The Future of Fire Resilience

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Building Fire Resilience

- Select FPE Research Areas @ UMD

  - Construction Materials and Furnishings

    ➤ Material Flammability Research [Prevention]

  - Building Systems

    ➤ Fire Sensing Research [Detection]

   ➤ Fire Suppression Research [Response]

Material Flammability

■ Focus

- Establish advanced **measurement techniques** and **models** to support development of

  ➢ virtual material analysis minimizing expensive, hazardous, and environmentally burdensome testing; and ultimately

  ➢ high performance (cost, toxicity, ignition, flame spread, etc.) materials through improved understanding and improved navigation of a broader discovery landscape.
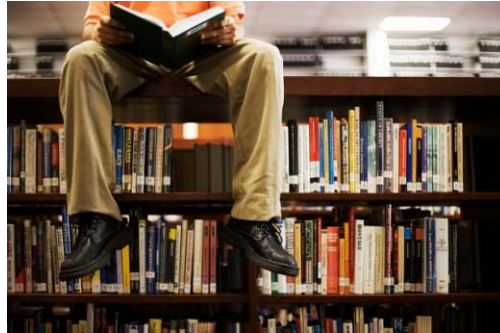
Material Flammability

We start with:
Material A
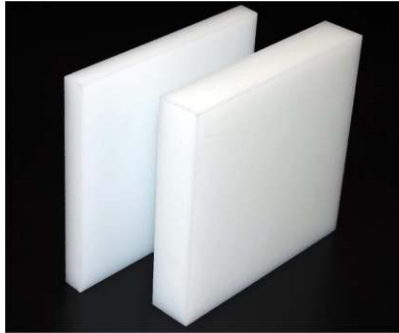
It has excellent mechanical properties and required functionality but, when ignited, could be easily mistaken for jet fuel.

……..

Step 2:
Search FR chemistry toolbox

Compounds or functional groups b, c, d, e, f, … have the right atoms and/or have shown to work in other materials. Should we mix all of them?

……..

Step 3:
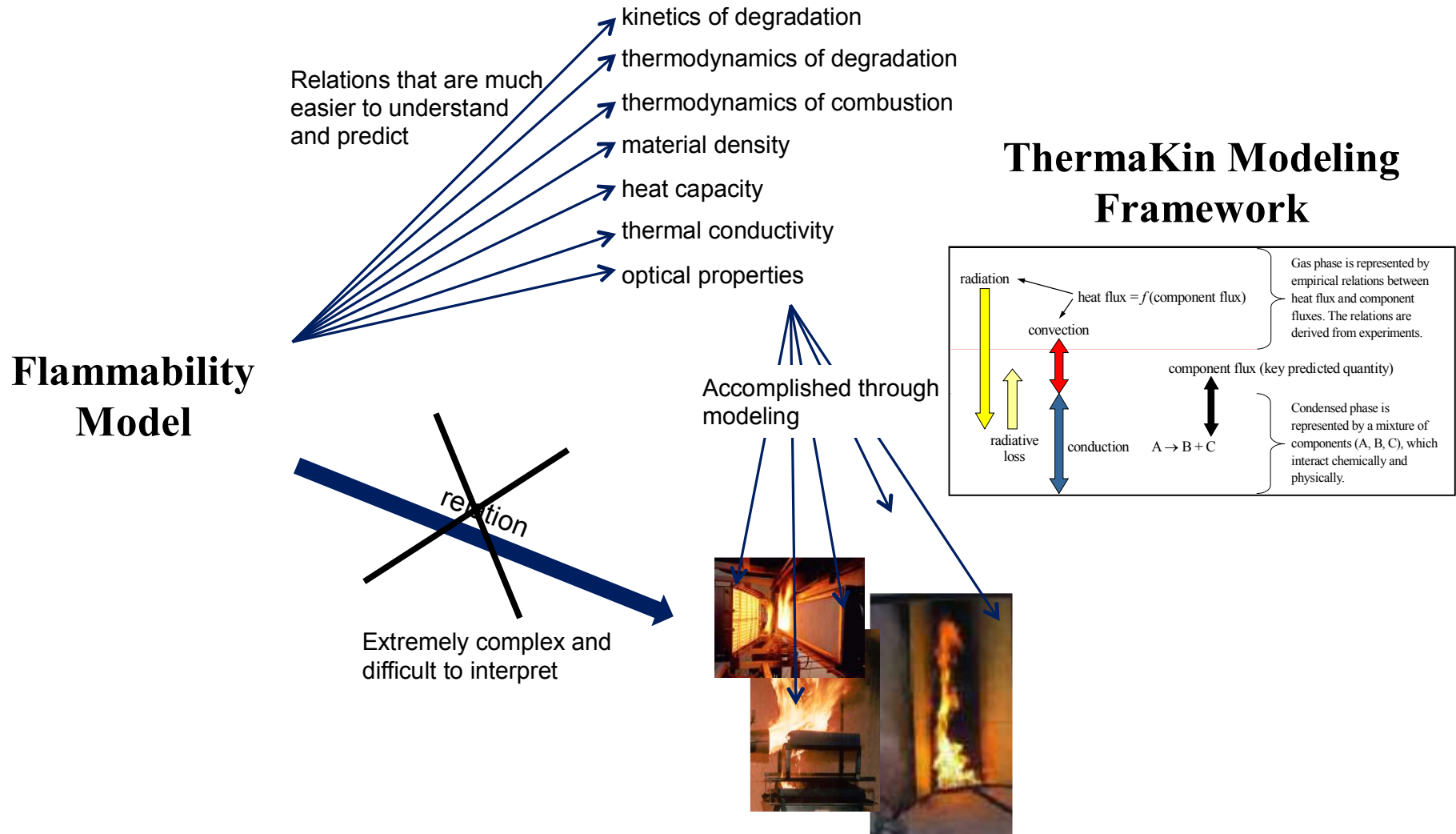**Prepare samples**

Step 5:
Update the toolbox

……..

Step 4:
Test samples

Material Flammability

■ Alternative Method

Flammability Model → kinetics of degradation
thermodynamics of degradation
thermodynamics of combustion
material density
heat capacity
thermal conductivity
optical properties

Relations that are much easier to understand and predict

relation

Extremely complex and difficult to interpret

Accomplished through modeling

ThermaKin Modeling Framework

radiation

heat flux = f(component flux)

convection

radiative loss   conduction $A \rightarrow B + C$

component flux (key predicted quantity)

Gas phase is represented by empirical relations between heat flux and component fluxes. The relations are derived from experiments.

Condensed phase is represented by a mixture of components (A, B, C), which interact chemically and physically.

Fire Sensing

■ Focus

- Leverage increasingly connected and sensor rich building environment along with cyber-physical system concepts to *transition fire detection objectives from alarm to actionable information delivery for decision-making*.
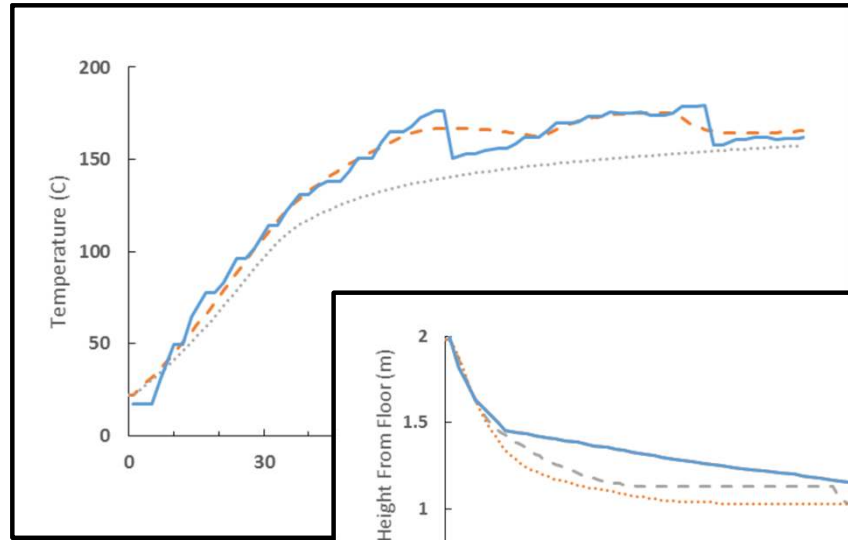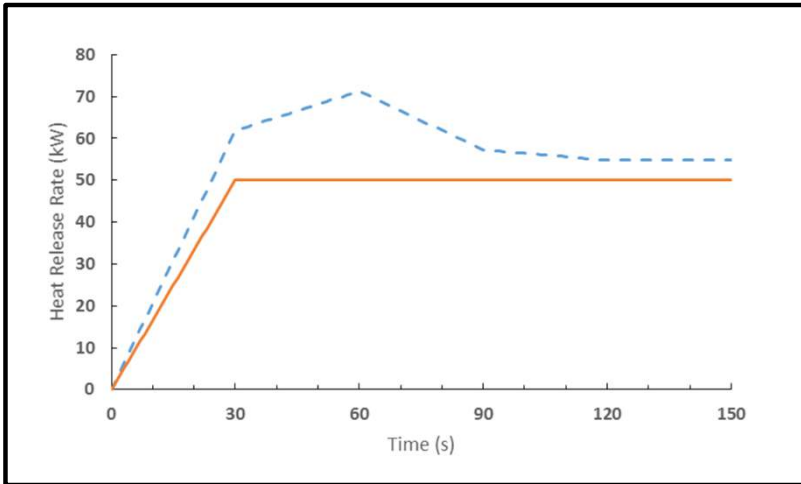
Fire Sensing

**Siemens Sensors
(Security and Fire)**

**MFRI Instrumented
Burn Tower**
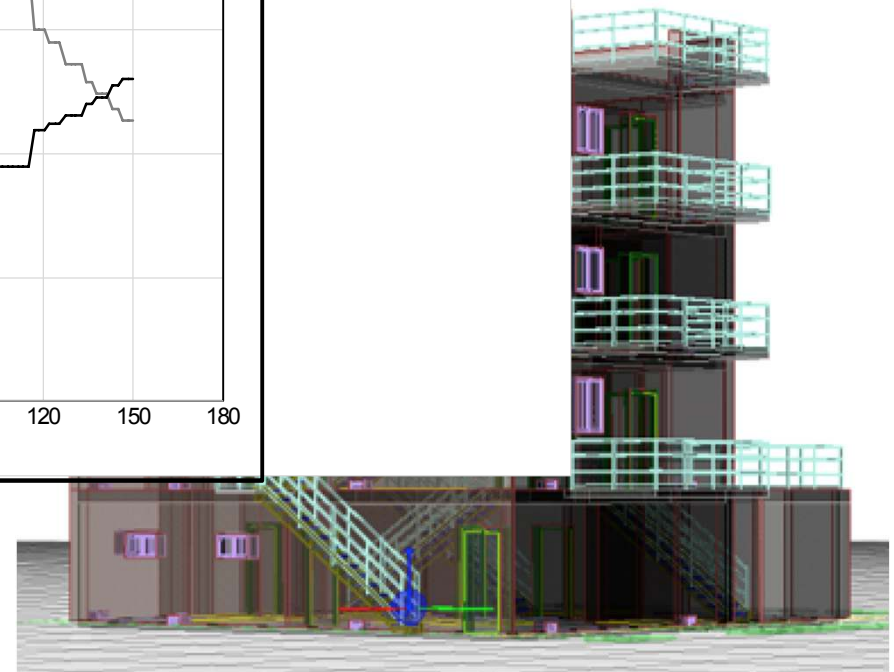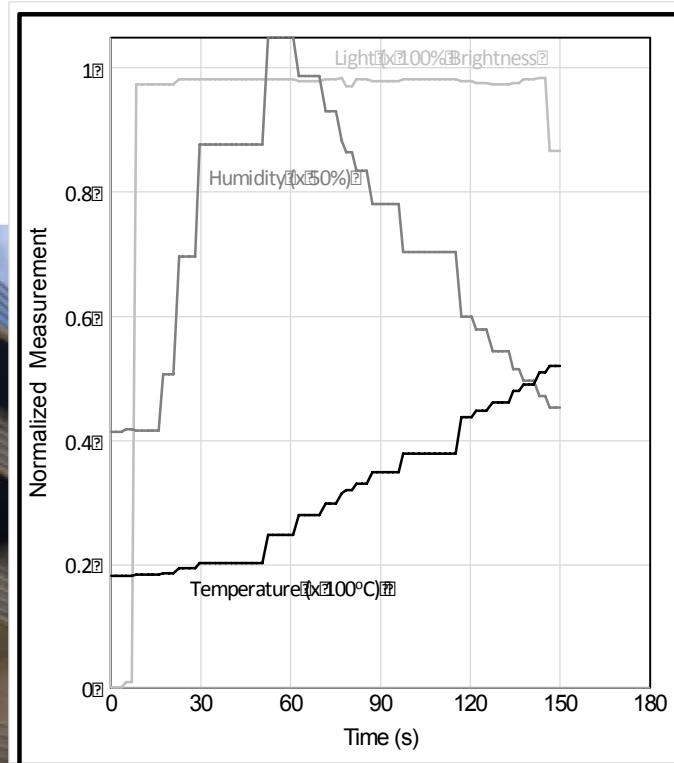
**Bentley MicroStation
Building Information Modeling (BIM)
Software**

Fire Sensing
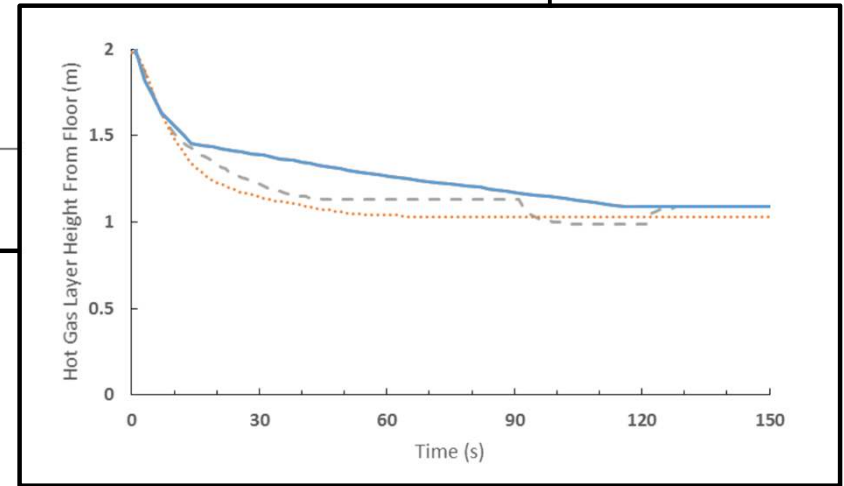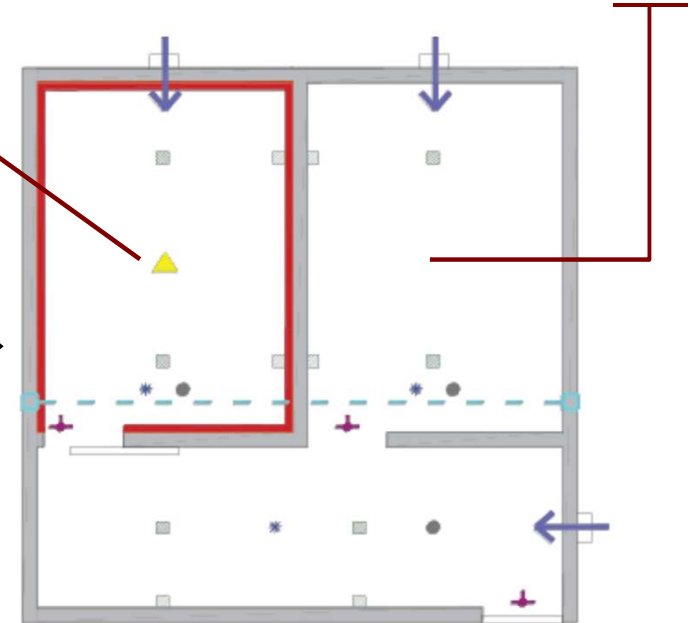
Suppression

■ Focus

- Establish advanced **measurement techniques** and **models** to support development of

  ➢ virtual suppression system analysis minimizing expensive, hazardous, and environmentally burdensome testing; and ultimately

  ➢ high performance (cost, water requirements, suppression efficacy, etc.) fire sprinkler systems through improved understanding and improved navigation of a broader discovery landscape.

Suppression

- Initial Spray Measurements

(drop size, drop velocity, volume flux)

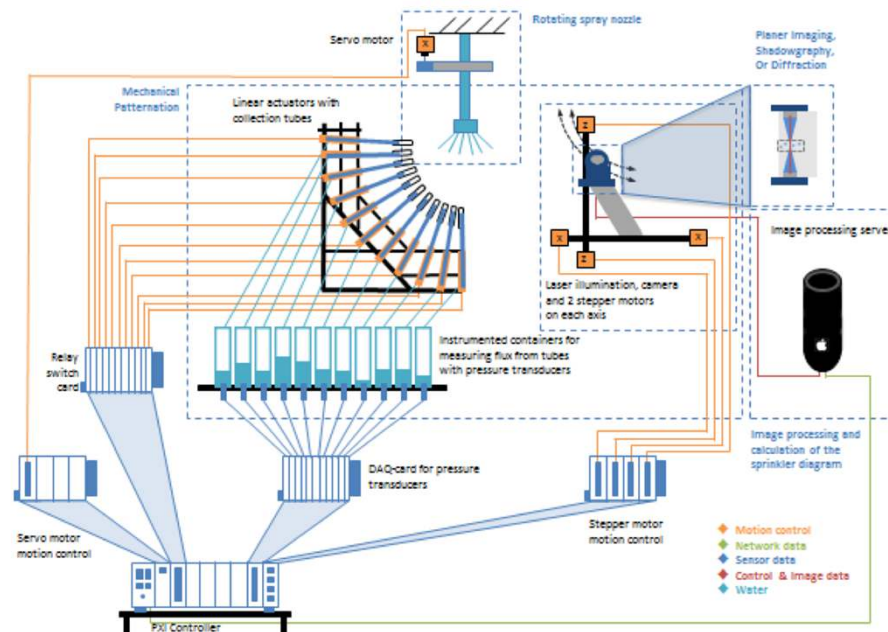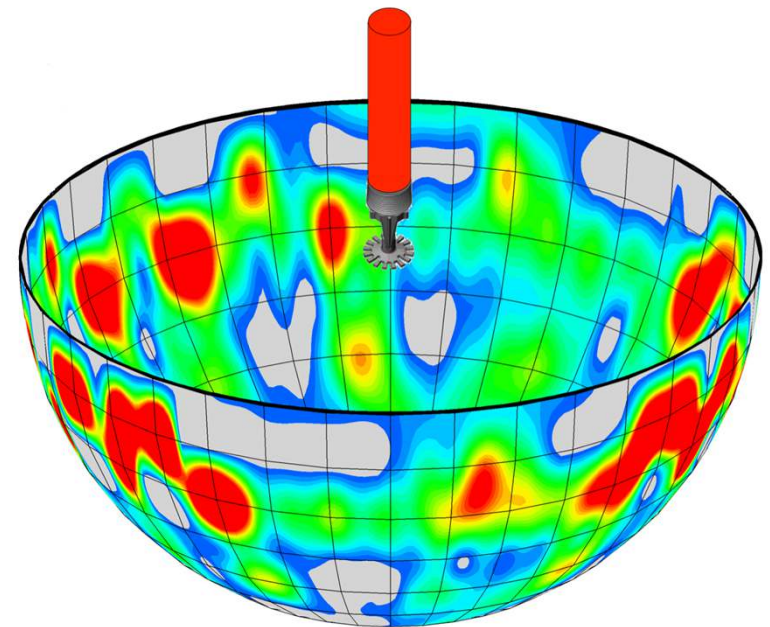**Spatially-Resolved Spray Scanning System (4S)**

4S Initial Sprinkler Spray Measurement

Figure 19: Theoretical setup of new electronics for 4S - System [16]

Suppression

- Modeling
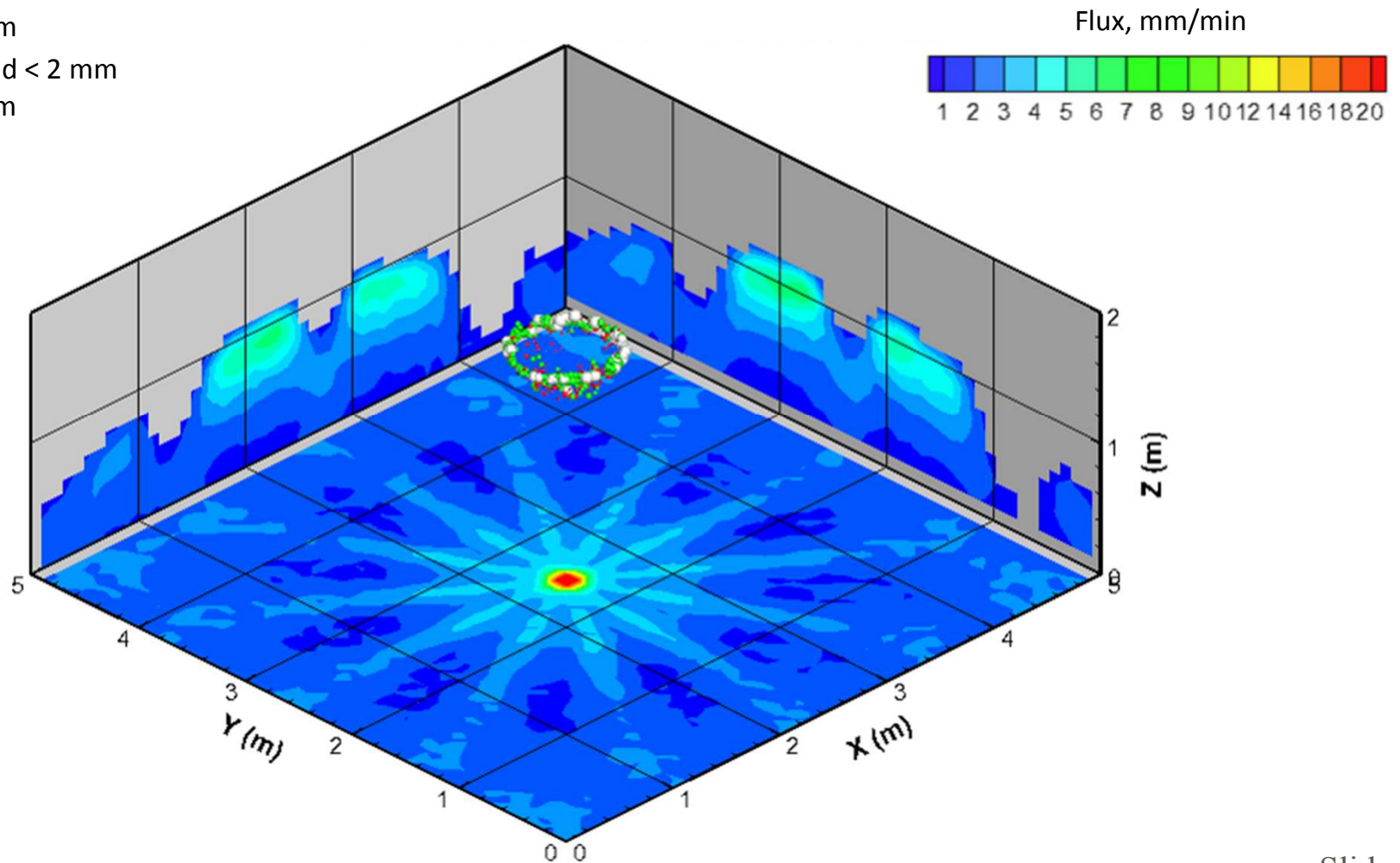
Suppression

- Virtual Testing

Physical UL1626 Test

Figure 43.1
Horizontal surface water collection for upright and pendent sprinklers
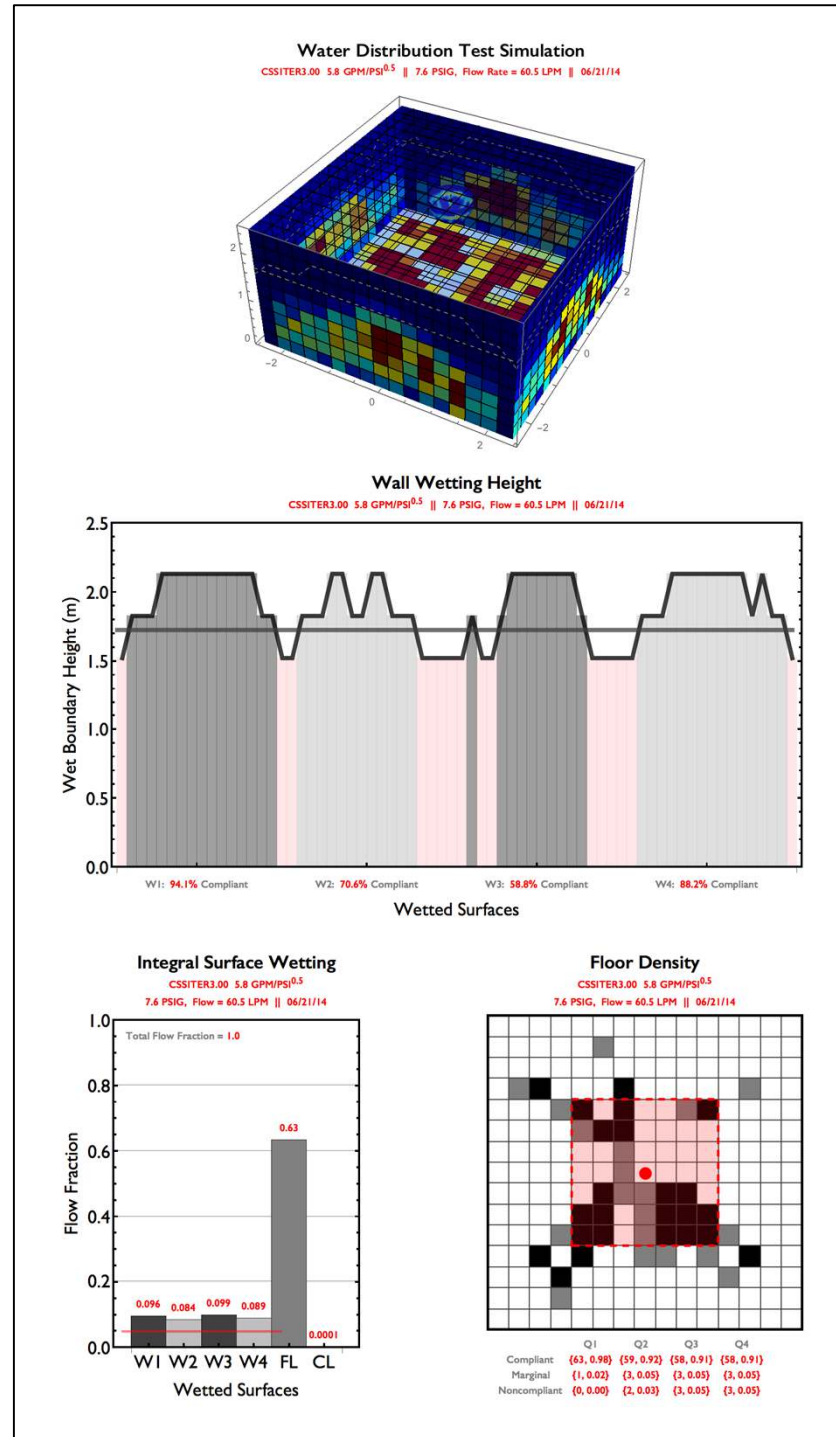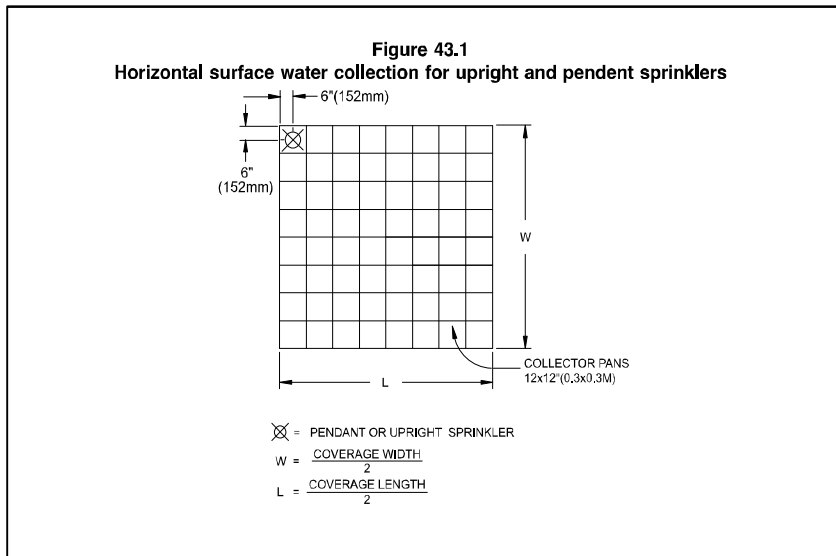
Summary

- Building fire resilience is adopting emerging information acquisition, integration, and synthesis paradigms for smarter fire design and response.