Streamlining Computational Methods in Industrial Hygiene

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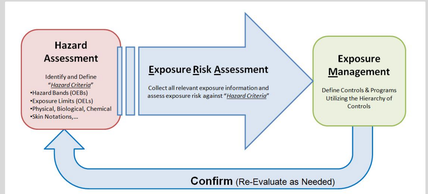
Introduction and Objective

The Industrial Hygiene office identifies health hazards and implements programs to protect employees at NASA Armstrong as outlined in NPR 1800.1. The office utilizes computational and survey-based analyses of potentially harmful instruments, including radio frequency (RF) instruments. Radio Frequency exposure limits are outlined by the Institute of Electrical and Electronics Engineers (IEEE) to avoid thermal effects, burns, or shocks. The computational predictions of hazard distances for RF instruments are based on IEEE 95.3, NPR 1800.1d, and Hitchcock and Patterson's Radio Frequency and ELF Electromagnetic Energies. Due to complexity of near field and far field power calculations for differing instruments, the process of finding hazard distances for radio frequency instruments is tedious and prone to computation mistakes. The goal this summer was to increase the efficiency and accuracy of computational analysis of RF hazard.



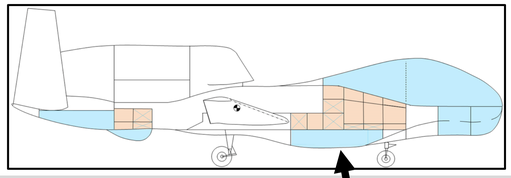
Structural flow of industrial hygiene. Computational analysis fits into the evaluation section.

Surveying a Ku Radar with a Narda Broadband Field Meter

Methods

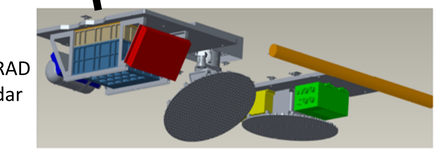
To streamline computational analysis, an excel calculator was created using traditional excel functions as well as Visual Basic for Applications. The calculator changes results for non-dipole and dipole antennae, partial and full body hazards, and continuous and pulsing antennae. Analysis of ground testing on a Global Hawk science mission's EXRAD antenna prompted the addition of an attenuation section. The excel calculator was regularly checked using antennae with known hazard distances. As the calculator was created, a user manual was written to support users in understanding and editing the tool. This ensures the longevity and flexibility of the tool in the face of new standards and new types of instruments.

Results: Evaluation of EXRAD



Global Hawk HOPE

The EXRAD calculations are shown below. Green cells are input values and gray cells are calculated values. The orange, yellow, and blue cells show results for worker and public hazard distances.



EXRAD Radar

RF Evaluations

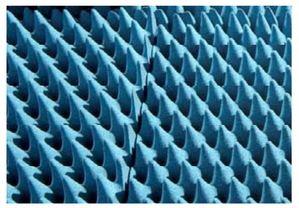
Fill in the following:

Name	EXRAD
Type	
Dimension of Antenna (m)	0.66
Frequency (MHz)	9600
Frequency (Hz)	9600000000
wavelength (m)	0.03125
Antenna size (small or large)	large
P_{peak} (Watts)	9000
pulsing	
Is the RF a dipole?	☐
Using an absorber/attenuator?	☑
P_{avg} (Watts)	45
Pulse duration (S)	0.000001
Pulse Repetition Frequency (Hz)	5000
Pulse Repetition Period (s)	0.0002
Duty Cycle (%)	0.5000%
Antenna Gain (dBi)	34.5
Absolute Gain	2818.382931
Insertion Loss (dB)	
$P_{effective}$ (W)	
Height above occupied area (m)	
Near Field Power Density (W/m^2)	526.13
Proceed with hazard distance calculations for Upper Tier?	yes
Proceed with hazard distance calculations for Lower Tier?	yes
Distance to NF/FF boundary (m)	27.88
Whole body hazard distance: Lower Tier (m)	31.77
Whole body hazard distance: Upper Tier (m)	10.05

Reset

Conversions			
mW/cm^2			W/m^2
W/m^2			mW/cm^2
Hz			MHz
MHz			Hz
MHz			GHz
GHz			MHz
kHz			MHz
MHz			kHz
s			us
µs			s
in	26	0.66	m

Categories	Category 4	Category 3	Category 2
	controls required	no entry during operation	safety training required
Whole Body Hazard Distance (m)	N/A	10.05	31.77
Whole Body Hazard Distance (ft)		32.96	104.23



ECCOSORB Absorbent RF Material

Evaluation After Absorber

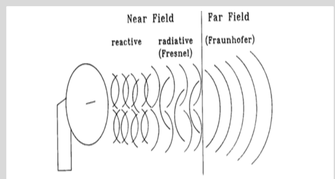
Reflectivity of absorber (dB)	-40	
Absolute Reflectivity		0.0001
Resulting Power		0.0045
Near Field Power Density (W/m^2)		0.052613204
Whole body hazard distance: Lower Tier (m)		0.317688376
Whole body hazard distance: Upper Tier (m)		0.100461886

Categories	Category 4	Category 3	Category 2
	controls required	no entry during operation	safety training required
Whole Body Hazard Distance (m)	N/A	N/A	N/A
Whole Body Hazard Distace (ft)			
Partial Body Distance (m)	N/A	N/A	N/A
hole body 10x hazard distance: Upper Tier (r		0.03	
Partial Body Hazard Distance: Lower Tier (m)		0.11	
Partial Body Hazard Distance: Upper Tier (m)		0.06	

Discussion

The Global Hawk

As predicted, the excel calculator increased efficiency and precision in computational analysis of RF hazards. Evaluations using the calculator yield precise calculations because rounding is not carried through multiple calculations. The calculator is an efficient analysis tool because plugging in fewer than ten RF characteristics yields all the necessary hazard distances for an RF instrument. For a small amount of low powered antennae, the calculator gave huge hazard distances. Although these results did not make sense, these hazard distances are in accordance with IEEE standards. This scenario involves the near field boundary of an RF. While the far power density relates inversely to the distance squared, the near field is not precisely calculable. If the estimated near field power density is small, the hazard distance is set at the edge of the near field. The calculator utilizes the IEEE 95.3 estimate for the near field far field boundary that depends on wavelength but not power. When we assess a low-powered instrument with a large dimension relative to wavelength, the hazard distance is huge because the calculator uses the near field boundary as the hazard distance. The calculator does ensure safety by keeping workers out of the near field, but these distances are unduly large for low powered emitters.



Near field and far field radiation

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