National Construction Safety Team Investigation

Report on
The Station Nightclub Fire

National Institute of Standards and Technology

U.S. Department of Commerce

June, 2013

NIST

Duties of National Construction Safety Teams

To establish likely technical causes of building failure;

To evaluate technical aspects of evacuation and emergency response procedures;

To recommend specific improvements to model building standards, codes, and practices based on findings; and

To recommend research and other appropriate actions needed to improve structural safety of buildings, evacuation and emergency response procedures, based upon findings of this investigation.

Conduct of Investigation into The Station Fire

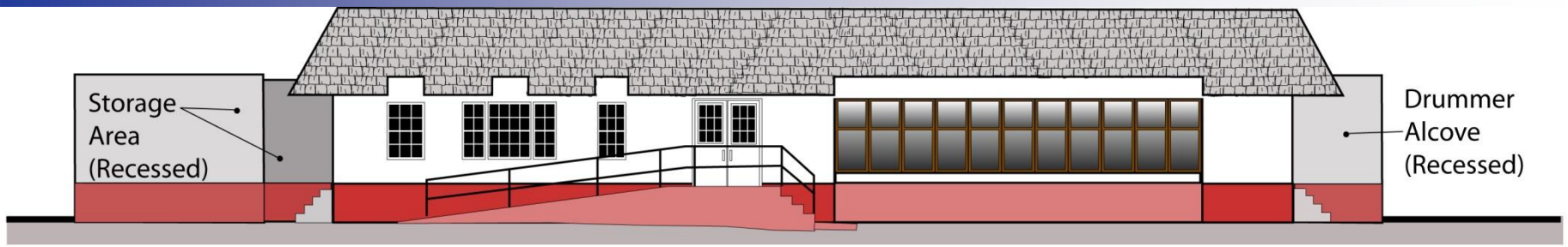
Identified technical issues through consultations with experts in fire protection engineering, emergency evacuation, and members of other investigative teams.

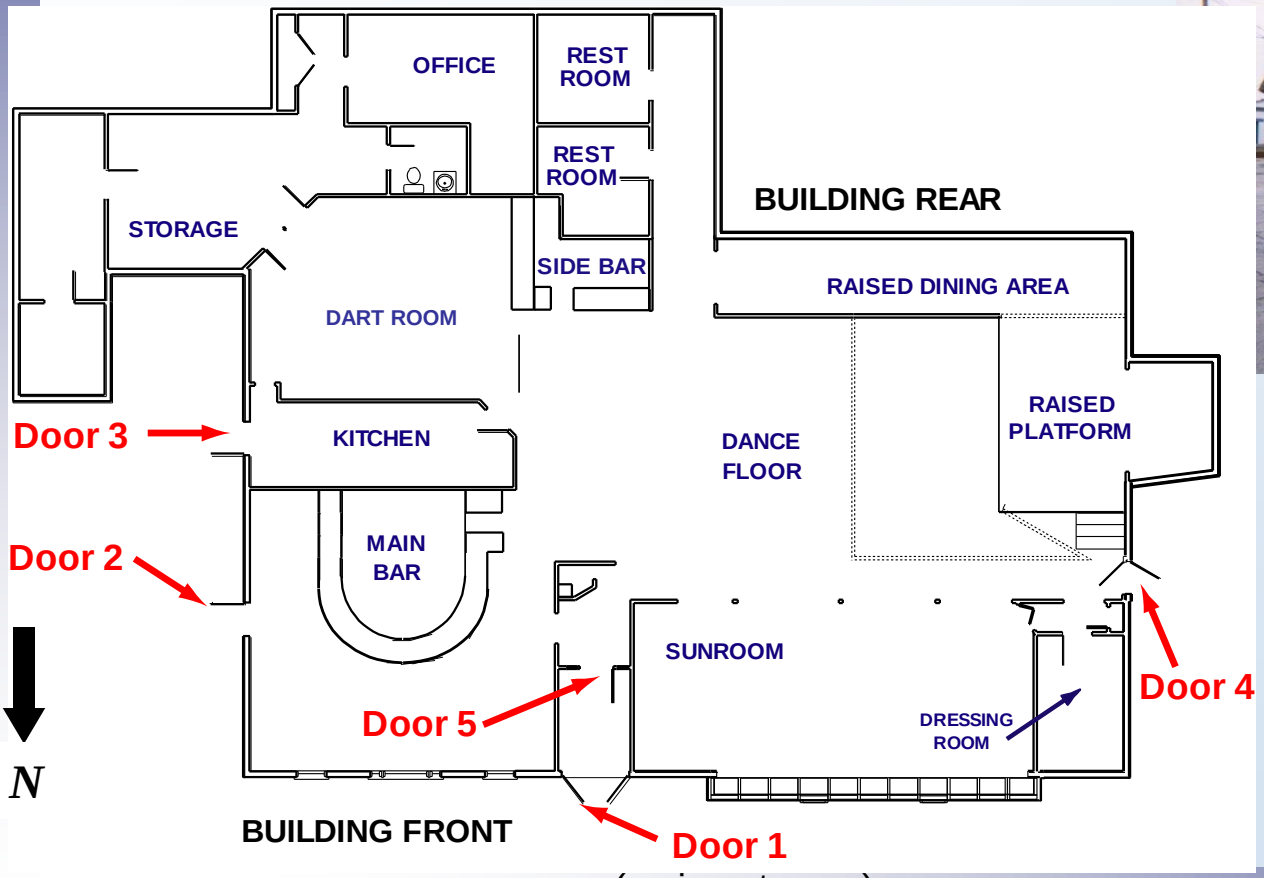
Collected data from the site, local authorities, contractors, building design documents, video/photographic data, telephone/radio transmissions, oral and written accounts.

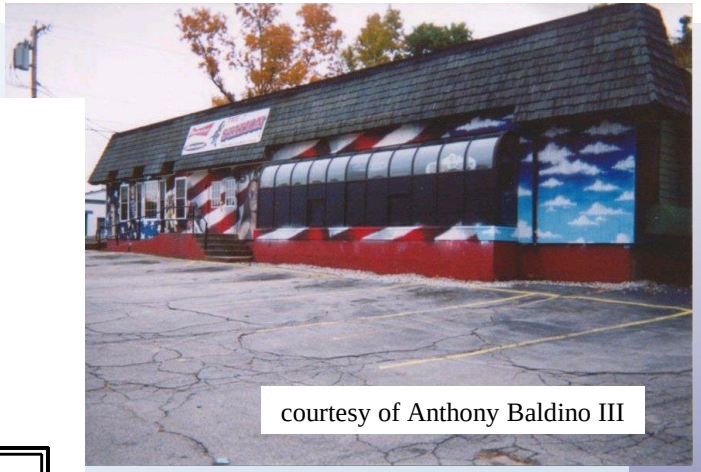
Compared model building and fire codes and practices, and reviewed practices used in operation of building.

Simulated and analyzed fire spread, smoke movement, tenability, evacuation, and operation of fire protection systems.

Conducted tests to support analysis and simulation predictions.






courtesy of Anthony Baldino III

Views of Building

NIST

Overall Timeline

Time	Event
11:08 pm	- ignition of foam by pyrotechnics
	- band stops playing, crowd begins to evacuate
11:09	- cell phone callers report fire to 911
	- fire alarm sounds and strobes begin to flash
	- report received of fire at Station nightclub; off-duty police on scene
	- people caught in doorway, smoke pouring out above
11:10	- 4 fire engines, a ladder truck and battalion chief assigned and dispatched
11:13	- Engine 4 on scene; running first hose line (1 3/4")
11:20	- master stream off Engine 2 operational
11:23	- Fire Chief 1: implement mass casualty plan
11:32	- roof over main bar appears down
12:15 am	- partial collapse of pool room area begins
~ 12:45	- State Fire Marshal on scene
~1:00	- all patients transported

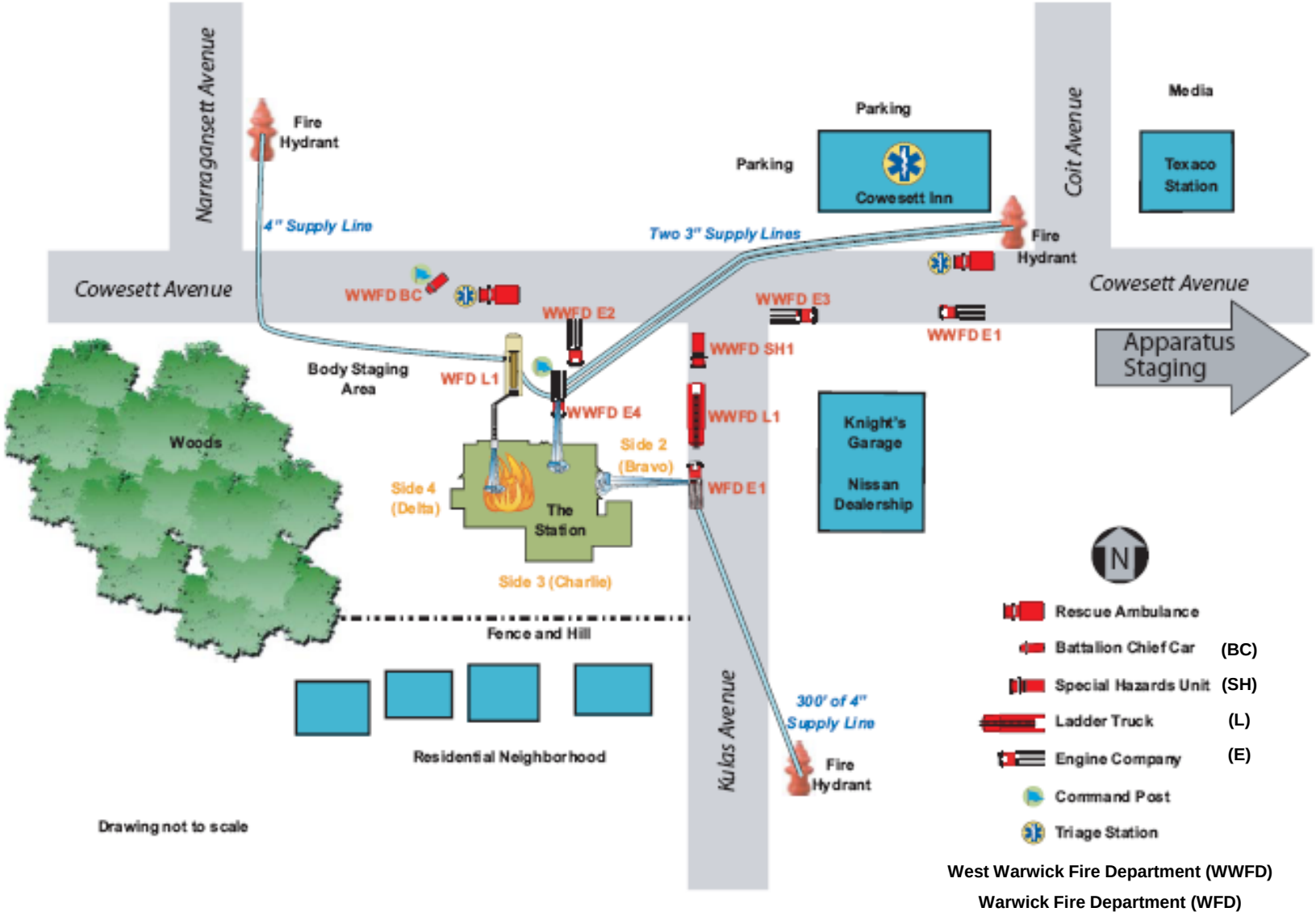


Figure 3-1. Schematic of primary apparatus deployment

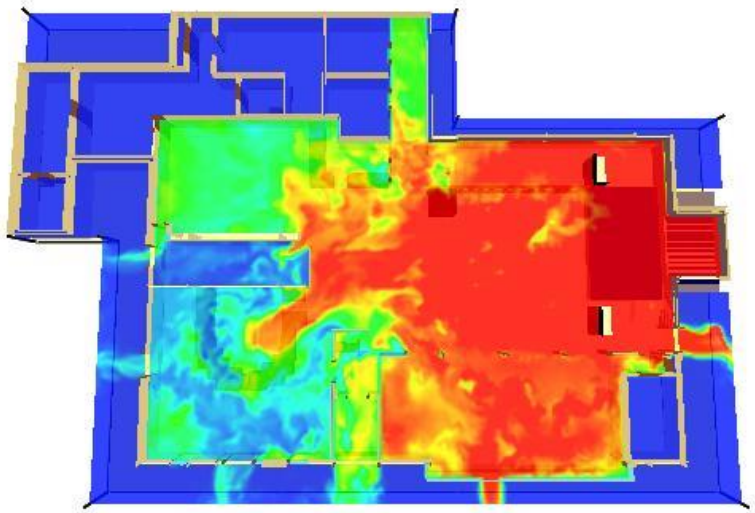
Computer Simulation of The Station Fire

View of fire from near entrance to front vestibule (near floor)

View of fire from far side of main bar (head height)

Temperatures in The Station at 90 seconds

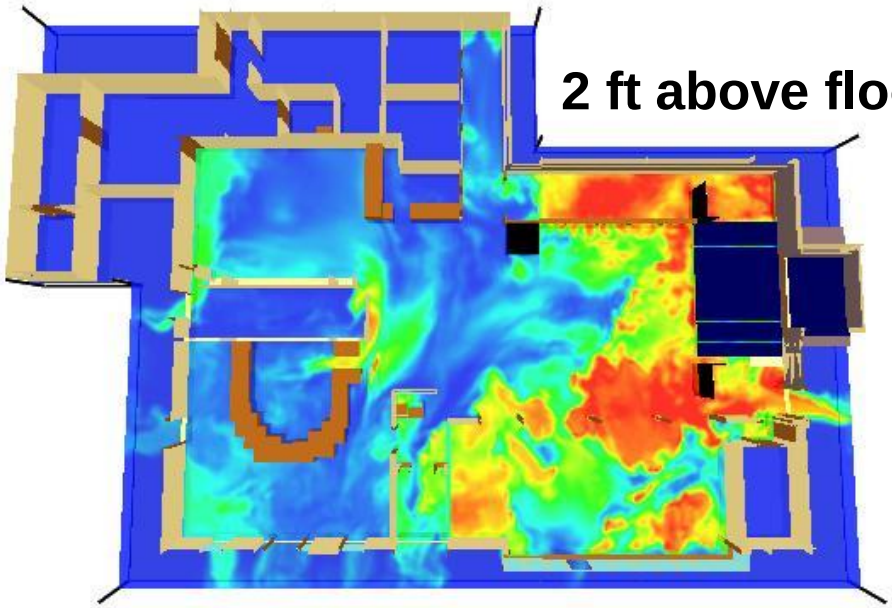
(from computer simulation)



temperature
°C
1000
900
800
700
600
500
400
300
200
100
0.00

5 ft above floor

Time: 90.0



2 ft above floor

temperature
°C
1000
900
800
700
600
500
400
300
200
100
0.00

Time: 90.0

Peak temperatures in red exceed 1000 °C (1832 °F)

Light blue indicates temperatures around the boiling point of water (100 °C, or 212 °F)

Direct contributors to substantial loss of life in The Station fire

- Hazardous mix of building contents
- Inadequate capability to suppress fire during its early stage of growth
- Inability of exits to handle all of the occupants in the short time available for such a fast growing fire

Major Conclusion

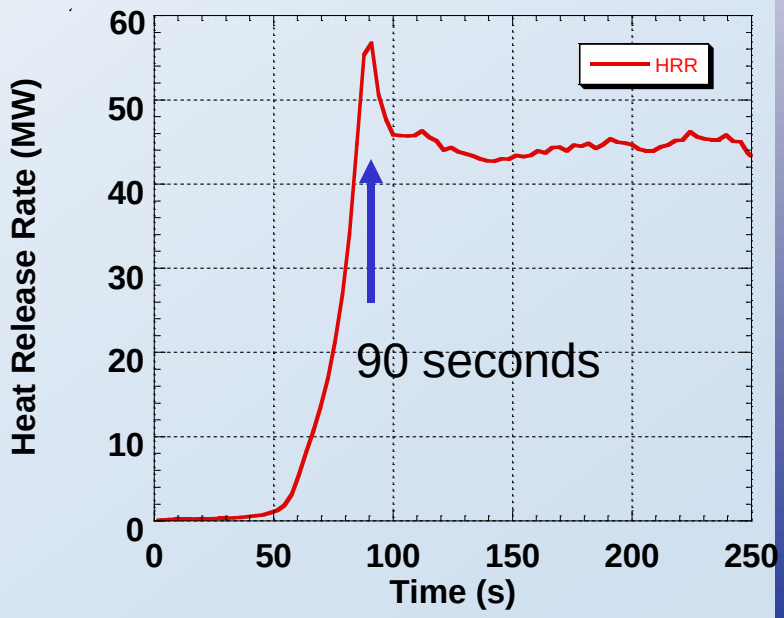
- Strict adherence to 2003 model codes available at the time of the fire would go a long way to preventing similar tragedies in future.
- Changes to codes subsequent to fire made them stronger.
- By making some additional changes – and state and local agencies adopting and enforcing them – we can strengthen occupant safety even further.

Key Findings Regarding Building Contents

- Non-fire retarded foam sample purchased by NIST ignited within 10 seconds when exposed to a pyrotechnic device; under similar condition, fire retarded foam sample did not ignite.

- Computer simulation of the nightclub fire shows that flames spread rapidly over foam finish material, igniting the wood paneling adjacent to the foam and generating intense heat in the first 90 seconds.

- Fire transitioned to more traditional, ventilation-limited wood frame building fire in about 2 minutes.



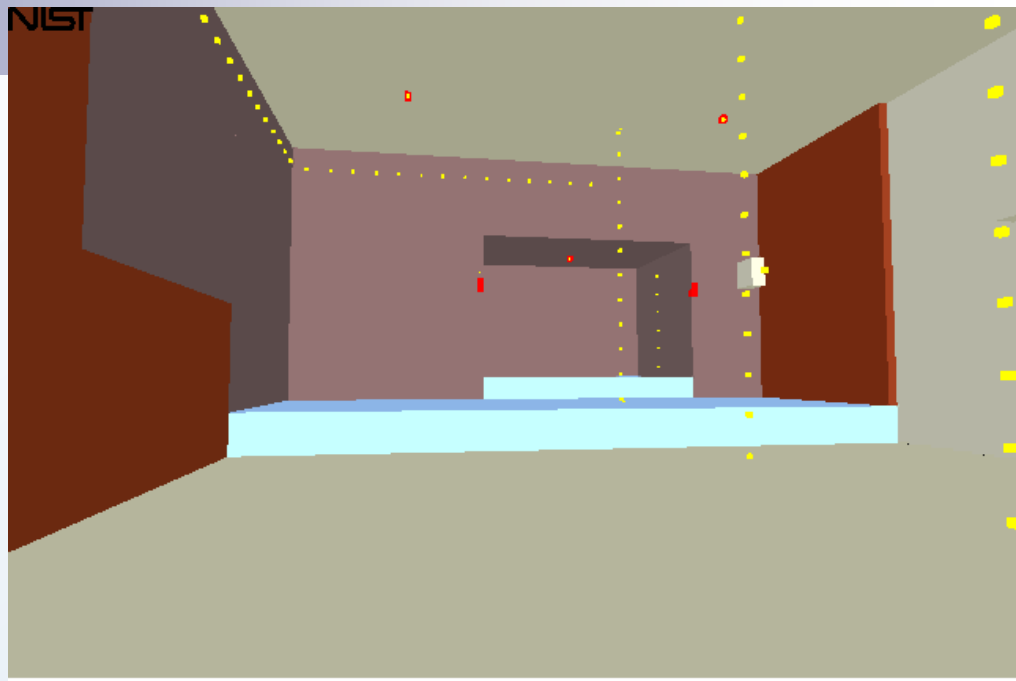
Key Findings Regarding Fire Protection Systems

- Experiments conducted at NIST demonstrated that a sprinkler system installed in test room in accordance with NFPA 13 was able to control a fire initiated in non-fire retarded polyurethane foam panels.

- Sprinklers were not installed in The Station, nor would they have been required for such existing structures under 2003 editions of the model codes

- A heat detection/fire alarm system was installed in the building and was activated (sound and strobe) by the fire 41 seconds after the fire started.

Computer simulation of platform area mock-up with sprinklers



Time: 0.0

NIST

Key findings regarding emergency egress

- First patrons recognized danger 24 seconds after ignition of foam; bulk of crowd began to evacuate around time band stopped playing (30 seconds).
- Up to 2/3 of occupants may have attempted to leave through main entrance; many were unsuccessful.
- Prior to 90 seconds, a crowd-crush occurred at main entrance which disrupted flow through front exit.
- Event precipitating crowd crush likely related to arrangement of single interior door with merging streams of traffic and pressure to escape rapidly deteriorating conditions in nightclub.

Key findings regarding emergency egress (cont.)

- Measurements in a fire test of a reconstructed portion of the platform and dance floor produced, within 90 seconds, conditions well in excess of accepted survivability limits.

- Computer simulation of the full nightclub fire suggested that conditions around the dance floor, sunroom, and assembly area behind kitchen would have led to severe incapacitation or death within about 90 seconds after ignition of the foam.

Areas of recommendations for improvements to model building & fire codes, standards and practices in nightclubs

- Adoption/enforcement by state/local jurisdictions of model codes
- Strengthening requirements for sprinklers
- Increasing factor of safety on time for occupant egress
- Tightening restriction on use of flexible polyurethane foam as an interior finish product
- Further limiting use of pyrotechnics
- Conducting research to underpin recommended changes

Recommendation 1

Model Code Adoption and Enforcement

All state and local jurisdictions

a) adopt building/fire code covering nightclubs based on model codes (as a minimum requirement) and update local codes as the model codes are revised;

b) implement aggressive and effective fire inspection and enforcement programs that address:

(i) all aspects of those codes;
(ii) documentation of building permits and alterations;
(iii) means of egress inspection and record keeping;
(iv) frequency and rigor of fire inspections, including follow-up and auditing procedures; and
(v) guidelines on recourse available to the inspector for identified deviations from code provisions

Recommendation 1 (cont.)

All state and local jurisdictions

c) ensure that enough fire inspectors and building plan examiners are on staff to do the job and that they are professionally qualified to a national standard such as NFPA 1031 (*Professional Qualifications for Fire Inspector and Plan Examiner*).

Recommendation 2

Sprinklers

Require sprinkler systems for all new nightclubs regardless of size, and for existing nightclubs with occupancy limit > 100.

Computer simulation of The Station fire had sprinklers been installed

Recommendation 3

Building contents and finish materials

(a) specifically forbid non-fire retarded flexible polyurethane foam, and materials known to ignite and propagate flames as easily, from all new and existing nightclubs;

(b) provide more explicit guidance to building owners, operators, contractors, and authorities having jurisdiction for when large-scale tests that are covered in NFPA 286 are required to demonstrate that materials (other than those already forbidden above) do not pose an undue hazard for the use intended

(c) modify ASTM E-84, NFPA 255, and NFPA 286 to ensure that product classification and the pass/fail criteria for flame spread tests and large-scale tests are established using best measurement and prediction practices available.

Recommendation 4

Indoor use of pyrotechnics

(a) Ban pyrotechnic devices from indoor use in new and existing nightclubs not equipped with an NFPA 13 compliant automatic sprinkler system.

(b) Modify NFPA 1126 to include a minimum occupancy and/or area for a nightclub below which pyrotechnic devices should be banned from indoor use, irrespective of the installation of an automatic sprinkler system.

(c) Increase clearance between building contents and range of pyrotechnic device.

Recommendation 5

Occupancy Limits and Emergency Egress

Increase factor of safety on time to egress by

(a) establishing the threshold building area and occupant limits for egress provisions using best practices for estimating tenability and evacuation time; and, unless further studies indicate another value is more appropriate, use 1-1/2 minutes as the maximum permitted evacuation time for nightclubs similar to or smaller than The Station;

(b) computing number of required exits and permitted occupant loads assuming at least one exit will be inaccessible in an emergency evacuation.

Recommendation 5 (cont.)

(c) increasing minimum capacity of main entrance (for nightclubs with one clearly identifiable main entrance) to accommodate 2/3 of maximum permitted occupant level (based upon standing space or festival seating, if applicable) during an emergency;

(d) eliminating trade-offs between sprinkler installation and factors that impact the time to evacuate buildings;

(e) requiring staff training and evacuation plans for nightclubs that cannot be evacuated in less than 1-1/2 minutes; and

(f) providing improved means for occupants to locate emergency routes for when standard exit signs become obscured by smoke.

Recommendation 6

Portable Fire Extinguishers

Perform a study to determine minimum number and appropriate placement (based upon time required for access and application in fully occupied building) of portable fire extinguishers for use in new and existing nightclubs, and level of staff training required to ensure their proper use.

Recommendation 7

Emergency Response

Ensure effective response to rapidly developing mass casualty events by adopting and adhering to existing model standards on communications, mutual aid, command structure and staffing, such as NFPA 1221, NFPA 1561, NFPA 1710, and NFPA 1720

Recommendation 8

That research be conducted to **better understand human behavior in emergency situations**, and to predict impact of building design on safe egress in emergencies.

Recommendation 9

That research be conducted to **understand fire spread and suppression better** in order to provide the tools needed by the design profession to address above recommendations.

Recommendation 10

That research be conducted to **refine computer-aided decision tools for determining costs/benefits** of alternative code changes and fire safety technologies, and to **develop computer models to assist communities in allocating resources**.

Actions Already Taken by Rhode Island

- Require the use across the board of up-to-date fire safety codes (elimination of grandfather clause) and coordinated administration of fire safety building codes

- Prohibit use of pyrotechnics in places of assembly such as nightclubs, and strictly regulate use in other large venues.

- Mandate sprinklers in nightclubs with occupancy of >150 in all class A and B places of assembly, with some exceptions.

- Provide greater enforcement powers to fire marshals to ensure ability to make inspections, to require immediate abatement of threats to public safety, and to increase access.

- Establish comprehensive planning requirements to identify future weaknesses in RI's approach to fire safety.

Summary of Other Actions Regarding Recommendations

- Recommendation 1: Adopt and enforce model codes
  - Continuous education and training effort required to raise awareness of the benefits and importance of embracing adoption and enforcement of codes
  - NFPA Technical Interim Amendment(TIA) #742R required owner to maintain records of egress inspection (NFPA 101:12.7.1 and 101:13.7.1); adopted in 2006 edition.
  - RI adopted NFPA 1 and NFPA 101, and strengthened fire marshal's enforcement power.

- Recommendation 2: Strengthen requirement for sprinklers
  - NFPA TIA #739R required existing nightclub facilities and festival seating venues with occupant loads greater than 100 to be sprinklered (NFPA 101:13.3.5.1); adopted in 2006 edition.
  - NFPA TIA #743R required all new nightclub facilities and festival seating venues to be sprinklered (NFPA 101:12.3.5.1); adopted in 2006 edition.

Summary of Other Actions cont'd

- Recommendation 2: cont'd
  - Continuous effort required to raise awareness of the benefits and importance of embracing recommendation.
  - RI strengthened regulation requiring sprinklers based upon occupant load of 150 rather than 100, some exemptions.
  - Change to Section 903.2.1.2 of the 2006 IFC (F58-03/04 [Approved as Modified]) to tighten threshold for sprinklers in Group A-2 assembly occupancies, such as nightclubs, restaurants and banquet halls. ICC membership voted to require such occupancies to be sprinklered where the occupant load exceeds 100 (rather than 300).

- Recommendation 3: Strengthen restrictions on foam plastic finish materials
  - ICC FS108-03/04 dealt with one small aspect of foam plastic finish materials; additional revisions need to be developed using established procedures

Summary of Other Actions cont'd

- Recommendation 3: cont'd
  - NIST will work with standards committees (UL 94, ASTM E84, NFPA 255, and NFPA 286) to develop ways to address recommendation. This will be a long term effort due to the research needed to support changes to building and fire codes and standards.
  - State and local jurisdictions can have immediate impact by adopting and enforcing existing model codes.

- Recommendation 4: Strengthen restrictions on use of pyrotechnics
  - NIST plans to work with NFPA 1126 to develop technical support for recommendation.
  - RI strengthened restrictions to prohibit use of pyrotechnics in places of assembly such as nightclubs and to strictly regulate their use in large venues that can accommodate them safely.
  - State and local jurisdictions can have immediate impact by adopting and enforcing existing model codes.

Summary of Other Actions cont'd

- Recommendation 5: Increase factor of safety on egress
  - NFPA TIA #737R and NFPA TIA #740 restricted festival seating in new and existing facilities if occupant load is greater than 250 unless life-safety evaluation in conducted (NFPA 101:12.2.5.4.1 and 101:13.2.5.4.1); adopted in 2006 edition.
  - NFPA TIA# 738 required trained crowd managers for existing and new assembly occupancies (NFPA 101:12.7.5 and 101:13.7.5); adopted in 2006 edition.
  - NIST will work with NFPA 101, NFPA 5000, and IBC; substantial research effort required, which NIST is pursuing.

- Recommendation 6: Conduct portable extinguisher study
  - Workshop held at NIST with equipment manufacturers, building owners, fire service, NFPA, ICC, and testing organizations to develop outline of study, and identify participants, to feed technical information into NFPA 10 committee.

Summary of Other Actions cont'd

- Recommendation 6: cont'd
  - Initiated NIST research project to develop performance metrics for portable fire extinguishers in fast growing nightclub fires.
  - RI now requires two 20 pound extinguishers in stage areas.

- Recommendation 7: Adopt and practice communication, response, and staffing guidelines
  - Continuous education and training effort required to raise awareness of the benefits and importance of embracing recommendation and practicing established guidelines for communication, response, command structures, and staffing.
  - No research nor code changes are required.

Summary of Other Actions cont'd

- Recommendation 8: Conduct research to understand human behavior better in emergency situations
  - NIST has established research program.
  - Energized multi-agency effort is needed.
  - NIST-sponsored workshop titled *Rethinking Egress,* to deal with building design for safe egress and access was released April 2008.

- Recommendation 9: Conduct research to understand fire spread and suppression better
  - Research is ongoing at NIST and elsewhere.
  - NIST projects underway on fire growth and spread on melting plastics, polyurethane foam flammability, and nanoadditive fire retardants.

- Recommendation 10: Conduct research to refine computer-aided decision tools
  - Research is ongoing at NIST and elsewhere.

For Further Information:

Web site to view final report: http://www.nist.gov/ncst

NIST Engineering Laboratory: http://www.nist.gov/el

NIST Fire Research – Data, Models, Reports: http://www.fire.nist.gov

NIST