LUNI

Universal station for testing laser range finders/designators

Fig. 1. Photo of LUNI test station

Fig. Sample LRFs that can be tested

1 What is LUNI?

LUNI is a station for testing laser range finders developed in 2020 year that can be treated as a more universal alternative to LTE station manufactured since 2011. However, at the same time tests of LRFs using LUNI station are less automatic and slightly more time consuming comparing to tests using LTE station.

LTE station has been Inframet flagship station for testing LRFs and has obtained very good reputation among its users worldwide due to its ability to carry out expanded tests of laser range finders at laboratory conditions without necessity of frequent costly and time consuming field tests. It can be also estimated that LTE enables testing over 98% of LRFs offered on market. However, there are also some limitations of LTE station:

1. Lack of ability to test LRF having thermal imager as an aiming channel or at least necessity to use special adapter with VIS-NIR camera
2. Special adapter needed when testing LRFs with an external sight located at significant distance from receiver or transmitter.
3. The station enables only rough measurement of boresight errors receiver-transmitter, transmitter – to aiming channel (the same as field test when shooting to a target of known angular size and measurement of LRF performance
4. Time consuming process of correction of boresight errors (regulation of module position and checking results without know how which direction if optimal regulation)
5. Only rough measurement of transmitter divergence angle (information how much power of the laser beam hit the target – no detail info on power distribution)
6. Only up to five targets of different angular size can be simulated

LUNI station has been designed in a way that removed or at least reduced limitations listed above.

1. Set of two refractive collimators used in LTE station has been replaced by a single large aperture reflective collimator. This solution enable easy testing LRFs having thermal imager as an aiming channel or when aiming channel is located at some distance from transmitter or receiver.
2. User of LUNI station obtained precision information on optimal direction of regulation of angular position of modules of LRF during process of correction of boresight errors of LRFs (alignment of transmitter and receiver and aiming channel) and alignment process is significantly shortened.
3. Power distribution of transmitter at infinity distance can be presented in detail graphical form. Divergence angle of transmitter can be precisely measured.

Removal of earlier listed limitations of LTE station makes LUNI station as a potentially fully universal station capable to test 100% of LRFs offered on market and capable not only to measure design /performance parameters of LRFs but also deliver accurate measurement of divergence angle and support for optimal alignment of LRF modules.

However, tests of LRFs using LUNI station are less automatic and more time consuming comparing to tests using LTE station. LTE station is a stand alone, remotely controlled test station that require only manual switching of modules when changing wavelength of tested LRFs. LUNI is a modular station that can be arranged into several configurations for different tasks but switching from one configuration to another is done manually. Therefore tests of LRFs using LUNI station are less automatic and slightly more time consuming but the station offers significantly wider test capabilities.

2 Testing laser designators

The LUNI station can be also used for testing laser designators. The latter devices can be typically treated as high power transmitter of design very similar to transmitters used by LRFs. The same parameters used to characterize transmitters of LRF are used also for characterization of laser designators. Therefore next section shall talk only on testing LRFs.

3 What can be tested?

From the point of optics the laser range finders can be divided onto several groups:

1. Dual channel LRFs with integrated sight (two separate optical channels (receiver and transmitter) and aiming system integrated with transmitter or receiver. The channels are located at very short distance from one to another. The aiming device can be optical sight, VIS-NIR camera, or night vision device.
2. Dual channel LRFs with a sight as a third optical channel located at short distance to transmitter or receiver.
3. Dual channel LRFs with an external sight located at significant distance from receiver or transmitter.
4. Dual channel LRFs built using an external thermal imager as a sight.
5. Single channel LRFs built using using a single coaxial optics channel (receiver is integrated with transmitter and sometimes also with an aiming device into one optical system)

All these types of LRFs can be tested using LUNI but with some limitations. Precision drawings of internal channel of single channel LRF is needed to prepare adapters needed to do testing such LRFs. Precision drawings are needed also in case of dual channel LRFs with an external sight located at significant distance from receiver or transmitter.

Next, LRFs tested using LUNI can operate at different wavelengths located in spectral band from 800nm to 1700nm. Typical calibrated wavelengths are: 910nm, 1064nm, 1530nm, 1550nm, 1570nm. Other wavelengths are optional. Change of wavelengths of LRF is done my manual exchange of pulsed light source.

Further on, LUNI is mostly targeted for testing medium/long range LRFs of maximal operational distance from about 1km to over 40km. However, short range LRFs can also be tested (distance as short as 40m can be simulated). The only limitation on LUNI is requirement to be used at typical laboratory/workshop conditions. It is not optimized to be used at extreme field conditions.

Tab. 1. Technical specifications of LRFs to be tested

Parameter	**Value**
Types of tested LRF	Optimized for all types of LRF
Spectral wavelength of tested LRFs	To be in band from 800 to 1700 nm
Central wavelength of pulsed light sources	905nm, 1060 nm, 1540 nm, 1550 nm, 1570 nm (the sources can be manually exchanged)
Optics of tested LRF	Collimator 120 mm diameter should overlap transmitter or receiver of LRF
Range of tested LRF	Optimized for testing medium/long ranger LRF but short range LRFs can be also tested: simulated distance from 40m to 40km (option 98km)
Ambient conditions	Typical laboratory/workshop conditions

4 How is built?

LUNI is a modular station built from following blocks:

Configuration A

1. CDT12100HR off-axis reflective collimator,
2. SOA set of optical attenuators,
3. LSC set of laser sensing cards,
4. CAP card pocket,
5. UPB universal projecting block

6. CLD set of exchangeable calibrated laser diodes
7. OR optical receiver
8. OTR optical trigger,
9. XNAS angular stage,
10. HEC camera,
11. UPB Control program,
12. Pulse Browser program,
13. MET Control program,
14. Laptop.

Configuration B

Additional blocks:

1. LSR10 laser beam profiler
2. BOR computer program

Configuration C

Additional blocks:

1. MTP multi-target projector
2. MLS set of multi light sources,
3. RUD reference uniform detector,
4. LATRA Control program.

5 How it works?

LUNI is a modular test system that can be arranged to work in three configurations:

A) Calibrated receiver/transmitter,
B) High dynamic SWIR camera,
C) Multi-emitter transmitter.

Changing configuration requires manual change (adding/removing) of some blocks. Configuration A is the most important and form base version of LUNI. Configurations B and C are optional.

LUNI in configuration A projects image of a target that works as a calibrated receiver (when testing transmitter of LRF) or calibrated transmitter (when testing receiver of LRF). The task of user is to aim tested LRF to the simulated target and to shoot. Configuration A enables measurement of virtually all important parameters of LRFs.

Configuration B offers capturing spatial distribution of light intensity of laser beam emitted by the transmitter at optical infinity. Divergence angle of transmitter is calculated. LUNI works as a special SWIR camera of ultra high dynamic (over 10^{10}) capable to capture without blurring pulses emitted by both high power monopulse LRF (peak power over 1MW) and pulses emitted by multi pulse LRF (peak power as low as 1W).

Configuration C enables fast user friendly measurement of boresight error between receiver axis and transmitter axis and potential fast aligning of both axis. The station works here as a special transmitter that simulates a series of targets located at different distance controlled from PC.

From another point of view parameters of LRFs are measured by LUNI stations in three different ways. First, tested LRF generates an optical stimulus that is measured by the test station. Second, tested LRF generates an optical/electrical stimulus that is measured by the test station that trigger test station to generate its own optical stimulus. The latter stimulus is finally detected by the LRF that produces an indication in form of simulated distance. Parameter of tested LRF is determined depending on value of stimulus generated by the test station. Third, tested LRF generates optical stimulus that generates image visible for an aiming device (human eye, VIS-NIR camera or thermal imager). The aiming device is later used to measure angular displacement of this image relative to reference position.

6 Test capabilities

LUNI has been developed as a quasi universal stations that can be used for RD projects, factory quality control, acceptance tests or maintenance tests of almost all LRF offered on the market.

LUNI test station enables expanded tests of laser range finders at laboratory conditions without necessity of frequent costly and time consuming field tests (it is still recommended to do some field tests). The station enables measurement of transmitter radiometric parameters, transmitter imaging parameters, receiver/performance parameters, and boresight errors. However, as mentioned earlier LUNI can work in three different configurations that offer differ in test capabilities:

6.1 Configuration A

Luni in configuration A enables following tests (measurement of parameters):

1. Transmitter radiometric/temporal tests: pulse energy, pulse peak power, pulse time width, pulse frequency, coding, missing pulses
2. Transmitter spatial tests: transmitter divergence angle (rough measurement),
3. Receiver tests: receiver sensitivity, FOV
4. Total performance tests: distance measurement, distance discrimination, extinction ratio (ER), and operational range. Two latter parameters can be measured for up to five angular sizes of simulated target.
5. Basic boresight errors: 1)transmitter to aiming channel (angle between transmitter axis and axis of aiming channel) – fast and accurate measurement, transmitter to receiver (angle between transmitter axis and axis of receiver) - slow measurement by repeated shooting to the target and finding position of maximal signal.

Tab. 2. Test capabilities of LUNI in configuration A

No	Parameter	Measurement range	Measurement uncertainty
		Transmitter parameters	
1	Pulse energy	10nJ to 200 mJ	10%
2	Pulse time width	4-600 ns	5% or 1ns
3	Pulse peak power	1W to 10 MW	10%
4	Pulse Repetition Frequency	0.1 Hz to 50 kHz	0.001% for 10Hz
5	Pulse coding	Yes (customer is expected to define type of coding used)	
6	Missing pulse	Yes	
7	Divergence Angle	Up to 10 mrad	Typically 50%
		Receiver parameters	
8	Receiver sensitivity	0.1 nW/cm² to 10μW/cm²(depends on wavelength)	10%
9	Field of view of the receiver	5 mrad	0.2mrad or 10% of FOV
		Performance parameters	
10	Operational range	40m to 40km (option 98km)	Calculation based on theoretical model
11	Distance measurement accuracy	At least 40 m – 40 000 m (option 98 km)	1.5 m (option 0.5 m)
12	Distance discrimination	Up to three echos with regulated distance difference: 50 m – 6 000 m	1.5 m (option 0.5 m)
13	Relative Extinction Ratio	At least 0.1 dB – 60 dB (for target at 500m distance)	1dB
14	Absolute Extinction Ratio	At least 100 dB -160 dB	1dB
		Boresight paramers	
15	Alignment error between transmitter of LRF and internal optical sight	22 mrad	0.1mrad
16	Alignment error transmitter to external thermal imager/VIS-NIR camera	22 mrad	0.1 mrad
17	Boresight of transmitter relative to receiver	Yes	0.1mrad or 10% of receiver FOV

* Maximal distance is dependent on used PRF

6.2 Configuration B

Test capabilities of LUNI in configuration B are listed in Table 3. At can we see LUNI in configuration B offers measurement of divergence angle that can be measured also in configuration A. However, configuration B offers much more accurate measurement.

Tab. 3. Test capabilities of LUNI-B test station

No	Parameter	Measurement range	Measurement uncertainty
1	Divergence Angle	Up to 10 mrad	0.1 mrad
2	Spatial distribution of light intensity of laser beam	Up to 10 mrad	0.1 mrad

6.3 Configuration C

Test capabilities of LUNI in configuration B are listed in Table 4. As can we seen LUNI in configuration C offers the same boresight tests as configuration A. However, it should be emphasized that boresight tests in configuration C can be done several times faster.

Tab. 4. Test capabilities LUNI in configuration C

No	Parameter	Measurement range	Measurement resolution	Measurement uncertainty
1	Alignment error between transmitter of LRF and internal optical sight used as an aiming device	22 mrad	0.04 mrad	0.1 mrad
2	Alignment error between transmitter of tested LRF and external thermal imager/VIS-NIR camera	22 mrad	IFOV of imager	0.1 mrad
4	Alignment error between transmitter and receiver of tested LRF	11 mrad	0.05 mrad	0.1 mrad 0.1 mrad or 10% of receiver FOV

Tab. 5. LUNI software capabilities

Software	Description
UPB Control	Program to enable PC control of settings of UPB universal projector block
Pulse Browser	Support acquisition and analysis of temporal profiles of pulses emitted by laser transmitter
MET Control	Program to enable control of pulse generator module (distance simulation)
BOR program	Support acquisition of images from LSR10 laser beam profiler
LATRA Control	Program to support boresight transmitter-receiver

7 Versions

LUNI is offered in form of several versions of different number of blocks and different test capabilities:

1. LUNI-A – basic version of LUNI that can work in configuration A
2. LUNI-AB – can work in configuration A and configuration B,
3. LUNI-AC – can work in configuration A and configuration C,
4. LUNI-ABC – can work in configuration A, configuration B and configuration C.

This solution makes possible for potential customer to choose optimal version. However, it should be noticed that more advanced versions are more expensive.

8 Options:

There is a series of options that help to operate LUNI station:

1. Additional external aiming channel in form of RTP reference target projector to enable testing LRFs having an VIS-NIR aiming channel at significant distance (more than about 100mm between optical axis) from transmitter optics of LRF
2. Additional adapters to enable testing single channel LRFs built using using coaxial optics solution. Coaxial LRF are rarely met on market but sometimes it is needed to test such LRFs.
3. Electrical triggering of emitter block in LTE station (enables distance simulation for receiver of tested LRF without necessity of shooting the transmitter - increases safety and easiness of such tests)
4. AT720 optical table optimized for LTE station.
5. Maximal simulated distance is increased to 98km from typical level 40km.
6. Uncertainty of simulated distance is improved to 0.5m from typical level 1.5m.
7. Inframet can deliver optional computer programs to calculate: 1)maximal operational range of laser designator at simulated work conditions (target size, target reflectivity, weather conditions, day level target illumination, laser designator parameters), 2)maximal operational range of laser range finder at simulated work conditions (target size, target reflectivity, weather conditions, parameters of LRF)

Coding: Number of interesting option should be added to the station code. LUNI-A-124 means that LUNI-A station with options 1,2 and 4 is to be delivered.

9 Why LUNI station?

LUNI is the only truly universal station for expanded testing and boresight of laser ranger finders. It offers measurement of a long list of parameters and boresight errors of LRFs. The station is particularly suitable for RD projects, manufacturing quality control or for acceptance tests.

Version 1.7

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