US ARMY
Ultralight Laser Designator (ULD) Development

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John E. Nettleton
US ARMY CECOM RDEC NVESD
10221 Burbeck Road Suite 430
Fort Belvoir, VA 22060

PH: 703-704-1704
FX: 703-704-2066
EM: john.nettleton@nvl.army.mil

James H. Burton
MTC SUPPORT TO PM SENSORS & LASERS
10170 Beach Road
Fort Belvoir, VA 22060

PH: 703-704-2543
FX: 703-704-3449
EM: james.burton@nvl.army.mil

Why Ultralight Laser Designator?

Answer:
Current US Army fielded laser designator systems are too heavy.

- G/VLLD ~ 61 pounds
- LLDR ~ 38 pounds (includes thermal sight)
- SOFLAM ~ 27 pounds

Having to carry a current US Army fielded laser system **impairs the combat effectiveness** of the soldier.

A lighter laser designator system allows the soldier to **increase his load in other areas** such as more munitions, water, food, etc.

A lighter laser designator system **enhances the soldiers mobility** and **reduces his fatigue**.

How do you reduce the weight of a Laser Designator system?

Answer: The ULD approach is to

First: Determine what the REAL requirements for laser designation for the mission are (energy, beam divergence, etc..).

Second: Develop a more efficient, simplified, athermal laser cavity.

Third: Incorporate system performance improvements such as optimum spot sizing and beam stabilization.

NOTE: The First and Third steps of the ULD approach are contained in a separate presentation.

What is an efficient, simplified, athermal Laser Cavity?

Answer:

The **TIR** (Total Internal Reflection) Solid State Laser is an efficient, simplified, athermal laser cavity design being developed at the US Army Night Vision & Electronic Sensors Directorate, Fort Belvoir, VA.

Why TIR Laser Cavity Design?

Answer:

-Simplified coupling of **end pump** laser diode - **no lensing** of diodes.

-Athermal laser cavity design requires **no cooling or heating of pump diodes** over mil-spec temperature range

- -No electrical load for thermal management
- -No mechanical load for thermal management

-High efficiency (electrical to optical)

-Lower electrical power requirements

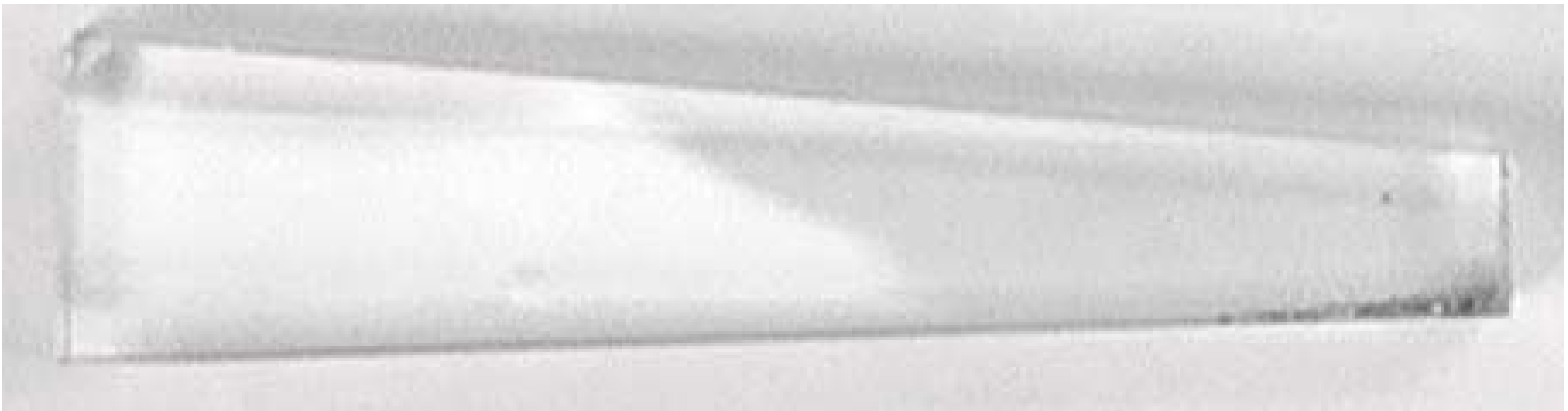
-Reduction in number of pump diode packages (1, 10/12-bar array)

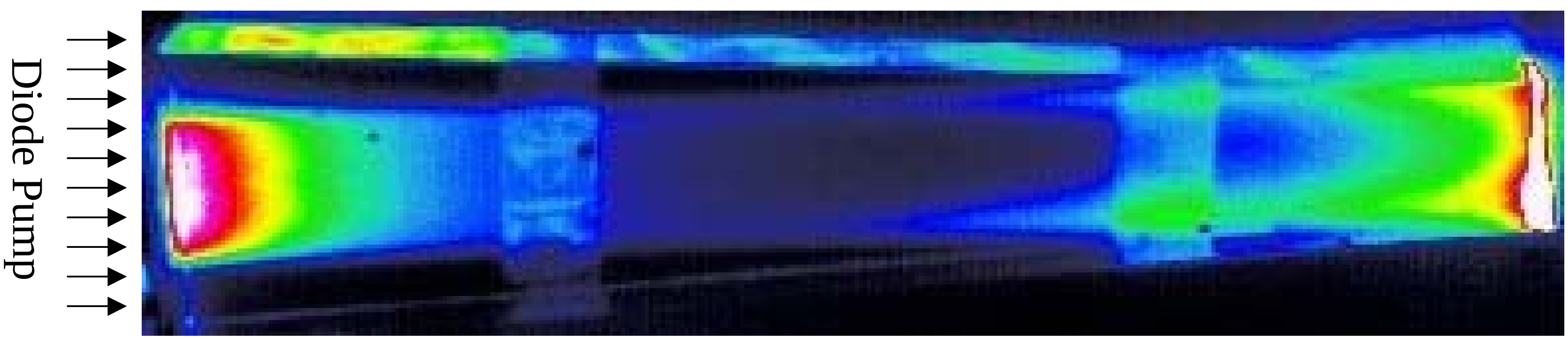
-Reduction in size and weight of electronic drivers

-Utilize Monoblock technology

-Small, Compact package

Total Internal Reflection (TIR) Solid State Laser Diode End-Pumped Crystal





Top view of 1 um florescence in TIR solid state laser diode end-pumped laser crystal

Making a Designator…
Specs NOT Well Understood

-Energy per pulse
-Target Reflectivity
-Atmospherics
-Laser Pulse Width
-Beam Divergence
-Aperture Size
-Target Size

Laser Designator Range Equation *

$$\text{Prec} = \frac{\text{Ptx}\, e^{(-\alpha\, \text{Rtx})}\, \rho\, e^{(-\alpha\, \text{Rrx})}\, \text{Arx Topt}}{\pi\, \text{Rrx}^2}$$

Prec = Received Power
Ptx = Transmitted Power
α = Atmospheric extinction coefficient
Rtx = Range from transmitter to target
Rrx = Range from receiver to target
ρ = Reflectivity of target
Arx = Effective Area of the receiver optics
Topt = Transmission of the receiver optical system

* Beam does not overspill the target.

Energy Required- Issue/Challenge

The amount of energy required drives system power, size and weight.

Specifically: More energy out means more energy in, resulting in larger capacitors, batteries and resonator.

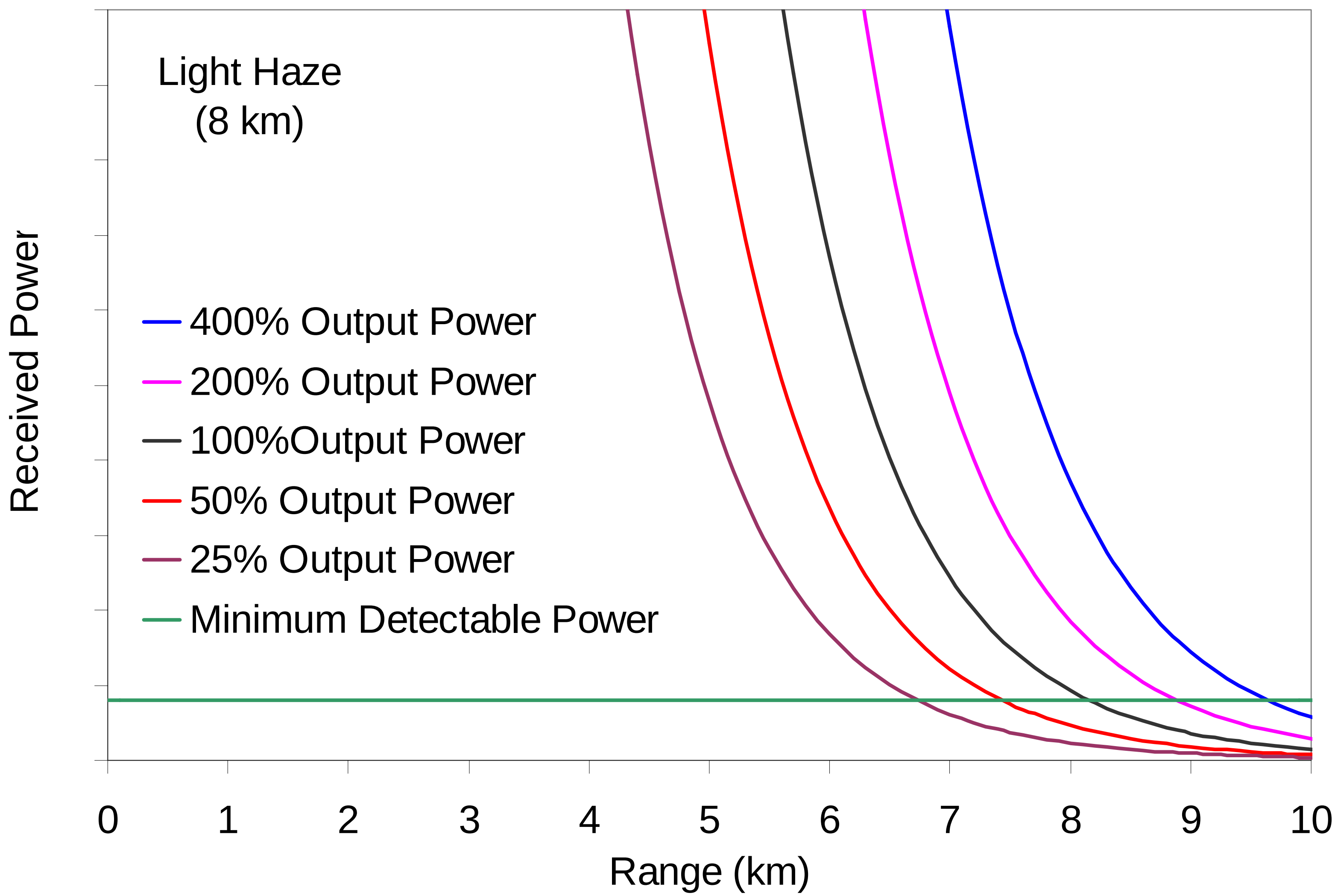
Past Standard G/VLLD (1970/80s): ~120 mJ

Past Standard MULE (1980s): ~100 mJ

Current Standard SOFLAM & LLDR: 80 mJ

Future ULD: ~ 40-60 mJ (Emerging results of Modeling, Simulation and Field/Lab testing)

Typical System Dependence on Laser Output Power



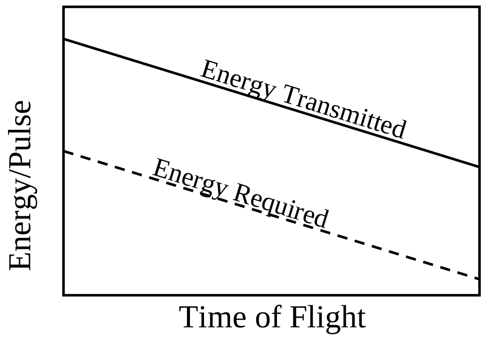
Energy Required - Emerging Result

Variable Energy Transmission - Vary output energy of next pulse based on Range to target (designator & seeker) and Quality of returned signal.

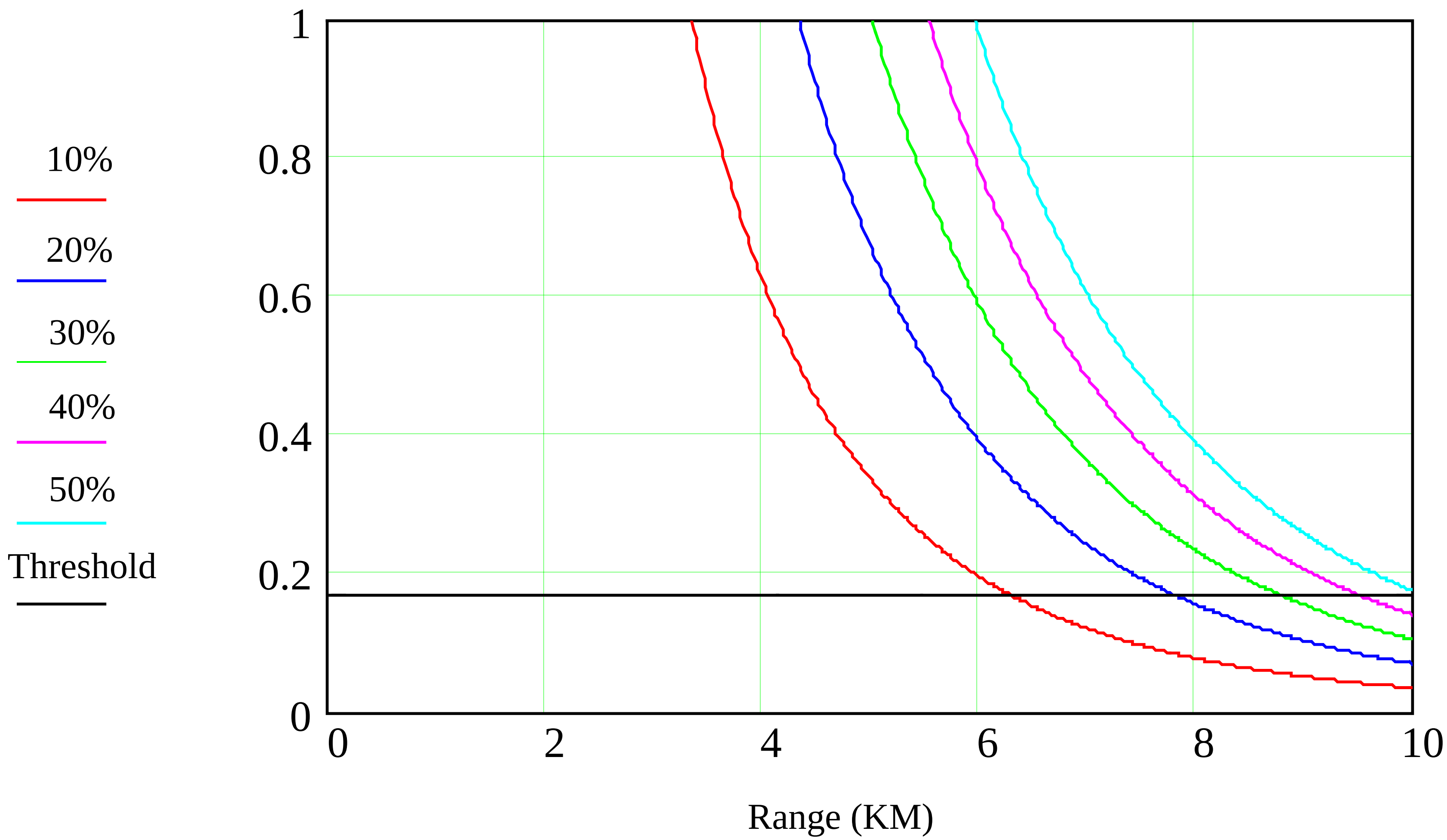
-Conserves Battery and decreases Thermal Loading.

- Improvement of performance for Short Range Targets
    - -Minimize effects of overfill, splash, port scatter, and seeker blinding

Variable Laser Energy Transmitted
During Missile Flight



Typical System Dependence on Target Reflectivity



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Reflectivity Data

Bradley Fighting Vehicle (muddy)

Brown = 0.228 Tan = 0.452 Black = 0.123 Green = 0.527 Skirt = 0.385

Average of reflectivity values = 0.343

Armored Personnel Carrier (Uniform Light Green)

Top = 0.61 Bottom = 0.595 Skirt = 0.54

Average of reflectivity values = 0.582

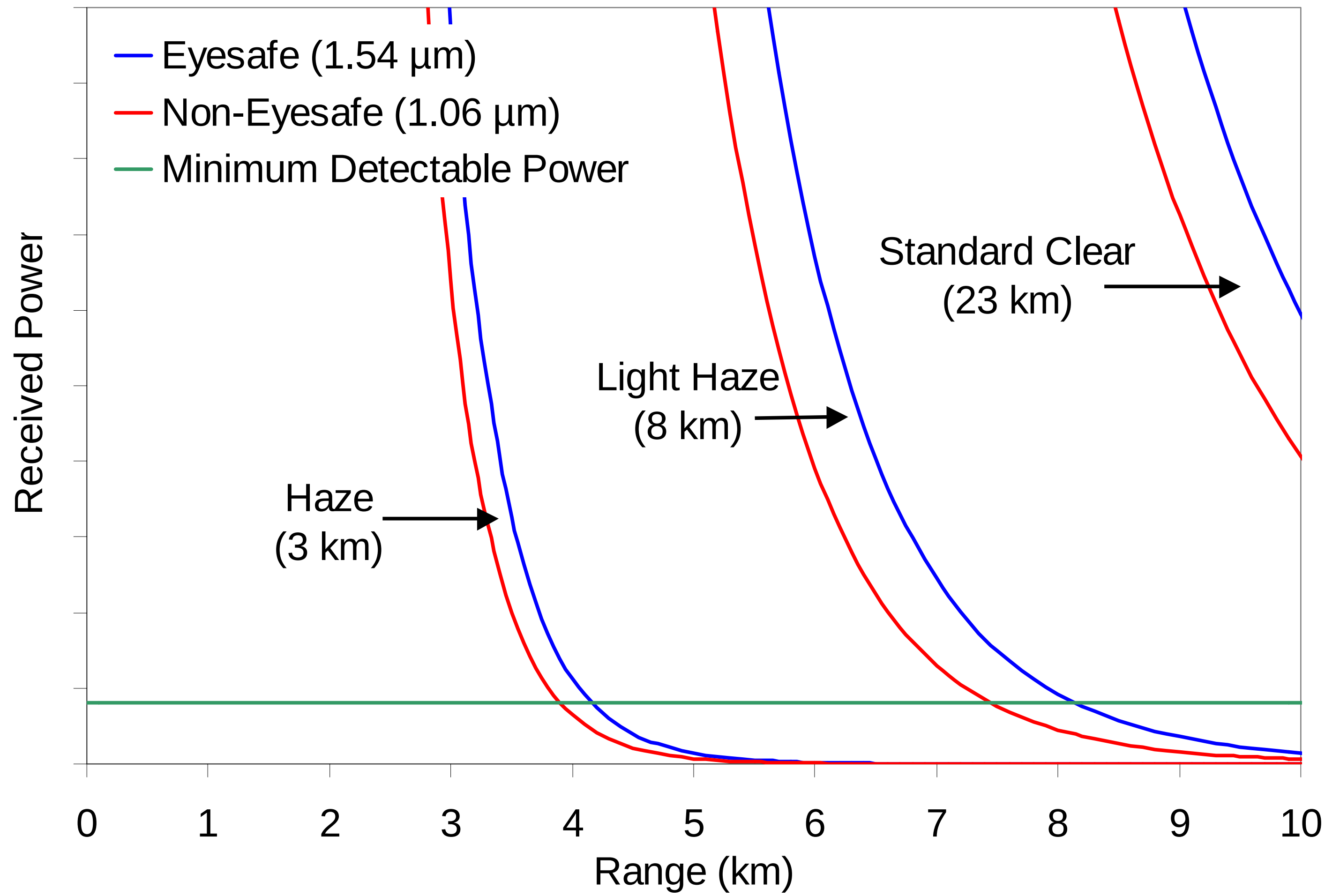
HMMWV (clean)

Brown = 0.152 Black = 0.062 Green = 0.322 Light Green = 0.488

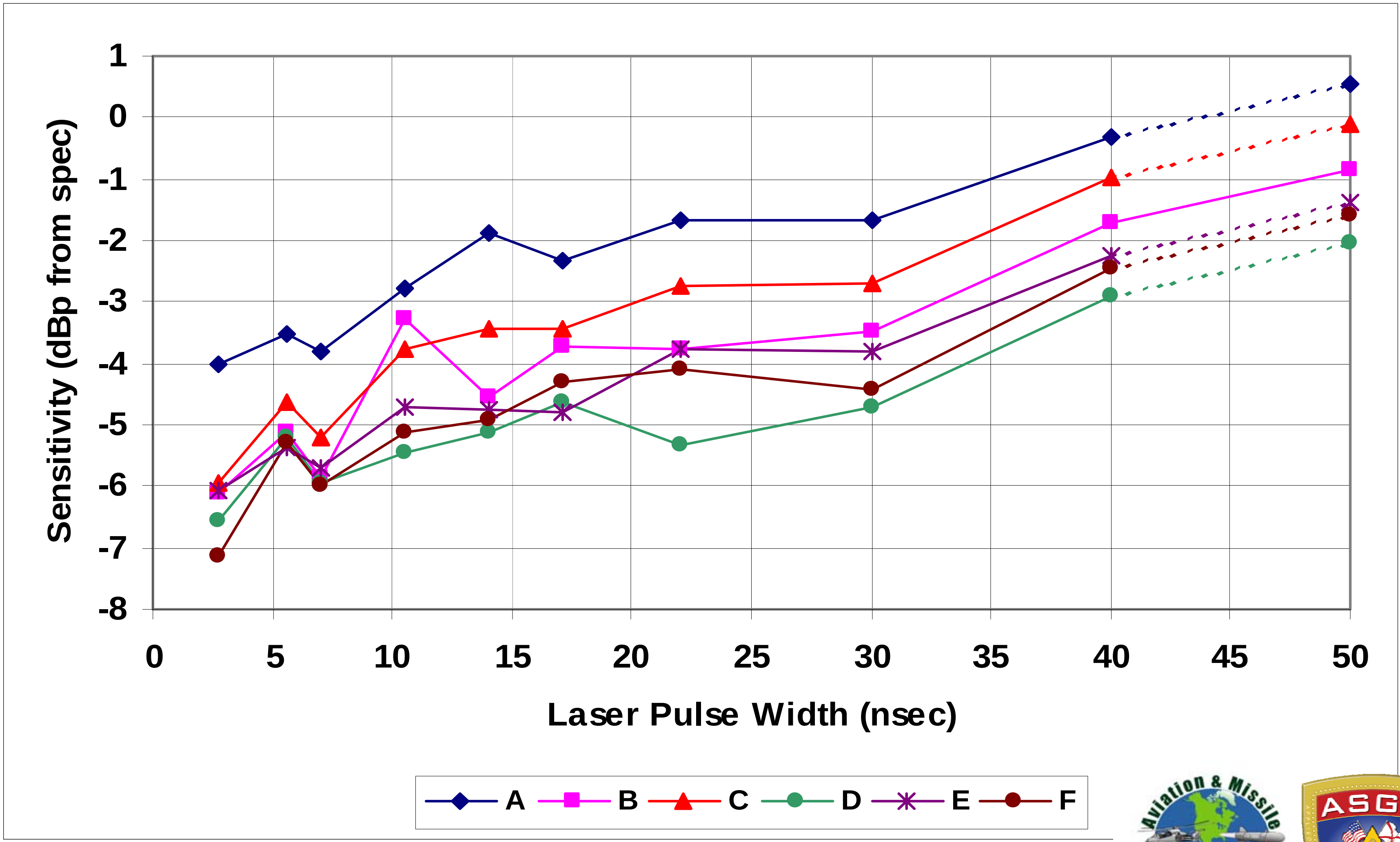
Door = 0.441 Tire = 0.06 Window Plastic = 0.05

Average of reflectivity values = 0.225

Typical System Dependence on Atmospheric Conditions (Visibility)



Laser Pulse Width ALSPES Results
Sensitivity Analysis



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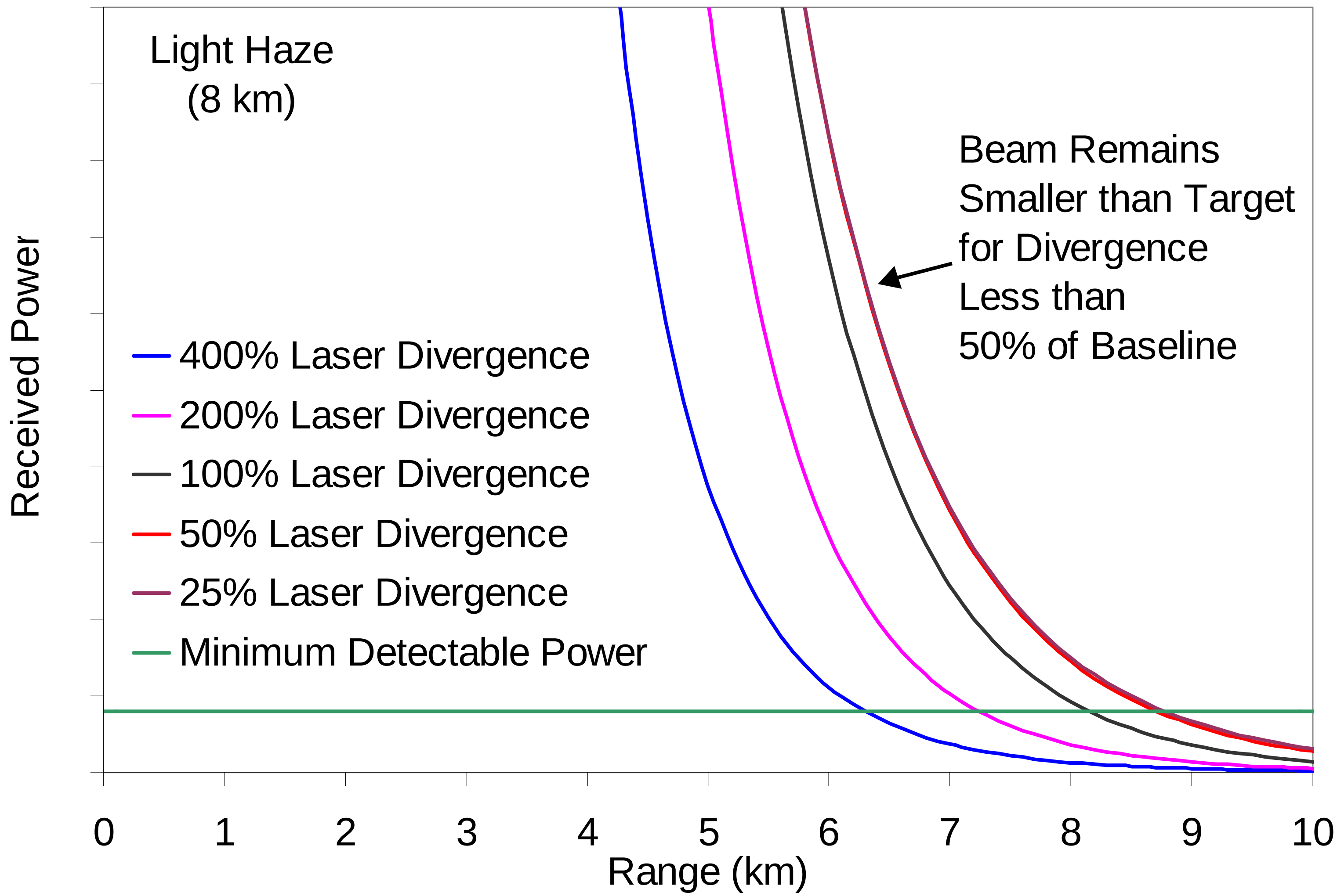
Beam Divergence/Quality-Issues/Challenges

The Beam Divergence/Beam Quality drives the size of the optics. The worse the beam quality the larger the telescope/optics for the required divergence. Another factor affecting Beam Divergence/Beam Quality is the selected lasing material. The Beam Divergence required will vary with Operational Range and Target Size.

Current LLDR Specs < 200 micro-radians

Typical System Dependence on Divergence



Ultra-Lightweight Laser Designator

EXAMPLES: Reduced LDWSS Results - SHORT RANGE - (Optimum Spot):

R-D(km)	R-M(km)	Vis(1/km)	Enrgy(mJ)	Bm Div*(mR)	Jit*(mR)	Phit-K
3	3	23/10/3	25 – 100	0.125	0.10	89%
“”	“”	“”	“”	0.25	0.10	91%
“”	“”	“”	“”	0.50	0.10	98%
2	3	23/10	25 – 100	0.125	0.20	73%
“”	“”	“”	“”	0.25	0.20	78%
“”	“”	“”	“”	0.50	0.20	80%
3	5	23	25 – 100	0.125	0.10	90%
“”	“”	“”	“”	0.25	0.10	96%
“”	“”	“”	“”	0.50	0.10	100%
3	5	10	25 – 100	0.125	0.10	90%
“”	“”	“”	“”	0.25	0.10	95%
“”	“”	“”	“”	0.50	0.10	99%

As Beam Divergence INCREASED Phit INCREASED….. Given BD * Jit << Target Size

Ultra-Lightweight Laser Designator

Laser Designation Weapon System Simulation (LDWSS)

Laser Designator Energy is not key factor in achieving good Phit.

Reduced LDWSS Results:

R-D(km)	R-M(km)	Vis(1/km)	Enrgy(mJ)	Bm Div*(mR)	Jit*(mR)	Phit-K	Phit-C
1 - 4	3 - 5	23/10/3	25 – 100	0.125 – 0.5	0.05	100%	100%
“”	“”	“”	“”	“”	0.10	>90%	>95%
“”	“”	“”	“”	“”	0.20	>50%	>90%
“”	“”	“”	“”	“”	0.40	<50%	<90%

**** Containing the laser designator beam within target is TOP PRIORITY!!**

Note: Beam Divergence and Jitter angles are ½ angle values in LDWSS

Operational Requirement – Assumed Requirements

Values based on existing LLDR ORD and "Missing Information"

Proposed Target:
Designation Range (tank frontal)- 3 KM
Designation Range (Building)- 6 KM

1.1.1.1.1 Normal Target.

The target is defined as a NATO Standard tank target having a frontal cross-section of 2.3 x 2.3 meters, and a side cross-section of 2.3 x 6.4 meters. The target is considered to be normal to the laser beam and to have a reflectance of 10% at the laser wavelength. Moving targets are defined as having a crossing speed of 40 kph.

The Best Technology in the World is Useless without Proper

TRAINING and IMPLEMENTATION

TRAINING REQUIREMENTS

-System Training: Train on operation and function of system (Firing Range)

-Operational Training: Train on utilization of system in force-on-force engagements (Tactical Engagement Simulation)

IMPLEMENTATION REQUIREMENTS

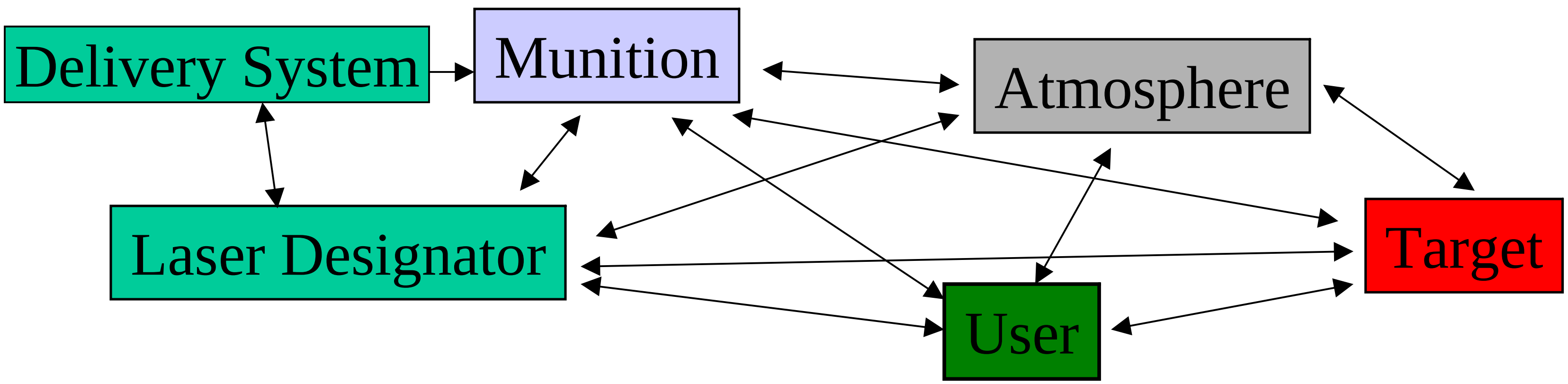
-Good Technology but Poor Implementation Leads to User Not using the system.

Example: Copperhead, Laser Designated Round For FA

-Communications: Very IMPORTANT, especially for remote designation

-Improved Tactical Integration: The Laser Designation system must make sense to the User and fit into the tactical scheme/operating procedures.

SUMMARY: Laser Designation Must Be Implemented As A System



-How is the system working now?
    -Is the system successful?

-How can technology improve the system?
    -Laser technology, communications, PDA's,…

-How can the system evolve to be improved?
    -Is the system understood?

Early ULD Brassboard - Technology Success

-4.1 pounds with batteries
(3.6 pounds w/o)
- 40 mJ/pulse
- 10-20 Hz
- 20 nsec pulse width
- >1 hour operation per set of batteries
-Beam Divergence < 400uRad

- Two (2) Systems Constructed

CONQUEST OF DARKNESS

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