Physics and Statistics of Combustion Safety

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Available draft is draft supplied by the vent system at the flue gas outlet.

$$D_a = D_t - \Delta p_{Loss} - D_p + D_b$$

2008 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 34

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$$D_a = D_t - \Delta p_{Loss} - D_p + D_b$$

- D_t: Theoretical Draft
- Δp_{Loss}: Flow Losses
- D_p: Depressurization
- D_b: Boost

Available draft can be broken down into several physical processes

$$D_a = D_t - \Delta p_{Loss} - D_p$$

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- Burner Size
- Appliance Efficiency
- Vent Dimension
- Weather
- Vent Location & Material

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Heat Output Rate

Burner Size

Appliance Efficiency

Vent Dimension

Weather

Vent Location & Material

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Burner Size

Appliance Efficiency

Buoyancy

Vent Dimension

Weather

Vent Location & Material

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Burner Size

Appliance Efficiency

Vent Dimension

Weather

Heat Loss

Vent Location & Material

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$$D_a = D_t - \Delta p_{Loss} - D_p$$

Vent Material

Vent Design (Bends)

Bird Nest

Available draft can be broken down into several physical processes

$$D_a = D_t - \Delta p_{Loss} - D_p$$

Exhaust Fans

CAZ Location

Envelope Tightness

Other Appliances

Usage Patterns

Available draft can be broken down into several physical processes

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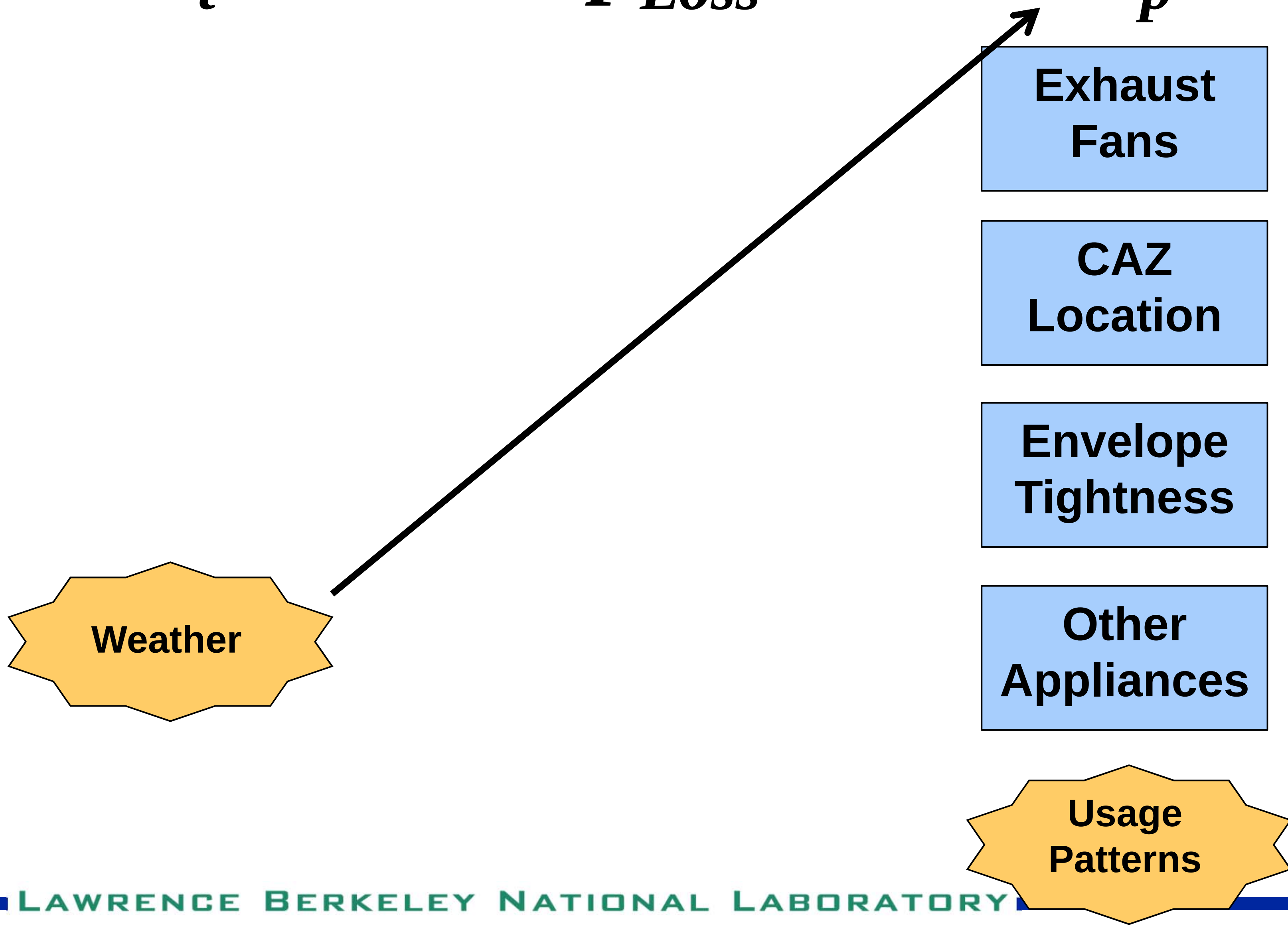

Short term tests include some of the physical processes impacting draft

Test	Physical Processes
House depressurization test with pre-set criteria	
Downdrafting test (Worst-Case Depressurization)	
Backdrafting test (Downdrafting test + Operation)	
Cold vent establishment pressure (CVEP) test	

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All tests are impacted by weather at time of test

Continuous tests measure more physical processes but are expensive

Test	Advantages	Disadvantages
Continuous backdrafting test	• Measures vent pressure • Measures appliance status	• Does not measure spillage events. • Cost
Continuous spillage test	• Measures CO/CO_2 • Measures spillage zone Temperature • Measures appliance status	• Thermal radiation • Cost

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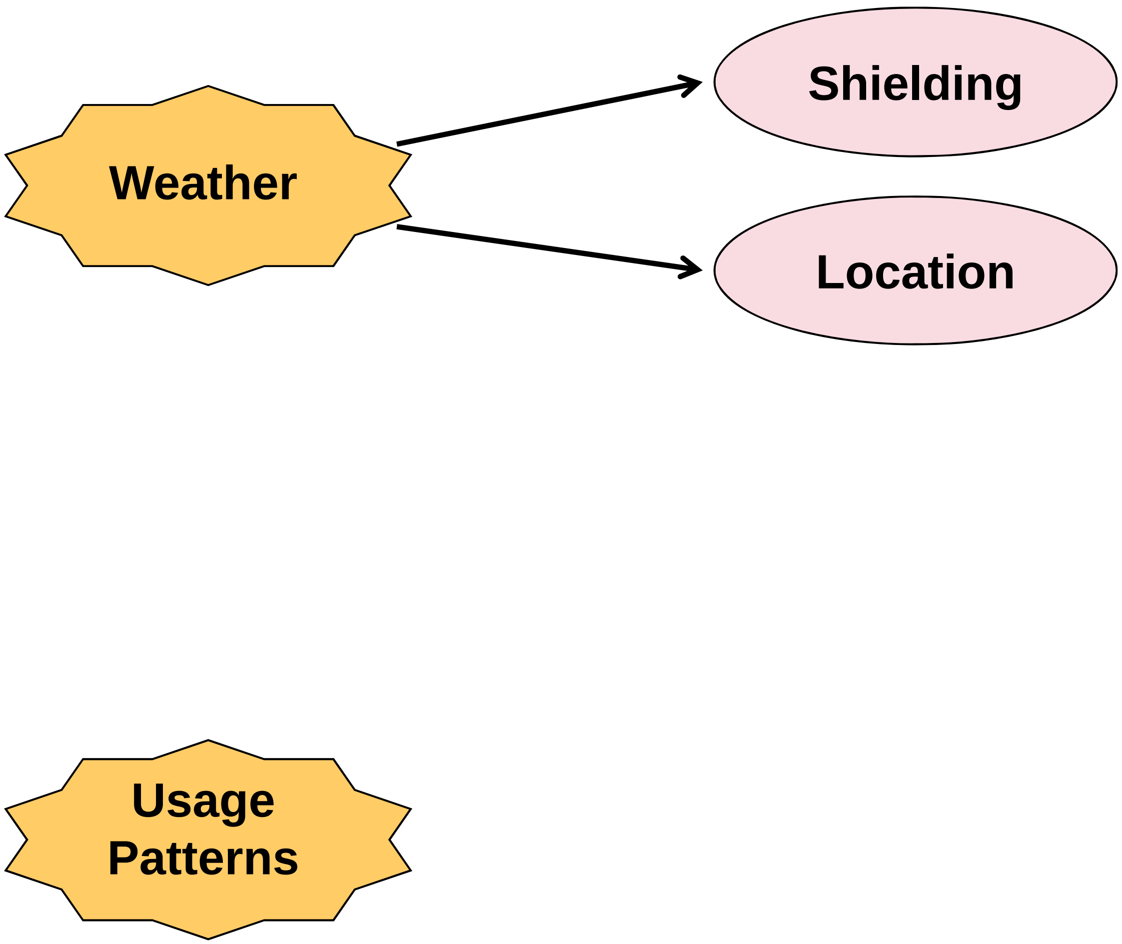
All tests require two visits, require data analysis, and may not capture weather effects

Time dependent parameters can be measured using statistical data

Weather

Usage Patterns

Time dependent parameters can be measured using statistical data



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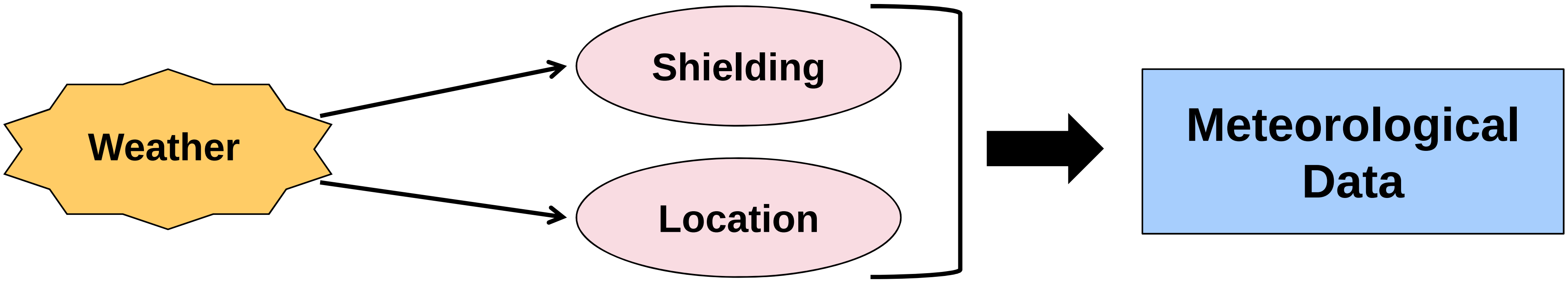

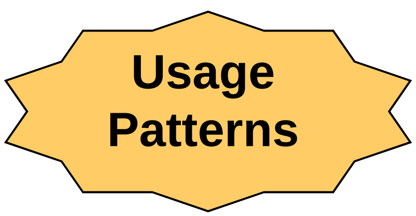

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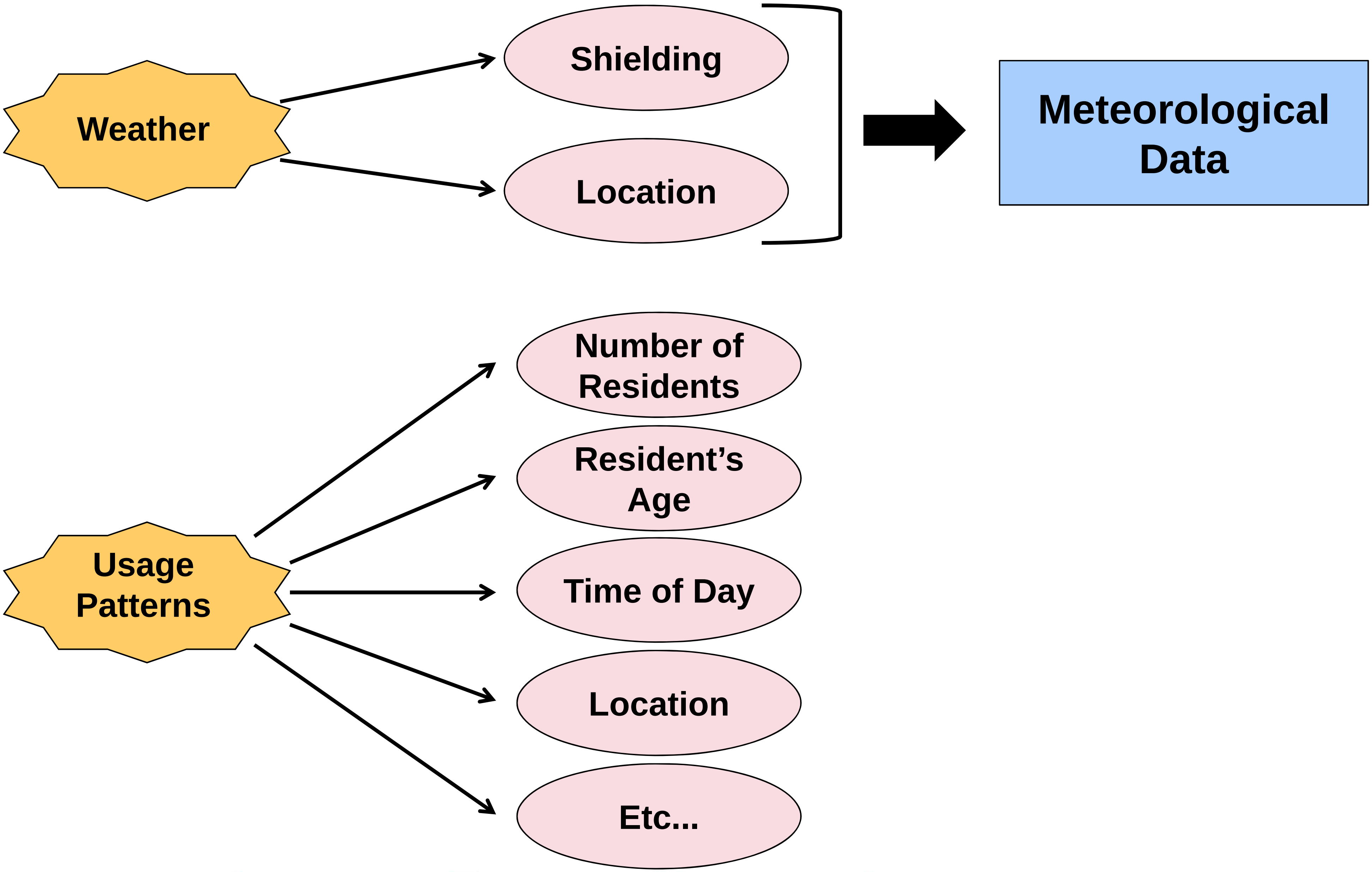

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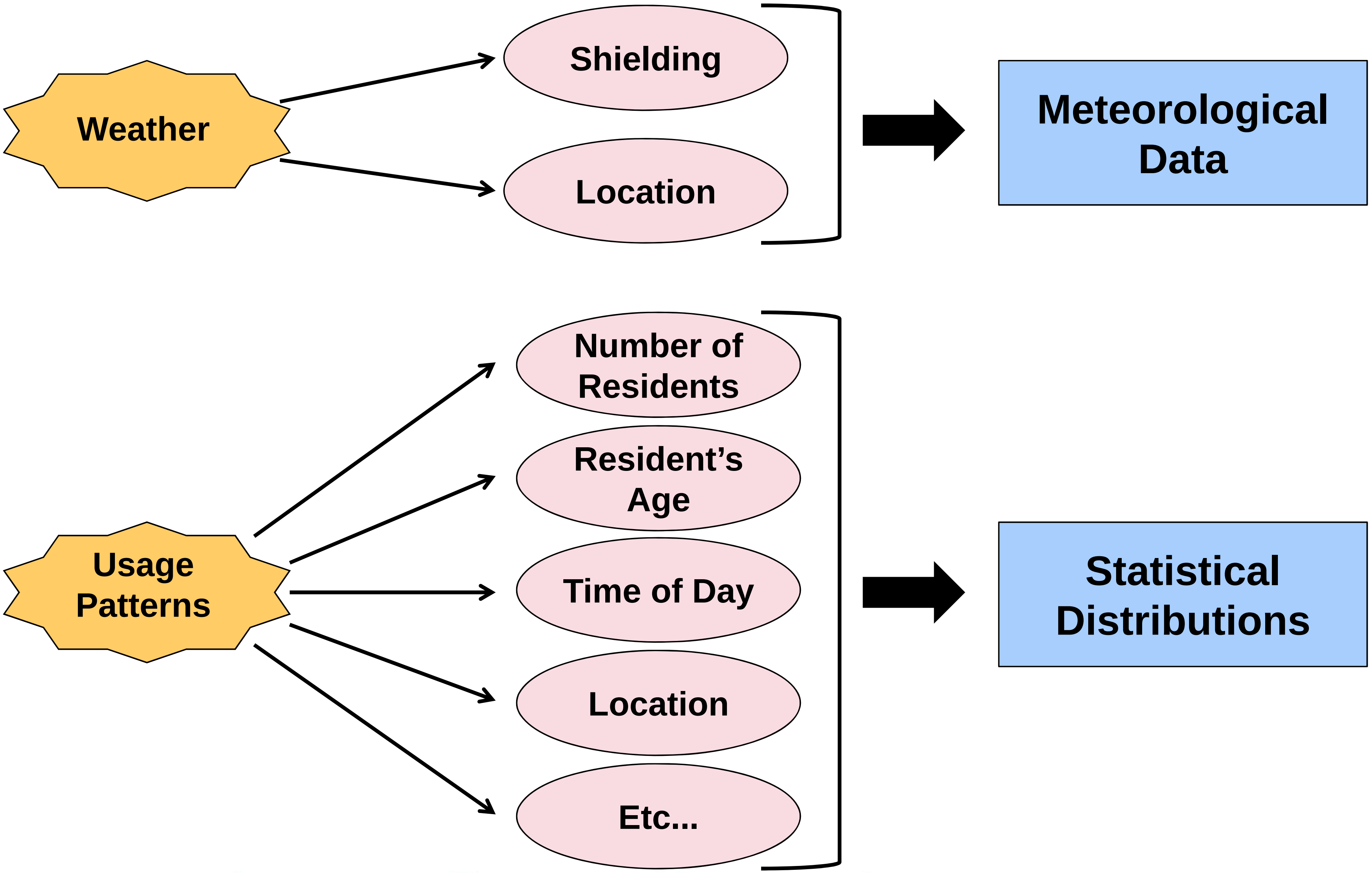
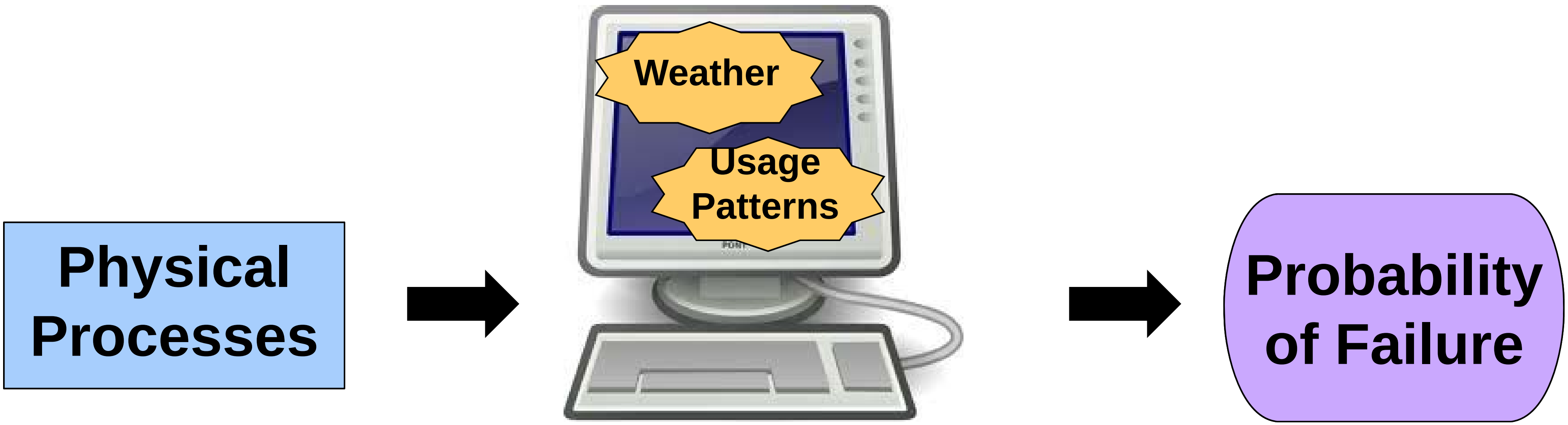


We can simulate physics to better understand the statistics of failure



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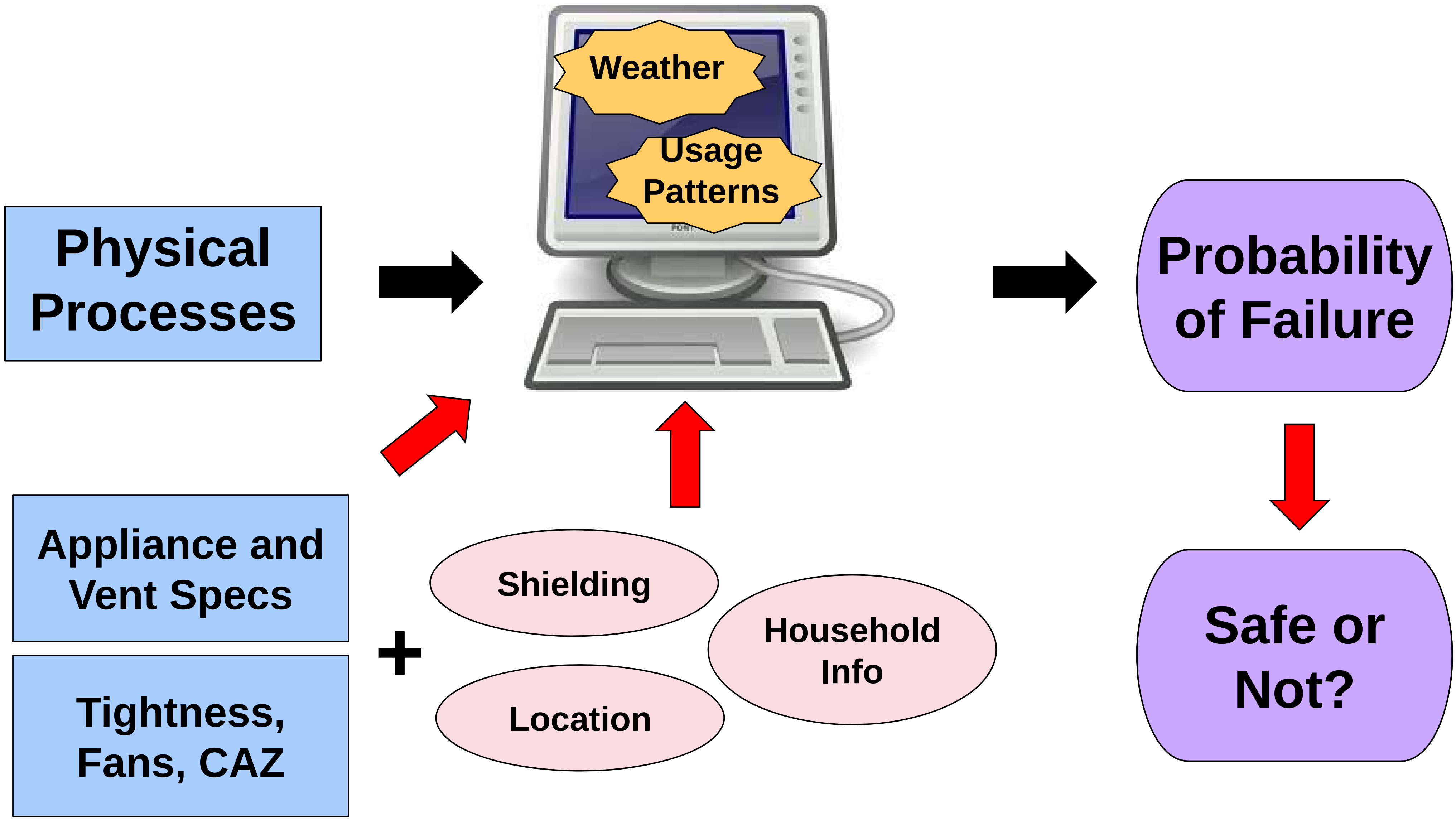
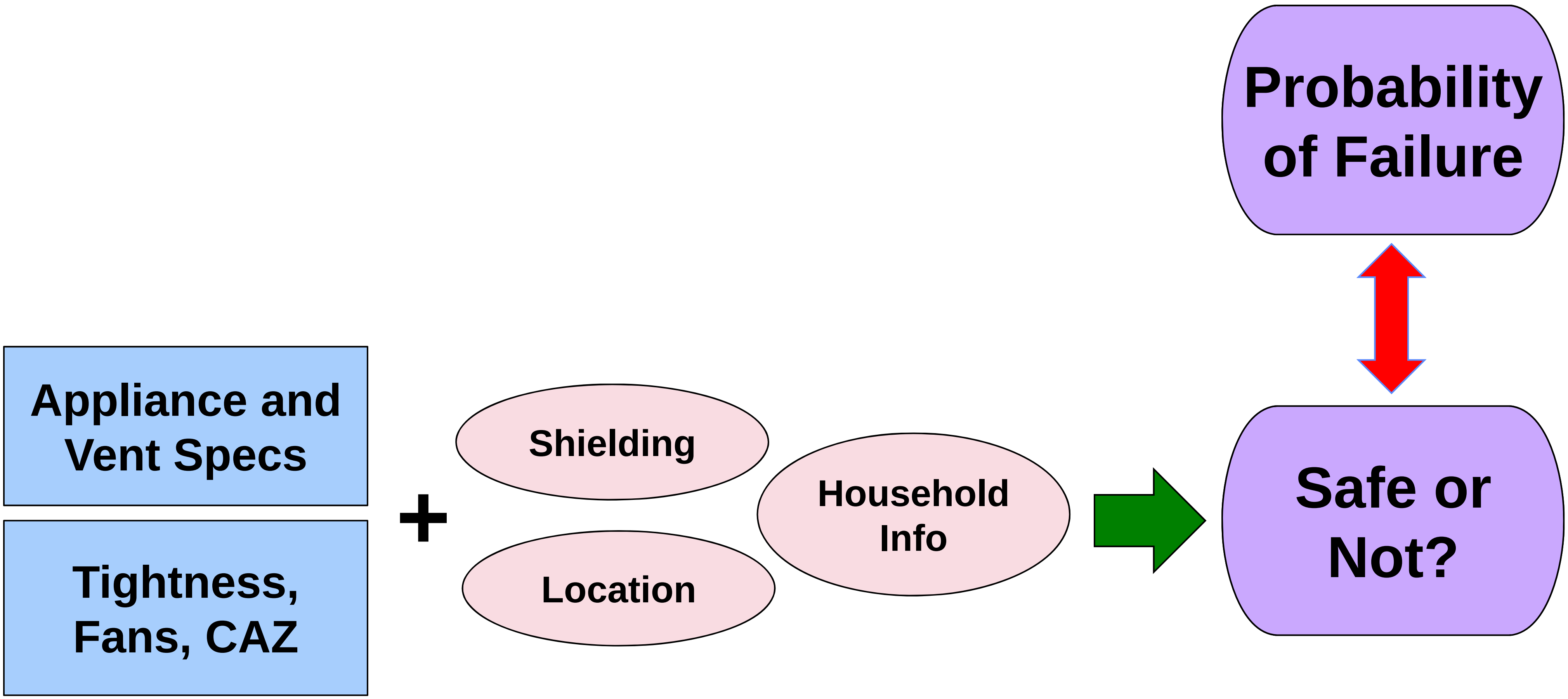


Goal: Diagnostic Tool



Open Questions

- What is acceptable probability / frequency of spillage? This is a policy question.
- Assess for currently installed (often bad) exhaust fans, or assume what should be there?
- Assess for current occupants, or assume standard or high intensity occupant use patterns?
- Do we need separate measurement of CAZ air tightness – or is envelope tightness good enough?

Extra Slides

Termination location of chimneys and single-wall pipes

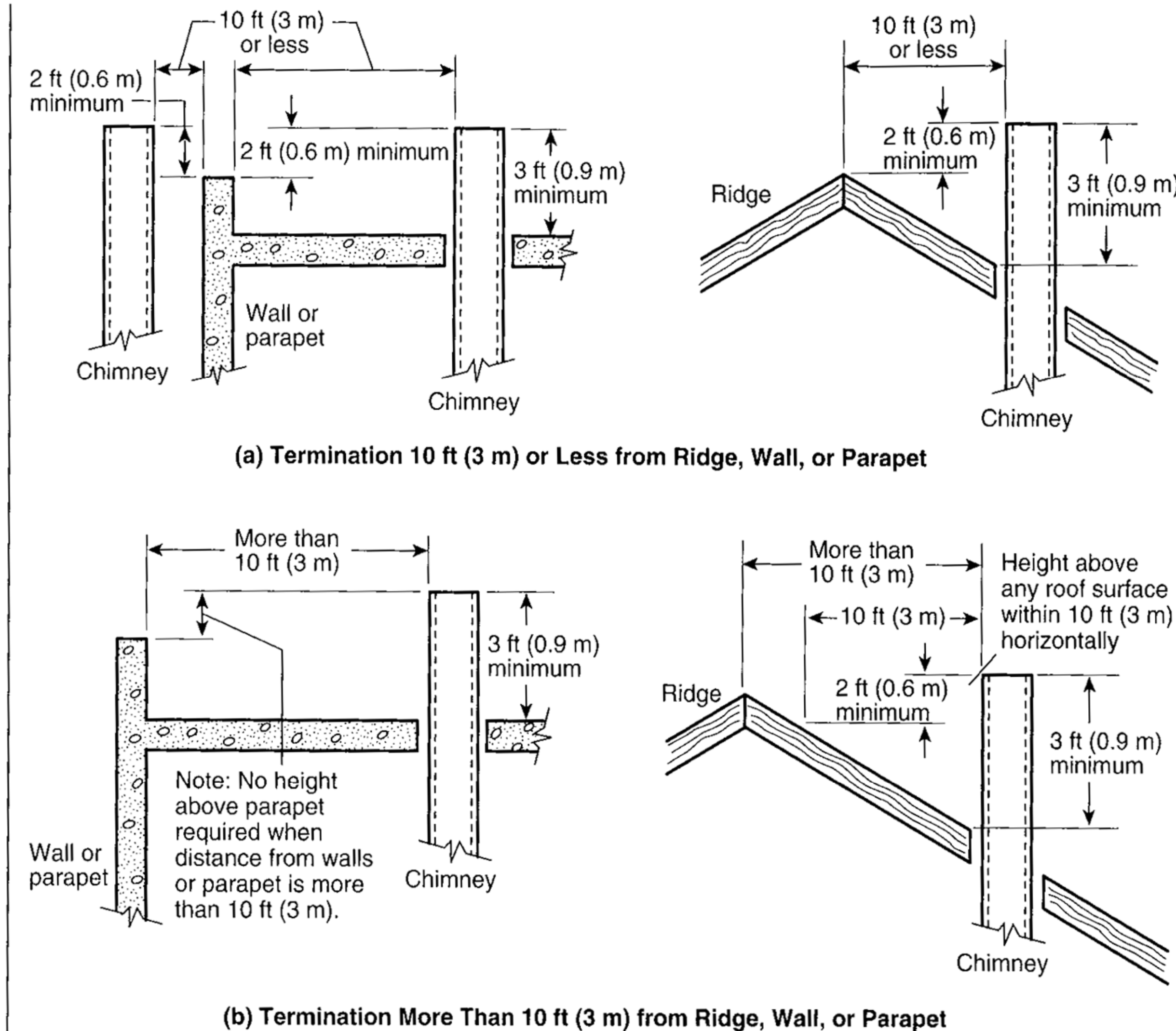


FIGURE A.12.6.2.1 Typical Termination Locations for Chimneys and Single-Wall Metal Pipes Serving Residential-Type and Low-Heat Appliances.