SPOL LESSONS LEARNED - PECAN

Mike Dixon

2015/09/02

This document lists the problems that occurred at SPOL during PECAN, to the best of my recollection, along with the actions that I believe should be taken to correct the problems and to try to prevent future failures, to the extent that this is possible.

1. Air conditioning systems

Problems encountered:

(a) The main end unit for the transmitter container failed and needed repair. Without this unit running, the transmitter cannot be operated – both AC units are required for transmitter operation.

(b) The wall unit in the UPS space sometimes just stops cooling, and as a result the UPS overheats. In the hot weather encountered at PECAN this required an immediate trip to the radar to reset the unit by cycling the power. We have not yet had any damage to the UPS that we know of, but this could certainly cause problems in the future if we cannot get to the site quickly. Also, sometimes the UPS wall unit shut off at night when the temperature dropped below 60F. This is a problem because the UPS room has no natural ventilation, so if the AC unit stops cooling the UPS overheats.

(c) The wall unit in the UPS room may be somewhat under-powered for hot (100F+) weather. The temperature in the UPS room climbs to above 95F (35C) when the outside temperature is above 100F.

(d) The wall unit in the annex also stops cooling sometimes – similar to (b) above. A power cycle seems to fix that.

Notes:

When the outside temperature is below about 90F, the AC units for the transmitter can keep the temperature within 2 degrees F of the the thermostat set point (74F).

When the outside temperature is above 95F, both main units run and the temperature in the container climbs above the set point. When the outside temperature is above 100F, the container temperature rises to about 78F. This is satisfactory provided both units are working correctly, but is not desirable from a redundancy point of view.

When the outside temperature is above 90F, it is unlikely that a single AC unit can cool the transmitter sufficiently for safe operations.

In reading the manuals, it seems possible that the wall units are not suitable for our application, and that they stop cooling in cold weather (outside temp less than 60F).

Action items:

(a) Review the AC setup for the transmitter. Request Jim Ransom's help in determining the correct mix of AC units for the transmitter container. We need a system with some redundancy, to allow for AC failure and repair while the transmitter remains in operation during hot weather.

(b) Review the specifications on the wall units, and replace them if they are not suitable for our application. The UPS AC unit is the most critical. The annex and tech container AC units are less critical, since if they stop working during remote ops they do not directly affect the ability of the radar to continue operating. Probably we should replace the UPS AC with a new unit that is more powerful and can operate in cold weather.

(c) Develop a method to remove and service the UPS AC unit from inside the container, rather than requiring it be removed from the outside.

(d) As part of the automatic monitoring and control system, add the capability to shut down the transmitter and the antenna if the UPS temperature exceeds a safe limit. This will reduce the load on the UPS and help to keep the temperature under control until the AC can be reset or repaired.

(e) Implement a routine AC testing, inspection and maintenance schedule, to keep all AC units in proper operational condition.

(f) As part of the site survey and preparation for future projects, set up a contract between UCAR and a local AC contractor, so that they are available on-call to quickly handle any problems that do occur in the field.

2. Transmitter temperature control / protection

Problems encountered:

When the AC units had problems, the klystron temperature climbed and exceeded 45C on occasion, and would have continued to increase if we had not manually shut the transmitter down.

Notes:

The klystron and cabinet temperatures are kept within limits by the AC system. When the AC system is operating normally the transmitter temperatures remain under control, with the klyston temp being around 34C (94F).

John Hubbert contacted the ROC hotline, who informed us that the temperature limits for the klystron are:

43C - start degrading components

45C - maximum operating temperature

At present we have no mechanism by which the klystron automatically shuts down in an over-temperature condition. We have seen the temperature exceed 45C.

Action items:

Add the capability to automatically shut down the transmitter when the temperature exceeds a safe threshold.

3. Arcing in the rotary joint and/or waveguide.

Problems encountered:

On June 3 we heard arcing coming from the pedestal area. Al Phinney entered the pedestal through the inspection hatch and determined that the arcing was occurring in the rotary joint.

On June 4 we obtained a nitrogen bottle and regulator, switched from the dry air compressor to the nitrogen tank, purged the waveguide, and then tested the radar to determine whether running with nitrogen would prevent the arcing. Waveguide pressure was maintained at 5 PSIG. We ran with nitrogen from that time onwards to the end of the project.

Over the following 4 days, while struggling with unrelated problems, we determined that we needed to run at significantly reduced transmit power to prevent arcing. We deduced that the rotary joint was probably damaged from the arcing, and that it would not be possible to run it at normal power.

On June 8 we replaced the rotary joint with the spare (the joint with the fiber connection through it). We purged the system using nitrogen and tested the transmitter, bringing the power back up to a more normal operating value (87.5 dBm).

From what we can tell no serious arcing has occurred during the remainder of the project and the installed rotary joint remains in good condition.

Notes:

I talked to Bob Bowie about how CHILL is operated, and how they avoid arcing problems.

SPOL uses a NEXRAD-type dryer-compressor.

CHILL uses a dryer-compressor type unit made by PureGas. See:

http://www.airdryers.com/air-dryers/cda.html

This is similar to the NEXRAD unit that we have, so the SPOL unit should be fine.

CHILL operates with a pressure of around 3 PSIG - they previously used 5 PSIG but the windows on the new feedhorn will only withstand 3 PSIG. CHILL has a ball-type purge valve on each waveguide at the edge of the dish, in a similar location to the Schrader valves on SPOL.

The purge procedure used at CHILL is as follows: open the ball valves, run the dryer/compressor for 12 hours, and then close off the valves. Only after that is it safe to run the transmitter.

Bob mentioned that on ship-borne radars they often create a small leak close to the feedhorn so that there is constant positive dry-air flow through the system, to constantly purge the waveguide in case moisture gets in.

Apparently NPOL uses this approach too. NPOL has pressure-sensitive purge valves on each waveguide near the feedhorn. NPOL operates at 5 PSIG. The purge valves allow a small positive flow to move from the dryer-compressor up to the feedhorn. This continually replaces the waveguide air, keeping it dry.

Action items:

(a) Add purge valves near the feedhorn as done with NPOL.

(b) Replace the Schader-type purge valves with ball-type units, to allow better flow during purging.

(c) Purge for 12 hours before operating.

(d) Add monitoring of humidity and pressure in the waveguide and/or at the compressor.

(e) Add monitoring of VSWR in the waveguides, to detect reflected power caused by arcing. Add an warning to nagios. Perhaps shut down automatically if arcing is detected.

(f) Repair damaged rotary joint.

For reference, the post-Dynamo action items were:

(a) Find cause of arcing.

(b) Determine whether arcing can be prevented with dry air only.

(c) Install arc detector system for remote ops monitoring.

(d) Would it make sense to add a purge valve on the waveguide high on the antenna, to assist with purging the waveguide?

4. Azimuth drive oil pump

Problems encountered:

On the evening of 06/02, Eric mentioned that he thought the azimuth drive sounded noisy.

On 06/03, Al entered the pedestal to inspect the azimuth drive oil pump. He determined that the return oil quantity was perhaps insufficient and that the oil pump may not have been producing sufficient pressure. There is a sensor on the oil line that should warn if pressure is low, but it is a good/bad-style censor rather than one that measures the actual pressure.

Al checked the pressure with a physical gauge and it was found to be 40 PSIG approximately. This seemed too low, as we expected it to be over 100 PSIG.

Therefore we decided to change out the oil pump. This procedure took about 2.5 hours.

Notes:

We are not absolutely sure that the pump was bad. The return flow seemed low, but with thin oil in summer temperatures it could be that the return flow looks less significant than in the winter.

We had to manufacture a gasket to fit between the oil pump body and the new pipe-connector housing machined by DFS.

Action items:

(a) Determine the correct operating pressure range for the oil pump unit.

(b) Install a monitoring transducer that provides pressure readings, rather than just a good/bad indication.

(c) Possibly get DFS to machine a second pipe-connector housing so that the replacement pump fully equipped and is ready to go.

(d) Inspect and check the (now) spare pump to see if it is functional.

5. Azimuth drive motor surge protector failure

Problems encountered:

One June 3 we started to notice problems with breakers tripping in the antenna control circuitry, and supply-line over-voltage faults occurred in transmitter.

At that time we began diagnostic efforts to track down the problem. This turned out to be a signnificant challenge. On June 4 Al found 140 VDC in the transmitter cabinet even though the transmitter power was turned off and no DC voltage should appear there. Diagnosis efforts continued throughout June 5. On the morning of June 6 Eric and Al traced the problem to a failed MOV (Metal Oxide Varistor) on azimuth motor 1. This was essentially causing a short circuit and allowing DC voltage to get into various parts of the system, including the antenna control and transmitter racks.

The MOV was replaced, which largely resolved the problem.

Notes:

From Wikipedia: MOVs have finite life expectancy and "degrade" when exposed to a few large transients, or many more smaller transients. As a MOV degrades, its triggering voltage falls lower and lower. If the MOV is being used to protect a low-power signal line, the ultimate failure mode typically is a partial or complete short circuit of the line, terminating normal circuit operation.

Action items:

(a) Replace all MOVs with new units.

(b) Purchase a full set of spares.

(c) Include regular MOV replacement in the maintenance schedule.

6. Transmitter trigger amplifier failure

Problems encountered:

On June 9, 3 days after replacing the azimuth 1 motor MOV, the transmitter shut down with a 'Transmitter over-voltage fault'.

According to the NEXRAD transmitter documentation, one of the possible causes for this fault is a faulty trigger amplifier (trigamp). Fortuitously, when we earlier experienced the problems caused by the failed MOV, John Hubbert had ordered a spare trigamp to be sent from the NEXRAD National Reconditioning Center, so we had a spare in hand.

The spare was installed, and this cleared up the fault.

However, the replacement trigamp required tuning – see notes below.

Notes:

When installing a replacement trigamp, the transmitter timing must be adjusted to form a good pulse, and the receiver timing must be adjusted for any changes in pulse delay through the transmitter. These transmitter tuning step is quite tricky and it took Eric and Al a while to get this completed successfully. Mike was able to adjust the receiver timing using the RVP8 configuration tools.

To adjust the transmitter timing, Joe had to recompile and modify the trigger generator code. This code hadn't been compiled in about 5 years, so we were fortunate that Joe could compile and modify it. Joe added the ability to read a delay value from a configuration file (this delay value had been embedded into the code.).

When we move trigger generation to the new processor, we'll need to document how to adjust this delay value.

Some time ago John Hubbert negotiated an MOU with the NEXRAD National Reconditioning Center to allow us to obtain exchange parts for the transmitter at minimal cost. As this experience demonstrates, this is an extremely valuable option for us to have. A new trigamp, supposing one were available for purchase, would probably cost tens of thousands of dollars.

Action items:

(a) Maintain our option to obtain spares from the NEXRAD repair center.

(b) Perhaps add to our collection of NEXRAD technical manuals.

7. Generators

Problems encountered:

(a) The outside generator overheated and shut down in hot weather (95F+) (June 20). The coolant temperature exceeded 205F, at which point the generator shut down automatically.

(b) On July 2 the fuel pump on the main diesel tank shut down because the fuel level in the return overflow tank exceeded the specified level. (This is a safety feature which prevents fuel spillage in the fuel tank container.) This caused both generators to run out of fuel. We shut down the transmitter and antenna in case of UPS failure. We switched the generators to the local tanks and got them running again. 30 mins of radar time was lost, but we were not in an active operation. Al fixed the fuel supply problem by pumping the excess fuel out of the overflow tank into the main tank.

Notes:

(a) On the outside generator, we noticed that a layer of dead insects had built up on the radiator, reducing the airflow through the radiator. We cleaned the radiator with detergent, water and compressed air. After that maintenance, the coolant temperature dropped to more normal levels, but it still reaches 203F when the outside temperature climbs into the high 90s. We increased the temperature shutoff temperature to 219F (this is a software-controlled unit) which seems rather high. We should reduce that temperature before operating the unit in the future.

The inside generator temperature climbs to around 200F in very hot weather (100F+) but is stable. The inside generator is less susceptible to insect buildup on the radiator.

(b) As mentioned above, the fuel pump shutoff is a safety feature to prevent diesel spillage in the fuel tank container if the return tank overflow gets too full. However, this does mean that we need to monitor the level in the overflow tank to make sure there is no fuel in there under normal operations.

Action items:

(a) Add radiator cleaning to the checklist for the generators.

(b) Consider having a tank of water on site, to facilitate this sort of maintenance.

(c) Check the fuel level in the overflow tank each time fuel is delivered.

8. UPS (Uninterruptible Power Supply)

Problems encountered:

While working to diagnose the motor MOV surge protector failure, we inadvertently put the UPS into 'remote mode'. In this mode, the UPS can be controlled remotely via the network. However, we do not operate it in that manner, so we need it in 'local mode'.

We were not able, via the menus on the front panel, to get the UPS back into local mode. We read the manual and contacted the vendor, and they told us what 'should' work, but we were not successful in changing to local mode.

To control the system locally while it is in remote mode requires using jumpers on a connector block behind the front panel. This allows you to switch between bypass mode and inverter mode.

We were able to use this jumper technique to get the UPS from bypass mode into inverter mode for normal operations. We plan to use this same jumper technique put it into bypass mode at the end of the project, to enable a normal shutdown.

Action items:

(a) Get the vendor to visit Marshall or Firestone to service the unit and get it back into local mode.

(b) Find out from the vendor the correct technique for toggling between local and remote mode using the front panel menus. Ensure we have this procedure properly documented.

9. Remote control / monitoring system.

Problems encountered:

(a) Eric found that some cable connections were loose at the back of the sixnet unit, leading to intermittent behavior of the antenna control system. These were fixed.

(b) The temperature sensor for the annex sometimes gives a spuriously high reading (> 200F). This should be replaced. The nagios configuration for these temperature sensors should be changed to add some filtering, so that a single spurious temperature value does not cause an alarm.

(c) The Mitch switch status in nagios continues to give erroneous readings.

(d) We observed that the Sixnet’s load average would gradually rise, the Sixnet would become less responsive and the Sixnet programs would crash if the Sixnet wasn’t rebooted every 7-10 days.

Action items:

(a) Add QC filtering to temperature data to filter spurious spikes.

(b) Fix the Mitch switch status monitoring.

(c) Cycle power on the sixnet pre-emptively once a week or so.

(d) Check for the availablility of upgraded firmware for the Sixnet to fix the load average problem, or whether there are memory leaks in our monitoring/control programs that could be causing this issue.

(e) Replace S-Pol's power meters with the Eldora Power meters that have ethernet connectivity. The existing power meters are attached with a GPIB-Ethernet converter. Both the power meters and the GPIB units are weak links, and need manual intervention after power is lost which is not good.

Notes:

With respect to action (c) above, the sequence should be:

(1) Stow antenna, disable run-line.

(2) Shut down transmitter, wait for cool-down to complete.

(3) Power cycle the sixnet.

(4) Bring transmitter back up.

(5) Re-enable run-line, restart scan.

10. Mitch switch.

Problems encountered:

The Mitch Switch started losing lock, resulting in a few dropped beams in the data each time this occurred (June 19).

Rich found this to be a problem with the controller rather than the rotary switch itself. He replaced the controller with the spare unit and the Mitch switch then ran fine for the remainder of the project.

In diagnosing the problem on the original controller, Rich eventually found that replacing the servo amplifier and tuning it fixed the problem.

From Rich Ericson's log:

On 6/19/15 1700: the Mitch Switch would periodically breaks lock with the transmitters T0-6 signal. The switch was questionable and suspect, I hooked up the spare switch to confirm. The spare switch exhibited the same problem, the controller is the failing link. Tried adjusting the servo amp in the controller to get a stable lock but was not successful. Option B is to replace the Mitch Switch Controller with the spare, this corrected the problem and SPOL was ready just in time for the nights IOP.

6/29/15: Connected the spare Mitch Switch controller to the Mitch Switch in the Transmitter container to verify that the spare Mitch Switch wasnâ€™t giving me a problem, the controller still has a hiccup once in a while. Set it up back in the Tech Lab, container 8 and did some more testing and adjusting of the Servo Amp. Added an earth ground from the power input terminal block to the chassis, this seems to have stifled the hiccups.

Notes:

The Mitch switches gave problems in during DYNAMO, but this was mostly related to poor quality bearings. Since DYNAMO DFS has rebuilt and balanced the units, and installed better bearings. The switch hardware now runs cool and seems reliable.

Action items:

(a) Continue to monitor the Mitch switches for problems at FRONT.

(b) Determine the typical run-time life of a set of bearings, so we can plan accordingly for future projects.

(b) Test out the spare switch and controller in the lab to ensure they are ready for operations.

11. Angle measurement system, PMAC

Problems encountered:

(a) After the PMAC runs for a long period of time, it seems to lose the ability to read the angles correctly. This occurred once during the project (June 30).

(b) Whenever the PMAC is restarted (power-cycled), it develops a 0.4 degree elevation offset and 0.5 degree azimuth offset.This was a known bug before PECAN.

Notes:

The angle measurement system was re-engineered before PECAN and seems in general to be working well.

The remedy for (a) is to power cycle the unit. This should be done with the antenna stowed and the brakes on (run-line off).

The remedy for (b) is to recompile and upload the firmware code for the PMAC. This is documented in:

projDir/doc/howto/PPMAC_problems_fixes_r5.pdf

Action items:

(a) Perform a pre-emptive power cycle on the PMAC once per week during operations.

(b) Try to find a solution to the angle offset problem.

(c) At FRONT, install and test the spare angle board computer to ensure we have a valid spare.

(d) Add documentation for the new angle board system.

(e) Eric and Joe should upgrade the motion control program and the cappi program on the PowePMAC. The current code relies on adding and removing the azimuth motor from the active coordinate system. This capability isn't supported in the current firmware. Since we can't use the current firmware, we can't get support from Delta Tau for our power-on angle issues (off by 0.X or 180 degrees). If we could upgrade to the current Delta-Tau firmware, it may solve some of our power-on issues.

12. Smearing of RHI data

Problems encountered:

Early in the project it was noted that for the up-going RHIs, the number of samples used to compute moments at the lowest angles was too high. This was caused by a bug related to the computation of antenna speed. This bug affected RHI data from June 01 to June 17.

Notes:

On June 17 a quick fix was implemented to limit the number of samples to 128, which effectively limited the RHI dwell width to 0.33 degrees.

Using this fix, the time series from June 01 to June 17 were reprocessed to produce correctlycomputed RHIs. These have been installed in the on-line data set on eldora.

By July 10 a permanent fix was made to the HAWK software to solve the problem properly. This fix was not implemented operationally in case it has side-effects that have not shown up in testing.

As as result of this experience, it was decided to archive all time series for the project onto 2 TB USB drives, and from there onto the HPSS. A script was developed to automate this process and the archive was successfully created.

Action items:

(a) Reprocess the RHI time series to produce covariances using the improved software.

(b) As part of the data QC, use these covariances to produce new RHI moments.

(b) Test the updated code in realtime mode at FRONT to ensure it is working as intended.

13. Antenna pattern / frequency / ZDR calibration

Problems encountered:

The H and V antenna patterns, as measured from sun scans, are not circular and do not match between H and V. This leads to complications in ZDR calibration, and is probably responsible for some of the variability we observe in the ZDR bias.

Notes:

We have known about this problem since before DYNAMO. And we are aware that changing the operating frequency can improve the antenna patterns and result in a better match between H and V.

During DYNAMO we operated at 2800 MHz, which was better than our normal operating frequency of 2809 MHz.

For PECAN we applied for permission to use 2802 MHz, but this was declined and we operated at our normal 2809 MHz.

Action items:

(a) Perform more tests to determine suitable alternative frequencies.

(b) Test whether changing the distance of the feedhorn from the dish affects the antenna pattern.

(c) If we are not able to get the system working well at 2809 MHz, apply for a suitable alternative operating frequency.

14. Computers / RAIDs / software

Problems encountered:

(a) The control1 server hung once, probably related to power problems. A reboot fixed the problem (June 3).

(b) On pgen1, one of the system RAID1 disks failed, as shown by an orange LED indication on the front panel (June 24). Dell sent a replacement disk within 2 days, and that disk was installed without having to bring system down, due to the RAID1 hot-swap capability. The old disk was returned to Dell.

(c) The main RAIDs on pgen1 and pgen2 got close to filling up because we are now saving time series data routinely.

Action items:

(a) Increase RAID sizes before next field project.

(b) Increase the memory for sci1, sci2, sci3, eng to at least 8GB. These computers only have 4GB, which is barely enough to run CIDD and the other displays.

(c) Use Linux High Availability for control1/control2 to give a hot backup for our control functions, that doesn't require human intervention and doesn't require users to use a different URL for the backup system. If control1 crashed, the High Availability utilities would automatically start the control programs on control2. We would have to sync the scan strategy file from control1 to control2 periodically.

(d) Use the IDRAC modules in each server to monitor raids and disks via SNMP and the check_mk “dell_idrac_disks” plugin. This would give us warnings about RAID/disk failures without requiring someone to notice warning lights.

(e) Buy some spare disks for the servers, so we don’t have to wait for Dell to ship replacements.

15. Laptops

Problem:

The PMAC and other windows laptops at SPOL are all very old and slow. It is only a matter of time until they fail.

Action items:

Replace all laptops with modern machines.

16. Chairs

Problem:

4 of the chairs at SPOL are in good shape, and the others are pretty bad.

Action items:

Buy 4 new chairs.