

# MRV TereScope 700/G Laser Link

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## 1 Abstract

This Report discusses the experience gained in installing and operating an MRV TereScope 700/G laser link over a distance of 400 m.

**Keywords:** free-space optics, laser data link, TereScope 700/G, tests, operating experience.

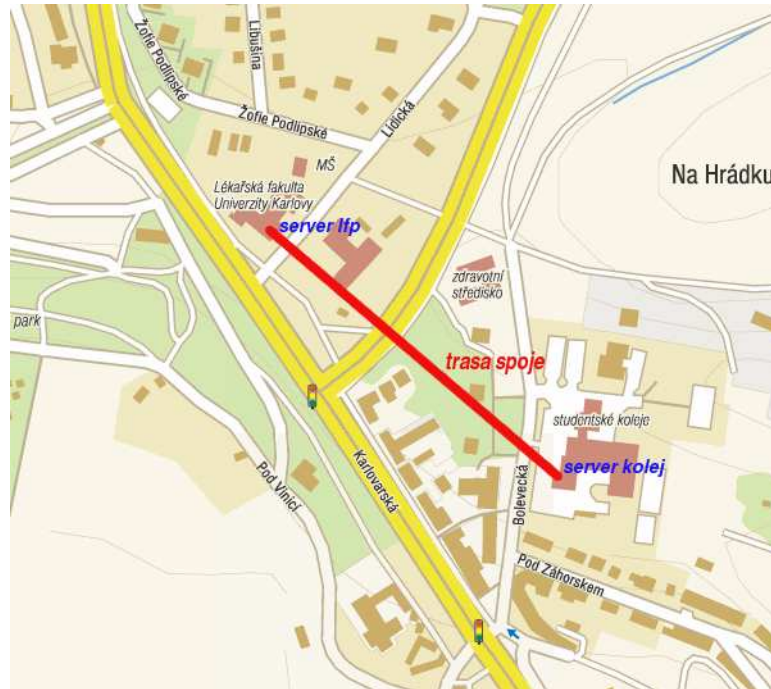
## 2 Introduction

Among the goals of CESNET's "Optical Networks and their Development" research program is testing the feasibility of new technologies with respect to providing first-mile connections to the CESNET2 gigabit network in locations that do not allow the use of optical fiber. Selected products that seem to be suitable for such use are being tested in real-life environment to determine their actual suitability.

In February and March 2007, we have tested the *MRV TereScope 700/G* – an FSO (Free Space Optics) laser system capable of transferring data at 1 Gb/s full duplex.

## 3 Location

The model used for testing has been designed for distances of 400 to 420 meters. The Lochotín site was chosen for the test. The laser link was used to connect the student dormitories of the University of West Bohemia located in the Bolevecká street to one of the buildings of the Charles University Faculty of Medicine in Pilsen, which is located in the Lidická street. The distance from one building to the other is – according to a GIS application – 400 m. The set-up was purely experimental.



**Figure 1:** Map of the test site – connecting UWB student dormitories (Bolevecká street) to the CU Faculty of Medicine (Lidická street)

## 4 Laser Link Description

We have taken the opportunity to borrow a *TereScope* laser system for testing. It is a Free Space Optics (FSO) device manufactured by Israel-based *MRV Communications, Inc*<sup>1</sup>. The system works as a so-called media converter. The manufacturer offers a wide range of models differing in bandwidth and range. The link is certified for use in the Czech Republic and users do not have to apply for any communications licenses or approvals. The laser link was provided by the local distributor – the *PROFComms Company*<sup>2</sup> – cooperating with a certified partner and retailer – the *DISK Company*<sup>3</sup>.

The model that best suited our needs was the *MRV TereScope 700/G*, designed for distances of 400–425 m. The power output of its laser is 16 mW, it operates at wavelengths of 830 to 860 nm, and according to the data sheet<sup>4</sup>, it should be capable of full duplex transfers at 1.062 Gb/s. The device connects to a duplex optical interface – 850 nm SC multimode by default. At the time of testing, the

<sup>1</sup><http://www.mrv.com/>

<sup>2</sup><http://www.proficomms.cz/>

<sup>3</sup><http://www.diskobol.cz/>

<sup>4</sup>[http://www.proficomms.cz/my\\_files/download/Brochure%20TS.pdf](http://www.proficomms.cz/my_files/download/Brochure%20TS.pdf)

price of the equipment (two units necessary to set-up a link) amounted approx. to CZK 200,000 (VAT not included).

The device is designed for out-door use. It is compact, consisting of a sturdy metallic case and a positioning mechanism. The case contains a laser transmitter and a receiver, electronic components, and an optical cross-hair pointer. The case has to be connected to a 230 V power supply and an optical fiber cable. The device is fitted with an SNMP module allowing its state to be monitored remotely.



**Figure 2:** Full installation of the TereScope700/G laser link (the opposite end of the link is located at the top of the tower marked by a red arrow)

## 5 Installation

Since it is necessary to align the laser beam very precisely, the manufacturer recommends to make the installation as sturdy as possible – preferably incorporating the device into the building structure. As our set-up was only intended for testing, we have decided for a provisional solution fastening the devices to massive metallic mounts weighted by concrete panels.

The actual installation was carried out by the employees of the DISK Company. Laser emitters need to be pointed using the integrated optical pointer and fine-

tuned by observing the optical signal intensity shown by the device's numeric display. In our set-up, signal intensity amounted approximately to 230.



**Figure 3:** An open case

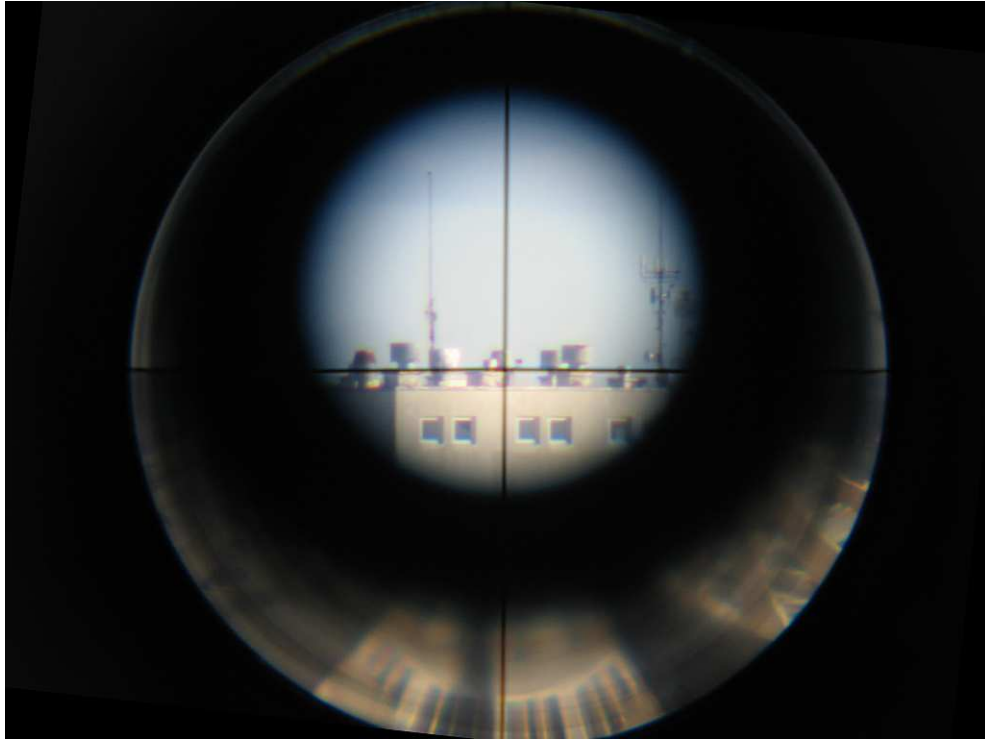
The device is engineered at a very high professional level. Correct alignment of both ends of the link can be achieved by two people using standard tools and equipment in the matter of several hours.

In the course of our tests, we have noted no deviations in the alignment of the emitters.

## 6 Tests and Results

Two PC servers running Linux kernel 2.6.19 were used to carry out the proposed tests and achieve result as precise as possible. Both machines were dedicated to the tests and their resources were not used for any other purpose.

The *kolej* server, which was located in the student dormitories, run on a *Dell PowerEdge 2850* hardware (2 x Intel Xeon 3.6 Ghz, 8 GB RAM, 2 x integrated Intel PRO/1000 gigabit Ethernet). One interface was used to connect the server to the Internet, the other one (with IP address 10.1.1.20) was connected to the laser link through a *Transition Networks J/GE-CF-01* media converter. The media



**Figure 4:** Viewing the opposite end of the link through the optical pointer

converter had to be used to allow us to connect the server's metallic interface to the laser system's optical interface.

The *lfp* server located at the Faculty of Medicine run on a *Dell PowerEdge 1850* hardware (1 x Intel Xeon 3.2 Ghz, 2 GB RAM, 2 x integrated metallic Intel PRO/1000 gigabit Ethernet). One interface was used to connect the server to the Internet, the other one (with IP address 10.1.1.100) was connected to the laser link through a *Transition Networks J/GE-CF-01* media converter.

To achieve maximum relevance of the results, we have started with connecting the two servers "directly" by means of an optical cable. Thus, instead of using the laser link, we were only using optical fiber in a laboratory environment. After that, the same tests were run again using the free-space laser link.

The *iperf* application was used to saturate the link. *iperf* is a client-server application used to generate intensive UDP transmissions capable of filling up the given bandwidth. Data stream is recorded to a hard drive. The test is very aggressive and demanding in the sense of both endpoints computing power (namely bus and network interface throughput). The amount of data transferred, bandwidth, jitter and packet loss were measured second-by-second – they were retrieved from the *iperf* log.



**Figure 5:** Installation and fine-tuning. The opposite end of the link is located on the roof of the block building in sight.

To avoid the nuisance of working with the multiplies of 1024 to convert bits to megabits and vice versa, all values will be given in bits per second and millions of bits per second.

## 6.1 Servers connected through a fiber link

Initial measurements were taken in a laboratory with both servers connected through media converters to an optical cable.

### 6.1.1 One-Way Traffic

The *kolej* server was running an iperf server started with the following parameters:

```
10.1.1.20# iperf -s -u -i 1 -f b > iperf.log
```

The *lfp* server was used to generate a UDP stream at 1,000 million bits per second for 10 hours:

```
10.1.1.100# iperf -c 10.1.1.20 -u -f b -b 1000000000 -t 36000
```

The initial test yielded the results shown in Table 1.

Interval:	0.0–36,000 sec
Transfer:	4,306,481,424,000 Bytes
Bandwidth:	956,995,872 bits/sec
Jitter:	0.017 ms
Lost / Total Datagrams:	86,400 / 2,929,665,600 (0.003%)

**Table 1:** Results of one-way traffic test with servers connected by a fiber link.

The results are perfectly balanced. During the 10 hours, 4,306 GB were transferred at the approximate speed of 957 million bits per second with almost zero packet loss.

### 6.1.2 Two-Way Traffic

Both machines were running iperf servers started with the following parameters:

```
10.1.1.20# iperf -s -u -i 1 -f b > iperf.log
```

```
10.1.1.100# iperf -s -u -i 1 -f b > iperf.log
```

At the same time, both machines were transmitting UDP streams generated at a speed of 1,000 million bits per second for 10 hours. The iperf clients were started with the following commands:

```
10.1.1.100# iperf -c 10.1.1.20 -u -f b -b 1000000000 -t 36000
```

```
10.1.1.20# iperf -c 10.1.1.100 -u -f b -b 1000000000 -t 36000
```

Similar results were recorded at both endpoints; they are shown in Table 2.

Interval:	0.0–36,000 sec
Transfer:	4,017,707,568,000 Bytes
Bandwidth:	892,823,904 bits/sec
Jitter:	0.017 ms
Lost / Total Datagrams:	3,110,400 / 105,467,961,600 (1.14%)

**Table 2:** Results of two-way traffic test with servers connected by a fiber link.

The results are once again balanced. In comparison to one-way data transfer, the bandwidth decreased slightly (893 million bits/sec as opposed to 957 million bits/sec achieved in the previous scenario) and packet loss increased (from 0 % to 1.14 %). This can be explained by limited throughput both endpoints must experience at such high transmission speeds. To rule out any possible media converter influence, we have repeated the same tests with both servers connected through a cross-over UTP cable. The results were the same.

## 6.2 Servers connected through a laser link

Once laboratory tests were completed, both servers were transported to the remote site and connected through media converters to the laser link.

### 6.2.1 One-Way Traffic

The *kolej* machine was running an iperf server started with the following parameters:

```
10.1.1.20# iperf -s -u -i 1 -f b > iperf.log
```

while *lfp* was generating a UDP stream at 1,000 million bits per second for 10 hours. The iperf client was started using the following command:

```
10.1.1.100# iperf -c 10.1.1.20 -u -f b -b 1000000000 -t 36000
```

The test results are summarised in Table 3.

Interval:	0.0–36,000 sec
Transfer:	4,306,460,256,000 Bytes
Bandwidth:	956,991,168 bits/sec
Jitter:	0.016 ms
Lost / Total Datagrams:	93,600 / 2,929,658,400 (0.003%)

**Table 3:** Results of one-way traffic test with servers connected by a laser link.

Once again, the results are balanced and – compared to results achieved with a fiber connection – have not change significantly.

### 6.2.2 Two-Way Traffic

Both machines were running iperf servers started with the following parameters:

```
10.1.1.20# iperf -s -u -i 1 -f b > iperf.log
```

```
10.1.1.100# iperf -s -u -i 1 -f b > iperf.log
```

At the same time, both machines were transmitting UDP streams generated at a speed of 1,000 million bits per second for 10 hours. The iperf clients were started with the following commands:

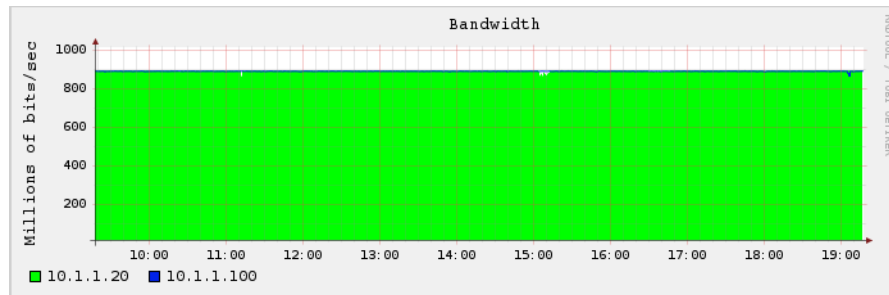
```
10.1.1.100# iperf -c 10.1.1.20 -u -f b -b 1000000000 -t 36000
```

```
10.1.1.20# iperf -c 10.1.1.100 -u -f b -b 1000000000 -t 36000
```

Similar results (shown in Table 4) were recorded at both endpoints.

Interval:	0.0–36,000 sec
Transfer:	3,972,705,881,760 Bytes
Bandwidth:	882,823,529 bits/sec
Jitter:	0.017 ms
Lost / Total Datagrams:	3,369,600 / 105,467,702,400 (1.97%)

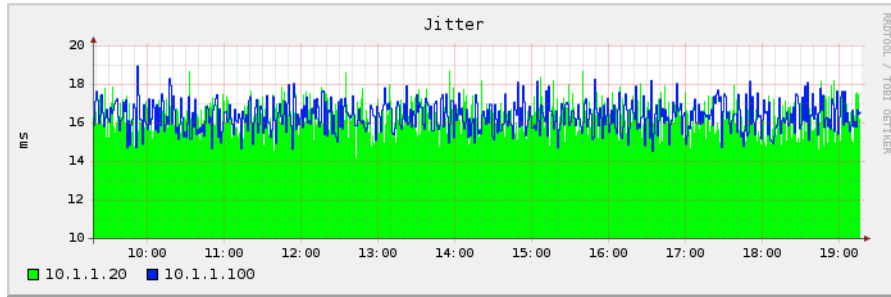
**Table 4:** Results of two-way traffic test with servers connected through a laser link.



**Figure 6:** Graph showing the bandwidth of a laser link connecting two computers

Once again, the results are balanced. Compared to the fiber-based connection, the bandwidth dropped slightly (883 million bits/sec as opposed to 893 million bits/sec measured previously) and packet loss increased (from 1.14 % to 1.97 %).

Test results show that in our set-up, the laser link works as well as an optical fiber. The fact that the actual bandwidth measured differs from the rated



**Figure 7:** Graph showing the jitter of a laser link connecting two computers

bandwidth is caused by the computers being unable to saturate the capacity of gigabit transmission channels (both fiber and free space) being used for the test. Measurement results are thus influenced by the throughput of the endpoint servers, which is lower than that of the laser link.

### 6.3 FLUKE – EtherScope Tester Measurements

To determine the full bandwidth of the laser link, we have replaced the endpoint servers with two *FLUKE Networks EtherScope* gigabit testers.

Bandwidth measured in a full duplex mode amounts to 999,998,000 bits/sec, corresponding with numbers given in the *TereScope* product specification. Packet loss was lower than 0.1 %.

EtherScope testers yielded results summarised in Table 5.

Frame Size	Max Test Rate [fps]	Throughput Rate [fps]	Max Test Rate [bps]	Throughput Rate [bps]
64	1,488,095	1,465,883	999,999,872	985,073,408
128	844,594	831,988	999,999,296	985,073,792
256	452,898	448,379	999,998,784	990,020,864
512	234,962	233,787	999,998,272	994,997,504
1,024	119,731	119,132	999,993,344	994,990,464
1,280	96,153	95,672	999,991,168	994,988,800
1,518	81,274	80,867	999,995,264	994,987,584

**Table 5:** Results of EtherScope tests

### 6.4 Measurement-Related Notes

Laser link measurements were taken in the course of a whole month. Results observed during that period did not differ significantly from those achieved in the 10-hour tests described above.

We have experienced only one drop-out caused by thick fog. This is a known problem in laser links, which can be overcome by setting up a back-up connection based for example on WiFi technology.

## **7 Conclusion**

The **MRV TereScope 700/G** system is a Free Space Optics (FSO) device. It uses a 16-mW laser and is intended for out-door use to provide full duplex 1 Gb/s connecting between two sites over a distance of 400 to 420 m. It is certified for use in the Czech Republic and the user does not need to apply for licensing or approval.

The TereScope700/G met our expectations fully.

The installation is rather simple and well documented. In the space of one month, there was no deviation in the initial laser beam alignment.

Test results are considered outstanding. The device was able to transfer all the bandwidth we were able to generate – 883 million bits/second full duplex with data generated by real servers and 1,000 million bits/sec with data generated by gigabit testers. There was almost zero packet loss.

There was only one outage caused by thick fog in the space of one month.

On the whole, we regard the **MRV TereScope 700/G** as a professionally built device that can be used in environments requiring high bandwidth and high reliability of data transfers at a distance of up to 400 m. To achieve uninterrupted communication even in the event of thick fogs, it is however necessary to provide a back-up link using for example a WiFi connection. The price/power ratio is regarded as very favorable.

In conclusion, we would like to thank the PROFComms Company for providing the laser link, the DISK Company for carrying out the installation, and the University of West Bohemia in Pilsen and the Faculty of Medicine of the Charles University in Pilsen for making their buildings available for the test.