



Independent Analysis of MUOS Radio Frequency Safety

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Outline

- **Statement of the Problem**
- **Approach**
- **Assumptions**
- **Results**
- **Conclusions**



Statement of the Problem

- **In April of last year, I was asked by the MUOS Program Office to perform an independent assessment of MUOS emissions at the Niscemi ground station**
- **There will be two types of MUOS related transmitters at the site:**
 - **Ka-band transmitters using 18-meter dish antennas (3)**
 - **UHF transmitters using helical antennas (2)**
- **The goal was to calculate the levels of emissions that the people living near the site could be exposed to and to compare those levels with:**
 - a. **The safety limits established by the U.S. and Italy**
 - b. **The levels of exposure from other common emitters**

Approach

- Determine the transmitted power level
- Determine the fraction of the power that is directed toward a person located at the nearest point on the perimeter fence
- Convert this power level to a flux density (power per unit area), as all safety limits are expressed in these units



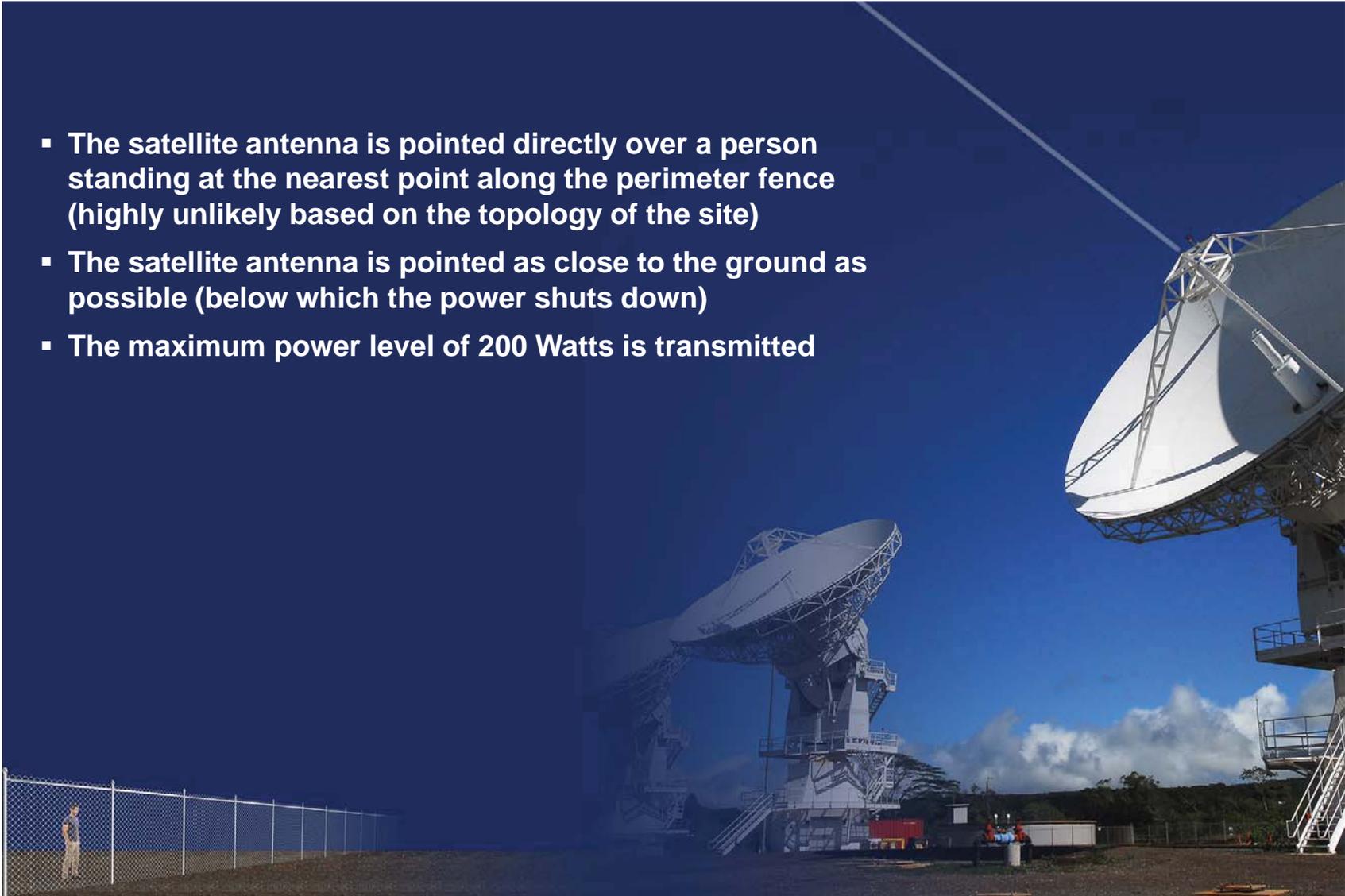
Assumptions

System	Frequency	Power	Distance	Beamwidth	Duty Factor
MUOS Ka	30 GHz	200 W	125 m	0.1 deg	100%
MUOS UHF	300 MHz	200 W	125 m	40 deg	very low
Cell phone	1.8 GHz	0.6 W	3 cm	omni	17%
Cell tower	1.8 GHz	10 kW	200 m	30 deg	100%
TV tower	800 MHz	110 kW	1 km	omni	100%

Note: Microwave ovens typically operate at 2.45 GHz

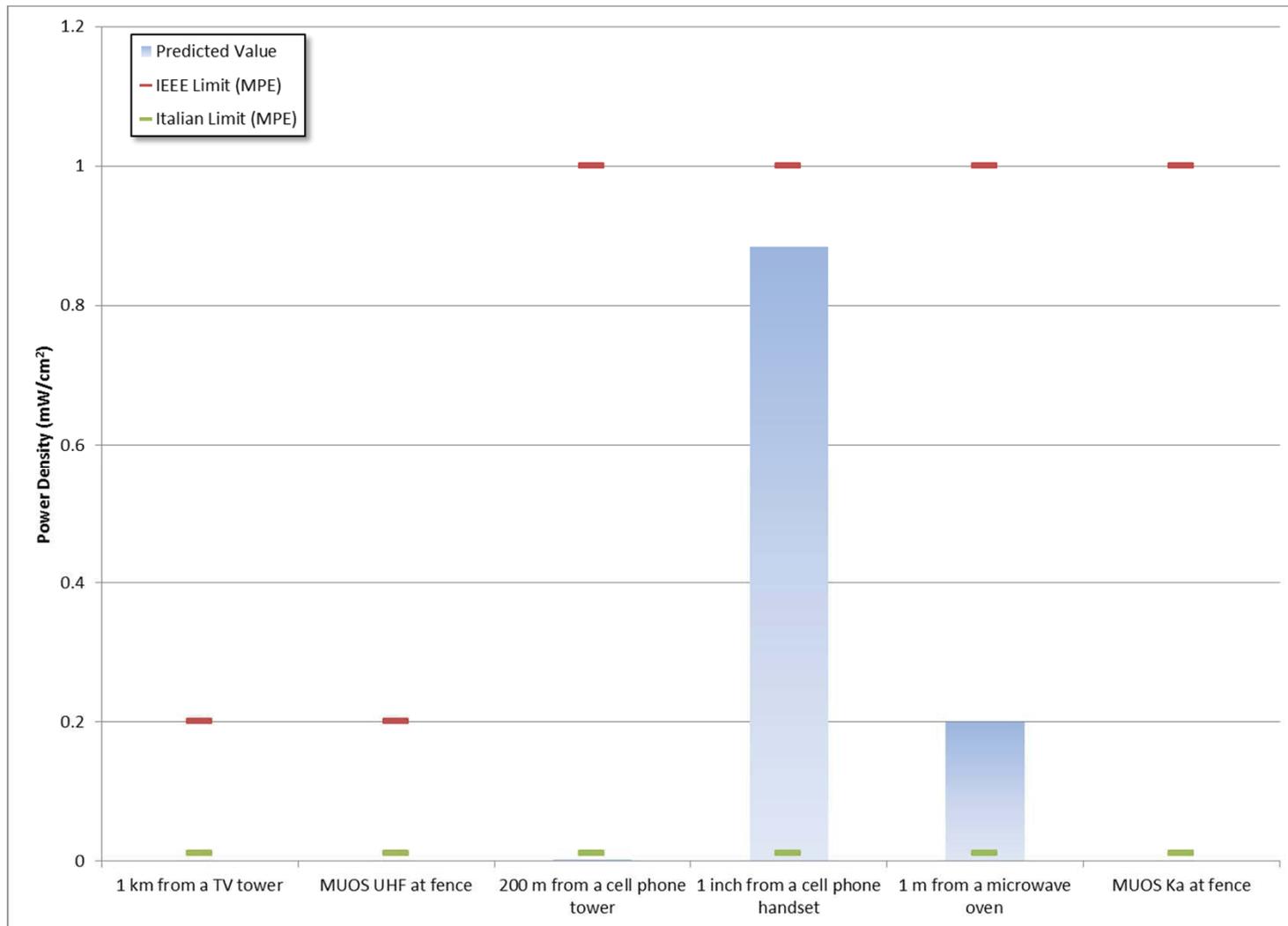
MUOS Worst-Case Assumptions

- **The satellite antenna is pointed directly over a person standing at the nearest point along the perimeter fence (highly unlikely based on the topology of the site)**
- **The satellite antenna is pointed as close to the ground as possible (below which the power shuts down)**
- **The maximum power level of 200 Watts is transmitted**



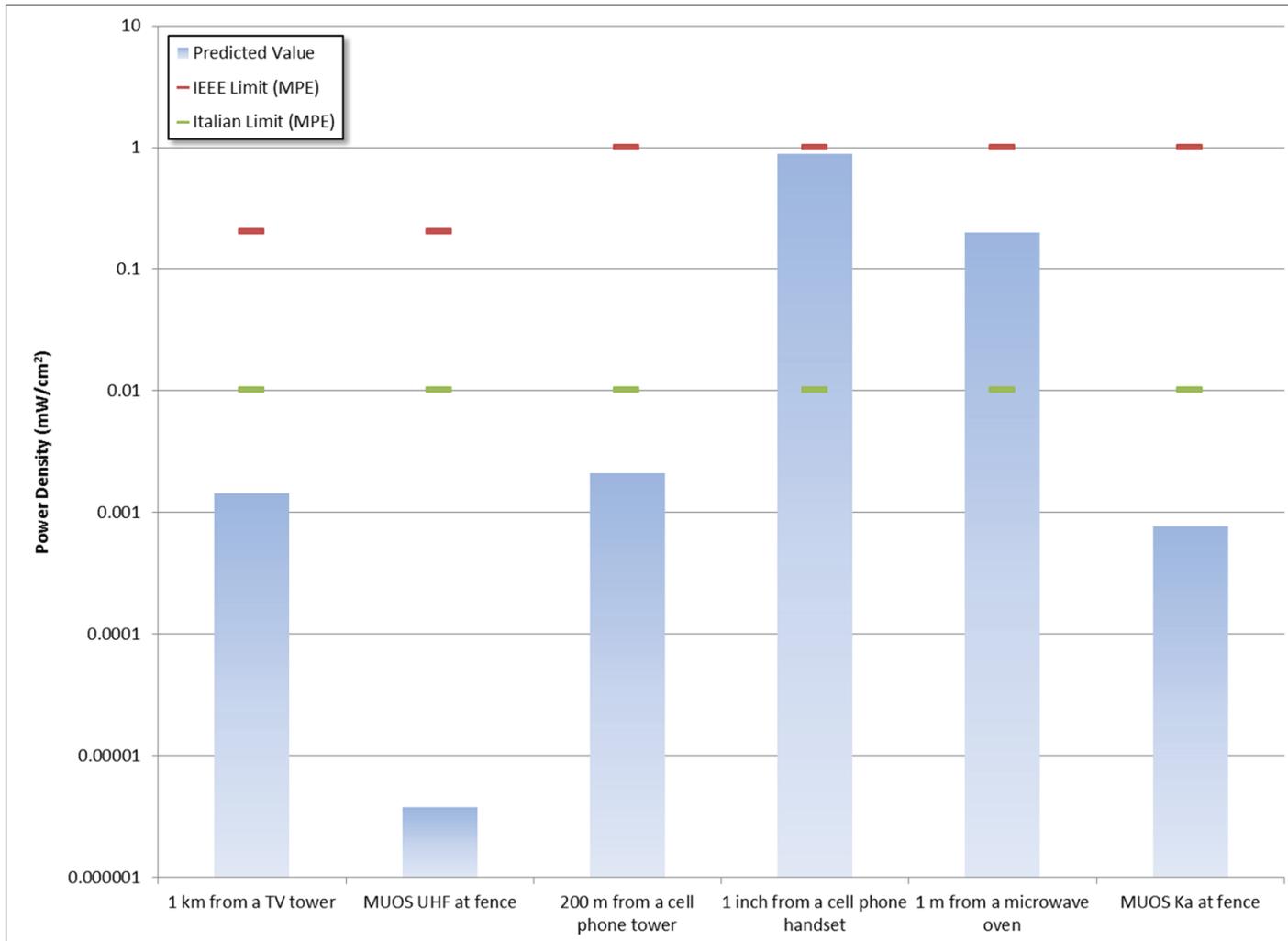


Comparison of MUOS RF energy with everyday sources of RF energy (linear scale)



On a linear scale, the power radiated by MUOS signals is negligible

Comparison of MUOS RF energy with everyday sources of RF energy (log scale)



On a log scale, the power radiated by MUOS signals is seen to be more than an order of magnitude below the Italian limit

Conclusions

- **A person standing at the worst possible location along the perimeter fence is exposed to less energy than:**
 - **Someone making five-minute cell phone calls twice per hour (more than 1000 times MUOS energy)**
 - **Someone standing within 1 km of a TV broadcast tower (about two times MUOS energy)**
 - **Someone standing 200 meters from a cell phone tower (about three times MUOS energy)**
 - **Someone heating food with a microwave oven (more than 250 times MUOS energy)**

- **As expected, measurements taken at operational MUOS sites in the U.S. have shown values significantly lower than our worst-case calculations**

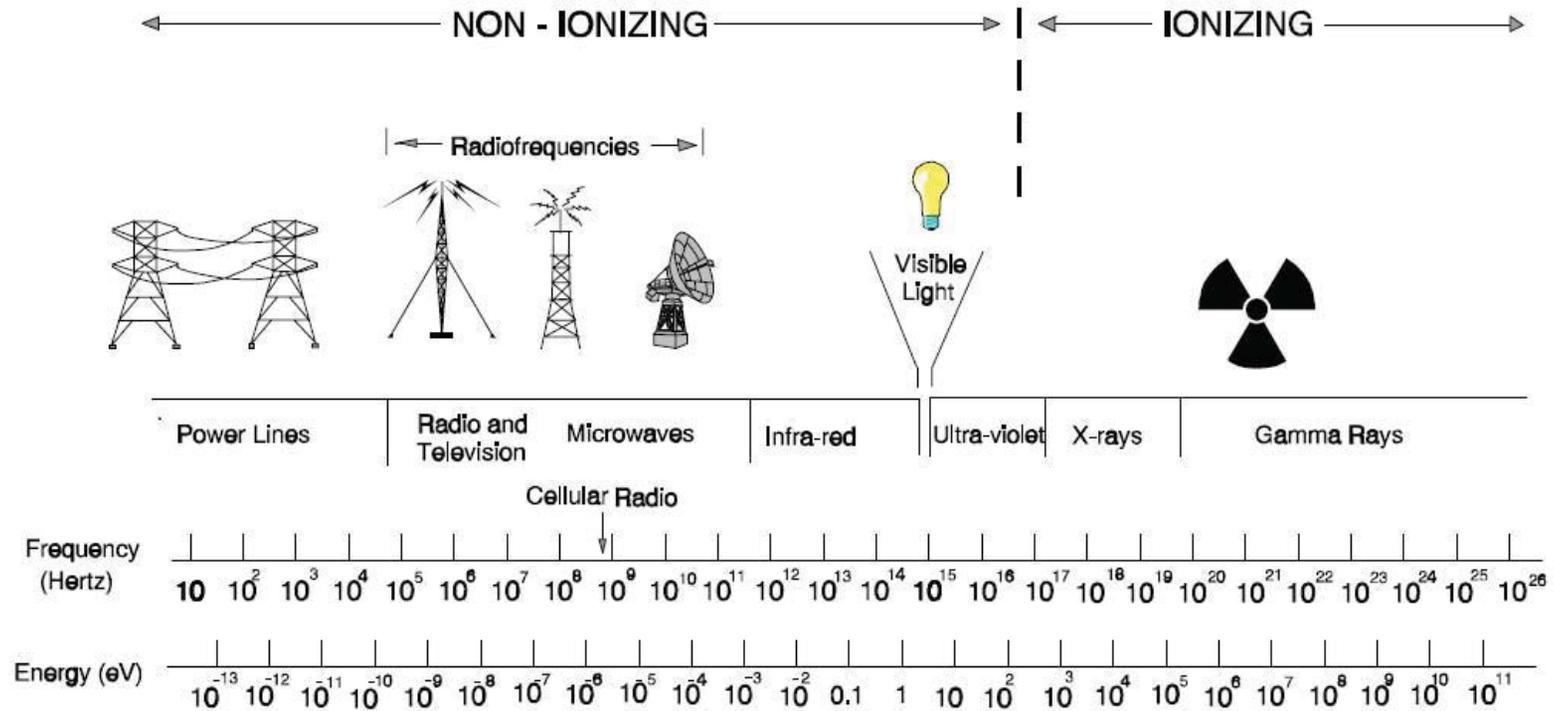


Why the MUOS transmissions at Niscemi are safe

- **MUOS site is on top of a hill**
- **Maximum transmitted power is only 200 Watts**
- **MUOS antennas are on top of 12 meter high pedestals and pointed upward (power cuts off below 5 degrees elevation)**
- **The Ka beam is extremely narrow and the “sidelobes” are one million to ten million times lower than the main beam power**
- **The only known safety impact of the frequencies used is heating**



The Electromagnetic Spectrum



Power Level Comparison



100 Watts



200 Watts



1200 Watts

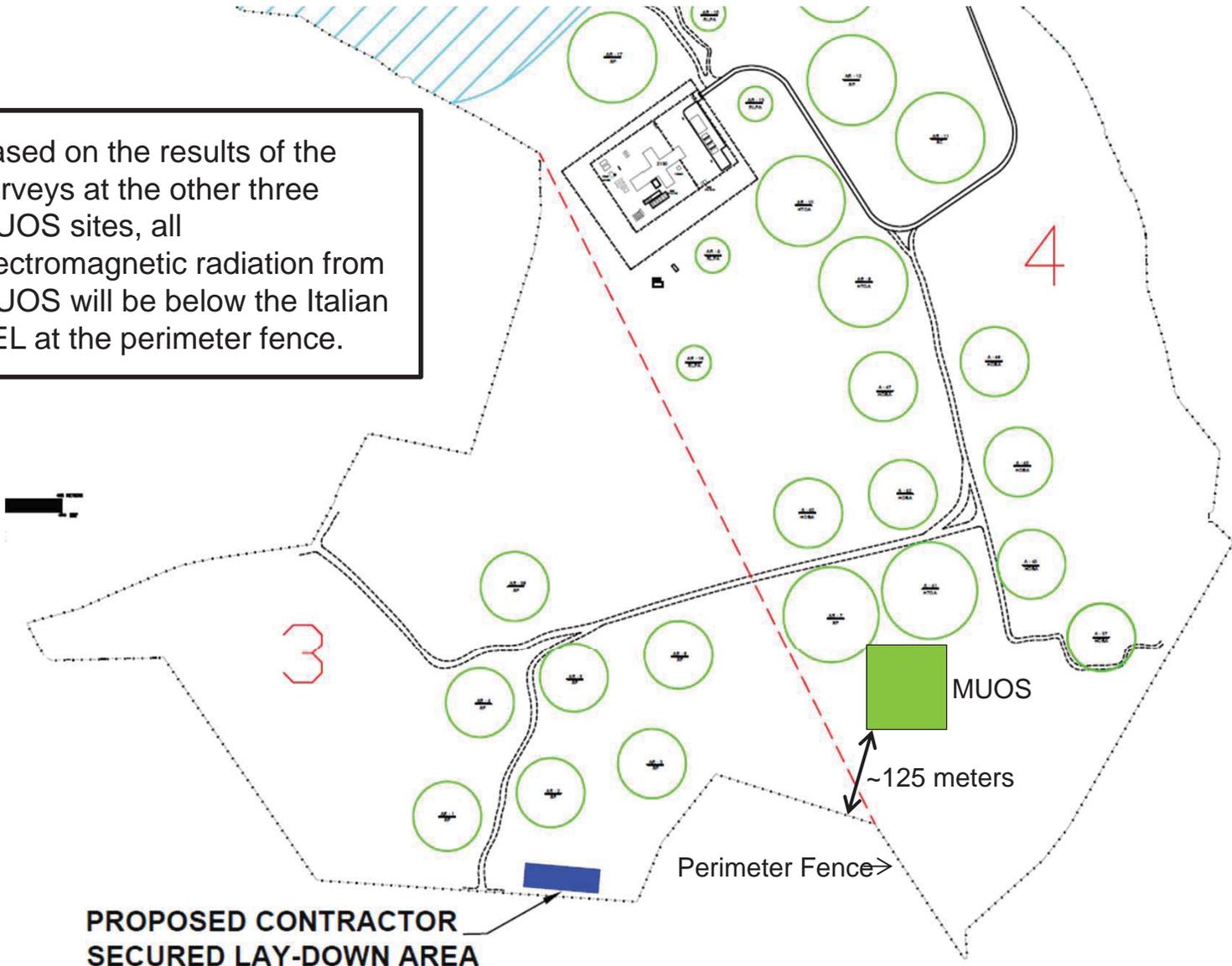


2000 Watts



Geometry of MUOS site at Niscemi

Based on the results of the surveys at the other three MUOS sites, all electromagnetic radiation from MUOS will be below the Italian PEL at the perimeter fence.



**PROPOSED CONTRACTOR
SECURED LAY-DOWN AREA**

Overhead Imagery of Site





JOHNS HOPKINS
APPLIED PHYSICS LABORATORY