Troubleshooting the INTRA at Summit

After reading the mails and their attachment, there are some puzzling questions left – or in short: We still do not yet understand what exactly the problem of the Summit-INTRA is. According to the log-file Tracker_log_10_31_16.docx, it worked normal until 21.09.2016. Then it produced "near zero timed out errors" until 25.10.2016. On this day, the rewind operation was executed correctly and this continued until 30.10.2016 when a "zero-0 timed out" message came up. But it recovered and completed the "search flag run" less than 2 minutes later. However, with a unsettling value of 9380 for the parameter eposo. Now let's first discuss what these messages tell us and then which questions the current set of data leaves open. But firstly a few words about basics of the tracker:

The tracker has an encoder disc on each axis. These two disks are firmly attached to the resp. axis - no gears in between. The encoder disc produces 9380 counts per full revolution of the axis. So far, it's an incremental sensor only, but he encoder disk has an additional track with one mark only – the so called zero mark – and with this, the system works as an absolute position encoder.

INTRAs firmware also uses the hall counts produced by the motors to deduce an alternative, less accurate (gears!) position indicator. This allows it to detect possible failures of an encoder circuit and stop the tracker. Otherwise, the thing could go wild....

During a day of 24 hours, the primary (vertical) axis (PA) of the tracker rotates from -180° to app. $+180^{\circ}$. The secondary axis (SA) follows the elevation of the sun, until it goes 3 degrees below the horizon. Then it stops at this angle. At local midnight – currently at Summit near 02:30 UT – the tracker initiates a rewind. During this rewind, it also attempts to check the position of the zero mark. It firstly moves either axis to a position app. 5° clockwise (+) of its zero mark. The tracker schedules an interval of time during which this position should be reached. If this interval elapses while the position is still not reached, it produces a "near zero timed out" error. This is what we have in the log files as of 21.09.2016 until 25.10.2016 when it resumed normal operation.

Q1:

Do you have observations of the tracker during its down time 21.09. to 24.10.? What did you observe? Please describe (e. g. approximate position of PA and SA, moving or totally blocked?)

On 21.09, after a routine cleaning of the solar alignment opening, the tracker attempted to point the arm straight up. This movement was outside of its normal movement range, and it caused one of the mounted instruments (the PFR) to strike the radiometer mounting plate. This mechanical interference forced the motion of the tracker to stop, with the azimuth near south or south-east, and the elevation near zenith. The PFR was removed. The tracker remained motionless in this position until 24.10.

rwb: Running in an obstacle usually damages the belt of the gear-assembly of the corresponding axis. In most cases it overstretches the toothed belt, causing it to slip in later movements. This slipping may stop the tracker but not in all cases. But the big question is: Why did the tracker move up to app. 90° of elevation? The settings in the eeprom should prevent it from moving above 75° - except of course, if it had completely lost its position and the firmware used an erroneous position below this limit. The following questions might help to shed some light on this issues.

Q6:

Did you connect to the tracker with IntraCfg prior (or later) for the removal of the PFR? Any commands sent? Position observed? Did values reported for the position correspond to the real position of the tracker? Power on during removal? Did the tracker then move – after or during removal? Did you leave it with or without power after removal?

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SWD #2: To my knowledge, no successful connection was made with IntraCfg between the time of the maintenance visit this summer until 25.10. I wanted to provide further description of the time of the impact on 21.9, this according to former tech Elissa:

"This morning when I went out to check on the PFR there was quite a bit of frost on the solar tracker window, which seemed to be preventing it from precisely locating the sun. It was pointed in the right general direction, but jerking back and fourth a couple centimeters trying to hone in. I cleaned the frost off, and it immediately rotated into an upright position, not pointed toward the sun at all. Elissa, 21.9"

We first learned of the location of the connector for INTRA communication on 24.10. As a result, no successful connection was made to INTRA before this time, no commands were sent to INTRA, and no position info was received. Throughout this time, the tracker continued to rotate in azimuth, but with the arm elevation nearly straight up. The tracker power was left on through the removal of the PFR, and remained on afterwards. I do not know if the tracker then moved after the removal of the PFR—I can contact the techs working during that time and ask for this information.

Q2:

When it resumed normal operation on 25.10, was there an intervention? Which kind of intervention?

On 25.10, there was an intervention. On Dany's request, we connected a laptop to the DB9 port in the lower power supply box of the tracker. Using IntraCfg, we re-sent the EEPROM flash settings specified by Dany, used the 'Run Motors' mode to confirm that the unit could move in both axes, and selected the 'Sun' mode. The tracker appeared to resume operation, pointing at a location near the point where the sun had set (near the horizon and to the south). When we checked the tracker the next morning (12z), the tracker arm pointed about 165 degrees behind the sun in azimuth, and at roughly the correct elevation. The EEPROM settings sent on 25.10 were as follows:

ite -38.46 ite lo [1] -38.46 ite lo [1] 72.58 ite el [m] 3250.00 lignment 0.417 t -156.794 p 1.735	101 INTRA s Axis Gears Offset[] Range low[] Range high [] Target-Ctrl* Target-Ctrl / Speed-Ctrl* Speed-Ctrl /	PA 66:1 ▼ 0.269 -200 200 30000 0 90000 1	79213 SA 66:1 ▼ 0.000 -4 75 30000 0 90000 1	Ottset PA [] Ottset SA [] Io sigma Iow sunrange low sunrange high sunfrac % sunfrac %	-0.350 -0.100 1.0 0.150 10.00 0.300 0.785 50.0 0.043400	Boud UART0 57600 Boud UART1 57600 bot b0f b1f b2* b0f b0f b1f b2* b0f b1f b1f b2* b0f b1f b1f b2* b0f b1f b1f b2* b0f b1f b2f b2* b0f b1f b2f b2* b0f b1f b2* b2* b0f b1f b2* b3* b0f b1f b2* b3* b0f b1* b2* b3*
Communication Stat	1	19 restored f	INTRA	3394 T	Registry Save	Read Defaults

rwb: The above values in the eeprom are those for the controller board that was used until June 2016. This can be seen from the serial number. When I installed the new board (#252) in June, I edited the serial number accordingly and also changed the Io-value from 1.0 to 5.0. The low value for Io may cause problems during low elevation or partially clouded conditions, because low level signals on the sensor that should be discarded are considered valid and lead to wrong movements.

When the tracker reaches the 5° positions, its submode is changed to WAITZERO and a "search zero run" is triggered. As previously, an interval is scheduled during which these flags should be detected. If this does not happen in due time, an "zero-0 or zero-1 timed out" error is reported. Zero-0 for the PA and zero-1 for the SA. This message popped up on 30.10. But less than 2 minutes later, the PA found its zero mark. And it issued the message:

16-10-30 02:36:07 chat, zero-0 found, eposo, 9380, eerrs, 0,

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hposo,59605, herrs,0

eposo = 9380 is the value of the position of the PA at the moment of detection of the zero mark. The strange thing is that 9380 counts correspond to exactly 360° , hence one full turn. The value of hposo=59605 corroborates this, because this as well corresponds app. to one full turn. This means, that the tracker was far above PA=360° when it started its zero search (which moves ccw). Note that positions above 200° are "illegal", because the settings in the eeprom limit the movement of the PA to the range (-200,+200). It looks as if the values in the eeprom were garbage to allow this to happen.

Q3:

What values did you find in the eeprom when you connected to the tracker on 31.10.?

When we connected to the tracker on 31.10, we found that the EEPROM values were unchanged since the time that we input them on 25.10. That is, they still matched Dany's values.

Q4:

Following the fix of the eeprom values when you switched to sun mode: What was the time of the day and what did the tracker do?

The switch to Sun mode has had different effects during different attempts. In the attempt on 25.10, the sun had recently set, and the tracker moved to a position near the location of the sunset (near the horizon and to the south), but was shown to be 165 degrees behind the sun at sunrise the next morning. On later attempts, e.g., 31.10 at about 13:00z or 14:00z, the sun was visible in the sky to the south, but the tracker pointed to a location near the horizon and to the north. We had input a new set of EEPROM parameters from Dany for this attempt. These new settings are as follows:

					L3			1000
n is: \$0101	INTRA 9	serial #:	79,252	sun-sensor		SerCfg		
	Axis	DA	C.A.	Offset PA ["]	-0,300	Baud local	57600	
72,580	Gears			Offset SA ["]	-0,500	Baud remote	57600	
-38,460				lo	5,0		01000	
3250.00				sigma	0,150		Bb16b	24
0200,00				low	10,00			10121
				sunrange low	0,300			0.000
0,284	Target-Ctrl /			-	0.785			
127,838	Speed-Ctrl *	-						000
1,621	Speed-Ctrl /	0	0			b070b15	5 b23 b	31
16 06 07 12 23	19 parameters from regi			sunzrad	0,043400			
	45 parameters non regi				Bogisto			
1						Dent	Defent	23
	-38,460 3250,00 0,284 127,838 1,621	Axis 72.580 Gears -38,460 Offset ['] 3250,00 Range low ['] Range high ['] Target-Ctrl * 0,284 Target-Ctrl * 127,838 Speed-Ctrl * 1,621 Speed-Ctrl / 16.06.07 12:23:49 parameters from regis	Axis PA 72.580 Gears 66:1 -38,460 Offset [] 0,269 3250.00 Range low [] -200 Range high [] 200 Target-Ctrl * 3000 127,838 Speed-Ctrl * 9000 1,621 Speed-Ctrl * 0 16.06.07 12:23:49 parameters from registry eeRAM or	Axis PA SA Gears 66:1 66:1 -38,460 Offset [] 0,269 0,000 3250,00 Range low [] -200 -4 Range high [] 200 75 0.284 Target-Ctrl * 3000 3000 127,838 Speed-Ctrl * 9000 9000 1,621 Speed-Ctrl / 0 0 16.06.07 12:23:49 parameters from registry eeRAM of INTRA	Axis PA SA Offset PA [] -38,460 Gears 66:1 ~ 66:1 ~ Io 3250.00 Range low [] -200 -4 low 3250.00 Range low [] -200 -4 low 0.284 Target-Ctrl * 3000 3000 sunrange low 127.838 Speed-Ctrl * 9000 9000 sunrange high 1.621 Speed-Ctrl * 0 0 sunrange high 16.06.07 12:23:49 parameters from registry EeRAM of INTRA EeRAM of INTRA	Axis PA SA Offset PA ['] -0.300 72.500 Gears 66:1 66:1 0ffset SA ['] 0.500 -38,460 Offset ['] 0,269 0,000 sigma 0.150 3250.00 Range low ['] -200 -4 low 10.00 3250.00 Range high ['] 200 75 sunrange low 0.300 0.284 Target-Ctrl * 3000 3000 sunrange low 0.300 127.838 Speed-Ctrl * 9000 9000 sunrange high 0.785 1.621 Speed-Ctrl * 0 0 sun2rad 0.043400 16.06.07 12:23:49 parameters from registry EeRAM of INTRA Registry	Axis PA SA Offset PA [1] -0.300 Baud local 38,460 Gears 66:1 66:1 offset SA [1] -0.500 Baud remote 3250,00 Range low [1] -200 -4 low 10,00 b01 b02 0.284 Target-Ctrl * 3000 30000 sunrange low 0.300 b030 b11 b03 b15 b03 b11 b04 b11 b04 b11 b04 b11 b04 b11 b04 b11 b05 b15 b05 b15 b05 b15 b05 b15 b05 b15 b06 b14 b06 b14 b06 b14 b06 b14 b06 b14 b06 b15 b16 b16 <td< td=""><td>Axis PA SA Offset PA [1] -0.300 Baud local 57600 -38,460 Gears 66:1 66:1 offset SA [1] -0.500 Baud remote 57600 3250,00 Range low [1] -200 -4 low 10,00 b01 b09 b17 b1 Range high [1] 200 75 sumrange low 0.300 b02 b10 b18 b1 b02 b10 b18 b1 b02 b10 b18 b1 b02 b10 b18 b1 b03 b11 b19 b1 b02 b10 b18 b1 b03 b11 b19 b1 b05 b13 b21 b1 b04 b12 b20 b1 b05 b13 b21 b1 b06 b14 b122 b20 b06 b14 b122 b1 b06 b14 b122 b20 b06 b14 b12 b20 b1 b06 b14 b22 b1 b06 b14 b12 b20 b1 b06 b14 b22 b1 b07 b15 b23 b1 b16 b07 b15 b23 b1 b16 b14 b22 b1 b06 b14 b12 b20 b1 b07 b15 b23 b1 b15 b23 b1 b15 b15 b23 b1 b16 b14 b12 b1 b16 b14 b</td></td<>	Axis PA SA Offset PA [1] -0.300 Baud local 57600 -38,460 Gears 66:1 66:1 offset SA [1] -0.500 Baud remote 57600 3250,00 Range low [1] -200 -4 low 10,00 b01 b09 b17 b1 Range high [1] 200 75 sumrange low 0.300 b02 b10 b18 b1 b02 b10 b18 b1 b02 b10 b18 b1 b02 b10 b18 b1 b03 b11 b19 b1 b02 b10 b18 b1 b03 b11 b19 b1 b05 b13 b21 b1 b04 b12 b20 b1 b05 b13 b21 b1 b06 b14 b122 b20 b06 b14 b122 b1 b06 b14 b122 b20 b06 b14 b12 b20 b1 b06 b14 b22 b1 b06 b14 b12 b20 b1 b06 b14 b22 b1 b07 b15 b23 b1 b16 b07 b15 b23 b1 b16 b14 b22 b1 b06 b14 b12 b20 b1 b07 b15 b23 b1 b15 b23 b1 b15 b15 b23 b1 b16 b14 b12 b1 b16 b14 b

The final attempt to switch to Sun mode is described below. I should note that the sun is low during the entire day, given our high latitude at this time of year.

Q7:

Silly question: The z following a time – does that mean "zonal time" at Summit UT – 2hours?

A word of caution: The most recent version of IntraCfg has a problem with the target and speed values in the Axis frame: The values 90000 and 30000 are shown as 9000 and 3000 because for some hitherto unknown reason, the right-most zero of these numbers is hidden. You can put the curser into such a field and using the shift right key, you may make this last digit to become visible. We will have to check IntraCfg to fix this issue.

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The attempt on 25.10. You write:the next morning it pointed 165 degrees behind the sun. But according to the log, the tracker performed a successful rewind and zero check during all days until and including the night from 28.10 to 29.10.

SWD #2: Apologies for the confusion about the 'z' notation. This refers to 'zulu' time, or UTC. E.g., 12:00z is equal to 12:00 UTC.

I noticed earlier that the final digit of these numbers disappears out of the text field. I have used the numbers 30000 and 90000, including the final '0' digit during my configurations on 31.10.

I cannot account for the successful log reports from the tracker during this time. It did not point at the sun. Could it be that it did move successfully through a daily routine, but that the alignment was off by 165 degrees?

Q8:

How did the tracker recover from this "165° behind"-condition? Any interventions?

The intervention of 30.10. I understand you entered the new (shown above and hopefully with enough zeros for the 90000 and 30000 numbers) values into the eeprom, but otherwise did not send it any commands. Please check this if you connect to INTRA next time.

SWD #2: I believe that the tracker remained in this 165 degree behind mode after the intervention in which we sent the new EEPROM values.

I will confirm the number of zeroes in the 90000 and 30000 fields each time I connect to INTRA. You can see in the following screenshot that we entered the correct numbers on 31.10.

Thunderbird									
G IROM	_							_ • ×	
RomVersio	on is: \$0101	INTRA 9	serial #:	79.252	sun sensor		SerClg		
Site	72.580	Axis	PA	SA	Offset PA['] Offset SA[']	-0.300	Baud local 57600	*	
a site lat [*]		Geors	66:1 -	66:1 -	lo	5.0	Baud remote 57600		
site lo ["]	-38.460	Offset [7]	0.269	0.000		0.150	tbits		
site el [m]	3250.00	Range law ["]	-200	-4	sigma.	10.00	b01 b09 b17 b25		
Alignment		Range high ["]	200	75	low	0.300	b02 b10 b18 b26		
zt	0.284	Target-Ctrl* Target-Ctrl/	30000	30000	sunrange low		b04 b12 b20 b28		
at	127.838	Speed-Ctrl *	90000	90000	sunrange high	0.785	b05 b13 b21 b29 b06 b14 b22 b30		
ap	1.621	Speed-Ctrl /	0	0	sunfrac % sun2rad	50.0 0.043400	607 b15 b23 b31		
To Cepturel	kkhine .	Eiase	iag, mode iag, mode iag, mode iag, mode 6.10.31	TEST SW: SUN SWIT TEST SW: INIT SW: SUN SWIT 12:33:12	tched to St tched to TE itched to II itched to St	ST NIT manu JN IT manua 15:rtime	Read Defaults al help needed l help needed out		
		6							De D al de 14:46

Q9:

Did you check its position (with IntraCfg) and compare it with what you see when looking at the tracker?

Hint: Checking the position means: Open window "Positions and Modes", then click GetPos to fetch the data from INTRA and to display them.

SWD #2: I believe we did perform this test. I will check our screenshots from our evening diagnostics on 31.10 and see if I have the results.

Q5:

Is the tracker now up and running or what is its current status?

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On the final time that we switched to Sun mode (31.10, 18:54z), the tracker completed a full 360 rotation in azimuth (moving ccw), and then continued to rotate. We were concerned that further rotation could damage the instrument, so we hit the 'reset' button in the 'position window' to stop motion. We used the "Run Motor" function to reverse this motion by 90 degrees, then hit 'reset' to stop. We left the instrument in this state.

Thank you for your help with the diagnosis of this issue!

Ok, this left the tracker with power on and mode "INIT". It would be helpful to have an idea about the current position of the tracker and compare it with what you see. And then you could perform a search zero and relaunch the tracker in clock mode. Sun mode currently is not advised, because of the very low elevation of the sun. So we better use clock mode for our "diagnostics" operation.

Tracker system of coordinates: When the tracker points to the crossing of the south-meridian with the horizon, this corresponds to PA=0 and SA=0 or short 0.00/0.00. The crossing of the east-meridian with the horizon then corresponds to -90.00/0.00 – and correspondingly +90.00/0.00 for the crossing of the west-meridian with the horizon.

Procedure to follow – please do the following:

- Set up a connection IntraCfg to INTRA. Check the link by clicking on Utilities>WhoAmI. You should receive a string identifying the firmware no timeouts! Please also check the issue about the 90000 and 30000 values in the eeprom. It might be helpful to also check the time setting of the tracker. Assuming you PC runs on (accurate) UT (not zone time) click on RemotCfg>TimeDate. Clicking on Now displays the time as read from the PC, clicking on Remote displays the time as fetched from INTRA and SendNow reads the time from the PC and sends it to INTRA, thereby updating INTRAs clock settings.
- Open the "Positions and Modes" window (if not yet open)
- Click GetPos and take a shot of this window.
- Write down what you think is the app. position the tracker is actually pointing to.
- Dismount the shader mechanism from the western flange (just to be cautious).
- Using the PA and SA settings in the "Run Motors" frame, position both axis of the tracker at slightly positive values. Do not believe the numbers you see in the position window, but check that the primary axis is slightly westward from the south point and the elevation points a few degrees up. The PA and SA fields in the "Run Motors" frame accept (speed-) numbers from 999 to +999. Then
- click Run and the tracker axis move accordingly. Click Reset to stop movements.
- Once the tracker is positioned to point to app. 5° / 5° check the settings in "FindZero" frame, both axis should be set for ccw operation.
- Click Go. Both axis start moving ccw and soon will hit their zero mark. This will stop the movement of the corr. axis, issue a message to the main window (and to the message buffer) and also clear the position of this axis. If the movement reaches a limit of -15°, the movement stops and an error message is generated. If you feel you might still be too far away from the true zero of this axis, you may e. g. set the other, possibly more successful axis to e. g. SA and hit Go again. The PA will then move again, the SA will not move.
- Once both axis have found their zero mark, we recommend to repeat the procedure but slightly modified as follows:
- Set the mode to REMOTE and enter 5 in both fields in the "Go to Position" frame
- Click on Set Target.
- Check by clicking on GetPos that the position has been reached.
- Set both axis for ccw zero search and click Go. Wait for the zero found messages.
- Set REMOTE again (check by clicking on GetMode), enter values -90 and 0 in the PA and SA field in the "Go to Position" frame and click SetTarget.
- Wait a few seconds, then set CLOCK-mode.

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- Observe what the tracker does. Does it correspond to expectations? If so, attach the shader mechanism to its flange again.
- Check tracker the next day (visually only).

In case you run into too many problems, park the tracker by setting it into INIT-mode, leave its power on and contact us again.

Thank you.

SWD #2: Thank you for the detailed diagnostic instructions. I am looking forward to performing these tests, and returning the tracker to normal operation! Very best,

Sam

Following text copied from Sams email. Comments by rwb interspersed in text.

I visited the tracker today at 17:20z and wanted to report the results of this diagnostic trip. I was accompanied by fellow science tech Nate Bowker. The tracker log file is attached. (relevant lines copied from there into this document)

```
16-10-29 02:34:40 chat,zero-1 found, eposo,0, eerrs,0, hposo,-1, herrs,0
16-10-30 02:34:40 chat,zero-1 found, eposo,0, eerrs,0, hposo,1, herrs,0
16-10-30 02:35:18 WARNING zero-0 timed out
16-10-30 02:36:07 chat,zero-0 found, eposo,9380, eerrs,0, hposo,59605, herrs,0
16-10-31 02:34:44 chat,zero-0 found, eposo,0, eerrs,0, hposo,-7, herrs,0
16-10-31 02:34:45 chat,zero-1 found, eposo,0, eerrs,0, hposo,0, herrs,0
16-11-04 17:28:39 chat,zero-1 found, eposo,0, eerrs,0, hposo,0, herrs,0
16-11-04 17:28:41 chat,WARNING:zero-0 not found
16-11-04 17:36:16 chat,zero-1 found, eposo,0, eerrs,0, hposo,1, herrs,0
16-11-04 17:36:18 chat,WARNING:zero-0 not found
```

--Result of WhoAmI query: INTRA FW V2.19 - build of Jun 8 2016 13:45:40 hw:icb_25 iROM-version: 101 string:

--Result of GetPos: See attached screenshot "GetPos_request" Estimated elevation: -10 degrees Estimated azimuth: -140 degrees (140 degrees counter-clockwise from South)

Q Positions and Mo	des	
Mode INIT	Sub-Mode	GetMode
🔘 SUN	EVENING	Go to Position
© CLOCK	NEARZERO WAITZERO	PA 0.000 SetTarget
© REMOTE © TEST		SA 0.000 Astro
Target Astron	Targ Tracker curre	nt Astro cur. Tracker Encoders Hallsensors
PA 1.621 F	PA 0.000 PA	138.957 PA -500.623 PA 13037 PA -82832
SA 0.168 S	6A 0.000 SA	-8.965 SA -8.981 SA -234 SA -1484 r
Run Motors	FindZ	ero
PA 0	Run PA c	
SA O	Reset	Go C₩ ▼ GetPos ChikAxis
16.11.04 17:23:39 Gel	tPos done - status:ok	

cur. Tracker PA = -500.623. Now -500 + 360 = -140 which corresponds to the observed estimated azimuth. Hence one full turn below where it should be and way below the -200 limit imposed on this axis. Similarly, the SA is outside its range [-5..75]. It looks as if parts of the firmware of this tracker is corrupted.

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--Position tracker slightly westward of South and above horizon using "Run Motors" This was done successfully.

--Use "Find Zero - Go" to move to the zero mark

We attempted to perform this task. In the elevation axis, the unit stopped at horizontal quickly. In the azimuth, the unit continued rotating for slightly longer. We do not know if the tracker passed over the zero and did not find it, or if we started too far away from zero in the first place (outside of the range 0deg - 15deg).

--Set mode to "REMOTE" and enter 5 in both fields in the "Go to Position" frame; click on "Set Target" Upon doing this, the tracker elevation increased slightly, while the tracker rotated clockwise azimuth over about 180 degrees, pointing roughly northward, and continued moving. To prevent damage, we hit 'reset' to stop this motion.

This looks ok. The PA was at -500, your positioning to slightly south brought it up to something like -500 + 140 = -360 and its normal that it starts cw if you instruct it to move to +5.

--We then repeated the manual positioning to ~5 degrees using "Run Motors" and tried to "Find Zero" again. The text output seemed to suggest this was unsuccessful.

If you are not sure if you are sufficiently cw of the zero mark – go further cw, run "search zero" for the PA repeatedly with the search of the SA disabled (SA- instead of SA ccw or SA cw)

At this point, we were unable to continue work outside, as the cold temperatures had made our laptop screen unresponsive. We left the unit in "INIT" mode and returned inside. We would like to repeat the attempt to find an azimuth zero, as we think we understand the system and available feedback a bit better. We will return to continue diagnostics at the next available opportunity.

Preliminary conclusion

It is not clear what's going on and how and why the tracker oversteps its range. Especially why the PA is one full turn more in the negative than it should be. The SA also showed such a behavior when it pointed straight up with the instruments end of October. This also overstepped the limits set for this axis. The firmware – or a part of it – looks corrupted.

Because the firmware is stored in flash, I consider it more likely, that some data in the RAM-area are corrupted – for hitherto unknown reasons. It would be helpful to test what happens if one shuts the tracker down (power off) and relaunches it again. But there is this disturbing fact that we do not know for sure how many full turns the PA is from its original position. It would make sense to open the service cover on top of the tracker and to check the cabling prior to continue any operations. And if you find the power cable of the tracker twisted or otherwise stressed – fix it by moving the tracker accordingly using the remote command or the "Run motors" command. Now let's assume you have done this, then proceed as follows:

- Position both axis cw of the zero mark allow sufficient margins for the PA
- Remove the power from the tracker, wait a few seconds and then apply it again. Because you have opened the service opening of the tracker, the easiest method to remove power is to unplug the power cable inside the service opening from the saver cable. The saver cable is a short cable (app. 30 cm) plugged into the power socket of the controller and providing a power socket on its other end. This because the power socket of the controller is difficult to access. Please note that this pair connector/socket has a locking mechanism which is however easy to understand.
- Check eeprom values by opening the eeprom window and clicking on GetRAM (take screenshot of window).
- Run search zero for both axis (PA ccw, SA ccw). If e. g. the SA find's its zero mark, disable it (SA-) and continue search on the PA only (still PA ccw) until you either find the zero mark or you are sure that you went over it, but the tracker did not recognize it.
- Assuming the find zero worked on both axis set remote mode and enter values PA = -90, SA = 5, click Set Target, then wait until it reaches this position.

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- Set clock-mode. Does the tracker react as expected?
- Check the next morning visually and also by accessing INTRAs message buffer.

Thank you for the diagnostic instructions. Here are the results from this series of tests.

We've returned from a diagnostic trip to the tracker. We opened the service hatch of the tracker. Inside, we could see the cables disappearing towards the rotation axis of the tracker, but could not determine from this view angle if the cables were wound up. As the PA position sensor reported a -500 degree position, we rotated the tracker a full turn in the positive direction, stopping with PA at ~15 degrees and SA at ~10 degrees. rwb: Yes, the current values of the tracker looked ok and hence rotating the PA one full positive turn makes sense. The reason why I advised to open the cover is, that we do not really know what happened during the days before. It thus was a precautionary measure.

With the tracker in this ready-to-zero position, we disconnected tracker power using the connection inside the service hatch. With the tracker power disconnected, we confirmed that the tracker was off by sending a 'GetPos' command, which returned a timeout message. We then reconnected tracker power. After about five seconds, the tracker began to move ccw in both axes (downward and towards the east). The tracker moved past the zero positions without stopping, and the vertical axis quickly encountered a mechanical stop, so we hit the 'reset' button to stop its motion. The INTRACfg console contained the following information:

Warning FLASH configuration checksum error or invalid key Use 'fconfig -i' to [re]initialize database RedBoot(tm) bootstrap and debug environment [ROM] Non-certified release, version icb_ser by brusag - built 15:35:17, Oct 29 2010 Copyright (C) 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009 Free Software Foundation, Inc. RedBoot is free software, covered by the eCos license, derived from the GNU General Public License. You are welcome to change it and/or distribute copies of it under certain conditions. Under the license terms, RedBoot's source code and full license terms must have been made available to you. Redboot comes with ABSOLUTELY NO WARRANTY. Platform: ICB NET (ARM7TDMI) RAM: 0x00200000-0x00220000 [0x002057f8-0x0021cf00 available] FLASH: 0x00100000-0x0017ffff, 2048 x 0x100 blocks == Executing boot script in 4.000 seconds - enter ^C to abort RedBoot> go 0x114000 INTRA FW V2.19 - build of Jun 8 2016 13:45:40 hw:icb 25 rwb: The above is the output of the bootloader. It starts with an error message which however can be

ignored. Then, after a 4s-timeout the INTRA firmware starts and writes out its start message (build version etc). That the tracker than started to move should have been avoided by setting it in INIT-mode prior to the power off/ power on sequence. Sorry I forgot about this in my instructions. The correct method to launch the tracker is: Power up – set INIT-mode if it is not yet in this mode – position tracker for a search zero on both axis using Run motors – search zero – set REMOTE-mode and Set target to - 90/5 – wait for it to reach 90/5 - set CLOCK or SUN-mode – and its ready for unattended operation. You did the right thing when you stopped it (Reset forces INIT-mode).

A screenshot of the EEPROM parameters is shown here:

now mVersion is: ≉™	INTRA	serial #:	79,252	sun-sensor	-0.300	SerCig	
e + lot[1] 72.590 - 38.460	Axis Geors	ра 66:1 -	sa 66:1 +	Offset PA [1] Offset BA [1] Is	-0.500 5.0	Boud remote 57600	
at [m] 3250.00	Cflset["] Bange low ["] Plange high ["]	0.269 -200 200	0.000 -4 75	sigma law	0.150	600 608 616 624 601 609 617 625 602 610 618 626	
gnment 0.284 127,838	Target Chi* Target-Ohi/ Speed-Chi*	3000 0	3000 0	sunrenge low sunrenge high	0.300	b13 b11 a19 b27 b14 b12 a20 b28 b15 b13 a21 b29 b15 b14 a22 b10	
1.621	Speed-CH/	9000	9000 D	suntrac.% sun2red	50.0 0.043400	bbc b14 b22 b30 b07 b15 b23 b31	5:17. Oct 29 2010
Status: 1611.0/16241 EProm in Flash	16 GelfillimP ok	eeRAM p			legistry		2005, 2009
Read Write	Erece	GetPAN			Save	Read Defaults	d from the or distribute s. RedBoot's
Xa 16210/_1	E F F	edboot c latform: AM: 0x00 LASH: 0x	omes with ICB_NET 200000-03 00100000-	(ARN7TDMI) (00220000 [0 -0x0017ffff,	x0020575 2048 x	NANTY. E0-0x0021cf00 available 0x100 blocks conds - enter ^c to abe	ende to you.

We then used 'Run Motors' to reposition the tracker in the ready-to-zero position, and hit 'Find Zero'. The tracker did successfully find zero and stopped in the zero position.

After setting 'REMOTE' mode, we then entered values PA=-90 and SA=5, then hit 'Set Target'. The tracker successfully moved to this position (slightly above the horizon and pointing east) and stopped.

We then selected 'CLOCK' mode. The tracker moved to point approximately to the sun's current position: just below the horizon and at roughly the azimuth at which the sun had passed below the horizon. As the sun was below the horizon and had been partly obscured by low clouds, it was difficult to determine how accurate the pointing was. A screenshot and photo of the resulting position is shown here:

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rwb: While the sun is still out you may use the Sun window to display the signals of the 4-quadrant sensor as well as the pointing-error (in degrees) as shown in the PA and SA-fields. Command is Utilities>Sun then click Update.

The 'Load Messages' command returned the following information:

00-00-00 00:00:00 eeram loaded from flash 16-11-07 16:22:50 INTRA FW V2.19 - build of Jun 8 2016 13:45:40 hw:icb_25 16-11-07 16:22:50 initial position ok

16-11-07 16:26:04 chat, zero-0 found, eposo, 1077, eerrs, 0, hposo, 6849, herrs, 0

16-11-07 16:26:06 chat,zero-1 found, eposo,2938, eerrs,0, hposo,18697, herrs,0

We will observe the tracker's position tomorrow morning, and retrieve the tracker log at the next available opportunity.

The next morning (8 Nov 2016), the tracker position was checked twice, at 12:14z and at 14:20z. During both visits, the tracker did point near the sun's location, although the presence of low clouds and the large solar zenith angle made exact comparison difficult. The log was retrieved and showed the following contents:

00-00-00 00:00:00 eeram loaded from flash 16-11-07 16:22:50 INTRA FW V2.19 - build of Jun 8 2016 13:45:40 hw:icb_25 16-11-07 16:22:50 initial position ok

16-11-07 16:26:04 chat,zero-0 found, eposo,1077, eerrs,0, hposo,6849, herrs,0

16-11-07 16:26:06 chat,zero-1 found, eposo,2938, eerrs,0, hposo,18697, herrs,0

16-11-08 02:34:57 chat,zero-0 found, eposo,0, eerrs,0, hposo,-2, herrs,0

16-11-08 02:34:58 chat,zero-1 found, eposo,0, eerrs,0, hposo,0, herrs,0

Thank you for your continued help with this project!

rwb: Its great. It seems to work again. Please keep an eye on it. While its working again, we still have no clue what caused this corruption of its internal data. We will have to work on this here.