

Practices in Cell Siting and Radio Frequency Energy Safety

A review of the state of the discipline for
the York Water District

Presenters:

David Maxson, WCP

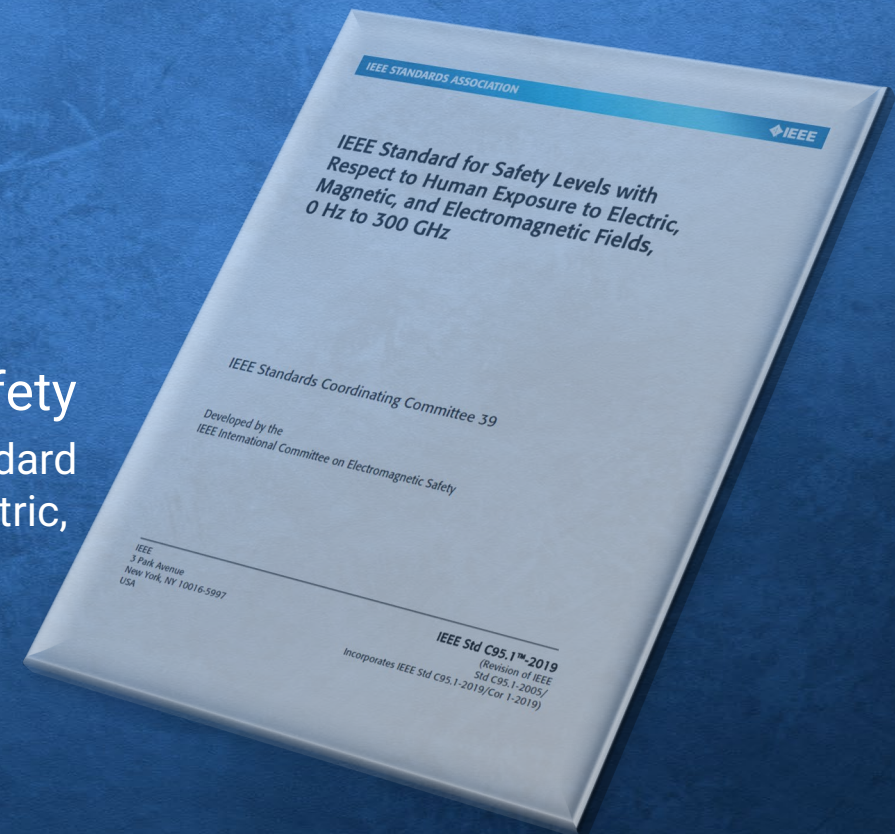
Professor Kenneth Foster

Simple ground rule

- *No ad hominem*
 - ✓ “An ad hominem argument is a personal attack against the source of an argument, rather than against the argument itself... [They] are used to attack opposing views indirectly, by attacking the individuals or groups that support these views.” [effectiviology.com]
 - ✓ Stick to facts, and opinions based on them
 - ✓ Do not impeach persons
 - for their supposed intent, affiliation, or any other characteristic

David Maxson, WCP

- See resume for full story
- On the topic of RF safety
 - ✓ RF safety planning
 - Since 1985
 - Help people comply with RF safety laws
 - Measure emissions
 - Calculate emissions
 - Write workplace RF safety programs
 - ✓ International Committee on Electromagnetic Safety
 - Editorial Working Group – Standard C95.1-2019 IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz
 - Available free at [IEEE Get Program](#)
 - ❖ (requires signing up for a free account – need not be a member)



David Maxson, WCP

- David is not
 - ✓ a bioelectromagnetics expert
 - ✓ a scientist
- David is
 - ✓ Highly experienced in RF safety compliance
 - ✓ A veteran of more than 500 cell siting reviews for municipalities
 - ✓ Comfortable with the safety standards in place today

David Maxson, WCP

David Relies on:

- Expert health agencies

- ✓ Systematic reviews of the literature
- ✓ Consensus on established impacts
- ✓ Pursuit of new data
- ✓ Professor Foster will present the background on expert health agency perspectives today

- Consensus technical standards

- ✓ Balance, openness, due process, consensus
- ✓ FCC relied on consensus standards in 1985, 1996, 2003, 2013 and 2019
- ✓ FCC relies on advice of expert health agencies

Scope of this presentation

- Scope of services requested by YWD

- ✓ Maxson:

- What is RF energy? (“RFE”)
- What is AT&T proposing?
 - ❖ Facilities and emissions
- Background on wireless facility siting
- Related issues

- ✓ Foster:

- Review of current guidance from expert bodies

- ✓ Conclusion

- Recommendation on the way to approach the proposal

Maxson provides a view of the world of RF through his eyes. His goal is to demystify the discipline for the board.

Foster provides a view of the expert bodies around the world who maintain surveillance of the issues of RF safety.

These presentations provide facts for the Board’s consideration.

Scope of this presentation

- Limitation of scope

- ✓ Premise:

Due to limitations of the Board's expertise and the time required, it is not possible for the Board to analyze the decades of scientific review and reengineer the exposure safety limits.

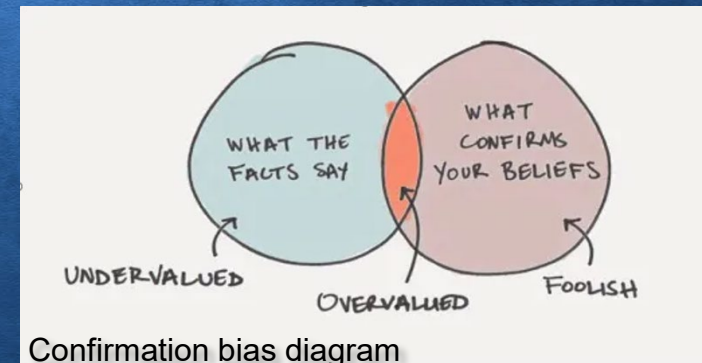
- Avoid debate on individual scientific studies – down the rabbit hole!
 - The scientific consensus is on the weight of the evidence
 - Routinely updated



- ✓ Caution:

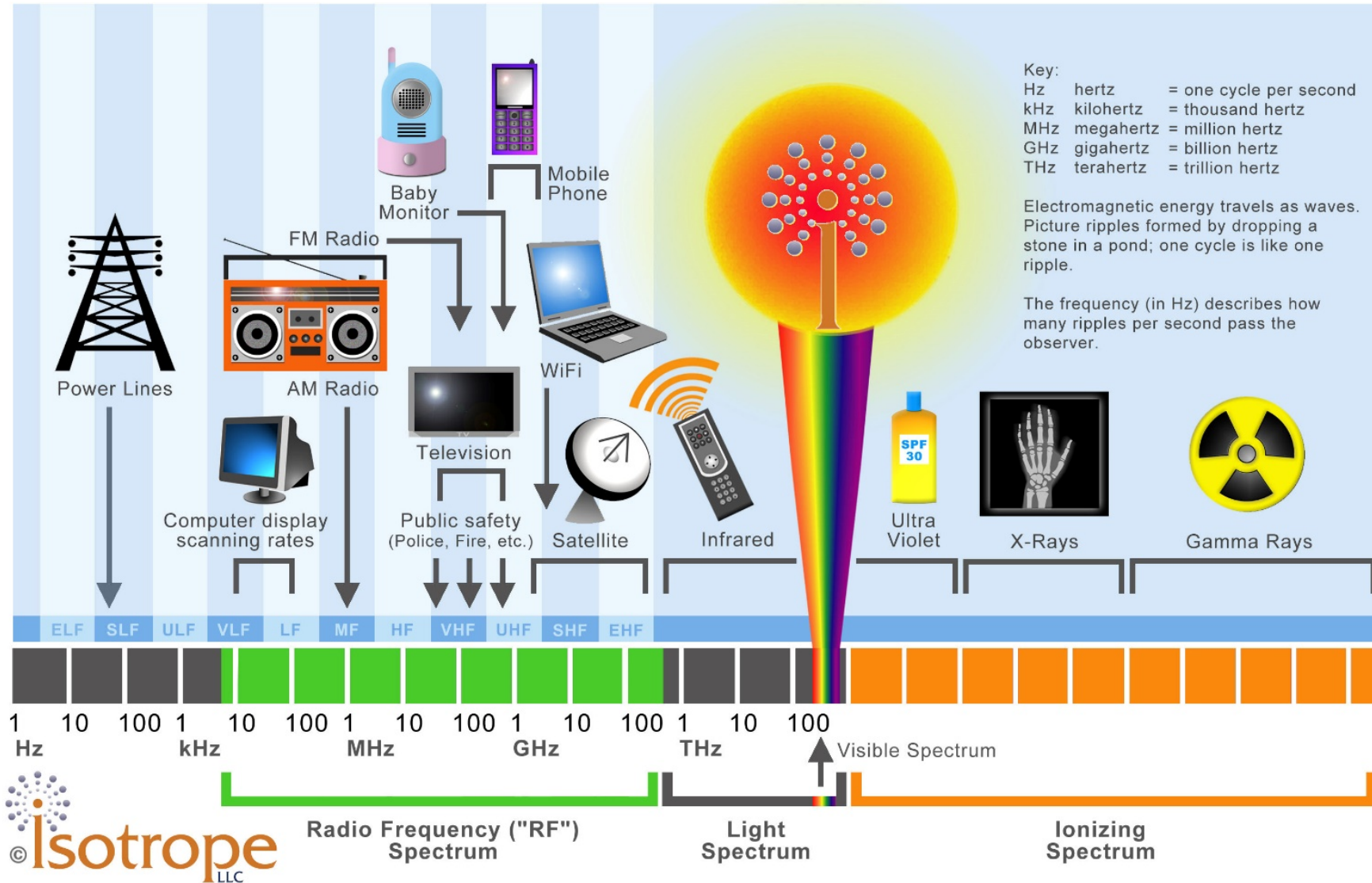
Hand-picked studies supporting one point of view are no substitute for scientific assessment

- Confirmation bias versus
 - Systematic review of the body of literature



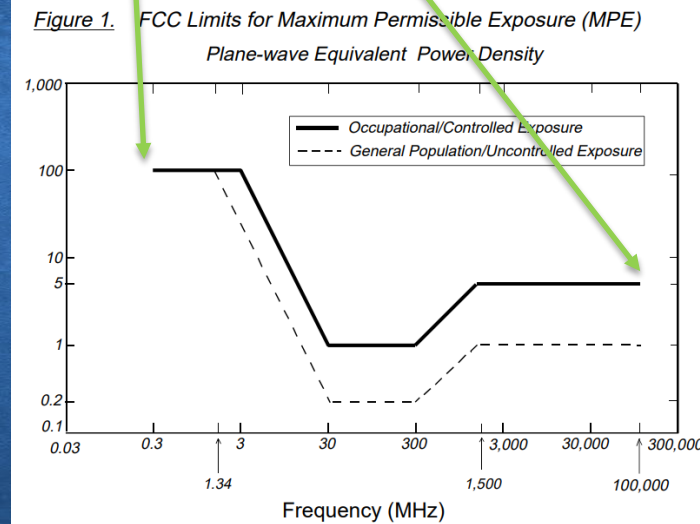
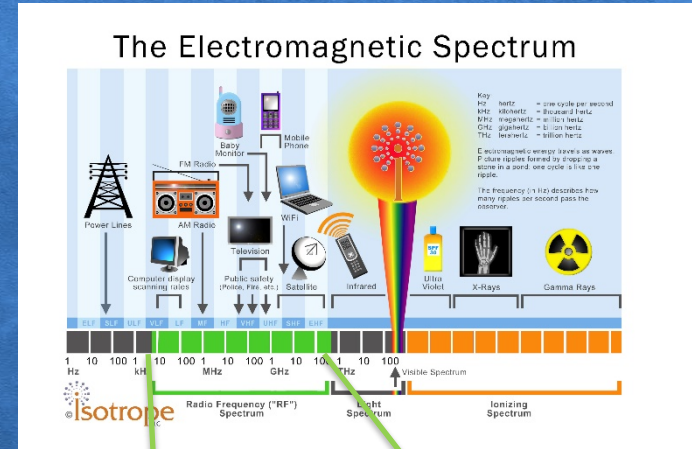
Confirmation bias diagram

The Electromagnetic Spectrum



1. What is RF energy?

- Safety standards intro
 - ✓ Frequencies are the “colors” of the radio spectrum
 - Microwaves are higher, e.g. “bluer”
 - AM radiowaves are lower, e.g. “redder”
 - ✓ Scientific consensus on adverse effects led to sets of safety limits
 - ✓ We look at all frequencies and evaluate a cell site’s total emissions against limits



1. What is RF energy?

- RF Energy is none of these:

Gas

Particulate

Fiber

Chemical

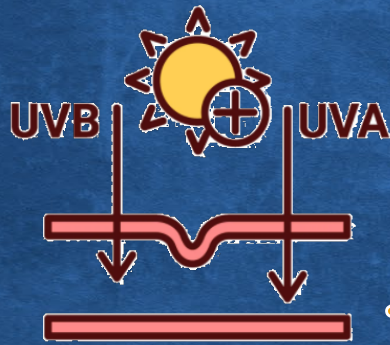
NOT A SUBSTANCE!



1. What is RF energy?

- RF Energy is none of these:

Ionizing radiation

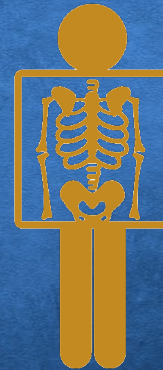


Ultraviolet B

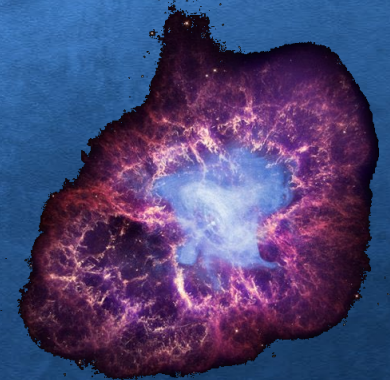
NO ELECTRON THEFT



Radioactivity



X-ray



Gamma-ray

1. What is RF energy?

- RF Energy is:

Non-ionizing electromagnetic energy

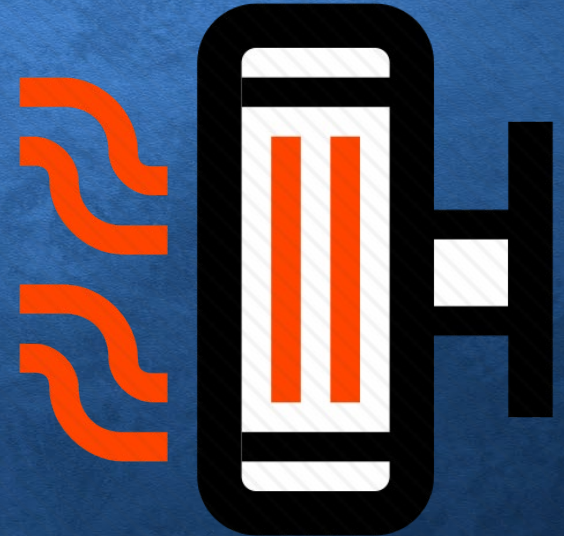
- RF Energy is like:



Electric stoves
(radiant and inductive coils)



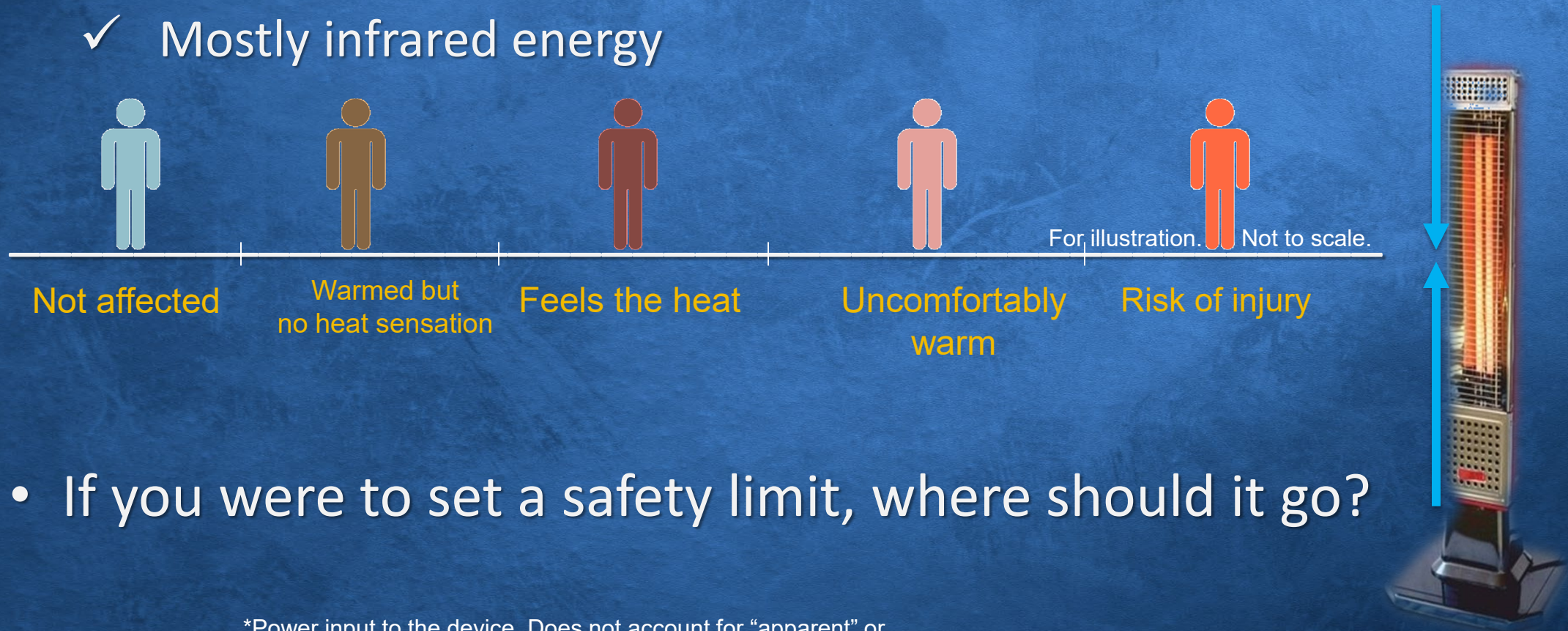
Visible light



Radiant heat

1. What is RF energy?

- Electromagnetic Energy Example – 1500-watt* radiant heater
 - ✓ Mostly infrared energy

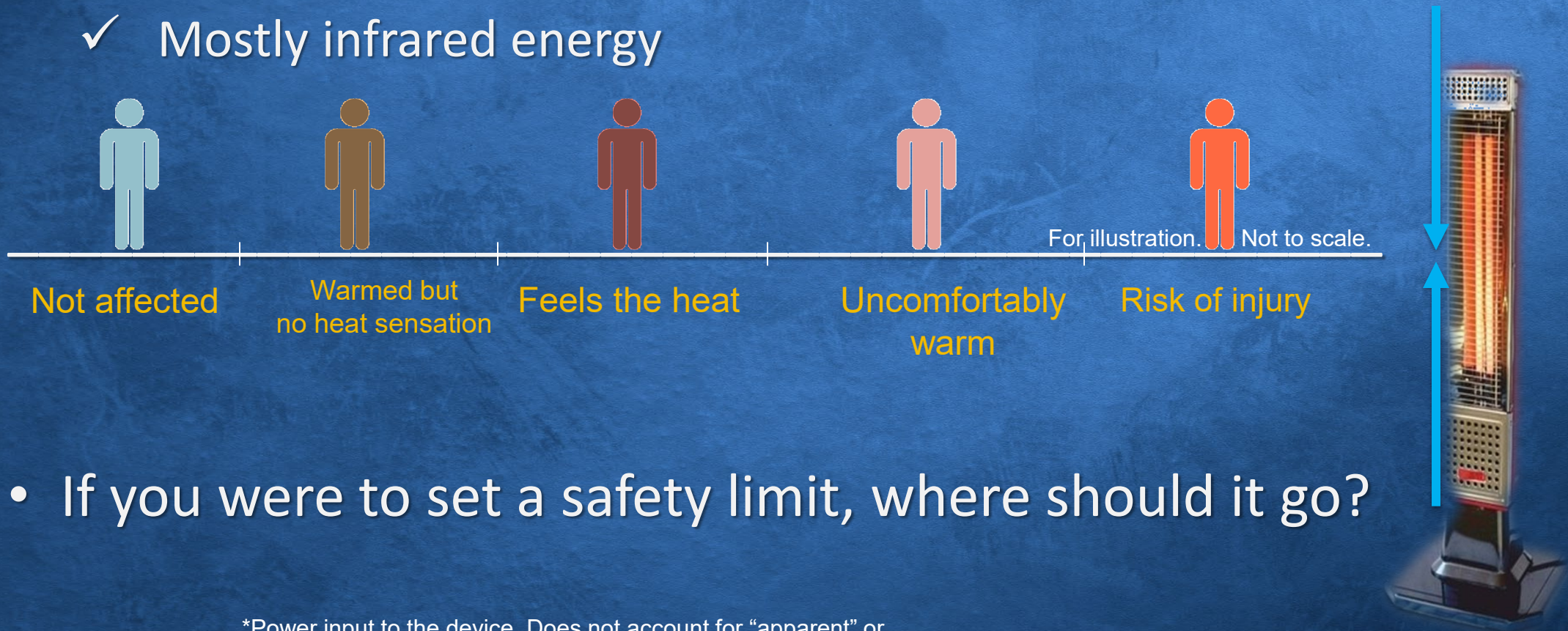


- If you were to set a safety limit, where should it go?

*Power input to the device. Does not account for “apparent” or “effective” power caused by the focusing effect of the internal reflector

1. What is RF energy?

- Electromagnetic Energy Example – 1500-watt* radiant heater
 - ✓ Mostly infrared energy

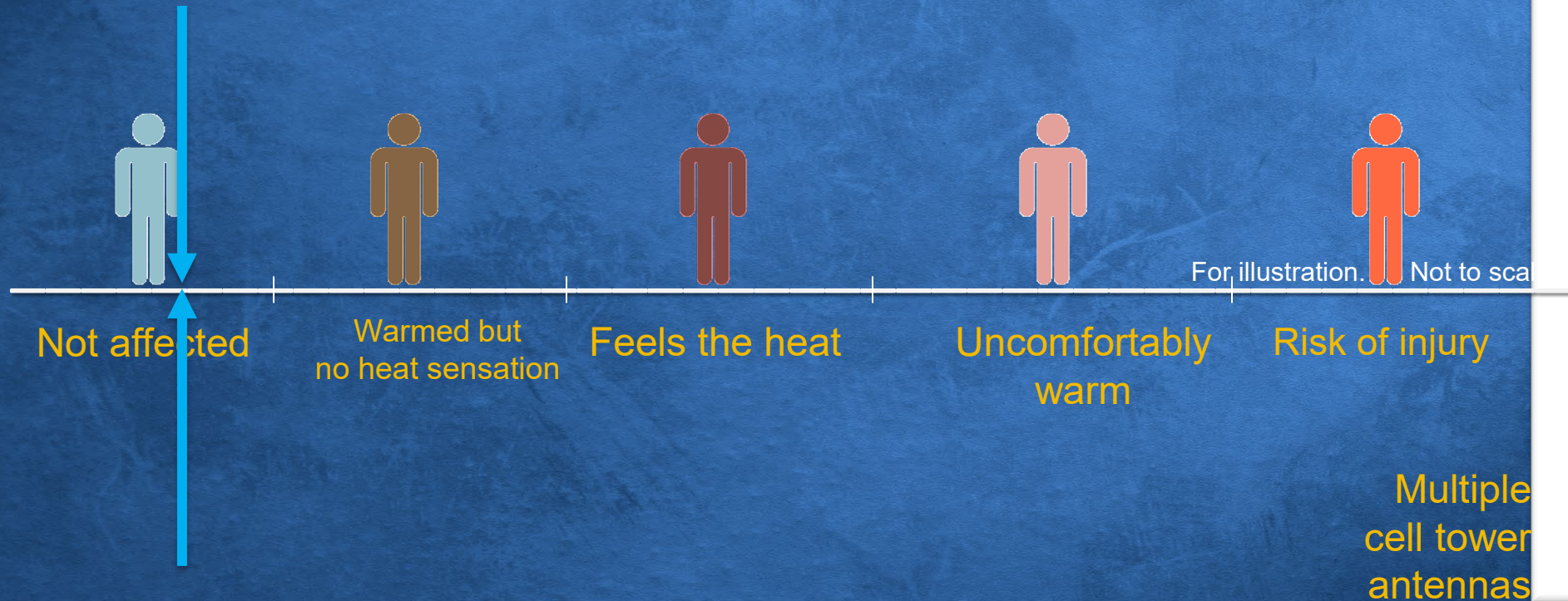


- If you were to set a safety limit, where should it go?

*Power input to the device. Does not account for “apparent” or “effective” power caused by the focusing effect of the internal reflector

1. What is RF energy?

- RF Energy concept – 40-watt* cell tower antenna

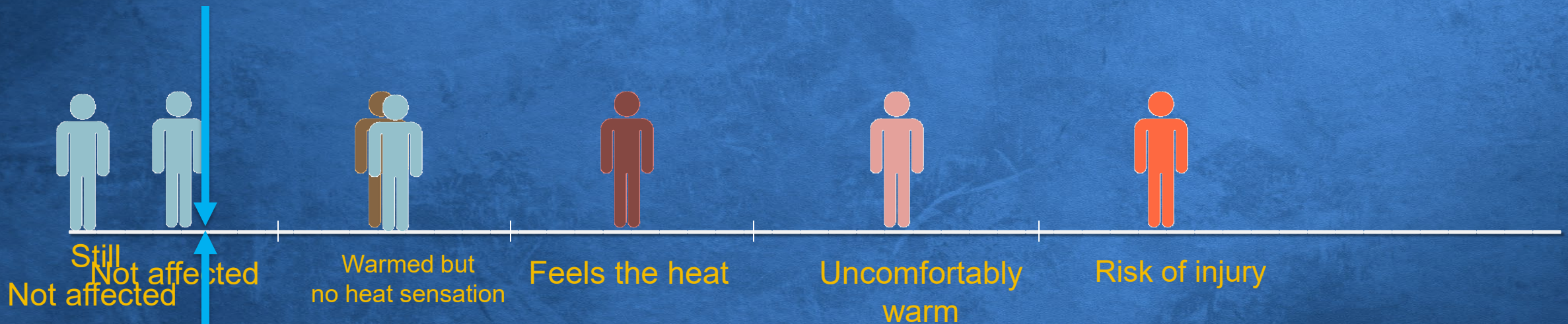


*Power input to the device. Does not account for “apparent” or “effective” power caused by the focusing effect of the internal reflector



1. What is RF energy?

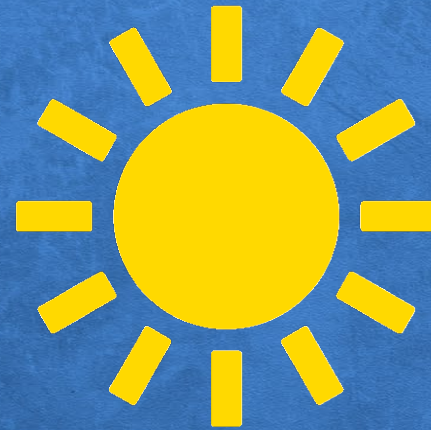
- Threshold effect



- Is it “Safer” to receive less?

1. What is RF energy?

- Intensity matters!
 - ✓ It is not enough to say:
there are radio waves present
 - ✓ Or that:
they put out how many watts
 - ✓ Instead:
How much energy is being *received*?
- Light analogy:
 - ✓ *There must be a threshold below which exposure is inconsequential*



Sun



Full Moon
(solar reflector)



Sirius
(69 suns)

Apparent intensity of 3 celestial bodies

Reference
1 sun

2 millionths
0.000002 suns

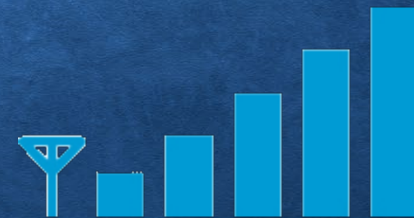
70 quadrillionths
0.00000000007 suns



Protective gear

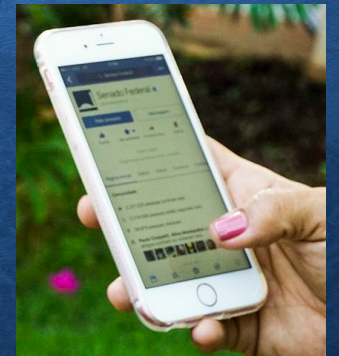
1. What is RF energy?

- How much energy, really?
 - ✓ Cellphones don't work with a few millionths of a watt received radio signal power
 - ✓ Why?
 - Because it is *too much energy* (>-25 dBm 3GPP specifications)
 - ❖ Cell sites must put out enough energy to make radios work
 - ❖ But not too much
 - ❖ Receivers are very sensitive instruments
 - ✓ “Five bars” on your cellphone
 - Received signal can be a *billionth of a watt* or less



1. What is RF energy?

- What is a watt?
 - ✓ Power
 - Energy delivered per second
 - Or work done per second



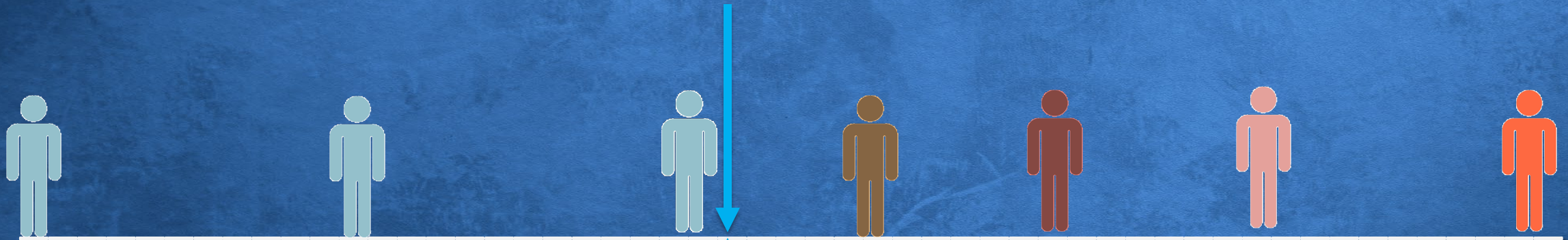
About 1 watt "heat" and light hits hand



Phone needs less than 1 billionth of a watt of received signal
 <0.00000001 W
-60 dBm

1. What is RF energy?

- Yes, but what about “low-level effects”?



This is the standard we enforce >>>

Science-based
Weight-of-evidence

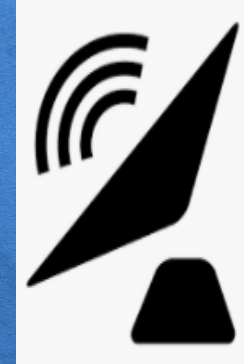
- Myth: standards are based solely on thermal effects
- The health standards consider all the science
- Standards are based on *established adverse effects*
 - ✓ Thermal at most frequencies, electrical stimulation at lower frequencies

1. What is RF energy?

- Radio waves



Used



- To communicate across short and long distances

- To measure things (MRI, radar, etc)

- To heat things

- ❖ medical diathermy

- ❖ microwave ovens

- ❖ manufacturing plastic products

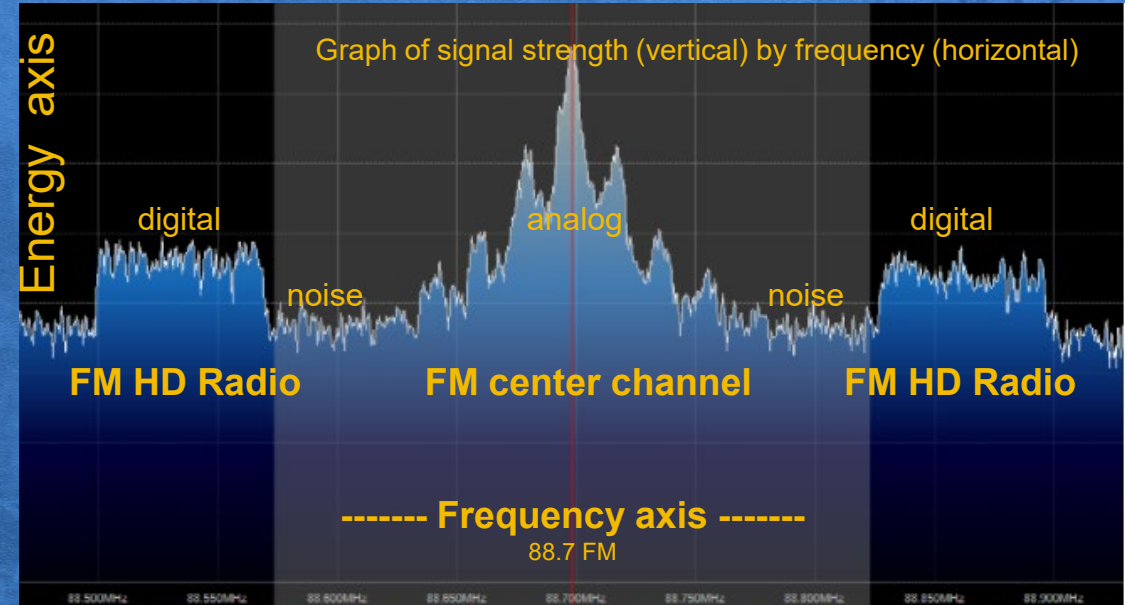


Tendency to need increasing intensity at recipient



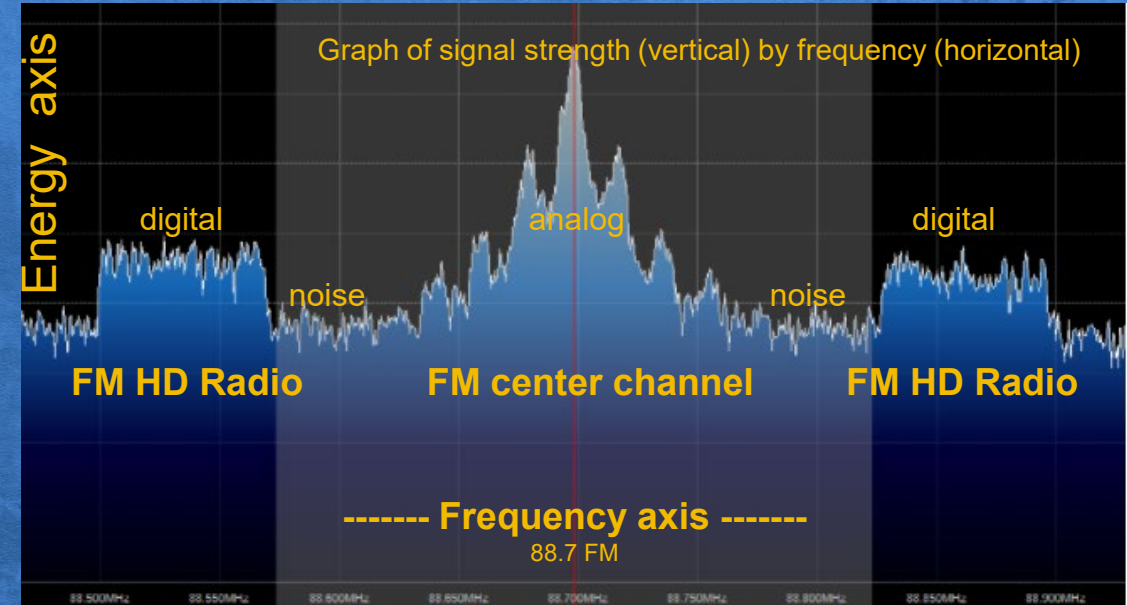
1. What is RF energy?

- Communication
 - ✓ “Modulation”
 - Carrying information
- Digital versus analog modulation
 - ✓ Spectrogram of a combined analog/digital FM broadcast
 - ✓ The HD digital signal has same characteristics as cellular signals
 - “OFDM”




1. What is RF energy?

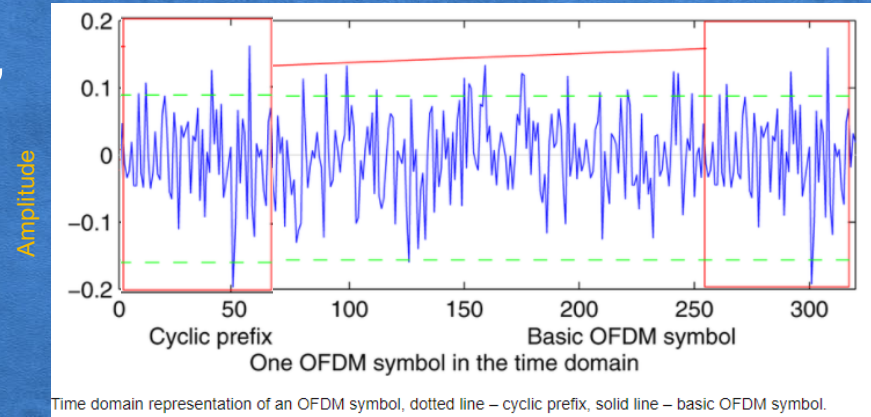
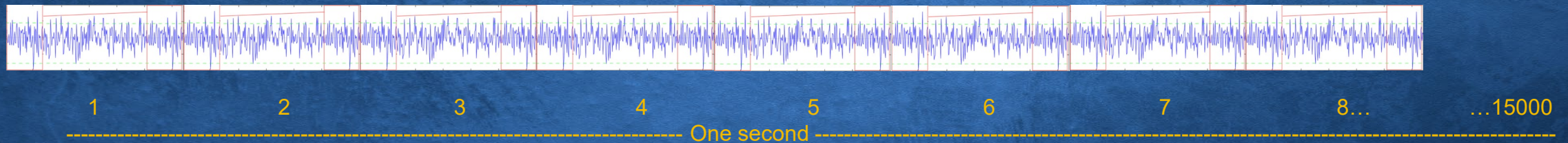
- Digital signals are “noiselike”
 - ✓ seem random
 - ✓ evenly distributed – time and frequency
- Digital signal symbols (“pulses”)?
 - ✓ Require a finely tuned receiver to detect
 - ✓ To an untuned recipient, one set of symbols is just part of the background noise spectrum with all the other signals
- The human body is a poor radio receiver
 - ✓ It is not finely tuned to one radio channel



1. What is RF energy?

- Some call the information symbols “pulses”
- This is one of those symbols 
- 15,000 per second
- Do not look at all pulse-like?
- Simulated stream of symbols:

Note: there is some smoothing (raised cosine filtering) at the junctions between symbols. Not shown.

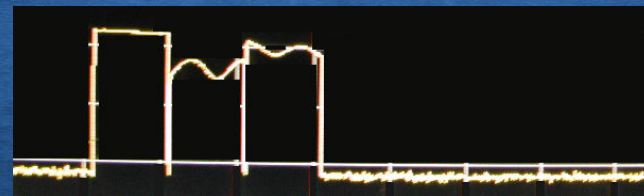


Time domain representation of an OFDM symbol, dotted line – cyclic prefix, solid line – basic OFDM symbol.

Time

Adapted from: Analysis of power consumption in OFDM systems July 2011
Conference: MIPRO, 2011 Proceedings of the 34th International Convention, Opatija, Croatia, 23-27 May, 2011

- A pulse, for comparison:



Radar triple pulse
received over the air

1. What is RF energy?

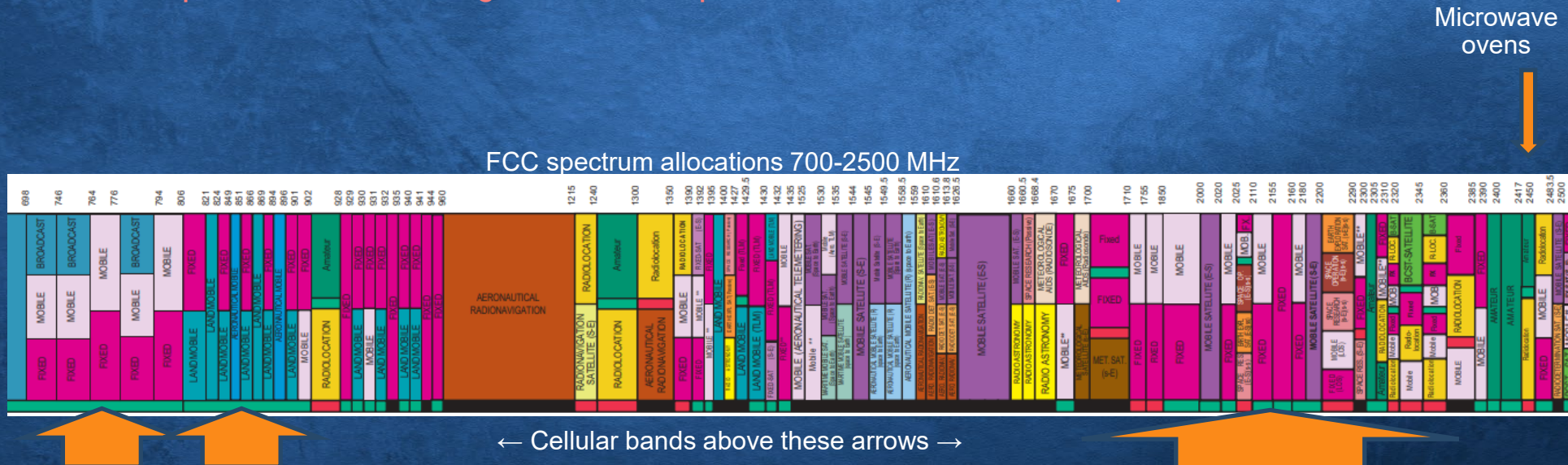
- Summary

- ✓ Nonionizing
- ✓ Not a substance
- ✓ Electromagnetic energy
 - Converts to heat in tissues
 - Like infrared and visible light
- ✓ Information (modulation)
 - Varies the intensity (“brightness”) and frequency distribution (“colors”)
 - Body is not tuned to one channel
- ✓ Intensity dissipates rapidly over distance
- ✓ Receivers need only a feeble signal
- ✓ Threshold effect
 - Below a certain level, adverse effects not observed

2. What is AT&T proposing?

- A “cell site”
 - ✓ A base station with antennas well above ground
 - ✓ Antennas emit and receive RFE
 - Lighthouse lens analogy
 - ✓ Multiple frequency bands to support multiple simultaneous users

❖ <https://www.ntia.doc.gov/files/ntia/publications/2003-allochrt.pdf>

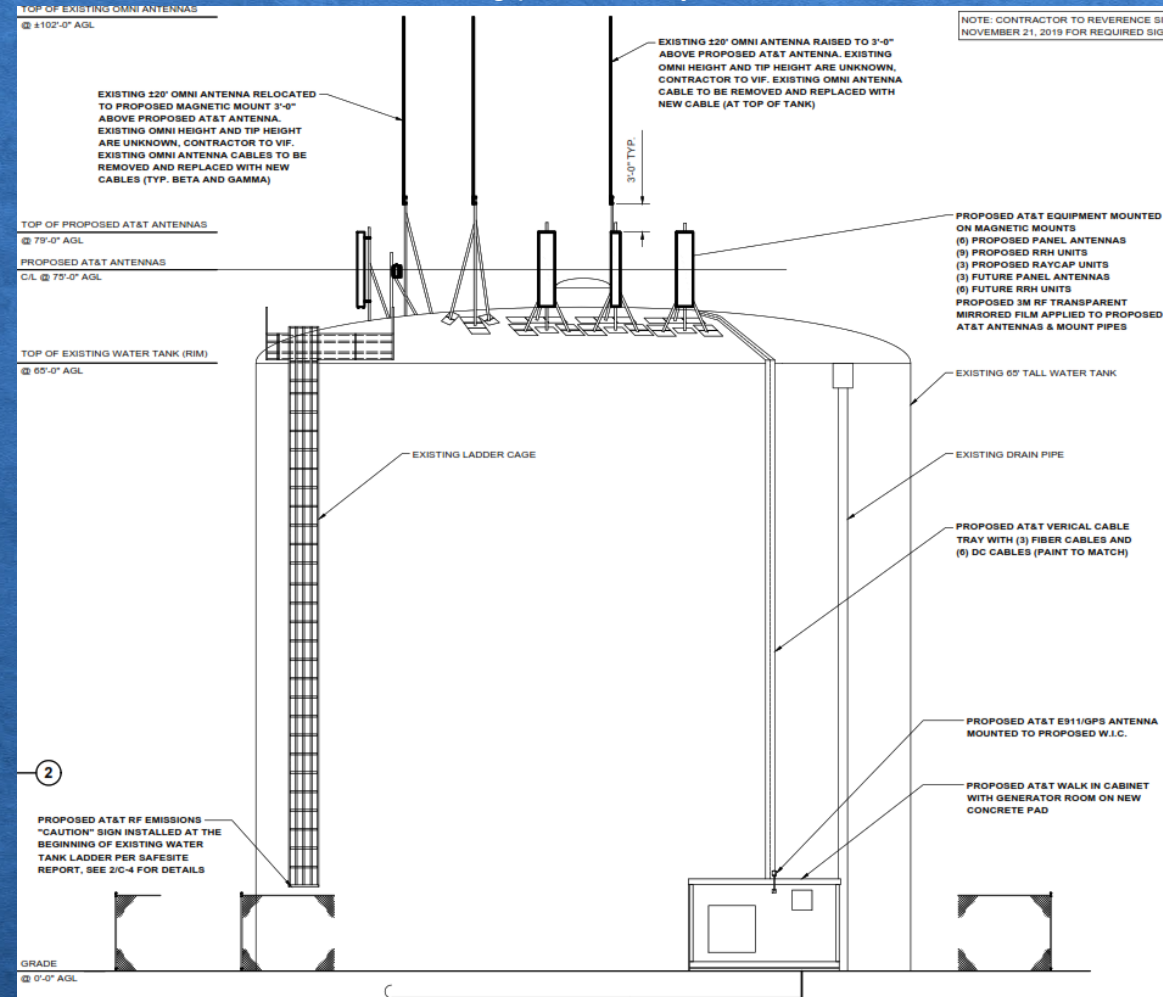


2. What is AT&T proposing?

Existing public safety antennas

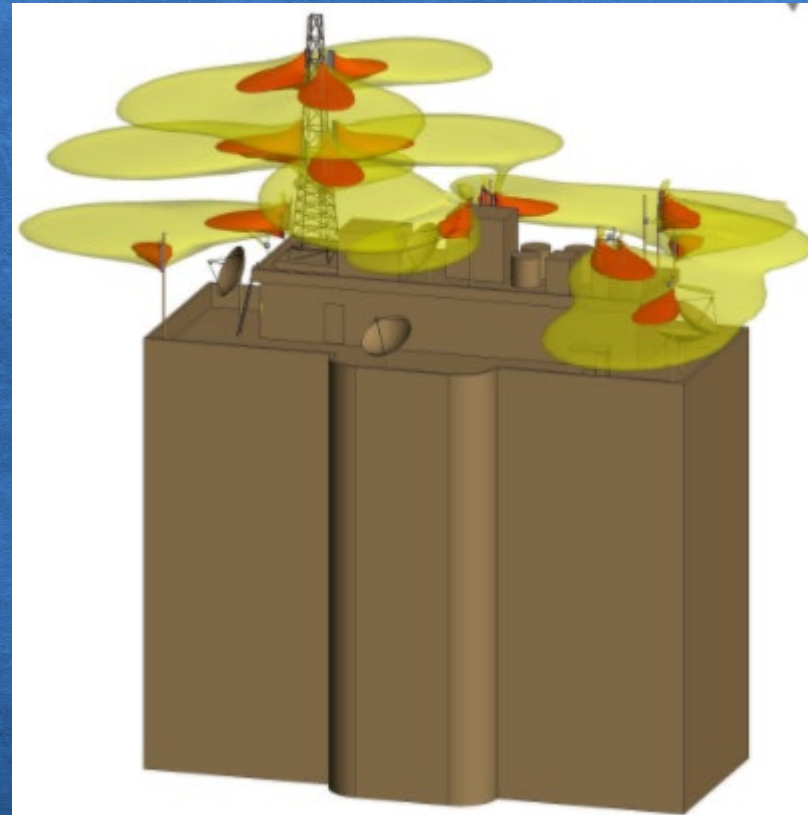
- A “cell site”

9 Panel antennas –
3 in each direction
75 feet above ground



2. What is AT&T proposing?

- Emissions
- Antennas have focusing property
- Cell safety zones
 - ✓ a number of yards directly in front of antennas
 - ✓ pancake shapes indicate antenna patterns



Model of cell antennas on a building
Occupational exclusion zones – orange
Public exclusion zones – yellow
(Source: Ixus literature)

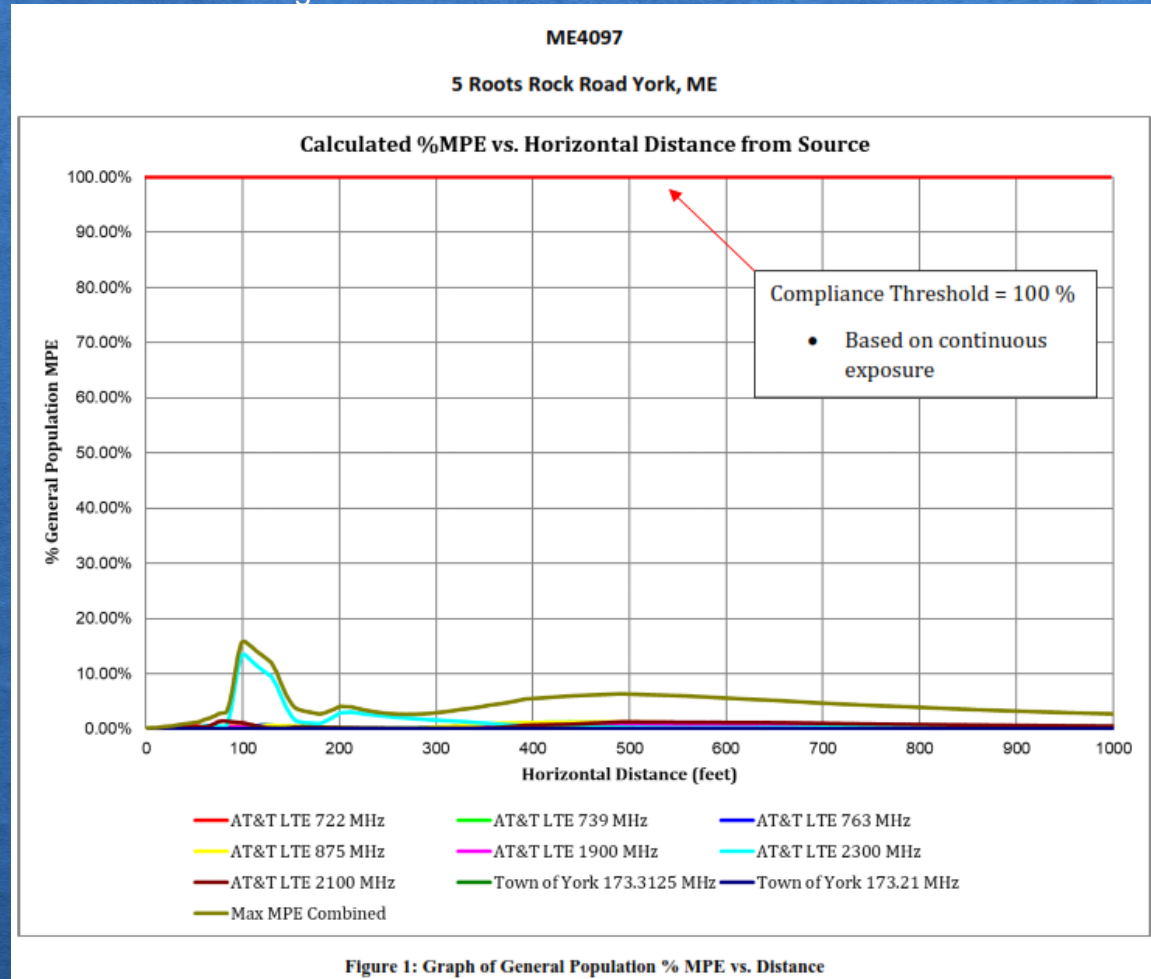
2. What is AT&T proposing?

Note – this is what AT&T is proposing relative to the FCC standards.
The background of the standards will be discussed below

- Emissions

- Calculations

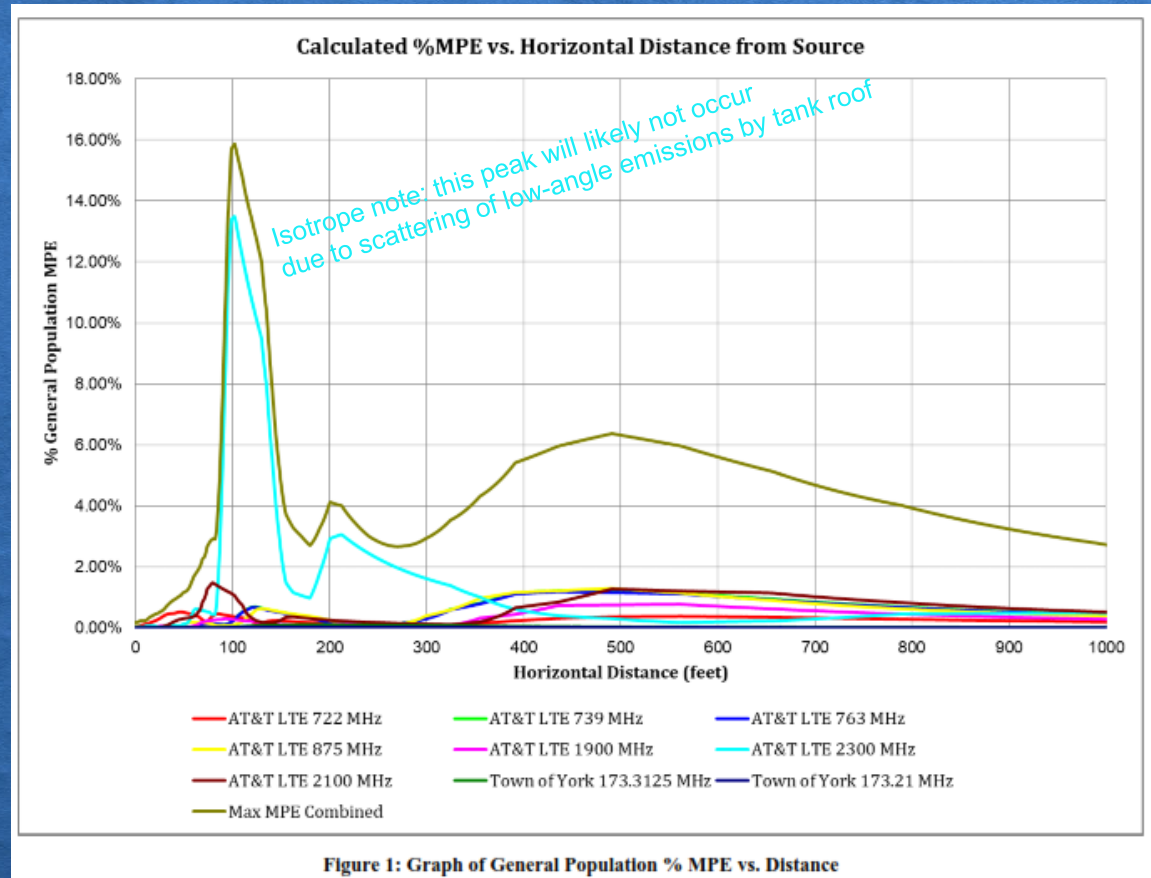
- ✓ Reliable methods
- ✓ Compare to safety standard
 - Red line is the public limit
- ✓ Consider all at once
 - Green line is the sum
- ✓ Assume level ground
- ✓ Assume all radios on full continuously for 30 minutes
- ✓ Assume outdoors
- ✓ Assume no vegetation or structure obstruction



2. What is AT&T proposing?

Expanded view showing detail of individual contributors

- Emissions
- Calculations
 - ✓ Reliable methods
 - ✓ Compare to safety standard
 - Red line/public limit is far above top of this graph
 - ✓ Consider all at once
 - Green line is the sum
 - ✓ Assume level ground
 - ✓ Assume all radios on full continuously for 30 minutes
 - ✓ Assume outdoors
 - ✓ Assume no vegetation or structure obstruction

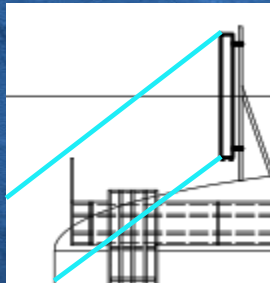


2. What is AT&T proposing?

- Emissions

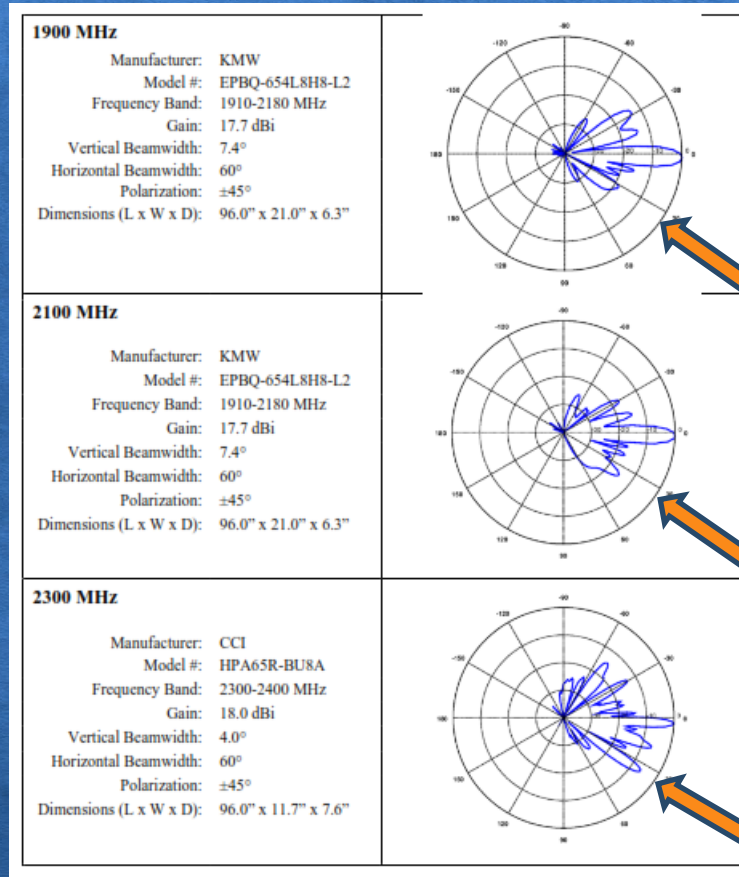
- Why is it 15% 102 feet away?

- ✓ One antenna: 2300 MHz
- ✓ Antenna “sidelobe” stronger than most (see arrows)
- ✓ But!
 - Roof of water tank will scatter signal at this angle
 - Likely to eliminate the effect at 102 feet



Effect of tank roof on downward emission

Mid-band antennas



2. What is AT&T proposing?

- Emissions
- Calculations
 - ✓ Levels are outside residences
 - ✓ Accounts for change in ground elevation
 - Positive numbers are below water tower ground elevation
 - Negative numbers are above
 - ✓ Percent of safety standard
 - ✓ Using safe-side assumptions above
 - ✓ Indoor levels typically less than 10% of outdoor
 - Varies with location in residence and type of construction

Location	Address	Latitude	Longitude	Dist. From Site (feet)	Ground Elevation Difference	Composite % MPE @ 6' AGL (Uncontrolled / General)	Composite % MPE @ 16' AGL (Uncontrolled / General)
1	12 Avon Ave.	43.14658	-70.64728	424	17.9	2.38%	4.03%
2	15 Avon Ave.	43.14700	-70.64724	278	9.6	2.26%	2.73%
3	16 Avon Ave.	43.14665	-70.64744	419	18.8	2.23%	3.71%
4	18 Avon Ave.	43.14675	-70.64778	437	18.7	2.45%	4.18%
5	22 Avon Ave.	43.14705	-70.64800	407	12.6	2.84%	5.04%
6	23 Avon Ave.	43.14727	-70.64776	309	8.2	2.15%	3.50%
7	26 Avon Ave.	43.14686	-70.64859	575	18.0	3.85%	5.01%
8	31 Avon Ave.	43.14751	-70.64845	461	7.5	4.65%	6.77%
9	32 Avon Ave.	43.14734	-70.64873	546	11.5	4.56%	5.87%
10	1 Camden Ave.	43.14777	-70.64561	301	0.1	2.94%	5.69%
11	3 Camden Ave.	43.14786	-70.64578	262	1.4	2.63%	3.83%
12	4 Camden Ave.	43.14782	-70.64639	108	0.5	14.96%	17.03%
13	5 Camden Ave.	43.14809	-70.64612	223	3.4	3.64%	3.53%
14	7 Camden Ave.	43.14829	-70.64635	247	6.2	2.89%	3.02%
15	8 Camden Ave.	43.14804	-70.64660	140	2.1	9.43%	4.49%
16	2 Field Ave.	43.14874	-70.64622	414	15.8	2.50%	4.29%
17	6 Fernald Ave.	43.14709	-70.64662	215	4.3	3.64%	3.77%
18	10 Fernald Ave.	43.14728	-70.64616	208	1.0	3.96%	4.01%
19	14 Fernald Ave.	43.14748	-70.64606	192	-0.7	3.63%	4.76%
20	23 Fernald Ave.	43.14758	-70.64483	510	-0.8	6.37%	7.82%
21	24 Fernald Ave.	43.14789	-70.64522	412	1.6	5.30%	8.07%
22	7 Huckins Ave.	43.14767	-70.64759	229	3.4	3.40%	3.40%
23	8 Huckins Ave.	43.14802	-70.64804	371	1.2	4.38%	7.66%
24	11 Huckins Ave.	43.14792	-70.64743	206	0.9	3.98%	4.10%
25	15 Huckins Ave.	43.14810	-70.64727	214	1.0	3.91%	3.83%
26	16 Huckins Ave.	43.14842	-70.64757	353	-0.1	4.28%	7.79%
27	21 Huckins Ave.	43.14852	-70.64689	313	7.0	2.25%	3.92%
28	22 Huckins Ave.	43.14878	-70.64715	423	3.9	4.94%	7.42%
29	64 Long Sands Road	43.14624	-70.64686	523	24.3	2.87%	4.07%
30	72 Long Sands Road	43.14670	-70.64631	372	13.7	2.18%	3.82%
31	78 Long Sands Road	43.14692	-70.64597	340	6.7	2.61%	4.82%
32	86 Long Sands Road	43.14721	-70.64539	396	1.3	5.13%	8.00%
33	90 Long Sands Road	43.14734	-70.64501	476	-0.1	6.29%	8.23%
34	96 Long Sands Road	43.14774	-70.64455	583	0.4	5.73%	6.62%
35	8 Roots Rock Road	43.14727	-70.64671	147	2.1	6.69%	4.02%

#4 Camden levels overstated due to tank obstruction

Table 3: Calculated % MPE Results at Selected Points⁶

3. Background on wireless facility siting

- Carrier decision process:
 - ✓ Locate coverage gap
 - AT&T coverage maps
 - ✓ Capacity is key today
 - “Repeaters” are a 2G technology – not viable here
 - ❖ Siphons service off distant cell sites
 - New signals are needed to handle all the users
 - ✓ Look to local ordinances for guidance
 - Ability to meet zoning is key to success



3. Background on wireless facility siting

- York wireless ordinance priority list
 - ✓ Hidden WCF
 - ✓ Collocation on existing tower
 - ✓ Disguised WCF
 - ✓ Existing structures
 - Includes water towers, among other things
 - ✓ Ground-mounted
 - Tower outside overlay district
 - <20 feet above trees
 - ✓ New monopole in overlay district
 - 85 – 120 feet tall



3. Background on wireless facility siting

- Higher priority than water tank

- ✓ Hidden WCF

- Are there any existing church steeples, silos or other tall structures nearby to hide antennas inside?

- ✓ Collocation on existing tower

- Are there any existing radio towers/sites nearby? (I-95 tower already in use)

- ✓ Disguised WCF

- New facility “to appear as an unrelated object such as a tree, [new] church steeple, or flagpole...”
- Must be “realistic in size and proportion”
- Other disguises used in the region
 - ❖ Clock or carillon tower, silo, fire tower, lighthouse, trackside water tank, etc.



3. Background on wireless facility siting

- Can the water tank antennas be disguised or hidden?
 - ✓ This could elevate the proposal to a higher priority
 - ✓ Example: Medfield water tower



10-ft high shroud
("top hat")

3. Background on wireless facility siting

- Lower priority than water tank

- ✓ A short cell tower anywhere
 - Ground-mounted
 - ❖ Tower outside overlay district
 - ❖ <20 feet above trees
- ✓ A tall cell tower by I-95
 - New monopole in overlay district
 - 85 – 120 feet tall



**YORK ORDINANCE:
WATER TANK IS PREFERRED
OVER A NEW TOWER**

3. Background on wireless facility siting

- Carrier decision process:
 - ✓ Frankly:

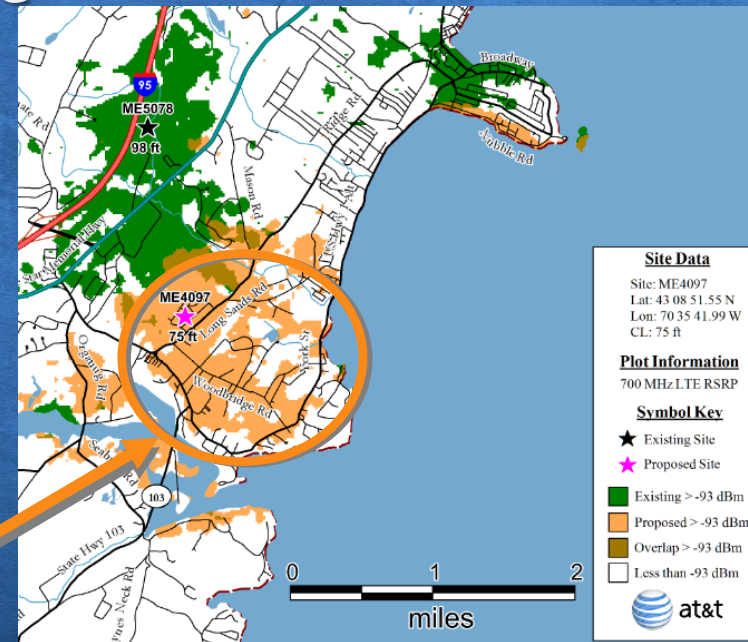


If not on this existing structure,

A new tower will be proposed nearby

3. Background on wireless facility siting

- Where to look for other choices?
 - ✓ In other words: what is “nearby”?
 - ✓ Proposed area of dominant service
 - Outdoor signal levels strong enough to be reliable indoors
 - Any higher-priority options in this general area?
 - ✓ This is zoning jurisdiction



3. Background on wireless facility siting

- High density residential area



3. Background on wireless facility siting

- AT&T
 - ✓ Needs to satisfy zoning
 - ✓ Proposes compatible use of existing water tank



3. Background on wireless facility siting

- York Water District

- ✓ Provides a community service three ways

- Provides space that prevents a new tower

- ❖ 1996 Telecommunications Act says carriers have the right to install facilities to provide service
- ❖ Town decides how to regulate (wireless ordinance)
- ❖ YWD can provide this opportunity and let the Planning Board be the final decider

- Generates revenue that benefits rate payers

- ❖ Hold harmless clause misunderstanding

- » The clauses say the party that owns the responsibility protects the other party. AT&T is responsible for its actions.

- Provides new and better wireless coverage in underserved residential area



3. Background on wireless facility siting



- Property values?
 - ✓ Visual impacts are the major concern for marketability
 - Is it presenting an “in your face”* experience to a property?
 - ❖ Does the cell tower loom over the neighborhood?
 - ❖ Does it wreck a high-value scenic view?
 - ✓ The use of existing structures has not been seen as a price influencer
 - ✓ Mounting exposed antennas on existing structures can be a quality-of-experience factor
 - Facility design managed in Site Plan Review by the Planning Board

*From the testimony of an appraiser working for Verizon on a North Hampton, NH case

3. Background on wireless facility siting



- Property values?
 - ✓ Fear of elevated exposure to radio waves?
 - Has not been demonstrated to affect property values
 - ❖ For every person cautious about buying a house next to a cell site, there are many people who are ambivalent or even welcome it
 - ❖ Real estate agents have testified to the fact that prospects often check cell phone service at homes they are looking at

3. Background on wireless facility siting

- Cell sites and water supply
 - ✓ Structural issues?
 - Structural engineering standards
 - Decades of experience with attachments to water tanks
 - This facility uses strong magnets instead of welds



3. Background on wireless facility siting



- Cell sites and water supply
 - ✓ Water quality issues?
 - Interior of tank is protected from contamination from all sources
 - No welds penetrating tank surface
 - Radio waves?
 - ❖ We know highly concentrated microwaves in an oven can boil water
 - ❖ Not enough energy reaching the water supply to heat it
 - » Antennas focused horizontally
 - » Tank is a giant metal shield

4. Related issues

- Section 1 covered RFE
 - ✓ Signal strength matters
 - ✓ Receivers are very sensitive instruments
 - ✓ Too much energy is bad for reception
- Section 2 covered predicted signal levels
 - ✓ Safe-side assumptions over-state predictions
 - ✓ All sources considered in combination
- Section 3 covered why AT&T proposes this site
 - ✓ Coverage/capacity need in the area
 - ✓ Ordinance points to using the water tank

4. Related issues

- Myth:
FCC does not require evaluation of each new cell site
- Fact:
 - ✓ FCC regulations require “*Routine Evaluation*” by operators
 - FCC 19-126 – FCC regulations reaffirmed in 2019
 - ❖ based on FDA confirmation the existing standards are appropriate
 - ✓ Local regulations and permits can require verification
 - Recommend requiring response on demand
 - Avoid annual requirement

4. Related issues

- Myth:
1500-foot setbacks in the ordinance will protect us
- Fact:
 - ✓ Giant setbacks just get in the way of good planning
 - ✓ Distance from a cell site is not a reliable proxy for signal level
 - ✓ Threshold effect standard allows for assurance all will be protected
 - ✓ Unintended consequences:
 - Good properties overlooked because of arbitrary setback
 - Applicant goes for zoning variance under federal law
 - These take planning initiative from planning board

4. Related issues

- How does “5G” factor in?

- ✓ 5G is a family of technologies

- Faster

- Smarter

- More capacity

- More simultaneous users

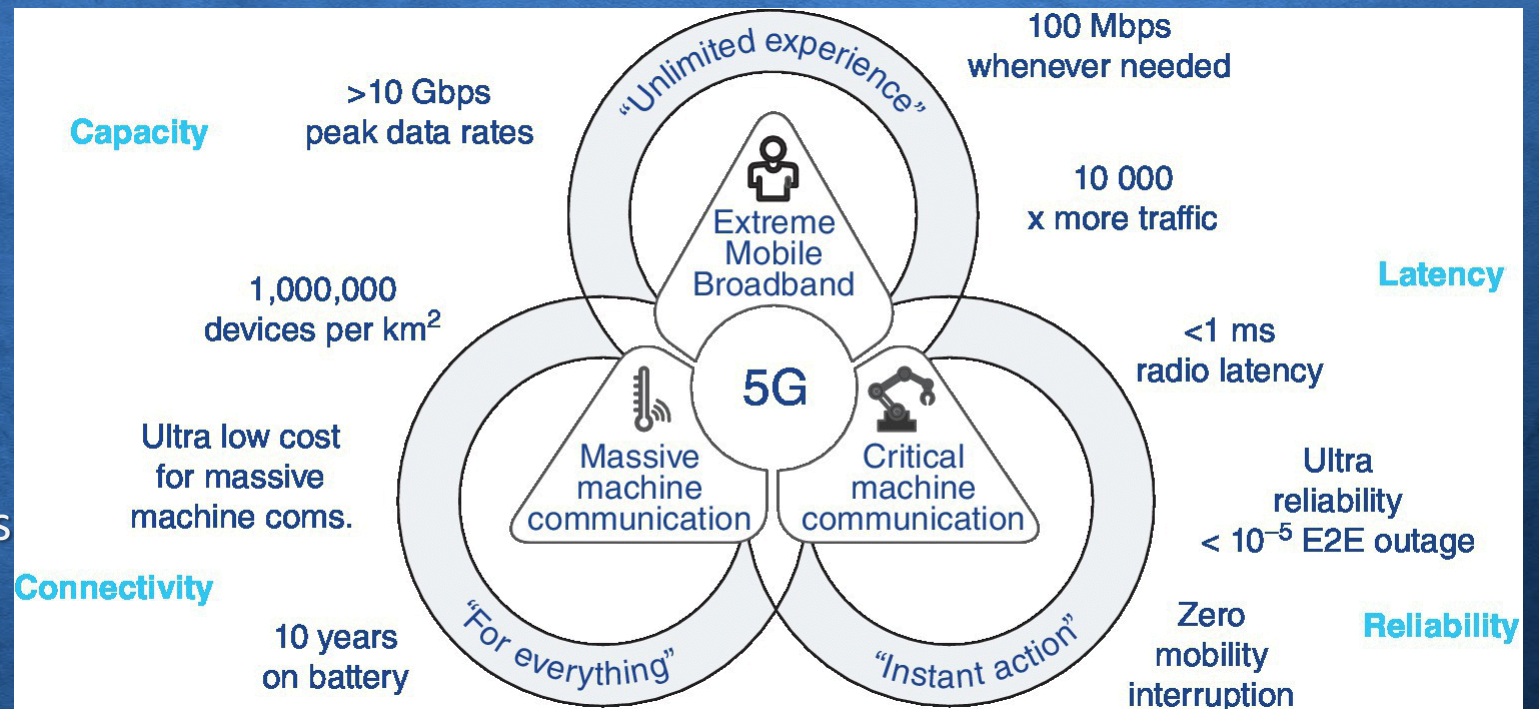
- More power-efficient

- More spectrum-efficient

- ✓ Not earth shaking

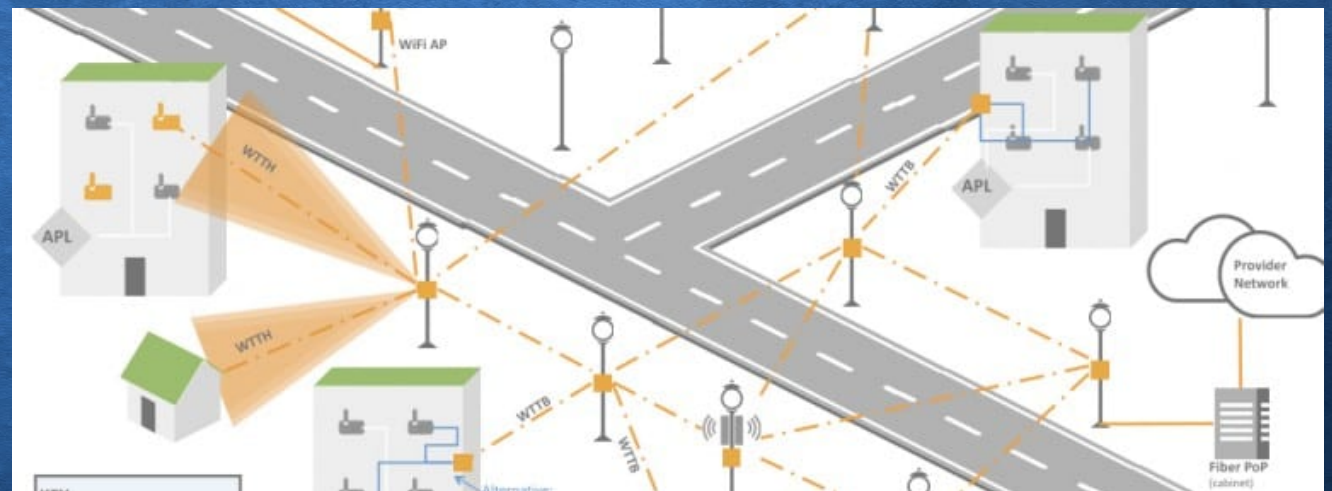
- Incremental improvements

- 2G-3G-4G-5G



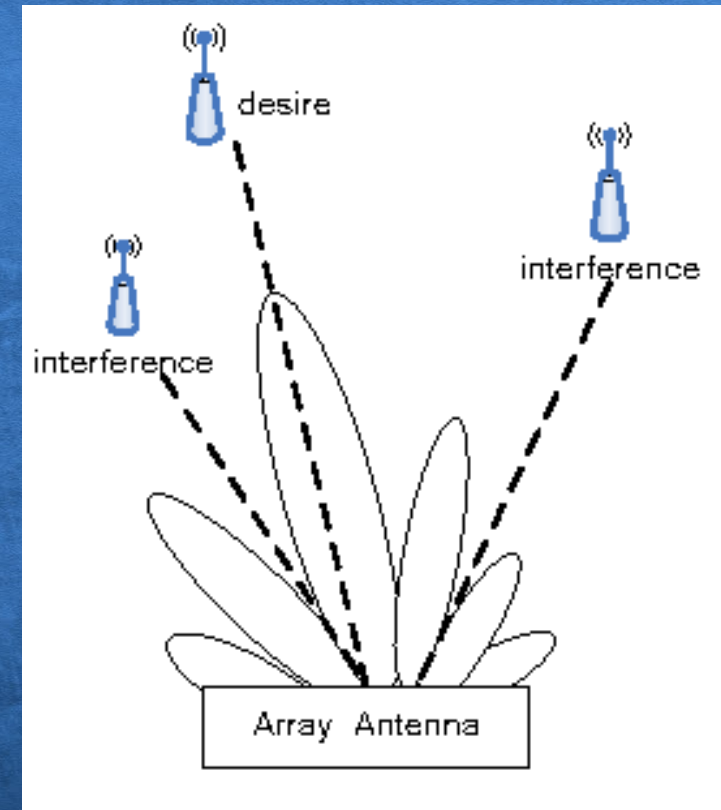
4. Related issues

- How does “5G” factor in?
 - ✓ Uses existing wireless bands
 - ✓ Can use millimeter waves
 - mm-waves are covered by safety standards
 - Not proposed at the water tank
 - Short-range communication on urban streets and in campus areas



4. Related issues

- How does 5G factor in?
 - ✓ 5G “Beamforming”
 - Does not produce laser-like “beams”
 - Aims the antenna in the general direction of the subscriber
 - ❖ Wastes less energy in other directions
 - ❖ Remains within the safety limits
 - ❖ Isolates desired user from undesired users for the brief duration of the communication with the base
 - ❖ Aids base station reception as well as transmission



5. Review of science and standards

- Professor Kenneth R. Foster
 - ✓ Ph.D. Physics, Indiana University
 - ✓ Registered Professional Engineer (P.E., Pennsylvania, 1981)
 - ✓ Faculty member (currently Professor) of Bioengineering, University of Pennsylvania (1977)
 - ✓ d'Arsonval Award (highest honor of Bioelectromagnetics Society) 2016

5. Review of science and standards

- Presentation by Professor Foster

6. Recommendations for York Water District

- Site is a preferred solution under ordinance
- There will be a cell site in this area, if not here, somewhere not far away
- By saying “no,” YWD denies the Planning Board the opportunity to decide
- Facility is compliant with safety standards by a large margin
 - ✓ YWD is not in a position to reinvent standards
- YWD risk/benefit analysis
 - ✓ Benefits are
 - No new AT&T tower in the area
 - Revenue benefits ratepayers
 - Better cell service in an underserved area
 - ✓ Risks are
 - Must be attentive to construction and modification of the facility



Questions?