



NJDOT Research Showcase

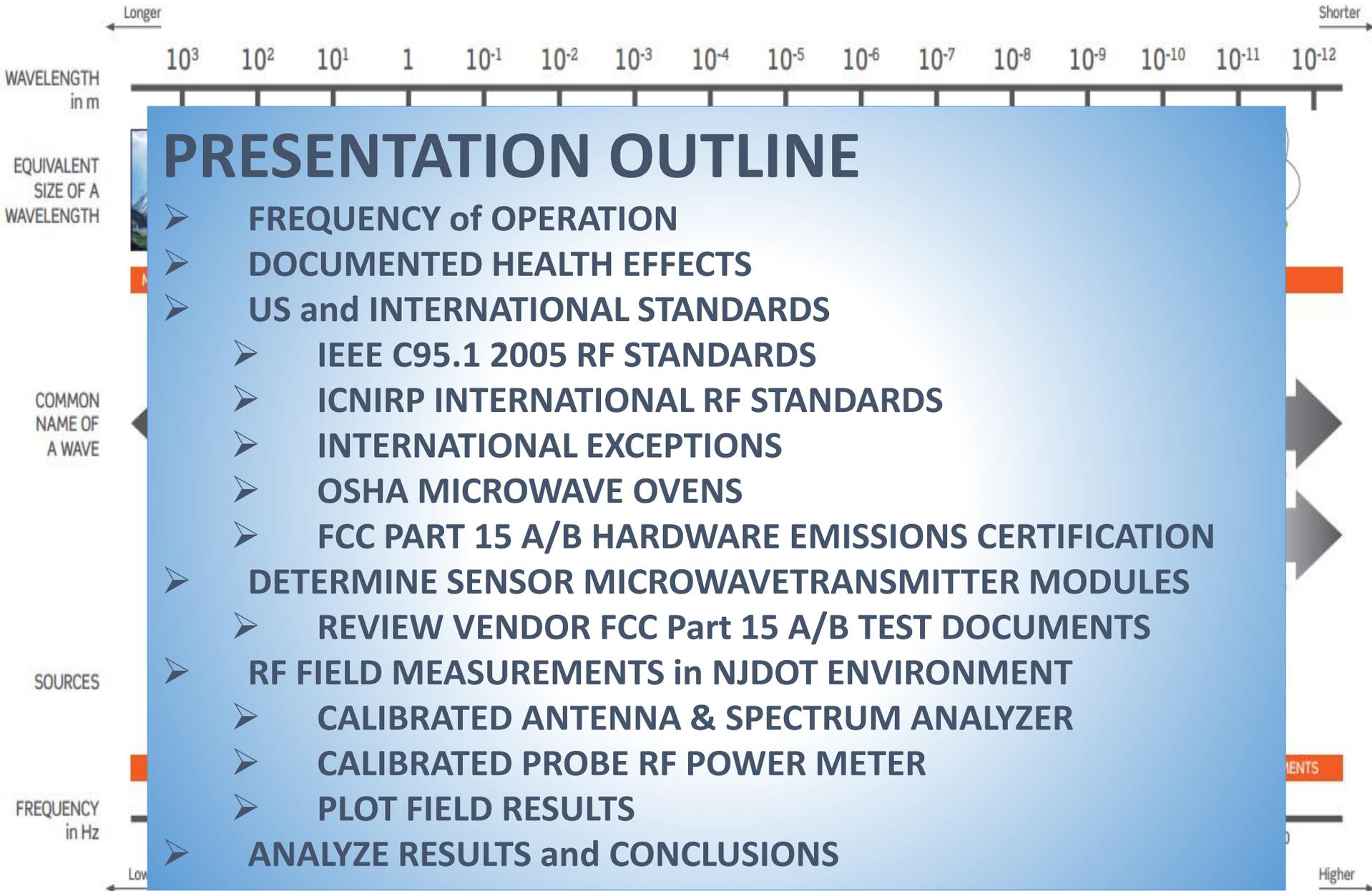
WORKER SAFETY ISSUES OF WIRELESS DEVICES

Allen Katz

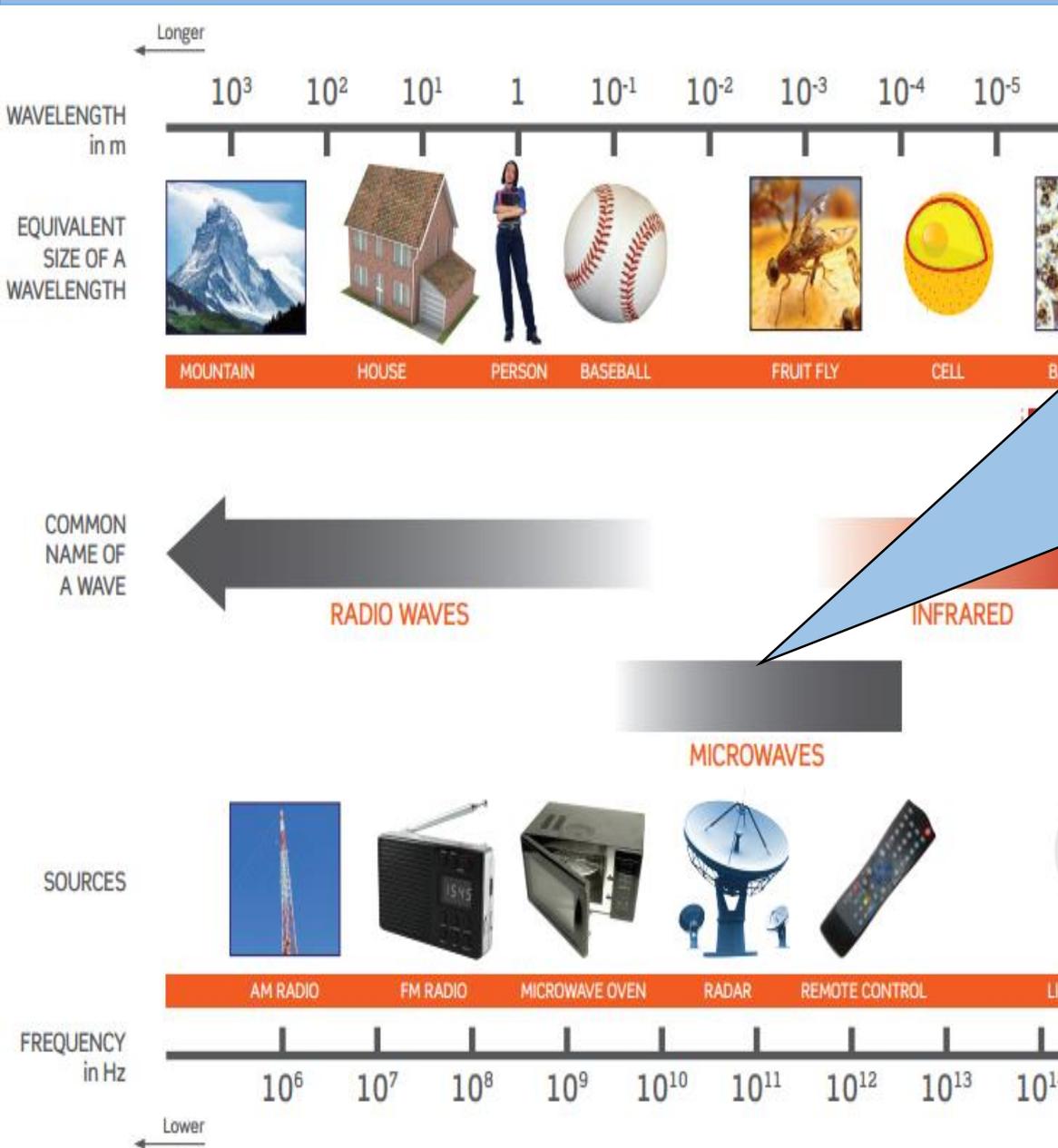
Joseph Jesson

School of Engineering
The College of New Jersey

RF ELECTROMAGNETIC SAFETY TRAINING



RF ELECTROMAGNETIC SAFETY TRAINING



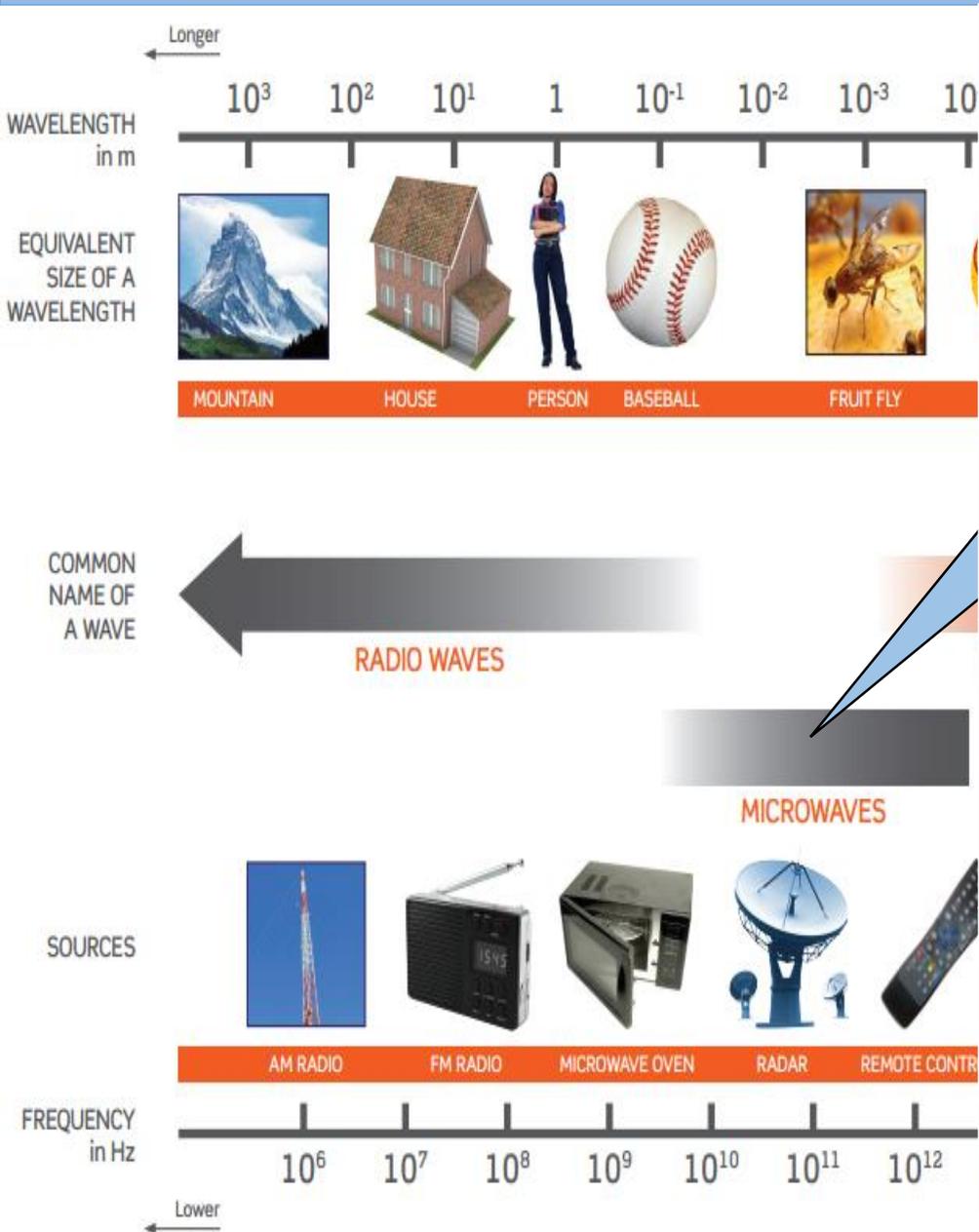
NON-IONIZING RADIATION MICROWAVE SENSORS:

- WiFi 2.4 GHz
- BLE, 2.4 GHz
- CELLULAR, 700 MHz to 1.9 GHz

BENCHMARK MICROWAVE OVENS:

- 2.4 GHz
- Electromagnetic waves are carried by particles called quanta and microwave energy. The quanta at this frequency and energy level are insufficient to break molecular bonds and hence called **non-ionizing radiation**. Thermal effects are observed at Microwave frequencies.

RF ELECTROMAGNETIC SAFETY TRAINING

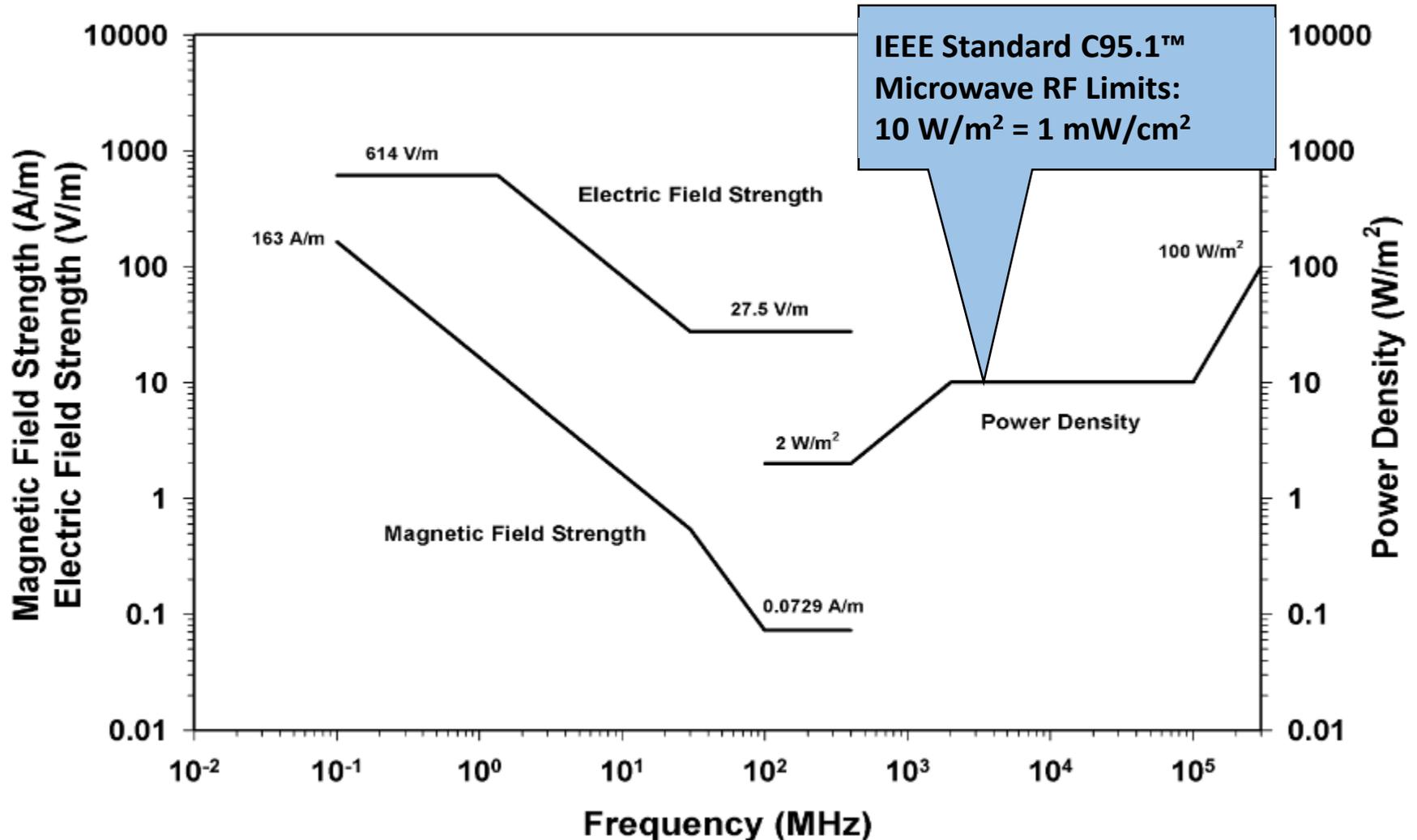


MICROWAVE RF LEVEL mW/cm ²	HEALTH EFFECT	STANDARDS & NOTES
0.01	None	
0.10	None	DOT Sensors Meas, 0.12 – 0.18 mW/cm ²
1.00	None	OSHA, ANSI C95.1-1982 STD FDA, Microwave Ovens (New, Mfg Limit)
5.00	None	FDA, Microwave Ovens (Repaired)
10.00	None	OSHA worker safety standard of the 1970's is 10 mW/cm ²
30.00	Heat is Sensed	
100.00	Eye Cataracts Develop Sperm Motility	Documented Long-Term Health Risks
1,000.00	Pain is Induced	
5,000.00	Burning and Cooking	

RF ELECTROMAGNETIC SAFETY TRAINING

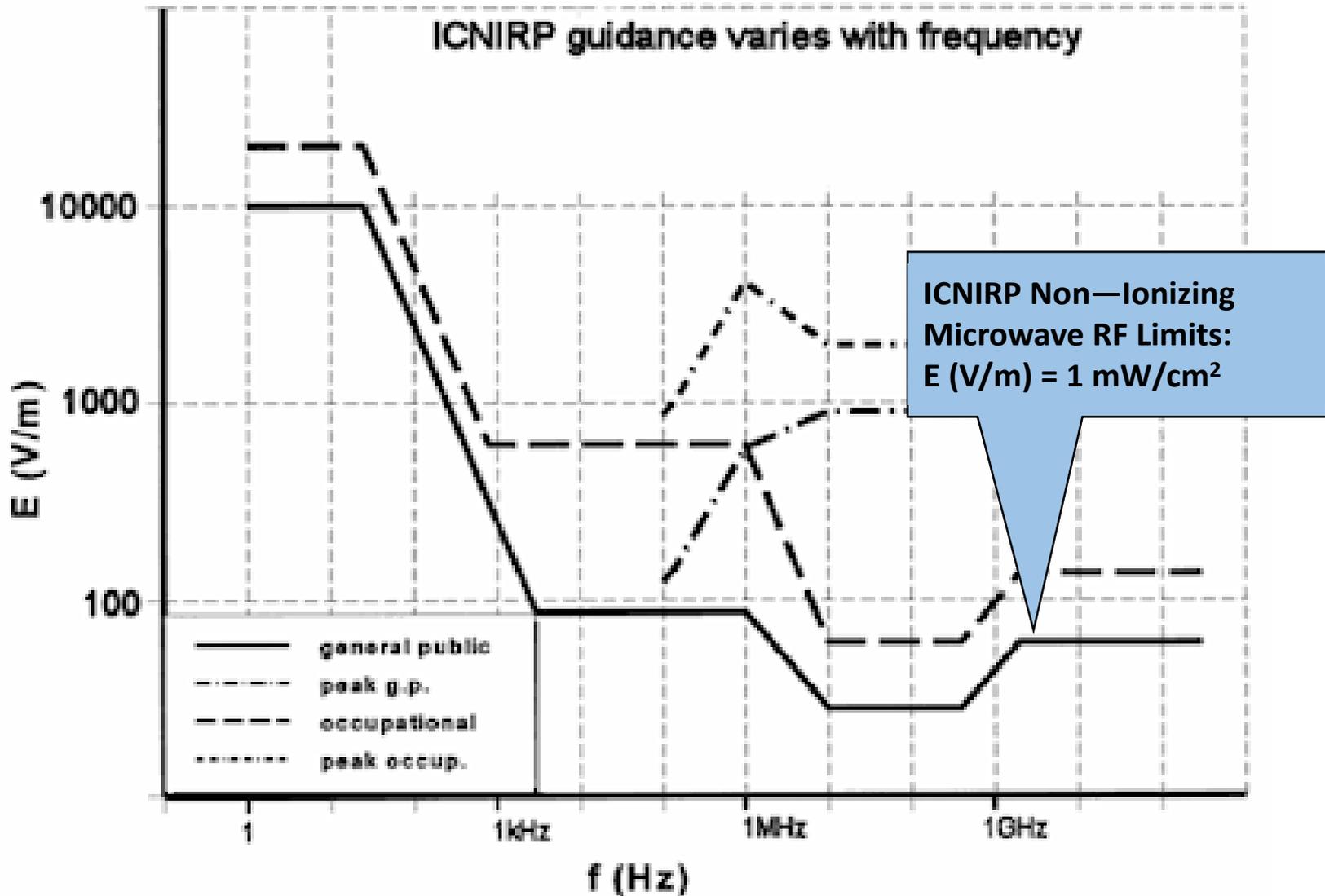
IEEE INTERNATIONAL COMMITTEE ON ELECTROMAGNETIC (SCC39)

OSHA, ANSI C95.1 - 2005 IEEE Std C95.1™ - 2005 Compliance Specifications:



RF ELECTROMAGNETIC SAFETY TRAINING

ICNIRP - INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION



RF ELECTROMAGNETIC SAFETY TRAINING

THE HUMAN BODY HEAT ENGINE

- Absorption of RF Power causes heating
- Specific Absorption Rate (SAR) Watts/kg
- A SAR produces same heating regardless of frequency
- A human at rest produces about 1 Watt/kg
- A SAR of 4 W/kg will raise tissue temp. 1 degree – same as a brisk walk
- Avg. 4 W/kg or PK 20 W/kg in limbs safe.

RF ELECTROMAGNETIC SAFETY TRAINING

THE HUMAN BODY RISKS

- The human body is a marvel at regulating its internal temperature through blood circulation and perspiration.
- Sperm in the testes are very temperature sensitive.
- The lens of the eye lacks blood flow to keep it cool. If “cooked” at high temperature, cataracts will form.

RF ELECTROMAGNETIC SAFETY TRAINING

OSHA STANDARDS

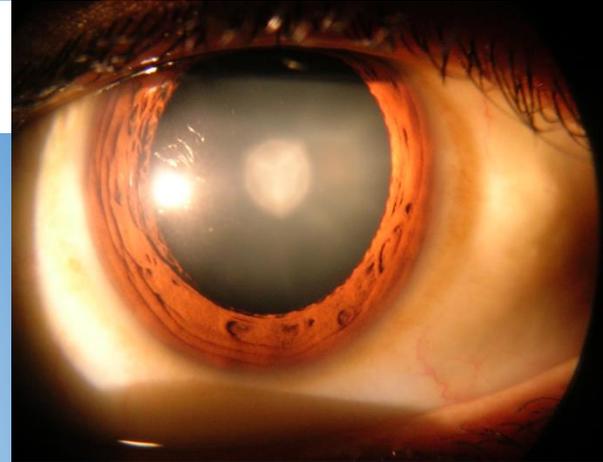
Power Density vs. Time in order to Develop Cataracts

23 States have their own OSHA Standards

Standards must be at least as strict as Feds

Most copy Federal standards & interpretations

Some require a Safety and Health Program



1910.97 - Non-Ionizing Radiation

10 mW/sq.cm, 6 min. average, 10MHz-100GHz

No spatial averaging

Uses voluntary language of 1966 ANSI

Mandates look of RF Sign

Cataracts:

Threshold @ 40 min
= 100 mW/sq.cm.

Safety factor of 10
= 10 mW/sq.cm.

RF ELECTROMAGNETIC SAFETY TRAINING

RF FIELD STRENGTH

- Electric E Field is in Volts per meter
- Magnetic H Field is in Amperes per meter
- Power Density, S is Watts per square meter
- $S = E \times H = E^2 / 377 = 377 H^2$ Watts/sq. meter
- 10 Watts/sq. m = 1 milliwatt/sq. cm
- For a point source, $S = \text{Power} / 4\pi d^2$

RF ELECTROMAGNETIC SAFETY TRAINING

RF FIELD STRENGTH EXAMPLES

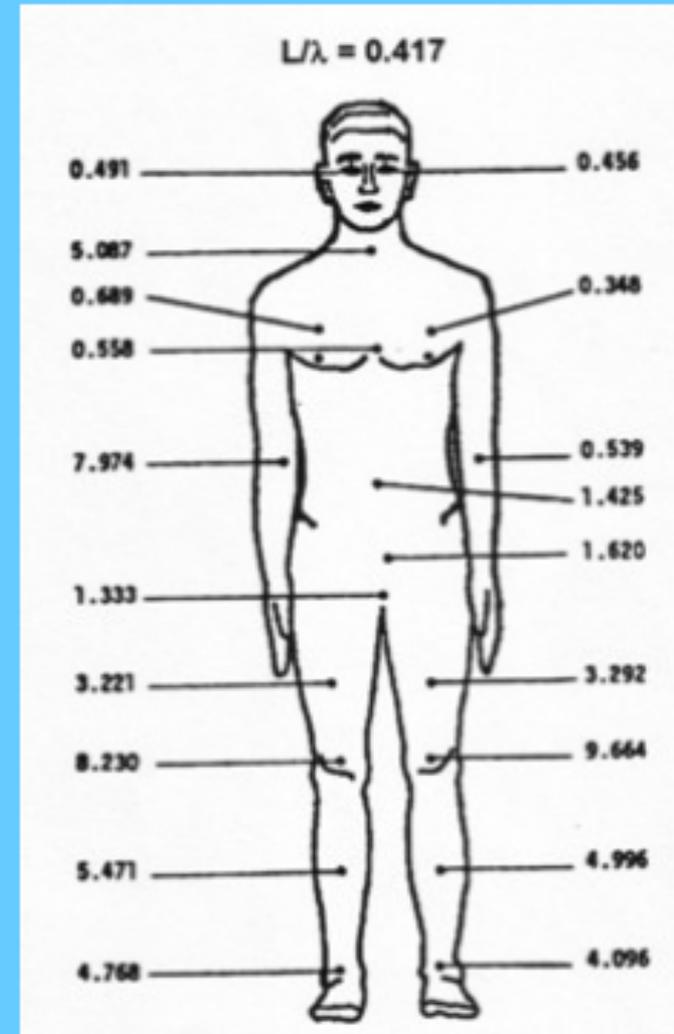
- For a point source, $S = \text{Power} / 4\pi d^2$

Eff. Rad. Power	Distance, d	Strength, S
1250 Watts	1.0 Meter	10 mW/sq. cm
125 watts	1.0 meter	1 mW/sq. cm
125 watts	0.1 meter	100 mW/sq. cm
125 Watts	10 Meters	.01 mW/ sq. cm

RF ELECTROMAGNETIC SAFETY TRAINING

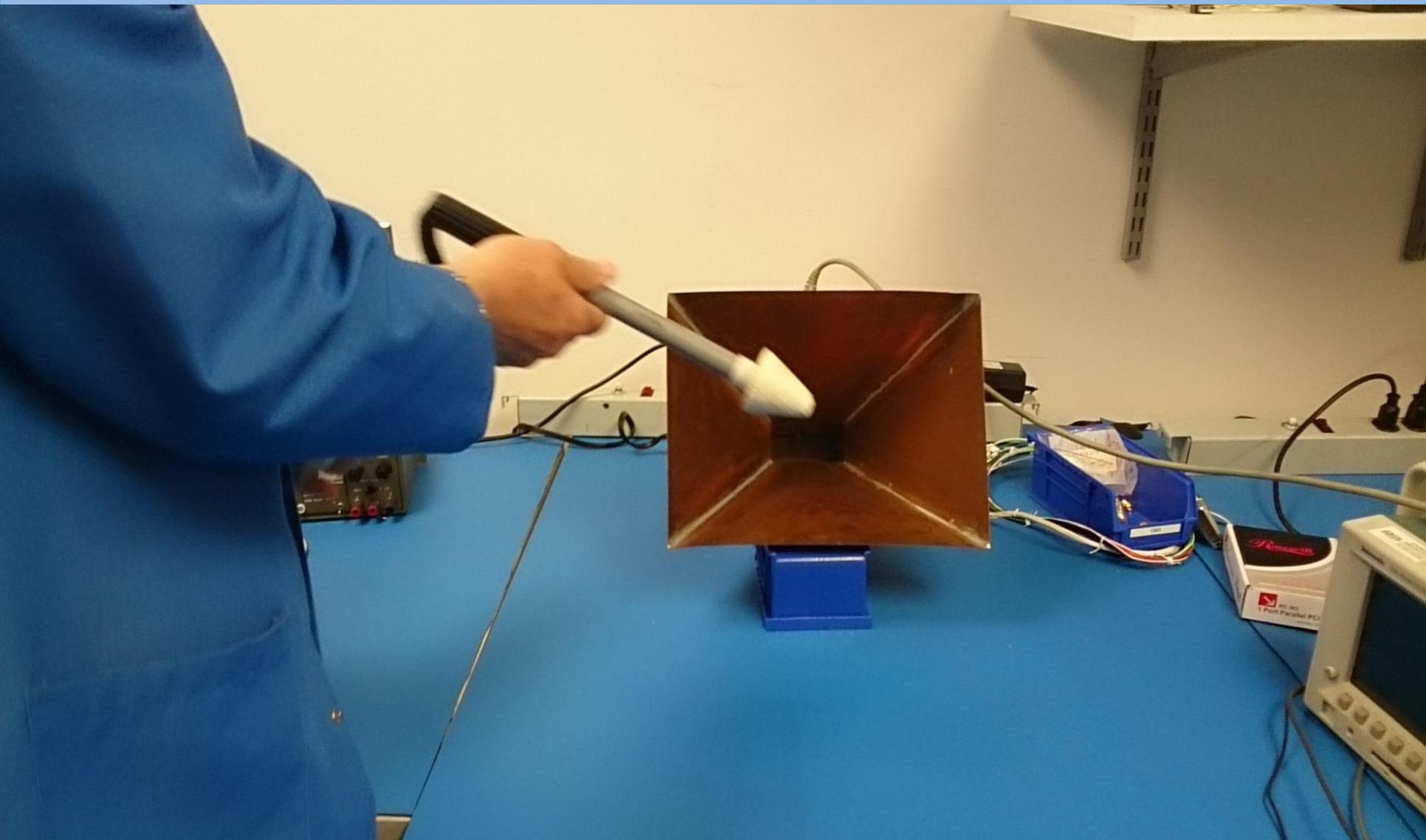
CONVERSION FROM SAR TO RF FIELD STRENGTH

- Exposing a human body to 10 mW/sq. cm
- Frequency of maximum absorption (about 70 MHz)
- Localized SAR values
- Average SAR is 1.88 W/kg
- From Proc. IEEE 68:27, 1980



RF ELECTROMAGNETIC SAFETY TRAINING

INITIAL PROBE CALIBRATION PROCEDURE



RF ELECTROMAGNETIC SAFETY TRAINING

NARDA 8611 RF MICROWAVE POWER METER

8611 METER SPECIFICATIONS

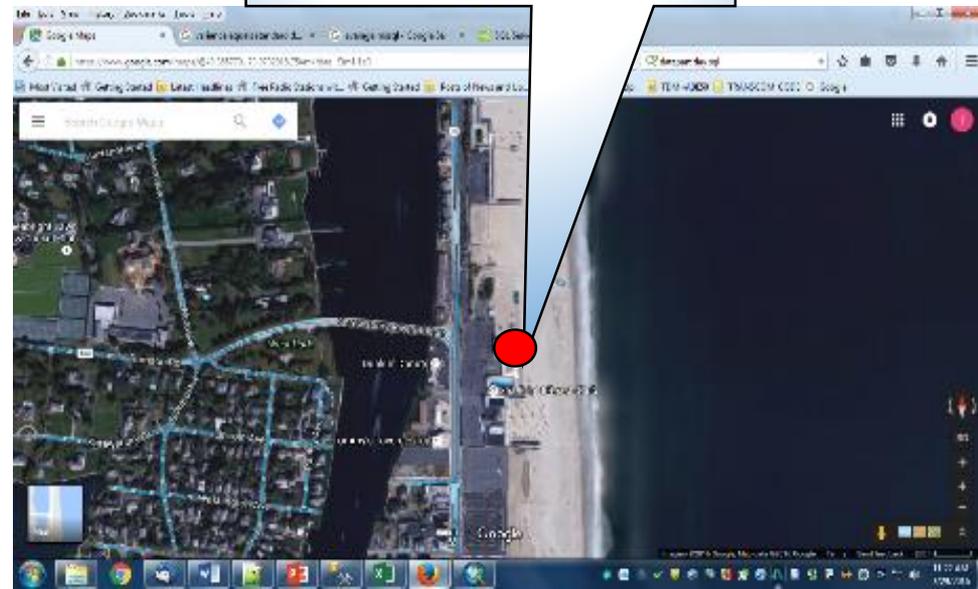


Dynamic Range	30 dB
Power or Field Strength Reading Ranges	See chart above
Meter Scales	Linear Marked 0-2 and 0-10
Instrument Accuracy	$\pm 3\%$
Sensitivity Ranges	Three, selected by front panel switch
Zero Control	Front panel knob
Response Time including Meter (The time it takes for the meter indicator to reach 90% of its final steady state reading when subjected to a stepped input signal.)	1 second (nominal)
Battery Data: Battery Type Battery Life	Two 5.6 volt-NEDA 1404 disposable 500 hours (approx.)
Battery Test Function	Selected by front panel switch
Operating Temperature	0-50° C
Size	4 ⁵ / ₈ " x 2 ⁵ / ₈ " x 1 ³ / ₄ " (11.75 cm x 6.67 cm)

RF ELECTROMAGNETIC SAFETY TRAINING

SENSOR BLUETOOTH & CELLULAR

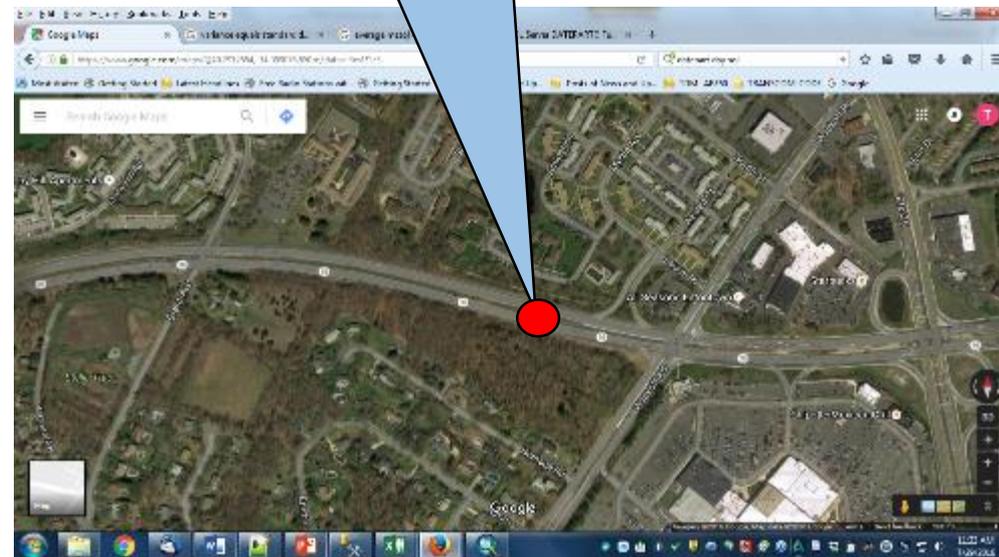
Rt 36. 9.4 Mile Marker 0.2mW/sq.cm 0.2mW/sq.cm



RF ELECTROMAGNETIC SAFETY TRAINING

SENSOR BLUETOOTH & CELLULAR

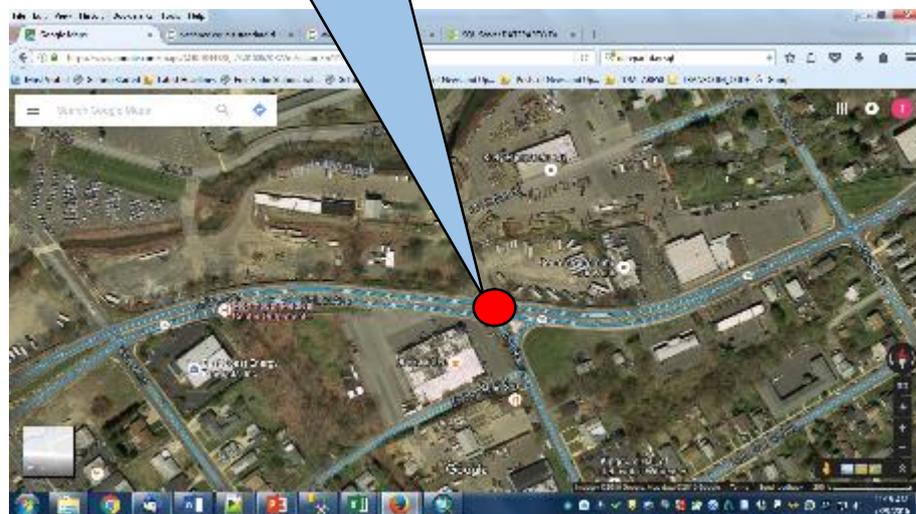
Rt 36. 1 Mile Marker 0.2mW/sq.cm 0.2mW/sq.cm



RF ELECTROMAGNETIC SAFETY TRAINING

SENSOR BLUETOOTH & CELLULAR (Cell BTS)

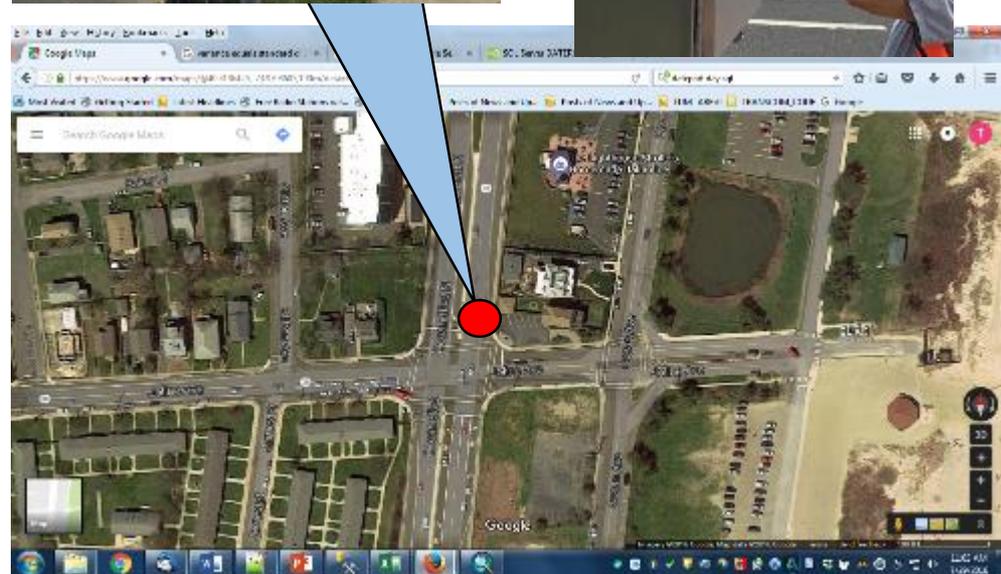
Rt 36. 4 Mile Marker 0.2mW/sq.cm 0.2mW/sq.cm



RF ELECTROMAGNETIC SAFETY TRAINING

SENSOR BLUETOOTH & CELLULAR (Flood Plain Sign)

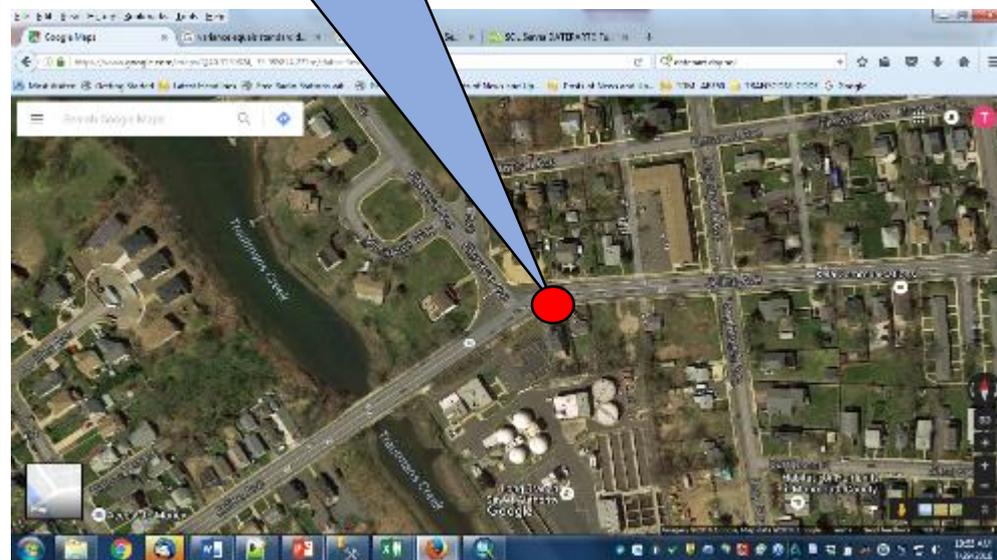
Rt 36. ~5 Mile Marker 0.2mW/sq.cm 0.2mW/sq.cm



RF ELECTROMAGNETIC SAFETY TRAINING

SENSOR BLUETOOTH & CELLULAR (Microwave Det.)

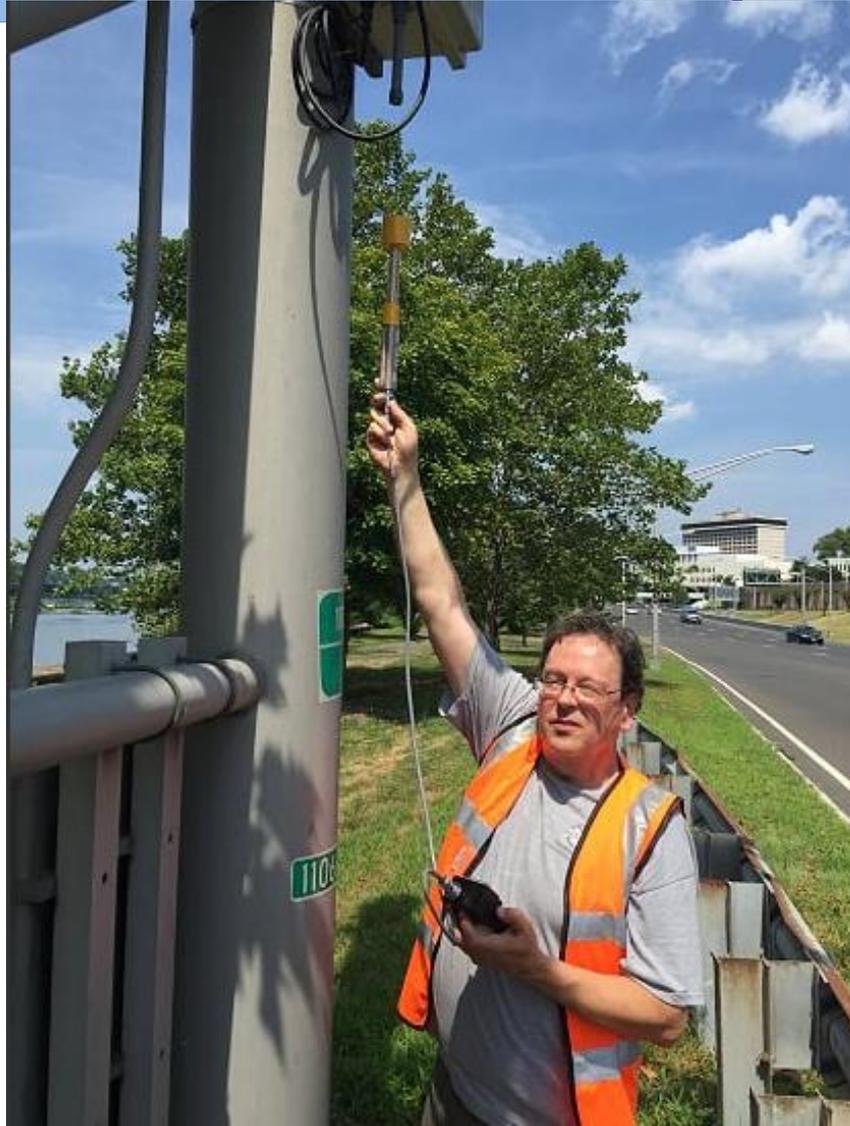
Rt 36. 5.8 Mile Marker 0.2mW/sq.cm 0.2mW/sq.cm



RF ELECTROMAGNETIC SAFETY TRAINING

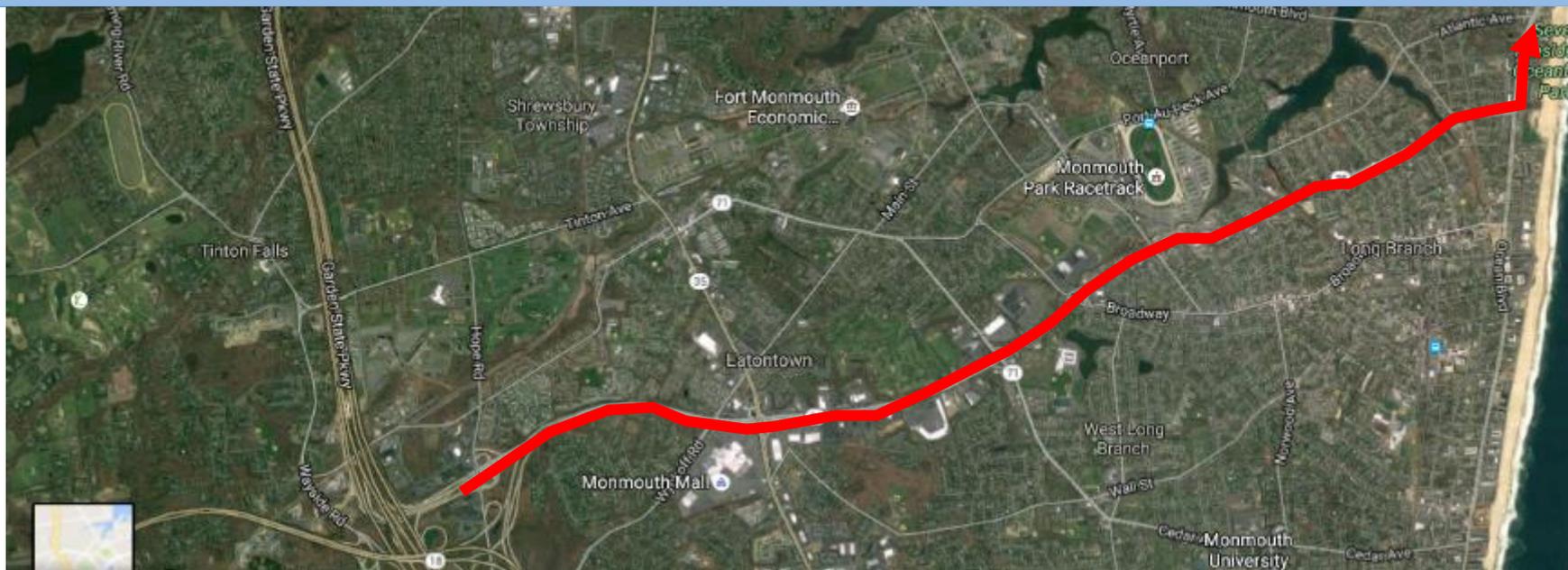
TRAFFIC SENSOR BLUETOOTH & CELLULAR

Rt 36. 5.8 Mile Marker 0.2mW/sq.cm 0.2mW/sq.cm



RF ELECTROMAGNETIC SAFETY TRAINING

NJ Rt 29 & Rt 36 FIELD EMF DATA COLLECTION



Rt 29 Near field = 0.2, 1m = 0.17

Rt 36. 1 mile mkr. 0.2 0.2 Messaging sign cellular

Rt 36. 4 mile mkr 0.2. 0.2. Cell BTS tower @ 400 yds

Rt 36. 5 mile mkr 0.2 0.2. Flood Plain Message Sign

Rt 36. 5.8 mile mkr 0.2 0.2

Rt 36. 9.4 mile mkr 0.2 0.2

RF ELECTROMAGNETIC SAFETY TRAINING

NJ Rt 29 & Rt 36 FIELD EMF DATA COLLECTION

DEVICE	1360	00000036__	00000036__	South to North	6.15	6.15	Long Branch City	Monmouth	TTSC	NJDOT	EXISTING	South - 961654 - 011961654 - - - Jacobs -	TTSC
DEVICE	1361	00000036__	00000036__	South to North	13.18	13.18	Middletown Twp	Monmouth	TTSC	NJDOT	EXISTING	South - 961654 - 011961654 - - - Jacobs -	TTSC
DEVICE	2354	00000036__	00000036__	South to North	24.12	24.12	Keyport Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - - TOCN -	TTSC
DEVICE	2355	00000036__	00000036__	South to North	17.79	17.79	Middletown Twp	Monmouth	TTSC	NJDOT	EXISTING	South - - - - - TOCN -	TTSC
DEVICE	2356	00000036__	00000036__	South to North	15.4	15.4	Middletown Twp	Monmouth	TTSC	NJDOT	EXISTING	South - - - - - TOCN -	TTSC
DEVICE	2357	00000036__	00000036__	South to North	13.14	13.14	Middletown Twp	Monmouth	TTSC	NJDOT	EXISTING	South - - - - - TOCN -	TTSC
DEVICE	2358	00000036__	00000036__	South to North	20.42	20.42	Keansburg Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - - TOCN -	TTSC
DEVICE	2359	00000036__	00000036__	South to North	22.61	22.61	Union Beach Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - - TOCN -	TTSC
DEVICE	2701	00000036__	00000036__	South to North	11.4	11.4	Sea Bright Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2702	00000036__	00000036__	South to North	9.4	9.4	Sea Bright Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2703	00000036__	00000036__	South to North	7.7	7.7	Monmouth Beach Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2704	00000036__	00000036__	South to North	5.8	5.8	Long Branch City	Monmouth	TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2705	00000036__	00000036__	South to North	4	4	Long Branch City	Monmouth	TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2708	00000036__	00000036__	South to North	0	0	Eatontown Boro	Monmouth	TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2706	00000036_S	00000036__	North to South	2	2			TTSC	NJDOT	EXISTING	South - - - - -	TTSC
DEVICE	2707	00000036_S	00000036__	North to South	0.5	0.5			TTSC	NJDOT	EXISTING	South - - - - -	TTSC

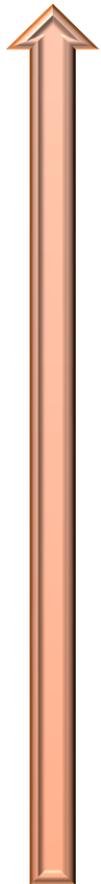
RF ELECTROMAGNETIC SAFETY TRAINING

ANATOMY OF A TRAFFIC SENSOR



RF ELECTROMAGNETIC SAFETY TRAINING

MICROWAVE RF LEVEL in mW/cm ²	DOCUMENTED HEALTH EFFECTS	NATIONAL and INTERNATIONAL STANDARDS	MEASURED NJDOT EXPOSURE LEVELS
5,000.00	Burning and Cooking		
1,000.00	Pain is Induced		
100.00	Eye Cataracts Develop Decreased Sperm Motility		
30.00	Eye Cataracts Develop		
10.00	None ¹	OSHA worker safety standard of the 1970's is 10 mW/cm ²	
5.00	None ¹	OSHA, FDA, Microwave Ovens (Repaired Limit) 5.0 mW/cm ²	
1.00	None ¹	OSHA, IEEE Std C95.1™ - 2005 Compliance Specifications: ICNIRP (International Standard) 1.0 mW/cm ²	
0.10	None ¹		DOT SENSORS
0,01	None ¹	¹ Russia, Switzerland, China, Italy have EMF standards based upon Continuous. Indoor, e.g. Hospital, Exposure	0.12 – 0.18 mW/cm ²



RF LEVEL

RF ELECTROMAGNETIC SAFETY TRAINING

MICROWAVE RF LEVEL in mW/cm ²	DOCUMENTED HEALTH EFFECTS	NATIONAL and INTERNATIONAL STANDARDS	MEASURED NJDOT EXPOSURE LEVELS
5,000.00	Burning and Cooking		
1,000.00	Pain is Induced		

CONCLUSIONS:

- RF POWER LEVELS WITHIN NATIONAL & INTL STANDARDS
- SENSOR MFG NEED TO SUPPLY THE REQUISITE FCC PART 15 CERTS INCLUDING PROPER EXTERNAL LABELING INDICATING FCC ID
- PERIODIC MONITORING IS RECOMMENDED BUT NOT REQUIRED
- TESTS MENTIONED WERE SPECIFIC TO THIS ENVIRONMENT, OTHER INDUSTRIAL WIRELESS SENSORS ENVIRONMENTS MAY HAVE DIFFERENT RESULTS

0.02	None	Russia, Switzerland, China, Italy have EMF standards based upon Continuous. Indoor, e.g. Hospital, Exposure	0.12 – 0.18 mW/cm ²
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