ZIMMERWALD REMOTE CONTROL
BY INTERNET AND CELLULAR PHONE

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Abstract

The Zimmerwald Laser Station can be operated from a remote system using telnet and X-window clients, supervised using any web browser, and controlled to a certain extent by cellular phone. The paper describes the control possibilities available on the different media. The presentation includes online demonstrations depending on the actual communication conditions during the workshop session.

1. Introduction

At the 14th International Workshop on Laser Ranging in San Fernando the author of this paper presented a live demonstration of the remote control of the Zimmerwald SLR station during the session "Automation and Remote Control". This paper is a written illustration of the demonstration.

A detailed description of most components necessary for a successful remote control and/or automated operation of the Zimmerwald SLR station has already been presented at earlier Workshops on Laser Ranging by the author (Gurtner et al.1999, Gurtner et al. 2002).

2. Remote Control Architecture

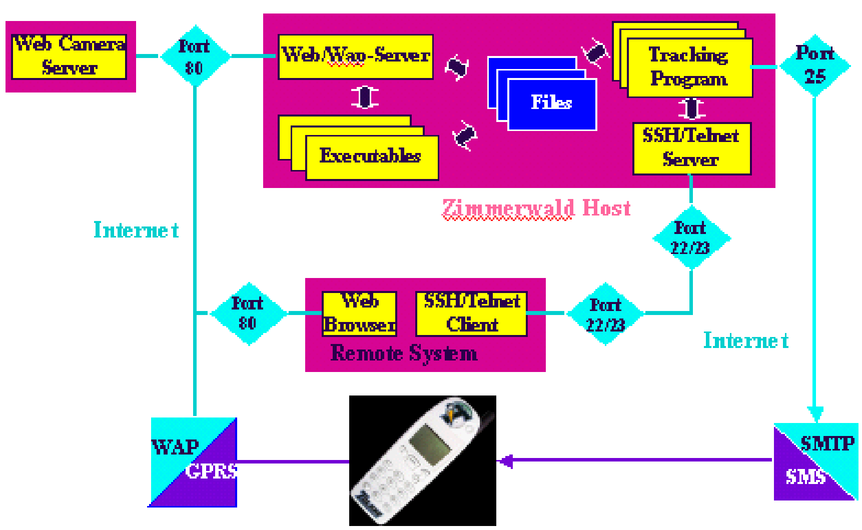

Figure 1: Remote Control Architecture

Fig. 1 shows the main components used for remote control of the SLR station. The station computer, an Alpha server running under the VMS operating system, hosts the programs used for the SLR operation (prediction management, satellite tracking, data acquisition, post-processing, and data submission) as well as a telnet and SSH (secure shell) server for remote login, and a web server. The latter also deals with Wireless Application Protocol (WAP) requests for Wireless Markup Language (WML) web pages to be sent to cellular phones. By means of an Email-to-SMS converter utility the programs running on the station computer can also generate short messages to be sent to any cellular phone (e.g., completion or error messages).

2. Web Access

The web server running on the main computer can, on request of the user, execute a number of programs to prepare web pages with system/station information in real-time:

2.1 System Status

Current use of the system, status of various components:

```
The Telescope / CAMAC are currently used by:

Account            : LASER
Terminal           : FTA15
Remote port        :
Mode               : INTERACTIVE
Program            : ZIMLAS
Observer           : EP
Start time         : 07:41 UT
Stop  time         : 08:42 UT
Remote ctrl        : No
Auto mode          : No

Laser              : ON
LS air temperature: 19.9
LS osc.temperature: 21.6
Dome               : Open
ZIMLAT PC          : ON
CAMAC PC           : ON
CAMAC Crate        : ON
Rain               : NO
```

Figure 2: Current System Status

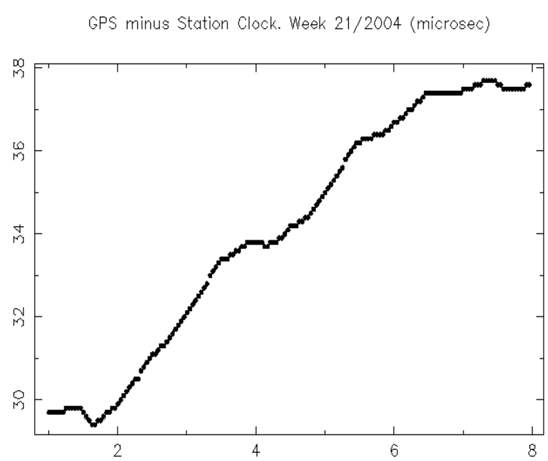

Figure 3: Station Clock Behavior

2.2 Station meteorology

Current met sensor readings, maximum/minimum values, time series, RINEX met files.

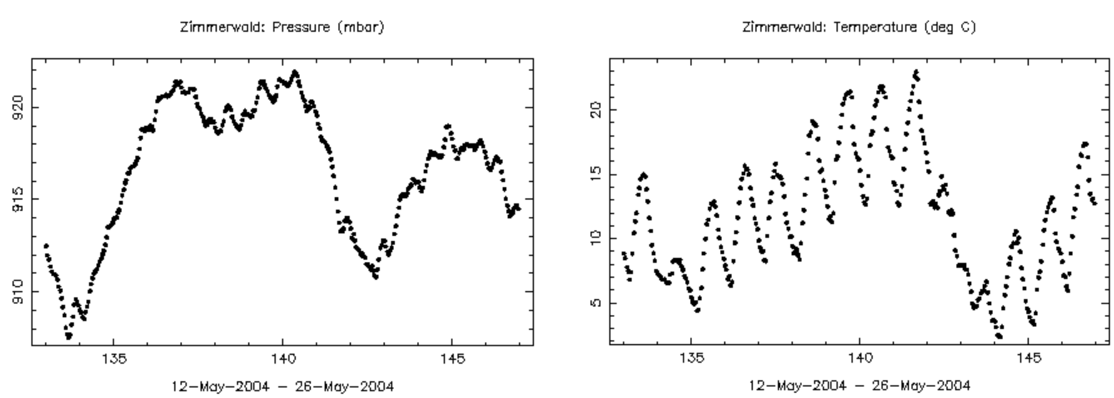

Figure 4: Surface Met Values (Pressure, Temperature)

```
2              METEOROLOGICAL DATA                     RINEX VERSION / TYPE
MET_STORE           AIUB                17-MAY-04 00:02     PGM / RUN BY / DATE
ZIMMERWALD                                                  MARKER NAME
     3    PR    TD     HR                                   # / TYPES OF OBSERV
PAROSCIENTIFIC      740-16B                        0.2   PR SENSOR MOD/TYPE/ACC
ROTRONIC PT100      MP409A                         0.3   TD SENSOR MOD/TYPE/ACC
HYGROMER C94        MP409A                         2.0   HR SENSOR MOD/TYPE/ACC
        0.0           0.0           0.0          950.0   PR SENSOR POS XYZ/H
                                                            END OF HEADER
 04  5 17  0  2  3  918.9    9.4   64.0
 04  5 17  0 25  2  918.8    9.2   65.0
 04  5 17  0 55  2  918.7    8.9   66.0
 04  5 17  1 25  2  918.7    8.8   65.0
 04  5 17  1 55  2  918.6    9.2   63.0
 04  5 17  2 25  2  918.6    9.3   62.0
 04  5 17  2 55  2  918.7    9.1   61.0
 04  5 17  3 25  2  918.7    9.0   62.0
 04  5 17  3 55  2  918.7    8.8   61.0
 04  5 17  4 25  2  918.8    8.2   70.0
 04  5 17  4 55  2  919.0    8.3   65.0
 04  5 17  5 25  2  919.1    8.9   73.0
 04  5 17  5 55  2  919.2    9.5   71.0
 ..  .  .  . ..  .  .....    ...   ....
```

Figure 5: RINEX Met File

2.3 Web cameras

Two cameras on the roof are connected to a camera web server. They show the current weather conditions. One camera also gives an external view of the SLR telescope.

The pictures are available as individual frames (jpeg files) or (password protected) as continuous streams ("server push" mode).

Figure 6: Roof North

Figure 7: Roof South

2.4 List of possible passes

Pass lists can be generated and displayed for any interval within the next seven days.

Observable Satellite Passes From 09-Jun-04 13:00 To 09-Jun-04 17:05 MESZ

No.	Satellite	UTC	MESZ	Filename	Sun	Day	Ele
267	GLONASS-87	11:00 - 13:07	13:00 - 15:07	R709JN04I	Y	Y	67
281	GFO-1	11:00 - 11:05	13:00 - 13:05	GF09JN04K	Y	Y	86
282	AJISAI	11:27 - 11:42	13:27 - 13:42	AJ09JN04L	Y	Y	58
283	GRACE-A	11:28 - 11:31	13:28 - 13:31	GA09JN04L	Y	Y	21
284	GRACE-B	11:29 - 11:31	13:29 - 13:31	GB09JN04L	Y	Y	21
285	JASON	12:09 - 12:21	14:09 - 14:21	JA09JN04M	Y	Y	39

```
286  TOPEX          12:16 - 12:28   14:16 - 14:28   TP09JN04M   Y    Y    37
     --- Break ---  13:07 - 13:30   15:07 - 15:30    23 min
287  AJISAI         13:30 - 13:44   15:30 - 15:44   AJ09JN04N   Y    Y    80
     --- Break ---  13:44 - 14:14   15:44 - 16:14    30 min
288  LAGEOS         14:14 - 15:01   16:14 - 17:01   L109JN04O   Y    Y    62
289  LAGEOS-2       14:20 - 15:05   16:20 - 17:05   L209JN04O   Y    Y    44
```

Figure 8: Pass List

2.5 Observers' schedule

The table shows the scheduled observers for the two daily shifts for the current month. It can be modified over the web by the observers (password-protected, if not on site).

```
               Beobachterliste für den Monat JUNI 2004

     +-----------------+--------+-----------+-----------------+   Abwesend
     |  Datum          |  Tag   | Betreuung |       Nacht     |  WG  JU  EP
     +=================+========+===========+=================+
     |  Di/Mi   1 Jun  |   JU   |           |        RM       |
     +-----------------+--------+-----------+-----------------+
     |  Mi/Do   2 Jun  |  A+R   |           |        MP       |
     +-----------------+--------+-----------+-----------------+
     |  Do/Fr   3 Jun  |   WG   |           |        CM       |
     +-----------------+--------+-----------+-----------------+
     |  Fr/Sa   4 Jun  |   EP   |           |        PF       |  *
     +-----------------+--------+-----------+-----------------+  *
     |  Sa/So   5 Jun  |   MP   |           |   U+M / (TF)    |  *   *
     +=================+========+===========+=================+  *   *
         ...      ...      ..         ...            ....
```

Figure 9: Observers' schedule

The following items are only available during the actual satellite tracking!

2.6 Operator screen

The web copy of the real-time operator screen is updated every 30 seconds.

```
+-----------------------------------------------------------------------------+
|  Satellite    :  TOPEX                                     Vis : SUN      99|
+-----------------------------------------------------------------------------+
|  Initialize   :  Maximum   # of Shots :  40     Actual # of Shots :   7     |
|      OK          Necessary # of Hits  :   6     # of Init Cycles  :   2     |
|                                                                             |
|  Manual Corr.:  Step:  4" Up/Dn Lf/Rg:   0/   0 Total:   1/   0 E/A:  -4/  0 |
|  Search      :  Step:  4" Along/cross:   0/   0 Total:   0/   0            9 " |
|                                                                             |
|  Obs.Interval:   0.1 s        ADC 1/2: 308   0 22.4 23.1 Obs:     0   -15 ns |
|      Window  :    40 ns       PredErr:       0 ns        Prev:          0 ns |
|  Div/Blue/IR :  600 1850 1750 Late by:  -0.002 s                            |
|                    2850 2600                                                |
|  Calibration :  Each 70. obs  ADC 1/2: 324       3.4 mJ  Obs.Value:      ns |
|                                                  2.2                55.27   |
|  Statistics  :  Calibr:    73 16%  Bad:    68  0R Ovfl:    757  Hits:   83 23%|
|                            35 22           46  0          750          150 24 |
|  Auto: ON        Mode: F  Obs.: ON                 ATC: OK         0130000000|
|                                                                   0102100001|
|  A 344.7940  E 17.8127  D 180      TRACKING      26-MAY-04 12:51:21.5    7:11 |
+-------------------------+---------------------------+-----------------------+
|  DAY_TV            ON   |  MOTION_DET       OFF     | CM_SHUTTER        OFF  |
|  ML_DRIVE     5463 OK   |  NDFILT_BL        0 OK    | R_SWITCH_1       1 OK  |
+-------------------------+---------------------------+-----------------------+
```

Figure 10: Operator Screen

The password-protected login (telnet or SSH) allows the user to display this screen with continuous update on the remote terminal in a separate window.

2.7 Pass scheduler

The tracking program automatically generates a pass schedule taking into account the priorities of the various satellites. This schedule can be overruled by the observer anytime during the tracking. The web copy shows the actual schedule (updated every 30 seconds).

```
-------------|--------------------------------------------------------
 # Satellite 12:54:51                13:23:00                 13:51:10
-------------|--------------------------------------------------------
01 GLONASS-84+++++++++++++++++++++++++++++++++++++++++++++++++++++++++
02 LAGEOS-2  #######++######++++####+---++++##++++++++++##++##++#####
03 LAGEOS    ------+##++++++####++++#######+++++++++------------------
04 JASON     -----------------------------+#++####+##++#+------------
05 TOPEX     -------------------------------------+#++##+++##++##+----
-------------|---------------------- 1 char =  60 seconds -----------
```

Figure 11: Pass Schedule

2.8 Sky plot

The sky plot shows the ground tracks of all selected satellites and their current position, the position of the sun and moon and the pointing direction of the telescope. It is continuously displayed on the operator's console and (updated every 30 seconds) as a copy on the web.

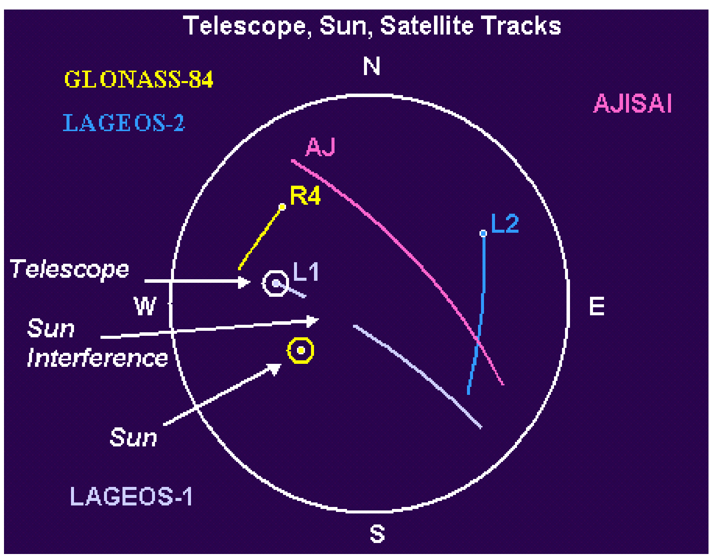

Figure 12: Sky Plot

2.9 Telescope cameras

The two telescope cameras show the sky in the pointing direction (there are two separate cameras for day and night). Their images are continuously displayed on a separate screen at the observer's working place. Their output signal is also branched to the above mentioned web camera server, which provides frames or continuous updates to any remote web browser.

Figure 13: Tracking (day)

Figure 14: Tracking (night)

2.10 Observed passes (lists, graphics)

Fig. 15 shows a list of all observed passes within a certain time period. The first two characters of the file names are a code for the satellite names. Other items are: Number of returns accepted in real time, the actual time bias (sec), a wavelength code, the number of accepted returns during post-processing, the rms of the observations, number, rms, and average value of the real-time calibrations, pass duration in minutes. The second line in each pass contains the data from the second receiver chain (infrared) and the average difference between the observations of the two receiver chains (calibrations and refraction corrections applied).

CONTENT OF LOG FILE "SATLOG.D30" FOR THE FOLLOWING TIME INTERVAL:
****
FROM: 2004-05-23 12:00 TO: 2004-05-24 12:00

FILE NAME	START	NHIT	DT0	WL	O-SCR	O-RMS	C-SCR	C-RMS	C-CST	O 1-2	Q	DUR
L123MY04M	12:51:36	334	-.001	1	342	.156	217	.111	31.21		Y	20
		899		2	843	.173	224	.172	54.91	0.05	Y	
JA23MY04N	13:27:35	523	0.003	1	517	.094	402	.104	31.21		Y	9
		378		2	315	.145	359	.176	54.91	-0.02	Y	
TP23MY04N	13:34:36	691	0.001	1	594	.204	615	.102	31.21		Y	12
		690		2	511	.236	567	.177	54.91	-0.06	Y	
L223MY04O	14:23:13	993	-.001	1	966	.131	851	.097	31.22		Y	53
		2147		2	2004	.167	858	.196	54.90	0.03	Y	
AJ23MY04O	14:39:24	301	-.002	1	286	.259	432	.096	31.22		Y	8
		326		2	292	.271	422	.194	54.91	-0.04	Y	
JA23MY04P	15:24:30	125	0.003	1	111	.120	583	.107	31.21		Y	11
		299		2	232	.155	604	.192	54.88	-0.03	Y	
TP23MY04P	15:32:13	276	0.002	1	240	.190	564	.107	31.21		Y	9
		310		2	222	.224	585	.190	54.88	-0.07	Y	
...	...	...	...	.	...	...	...	...	...	...	.	..

Figure 15: Observed Passes

2.11 Documents

Operator manuals, documents, protocols, etc. can be accessed over the web (password-protected for remote users).

3. Access by Mobile Phone

The web server at Zimmerwald also accepts requests for wireless markup language (WML) pages using the wireless application protocol (WAP). As the functionality of WML documents is smaller than the one of HTML-based web pages and the display possibilities on cellular phone screens are rather limited, only part of the web-based access and control has been prepared for cellular phones.

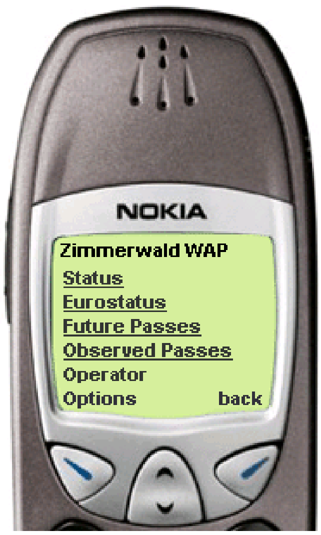

Figure 16: Zimmerwald: (Part of the) Main Access Menu

The following samples have been generated using a PC-based WAP emulator (and not an actual cellular phone).

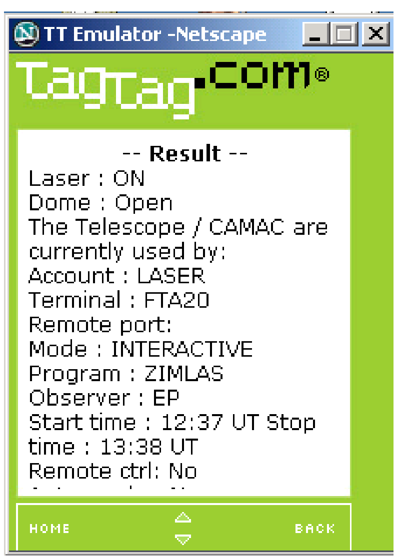

Figure 17: Station Status

Figure 18: Roof Camera

Depending on the cellular phone capabilities images from the four cameras can also be downloaded (Fig. 18).

There are interactive WAP pages allowing to remotely switch on/off the laser or to even start a fully automated observation session in batch mode.

Figure 19: Switch Laser On/Off

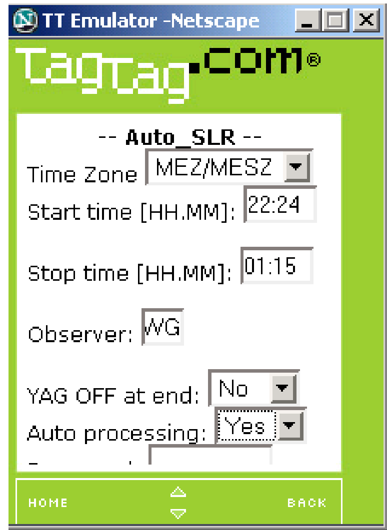

Figure 20: Start a Session

By entering a start time and a time interval the system generates a list of possible passes within this interval (satellite, start time, pass duration): Fig. 21.

Fig. 22 shows a list of recently observed passes: Satellite, day of the month, hour of the day (A = 00 h, B = 01 h, etc.), number of observations, number of accepted observations after post-processing).

Figure 21: Future Passes

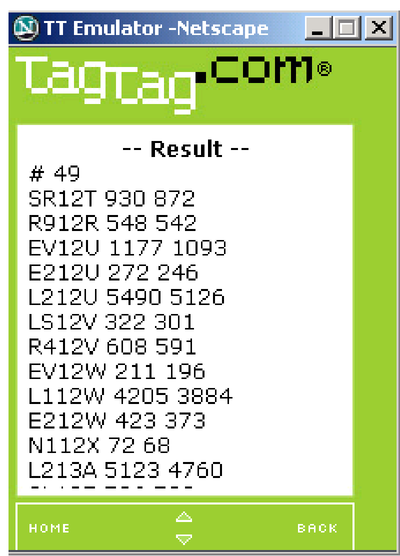

Figure 22: Observed Passes

4. Full Remote Control

Using Telnet (within the University's Local Area Network) or an SSH Secure Shell client the authorized user can remotely connect to the main station computer. All the functionalities of the onsite operation is available at the remote site.

Graphics as e.g. the sky plot or a real-time display of the returns are transferred to the remote location as x-window applications.

The images of the cameras (external cameras, cameras on the telescope) can be transferred to the remote web browser as a continuous stream of frames (depending on the available band width of the internet connection).

During onsite operation it is also possible to remotely connect to the running tracking program to enter commands in parallel to the onsite control. This possibility is used in three situations: Remote support for new observers, remote trouble shooting, and occasional interaction with a fully automated program run.

4. Conclusions

Thanks to the remote control of the Zimmerwald SLR system by Telnet and SSH it is possible to quickly support onsite observers in case of problems and to occasionally control or intervene during fully automated operation.

Web-based information about the station can be used for public relations, tutoring, and remote status checks with simple web browsers.

The interaction with the station by mobile phone is another means to easily and quickly check the system status under fully automated operation or to launch (or abort) an observing session during unexpected weather changes. The station is not manned by default, the observers usually depend their presence on the actual weather conditions, and they may extend their shift or bridge gaps between the two daily shifts by unmanned, fully automated operation.

References:

Gurtner W., E. Pop, J. Utzinger (1999). „Automation and Remote Control of the Zimmerwald SLR Station“. Proceedings of the 11th International Workshop on Laser Ranging, Deggendorf, September 20-25, 1998. Mitteilungen des Bundesamtes für Kartographie und Geodäsie, Band 11, Frankfurt am Main, 1999.

Gurtner, W., E. Pop, J. Utzinger (2002): "Improvements in the Automation of the Zimmerwald SLR Station". Proceedings of the 13th International Workshop on Laser Ranging, October 7-11, 2002, Washington D.C.