Slope Monitoring Specialists

White Paper on

Autoslope System Inner Workings

The Autoslope program was developed originally by Surquik Software in the early 1990s. Softrock Solutions was formed in 2000? And took over the software development. Autoslope is a computer program designed to:

- Use of single or multiple instruments using the scheduling function
- Continuous measurement of a group of prisms
- Scheduled measurement periods for prisms or prism groups
- Alarming notification features, which include e-mail, SMS cell phone messaging and audible tone transmission over local mine communications channels
- Visual alarming features that are displayed graphically on the control or remote computers
- Graphics that display current prism being measured and prisms within that group relative to the point being measured from
- Ability to set individual prism thresholds or global thresholds for alarming
- Indicators to identify the connectivity to both the instrument and radio modem network
- Ability to activate and de-activate the alarming feature
- Ability to update the background graphic
- Display of 3D movement of last prism
- Option for reports to be sent via e-mail to various recipients by simply clicking on the appropriate report
- Edit control, prism data
- Create, edit & delete prism group
- Export Windows CE for exporting a file for uploading to the iPaq palm computer
- Communication parameters for setting communication ports, radios etc
- Ensures that data is being stored in the correct database using QuikSlope
- Data file location, files created by the instrument used for debugging
- Group databases. Database used by the ATS software to keep prism co-ordinates and status
- Instrument measure options setting for single or multiple face readings passive or active targets, number of re-try of the instrument has problems with locating the REF prism
- Search options which allows a search pattern to be entered in the case of fast moving prisms
- Compatible with Leica and Geodimeter instruments
- Exceeds statutory compliance
- Improves business efficiencies
- Improves safety
- Improves risk management
- Cost effective solution

Softrock Solutions Pty Ltd
Also trading as Surquik Software
PO Box 1151 Fremantle Western Australia 6959
Tel: +61 8 9430 7243 **Fax:** +61 8 9336 3093
Email: info@softrock.com.au **Web:** www.softrock.com.au **ABN:** 45 009 390 729

Overview

These are the main modules in Autoslope.

- Communications
- Instrument control
- Calculation of prism XYZ, movements and storing of this data
- Alarming
- Reporting

Communications

There are 3 basic methods:

- Basic RS232 com port from the computer to the instrument via cable.
- RS232 com port from the computer to a base radio modem. Connections made to multiple radio modems (at instruments and weather sensors) via radio addressing.
- Windows sockets (TCP/IP) using IP addressing. This opens up easy communication through existing networks and Ethernet radio systems.

Communication may require routing though repeater radios to get the signal around/over obstacles. It must be robust. It must have the ability to automatically restore if the signal is lost. In some situations, this can be impossible if another radio system has unexpectedly started broadcasting in the same area.

Instrument Control

This takes in a host of features.

- Use correct command set for each instrument type.
- Recognise when radio communications are good. Are we connected?
- After getting temperature and pressure from the weather station, write this data to the instrument.
- Measure to REF prism
-
- Measure to a prism
    - Using Autoslope control dbase, calculate bearing and vertical angle to the prism
    -
    - Geodimeter Sequence

Aa

Appendix A

Major Generic Tasks

Job	Task	Description
Contact weather stn	• C2/C3/C4	• Connect to weather
Read weather stn	• W1/W2	• Read temperature + pressure
Contact instrument	• C2/C3/C4	• Connect to instrument by #
Switch On instrument	• L1/A2	• Turn instrument ON
Write weather to instrument	• A5/L3	• Write temperature & pressure
Read instrument settings	• A4/L5	• Read the settings of instrument
Read the Ref prism	• A3/L6	• Point and read to the REF prism • Get Mean HA, VA, SD • HaDiff is difference between actual HA reading and design bearing. This is needed to calculate a HA pointing for each prism. • HaDiff=DesignRefBrg-MeanHA • VertAdjustFactor is the vertical adjustment factor expressed per 1000 metres. • VaAdjustFactor = (DesignVert - MeanVa) * 1000 / MeanSD • SdistAdjustFactor is the slope distance adjustment expressed per 1000 metres. • SdistAdjustFactor = ((DesignSD - MeanSD) * 1000) / DesignSD
Cycle through a prism group		• Loop through the group prisms and read a prism in the list • Continuous method will continuously measure a particular group • 24 Hour Schedule will measure particular groups at particular times • Scheduled list will measure each group on the list in sequential order
Read a prism & calculate XYZ	• A3/L6	• Read the prism from the previously stored XYZ position.

		• Get the mean HA, VA, SD • Store measurements in quality dbase. • Apply the HaDiff to calculate the bearing • Bearing = MeanHA + HaDiff • Apply the DistanceFactor to adjust the MeanSD • AdjustedSD = MeanSD + (SdAdjustFactor * MeanSD / 1000) • Vertical adjustment is restricted if the MeanSD exceeds the RefDist. The maximum adjustment can only ever be the same as at the REF. So a distance of twice the REF distance will NOT calculate twice the adjustment factor. It will use the distance adjustment as at the REF. The maximum vertical adjustment = the vertical adjustment at the REF. • If SD < RefDist then • AdjustedVA = MeanVa + (VaAdjustFactor) * MeanDist / 1000 • If SD > RefDist then • AdjustedVA = MeanVa + (VaAdjustFactor) • Prism Ht always=0 • Calc XYZ by using task #S5. • XYZcalc(InstNorth, InstEast, InstRL, AdjustedSD, AdjustedVA, Bear, TargetHt, InstHi, • Calculate PsmNorth, PsmEast, PsmRL • Get benchmark data • Calculate movements from benchmarks •
Calculate velocity and movement		• Get previous reading 24 hours (or more) ago as basis for velocity calcs. • Calculate SdVelocity (in mm/day)

		• Td=Time between readings in days • SdVel = (Abs(ThisDist - PrevDistance) * 1000) / (Td) • Calculate 2dVelocity (in mm/day) • Dist2d is horiz join dist between current position and previous reading • Dist2d calculated using.. • Polar(PsmN, PsmE, LastN, LastE, aHA, Dist2d) • 2dVel = (Abs(Dist2d) * 1000) / (Td) • 3dMove is total dist moved from benchmark XYZ. Calc as…. • 3dMove = Sqr(dN * dN + dE * dE + dRL * dRL)
Alarming	Preliminary	• If master alarm switch is OFF then abort • Get thresholds for current prism • If 3dMove threshold is OFF then abort this threshold. Try another threshold. • If SdVelocity threshold is OFF then abort this threshold. Try another threshold. • If 2dVelocity threshold is OFF then abort this threshold. Try another threshold. • If 3dMove exceeds threshold 3dMove then Sound Preliminary Alarm • If SdVelocity exceeds threshold SdVel then Sound Preliminary Alarm • If 2dVelocity exceeds threshold 2dVel then Sound Preliminary Alarm
Alarming	Sounding	• After preliminary alarm is received then re-measure the REF prism • REF measure results in new results for adjustment factors • Re-measure the current prism.

		• If threshold values are exceeded then sound alarm • Alarms can be linked to survey control stations so that an alarm will only be sounded on any particular physical alarm, when measured from instrument number #
Alarming	Email alarm	• Basic alarm is email. Send an email via the default email program (probably MS outlook). Or we can send direct to a SMPT server • Attach a graphic to the email. For this to work correctly, it is important that the Autoslope sequence s not altered or interfered with. That is do not change MS Windows windows. • Autoslope will draw the position of the latest alarmed prism on the graphic window. • Autoslope will change focus to the graphics window • Autoslope will store the current window to the Windows clipboard • Autoslope will store as a BMP file • Autoslope will transform to a GIF file • Autoslope will attach this file to the email. • Note that any interference of this sequence can cause an incorrect graphic file to be sent. • Softrock has re-coded this part of Autoslope and made it somewhat more secure but the sequence still needs to be protected. • Autoslope will send an ALERT email to all current active email recipients.
Alarming	SMS alerts	• There are 2 ways to send an SMS alert. • Using a normal email and mark it in the recipient list as a brief email. It can

		then be sent to an SMS server. • Or using the SRS SMS server attached to the computer. You must purchase the device which is basically a mobile phone unit attached to the serial device on the computer.
Alarming	3rd party alerts	• Autoslope will start a 3rd party program that can start a series of events to happen
Alarming	Asor	• The ASOR is the most exciting alarming feature we have released • The ASOR will transmit a sound file over the site voice radio communications • The sound file is computer generated using the new generation of Windows voices • The unit is very intelligent and will check for current radio traffic before broadcasting
Alarming	Autoslope profile	• Now you can construct your own physical alarm using the Softrock alarm relay • There are 4 relays per unit and these can be programmed to perform different tasks like ON, OFF, ALL CLEAR

Communications

Task #	Radio Modem	Topic	Description
C1	ELPRO 905U-D	Command mode	• Spread spectrum frequency hopping 900 mHz with 1 watt power. • Using "point to point" communication method means that Autoslope can direct the base radio to connect to any radio (or instrument) in the network. This is done by placing the base radio into Command Mode and then connecting to the required radio (by address #). This connection then drops the base radio out of command mode and into normal mode so that communications go straight through to the slave device (instrument or weather stn). • Send "+++" to enter command mode on the base radio. Receive "OK" when in command mode. • Send "ATI" to receive firmware version • Send "ATH" to disconnect the current connection. • Send "ATD1" to connect to radio with address "1" • Send "ATD101,2" to connect to radio with address "2" via repeater radio "101" • Receive a "CONNECT" after an "ATD" command. Also, the DCD light will be on when connected. • After a successful "ATD" command, all commands will be delivered through the base radio to the end device.

C2	ELPRO 905U-D	Connect to inst #3	• While in command mode • Send “ATD3” to connect to radio with address “3”
C3	ELPRO 905U-E	TCP/IP	• Spread spectrum frequency hopping 900 mHz with 1 watt power. • Using TCP/IP communications between Ethernet devices using IP addressing • Able to communicate with multiple devices simultaneously
C4	Pacific Crest PDL	Command Mode	• Frequency is programmable around 470 mHz. • 2 power modes of 4 watt and 35 watts • Command mode is accessible via the “+++” signal • Connection to another radio is via selecting a dedicated channel or “point to point” address connection. • Connection commands are binary

ATS Instrument Functions

#	Inst	Topic	Steps & Calculations
A1	ATS	ATS switch OFF	• Exit remote control “WS=E” • Set remote control “WS=O” • Power OFF with “PG,21”
A2	ATS	ATS switch ON And Calibrate. *This ATS sequence is very fussy and can be easily upset.*	• In manual operation, calibration occurs normally when switching the instrument ON, except when using the “Y” response to “Continue?” • The calibration sequence is a beep, then turn around 180 degrees, wait a bit, a beep, then turn 180 degrees back to original position. And beep. This sequence is affected by outside influences like the wind or a vibrating instrument pillar. It can take from 10 seconds to 3 minutes. • Remotely we will see this sequence: • Send “AAAAA**********AAAAA”. This will awaken the ATS. • A return of a single character will be received. • “N” character is sent • “>” received. Send calibrate command “PG,20” • “>” received and another “>” when calibration is complete. The reception of the “>” character happens as the instrument beeps at start and end of this sequence.
A3	ATS	Read a prism	• Common commands: • All commands return a “>” • Remote control is “WS=O” • Break is “WS=B” • Measure mode “WS=N02ADCHV” refers to number measurements(2), type of prism etc • Get XYZ of last position of current prism • Calculate HA and VA settings required to

			point to current prism • **LABEL 27** Write to a Label is "WG,27=301.0038" which is write to label 27 (HorAng) • **LABEL 26** Write to a Label is "WG,26=90.5934" which is write to label 26 (VertAng) • Point to prism with "WS=PH10V10" • The return data is shown by Geodimeter label number (see Appendix A of the ATS manual). Status label "32" is important here. A status of "17" is signal strength being returned. A status of "16" is a poor or nil signal strength. If a status of "16" then try again and abort if still status=16. • Return of "32=17" is Good signal • Return of "32=16" is poor or no signal • Measure command "WS=M5B" will measure 2 measurements each face and mean results. • **LABEL 32** 32=17 (Status good) • **LABEL 7** 7=301.00306 (HA Face 1) • **LABEL 8** 8=90.5938 (VA Face 1) • **LABEL 17** 17=121.00536 (HA Face 2) • **LABEL 18** 18=269.0035 (VA Face 2) • **LABEL 9** 9=108.9998 (Slope distance) • The mean HA is 301.00415 (sDev=11) • The mean SD is 90.59315 (sDev=7) • The mean SD is 108.9998 + (Autoslope PrismOffset)
A4	ATS	Read Inst settings	• Get settings by reading Geodimeter label values • **LABEL 23** Get units with "RG,23" where label 23 has codes for all unit values. A return of "XXXX" is expected. Units are set in the ATS from the "Menu" button. o "xxx1"=Grads angle

			o “xxx2”=Deg.mmss o “xxx3”=Dec Degrees o “xxx4”=Mills o “xx1x”=Metre o “xx2x”=Feet o “x1xx”-Celsius o “x2xx”=Fahrenheit o “1xxx”=mbar o “2xxx”=mmHg o “3xxx”=inchHg • **LABEL 30**. Read PPM reading “RG,30”. Returns “30=3” • **LABEL 20** Read prism offset “RG,20” • **LABEL 99** Read inst number “RG,99” • **LABEL 3** Read Inst Ht “RG,3”. If zero (normal) then HI is set by dbase value
A5	ATS	Write METS settings	• **LABEL 56** Send “WG,56=19.7” where 19.7 is temperature in Centigrade • Receive a “>” for confirmation. • **LABEL 74** Send “WG,74=1011” where 1011 is pressure in hPa • Receive a “>” for confirmation. • Check by reading ppm setting as in A4 above

Leica Instrument Functions

#	Inst	Topic	Steps & Calculations
L1	LEICA	Turn ON	• Instrument needs to be in GSI mode • Any communication will awaken the instrument. If the instrument is asleep, it may take a few commands to wake up. In this situation it may return some Leica errors. • Send “a” • “?” is returned
L2	LEICA	Turn OFF	• Send “b” • Nothing returned.
L3	LEICA	Write METS	• h = Humidity = 60% (default) • A = 1 / 273.16 • T = Temperature (Centigrade) • p = Pressure (hPa) • X = ((7.5 * T) / (237.3 + T)) + 0.7857 • ppm = 281.8 - ((0.29065 * p) / (1 + A * T) - ((0.0004126 * h) / (1 + A * T)) * 10 ^ X) • PPM setting is sent to Leica by sending “PUT/59...0+00033000” and getting a return of “?” for a successful write of ppm=33
L4	LEICA	Read METS (current inst settings)	• Current PPM setting in Leica is always checked at start of group by sending the enquiry to the Leica “GET/I/WI59” with return of “59..16+00330000” to indicate PPM = +0033

L5	LEICA	Read inst settings	• Get instrument battery level – Send “CONF/90” and get a reply of “0090/0009” where power is the right side value of 9. Values are returned from 0 to 10
			• Check if instrument is compensated send “CONF/173” and get return of “0173/0001" for YES and “0173/0000” for NO.
			• Check EDM mode is correct. Send “CONF/161” and a reply of “0161/0003” or (meaning 3) which is IR precise
			  o 0=IR Standard
			  o 1=IR Fast

			o 2=IR Average o 3=IR Precise o 4=IR Tracking o 5=IR Rapid Tracking o 6=RL Stand. Long Range o 7=RL Standard o 9=RL Tracking • Check angle units send “CONF/40”. A return of “0040/0002” (or “2”) is “Deg.mmss” o 0=Gon o 1=Decimal Degree o 2=Degree.mmss o 3=Mils • Check distance units send “CONF/41”. A return of “0041/0000” (or “0”) is “Metres” o 0=Metre o 1=US feet (Decimal) o 2=Intl feet (Decimal) o 3=US Feet/Inch o 4=Intl feet/inch • Check temperature units send “0042/0000” . A return of “0042/0000” (or “0”) is “Centigrade” o 0=°C o 1=°F • Check pressure units send “0043/0000” . A return of “0043/0000” (or “0”) is “hPa” o 0=hPa o 1=mmHg o 2=mbar o 3=PSI o 4=inchHg • Check prism offset send “GET/I/WI58” . A return of “58..16+00000000” is an offset of zero • Check instrument serial number send “GET/I/WI12”.

			A return of “12....+00425785” is a serial of 425785
L6	LEICA	Read a Prism	• Get XYZ of last position of current prism • Calculate HA and VA settings required to point to current prism • Get battery setting (see L3 above) • Get internal temperature with “%R1Q,5028:” and reply of “%R1P,0,0:0,21.651204427083432” where temperature = 21.65 • Set EDM mode with “%R1Q,2020:1” where “1” = Exact single measurement o 0=Standard single measurement o 1=Exact single measurement o 2=Fast single measurement o 3=Repeated measurement o 4=Repeated average measure o 5=Fast repeated measurement • Set accuracy to 8 places of radians by send “%R1Q,107:8” • Turn ATR on with “%R1Q,9018:1,”. Reply of “%R1P,0,0:0” is expected • SHOT 1 • Check if on face 1 with “CONF/170” and expect “0170/0000”. A reply of “0170/0001” means face 2. If face 2 then CFACE back to Face 1 and check again. • Write angles (Radians) with “%R1Q,9009:0.62841070,1.51609100,0” • Get measurement with “%R1Q,2108:15000” using a 15 second wait for data • %R1P,0,0:0,0.62838927,1.51617818,1231.34712033 • Previous line is return of HA, VA, SD. If SD=0 then measurement has failed. • If measure fail, try again one more time. Abort if fail. • This data is HA1, VA1, SD1 • SHOT 2 • Add 1 degree to HA and set vertical to 90 degrees.

			• Write to instrument • Set angles to previous settings and write to inst. • Get measurements as previously explained • This data is HA3, VA3, SD3 • SHOT 3 • Change face of instrument with “CFACE” • Check that it is on Face II • Get measurements as above • This data is HA2, VE2, SD2 • SHOT 4 • Pont telescope away as explained above • Point back again to same as shot 3 • Get measurement • This data is HA4, VA4, SD4 • Get mean values of each HA, VA, SD • SD=SD + (Autoslope PrismOffset) • Set inst back to Face I

Weather Station Functions

#	Inst	Topic	Steps & Calculations
W1	ECO-WEATHER	Get METS	• Get temperature send a “1” or “2” depending on config and receive the temp • Get pressure send a “3” depending on config and receive the pressure • Get rain gauge (if installed) reading send a “4” depending on config and receive the gauge reading. • Rain gauge can be reset to zero by sending a control command.
W2	LEICA DTM WEATHER	Get METS	• Get temperature send a “t” and then receive a “A” • After getting “A” then send a “m” • Temperature is returned • Get pressure send a “p” and then receive a “A” • After getting “A” then send a “m” • Pressure is returned

Programming Subroutines & Functions

#	Sub Programs	Steps & Calculations
S1	SUB POLAR	• Calculate Brg & H Dist between coordinates • Brg output in Decimal Deg • POLAR(BaseN,BaseE,NewN,NewE,Brg,HD) • Pi=3.141592653589/180 • DeltaN=NewN-BaseN • DeltaE=NewE-BaseE • HDist=SQR(DeltaN^2 + DeltaE^2) • Brg=ATN(DeltaE/DeltaN)/Pi
S2	SUB RECT	• Calc New Coords from start XY & Brg+HD • Brg Input in Dec Degrees • RECT(BaseN,BaseE,Brg,HD,NewN,NewE) • Pi=3.141592653589/180 • DeltaN=Cos(Brg*Pi)*HD • DeltaE=Sin(Brg*Pi)*HD • NewN=BaseN+DeltaN • NewE=BaseE+DeltaE
S3	FUNC Dec2Deg	• Express decimal degrees in DDD.mmsss • Dec2Deg(DecDeg) as String DDD.MMSSS • Save sign of angle • Degree=fix(DecDeg) • Minute=(DecDeg-Degree)*60 • Second=((Minute-Int(Minute))*60)*10 • Dec2Deg=Sign + Degree + “.” + Minute + Second
S4	FUNC Deg2Dec	• Express DDD.MMSSS in decimal degrees • Deg2Dec(“DDD.MMSSS”) as decimal degrees • Degree=Value of “DDD” in “DDD.MMSSS” (with sign) • Minute= Value of “MM” in “DDD.MMSSS” • Second= Value of “SSS” in “DDD.MMSSS” expressed as “SS.S”

		• Deg2Dec=Degree + (Minute / 60) + (Second / 3600)
S5	SUB CalcXYZ	• Calc XYZ from an XYZ position • Knowing BaseN, BaseE, BaseRL • Knowing SlopeDist, Brg (decimal), HS (Ht Targ), HI (InstHt), VA • Calc NewN, NewE, NewRL • Activate with • CalcXYZ(N,E,RL,SD,VA,Brg,HS,HI,NewN,NewE,NewRL) • Calculate…. • Calc HD & VD by RECT(0#, 0#, VA, SD, HD, VD) • NewRL=BaseRL + HI + VD – HS • Calc NewN NewE RECT(BaseN,BaseE,Brg,HD,NewN,NewE) •

Leica Error Listing

#	Error	Error description
E1	@W100	• Instrument busy. Other device is still interfacing with instrument.
E2	@W127	• Invalid command. The command string is unknown. Buffer overload.
E3	@E139	• EDM error. None or weak signal. Check EDM mode and target.
E4	@E158	• One of the instrument sensor corrections could not be assigned. • Instrument is not stable, not leveled or suffering vibration. • Tilt is out of range • Level instrument
E5	@E101	• Value out of range • Check parameter range
E6	@E103	• Invalid value
E7	@112	• Battery low.
E8	@E114	• Invalid command. Check syntax.
E9	@E117	• Initialization error. Contact service.
E10	@E119	• Temperature out of range
E11	@E121	• Parity error
E12	@E122	• RS232 time out. Instrument waiting for a response for the last 2 secs
E13	@E124	• RS232 overflow. Check port settings
E14	@E151	• Compensator error. Check instrument setup
E15	@E155	• EDM intensity. Weak signal or target lost.
E16	@E156	• EDM system error. Contact service.
E17	@E158	• Sensor could not be assigned • Inst not stable, not leveled, or vibrating. • Tilt out of range
E18	@E190	• General hardware error. Contact service
E19	@E197	• Initialization error. Contact service.

Geodimeter ATS Error Listing

#	Display Error	Error description
E101	1	• Compensator out of range.
E102	2	• Wrong measuring procedure. EG not possible to track in C2
E103	3	• Distance already recorded.
E104	4	• Measurement invalid.
E105	5	• Undefined mode, display or output table not set, measurement not completed.
E106	6	• Vertical angle less than 15 gon from horiz in Test Mode
E107	7	• Distance not yet measured
E108	8	• Battery low not possible to register
E109	9	• Battery low, in external unit.
E110	10	• Memory device not connected
E119	19	• Communication error (Pgm 54). File transfer problem
E120	20	• Label error, Label not accepted.
E121	21	• Disturbance of the serial channel or wrong paramerters
E122	22	• No or wrong device connected.
E123	23	• Time out.
E124	24	• Tries to communicate in Face CII or not in theodolite mode
E125	25	• Real time clock error
E126	26	• Recommendation to change backup battery
E129	29	• Output or display table activated, operation not allowed
E130	30	• Syntax error.
E131	31	• Out of range
E132	32	• Not found (Files or program)
E134	34	• Wrong data record separator.
E135	35	• Data error. Wrong data eg Offset value too large or alpha sign in a numeric value
E136	36	• Memory full. Imem or buffer.
E141	41	• Wrong label type.
E142	42	• UDS prgm memory full.

E143	43	• Calculation error, redo the procedure
E146	46	• GDM power error, RPU can't switch on GDM
E147	47	• UDS Call stack error
E148	48	• No, or wrong stn establish, redo stn establishment.
E149	49	• RPU not logged on to GDM
E203	103	• No carrier, disturbance or no contact
E207	107	• Channel busy, try to change channel.
E222	122	• Radio not connected
E223	123	• Time out.
E253	153	• Limit switch engaged.
E255	155 *	• The horizontal positioning isn't good enough. *
E256	156 *	• The vertical positioning isn't good enough. *
E257	157 *	• The horiz & vert positioning isn't good enough. *
E258	158	• Can not find the target. Redo the search procedure
E261	161	• The target is lost
E266	166	• No measuring signal from prism
E299	199	• Internal program error
E301	201	• Calculation error.
E307	207	• Too many commands sent on the serial channel
E318	218	• Input string too long.
	Note	• In some cases the info code also includes a device code 1 Serial 2 Imem 2 Xmem 6 Radio
	*	• If this error (*) appears frequently leave the instrument to authorized service adjustments.