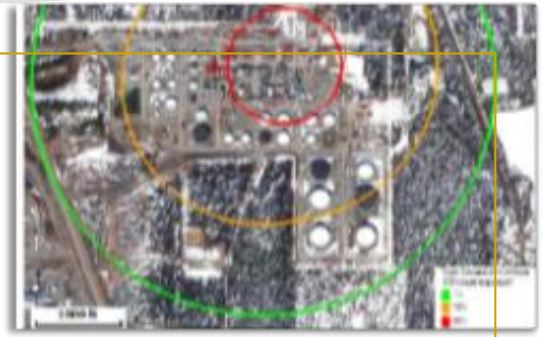


Hazard Identification & Evaluation

Blast Overpressure

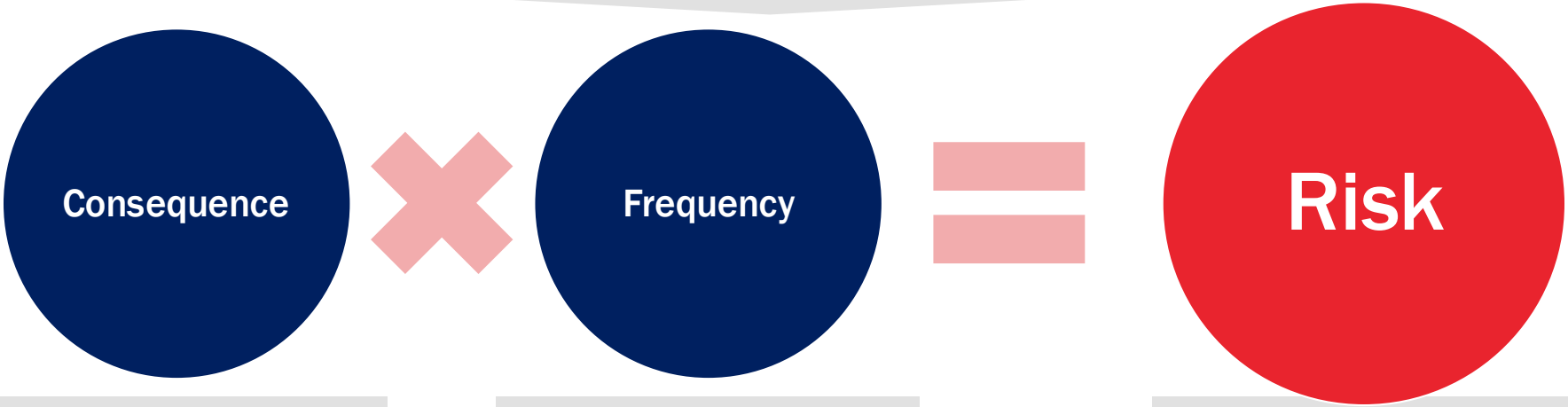


Toxic Dispersion

Thermal Radiation

Flammable Dispersion

Derivation of Risk



Identify Scenarios
- Fires
- Explosions
- Toxic releases

Evaluate Consequences
- Fatalities
- Equipment damage
- Economic losses

How often do the scenarios occur?
- Frequency of leaks / failure of safeguards, etc.
- Other conditional probabilities (ignition, wind conditions, etc.)

Main outcome from a Risk Assessment
- Annual probability of death
- Potential fatalities per year
- Different ways to express
  - site-wide risks
  - work group risk
  - etc.

Common Weaknesses – Limited Scenarios

Screening out low consequence scenarios:

- COMAH legislation vs. CIA guidance
- Cumulative effect on risk may be significant
- Potential underestimation of risk

Screening out high consequence scenarios:

- PHA vs. CIA guidance
- Based on low frequency perception
- Potential underestimation of risk

Neglecting site specific hazards, such as:

- Runaway reactions
- BLEVE
- BPVs
- Fire Box explosions
- Exothermic reactions ››› fragmentation

Common Weaknesses – Blast Damage

Empirical (P_{so})

- Highly expedient
- Generic construction types?
- Based on limited empirical data
- No indication of actual building response – damage prediction defined by pass/fail
- Pass/fail defined by max. tolerable pressure only – no account of dynamic response
- Not repeatable

Empirical P-i

- Highly expedient
- Generic and broad construction types?
- Based on limited empirical data
- Not repeatable

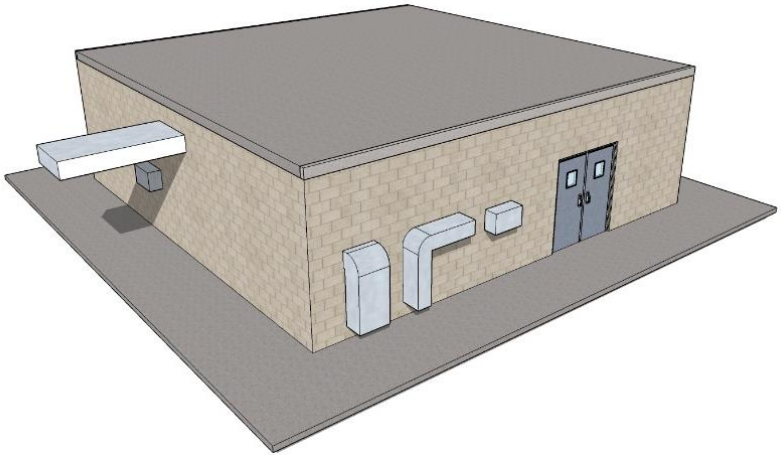
SDOF

- Expedient
- Building/ scenario specific modelling
- Complete damage/ response feedback
- Repeatable
- Varying degree of conservativism in damage prediction – tends to conservative
- Experienced practitioners only

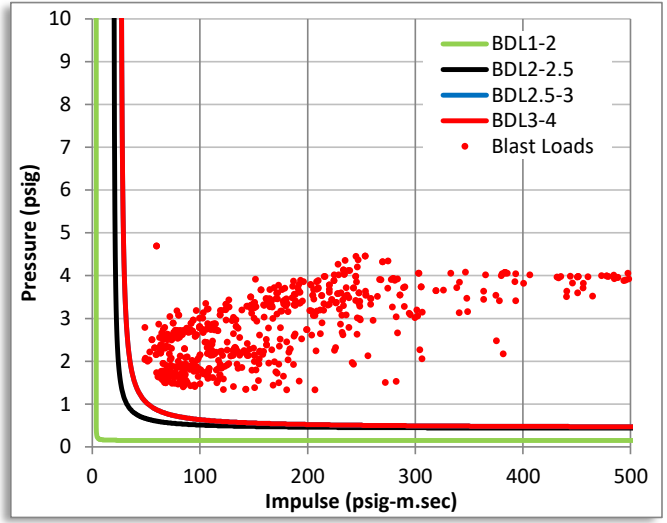
High fidelity

- Time intensive
- Building/ source specific modelling
- Repeatable
- Reduced conservativism in damage prediction
- Experienced practitioners required
- Validation required

Common Weaknesses – Damage Modelling

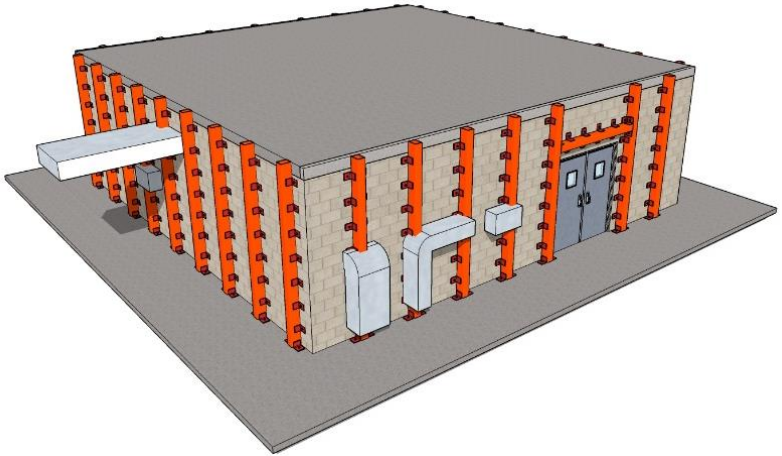


Schematic of existing building

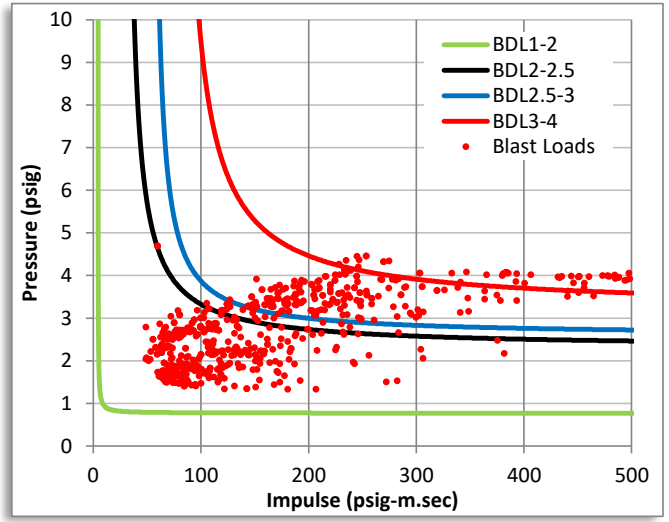


P-i Diagram for existing building

Common Weaknesses – Damage Modelling



Schematic of upgraded building (ext. wall post retrofit)



P-i Diagram for upgraded building

Common Weaknesses – Occupant Vulnerability

Fire

- Building resistance *[overestimate]*
- Escape route *[overestimate]*
- Escape time *[underestimate]*

Toxic

- Building resistance *[overestimated]*
- Evacuation plans & available PPE *[overestimated]*
- Exposure time *[underestimate]*

Blast

- Building resistance *[overestimated]*
- Primary building response vs. OV *[inadequate]*
- Secondary building response vs. OV *[underestimated]*

Commonly underestimating risk by giving unconservative/unvalidated credit

Common Weaknesses – Results Format

Factor	F-P Exceedance Curves	BIR & BSR
Blast, fire and toxic risk feedback?	↻	✓
Able to interpret OV?	↻	✓
Able to interpret risk drivers?	↻	✓
Able to predict building response?	✗	✓
Economic design possible?	✗	✓
…		

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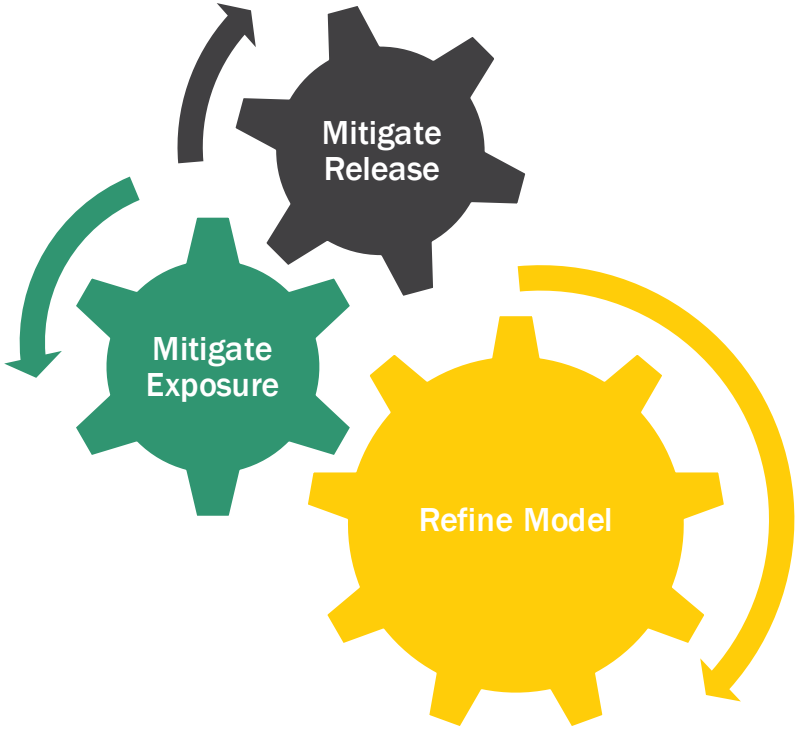
Risk Mitigation Decision Making

Potential Mitigation Options



Potential Mitigation Options

Refine Release Source Modeling

- Inventory limitations
- Pump and compressor capacities
- Emergency shutdown valves
- Operator response
- Check valves
- Detailed CFD modeling

Mitigate Release Source

- Flammable and gas detection
- Water curtains for toxic releases
- Sprinkler systems
- Dikes and runoff systems
- Enhanced maintenance procedures
- Extensive testing and inspection programs
- Detailed start-up procedures
- Thorough lockout/tagout programs
- Verification & validation programs

Mitigate Personnel Exposure

- Personnel/building relocation
- Safe Havens / SIP locations
- Building upgrades for blast resistance
- Emergency escape packs
- Supplied breathing air
- FRC requirements
- Emergency response plans
- Pressurized buildings with limited air ingress
- HVAC isolation interlocks and manual isolation
- Building thermal shielding
- Roll-up door interlocks to prevent flammable ingress

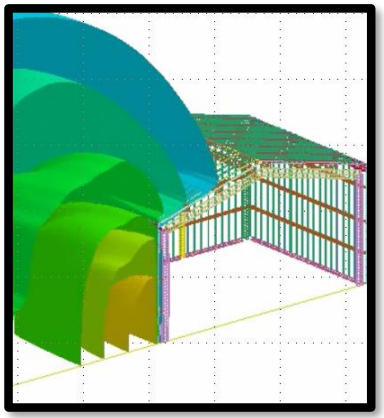
Identify Buildings for Risk Mitigation

- Risk profile
  - Risk above owner's criteria
  - Similar risk contribution from multiple sources
- Functionality
  - Buildings can be grouped based on function for mitigation
- Location
  - "Indirect-costs" related to increased distance from personnel work area
- Potential
  - Some buildings have more potential for risk reduction based on cost efficient options than others

Explosion Risk Mitigation

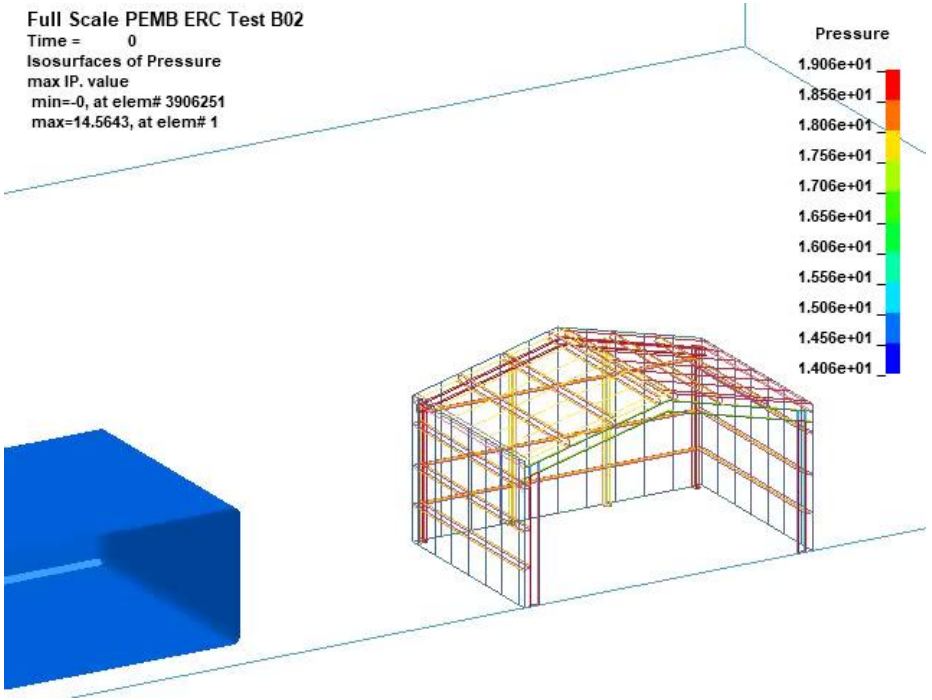
Building exceeds owner's risk threshold

Strengthen building | *High fidelity modeling* | *Relocate function* | *New building*



High Fidelity Model - Example

Full Scale PEMB TEST – Explosion Research Cooperative Box Canyon



Finite Element Model – "Full Scale PEMB Test"

Explosion Risk Mitigation

Building exceeds owner's risk threshold

↓

Strengthen building | *High fidelity modeling* | *Relocate function* | *New building*

Explosion Risk Mitigation

Building exceeds owner's building damage threshold

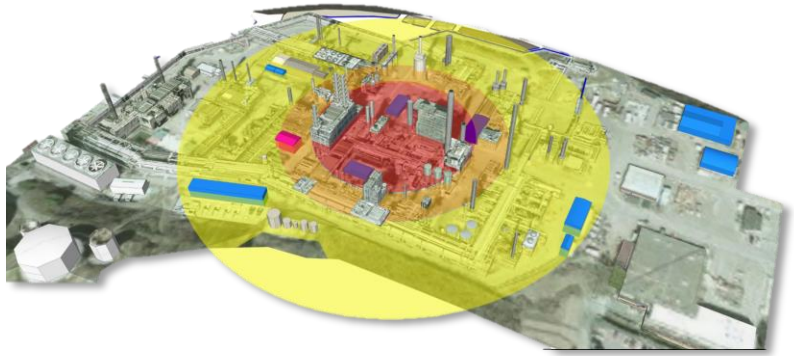
Strengthen building

Is upgrade achievable and practical?

High fidelity modeling

Relocate function

New building



Explosion Risk Mitigation

Building exceeds owner's building damage threshold

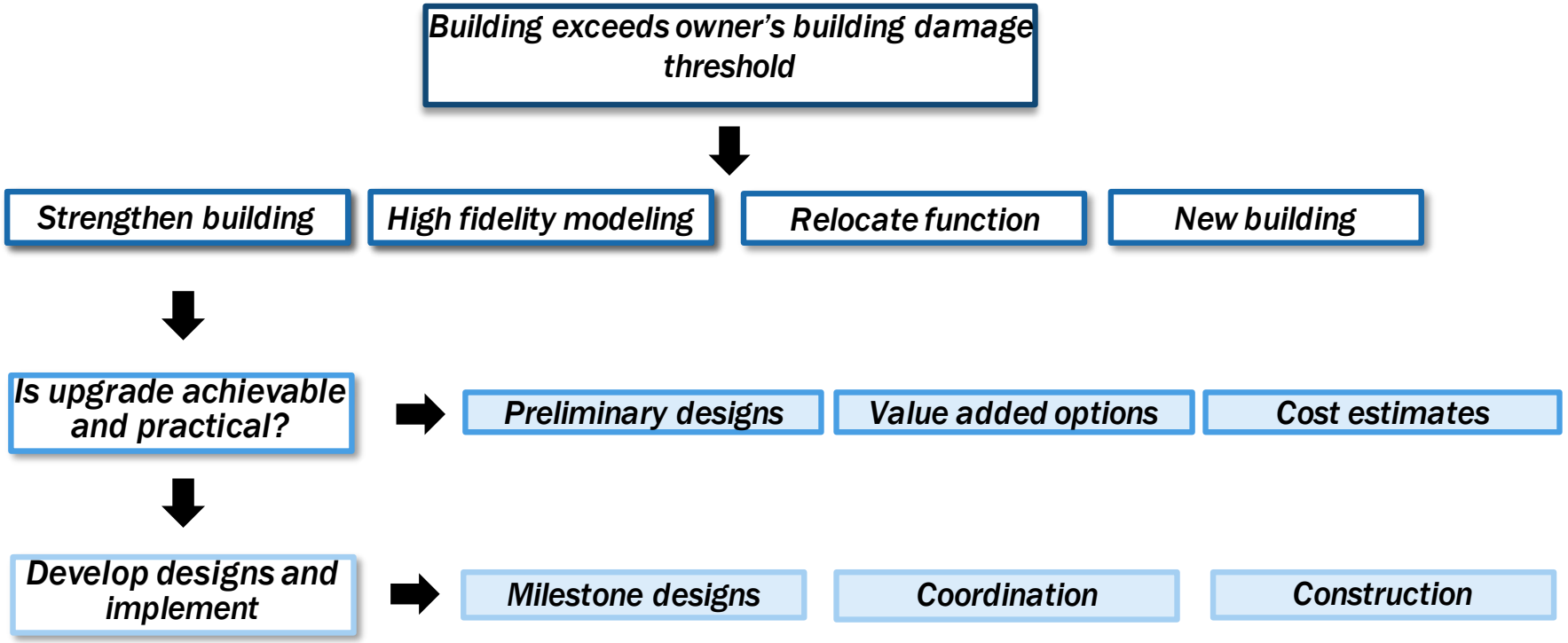
↓

Strengthen building | *High fidelity modeling* | *Relocate function* | *New building*

↓

Is upgrade achievable and practical?

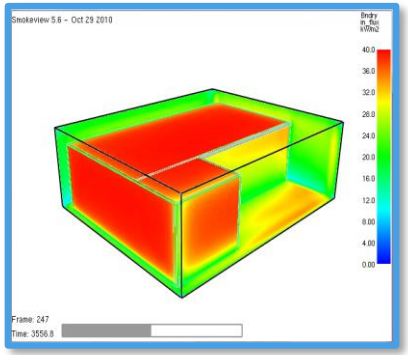
Explosion Risk Mitigation



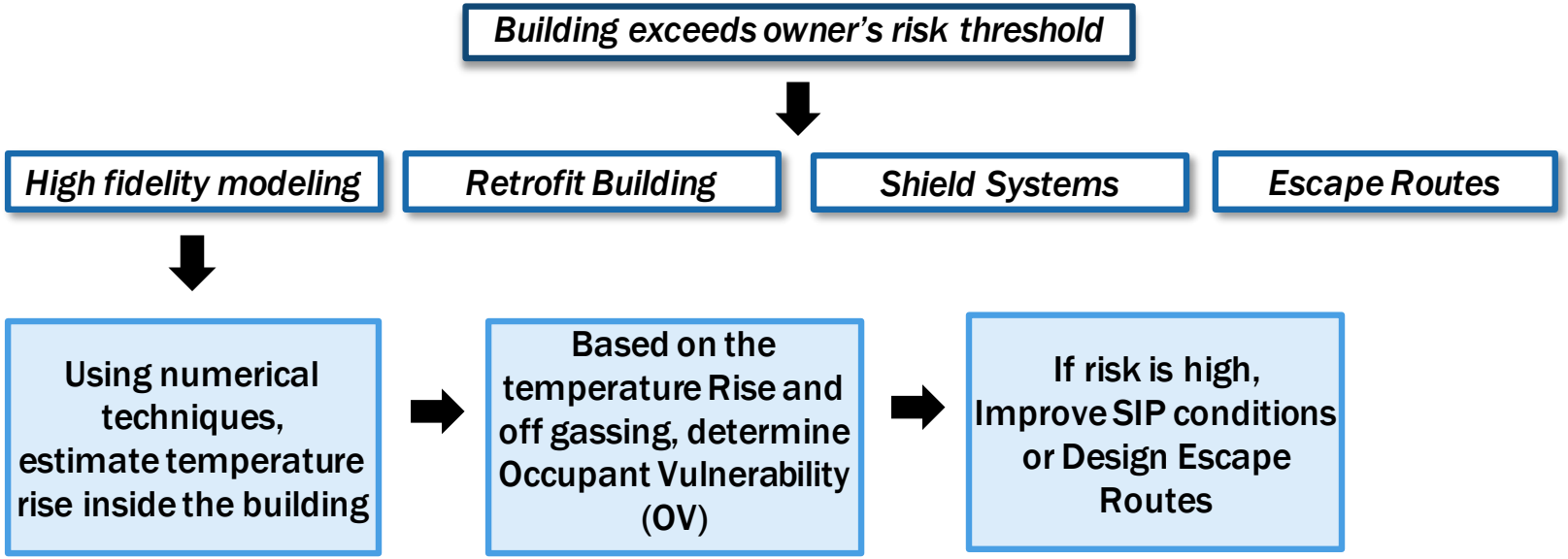
Thermal Risk Mitigation

Building exceeds owner's risk threshold

High fidelity modeling | ***Retrofit Building*** | ***Shield Systems*** | ***Escape Routes***



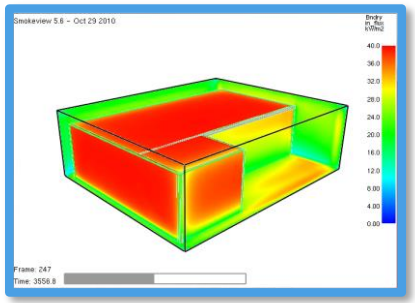
Thermal Risk Mitigation



Thermal Risk Mitigation

Building exceeds owner's risk threshold

High fidelity modeling | *Retrofit Building* | *Shield Systems* | *Escape Routes*



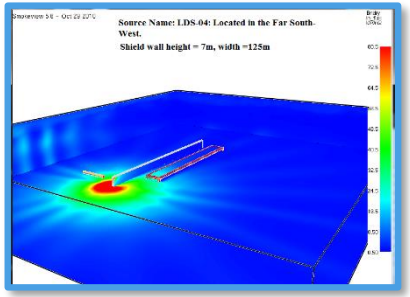
- Retrofit the building at openings or locations of low thermal resistance
- Exterior intumescent paint can reduce temperature rise

Thermal Risk Mitigation

Building exceeds owner's risk threshold

High fidelity modeling | *Retrofit Building* | *Shield Systems* | *Escape Routes*

Shield wall can be designed to mitigate direct exposure from jet fire radiation and impingement

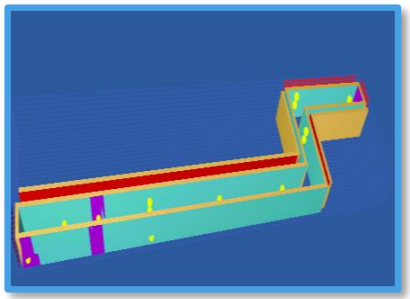


Thermal Risk Mitigation

Building exceeds owner's risk threshold

High fidelity modeling | *Retrofit Building* | *Shield Systems* | *Escape Routes*

Escape corridors can be designed to provide occupants sheltered route to a safer location



Toxic Risk Mitigation

Building exceeds owner's risk threshold

Detection & Isolation | *Leak-tight SIP* | *SIP Training* | *Evacuation*

- Reliable detection
  - Outdoors
  - At the HVAC Inlet
  - Inside

Timely and reliable isolation of ventilation system

Toxic Risk Mitigation

Building exceeds owner's risk threshold

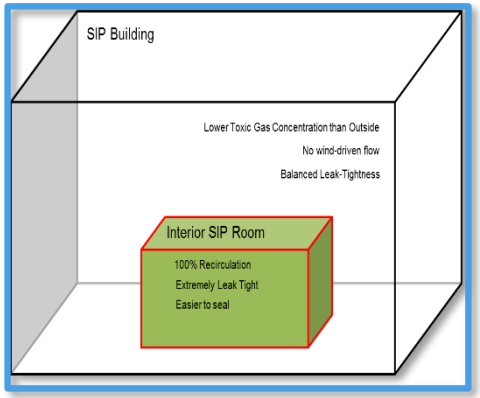
Detection & Isolation | *Leak-tight SIP* | *SIP Training* | *Evacuation*

- Testing to determine current leak tightness
- Minimize leak paths

Toxic Risk Mitigation

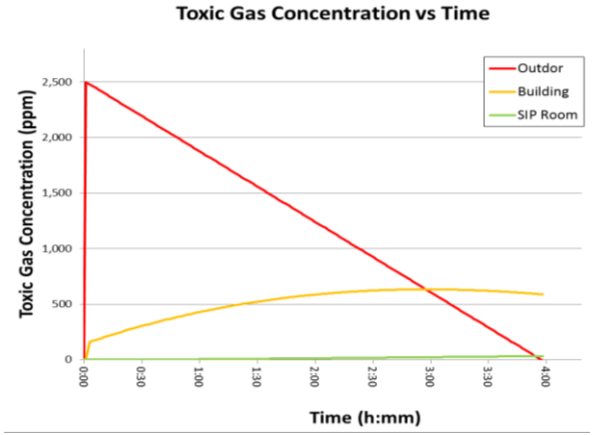
Building exceeds owner's risk threshold

Detection & Isolation | ***Leak-tight SIP*** | ***SIP Training*** | ***Evacuation***



Interior SIP

- Easier to isolate and make leak tight
- Reduces impact of later entries



Toxic Risk Mitigation

Building exceeds owner's risk threshold

Detection & Isolation | *Leak-tight SIP* | *SIP Training* | *Fallback Plan*

Things to know

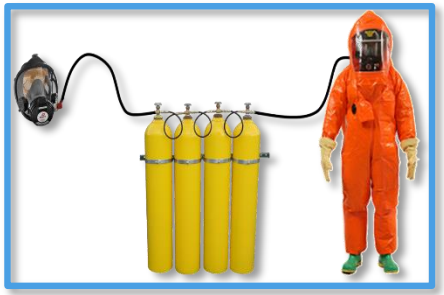
- Strategy for toxic risk mitigation
- SIP Actions
- When to implement fall back plan

Toxic Risk Mitigation

Building exceeds owner's risk threshold

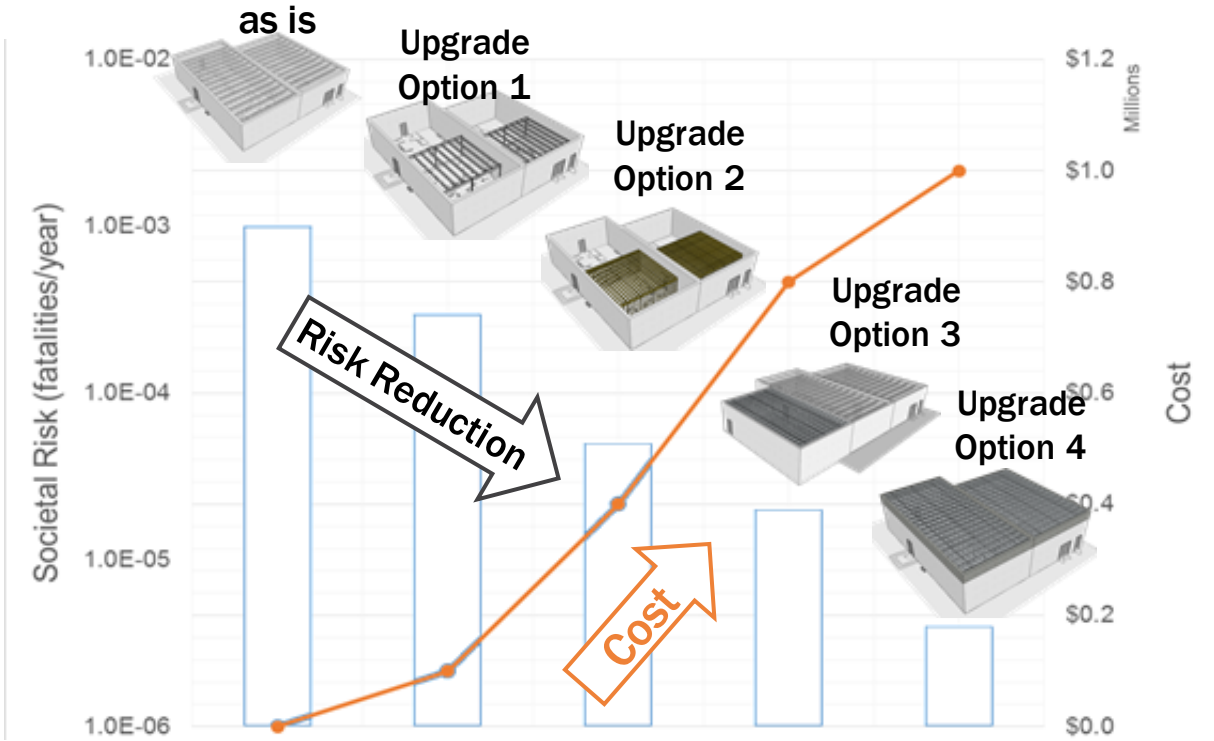
Detection & Isolation | *Leak-tight SIP* | *SIP Training* | *Fallback Plan*

- Evacuation with escape masks
- SIP with Supplied Air

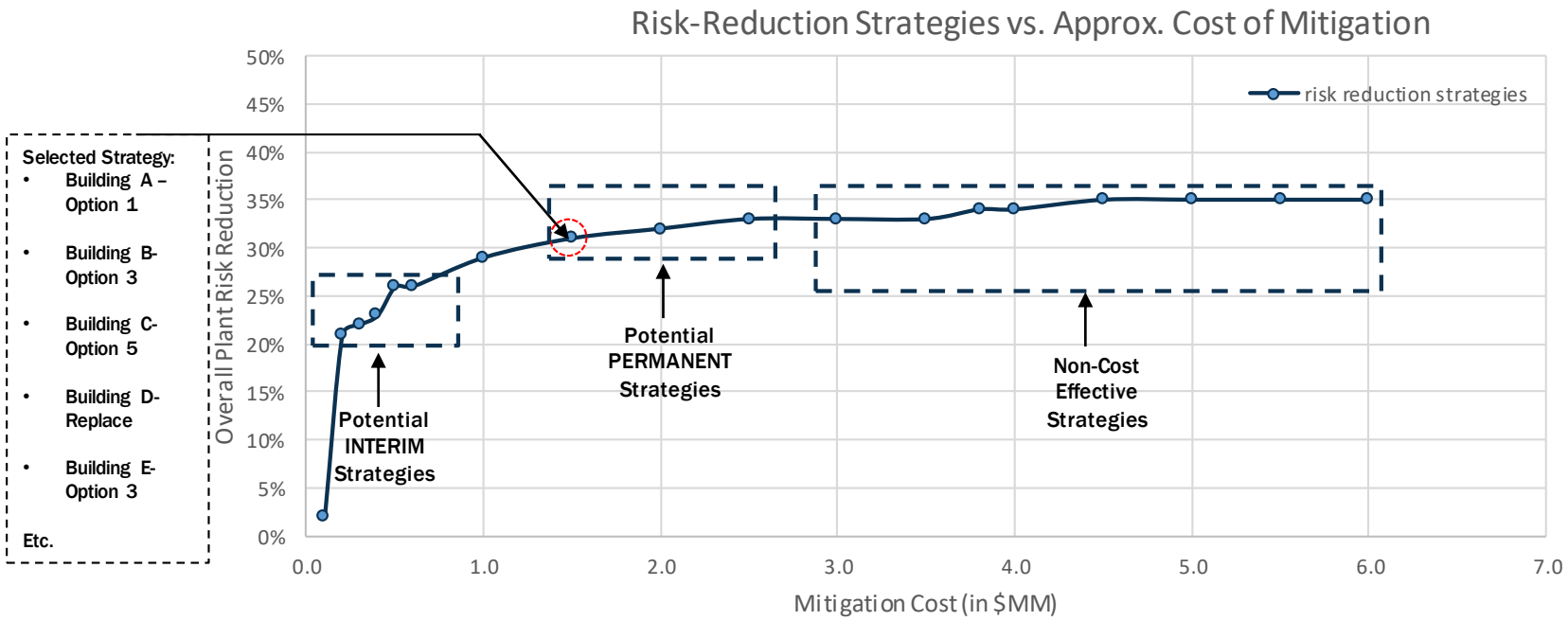


Decision Making

- Compare options based on one or more of the following factors
  - Cost
  - Interferences
  - Business Interruptions
  - Implementation time
  - Indirect-costs



Strategy Selection (Example)



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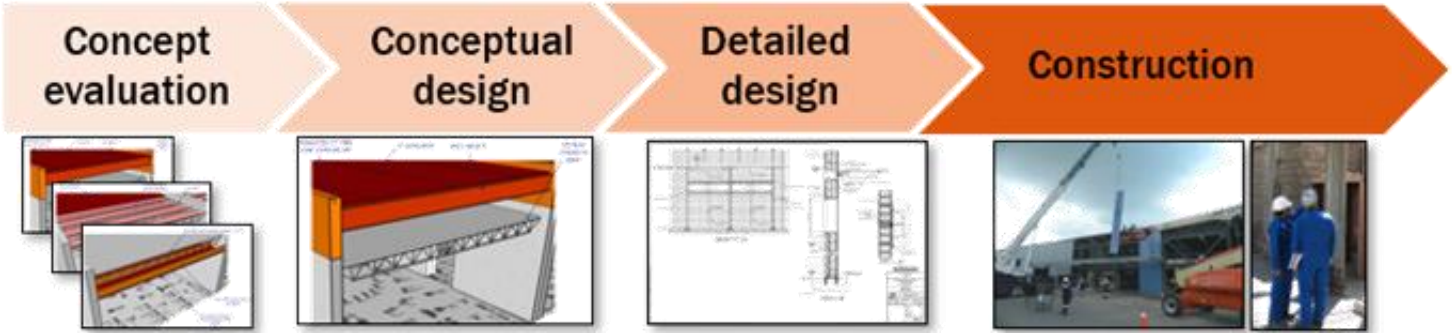
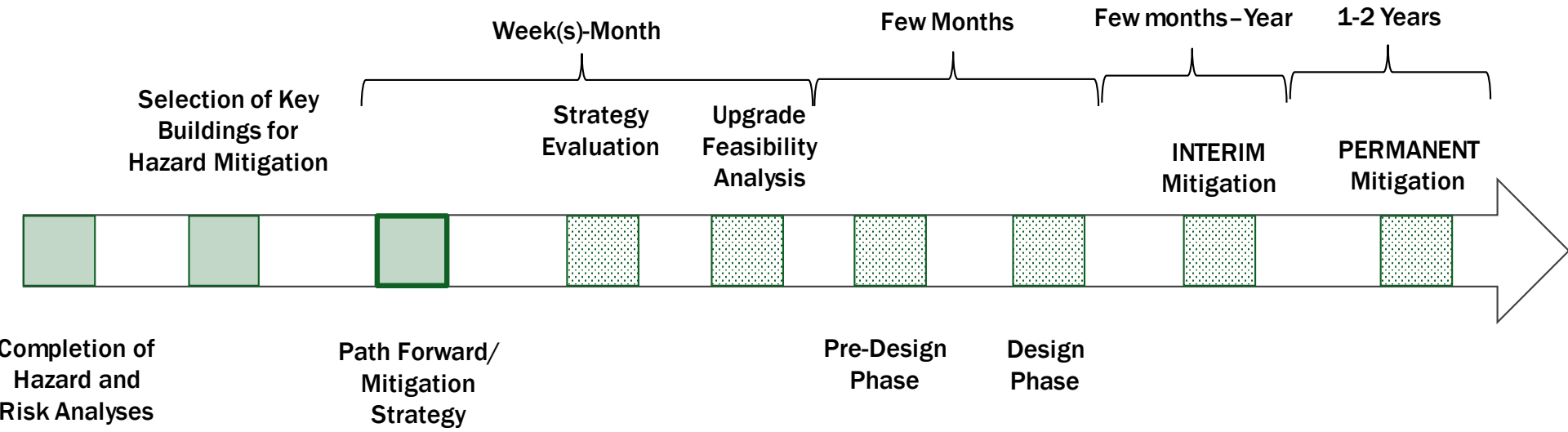
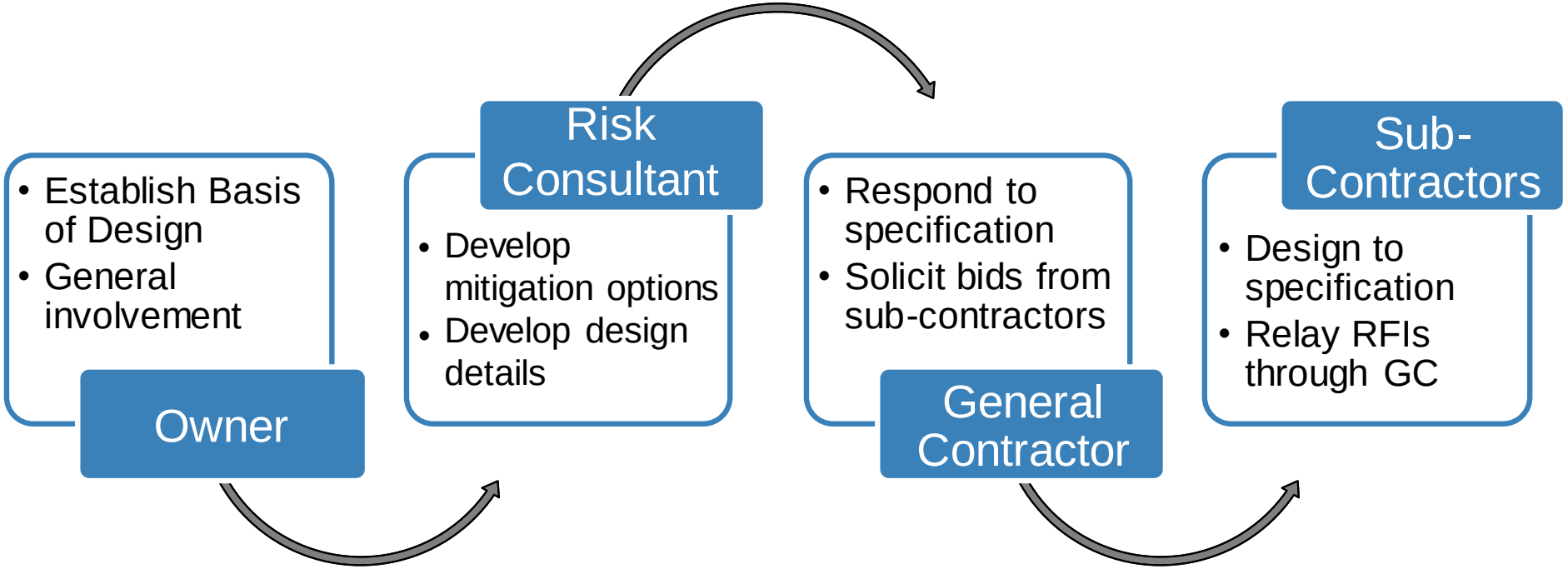
Risk Mitigation Implementation



Risk Mitigation Implementation Time Line

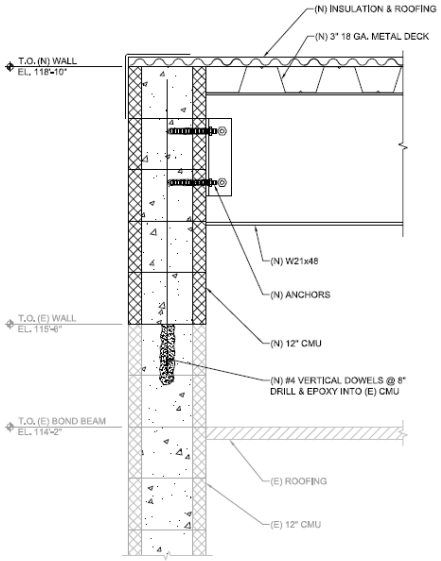


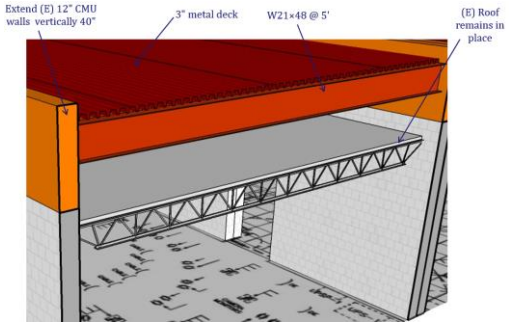
From Hazard Study to Design to Implementation

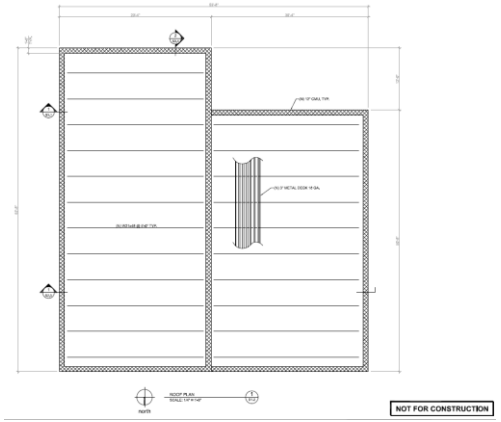


Building Upgrade
Conceptual Design Example

- Owner selects a mitigation option
- Risk consultant develops conceptual design
  - Provide basic details of design
  - Assess windows and doors
  - Architectural details
  - Mechanical equipment
  - Provide 30% level design drawings
- Preliminary construction cost estimates

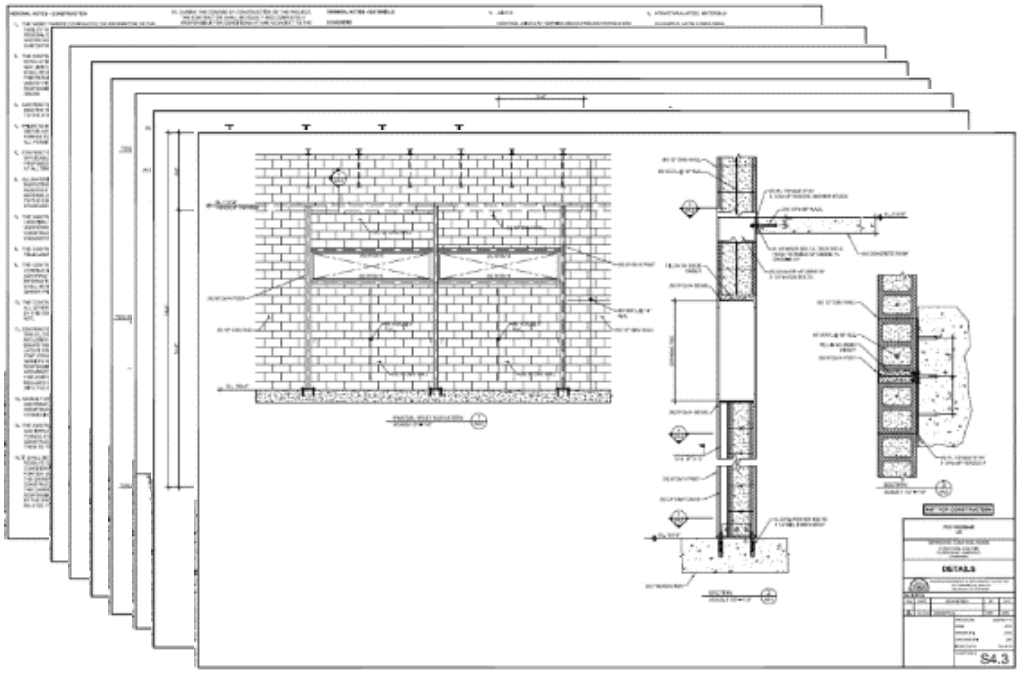






Building Upgrade
Detailed Design Example

- Developed detailed design
  - Detailing to adapt concept to specific areas of building
  - Non-typical conditions
  - General notes/specs
  - Connection details
  - Windows/doors
  - Mechanical systems
  - Architectural
- IFC drawings



Building Upgrade Construction Example

- **Pre-Construction Support**
  - Support bid process
  - Review construction contractor bids
- **Construction support**
  - Review shop drawings
  - Evaluate/approve vendor submittals
  - Respond to RFIs from construction contractor
  - Adapt design to reflect as-built conditions revealed by work in progress

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