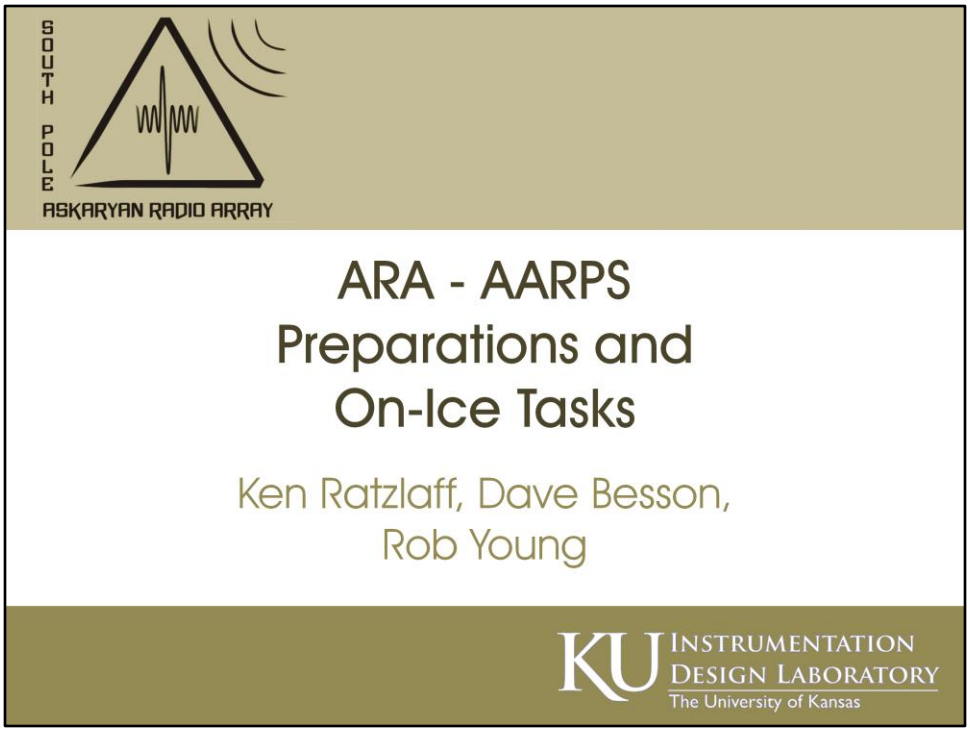


Detailed deployment notes begin with slide 27.

Discussion points for RPSC as of 11/21:

1. Are Jason Hunter and Jesse Palmer around? If so, Rob should meet them soon.
2. What do we need to retro? As of now we plan to leave the WT2 tower to RPSC; the derelict turbine should be shipped somewhere. We would study it if we had it here, but that's not critical.
3. We brought a spare turbine. Either it or the one replaced needs to return. How do we do that?
4. In addition to a snow machine we need some small items: an additional sawhorse, a spade, some flags, and possibly some short timbers for anchors. Dave Besson probably know, but who does Rob ask?
5. We might like to have a regular call – Rob, Dave, Jim Haugen, and me. How do we do that?

2011-2012 Summary

- Wind Turbine noise tests at the Testbed.
- Upgrade WT1 site: System Health Monitor (SHM), etc.
- Repair and upgrade WT2 site: new turbine, SHM, antennas.
- Inspect WT3 site, add PV, upgrade system, install ARA Tx/Rx.
- Test XBee Store-and-forward system.

Part I

- ARA Autonomous Renewable Power System (AARPS)
- Component Development

Tower Technology

- Design change:
  - shorter (benefit from low alpha) – typ. 30 ft.
  - Lighter (benefit from low maximum winds).
  - Easier erection.
  - Will test auger anchors.
- Continue to use 8-10' gin pole.

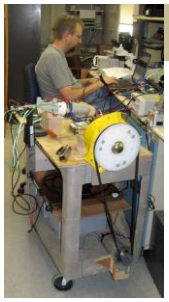
PV Tower

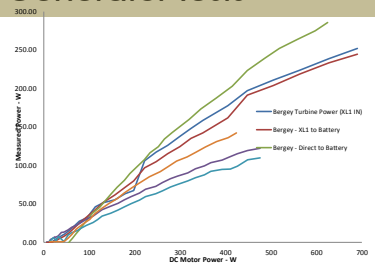
- Objectives:
  - Test mounting/ erection methods
  - Observe diurnal cycle.
- 235 watt panel.
- Must be raised manually.
- Will compare use of auger anchors and deadmen for guy wires.

Turbine Preparations

- Factors for a successful turbine
  - Efficient conversion of wind energy to rotational energy (blade design.)
  - Efficient conversion of rotational energy to electrical power (generator design.)
  - Other efficiencies (number of phases, downstream design, etc.)
  - Robustness – cold, fatigue
  - Amenable to maintenance.
  - Suitability for ARA – noise production, ease of deployment.

Generator Tests



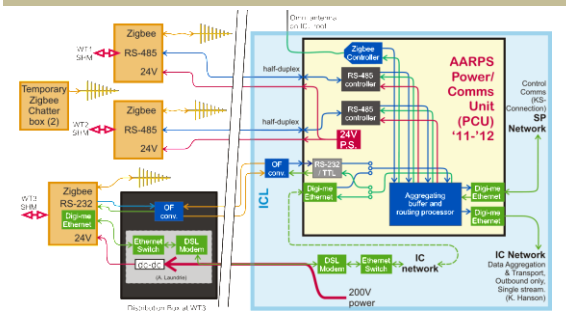


- No measure of efficiency of electrical to rotational energy… yet.
- Conducted on Bergey XL.1, Southwest Whisper, Aero6gen thus far.
- Efficiency roughly the same.

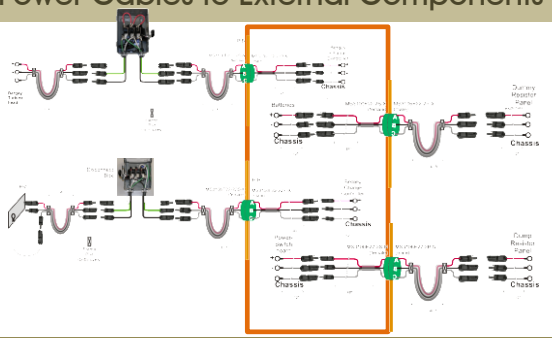
Turbine Comments

- Generator performances similar within experimental error. (Force sensor for exact measurement are exorbitantly expensive.)
- Bergey, Southwest, Aero6gen can readily be maintained. Raum, Hummer, Sankyo (WindSpot) cannot.
- Conclusive noise data still not available (nothing detected . . . yet.) More tests in North being designed; test at Pole to be set up.
- Hummer totally failed; some anomalies with Raum.
- Future design possibilities: We believe that with the relatively light winds at Pole, these turbines should support longer blades (bigger swept area). Plan to pursue in 2012.

Comms Summary



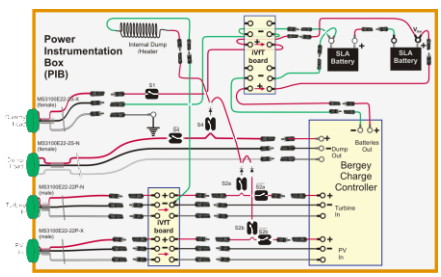
Power Cables to External Components



PCU

- Is being Hand-carried.
- Minor bug with Zigbee reception being studied now.

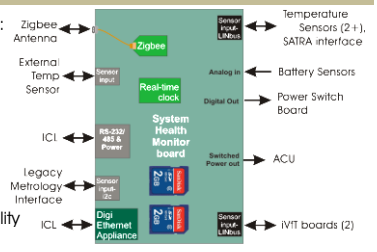
PIB Power Flow: WT3



- Internal power connectors: Helios or crimped rings (used hydraulic crimper.)
- Penetrations: MS310x22 through irdited panel.
- Switches: High-current dc SSRs.
- WT1 and WT2 have only switched power (no CC).
- Pre-connected where possible.

Upgraded SHM

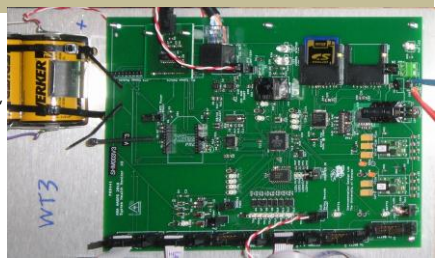
- Multiple sensor inputs:
  - i2c
  - LINbus,
  - digital I/O,
  - Analog.
- Multiple Comms:
  - RS232/RS485
  - Ethernet,
  - Zigbee.
- Dual SD card capability
  - (2GB each)



- LINbus implemented to enable full-duplex multi-component comms with power over a single pair. The LINbus is a master-slave network used in automotive networks

SHM board

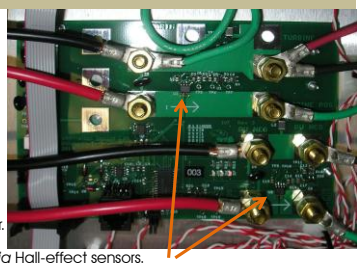
- Boards completed, cold-tested, mounted, hand-carried.



- Mounted on Instrumentation board.

iVfT board

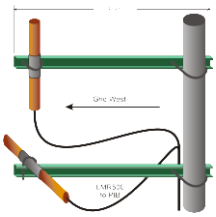
- Measures current, Voltage, frequency and Temperature.
  - f measurement not possible in presence of Charge Controller.
- Reports *via* LINbus through a local CPU.
- Temperature *via* solid-state sensors. Can be used to correct T-sensitive current sensor.



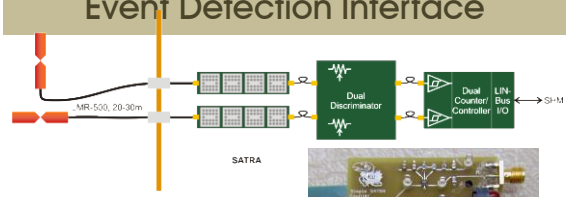
- Current Measurement *via* Hall-effect sensors.
- Mount on Instrumentation Board

RICE Antenna Deployment

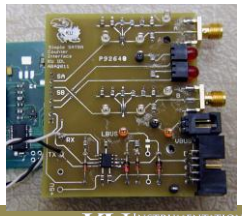
- RICE dipole pair
- Dual use:
  - Turbine noise detection
  - On WT3, pulser source



Event Detection Interface



- Two-channel pulse-counter.
- Measure only counts.
- Threshold adjust with pot on Discriminator board

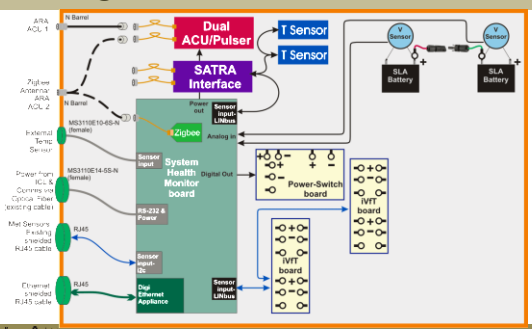


SATRA Interface

ACU (Pulser)

- Using design previously deployed (2009):
  - 1-wire power/comms driven from ICL; KUIDL-developed protocol.
  - Pulse circuit (250V) by Rob Bard.
- Firmware has been modified to remove communications – will alternately pulse pair of antennas when dc power is provided.

Signal Connections in PIB



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Power Instrumentation Box (PIB)

- Double-walled plywood with penetrator plate for 10 cables.

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Mounted boards

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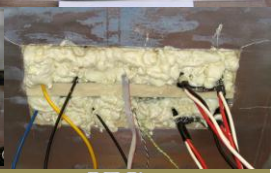
Penetrations

- Iridited plate, mounted against shielding fabric.
- Connectors *not* fully shielded.



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Component Mounting

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Shielding fabric

- Ni-Cu-plated polyester fabric.
- Double-overlapped and stapled every 2" or less.
- Fingerstock on ledge deforms to the same degree as Si gasket on top.
- Unable to measure radiation from "Sparky" in lab environment. No other "warranties" made.

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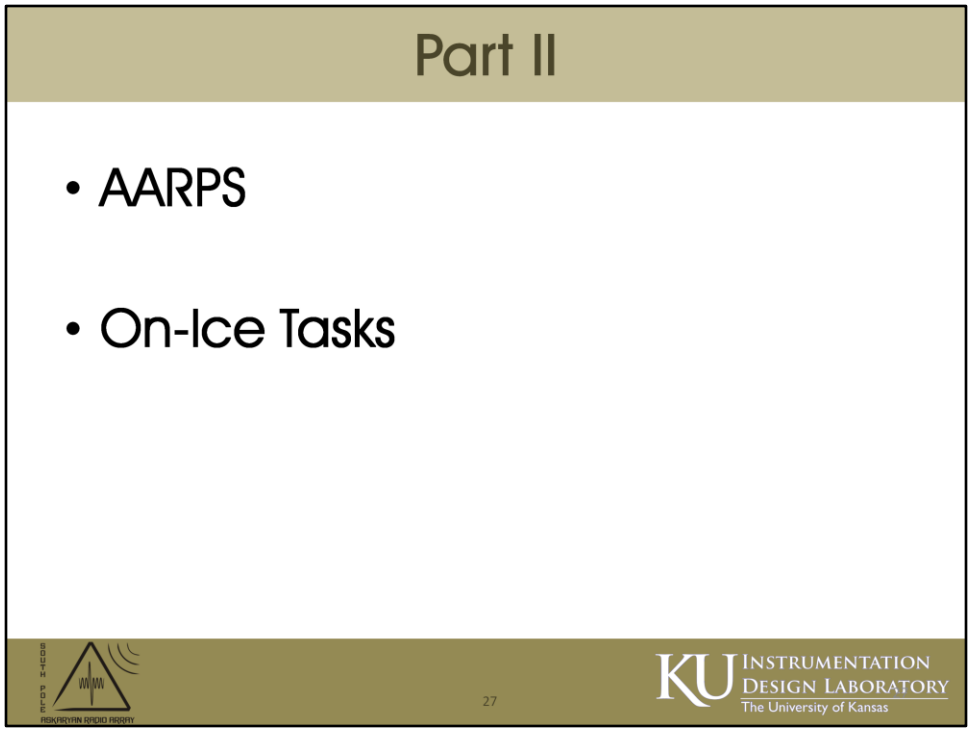

To do early:

1. Make contact with Julie Bonneau, Joe Crane and Paul Sullivan.
2. Make contact with Jesse Palmer and Jason Hunter, if either are there. They did the tower work last year.
3. ICL testing of PCU/SHM
4. Install PCU – checking DCHP values. Make the IP values permanent.
5. Retrieve SHMs from WT1, WT2, WT3. Transfer solid-state relays to new systems. Make notes of anything that could have caused the anomalies that we saw.

Task 1: Testbed tests -- Objectives

- Look for noise in a turbine that is mounted directly over the Testbed using the Testbed as a detector.
  - More sensitivity in noise measurement;
  - Study feasibility of Power System for each Station.
- Test deployment and operation 300W turbine (Aero6gen) on a short tower (20').
  - Include dump and dummy resistors.
  - Slip rings in tact.
  - Temporarily deploy shielded Power Instrumentation Box (PIB); power cables unshielded with ferrites.
- Operate in two modes:
  - controlled dump resistor.
  - switching charge controller.
- Will require coordination with Testbed operator(s) in the North.

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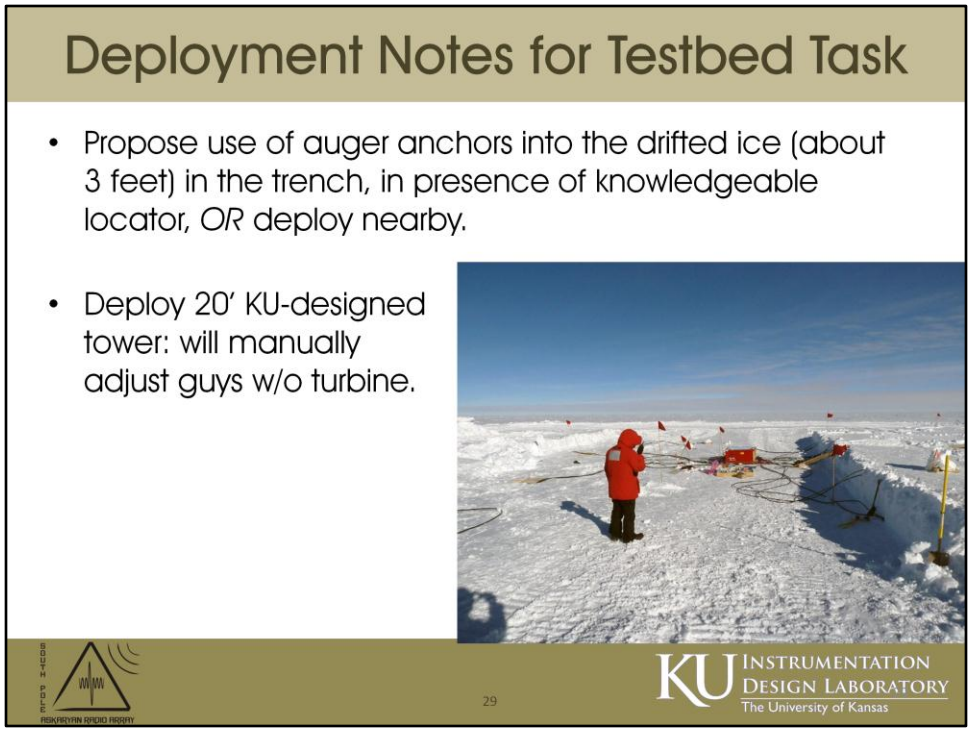
Tools from RPSC:

1. A sawhorse would be useful (or an empty crate the same height).
2. Spade.
3. Snowmobile or Pisten Bully.
4. Flags to mark the anchors at the testbed.



With Duvernois and others delayed, they may not be able to help find a location. Then find a spot outside the pad area that is NOT on the packed ice and see if you can put in the anchors.

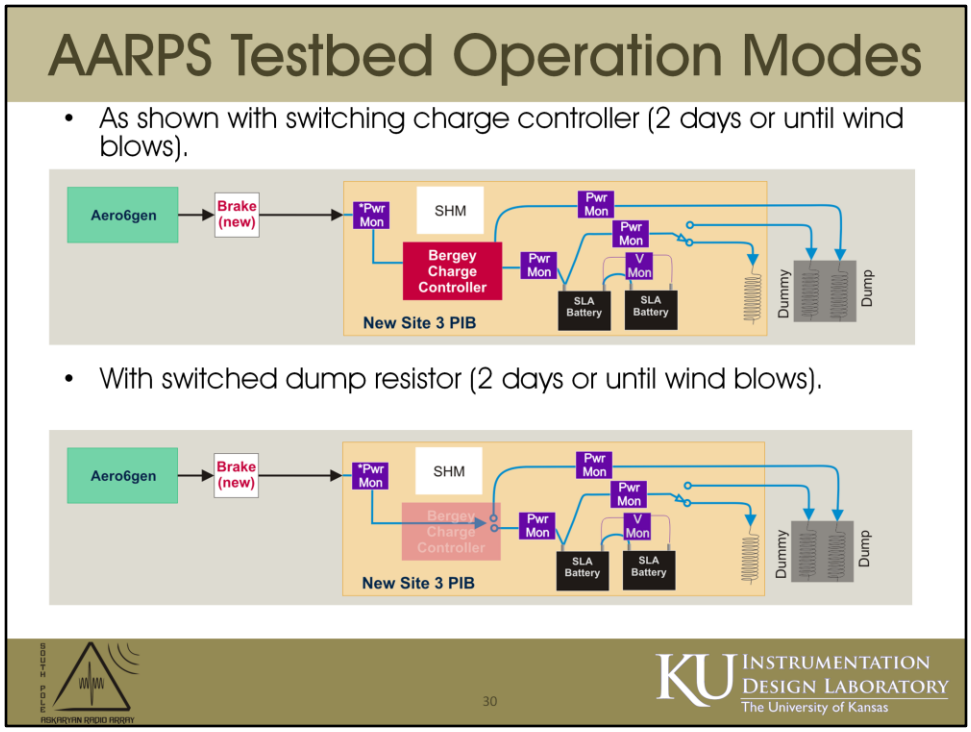
If you cannot, we could be in a bit of a spot. You might have to dig a hole and pack the anchors. OR get some timbers for deadmen from the Carp Shop. There are probably spare steel cable, thimbles and Crosby clamps in the ICL plus more shipped with Dave to wrap around the deadmen. The cut-off wheel on our grinder cuts the cable nicely. Be sure to flag the anchors. We'll find out where to get them.

You need a sawhorse to hold up the end if the tower when you are attaching the turbine; probably a crate would work just as well.

Place the tilt-up base in position and drive the T-posts to keep it in position. The tower when laid down should point into the prevailing wind, if you can figure that out (nominally parallel to the runway.) The guys are designed for a 45-degree angle, and since they attach at 16', that puts the anchors out 16' from the base. (There is a long tape measure in the ICL.)

Be sure to adjust the guys before attaching the turbine. After the guys are adjusted and tested, lower the tower and install the turbine. The power cable will travel inside the tower; make sure it is not kinked or pinched at the bottom. You may want the insurance of another volunteer to safely get it up, even though it worked pretty well

in Kansas.



Connect the Aero6gen cable into the brake box and mount the dummy/dump resistor panel. (Were we using the one from WT2 for that?)

Find the cables to lead to the PIB for load and dump.

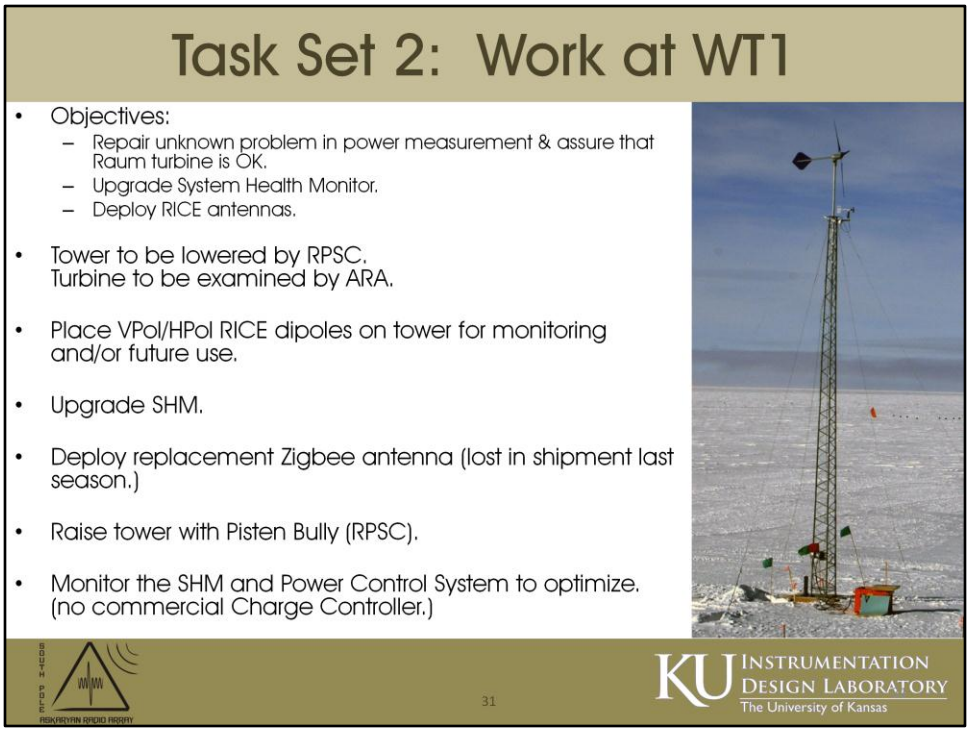
The internal connections are diagrammed earlier in this document.

Data to be collected on the SD drive, but there should be regular inspections of the installation during the test period.

When it is time to take it down, it could be even trickier than getting it up without damaging the turbine. (Remember, Vladimir said we are not to employ RPSC help for this.) You might say yes to someone who asks you if you'd like some help.

Next trick – getting the anchors back out. If not, I'm sure they have to be flagged.

When done, the Aerogen gets retro'd, the tower goes to WT2, the PIB to WT3. Don't know where the footing with the base goes. The T-posts go to WT3.



RPSC should have the tower down and on a saw horse when Rob arrives.

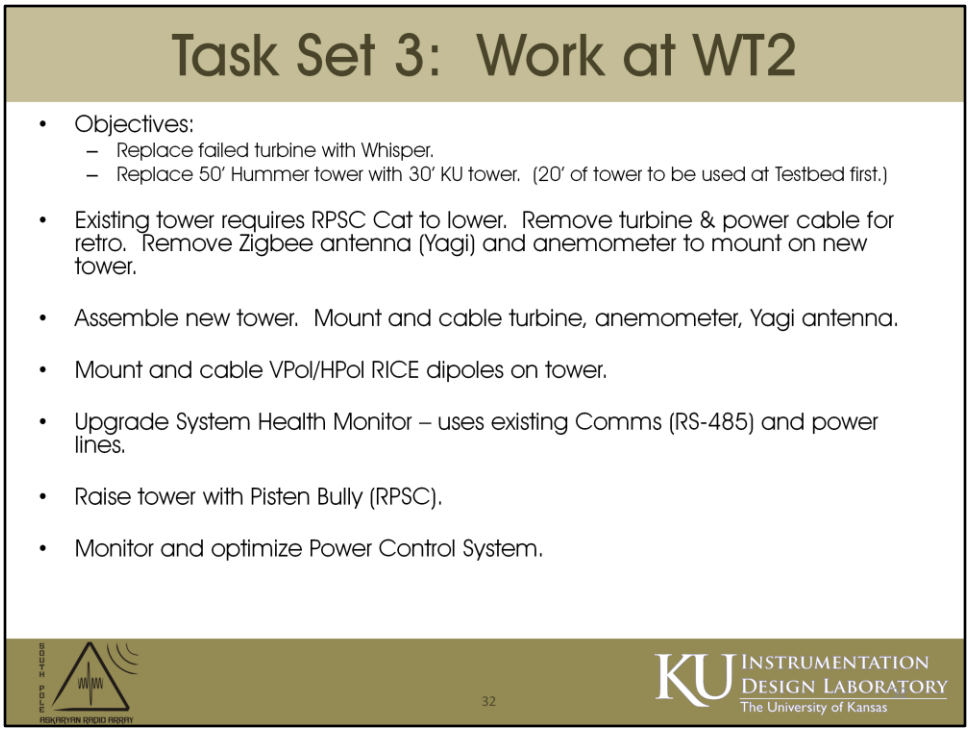
First item (Rob might check during first week): inspect the turbine. How does it look and how does it feel when you turn in by hand (with brake off).

Need to mount the pair of booms and antennas for the RICE antennas and the boom and Yagi for Zigbee.

Inspect the drill tape we used last year. Either fasten the cables to the tower with drill tape or with Tefzel (blue) zip ties.

Open the PIB and Rob will replace the SHM. Rob: note that last year I just had to drill a hole in the box and feed the met cable in. I don't think anything can be done about that.

RPSC will raise the tower. It would be good if you asked them to do that early so you could monitor it. Maybe leave it down for a day after completely assembling to test all links; then get it up and start logging.



This step cannot be finished until the Testbed is dismantled.

RPSC lowers the tower (probably before AARPS people arrive.) Will rest on Sawhorse.

The tower has to be dis-mantled. (By who?)

Carefully remove the met boom and cable and the Yagi boom and cable for transfer to the new tower.

Replace the SHM so that it is ready when the turbine is up.

The tower components will be given to RPSC. We'll check with RPSC about the turbine.

Check that the new tower will mount OK on the existing base. We sent some spacer washers.

Set up the tower. It will require both the tower lengths from the Testbed plus the third length. You will use the existing anchors.

RPSC will test-raise it for you and help adjust the guy wires.

Then lower it. Put on the Whisper turbine. (Cable goes inside the tower) Mount the pair of RICE antennas. Re-mount the Yagi and the Met boom.

You will use the existing brake box, but the connections on the turbine side will change. The tower cable will be removed and discarded. "Pigtails" are provided with Helios connectors to make the actual connections.

RPSC will raise it, probably with the Pisten Bully.

Task Set 4: WT3 Objectives

- Inspect turbine.
- Upgrade Power Instrumentation: new shielded Box, switching Charge Controller and batteries.
- Deploy *pair* of Tx/Rx HPol/VPol Dipoles on tower with 2009/2010 NARC pulser circuit in the PIB.
- Deploy a single Photovoltaic Panel (*sans* RPSC support.)
- Upgrade System Health Monitor.
- Set up Comms, either full-duplex O.F. or Ethernet *via* DSL.

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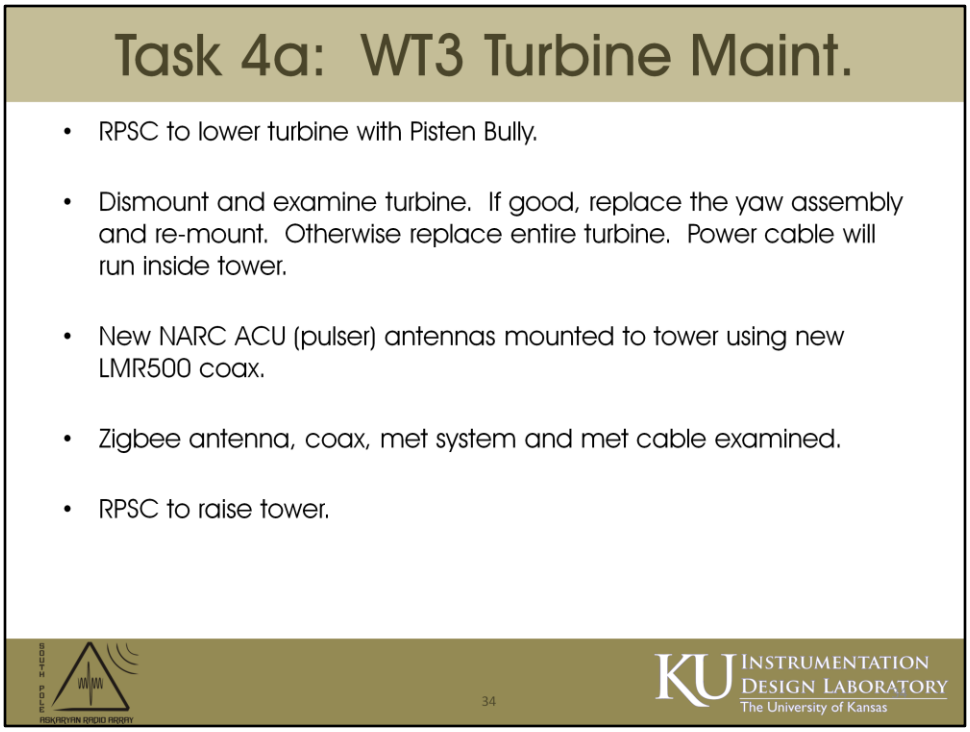
RPSC will lower the tower onto a sawhorse. They have the diagrams, etc.
Remove the SHM and SSRs for transfer in the ICL.
Inspect the (black) connection box. Andy will be working with that.



Inspect the turbine. With the brake off, it should rotate smoothly. Rob has a feel for that from our work here.

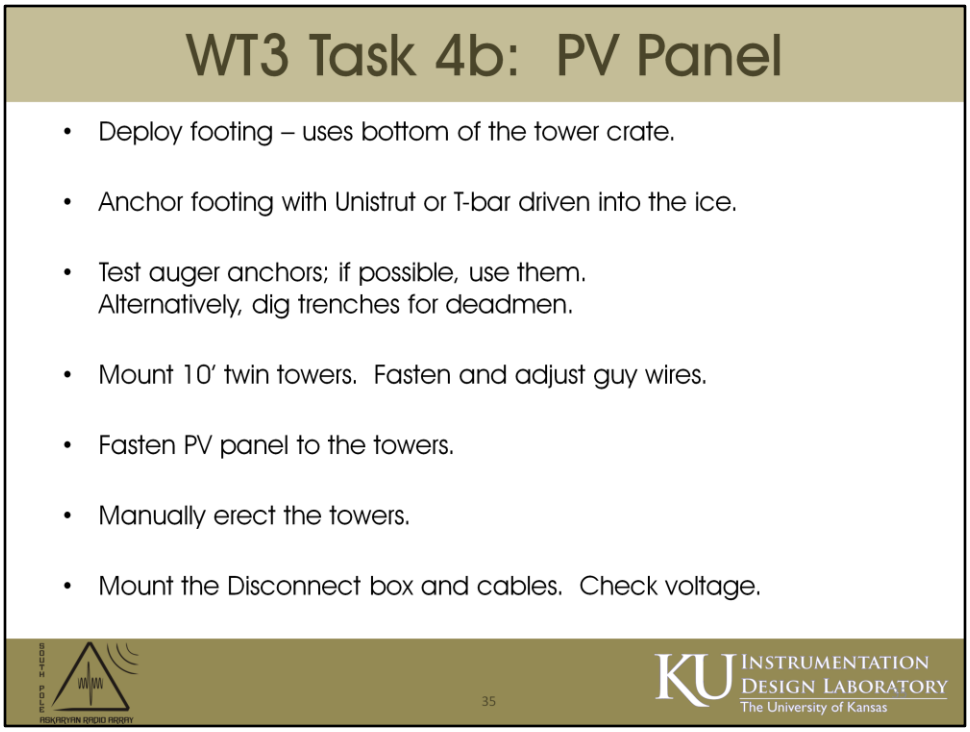
Remove the turbine from the tower and the Yaw post from the turbine. Replace it with the one that we brought. With this replacement yaw post, the cable will go inside the tower.

If the turbine feels "bad", replace it and retro the old one for inspection.

Check the met system and its cables.

Mount and cable the RICE antennas.

Connect everything into the PIB (which has not yet been buried.)



Position footing so the long axis is in the direction of the prevailing breezes and anchor with the t-posts.

Here is where you will have to decide how to anchor the towers, whether the auger anchors will work or not. Put in the anchors , attach the tower components and cross bars, and hand-raise the unit. Connect two of the guys and test again, and then connect the last two guys.

Mount the PV panel on the Unistrut cross-pieces. There are strips of silicone pad to cushion and space it.

Raising and completing the guy wires may require either help to hold the towers or the rope to tie it to something firm. (snowmobile?)

Mount the disconnect box on one of the towers using the U-bolts provided.

There is a power cable that connects the PV to the disconnect box. They should just snap together using the Helios connections. The next cable goes from the disconnect box to the PIB.

WT3 Task 4c: PIB

- Connect coax cables from ACU antenna and Zigbee antenna to PIB.
- Connect cables with ferrites and MS3106-22-22S circular connectors for turbine and PV to PIB (separately keyed.)
- Connect cables with MS3106-22-2P circular connectors to dummy load and to dump (separately keyed.)
- Connect cable for O.F./power with existing MS3116 circular connector.
- We may need to use DSL if the O.F. is not ready, connecting the shielded RJ45 cable from the PIB to the Ethernet switch.
- Connect the external temperature probe (MS3116-10-6P connector) to be positioned in the trench with the box when it is buried.

Ferrites: There are 2 sizes. Snap on one of each at each end of a run. Wrap with driller's tape (I hope there is some!) so they don't fall off.

Work with Andy on Comms.

Get the system up and going and monitor that all goes well.

Task 5: XBee Mesh Test

- Objectives:
  - Demonstrate Store-and-forward operation.
  - Test self-healing capability.
- Locations:
  - One fixed Yagi on each tower.
  - Portable, battery-operated units with Yagis at other locations.
  - Omni receiver at ICL (100' LMR500 coax from ARA rack to roof).