Northern California Soaring Association

N3981C System Documentation

January 2021

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Dedicated to John Scott. Friend, Mentor, Fellow-Aviator, True Gentleman

Overview

During the period of December 2019 – February 2021, we performed a major refurbishment of the electrical, oxygen, and pitot-static systems of N3981C. In addition we did a refurbishment of 81C's interior which included reupholstering the seats and headrests and removing old carpet from the glider sidewalls, cleaning and then painting the sidewalls and other components. As a general rule, we kept the configuration of 81C as close as practical to that installed in KP. This has obvious benefits for those flying and maintaining the two aircraft and allowed us to use lessons learned in refurbishing KP on the 81C Project.

Essentially all instrumentation, wiring and pneumatic tubing was removed from the aircraft. Only the radio antenna wire and the section of the pneumatic tubing that runs into the tail boom were kept. This was replaced by a new electrical distribution system using aviation grade wire and connectors. The glider battery was replaced with a new 20 Ah LiFePo unit, a new battery tray and tie-down were fabricated and installed and various connections were terminated with Powerpole Connectors. New instrument tubing with metal connectors was installed throughout.

The Terra radio and transponder were replaced by Becker units that have much lower power consumption. Headphone and microphone jacks and connecting wire were replaced and a boom mic was installed for the rear seat. New grips and PTT switches were installed for both seats.

The Cambridge vario/navigation unit was removed and an LXNAV S8 electronic variometer was installed. For navigation, there is a RAM mount and USB power port installed in the panel so that pilots can easily use their own navigation unit (Oudie or comparable unit). The instrument panels themselves were removed and replaced by ones cut to accommodate the new avionics.

The old oxygen system was removed and upgraded. The tank received a fresh hydro and fill. A new regulator and distribution tubing were installed, and new CPC style connectors replaced the old, non-standard connectors that were previously used. Also, the location of oxygen system plug-in ports was moved from the instrument panels to the mounting surface used to mount the headphone and microphone input jacks.

Carpet that was glued to the interior sidewalls of the glider had badly deteriorated. The carpet was removed, the surfaces cleaned, prepped and painted. The upholstery on the seats and cushions was also in poor condition so it was removed, the seats painted, camloc connectors replaced and new upholstery was fabricated and installed. New tread was installed on the floor in the rudder pedal foot-wells. The cabin vent control cable was inoperable due to corrosion so a new cable was procured and installed. Instrument panel glare shields were in poor condition so were refurbished, painted and the camloc support structures were reinforced with fiberglass.

At various times in the past, 81C's wings have been stored on an open trailer with wing spars exposed to direct sunlight. As a result, the top layer of fiberglass on the spars experienced significant UV damage. Corrie Volinkaty, an A&P with a composites background, removed the damaged layer and resurfaced the spar with new fiberglass fabric and resin.

Finally, the chain canopy restraint lanyards, which were unlikely to break away in a canopy jettison, were replaced with lightweight paracord lanyards.

Total cost for the refurbishment was about $6000 (2020 dollars) and total labor is estimated to be somewhat in excess of 500 person-hours, somewhat more than the KP project because of the interior restoration work and spar resurfacing. Transponder verification was done by Precision Static in March, 2020. At the end of the project, Steve Radcliff (certified A&P mechanic) conducted a fresh Annual Inspection of the aircraft and the modifications. Both the transponder verification and the Annual Inspection are documented in the aircraft logbook.

The completed scope of work is summarized below. Figures 1 and 2 show before and after views of the two instrument panels.

- Installed new fuse block for branch circuits
- Installed new ground buss
- Modified the LiFePO3 battery, charger, and glider to use Powerpole connectors
- Fabricated and installed new battery tray and tie-down
- Removed all the old Cambridge units

- Removed old Terra radios and transponder
- Added circuit and custom cable for Power Flarm to S8 connectivity
- Fabricated new wiring harness and installed Becker 4201 radio
- Installed new grips and PTT switches for both seats
- Fabricated new wiring harness and installed a Becker 4401 transponder and ACK SSD120 encoder
- Installed new Mic and Phone jacks and wiring
- Developed custom boom mics that are compatible with Becker radios (to be installed)
- Installed a new radio external speaker
- Installed an external speaker for the electronic vario
- Installed a new Digital Voltmeter in panel
- Installed Ram mounts and USB power ports in the new instrument panels
- Removed old oxygen system
- Removed old, non-standard oxygen ports from panels replaced with side mounted CPC plug in ports
- Installed new oxygen system regulator and distribution hardware
- Installed new LXNAV S8 Club electronic variometer
- Removed UV damaged areas and resurfaced wing spars
- Repaired and fiber glassed the front and rear glare shields; installed new Camloc fasteners
- Painted and trimmed the glare shields
- Removed deteriorated carpet from the interior walls of the glider and painted surfaces
- Removed deteriorated upholstery from seats and painted surfaces
- Fabricated and installed new upholstery for seats and headrests
- Replaced old “chain” canopy lanyards with lightweight paracord

Figure 1: Legacy front and rear panels

Figure 2: Panels after refurbishment project

Electrical Distribution System

As noted, all of the existing wiring was removed except the aircraft structural grounding wire and the cable to the radio antenna. Both of these wires extended into the tail boom and were not accessible enough to justify replacement.

All of the new wire was aviation grade with Tefzel insulation. Connections were made using either aviation grade terminals/splices and appropriate crimping tools or by soldering. Minimum wire gauge was AWG 22 and all wires were at the gauge specified by the relevant installation manual or larger (meaning larger wire). Larger wires were used to minimize voltage drop for power carrying wires, or in some cases for convenience because of what was on hand. John Scott did an electrical current assessment for KP showing that this approach was conservative with respect to wire protection. The interested reader is referred to the KP documentation for the details. Wire and connectors were typically procured from either Wings and Wheels or Aircraft Spruce. Similarly, switches were of “Mil-Spec” quality level procured from Aircraft Spruce.

Wire routing mostly followed the same paths as the legacy system. Wherever appropriate, service loops were included to simplify future maintenance or modification. Where needed, wires were secured using cable ties and Weld Mount cable tie anchors. Weld Mount anchors are high quality epoxy-on mounts often used in the marine applications. They are much more reliable than the typical stick-on mounts used in less stringent applications. The epoxy sets in 10 minutes and achieves handling strength within 30 minutes making it convenient for this type of work. Weld Mounts were procured from Western Marine. It is advised to avoid to using generic vendors, such as Amazon or E-Bay, to procure Weld Mount adhesive as it requires refrigerated storage and proper handling.

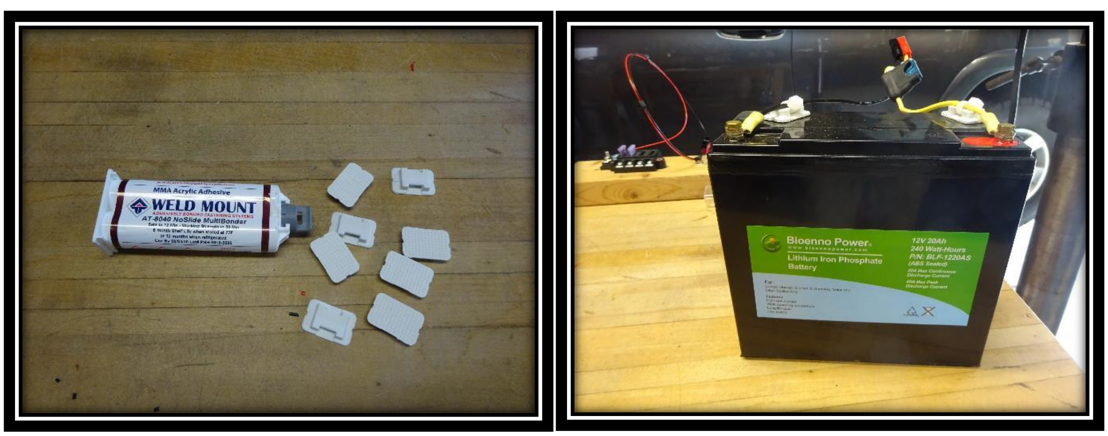

Figure 3: Weld Mount cable tie anchors, 20 Ah LiFePo Battery

The wires from the battery are continuous 16 gauge terminating at the Master Switch (+ Lead) or Ground Buss. During disassembly, multiple, casually implemented splices were discovered along the length of the main power leads. Future branch circuit connections should be made at the fuse block and ground buss to maintain the integrity of the current build.

The battery tray was fabricated by Tap Plastics from ABS plastic. Fit-up testing showed that the ABS to battery interface was excessively slippery. To mitigate this, neoprene rubber was bonded to the bottom of the battery to provide better surface to surface adhesion. The tie-down is a simple camlock strap that is threaded through a channel in the bottom of the battery tray. Similarly, the wires leading to the battery pass underneath the tray in a channel cut for this purpose.

The Ground Buss and Fuse Block were manufactured by Blue Sea Systems and procured through Amazon. The mounting scheme was the same as used in KP and the interested reader is referred to the KP documentation for details. The battery wiring is protected by a 15 A inline fuse. Branch circuits are protected by either 3 A or 5 A fuses depending on component installation manual recommendations. Branch circuit wires are labeled as the buss/fuse block end. A top level wiring diagram appears in Figure 4 and the corresponding photo. Note that the variometer wire assignments are in a sense out of order. This was done in order to optimize wire routing.

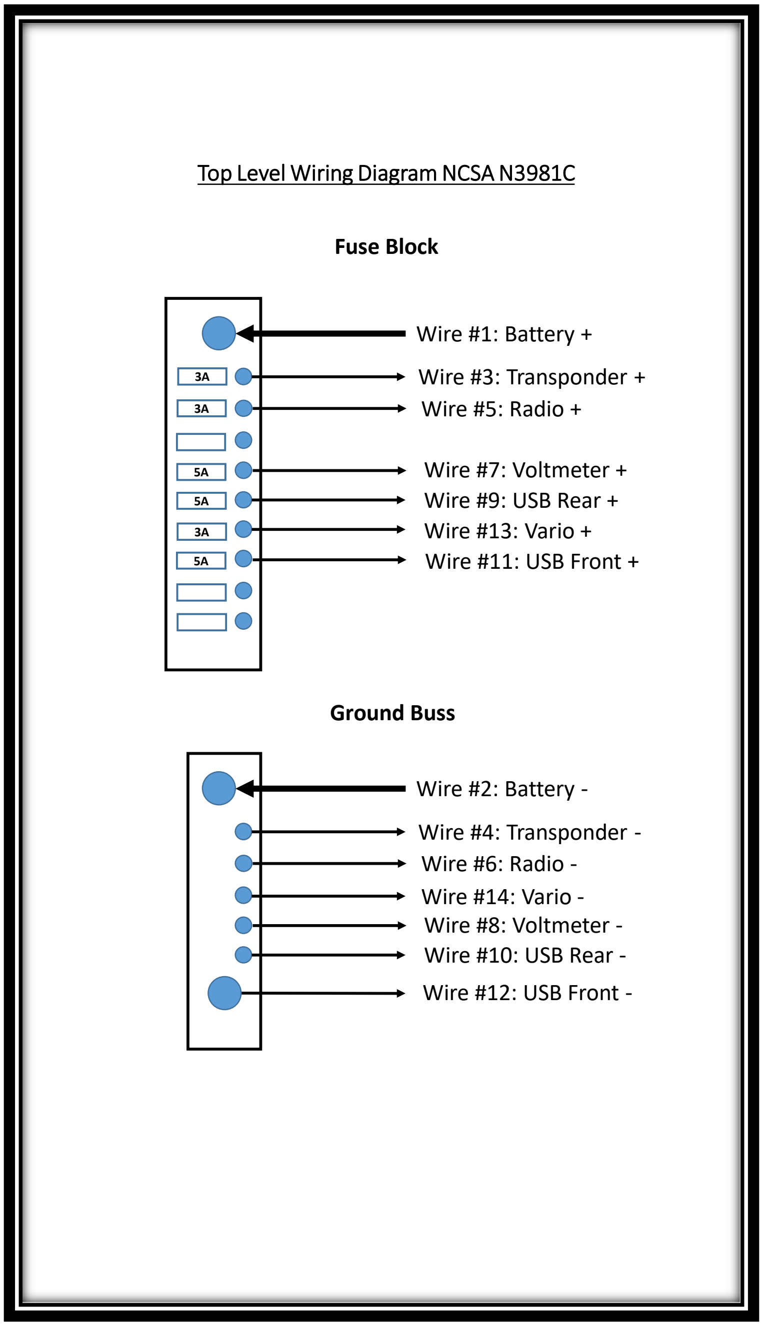

Figure 4: Top level wiring diagram

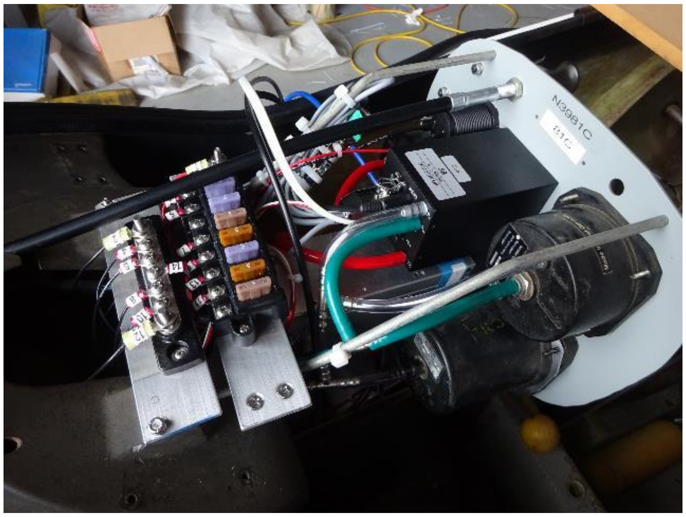

Figure 5: Ground buss and fuse block

Instrument tubing

All legacy instrument tubing and connectors were removed except for the part of those lines that run into the tail boom. New, 3/16” ID vinyl instrument tubing was procured from Wings and Wheels and installed. Plastic connectors in the legacy system were replaced with metal connectors, also procured from Wings and Wheels. Lines were fixed in place using Weld Mount anchors and cable ties.

The two mid-fuselage static ports use 1/4 inch, rather than 3/16” fittings. An adapter was fabricated using 1/4 inch ID Laboratory Grade Silastic Tubing and a 1/4 inch to 3/16” reducing fitting. Similarly, the transponder encoder requires 1/4 inch tubing, so an adapter was also fabricated for that location.

The legacy installation used three 0.45 liter capacity bottles. In the new configuration, the S8 variometer does not require a capacity bottle. However, all three bottles were reinstalled in their original locations. The line for the unused bottle was terminated, but left in place in case needed for a future application.

Instrument Panels

New instrument panels were fabricated to accommodate the new avionics used in the 81C build. John Scott designed the panels and used CAD software to generate the files needed for fabrication. The aluminum panels were then laser cut by a local fabricator.

On Grob 103s, the upper half of the instrument panel is vertical whereas the lower half is angled slightly to better match the pilot’s sight angle. On the KP build, the front panel was fabricated as two separate subpanels and then match drilled to the mounting support. The rear panel was salvaged from the legacy panel. For 81C, we fabricated new panels for front and rear from single pieces of aluminum. After laser cutting, the panels were bent to accommodate the change in viewing angle. After fabrication, the panels were cleaned and powder coated by Fusion Coatings of Livermore.

The panels were labeled using a label-maker with transparent tape and then clear-coated to provide better adhesion. Unfortunately, after several coats of clear coat, there was a significant fade in the labels either due to the opacity of the clear coat or chemical fading. While still visible, some of the labels are faint and are candidates for replacement in the future.

The original Grob instrument panels used countersunk machine screws for instrument mounting. This scheme is intolerant of slight dimensional mismatches, so all countersunk screws were replaced with normal round or socket head screws.

Figure 6: New panels after powder coating

Radio

John Scott procured several used Becker 4201 radios for Club use. One was installed in KP and another was installed in 81C as part of this project. The wiring harness is set up to support standard microphones using 0.208" microphone jacks, dynamic mics are not supported. Each pilot has the option of using a hand-held mic, a headset with integrated microphone or a gooseneck mounted standard mic. To switch mics, unplug one mic and plug in another.

Note that the input impedance of the Becker is roughly 100 ohms. Compatible microphones will have output impedance similar to this. Note that some standard aviation gooseneck mics have much higher impedance, ~2000 ohms. These mics are not compatible with Becker radios. The gooseneck mics in 81C were custom designed and fabricated by Michael Demeyer. See section on boom mics for the details.

Audio output uses a small speaker mounted behind the front seat. Audio can also be accessed through the radio headphone jacks. Note that the speaker remains operable regardless of whether headphones are plugged in or not. A toggle switch on the front panel allows use of the radio's intercom function. Turning on the intercom allows the front and rear seats to talk to each other without transmitting. Push the PTT switch to transmit; it's not necessary to turn off the intercom when doing so. The intercom will work with either a headset mic or the gooseneck mic, it will not work with a hand-held mic. Intercom audio is only available on headset audio. Intercom audio is not audible on the radio speaker.

Note that the radio was installed with a 2 foot service loop so that it should be possible to remove and replace the radio without having to remove other instruments or wiring. Note that the service loop is secured by a single cable tie that must be cut before the radio can be removed.

The Becker 4201 is relatively simple and intuitive to use. But pilots should consult the manual or get a briefing from a knowledgeable pilot before flying with it for the first time.

Figure 6 is an as-built schematic for the radio. A complete schematic, including outputs/inputs not used in the 81C build, can be found in the Manual.

Custom Boom Mics

As noted, commercial boom mics that we evaluated had a poor impedance match with the Becker standard mic input circuitry. Instead we fabricated a custom boom mic using the microphone cartridge from a headset mic, David Clark or equivalent. The headset mic was mounted to gooseneck and is designed to be mounted to the glider cockpit sidewalls.

A prototype boom mic was fabricated, installed and beta tested in Tom Anklam’s private plane. The mic works very well and is relatively inexpensive. One difference between the custom mic and a commercial one is that the custom mic needs to be placed close to the mouth in order to work properly.

Michael Demeyer has fabricated a second boom mic that will be installed in 81C in the future.

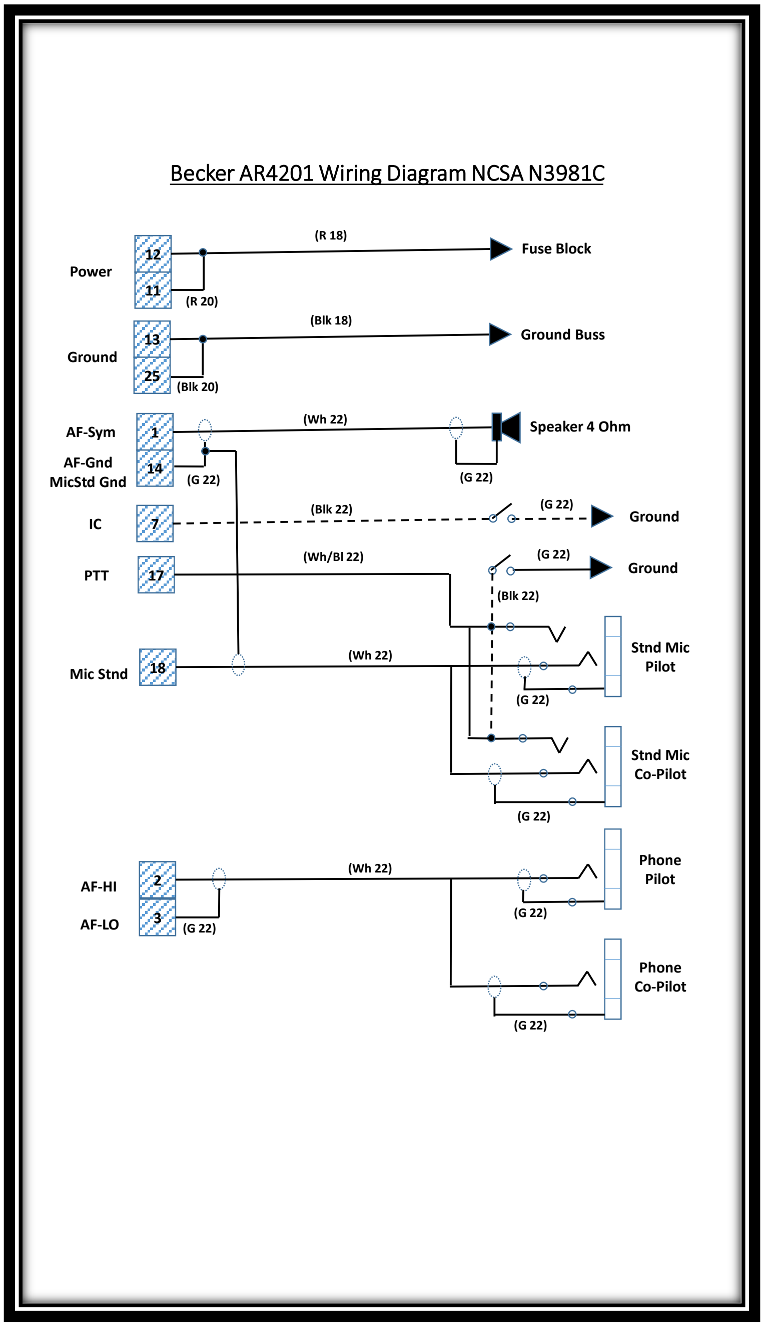

Figure 6: Schematic for radio wiring harness

Transponder

A Becker 4401 transponder was installed in the front instrument panel. This is the same transponder installed in KP. The 4401 requires an external encoder. A Trans-Cal SSD120 encoder was installed underneath the front seat pan; right side, forward. The schematic for the transponder/encoder interconnect appears in Figure 7. The antenna is mounted to the front panel glare shield. Ensure that the antenna is connected before turning on the transponder to avoid the potential for damage from reflected RF energy.

As with the radio, there is sufficient service loop to permit the transponder to be removed and replaced without the need to remove other instruments; mind the antenna cable when doing so.

Consult the 4401 Manual for further guidance on operations.

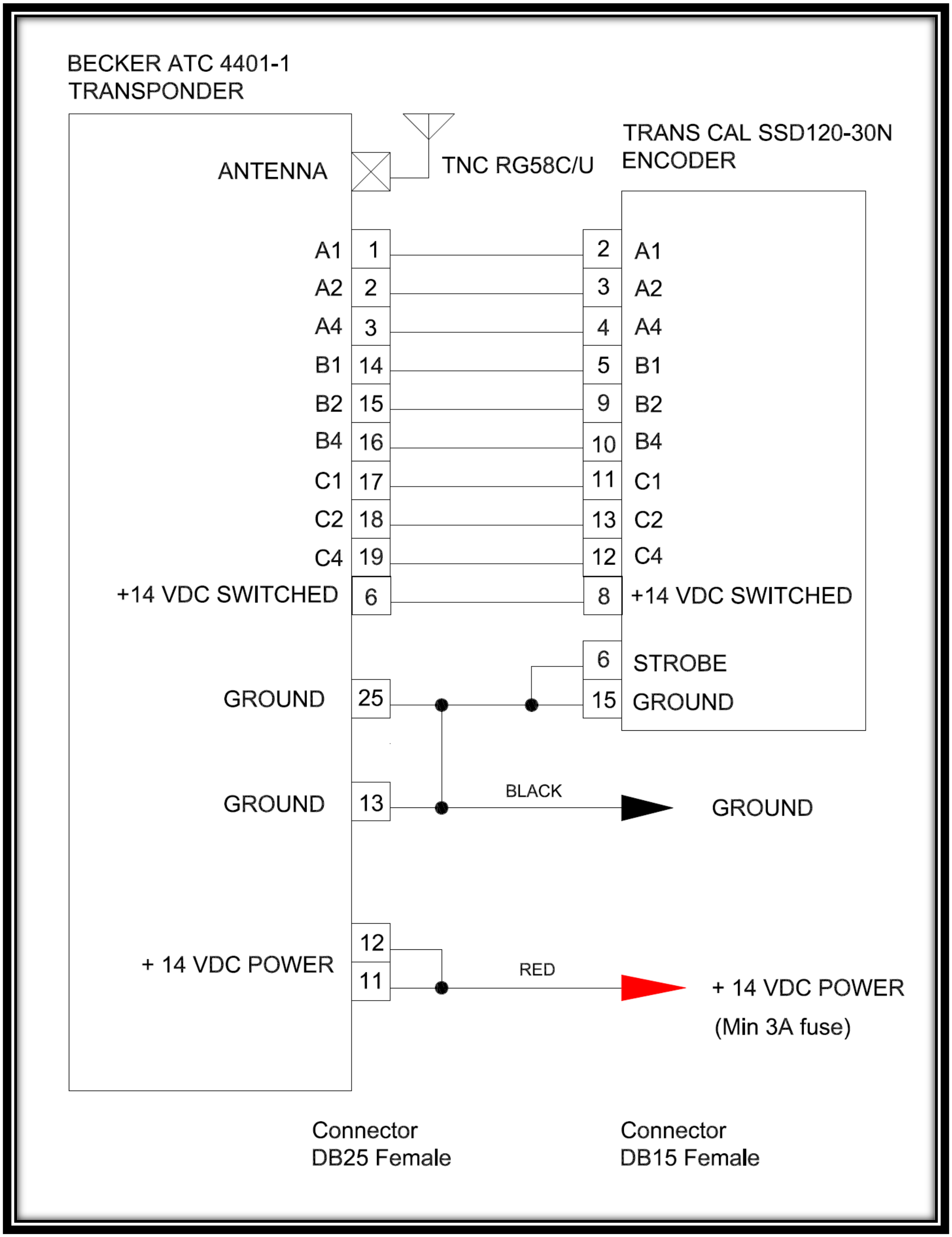

Figure 7: Transponder wiring diagram

S8 Electronic Variometer

A new LXNAV variometer was installed in the front instrument panel. The S8 variometer is a highly capable instrument, but one that also requires a knowledgeable user to get the full benefits. Those not familiar with the vario are encouraged to consult the operating manual. Note that the vario has been configured by the 81C Crew Chief (Michael Demeyer at publication date) and is under password control.

The S8 provides power to the portable PFLARM unit that is mounted on top of the rear panel glare shield. In return, the PFLARM provides GPS and PFLARM data to the S8. Traffic data is available on the relevant S8 screen (see the Manual for details). Traffic alarms are available on all S8 screens and will override other content to ensure that alarms are presented in a timely way. Ramy Yanetz, NCSA point of contact for PFLARM, configured 81C's PFLARM. If pilots have configuration related concerns or questions, they should contact Ramy and not independently modify the configuration themselves.

The PFLARM unit and the S8 communicate via a custom cable fabricated by Brian Roach. The S8 provides +12V and DC return to the FLARM, and the FLARM provides GPS position and FLARM information to the S8 via an RS232 serial interface. The FLARM computes and asserts collision alarms for the S8.

The S8 has an RJ12 connector (2-telephone plug) and the FLARM has an RJ45 connector (aka ethernet). This is a non-standard configuration, so the approach was to procure an ethernet cable and a 2-phone patch cord, cut the connectors off one end of the two cables and then splice the two cables together. Because the ethernet cable has unused wires, we chose to double up on the power leads to reduce voltage drop. So the end result is a long ethernet cable spliced to a short pigtail fabricated from the phone patch cord. The pin assignments are shown in Figure 8.

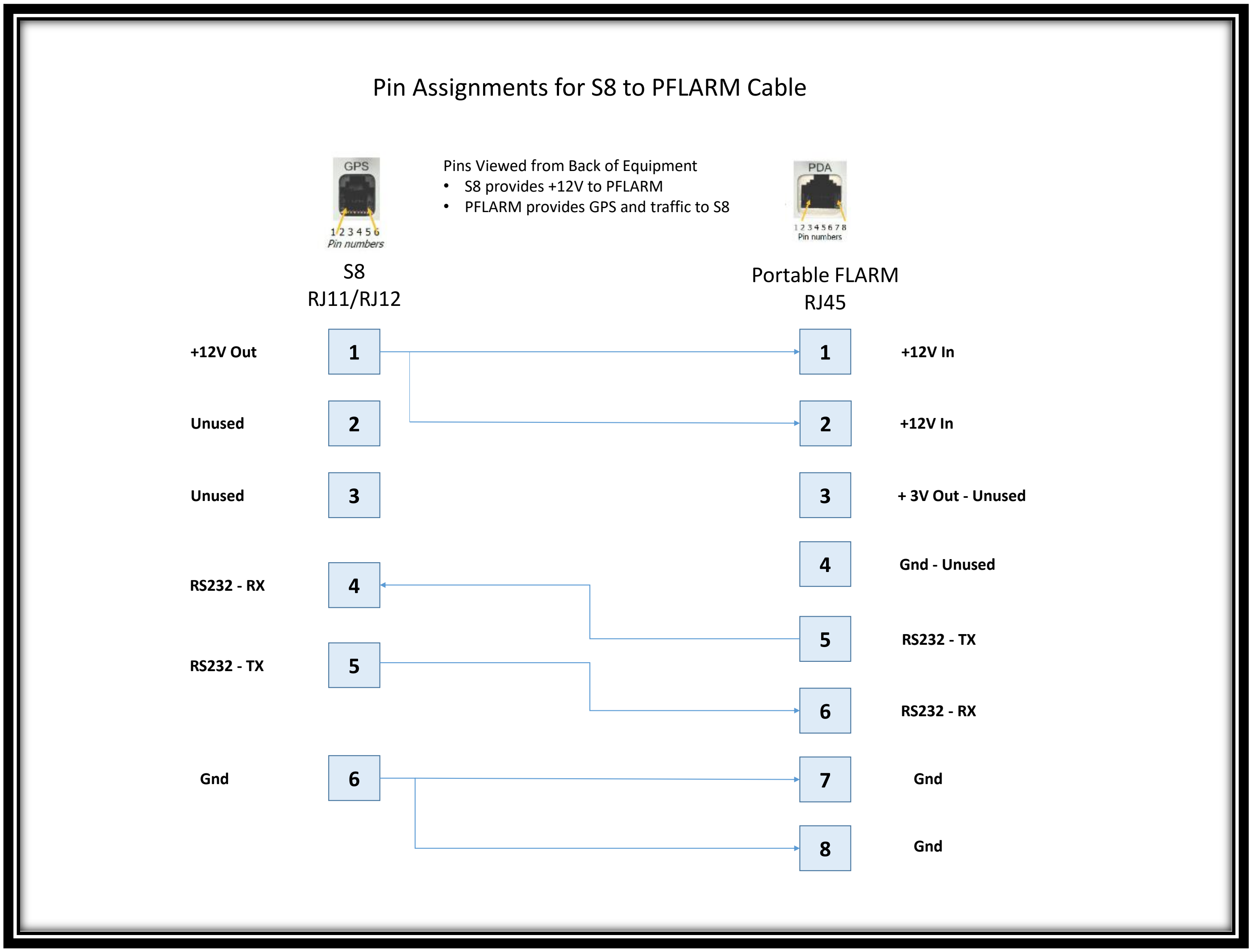

Figure 8: Pin-outs for S8 to PFLARM Cable

Oxygen System

Except for the oxygen tank and its mounting harness, the legacy oxygen system was completely removed and replaced. The tank itself was 4 years out of hydro test compliance, so the tank received a fresh hydro test and fill. This service was procured through Maintenance Express at the Livermore Airport.

A new regulator and distribution hardware were procured from Mountain High and installed in 81C. The regulator configuration is different than used in KP in order to have a more compact footprint for the valves and fittings (Figure 9).

Figure 9: O2 Tank and Regulator

To fill the tank, unscrew the regulator, set it aside and attach the fitting from the fill station. Note that the regulator fitting is designed to be hand tightened. Use of a wrench is not necessary and may damage the regulator. If difficulty is encountered in removing the regulator, check to see that the regulator is fully depressurized. Even a small amount of residual pressure is sufficient to lock the threads. Note that there is a relatively large service loop in the oxygen tubing at the regulator end. This is to enable the regulator to be set aside without disconnecting the tubing during bottle filling operations.

New tubing, sized for a two seat aircraft, as well as a splitter and other fittings were also installed. In the legacy system, the oxygen ports were mounted on the instrument panels. In the new build, the oxygen ports have been standardized to CPC style fittings and mounted adjacent to the headphone jacks.

Interior Refurbishment

The interior sidewalls of 81C were covered in carpet that was badly deteriorated. The old carpet was removed and the sidewalls were cleaned to remove old contact cement residue, prepped and primed with Interlux Prime-Kote polyurethane primer. After priming, two coats of Interlux single part polyurethane Topcoat were applied. The paints were marine grade products procured from West Marine.

The tread in the rudder foot-wells was worn out from many years of use, so the remnants of the tread were removed and new tread was installed.

The instrument panel glare shields were in poor condition; significantly worse than on KP. 81C glare shields were warped, showed significant cracking and were badly faded. Most of the shield warping was removed by repetitively using a heat gun to soften the material and then reshaping the material while still soft. Fiberglass was applied to repair cracked areas and also to reinforce the mountings for the Camloc fittings. Finally, the shields were cleaned, painted and had new vinyl edge trim applied.

The fabric and upholstery on the seats and headrests was badly deteriorated. The seats were stripped, sanded and painted. New upholstery was fabricated and installed by Michael Demeyer.

Marianne Guerin cleaned and prepped and painted the glider side rails and various metal components.

Figure 10: Cockpit After Painting and Seat Upholstering

Canopy Lanyards

The legacy canopy restraint lanyards were fabricated from chain. While quite sturdy, we had concerns that the lanyards would not break away in a canopy jettison event. Unfortunately, there aren't commercial solutions or community standards on how to fabricate a lanyard that will both securely restrain the canopy under normal ground handling operations and yet break away in a jettisoning event. After some analysis and bench testing we selected 275 weight paracord to fabricate new lanyards. The analysis and test results are summarized in Appendix A.

Lessons Learned and Notes for Those Doing Future Modifications

The 81C project benefitted greatly from lessons-learned in refurbishing KP. The techniques and materials, developed on KP, by and large worked well on 81C. A significant improvement was the use of one piece instrument panels on 81C. The two piece design used on KP was cumbersome and required precise match drilling to be done in the field. Also, it was much easier to make a new rear panel than trying to patch and reuse the old panel as was done on KP. On 81C we had the instrument panels powder coated rather than hand spraying them ourselves. This was a significant time saver, produced a superior finish and the modest cost was well worth it.

Something that did not work well was using a label maker to label the instrument panel followed by several layers of clear coat. After several coats, we noticed significant fading of the labels, due either to the opacity of the clear coat or chemical fading. Ultimately, we will probably install an engraved plaque to ensure proper visibility of the N number.

Another thing that we would change is the number of ground buss terminals. The ground buss used has only 5 branch circuit connections. While the fuse block has several unused connections, the ground buss is completely full, providing no room for future expansion. One option would be to splice the two USB port grounds together, this would open an additional connector. The same could be done with the digital voltmeter, opening a second expansion option. But beyond this, it is probably better to add another ground buss, or replace the existing one with a buss that has more branch circuits. While this involves some effort, it is preferable to extensive, ad-hoc splicing of wires.

Another area of improvement was on providing the option of boom mics. We installed a Peiker standard boom mic on KP. But the result wasn't very satisfactory because the mounting configuration made it difficult for pilots to position the mic head. Also, the Peiker's have an output impedance of about 2000 ohms whereas the Becker's want to see something closer to 100 ohms. As a result, even under the best of conditions, the Peiker mic produced only a very faint output. We resolved this issue by procuring what would normally be a headset mic and mounting to a gooseneck. This setup has an excellent impedance match and is very compatible with the Beckers. It's also has a compact form factor and is relatively inexpensive. The only real downside is that the mic must be positioned closer to the mouth than a normal boom mic. But overall the setup works well and provides a second hands-free option for those who prefer not use a headset.

Another improvement was to wire the Becker radio to enable its intercom function. 81C is often used for instruction and some instructors have expressed an interest in having an intercom to improve communications. So hopefully, this will be a useful addition.

Future modifications are of course inevitable. We hope that those embarking on future work will first read this document. Significant time and resources were expended to refurbish KP and 81C to a high standard using aviation quality materials and methods. Some aspects of the electrical distribution system, the radio wiring harness for example, are simple in concept but complex in execution. Casual field modifications have the potential to create unintended consequences. It is worth the extra time and effort to implement modifications in a way that maintain the integrity of the new build.

For the benefit of future restorers, a good soldering iron, small screwdriver set, flush cutters and automatic wire stripper are almost mandatory. Also, specialized crimp tools are needed for Powerpole Connectors, aviation terminals, SUB-D connectors and coax cable BNC and TNC connectors. NCSA has most of these tools for use on future projects.

So with that, we return 81C to the NCSA flight line and hope that it provides the Club with many additional years of useful and enjoyable service.

The 81C Team: Tom Anklam, Michael Demeyer, John Scott, Marianne Guerin, Corrie Volinkaty, Miggi Demeyer, Brian Roach

Appendix A

Canopy Lanyard Analysis and Testing – Tom Anklam

Introduction

This note is to close the loop on the discussion that we had about appropriate materials for canopy lanyards. Based on our discussion with Robert Mudd, there does not appear to be a community consensus or standard on materials and methods to fabricate canopy lanyards. Therefore, it's up to each owner to select what's appropriate for their particular situation. The goal of course is to fabricate a lanyard that protects the canopy from wind gusts and rough handling while on the ground, yet breaks away when the canopy is jettisoned.

To this end, I've done a few calculations and tests of different materials to help inform the Club's choices. There is no intent for this to be interpreted as a "certified" or "approved" set of materials; informal-advice-only.

Summary

The bottom line from the testing that I did is that 275-weight paracord appears a reasonable choice for lanyards. The cord survives repeated bench tests under mechanical loads that are representative of those calculated for a 30 kt wind gust while on the ground. Yet the cord fails at about 2x of these loads. Heuristically, aerodynamic forces scale as the square of the velocity, so if the lanyard is designed to withstand a 30 kt gust on the ground, then jettisoning at 60 kts would be expected to generate forces on the order of 4x higher. So if the cord fails at 2x higher loads during bench testing, it's not unreasonable to expect it to break on jettison.

Several other weights of paracord were also tested. The 95-weight paracord failed immediately and is too weak to reliably protect the canopy from wind gusts. The heavier grades of paracord survive the 30 kt gust-test, but would reduce the chances that the lanyard will break during jettison.

I also tested 1/8" diameter polyester cord. Polyester rope/cord has strength and environmental performance similar to paracord, but is a less stretchy material. While I think that polyester is likely a suitable material, the 1/8" cord as tested was too strong to reliably fail during jettison. I didn't pursue this line of inquiry further as paracord seems like a suitable choice.

An important thing that I observed was that paracord knots tend to slip when impact loaded. I had several tests where I thought that the cord failed, but in fact the knot had just slipped through. Eventually, I settled on using bowline knots to attach to the test stand and test weights. The bowline knots had no measureable slippage during repeated load cycles. Interestingly, the cord failures that I observed did not occur at a knot but tended to be just above the knot used to fasten the weights to the lanyard.

When attaching a paracord lanyard to the glider, it's important to use secure knots and to periodically check that the knots aren't slipping or otherwise loosening. As mentioned, bowline knots worked well during testing. As additional insurance, I would suggest that either stopper knots or other means to secure the loose end of the rope be used in the actual lanyard.

Another important observation is that, when I first started doing tests on the paracord, I found that the cord seemed to permanently elongate about 25%. However, I eventually determined that most of this “elongation” was coming from knot slippage and also general tightening of the knot. Once I changed to using bowline knots, the elongation was reduced to less than 5%. So this is another reason to pay particular attention to the type of knot used to attach the lanyard to the fuselage and canopy.

If the Club chooses to use paracord, the cord can be pre-stressed prior to use so that elongation during service is minimized.

Design Basis Impact Load Estimate

The design basis event used to estimate impact load is that a pilot or passenger is holding the canopy at a 45 degree angle when a 30 kt wind gust causes the canopy to violently swing open. The lanyard has to be strong enough to arrest the motion before the canopy impacts the side of the fuselage.

The impact load is estimated as an energy that the lanyard must dissipate in order to arrest the canopy motion. This energy is calculated from the wind force on the canopy acting through a distance defined by the arc that the canopy moves through as it rotates on its hinges. Wind force is

$$\mathbf{Force = (C_D * \rho * V^2 * A_P * \sin(\Theta))/2}$$

Where C_D is the drag coefficient, 1.2 for a half cylinder, ρ is air density, V is wind speed, $A_P * \sin(\Theta)$ is the canopy projected area normal to the wind. The canopy projected area is calculated by treating the canopy as a 2’x4’ flat plate. The calculated wind force on a fully open canopy from a 30 kt wind gust is about 30 lb_f. To calculate energy gain, the wind force is treated as acting on the canopy center of mass (canopy width/2) as it swings from 45 degrees to 90 degrees. Energy gain from the design basis event is about 50 Joules. In a benchtop test, this impact loading can be simulated by allowing gravitational, rather than wind, force to accelerate a test weight through an appropriate distance and then challenging the lanyard to arrest the motion. Ten pounds, dropped about 47 inches will generate about the same energy as the design basis event.

Once a cord is found that reliably arrests during the design basis event, the test weight can be increased until the cord fails. In our case, if the cord fails before the test weight is increased to 40 pounds, then it is reasonable to expect the cord to break in a jettison. The logic for this assertion was already discussed above. For the 275 weight paracord, the cord successfully arrested 5 design basis tests and then failed when the weight was doubled.

Test Setup and Procedure

The test setup is relatively simple. As the photo shows, a heavy steel chain leader was wrapped around a piece of angle iron that rested on two jack stands. This created a relatively stiff platform so that the impact load is absorbed primarily by the lanyard and not the test stand. One end of the test lanyard was tied to the chain and the other end tied to the test weight. The weights were raised by hand to the height of the angle iron and then simply released.

The length of the lanyard was measured before and after each test. I also measured the lengths of the two short tags of cord at the two knots in order to detect if the knots were slipping. For practical reasons, actual drop heights were closer to 40 inches (rather than 47 inches). Also drop height varied as much as several inches between drops because of the lanyard elongation. These comments just emphasize the approximate nature of this exercise.

Bottom Line

Pre-stressed, 275-paracord is a reasonable choice for fabricating canopy lanyards. Care should be taken to use a secure knot, such as a bowline knot, to avoid in-service slipping of the lanyard. The length of the lanyard should be measured upon installation and then periodically checked to ensure that its length hasn't changed or that the knots haven't slipped or otherwise loosened.
The paracord can be pre-stressed using the same method that was used to test the material. A reasonable approach would be to cut a lanyard blank of appropriate length and then use it to arrest a 10 pound test weight dropped from about 40 inches. Several load cycles should be done, until the measured length of the lanyard blank stops changing. Load cycling of the lanyard blanks in this way does not appear to significantly weaken the paracord, at least at the loads we are using.