Fire Sprinkler International Conference, London, UK, May 31 - June 1, 2022

SMART Sprinkler Systems to Save Water

Yibing Xin

FM Global, USA

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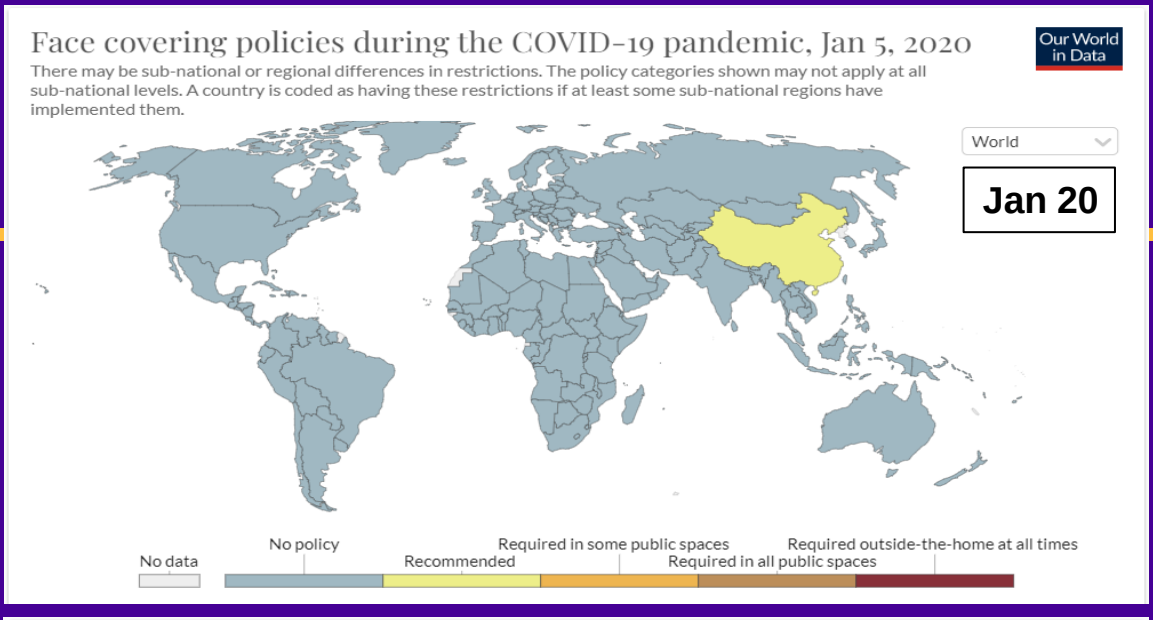

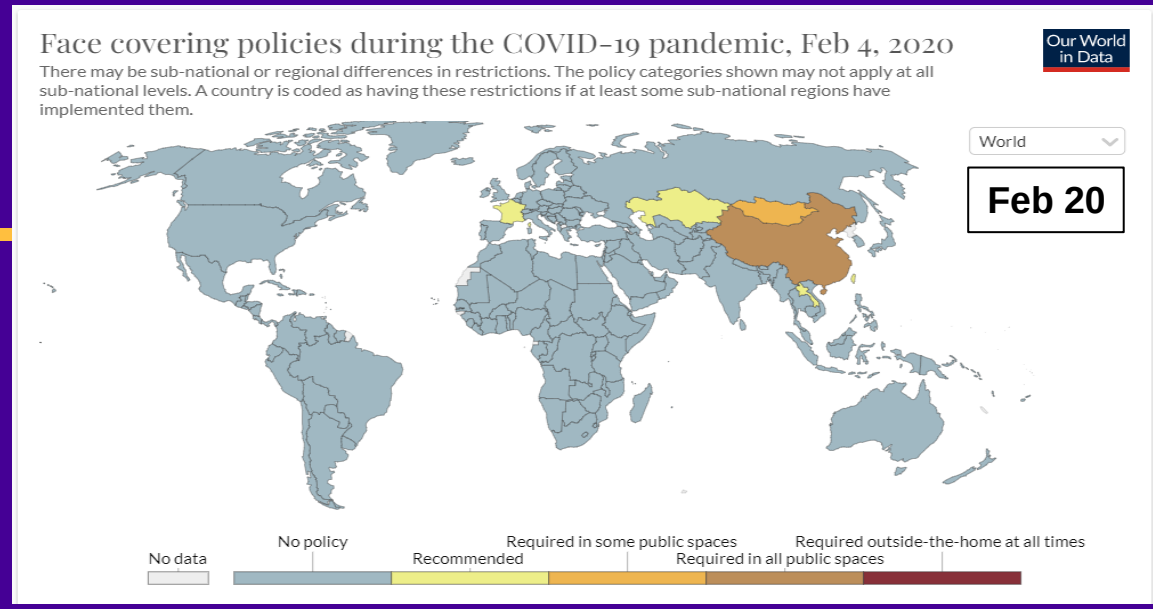

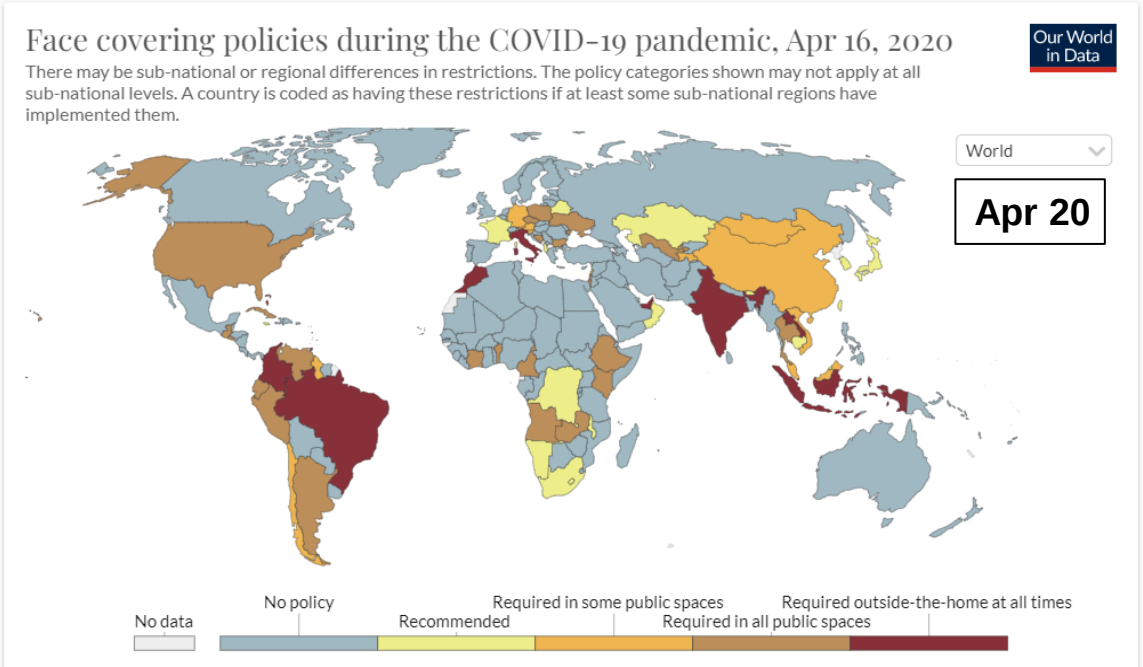

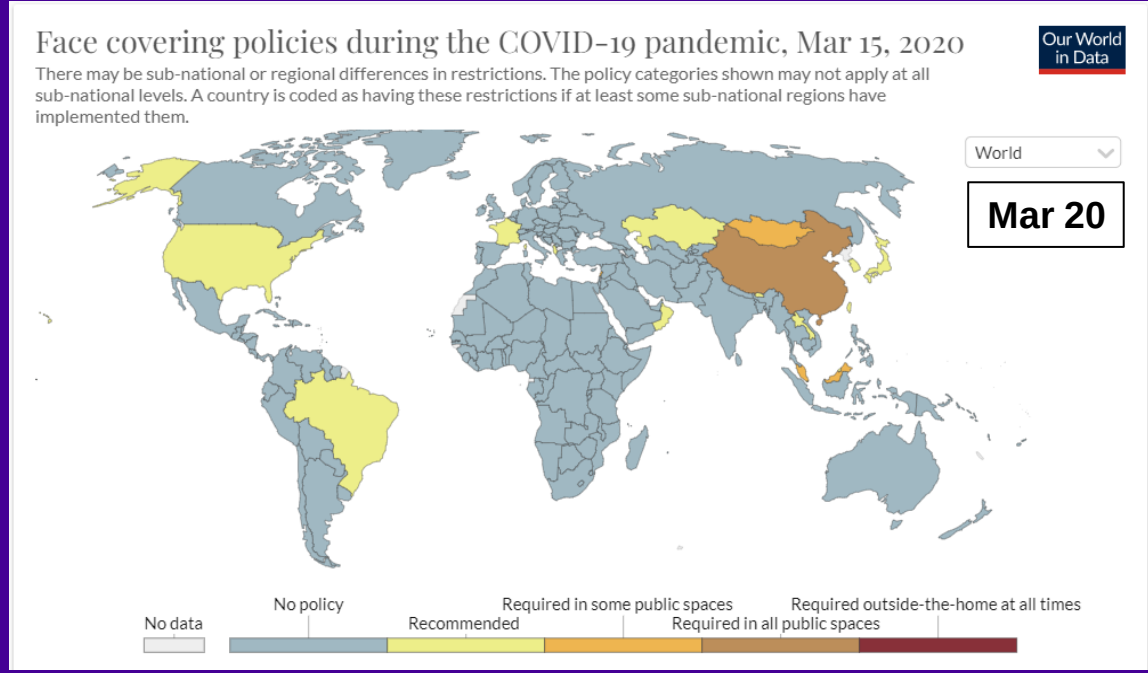

What can we do better?

Source: Oxford COVID-19 Government Response Tracker, Blavatnik School of Government, University of Oxford – Last updated 29 April 2022
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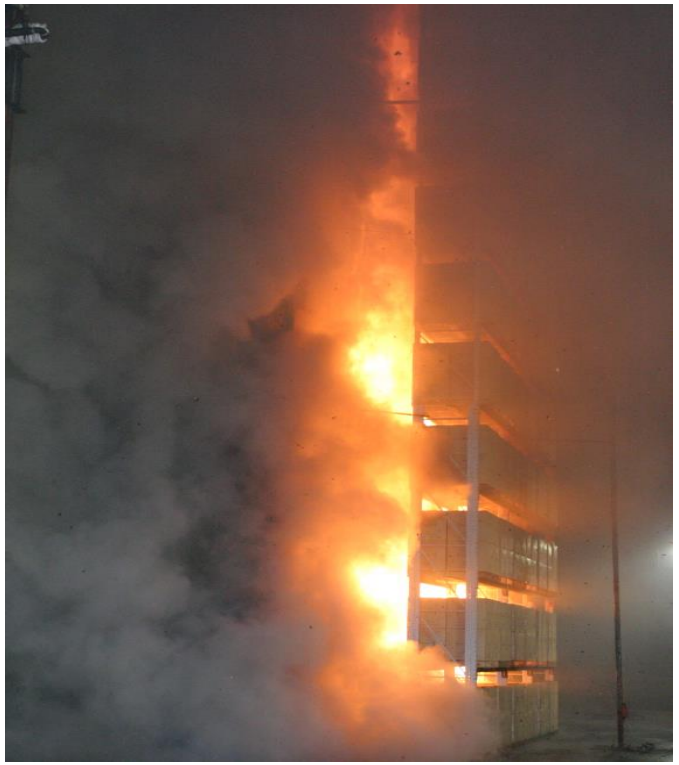
Outline

- Introduction to SMART sprinkler
- Previous work
- Evaluation of applications
  - Storage applications
  - Open-top combustible containers
- Potential future applications
  - Roll paper, ASRS, LIB/ESS
- Summary

Introduction to SMART Sprinkler

- **A sprinkler system that utilizes**
  - Simultaneous, Monitoring, Assessment & Response Technology
- **Target highly challenging fires**
  - Increasing fire hazards
    - High storage
    - Fast fire spread
    - Slow water transport
  - Traditional sprinklers
    - Slow detection
    - Reactive to fire spread
    - Sprinkler skipping



Previous Work –

Proof-of-Concept using FM Global SMART Sprinklers

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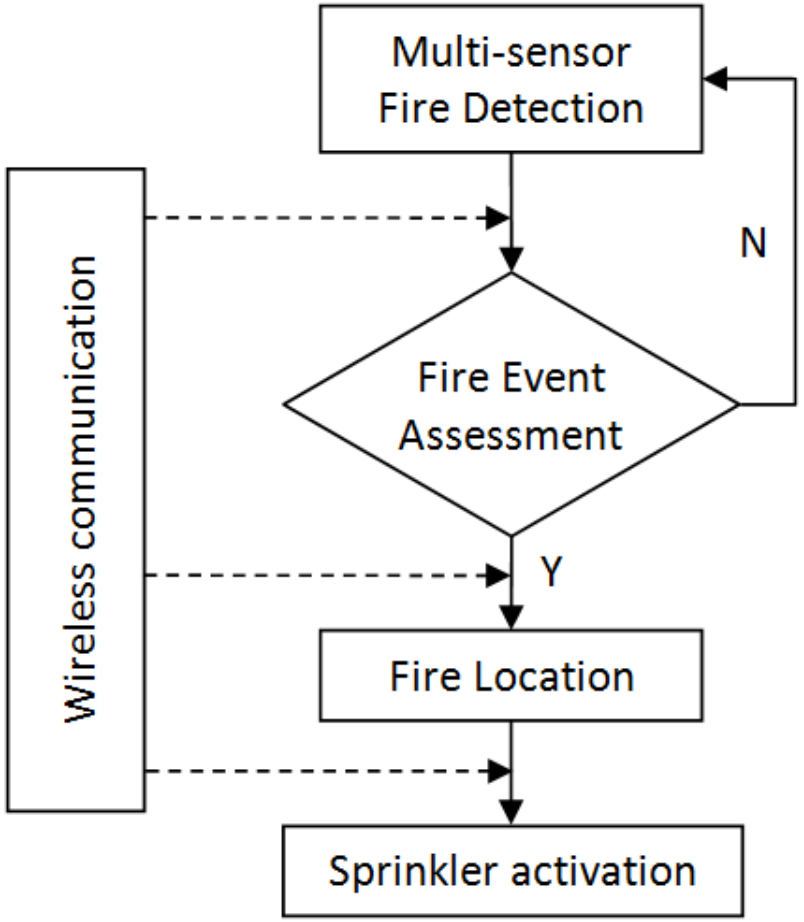
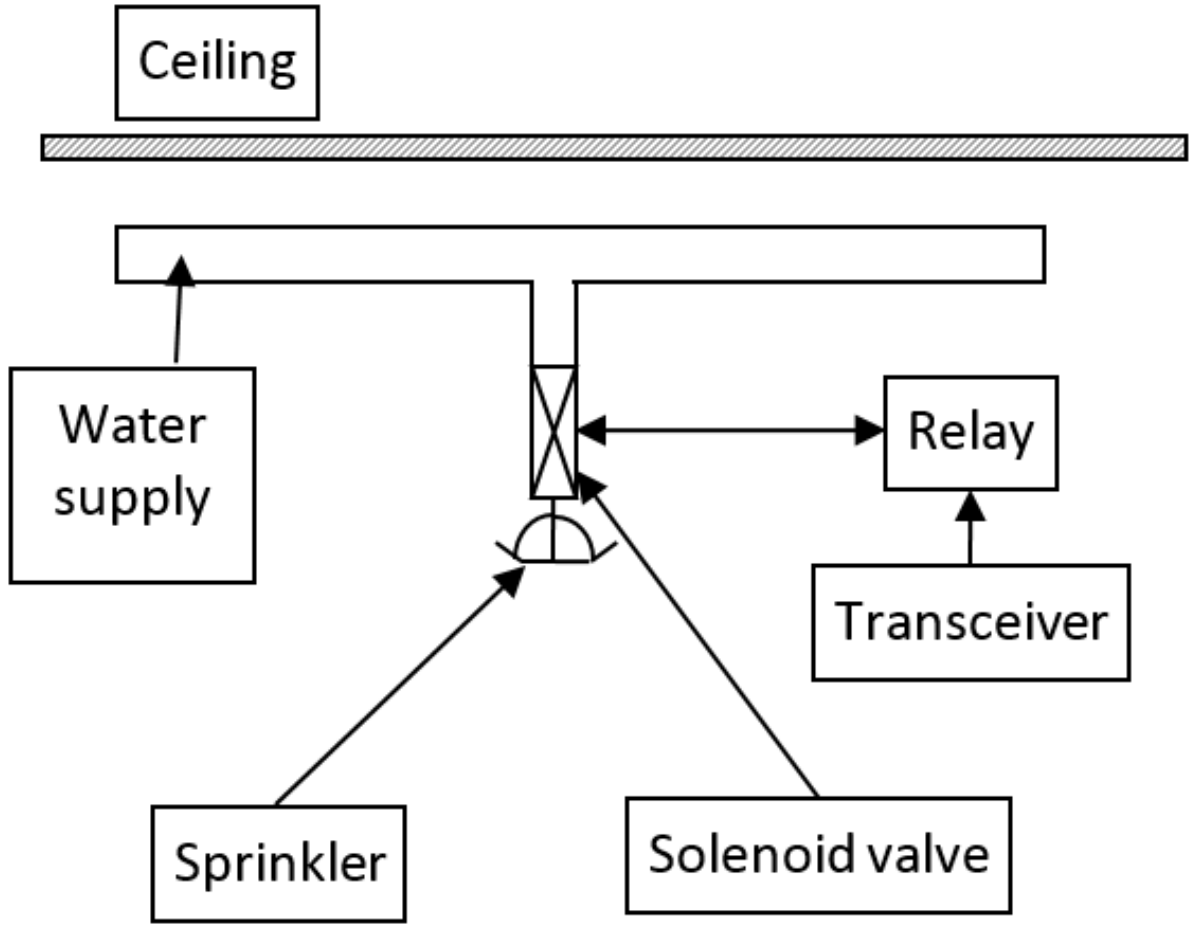
Previous Work – Proof of Concept

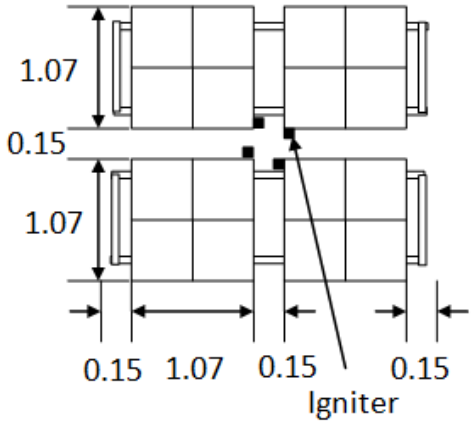


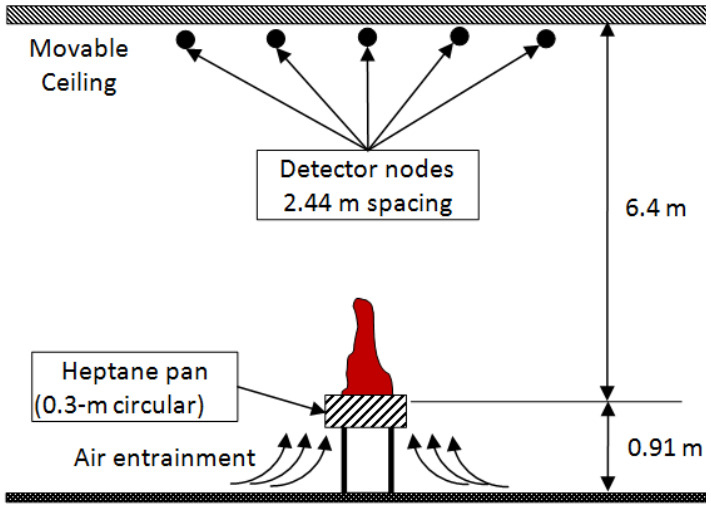


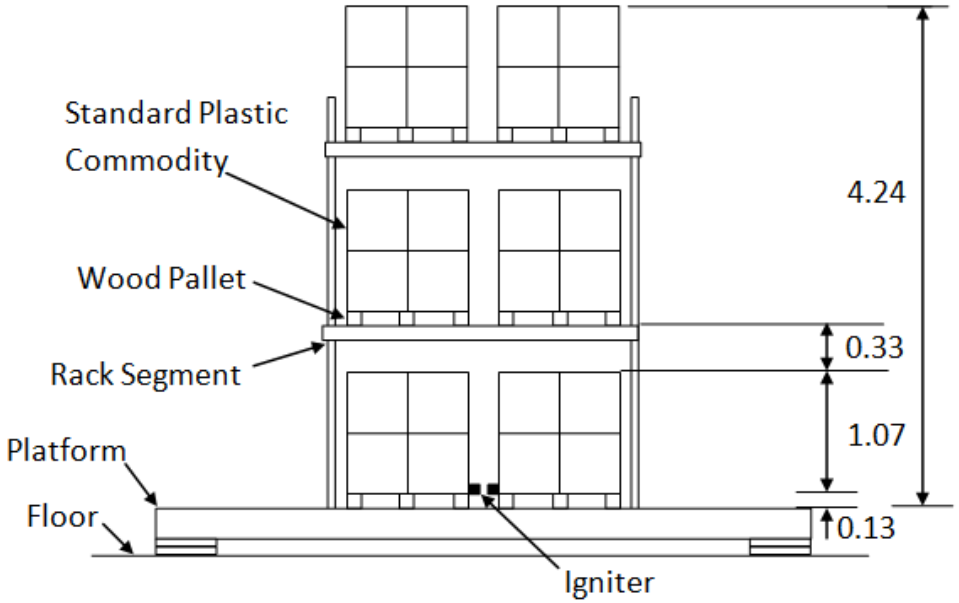
Ref: Fire Technology 53(5):1-22, 2017.

Previous Work – SMART Sprinkler Development

- **Fire detection times**
  - Sand burner fires
- **Sprinkler activation**
  - Heptane pan fires
- **System performance**
  - Rack storage fires

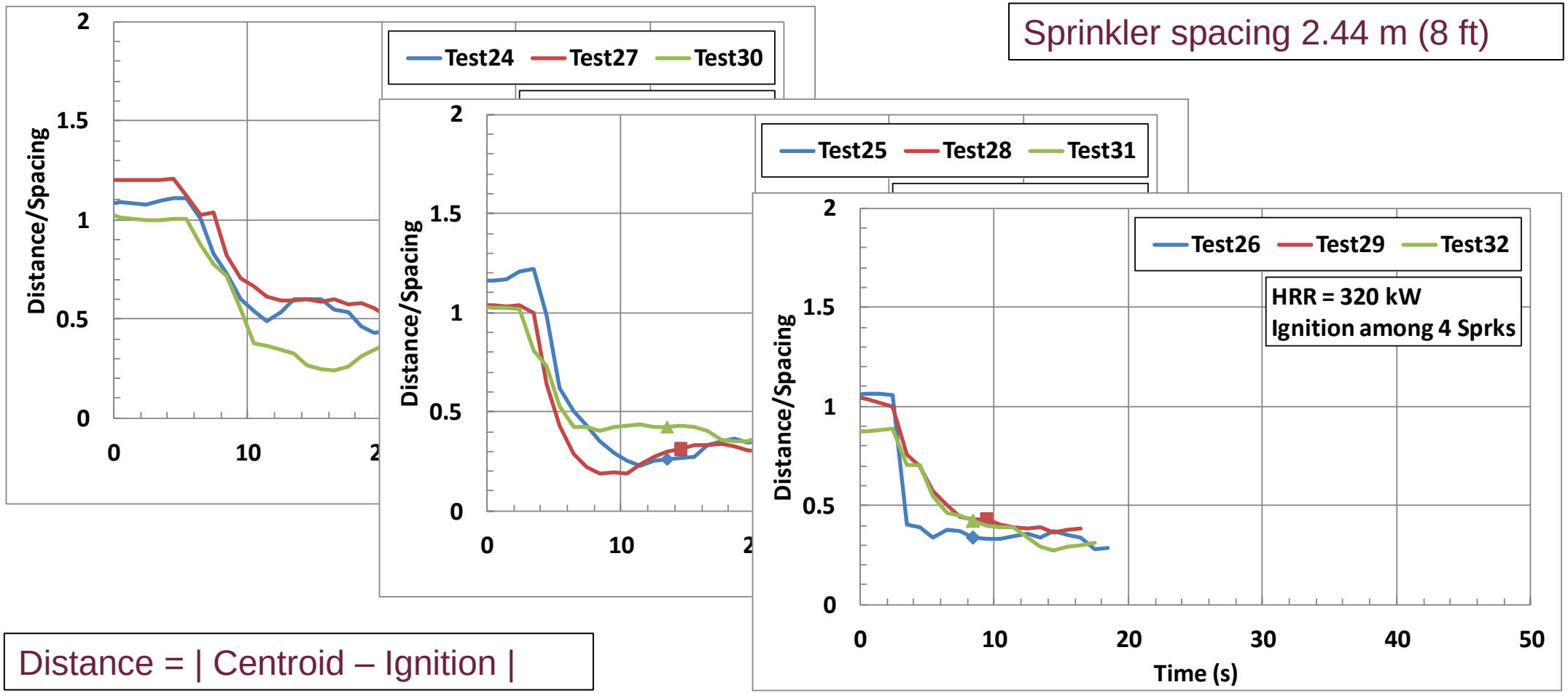






Previous Work – Detection Accuracy

- **Where is the fire?**



Sprinkler spacing 2.44 m (8 ft)

Distance = | Centroid – Ignition |

Previous Work – Activation Patterns

- **Which sprinkler to activate?**

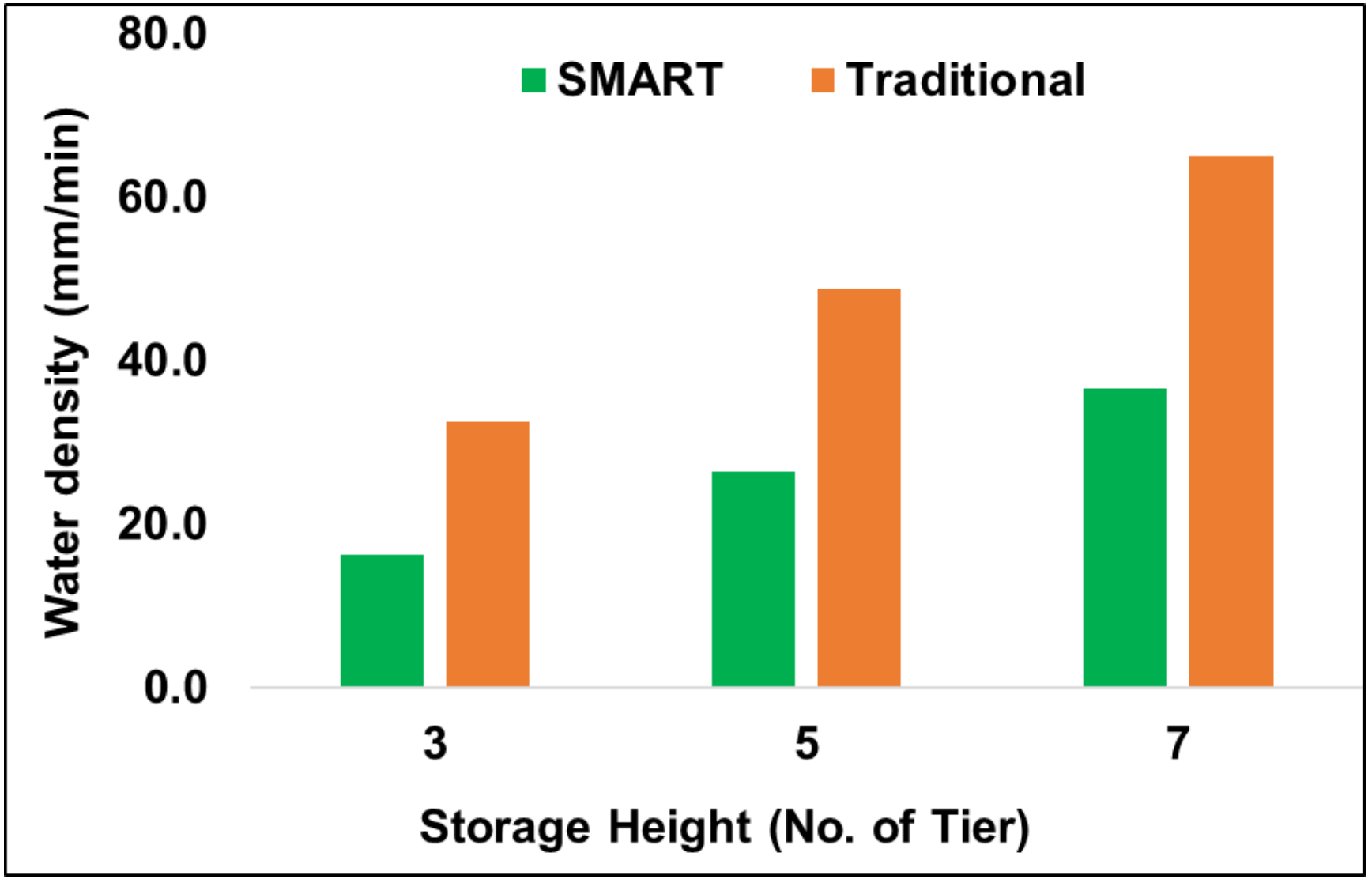
		(South Up)		
	Node: 08e5 14.19	Node: 0a4c 13.29	Node: 0a48 13.94	
Node: 0a66 14.58	Node: 0741 16.00	Node: 0a54 21.03	Node: 0934 17.29	Node: 0a4a 16.52
	Node: 0a27 16.26	Node: 0730 17.29	Node: 0a50 17.03	
		Node: 6180 15.87		

		(South Up)		
	Node: 08e5 10.71	Node: 0a4c 11.74	Node: 0a48 10.84	
Node: 0a66 10.71	Node: 0741 11.74	Node: 0a54 13.81 SMOKE!	Node: 0934 13.94 SMOKE!	Node: 0a4a 11.35
	Node: 0a27 10.97	Node: 0730 12.13	Node: 0a50 11.61	
		Node: 6180 11.74		

Previous Work – Rack Storage Assessment

- **Test conditions**
  - 2x4,7-tier CUP
  - Ignition between 2 offset
  - Smoke alarm & ΔT=5ºC
  - SMART: K300, 6 @ 37 mm/min
  - AS_QR: K300, 12 @ 73 mm/min

Previous Work – Effectiveness Comparison



Current Studies –

Evaluation of Applications in Storage Facilities

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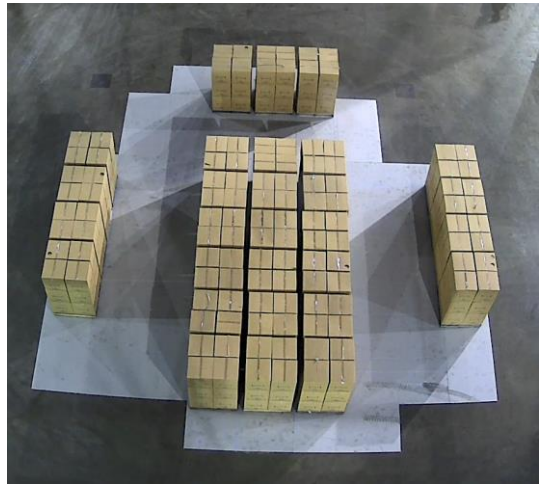
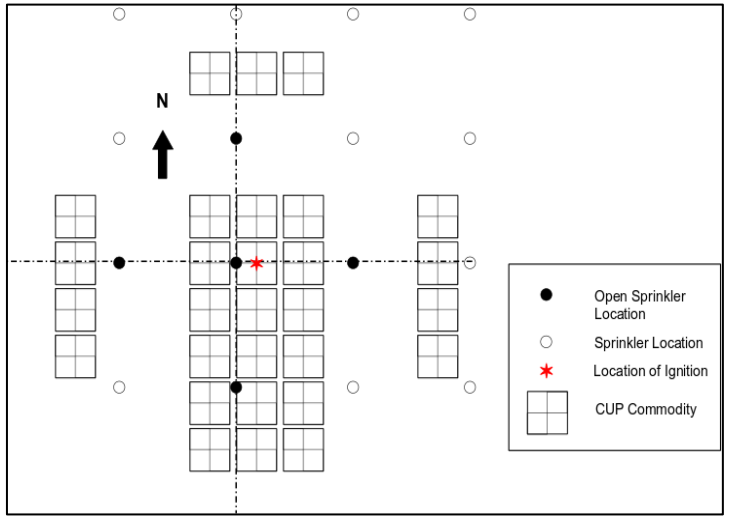
Current Studies – Potential applications

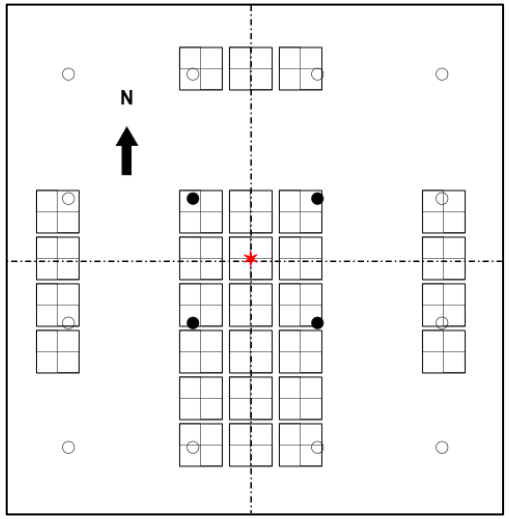
- **Low piled storage**
  - Non-storage occupancies, high water demand
- **High-bay rack storage**
  - Storage occupancies, Highly challenging fires
- **Open-top combustible containers**
  - Challenging water transport, explore feasibility

Current Study – Low Piled Storage

- **Applications**
  - Manufacturing facilities
  - Incidental storage
- **Test conditions**
  - CUP, CEP, UUP Commodities
  - Under 9- & 18-m ceiling
  - Target 2.4-m from main array
- **Activation criteria**
  - 1) $\Delta T > 5^{o}C$ / min
  - 2) $T > 57^{o}C$

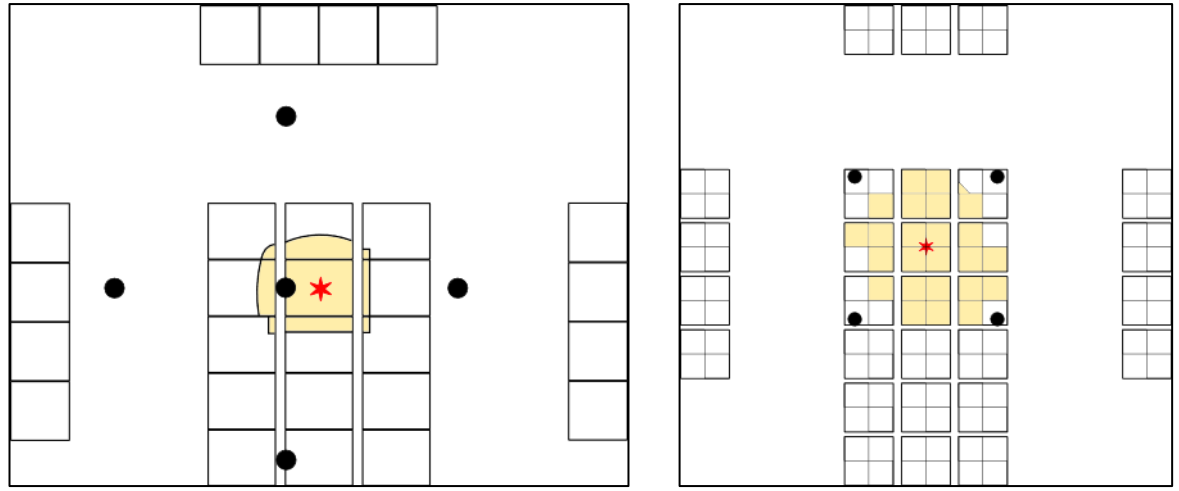






Current Study – Low Piled Storage

- **Test results**
  - Fire contained in main array
  - No target ignition
  - 4-5 activation sufficient
  - CUP performed better than UUP
  - Algorithm's impact clear



Algorithm 1
(143 s)

Algorithm 2
(182 s)

First QR Sprinkler Activation
(214 s)

Current Study – Low Piled Storage

- **Water demand: SMART vs traditional sprinkler**

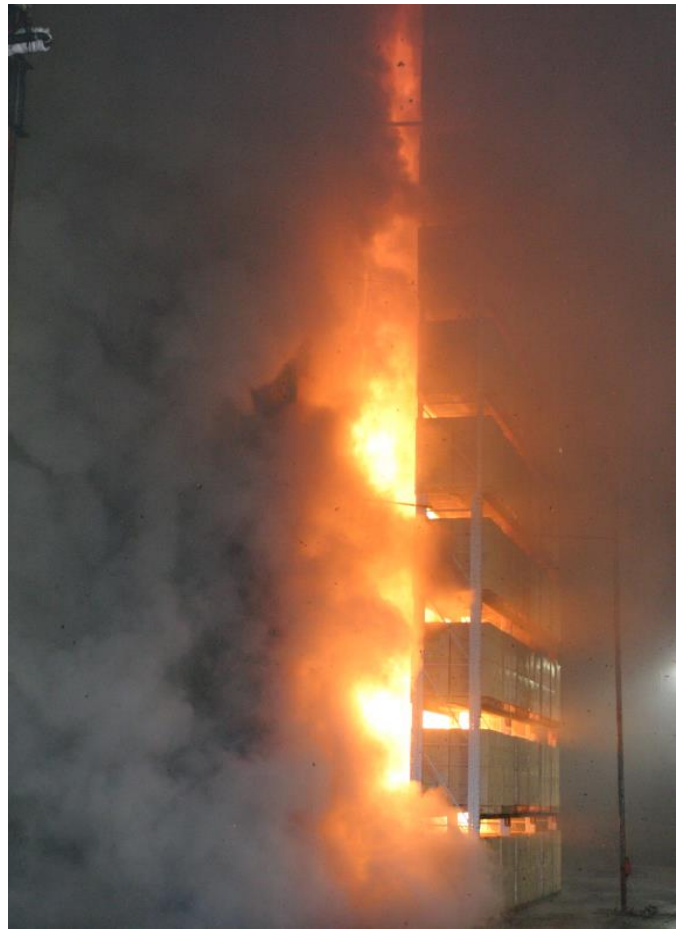
Commodity	Ceiling Height m (ft)	DS 3-26 Design* mm/min over m^2 (gpm/ft^2 over ft^2)	SMART Sprinkler System Density mm/min (gpm/ft^2)	Reduction in Water Demand	
				5-Sprinkler Design	9-Sprinkler Design
CUP	9.1 (30)	12/232 (0.3/2,500)	8 (0.2)	87 %	76 %
	18.3 (60)	20/280 (0.5/3,000)	15 (0.37)	88 %	78 %
UUP†	9.1 (30)	45/93 (1.1/1,000)	24 (0.6)	73 %	51 %
	18.3 (60)	65/93 (1.6/1,000)	41 (1.0)	69 %	44 %

* Assuming 9.3 m^2 (100 ft^2) coverage area per sprinkler.

† UUP sprinkler design listed in DS 3-26 (Table 3) [6] as number of K360 (K25.2) sprinklers at a specified pressure.

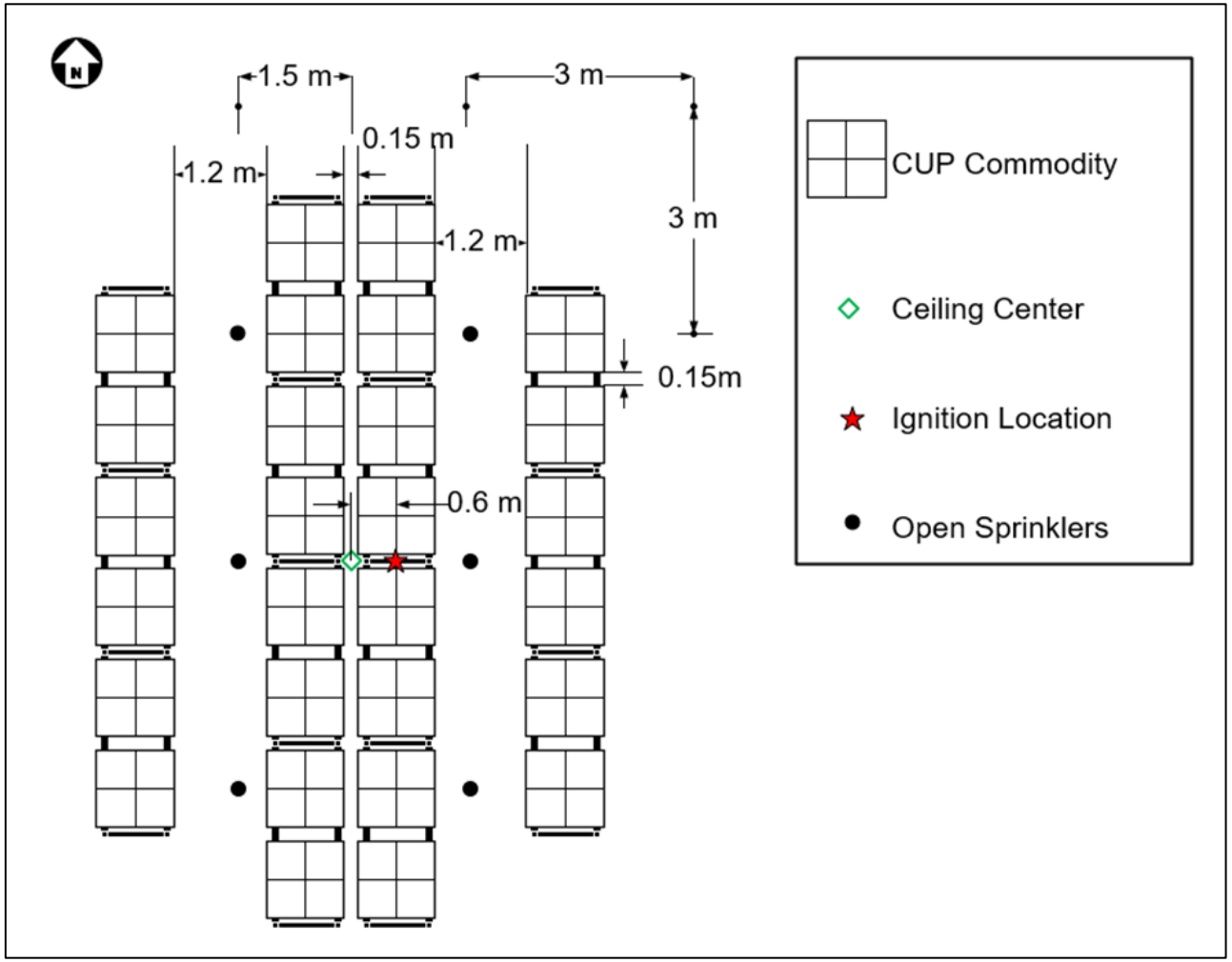
Current Study – High-Bay Rack Storage

- **Application: storage facilities**
  - Very high storage
  - Fast fire spread
  - Long-distance water transport
  - In-rack protection often applied
- **SMART sprinkler**
  - Early fire detection
    - Combined w/ in-rack detectors
  - Localized water application
    - Avoid sprinkler skipping



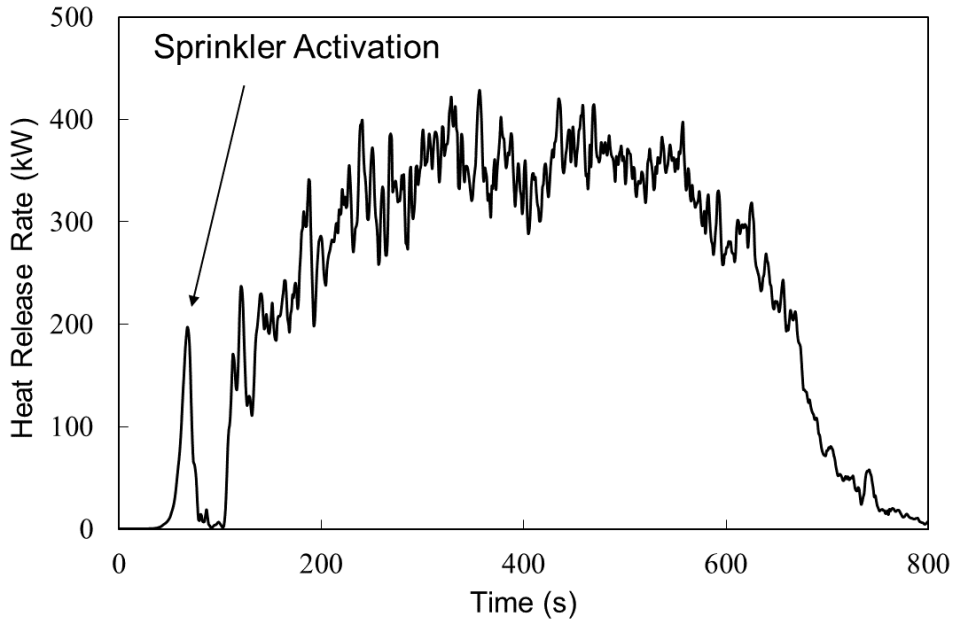
Current Study – High-Bay Rack Storage

- **In-rack detection: 40' CUP under 45' ceiling**



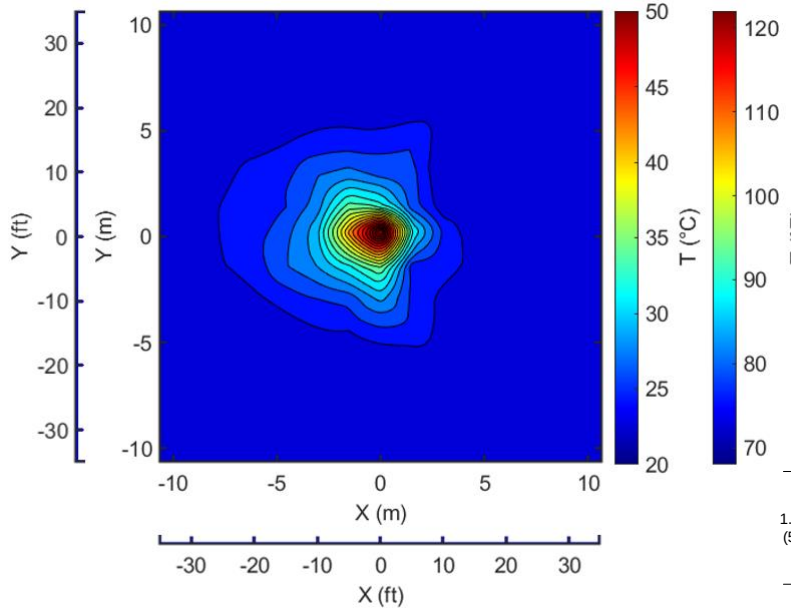
Current Study – High-Bay Rack Storage

- **Comparison of sprinkler activation**
  - In-rack detection → 1/3 HRR
  - Effective activation pattern
  - Reduce water demand
  - Avoid in-rack sprinklers



Current Study – High-Bay Rack Storage

- **In-rack or ceiling detection**
  - Absolute temperature
  - Temperature rise
- **Activation pattern**
  - Fixed # sprinklers
  - Fixed radius
- **Limited damage**
  - Early suppression
  - 77%↓ density

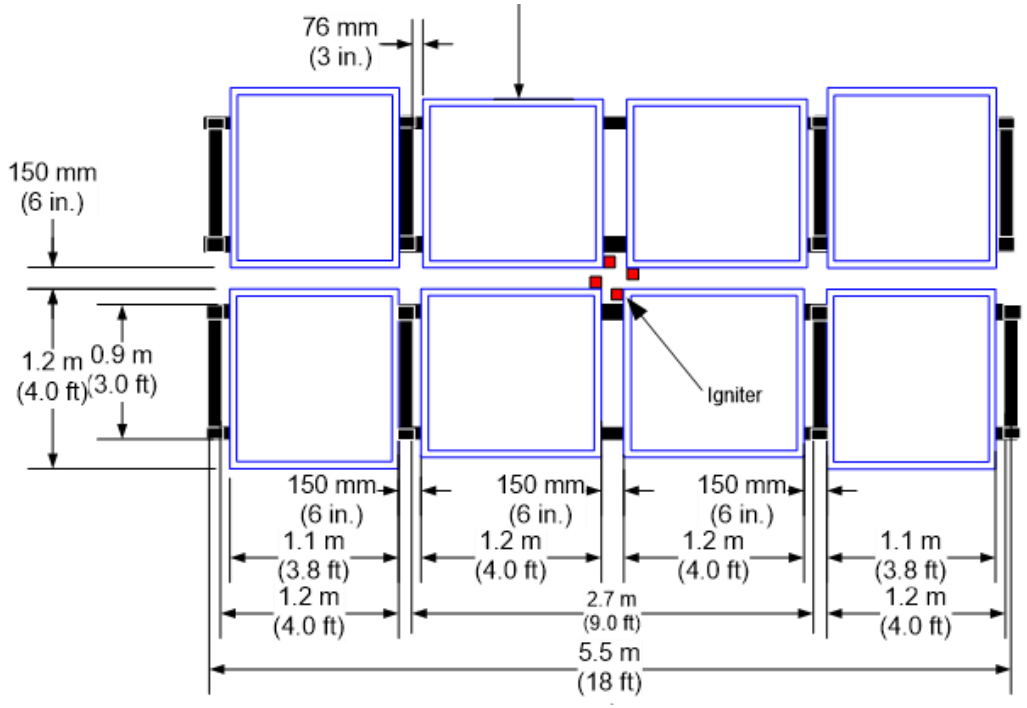


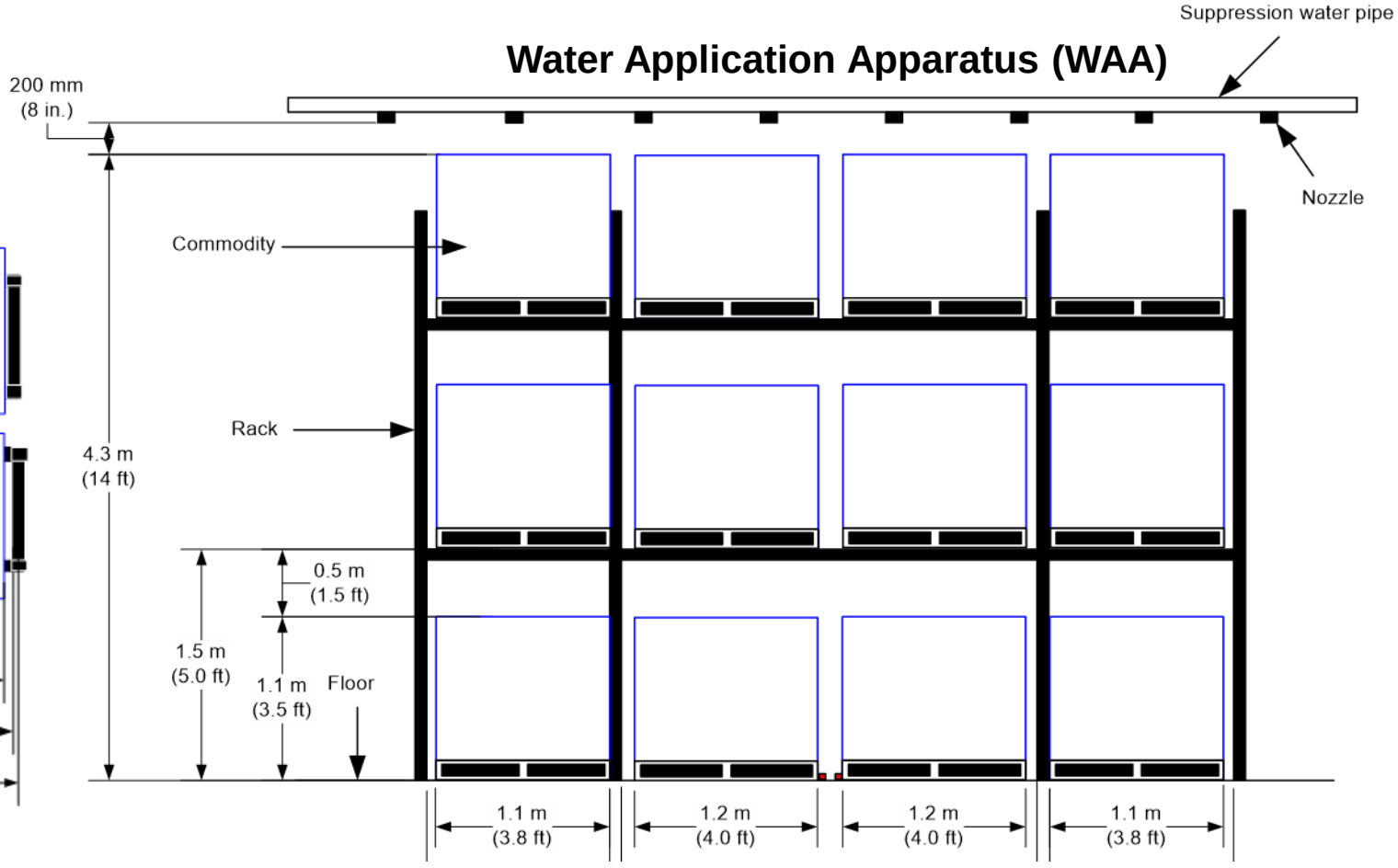
Current Study – OTCC Storage

- **Open-Top Combustible Containers**
  - Widely used in storage facilities
  - Arranged in racks or solid piles
  - Unexpanded plastic fires
  - Water transport significantly delayed
- **SMART sprinkler**
  - Early activation upon small fires
  - Potentially mitigate water delay

Current Study – OTCC Storage

- **Rack storage test**
  - Meas. Critical Delivered Flux (CDF)
  - 2x4, 3-tier configuration





Current Study – OTCC Storage

- **Test matrix and conditions**

Test Result	Test 1	Test 2	Test 3[a]	Test 4	Test 5	Test 6
Test Date	9/13/18	9/17/18	9/20/18	10/02/18	10/05/18	10/31/18
Theoretical Sprinkler Response	Commodity Classification	Commodity Classification	SMART	SMART	SMART	SMART
Sprinkler Activation Temperature, °C (°F)	141 (286)	141 (286)	57 (135)	57 (135)	57 (135)	57 (135)
Response Time Index (RTI), $(m \cdot s)^{1/2}$ $[(ft \cdot s)^{1/2}]$	276 (500)	276 (500)	28 (50)	28 (50)	28 (50)	28 (50)
Plastic Liner Present	Yes	Yes	Yes	Yes	No	No
Delivered Water Flux, mm/min (gpm/ft²)	73 (1.8)	17 (0.42)	17 (0.42)	17 (0.42)	73 (1.8)	41 (1.0)
FGR_{be}, kW/s	97	111	16	15	6	8
HRR_{be} ($\dot{q}_{be}$), kW	3,332	3,250	337	445	244	350

Current Study – OTCC Storage

- **Traditional sprinklers**
  - High HRR @ suppression
  - Uncontrolled fire
  - Excessive CDF
- **SMART sprinkler**
  - Low HRR @ suppression
  - Controlled fire
  - Est. CDF ↓ >50%

Test Conditions	Water Applied	1 min after Water Applied	2 min after Water Applied
Simulated traditional sprinklers			
Simulated SMART sprinklers			

Potential Future Applications

- Reduce water demand
  - ASRS: mini-load, top-load, other arrangements
  - Lithium-ion batteries / energy storage systems
- Highly challenging fires
  - Roll paper storage
  - Tight-packed storage (TL-ASRS)
  - Open-top combustible containers (OTCC)

Summary & Key Takeaways

- Today's commercial properties requires SMART protection
  - Challenging fires, limited water supplies, resilient operations
- Proof-of-concept studies showed effectiveness
- Current studies focused on water saving
  - Low piled storage, high-bay storage, OTCCs
  - Substantial water demand reduction
- Future potential applications expanding
  - Roll paper, ASRS, LIB/ESS, OTCC

Reference: FM Global Technical Report

https://www.fmglobal.com/research-and-resources/research-and-testing/-/media/25C4E9A7288D4ED3B04

Thank you.
Any questions?

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Contact: yibing.xin@fmglobal.com