LIGHTNING, OUTDOOR STADIUMS, AND SPECTATOR SAFETY

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with Erik Noble & Ryan Church

Wednesday, January 21st, 2004
LIGHTNING STORIES...
JUNE 6\textsuperscript{TH}, 1998

WASHINGTON D.C. – RFK STADIUM

1 WOMAN STRUCK

MANY INJURED

CHAOTIC EVACUATION OF 50,000 PEOPLE...

AFTER THE STRIKE
Blacksburg, VA
August 27th, 2000
8:05 pm
What happened?

- Lightning struck the ground, 6/10-mile
- During next ten minutes, 16 strikes occurred within one mile of the center of the stadium

Fans?

- Reacted immediately
  - Ran out of the stands
  - Crowded stadium tunnels and exits
  - Braved the elements
Virginia Tech

Carol Hart- Roanoke Times Columnist

“What I saw disturbed me. The tunnels leading from the stands to the concourse were packed solid, Ushers, emergency, or security should have been clearing those people out. Some fans tried leaving the stadium, but could not get through the tunnels. They were forced to find protection in the open.”
How did this occur?

- Game management did not heed threat of approaching storm
- Police and ushers were still tending tickets
- Inadequate loud speaker system
- There was no stadium lightning evacuation policy.
LIGHTNING STORIES...

AUGUST 27TH, 2000

BLACKSBURG, VA – VIRGINIA TECH

16 STRIKES < 1 MILE FROM STADIUM

CHAOTIC & INEFFECTIVE EVACUATION OF 50,000 PEOPLE...

DURING & AFTER THE STRIKES
LIGHTNING STORIES...

AUGUST 20TH, 2003

DENVER, CO – INVESCO FIELD (CU vs. CSU)

MULTIPLE CLOSE LIGHTNING STRIKES

PLAYERS RAN FROM FIELD

FANS GIVEN NO DIRECTION
2003
INVEСCO FIELD – NO DIRECTION GIVEN TO SPECTATORS

2000
VIRGINIA TECH –
MASS CONFUSION/UNCONTROLLED CROWD MOVEMENT

1998
RFK STADIUM – SPECTATOR STRUCK
The Problem

Large outdoor stadiums face a significant and growing vulnerability to lightning due to increased size and frequency of events. This growth is not paralleled in the knowledge and management of spectator safety.
1st quarter

- Lightning struck within 6 miles
- Officials removed players from field
- Management informed crowd of 75,000
  - Crowd evacuated
- Some fans stayed in seats, exits very crowded
1st quarter
- Lightning struck 5 miles away
- Officials removed players from field
- Management asked crowd of 84,227 fans to exit stadium
- Crowd evacuation very slow
- Many fans stayed in seats while lightning flashed overhead
1st quarter, football staff located lightning within 6 miles using lightning detection software

Game officials notified
- halted game within one minute

Players were removed from field

84,000 fans were given an option to leave stadium
Just before kickoff
- Lightning struck 3 miles away
- Warning issued to management by National Weather Service
- Officials removed players from the field
- Fans asked to leave
  - most were already leaving
- Fans crowded tunnels and blocked some exits
NCAA Division-I Football Attendance

- Total Attendance in 2002 was 34,384,264 people
- Attendance increased 7.38% annually since 1999
- 117 teams in Division-I football
  - more than 16% of them have reported 100% or higher attendance at home games through November 2003.
  - 42.7% of schools averaged over 90% of capacity through November 2003.
NCAA Division-I Football Event
Frequency

► 117 teams in Division-I football in 2002
  ▪ 775 home games
► 3 teams added to D-I football since 2001
Flash Density (flashes/km²*yr.)

Annual flashes per year in a 6-Mile Radius during games

Annual flashes in the seating area of Bryant-Denny stadium during games

6.0012
Flash Density (flashes/km²·yr.)

Flash probability for total NCAA attendance during play

Probability of one or more flashes for NCAA attendance during play over the next 20 years

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<th>Flash Density (flashes/km²·yr.)</th>
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NCAA Guidelines

- Recommend that all individuals should have left the athletics site and reached a safe structure or location by the time the monitor obtains a flash-to-bang count of 30 seconds.
  - Lightning can ‘jump’ six miles from strike to strike
NCAA Guidelines are recommendations

In-house policies/procedures are highly variable and do not always follow NCAA recommendations!
**Alternatives**

**A**
- Make existing NCAA guidelines **MANDATORY**
- All persons in safe place **BEFORE LIGHTNING IS 6 MILES AWAY**

**B**
- In-Situ protection
  - Retrofit stadiums to protect all areas – no evacuation necessary
Make existing NCAA guidelines **MANDATORY**

**CROWD DYNAMICS**

Can you fit people in safe locations?

3 ft$^2$ per person = involuntary contact

How long will it take to move people?

Lightning Detection lead time > Evacuation time

**SAFETY ACHIEVED BEFORE LIGHTING WITHIN 6 MILES**
In Situ Protection

**AUGMENT EXISTING STRUCTURAL PROTECTION**

- Additional Lightning Rods
- Suspended Thin Wires over Open Locations

**STADIUM PROTECTED = SPECTATORS DO NOT MOVE**
In Situ Protection

Andrews, 2003
In Situ Protection
In Situ Protection

Andrews, 2003
In Situ Protection

Andrews, 2003
RECOMMENDATION

**NCAA guidelines**
- Fear of Repeat from Past Lightning Problems
- Satisfies Human Desire to Seek Shelter

**In-Situ Protection**
- No Planning/Resources for Crowd Control
- Leverages Inertia: Fans Won’t Move Anyway

A \(\leftrightarrow\) USER DECISION \(\leftrightarrow\) B
WHEN THINGS “FALL” INTO PLACE

Probability of Tornado (Oct-Dec)

Probability of Tornado (Jan-Sept)
“...a SLIGHT CHANCE of a GREAT HARM can be condemned as an unreasonable risk, especially where the burden of adequate precautions...is relatively slight.”
YOU CAN HELP...(yourself)

- **Contact local stadiums**
  - Jr / Sr High school
  - **College** (most colleges have athletic facilities far beyond a single large stadium)
  - **Professional Teams** (baseball, football)

- **Inquire about their weather planning**
  - Do they have on-site warning equipment?
  - Do they have an emergency plan for weather?
  - What can you/your station do to help?