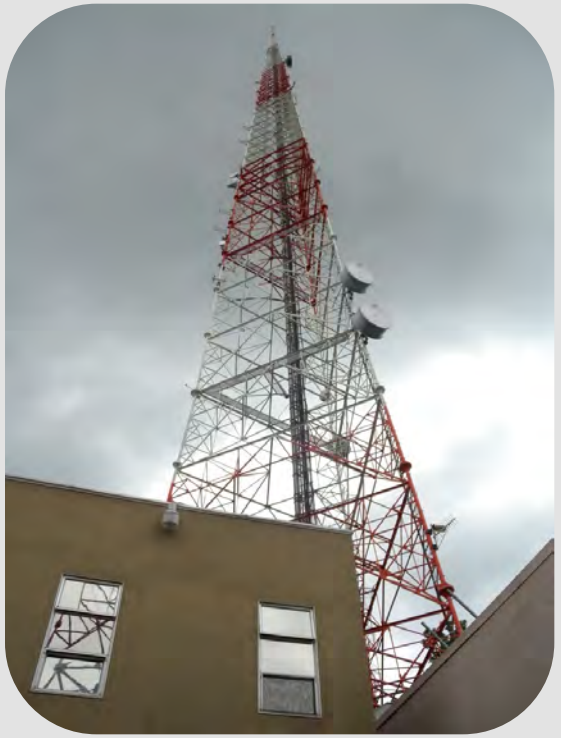
Introduction to Radiofrequency Safety

By Chris Mak

CM598

University of Washington



Topics Covered

- Scope of the Issue
- What is NIR and RF?
- Where is RF Found?
- Is it Dangerous?
- Standards and Measures
- Controls
- Conclusion

In the News

Local News

City of Seattle urges Seahawks fans to back off cell phone sharing

BY JOSH KERNS, KIRO Radio Reporter | September 4, 2014 @ 9:29 am

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With tens of thousands converging on CenturyLink Field for Thursday's Seahawks season opener, the mayor's office is pleading with people to back off on some of their cell phone sharing.

The city is asking people to delay streaming videos, sharing pictures and other data-intensive activities to help preserve bandwidth on local cell networks so emergency

The Seattle Times Eastside

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ROSEANNE BARR MAY 26 TICKETS ON SALE NOW! TULALIP RESORT CASINO

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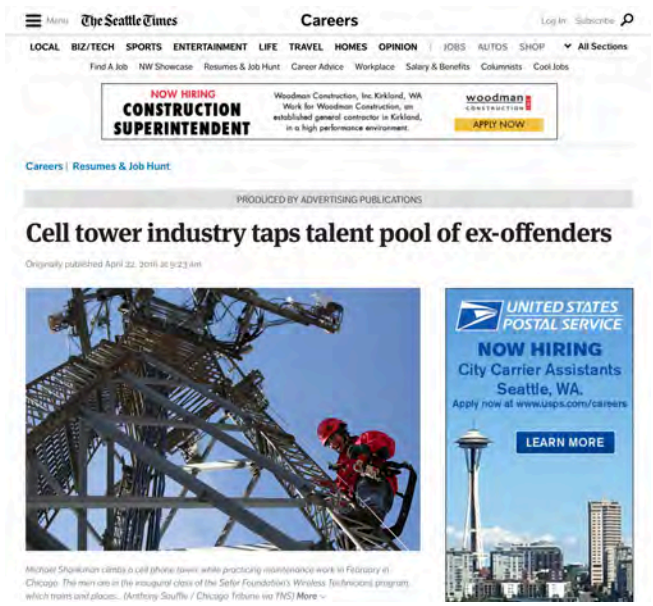
Medina residents fighting proposed cellphone tower

Originally published January 24, 2016 at 8:35 pm | Updated January 24, 2016 at 8:44 pm

1 of 2 Members of RespectMedina stand in front of a temporary cellular tower recently erected by T-Mobile. (Mike Siegel / The Seattle Times)

HER PRIMARY CARE? YOU.
Call 206.329.1777 to schedule an appointment.
POLYCLINIC

Medina residents are fighting a proposal for a cellphone tower in a



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Cell tower industry taps talent pool of ex-offenders

Originally published April 22, 2011 at 9:23 am

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Michael Shankman climbs a cell phone tower while practicing maintenance work in February in Chicago. The men are in the inaugural class of the Safer Foundation's Wireless Technicians program, which trains and places... (Anthony Souffle / Chicago Tribune via TNS) More

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Wireless companies put up more 'stealth' towers

Originally published June 18, 2014 at 2:23 am | Updated June 19, 2014 at 4:31 am

One might be hidden in a cross on a church lawn. Others are disguised as a cactus in the desert, a silo in farm country or a palm tree reaching into a sunny sky.

By BARBARA RODRIGUEZ
Associated Press

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One might be hidden in a cross on a church lawn. Others are disguised as a cactus in the desert, a silo in farm country or a palm tree reaching into a sunny sky.

Whatever the deception, the goal is the same: concealing the tall, slender cellphone towers that most Americans need but few want to see erected in their neighborhoods.

As telecommunications companies fill gaps in their

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Scope of the Issue

- **Growing number of cellular antenna in our urban environment: schools, offices, churches, homes and apartments.**
- **FCC and City of Seattle do not keep track of all cellular antenna.**
- **Number of antenna in an area is proprietary information**
- **Demand for construction and maintenance workers in the field.**
- **2016, Department of Labor listed Seattle-Everett-Bellevue area with the 4th highest employment of cellular installation and maintenance technicians.**

"The biggest problem with rooftops is the large number of people who may require access. HVAC and elevator repair people, exterminators, painting contractors, window washers, building maintenance, and real estate practitioners all may need to access rooftop areas. Most have little or no knowledge of RF radiation. When multiple antennas are located on rooftops, it is easy to exceed the FCC regulations in some areas of most rooftops."

-Richard Strickland, Director for Business Development at Narda Microwave

Cell Sites

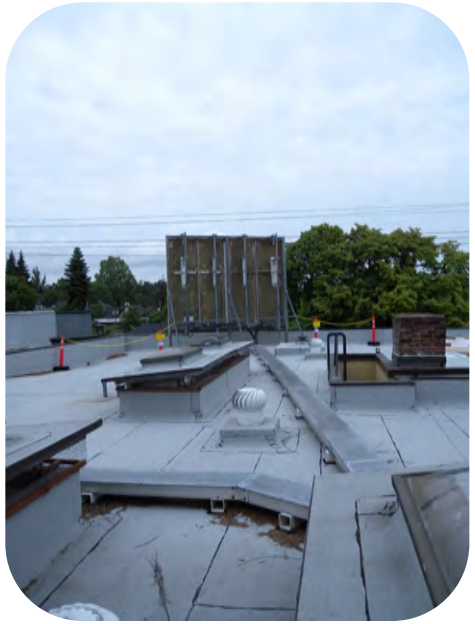
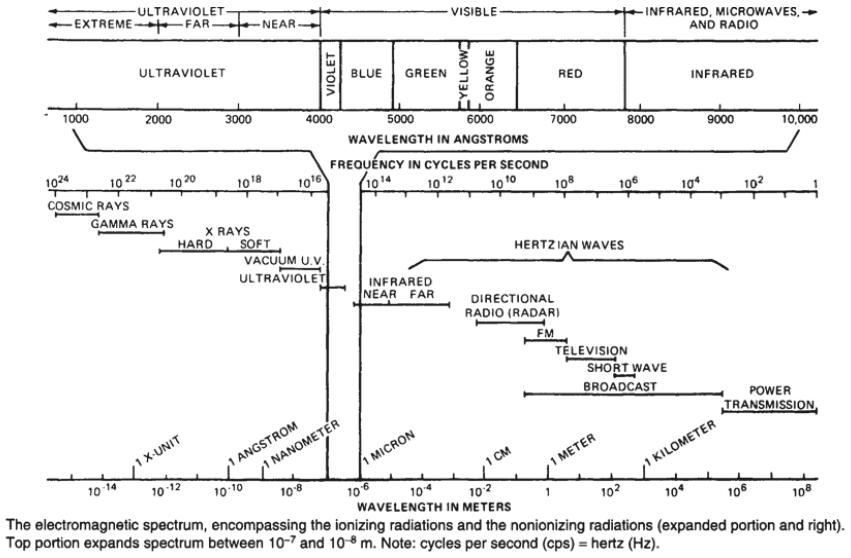


Photo Source: Christopher Mak

What is NIR and RF?

- Part of the Electromagnetic Spectrum
- Frequency and Wavelength dependent
- Longer wavelength, lower frequency = less energy
- NIR lacks energy to strip electrons from atoms, hence nonionizing.
- RF = 3kHz-300GHz
- MW = 1GHz-30GHz



The electromagnetic spectrum, encompassing the ionizing radiations and the nonionizing radiations (expanded portion and right). Top portion expands spectrum between 10^{-7} and 10^{-8} m. Note: cycles per second (cps) = hertz (Hz).

Electromagnetic Spectrum (Photo Source: Fundamentals of Industrial Hygiene)

Where is it found?

Cell sites and cellular antenna in urban environments are usually constructed on elevated structures, such as apartments, offices, etc..

Fixed to free standing towers ~50-200 feet in height

Clustered panel design: antenna are 1x4' in rows of three

Transmit 1850-1950 MHz around 500Watts of power

Photo Source: Christopher Mak

Is it Dangerous?

- Short answer: not really, but maybe…
- According to FCC, ground level exposure is safe.
- Detrimental health effects in humans and animals exposed to large doses of high power density RF in certain frequency ranges.

<u>Harmful effects:</u>

- Thermal heating of body
- Burns induced by touching energized metal
- Clicking noises in ears
- Cataracts
- Electric Shock
- Affect pacemakers and insulin pumps: TLV may not protect

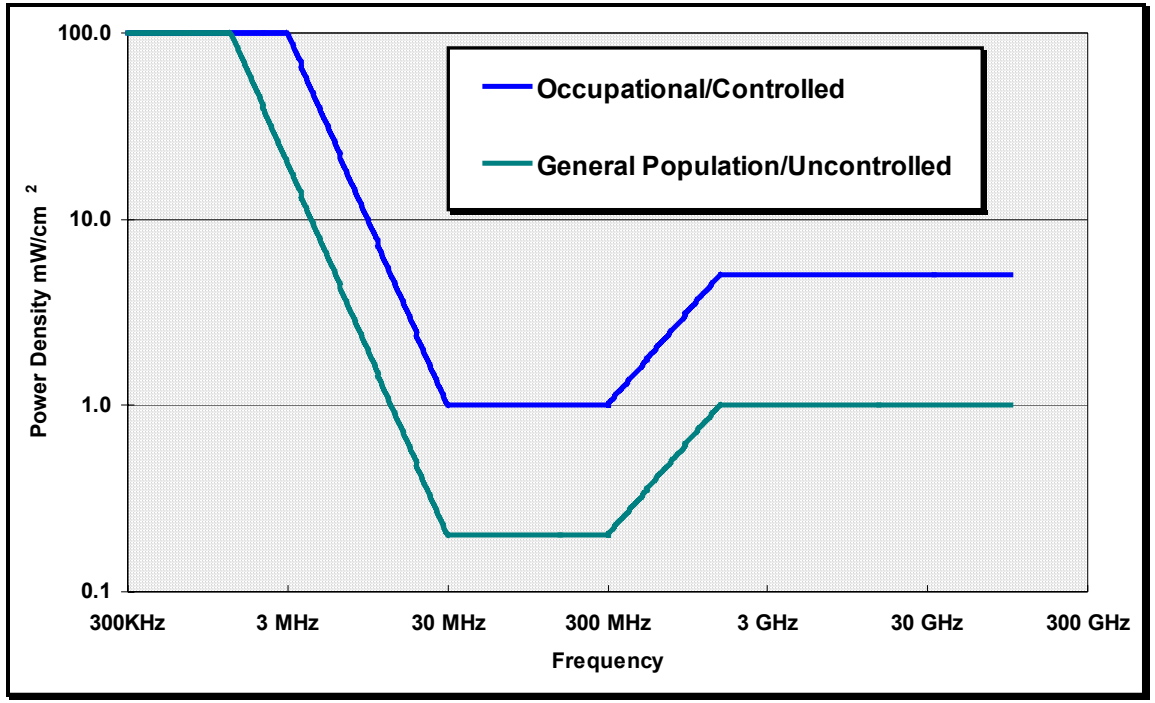
Standards & Measures

- OSHA & FCC enforce Institute of Electrical and Electronics Engineers (IEEE) and American National Standards Institute (ANSI) Standard of IEEE/ANSI C95.1-2005 for RF exposures.
- Based on Maximum Permissible Exposure (MPE) categorized by Power Density (w/m2), Frequency (hz), and Specific Absorption Rate (w/kg)
- Limit whole-body thermal heating, like a microwave oven, or electric shocks.

Standards & Measures

Two categories:

- Occupational/Controlled Environment = 6-minute TWA
- General Public/Uncontrolled Environment = 30-minute TWA



FCC Adopted Maximum Permissible Exposure Limits
Chart 1

Photo source: EME Evaluation and Management for Antenna Sites

Standards & Measures

One Method for Predicting Power Density (S):

- Workers using documented data for the antenna in question, and power tables on antenna gain can use the inverse-square law to predict power density at specific distances from a source of radiation.

- RF fields follow the inverse-square law, we know that power is reduced by the square of the distance, meaning that distance matters in terms of keeping exposures low!

$$S = \frac{PG}{4\pi D^2}$$

S = Power Density (mW/cm^2)
P = Total Power into Antenna (mW)
G = Gain Ratio of Antenna based on an Isotropic radiator
D = Distance from Antenna (cm)

Standards & Measures

Measuring Power Density (S), Magnetic Field (H), and Electric Field (E):

- Non-directional antenna array (S)
- Dipole antennas (E)
- Loop antenna (H)

Note: Doing exposure assessment it is important To measure target organs that will be affected the most, primarily the eyes and testes. Furthermore, note which frequencies are being emitted Before selecting tool.

Frequency range (MHz)	RMS electric field strength (E)[a] (V/m)	RMS magnetic field strength (H)[a] (A/m)	RMS power density (S) E-field, H-field (W/m^2)	Averaging time $|E|^2$, $|H|^2$ or S (min)
0.1–1.0	1842	$16.3/f_M$	$(9000, 100\,000/f_M^2)^b$	6
1.0–30	$1842/f_M$	$16.3/f_M$	$(9000/f_M^2, 100\,000/f_M^2)$	6
30–100	61.4	$16.3/f_M$	$(10, 100\,000/f_M^2)$	6
100–300	61.4	0.163	10	6
300–3000	–	–	$f_M/30$	6
3000–30 000	–	–	100	$19.63/f_G^{1.079}$
30 000–300 000	–	–	100	$2.524/f_G^{0.476}$

NOTE—f_M is the frequency in MHz, f_G is the frequency in GHz.

[a]For exposures that are uniform over the dimensions of the body, such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the MPEs in the Table. For non-uniform exposures, the mean values of the exposure fields, as obtained by spatially averaging the squares of the field strengths or averaging the power densities over an area equivalent to the vertical cross section of the human body (projected area), or a smaller area depending on the frequency (see NOTES to Table 8 and Table 9 below), are compared with the MPEs in the Table.

[b]These plane-wave equivalent power density values are commonly used as a convenient comparison with MPEs at higher frequencies and are displayed on some instruments in use.

Photo Source: Fundamentals of Industrial Hygiene

Safety Controls

Photo Source: Christopher Mak

Administrative Controls

- OSHA/FCC & WAC 296-62-09005: Institute training program, which includes dangers of RF, how to measure and control hazards, and acknowledge health ramifications working around antenna.
- Establish an area where only authorized/trained people may enter
- Signage Guidelines
  - Notice, Caution, Warning
  - Must have: who's in charge, what danger is present, safety controls needed, regulations the sign is referencing from, and EMF hazard symbol

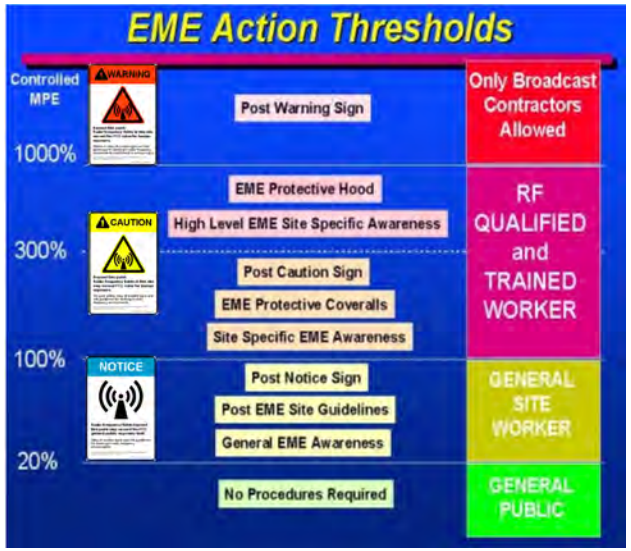


Photo source: EME Evaluation and Management for Antenna Sites

Photo Source: Steve Reno

Administrative Controls

- Site safety analysis before heading to jobsite to strategize work around antenna arrays, limiting distance (3 feet) and time spent near RF emissions
- Contact owner and shutdown and ground power
- Establish a Lockout/Tagout program

Interviewed Washington Firefighter Steve Reno on standard operating procedures (SOP)

- They do not have one
- Often called to towers for fatalities
- They do have a Lockout/Tagout training program
- Firefighting Union (IAFF) has a policy that does not allow for cellular arrays to be installed on firehouses in order to protect health of firefighters.

Safety Controls

Engineering Controls

- Barriers
  - Locked rooftop door, chain-link fence, engineered protective clothing
  - Insulate with engineered foam or copper tape to prevent leaks
  - Grounded metal screens to block waves
    - Penetrations in screen must be less than ¼ wavelength dimension
- Distance
  - Design and construct antenna higher off of the ground

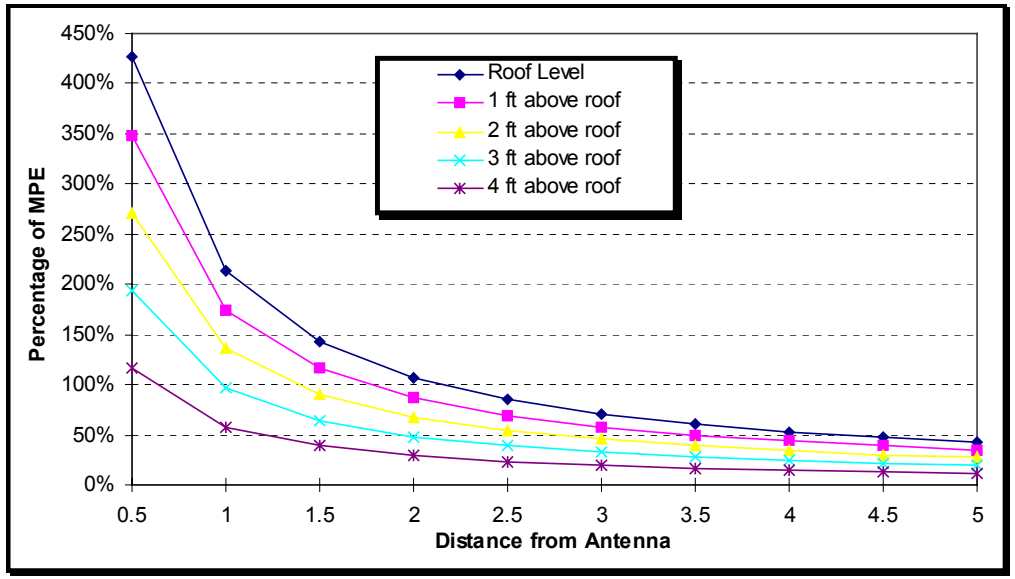


Photo source: EME Evaluation and Management for Antenna Sites

Safety Controls

PPE

Insulating Suit

- German company Naptex manufactures a hooded suit
- Made from polyester yarn and stainless steel fibers
- Shield from 1000% over FCC MPE

Personal Monitor

- Alerts to RF field
- Helpful to determine if your Lockout/Tagout has been compromised
- If worn, may not alert user to target organ exposure

Long-handled Tools

- Help extend reach into RF field

Thank you!

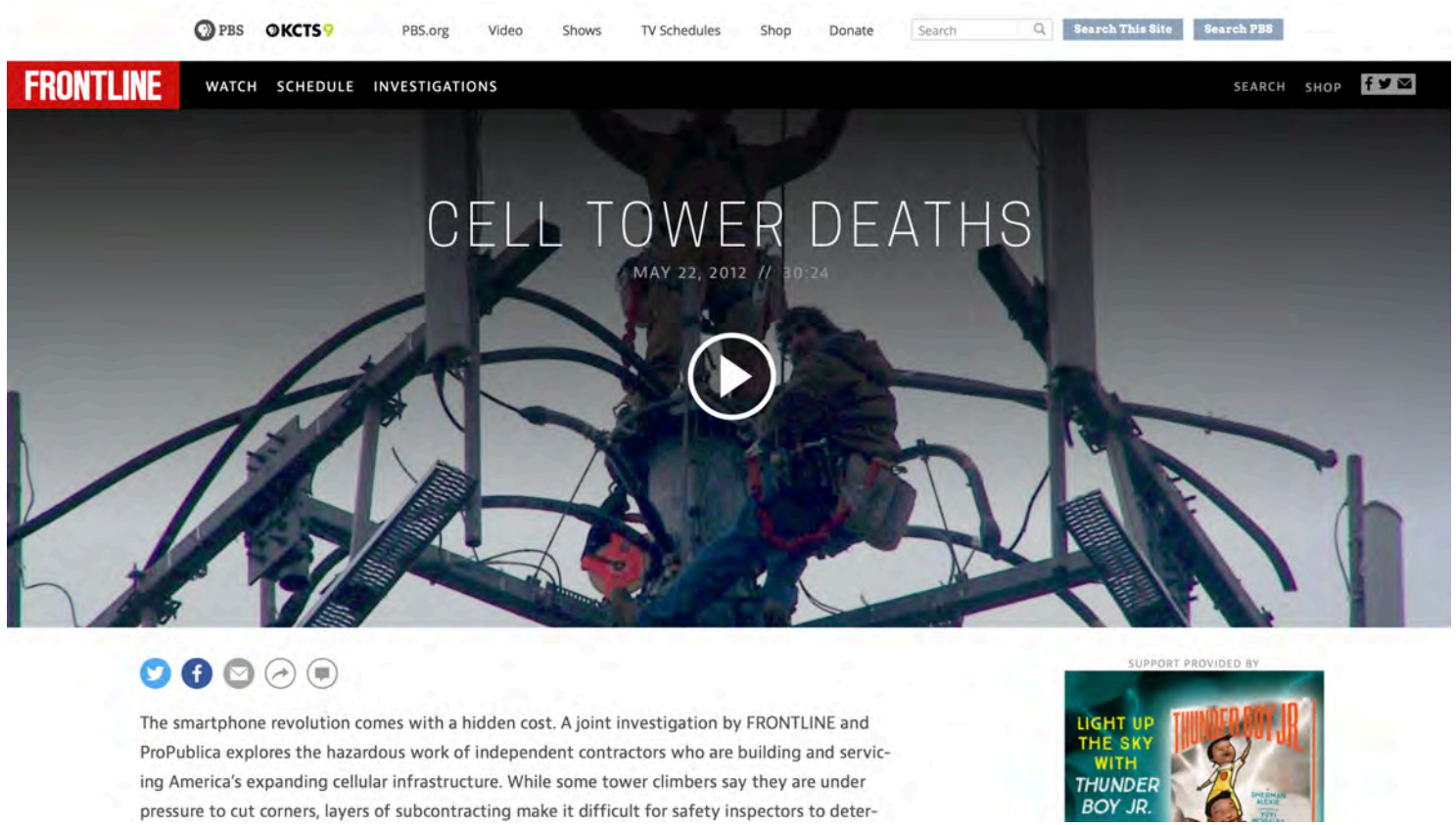
Learning Objectives:

- What is nonionizing radiation?
  - Low energy EME
- Why it is dangerous
  - Heating and shocks
- Standards and Measures
  - Occupational vs. General Public
- Controls
  - Administrative, Engineering, PPE

There is no reason for fear or panic!

HOWEVER!

Fatal Falls on Cellular Towers!



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