### Performance Calculations for Low Observable Tracer (LOT)

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US Army Corps of Engineers BUILDING STRONG®

Description Tracer fire at MCB Camp Pendleton DM-ST-89-00210.jpg en.wikipedia.org

# Tagging, Tracking & Locating (TTL) Performance Calculations

• There are limited predictive tools that enable the TTL user, product developer, or technology evaluator to assess the capabilities of emerging TTL technologies for operational use.

• Our approach compares new product developments in a quantifiable manner. It allows for the prediction of *system performance* of sensors and taggants in terms of detection range.

• It accounts for sensor parameters, taggant and background characteristics, solar illumination, and most weather conditions.

• Our system-level approach is to devise a method to quantify whether specific TTL materials, coupled with EO sensors, will indicate a tactical advantage prior to development, procurement, and fielding of those systems.



## **TTL Performance Calculations**

#### Accommodates specific imaging sensor parameters:

- Detector (Spectral quantum efficiency, Pixel size, Wavelength range, Pixel blur)
- Lens (F number, MTF, Spectral transmission)
- Illumination (Wavelength, Power, Divergence, Solar)

Calculates and displays performance metrics as a function of range for:

- Signal, Background and Noise
- Signal-to-Noise ratio (SNR)
- Probability of Detection (Pd) Rosell Model
- Contrast Ratio

1800 Power (m 1 Sean div	iv) ingence (im, full angle)	(Diffraction limit at P (Diameter of pointer	3.90 : 7.69 : 14.423	microne) pavelle)
(# Use Gaussian spectral profile	0.008 Wavelength 0.0015 Spectral PWH	(microne) M (microne)		
C Use spectral profile from file				1000
	Diffiaction wavelength 1	microns (the diff Diffisct Receive	Faction wavelength on Limited MTP is sel r/Optics Tab)	e used only if lected in the
Reset pointer parame	ters from ini file			



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### **LOT Scenario**



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## Background Irradiance at Receiver Aperture



Beacon Scattered Solar (or lunar) Irradiance Beacon Beacon

Path Irradiance at Receiver (W/(cm2 micron)) Range = 600 m
 Reflected Path Irradiance at Rec. (W/(cm2 micron)) Range = 600 m
 Solar Reflected Irradiance at Receiver (W/(cm2 micron)) Range = 600 m
 Total Background Irradiance at Receiver (W/(cm2 micron)) Range = 600 m

#### **Mixed Forest**

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### **Important Parameters**

1.5     Power (m)       90.     Beam dive	N) (Diffraction limit at F 1.80 : 4.39 microns ) rgence (deg, half angle)	
Use Gaussian spectral profile	1.55     Wavelength (microns)       .015     Spectral FWHM (microns)	•Power
Use decay constant	C:\TTL Performance Calculator\Input Data\Yellow Strobe Normalized.txt       Browse         Diffraction wavelength       1.         microns       (the diffraction wavelength is used only if Diffraction Limited MTF is selected in the Receiver/Optics Tab)         0.36       /sec	Divergence
C Use decay profile from file	C:\TTL Performance Calculator\Input Data\pyrotacer decay - M856.txt Browse	<ul> <li>Decay constant</li> </ul>
Firing table time(sec) vs range(m) Reset projectile parame	C:\TTL Performance Calculator\Input Data\M80 Firing Table.txt Browse	• Spectra
Reset All Input Parameters C:\	OWL\2014-11-26\Yellow Strobe Sun Fresh Snow_TTL.ini	
OK Cancel H	ielp	Ĩ

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### **Phosphor- Forest Background**



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### **Phosphor- Forest Background**



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## Background

Show 📀 Input C Output	100
General Output Files Target Receiver Spectral Parameters Met Data Background Display Parameters	
Extraterrestrial source: © Sun © Moon phase angle 95 deg (0 deg = full moon) Sensor Altitude 0.002 km Source Zenith 30 deg (0 = overhead, 90 = on horizon)	
Surface albedo file C:\TTL Performance Calculator\Modtran5\Data\spec_alb.dat Browse	
Surface Albedo 59 Fresh Snow ! (= Mosart 43, fresh snow (50 micron radius))	
Use constant reflectivity 90 %	
Background zenith angle (also target zenith angle for reflective case)	
✓ Include path radiance	
Reset All Input Parameters C:\OWL\2014-11-26\Yellow Strobe Sun Fresh Snow_TTL.ini	
Compute	
OK Cancel Help	

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### **Phosphor- Snow Background**



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### **Phosphor- Snow Background**



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### **Angle Dependence**



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## Various Concepts



### Various Concepts vs M62



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## Conclusions

•Performance calculations were used to determine the distance that various tracer concepts can be seen with the naked eye.

• Performance calculations were done spectrally, to account for atmospheric transmission, fluorescent wavelengths, filter transmission, and background reflectivity.

Calculations were performed under various solar and lunar conditions.

•Weather conditions (fog, clouds and rain) will also be studied.

• Upper boundary- 800 meter range desired in full sun with snow as the background.

