Defense Systems Information Analysis Center

DSIAC TECHNICAL INQUIRY (TI) RESPONSE REPORT

Compact Laser Designators (LDs) for Miniature Unmanned Aerial Vehicles (UAVs) and Handheld Targeting Systems

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ABOUT DSIAC

The Defense Systems Information Analysis Center (DSIAC) is a U.S. Department of Defense Information Analysis Center sponsored by the Defense Technical Information Center. DSIAC is operated by SURVICE Engineering Company under contract FA8075-14-D-0001.

DSIAC serves as the national clearinghouse for worldwide scientific and technical information for weapon systems; survivability and vulnerability; reliability, maintainability, quality, supportability, and interoperability; advanced materials; military sensing; autonomous systems; energetics; directed energy; and non-lethal weapons. We collect, analyze, synthesize, and disseminate related technical information and data for each of these focus areas.

A chief service of DSIAC is free technical inquiry (TI) research, limited to 4 research hours per inquiry. This TI response report summarizes the research findings of one such inquiry. For more information about DSIAC and our TI service, please visit www.DSIAC.org.

ABSTRACT

The Defense Systems Information Analysis Center (DSIAC) was asked to identify if there are any low size, weight, and power laser designators available for use in miniature unmanned aerial vehicles or handheld targets. DSIAC reached out to subject matter experts with QinetiQ to field the inquiry. A report was created, and the requested information was delivered to the inquirer.

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1.0 TI Request

1.1 INQUIRY

Are there any available compact or low size, weight, and power (SWaP) LDs for use in miniature UAVs or handheld targeting systems?

1.2 DESCRIPTION

The inquirer requested information on low-SWaP LDs available for use in miniature UAVs or handheld targeting systems, particularly for military use.

2.0 TI Response

Defense Systems Information Analysis Center (DSIAC) staff reached out to subject matter experts at QinetiQ to provide a response to the inquiry.

LDs have served as a fundamental means of targeting for multiple generations of combat aircraft. With advancements in high-efficiency, diode-pumped laser technology, pulse length control, efficient thermal design, and unique beam stability techniques, laser designators that can fit into mini UAVs or handheld targeting binoculars are becoming a reality. Very lightweight/low-power LDs can execute tactical target designation missions at ranges up to 1 km from mini-UAVs and quadcopters or as part of handheld soldier-borne targeting systems. They stand to add significant capability to ground forces engaged in short-range tactical missions, enabling effective target marking for laser-guided munitions (LGMs). An understanding of key laser performance parameters will promote the development of effective miniaturized LD systems. For purposes of our discussion, low-power laser designators typically range from 10 to 30 mJ, but even 50-mJ lasers can fall into this class.

2.1 LD CHARACTERISTICS AND CONSIDERATIONS

Military-grade LDs emit pulse trains at a 1064-nm wavelength, not visible to the human eye. They must comply with the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 3733 standard for pulse codes. The standard defines specific pulse repetition frequency (PRF) structures of emitted pulses that must be compatible with LGM missile seekers detection electronics. As seen in Table 1, output energy, beam divergence, and beam jitter are key contributing parameters to effective target designation. High output energy, narrow beam divergence, and low beam jitter increase overall designation range. LD range varies with atmospheric transmission and visibility conditions. For example, poor visibility conditions can reduce designation range due to high absorption of laser energy in the atmospheric path. Most LDs generate significant heat during target designation, limiting the operational duty cycle to ~25% to enable heat dissipation (e.g., laser on for 1 minute followed by laser off for 4 minutes). The power that an LD can output is scaled to the SWaP allocated to the system. A low-power, 10–30-mJ LD weighs about 100 g, where a 50-mJ LD could weigh 500 g or more. Since limited SWaP is available on mini-UAV payloads and handheld targeting systems, LD power is limited. However, 10–30 mJ power is enough to designate most tactical targets at a 1-km range, as shown in Table 1 [1].

Table 1: Key Performance Parameters

Parameter	LD Performance
Wavelength	1064 nm
Output Energy	10–30 mJ
Beam Divergence	500–1000 µrad
Pulse Width (FWHM)	20 ns
Pulse PRF Code	Bands I and II defined by NATO STANAG 3733
Pulse-to-Pulse Stability	4 µs
Duty Cycle @ 20 Hz	1 min continuous/4 min OFF period
Beam Jitter	<50–100 µrad (<10 % of beam divergence)
Pulse-to-Pulse Energy Stability	<10% in any 100 pulses <10% consecutive pulses

Pulse energy should be stable over temperature to provide sufficient energy for standoff designation range and enable uninterrupted munition guidance. It should also be stable under all STANAG 3733 PRF codes to enable secure and uninterrupted designation. Figure 1 shows pulse energy and pump time performance over temperature for a 50-mJ laser designator operating at 10- and 20-Hz PRF. While there are some variations, the laser provides consistent >50 mJ of output power and >100 µs pump time over the entire temperature range [1].

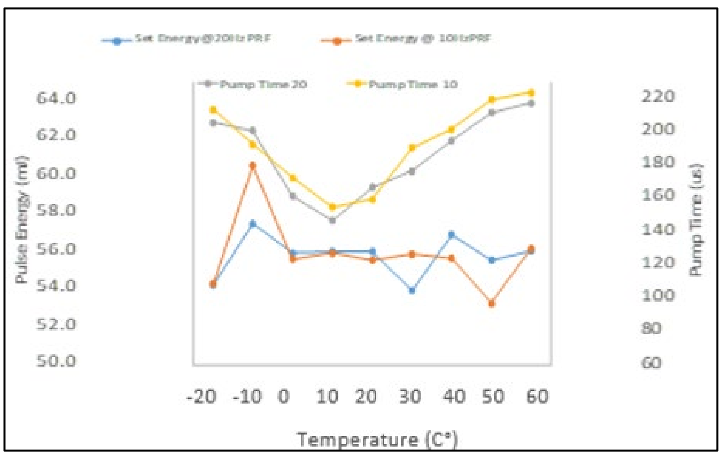

Figure 1: Pulse Energy and Pump Time Over Temperature for a 50-mJ Laser [1].

Another important parameter required for adequate designation is pulse width. As seen in Figure 2, laser designators should have a pulse width of 10–25 ns for effective target designation, compliant with the NATO STANAG 3733 standard [1]. Pulse temporal width is an important parameter because it determines the amount of energy emitted from the LD. Pulse width is typically between 10 and 25 ns and has a direct impact on LD range performance. A narrow pulse will not carry enough energy, while a wide pulse will not be compatible with missile seekers' detection electronics.

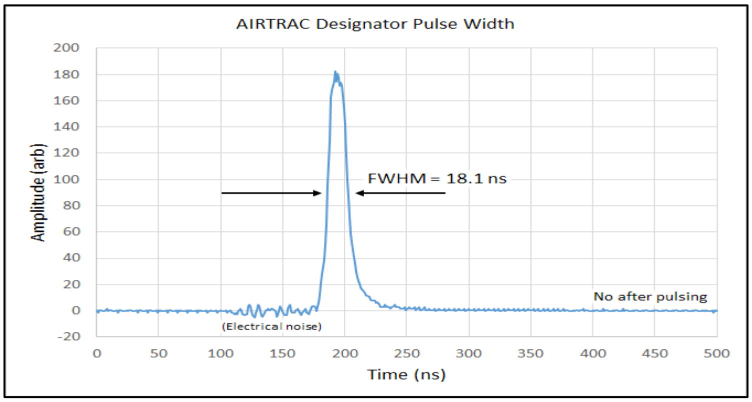

Figure 2: Laser Pulse Width [1].

The beam parameter product (BPP), which is a product of laser beam waist and laser beam angle, quantifies the quality of the beam and how well it can focus. The beam angle, combined with beam jitter and stabilization system residual jitter, will define the laser's total beam divergence. A wide angle of total beam divergence (determined by the "beam waist") will spill over energy outside the target, reducing the amount of energy reflected from the target back to the missile seeker.

Table 2 provides round trip range performance estimations using the EDR95 model for a standard 10–30-mJ laser. A total beam divergence angle of 500 µrad with residual motion of 100 µrad will enable designation of a 2.3-m NATO target from 2.9-km under clear day conditions. A 1000-µrad divergence and 100-µrad residual motion will enable designation from 1.9 km.

Table 2: Laser Beam Divergence, Residual Motion, and Target Size Estimates

Total Beam Divergence (µRad)	Residual Motion (µRad)	Target Size (m)	EDR95 (Km)
200	0	2.3	11.9
200	20	2.3	9.7
200	40	2.3	7.3
200	60	2.3	5.8
200	80	2.3	4.7
200	100	2.3	4.0
500	0	2.3	4.8
500	20	2.3	4.6
500	40	2.3	4.1
500	60	2.3	3.7
500	80	2.3	3.3
500	100	2.3	2.9
1000	0	2.3	2.4
1000	20	2.3	2.4
1000	40	2.3	2.3
1000	60	2.3	2.2
1000	80	2.3	2.1
1000	100	2.3	1.9

Laser BPP and pulse width performance over temperature for a 50-mJ designator is shown in Figure 3. A laser operating at 0 °C ambient temperature, with a beam waist of 20 mm and BPP = 2, will have a beam divergence of 200 µrad. At –20 °C, the BPP will exceed 4, more than doubling the divergence and significantly decreasing the designation range due to laser spillover and reduction in reflected laser energy.

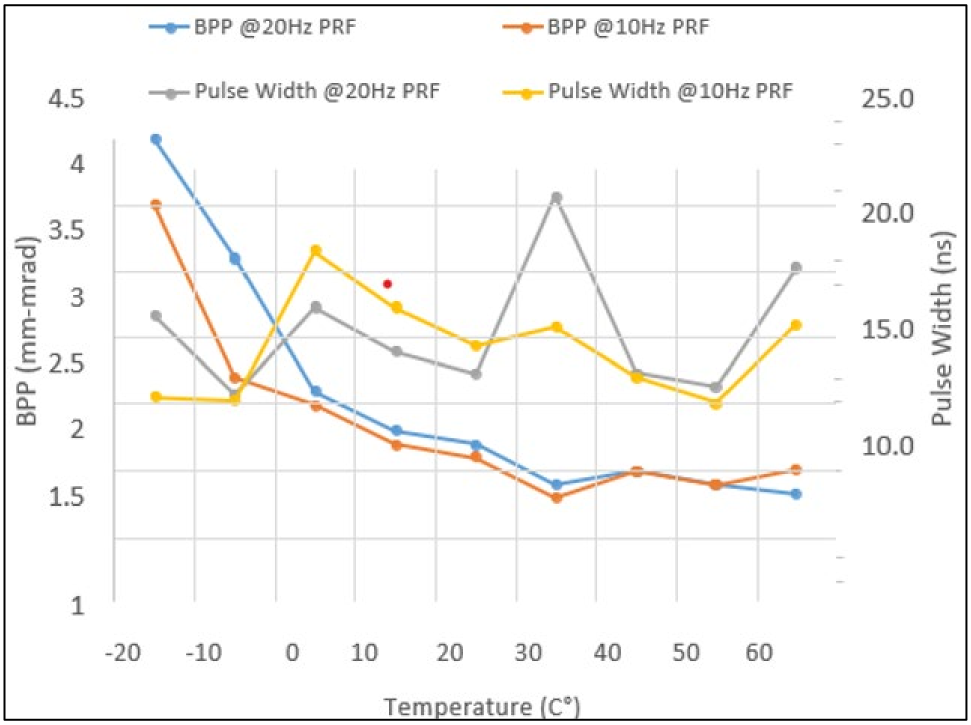

Figure 3: Laser Pulse Width and BPP Performance Over Temperature for a 50-mJ Designator.

In order to provide reliable laser designation throughout missile flight, the missile seeker's detector requires a signal-to-noise ratio (SNR) of at least 7:1. Figure 4 provides a range performance estimation for a typical 50-mJ laser designator operating at a lock on before launch (LOBL) mode in which the weapon operator receives an indication of sufficient laser power to lock the LGM on a safe trajectory toward the target prior to missile launch. A lock on after launch mode can also be used with similar SNR.

In the figure, the gray curve indicates a condition of self-designation, where the laser transmitter Tx range to the target (R1) equals to the missile seeker receiver Rx range to the target (R2). A 10–30-mJ LD designating from 1 km (Tx) will enable LOBL from more than 6000 m [1].

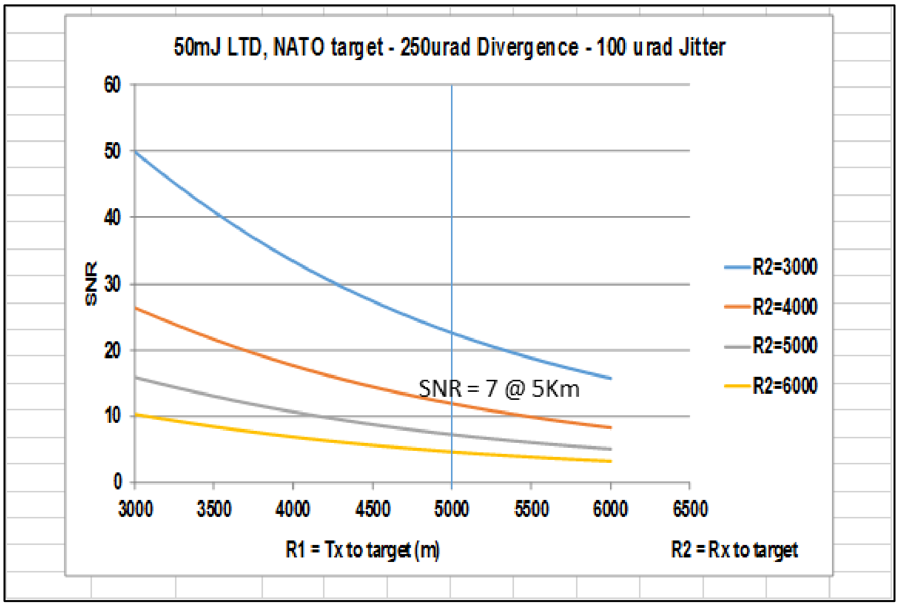

Figure 4: A 50-mJ Laser Designator Predicted to Provide a Reliable LOBL (SNR >7) From a 5000-m Range.

A handheld LD or LD equipped payload for a mini-UAV could enable target designation at close range to provide longer standoff ranges for LGM-carrying platforms (e.g., Apache helicopter or Reaper UAV). For example, a 10–30-mJ LD onboard a mini-UAV designating a target at 1 km will enable a LOBL for a Hellfire missile onboard an Apache helicopter at a 6-km standoff range, increasing platform survivability.

2.2 MARKET FORECAST AND COMPETITIVE LANDSCAPE FOR LDS

The global military LD market is anticipated to reach $3.6B by 2027 and expand at a stable compound annual growth rate (CAGR) of 8% worldwide, including 4.3% in North America and 8.6% in Asia between 2019 and 2027, according to a new research report published by Transparency Market Research titled "Military Laser Designator Market – Global Industry Analysis, Size, Share, Growth, Trends, and Forecast" [4]. Europe's share is also expected to grow, while many of Europe's aircraft manufacturers are incorporating military LDs in their designs. Adoption is also increasing by homeland security agencies, while military LDs are increasingly used on unmanned and handheld systems.

Industry will continue to advance low-SWaP lasers to support these trends. Enhancements to power, stability, and beam divergence will be required to achieve accurate aim for precision ground strike. These will play a significant role in the vehicle-mounted segment maintaining market position. Industry will also mitigate risks like indiscriminate firing. LGM manufacturers should consider redesigning current missile seekers compatible with NATO STANAG 3733 to enable detection of continuous wave laser designators. Weather effects, deployment of smoke screens, and hazards associated with laser operations may hamper the growth of the military LD market over the forecast period.

Table 3 lists key features of currently available LDs providing output power >50 mJ but weighing >1 lb. Although most LDs available today provide this output, several companies are developing lower SWaP LDs that can fit into mini payloads, including the Areté Airtrac LD (10–20 mJ and 30–70 mJ) and Elbit System's mico designator marker LD (10 mJ) [1–3].

Table 3: Available LDs

				Laser Designator Comparison				
Manufacturer	**Model No**	**Wavelength (LD,LRF)**	**Size L x W x H (mm)**	**Weight (gr)**	**Pulse Output (mJ)**	**Power Consumption (W)**	**Beam Div. (urad)**	
FLIR	MLR/TM-10K	1.064/1.535		1000	50	25	350	
L3-ALST	MLD	1.064	145 x 78 x 78	818	80	40	300	
Arete	Airtrac	1.064	117 x 43 x 43	680	70	25	250	
Cilas	AlaDem - R 180	1.064	170x 65x 45	1500	80	65	200	

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