## Introduction

DRS Surveillance Support Systems, Inc. a DOD Electronic Manufacturing, Integration and Test Facility located at 6200 118th Avenue North, Largo Florida. DRS-SSS is currently under contract with the US Navy to build Radar systems and Radar upgrade kits. The current customer base includes customers such as US Navy, NSWC, NAVICP, Defense Supply Center, NOAA, Lockheed Martin, Harris Corporation, EADS, and Northrop Grumman.

DRS-SSS is currently under Subcontract Number DMPM1968 in support ot the Egyptian Navy fast Missile Craft (EN FMC) Program with Lockheed Martin under U.S. Government contract number N00024-06-C-2212 to build and deliver three (3) shipsets of radar systems equipment and provide ship yard services and spares.

## Outdoor RF Test Range

This current contract would require DRS-SSS to expand its test capabilities with an outdoor RF test range. A Transponder signal would simulate a target at a fixed range. The minimum range should be no less than 700 ft from the radar test and integration area located on DRS-SSS property approximately at Latitude 27.8781 north and Longitude -82.7219 west. See Figure 1. The Outdoor test range shall consist of Four platforms for Antenna's Under Test (AUT), a free standing tower, approximatly 810ft from the AUT, that is 40 feet tall, with a Beacon antenna and transponder, mounted on a 16ft x16ft concrete pad with a mobile shelter to house test equipment necessary to test the radar systems.

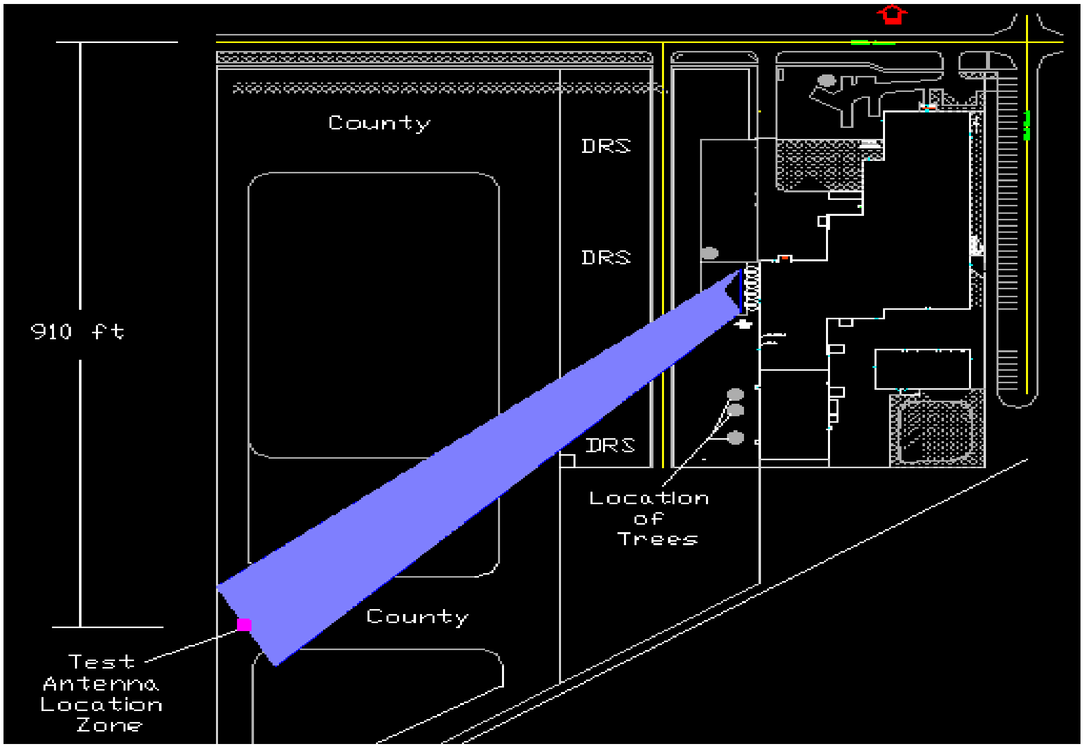


**Figure 1 Test Range Overview.**

**Radar Systems Parameters**:

**Multi Role Radar (MRR) System**

The MRR system provides long range 3D air and surface surveillance, tracking, target evaluation, and weapon control. It is designed for use on patrol boats, corvette class ships, and as a self defense radar on frigates. The radar air surveillance capability is 180Km and surface surveillance capabilities can reach beyond the horizon. The antenna is electronically scanned to provide a 3D target bearing, elevation, range and speed. The operating parameters are as follows:

| Frequency Band | C Band (5.25 GHz to 5.85 GHz) |
|---|---|
| Pulse length | up to 30mS |
| Transmit | 100kW Peak |
| Duty Cycle | 2% |
| Antenna Beam Width | 7.9° Vertical, 1.75° Horizontal |
| Antenna Gain | 29.5 dB |
| Frequency Tolerance | 0.1% |
| ERP | 10KW |
| Emission Designator | 3M4Q3N |
| Modulating Signal | Chirp |

**STING E-O Radar System**
The STING E-O Radar System is used as a target tracking system. It is suitable for various size naval vessels. It provides automatic target acquisition through X & Ka Band radar as well as passive Electro-Optical capabilities. The Sting E-O Radar system supports functions such as sector search, missile launch detection, projectile position during gun fire and assessment support. The operating parameters are as follows:

**Sting MK 2**

| Frequency Band | X Band (8.5 GHz to 9.6 GHz) |
|---|---|
| Peak Transmitted Power | 500 Watts |
| Max Duty Cycle | 30% |
| ERP | 407 kW |
| Frequency Tolerance | 0.1% |
| Emission Designator | 5M0Q3N |
| Modulating Signal | Chirp |
| Antenna Gain, far field | 37dB |
| Beam Width | 2° Vertical & Horizontal |

| Frequency Band | Ka Band (34.5GHz to 35.5GHz) |
|---|---|
| Peak Transmitted Power | 40 Watts |
| Max Duty Cycle | 30% |
| ERP | 234 kW |
| Frequency Tolerance | 0.1% |
| Emission Designator | 5M0Q3N |
| Modulating Signal | Chirp |
| Antenna Gain, far field | 37dB |
| Beam Width | 2° Vertical & Horizontal |

**Scout Radar System**
The Scout Radar system is a surface surveillance and tactical navigation radar system. It operates in a low power (<2 watts) frequency modulated continuous wave (FMCW) mannor. The operating parameters are as follows:

| | |
|---|---|
| Frequency Band | X Band (9.2GHz to 9.5GHz) |
| Power Level | 2 Watts (peak) |
| ERP | 15.8 w |
| Frequency Tolerance | 0.01% |
| Emission Designator | 48M0F3N |
| Modulating Signal | FMCW |
| Beam width | 1.4 Degrees |
| Antenna Rotation | 24 RPM |
| Antenna Gain | 32 dB |

**RF Safety**

The radar antennas under test at DRS-SSS facilities rotate and will vary to the design of the antenna beam width. The MPE average power values calculated for DRS-SSS radars are at a peak of field point and then multiplied by the beam width to take in account the rotation of the radar. The results are found on the following calculations for each radar unit that DRS-SSS is manufacturing and testing.

**MRR System**

In normal operations (antenna turning) the MRR Sytem produces less than 5% (0.044 mw/cm$^2$) of the FCC Maximum Permissible Exposure (MPE) level for the general population distance of 150 feet from the antenna. At the 810ft distance the level is reduced to less than 0.2% (0.0013 mw/cm$^2$) of the FCC Maximum Permissible Exposure (MPE) level for the general population. The Calculations are included below :

**Power Density from MRR System**

$$Pd = \frac{Pt\ Gt}{4\pi R^2}$$

**Max Power** Pt = 100 Kw (0.02) = 2000 W = **63 dBm**

**Antenna Gain** Gt = **29.5 dB**

**Transmit Loss** Lt = **2.6 dB** (waveguide run, etc.)

Effective Radiated Power (for non rotating Antenna)

**Erp** = Pt Gt = 63 + 29.5 = 92.5 dBm

Including Xmtr loss = 92.5 – 2.6 = 89.9 dBm **~ 90 dBm**

Reduction for rotation = 2(antenna beam)/360) = 2(1.75/360)

= 9.722 x 10-3 = -20.12 dB

**MRR System rotating Erp ~ 70 dBm**

**MRR System (rotating) Power Density Calculation (Far Field)**

$$Pd = \frac{Pt\ Gt\ (2\theta)}{4\pi R^2\ 360}$$ $\theta$ = antenna beam width = 1.75 degrees

Pt = Xmit power – Xmit loss = 63 - 2.6 = 60.4 dBm
Gt = 29.5 dB
$4\pi = 12.566 = 10.99$ dB
R = 30 ft (30.47 cm/ft) = 9141 cm
$R^2 = (914.1)^2 = 83.56 \times 10^3 = 59.2$ $dBcm^2$
$2\theta/360 = 9.722 \times 10^{-3} = -20.12$ dB

$$Pd = \frac{Pt\ Gt\ (2\theta)}{4\pi R^2\ 360} = 60.4 + 29.5 - 10.99 - 59.2 - 20.12 = -0.41 dBm/cm^2$$

**$-0.41\ dBm/cm^2 = 0.909\ mW/cm^2$**

At 30 feet the exposure is below the FCC General Population Limit for "Far Field Calculations" but 30 feet is in the near field…

**MRR System Near Field Calculation (rotating Antenna)**

The near field for the MRR is 150 feet requiring additional calculation.
The near field ***Pd*** varies due to phase and amplitude therefore worst case:
Near Field $R = 0.5D^2/\lambda$ D = 7.2 ft $\lambda = 0.178$ ft
(Effective) $R = 0.5(7.2)^2/0.178$ = **145.6 ft**

For Near Field calculations, within 150 ft the following formula applies:

$Pd = 4(Pt/A)(D/2\pi R)$
A = eff Area of Antenna = $1m^2 = 10{,}000\ cm^2 = 40\ dBcm^2$
Pt = 60.4 dBm, 4 = 6.02 dB, D = 8.57 dBft, $(2\theta/360) = -20.12$ dB
$2\pi = 7.98$ set R = 150 ft = 21.76 dBft
$Pd = 4(Pt/A)(D/2\pi R)$
$Pd = 6.02 + 60.4 - 40 + 8.57 - 7.98 - 21.76 = 5.52\ dBm/cm^2$
**Pd = 3.3 $mW/cm^2$ for the region inside the near field.**

**MRR System rotating antenna Minimum Safe Range >150 feet**

Outside the near field we have:
**$Pd_{150} = 0.044\ mW/cm^2$ well below FCC limit of 1 $mW/cm^2$**

**MRR System Power Density Levels at Tower Site (810 ft)**

(Antenna rotating)

$R = 810$ ft (30.47 cm/ft) = 24,680.7 cm
$R2 = (24,680.7)2 = 609.1x\ 106 = 87.8$ dBcm2
$2\theta/360 = 9.722 \times 10\text{-}3 = -20.12$ dB

$$Pd = \frac{Pt\ Gt\ (2\theta)}{4\pi\ R^2 360} = 60.4 + 29.5 - 10.99 - 87.8 - 20.12 = -29.01 \text{ dBm/cm2}$$

**-29.01 dBm/cm2 = 0.0013 mW/cm2**

**Sting E-O Radar System**

In normal operation the Sting E-O Radar System is not a rotator radar: it is a controlled directional system. The technical personnel have control of pointing accurately to a target. In DRS-SSS facility the Sting E-O Director will be positioned to a test target on the tower site located 40ft above the ground. The RF Exposure will not be directed towards the ground. The RF path is limited to the size of the antenna capture area. The RF power density will drop as the distance increases see figure 4.

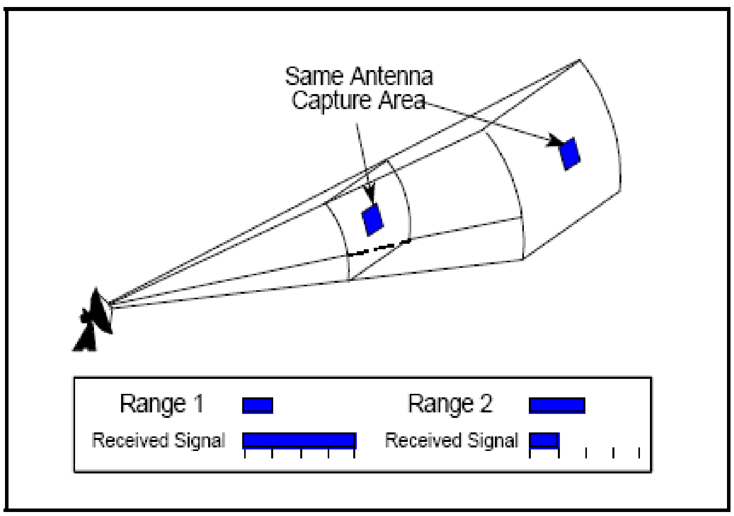


**Figure 4 Sting E-O System - Power Density vs. Range**

Power density calculations for the Sting E_O System are as follows:

**Power Density from Sting E-O System at 200 Feet**

$$Pd = \frac{Pt\ Gt}{4\pi\ R^2}$$

| | |
|---|---|
| Avg Power | Pt = 500 W (0.3) = 150 w = 51.7 dBm |
| Antenna Gain | Gt = 37 dB |
| Transmit Loss | Lt = 2.6 dB (waveguide run, etc.) |

Effective Radiated Power

Erp = Pt Gt = 51.7 + 37 = 88.7 dBm

Including Xmtr loss = 88.7 – 2.6 = 86.1 dBm ~ 86 dBm

**Sting System X band rotating antenna Minimum Safe Range >175 feet**

$$Pd = \frac{Pt\ Gt}{4\pi\ R^2} \quad \text{(at 200 ft)}$$

Pt = Xmit power – Xmit loss = 51.7 - 2.6 = 49.1 dBm

Gt = 37 dB

$4\pi$ = 12.566 = 10.99 dB

R = 200 ft (30.47 cm/ft) = 6094 cm

R^2 = (6094)^2 = 37.14 x 10^6 = 75.6 dB

$$Pd = \frac{Pt\ Gt}{4\pi\ R^2} = 49.1 + 37 - 10.99 - 75.6 = -0.48 \text{ dB}$$

**-0.48dB = 0.895mw/cm2**

**Sting E-O Sysetem Power Density Levels at Tower Site (810 ft)**

Pt = Xmit power – Xmit loss = 51.7 - 2.6 = 49.1 dBm

Gt = 37 dB

$4\pi$ = 12.566 = 10.99 dB

R = 810 ft (30.47 cm/ft) = 24,680.7 cm

R2 = (24680.7)2 = 609.1x 106 = 87.8 dBcm2

$$Pd = \frac{Pt\ Gt}{4\pi\ R^2} = 49.1 + 37 - 10.99 - 87.8 = -12.69\text{dBm/cm2}$$

**-12.69dBm/cm2 = 0.054 mw/cm2**

**Ka Band calculations**

$$Pd = \frac{Pt\ Gt}{4\pi\ R^2}$$

| | |
|---|---|
| Avg Power | Pt = 40w (0.3) = 12 w = 40.8 dBm |
| Antenna Gain | Gt = 44.5 dB |
| Transmit Loss | Lt = 1.6 dB (waveguide run, etc.) |

Effective Radiated Power

Erp = Pt Gt = 40.8 + 44.5 = 85.3 dBm

Including Xmtr loss = 85.3 – 1.6 = 83.7 dBm = 234.4kW

**Sting System Ka band rotating antenna Minimum Safe Range >150 feet**

## Scout Radar

The Scout radar operates with <2 watts in normal operation and produces less than 0.5% of the FCC Maximum Permissible Exposure (MPE) level for the general population distance from the antenna; table 1 summarizes the minimum safe distance for the Scout Radar.

**Table 1**
**Scout RF Safety Distance**

| | Controlled Exposure | Uncontrolled Exposure |
|---|---|---|
| Minimum distance | 12.2 Feet | 27 Feet |
| Non-rotating Antenna peak power density | 4.93 $mw/cm^2$ | 0.996 $mw/cm^2$ |
| Rotating Antenna Average power | 0.019$mw/cm^2$ | 0.00387 $mw/cm^2$ |

## Power Density at Tower Site

The Tower site will be located approximately 810 feet from the test and integration area. Table 2 will show results of the power density at the Tower Site location.

**Table 2.**
**Power Density at Tower Site VS. FCC Uncontrolled Specification.**

| Tower Site distance | 810 Feet | Comparison to FCC uncontrolled Spec. 1$mv/cm^2$ |
|---|---|---|
| Scout power density | 0.00000333 $mw/cm^2$ | < 0.001% |
| MRR Power density | 0.0013$mw/cm^2$ | < 0.2% |
| Sting Power density | 0.054$mw/cm^2$ | < 5.0% |

## Radar Exposure Area Summary

The FCC office of technology (OET) bulletin (OET Bulletin 65, Edition 97-01, August 1997 sets the Maximum Permissible Exposure Limits (MPE) for C, X, K Band electro magnetic radiation exposure as follows:

5 $mW/cm^2$, average, for occupational/controlled exposure
1 $mW/cm^2$, average, for general population/uncontrolled exposure

The limits for occupational/controlled exposure “apply to situations in which persons are exposed, are fully aware of the potential for exposure, and can exercise control over their exposure”. The limits for general population/uncontrolled exposure “apply to situations in which the general public may be exposed, are not aware of the potential for exposure, and can not exercise control over their exposure”.

MPE limits specified in the reference OET Bulletin are average values with averaging times of 6 minutes for occupational/controlled exposure and 30 minutes for general population/uncontrolled exposure. The exposure levels set forth by the FCC (OET) shown above apply to the peak beam width or otherwise known as the peak of the antenna radiation pattern.

The MRR is designed to radiate out the antenna only when the antenna is rotating. If the antenna is in a fixed position, the radar is non operational. The MRR a radar uncontrolled exposure safe area would fall ~>150 feet from the rotating antenna. The Sting director exposure safe area would fall >175 feet from the antenna. DRS-SSS will take precautions when radiating the radars. The private access road crossing DRS-SSS property is located within the FCC acceptable occupational/controlled exposure area.  DRS-SSS will post OSHA standard warning signs “to keep moving” for vehicles when entering the designated exposure area. The signs will conform to the outline in OSHA document 1910.97 paragraph A section 3. DRS-SSS property will also be secured and posted with proper OSHA signs.
The radar systems DRS-SSS manufactures and test are designed to meet tight Electro Magnetic interference specifications and the equipment is manufactured to military standards. The transmitter is shielded to minimize the spurious harmonics that cause the interference. The MRR/Scout/Sting Radars operate with in the designated military frequency bands specified in paragraph 2.0 to 2.3. The designated frequency band is outside of the commercial equipment bands and will not cause any interference. A good example is the Police X, K band radar. The X band police radar operates in a narrow band 10.500 to 10.550 GHz. The K band police radar operates at 24.050 to 24.250GHz. DRS-SSS radars operate on designated military frequencies located outside the frequency spectrum of the police radars and will not interfere.

The Institute of Electrical, Electronics, and Engineering (IEEE) defines radio frequency (RF) radiation as waves that move through space residing in the frequency range of 3KHz to 300 GHz. Radiation exposure is defined as being non-ionizing. Non-ionizing radiation is defined as electromagnetic waves that are not capable of ionizing matter and do not cause permanent biological changes to molecular structure. This type of radiation is what radio transmitter produce out of an antenna. The effects of non ionizing radiation are not cumulative and as long as the FCC rules and guide lines are followed, the exposure over a number of days, months, and years is considered safe.