LAFELD

System for testing laser effectors at field conditions

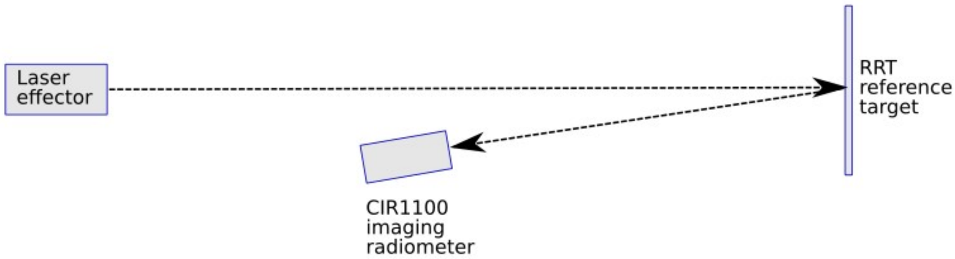
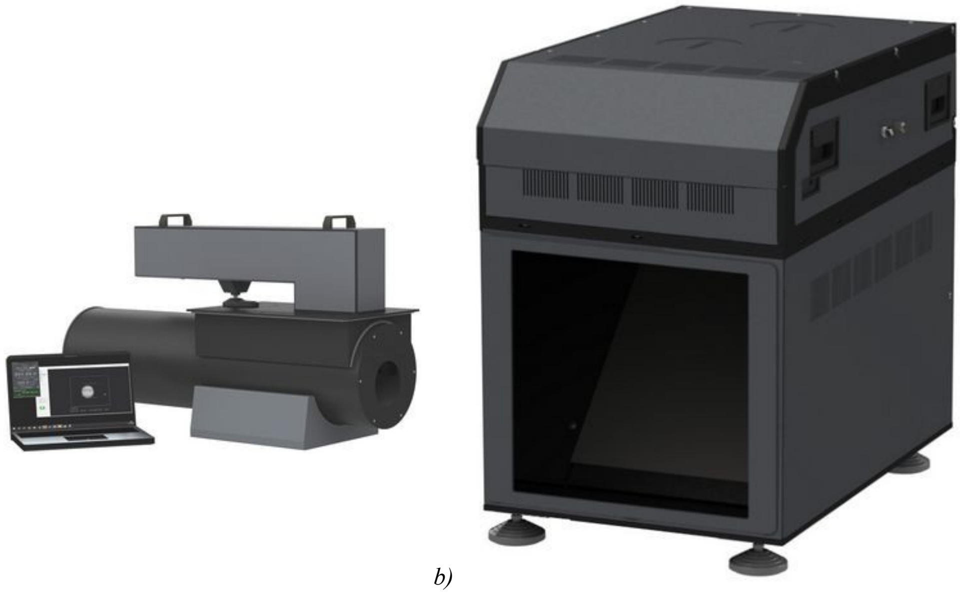


Fig. 1. Block diagram of LAFELD system



a) *b)*

Fig. 2. Main blocks of LAFELD system: a)CIR imaging radiometer, b)RRT reference target

1 Introduction

Laser effectors are high power, low divergence lasers (typically integrated with an aiming device) that can be used to damage targets in a way equivalent to effects of traditional weapons. There is a huge interest in these lasers due to a series of military, dual use or civilian applications. However, practically laser effectors are novelty technology that needs to prove its usefulness and so far practical applications of laser effectors are mostly limited to defense against short distance, agile targets like small drones.

Majority of laser effectors operate at wavelength located at near infrared band from about 800nm to 1100nm. Smaller group of laser effectors operate at longer wavelengths up to 1700nm. Finally, there are rare laser effectors that operate at wavelength located at long part of SWIR spectral range: from 1900nm to about 2400nm.

Typical laser effectors are CW or quasi CW lasers. It means that they emit laser beam of temporally continuous power or emits low/medium energy pulses at high repetition frequency. Damage to target is generated due to high energy absorbed after a relatively long time period (over a second) that generates increased temperature of the target surface.

There are also more rare pulse laser effectors that emit low repetition high energy pulses of short time width pulse. These pulses of ultra high peak power (over 1 MW) generate damage to irradiated target due to ablation effect.

Testing laser effectors is typically done using two methods. First, laser effector is tested at laboratory conditions by measurement of a series of parameters of laser beam (mean power versus time, beam profile versus simulated distance and time, and divergence angle). Second, tests of laser effector are done at field conditions by firing against real targets and checking damage of the target.

Both methods have some advantages and disadvantages.

Lab testing method offers a series of objective parameters that characterize performance of laser effector. However, tests are typically carried out at laboratory ambient temperature and therefore performance of the laser effector can be different at real work temperatures. In addition, it is often difficult to transport to laboratory laser effector integrated with other blocks (aiming imager, angular platform and so on).

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Field tests against real target deliver precise evaluation of performance of laser effector but only against the target used during the field tests. Further on, Yes/No results of field tests do not deliver precise information about non perfections of laser beam generated by the laser effector (temporal changes of both beam profile and beam mean power).

2 What is LAFELD?

LAFELD is a system for testing laser effectors at field conditions that enables measurement of objective parameters of laser beam that irradiates reference uniform target. Practically it means that field tests deliver Yes/No information on performance of tested laser against one specific target when LAFELD tests deliver set of objective parameters that characterize laser beam emitted by laser effector.

In detail, LAFELD work is based on a concept to reflect laser beam using a reference uniform target and to capture video image of this target using a calibrated imaging radiometer coupled with software capable to carry out radiometric image analysis and determine parameters of tested laser effector.

Design of the reference target capable to withstand high power laser beam and design of imaging radiometer capable to capture quantitative images of ultra high light intensity are two main challenges of design of LAFELD system.

3 Test capabilities

LAFELD is optimized for testing typical laser effectors of parameters as in Table 1.

Table 1. Parameters of laser effectors tested using LAFELD system

No	Parameter	Value
1	Mode of work of laser	CW/quasi CW laser (option: additionally high energy pulse laser)
2	Mean power	1 – 30kW (option: up to 100kW)
3	Divergence angle	Up to 0.5mrad (limit depends on angular size of RRT target during tests)
4	Wavelength of laser	Band 1: 800 – 1100nm Band 2: 900nm – 1700nm Band 3: 1950 – 4000nm
5	Distance between tested effector to reference reflective target	Typically in range from 200m to 2000m

Parameters of laser effectors that can be measured using LAFELD are listed in Table 2.

Table 2. Parameters of laser effectors that can be measured

No	Parameter/function	Comments
1	Mean power versus time	Mean power: up to 30kW (option 100kW) Attention: max work time period: up to 60 sec (can be increased)
2	2D beam profile at different distances versus time	Distance: manually regulated distance effector – reference target max work time period: up to 60 sec (can be increased)
3	Effective beam diameter	Calculated on basis of 2D beam profile
4	Divergence angle	Calculated on basis of 2D beam profile

4 Blocks of LAFELD

LAFELD is a modular test system built from five main blocks:

1. RRT reference reflective target,
2. CIR calibrated imaging radiometer (different versions are possible depending on spectral band),
3. T15 tripod,
4. laptop,
5. CIR Control program.

5 Technical specifications

Technical specifications of LAFELD system is presented in form of details of two critical blocks: 1) RRT target, 2) CIR radiometer.

Table 3. Technical parameters RRT target

Parameter	Value
Dimensions of active part	At least 1 x 1m (1 x 1 mrad at 1 km distance) Option: can be increased to 1) 1.5 x 1.5m, 2) 2 x 2m
Maximal acceptable laser irradiation	500 W/cm^2
Maximal total laser power that irradiate target	30 kW (short term - up to 60 sec) – option up 100kW
Wavelength of incoming laser light	In range from about 800nm to about 4000nm (CO_2 lasers are not acceptable)
Total dimensions	Approximate 2.4 x 1.6 x 1.6m
Mass	Approximate 85kg

Table 4. Technical parameters CIR imager

Spectral band	Band 1: 800 – 11000nm	Band: 900 – 1700nm	Band 3: 1950-4000nm
Image resolution	At least 640x480 px	At least 320x240 px	A least 640x480 px
Maximal irradiance of RRT target that can be analysed using CIR1100 radiometer	At least 500 W/cm^2	At least 500 W/cm^2	At least 500 W/cm^2
Max time duration of captured and analysed video sequence	60 sec	60 sec	60 sec
FOV	22.5 x 14.06 mrad (2.25 x 1.4m at distance 100m)	22.4 x 1.68 mrad (2.24 x 1.68m at distance 100m)	21.7 x 16.32 mrad (2.17 x 1.63m at distance 100m)
Image intensity calibration	In W/cm^2 unit	In W/cm^2 unit	In W/cm^2 unit
Recommended distance CIR to RRT target	50 – 150m	50 – 150m	50 – 150m
Operating temperature	+5ºC to +40ºC	+5ºC to +40ºC	+5ºC to +40ºC

6 Test procedure

Tests are carried out using this simplified procedure

1. Locate RRT target at distance R1 of interest from tested effector (typically distance in range from 200m to 4000m)
2. Fix CIR radiometer at T15 tripod
3. Locate CIR radiometer at distance R2 that is short enough to achieve situation when laser beam fills at least 25% of FOV of CIR imaging radiometer (typical distances in range 50 – 200m)
4. Connect CIR with laptop
5. Activate CIR Control program
6. Aim laser effector to center of RRT target
7. Shoot laser effector
8. CIR Control program shall automatically record video sequence
9. Recorded images are analysed by software and parameters of tested effector are calculated.

Attention:
Tests using laser effectors are extremely dangerous for humans due to ultra high power of laser beam. No humans are allowed to be close to RRT target. All humans should wear laser protection glasses and pass special laser safety course.

7 Version

LAFELD can be delivered in three main versions depending on criterion of wavelength of laser:
LAFELD-1: 800 – 1100nm,
LAFELD-2: 900 – 1700nm,
LAFELD-3: 1950 – 4000nm.

8 Options

Previous sections present typical LAFELD system that can be optionally expanded by adding new features:

1. Ability to test laser effectors of mean power up to 100kW
2. RRT target of increased active area (up to 2 x 2m)
3. Ability to test pulse laser effectors.

Option 1 enables testing virtually all laser effectors offered on market.
Option 2 is useful when testing laser effectors at distances over 2 km.
Option 3 enables to test pulse laser effector that use ablation effect to damage targets.

9 Summary

LAFELD is an unique test system that enables accurate performance tests of laser effectors at field conditions. It combines advantages of typical lab tests (measurement of objective technical parameters) with advantages of field tests (work at real work temperatures, testing laser effectors integrated with other EO systems). It is a near perfect tool for both users (ability to verify advertising claims of manufacturers/distributors of laser effectors) and designers (precision information about weak spots of laser effector like temporal deterioration of mean power).

Version 1.3

CONTACT: Tel: +48 22 6668780 Fax: +48 22 3987244 Email: info@inframet.com