Noise prototype Assembly procedure

1. INTRODUCTION/NOTES

HISTORY

T060040-01 2 page procedure; briefly discussed at LSC, March 06.
T060040-02 6 page procedure; worked out by JG, TH, JO & IW on 17th May 06
T060040-03 7 page procedure; Glasgow University on 25th May 06, CIET, RJ, CAC, IW, JG,IO,TH,SA
T060040-04 7 page procedure; as 03 but bulked out for PDR-03 by IW
T060040□05 9 page procedure; revised to represent a real assembly document for the clean noise prototype assembly (Ian Wilmut), Note a lot of conjecture has been removed. Since this may be useful T060040□04 should be referred to.
T060040-06 ? page procedure; revised using knowledge from noise prototype
T060040-v1 9 page procedure; released onto new DCC by MB

NOTES

References to controls assembly procedure T060039 marked in square brackets.

2. CLEAN METAL ASSEMBLY

PREREQUISITES OF CLEAN METAL ASSEMBLY

- Ensure that the metal masses to be used have the same mass as the non-metal masses they are to replace, if this proves difficult in the test chain the important thing to ensure is that the test and penultimate mass sum is correct.
- The blades have had an initial creep bake as detailed in T040108-03 and have then been matched in stiffness (equal deflection under a constant load), and have similar (within 5mm) deflected shapes.
- Ensure all the blade clamps have been correctly angled to allow for blade stiffness.
- Ensure by trial fit that the upper and lower structure correctly interface to the sleeve.
- Install all the helicoils in all the parts and make sure they are free running and not cross threaded, remove the tangs.

INFRASTRUCTURE REQUIRED

For the dirty metal assembly the following will be available:

Gazebo:	Small footprint gazebo preferred.
Manual fork truck:	Similar to Caltech Genie
Bench:	May be an optics bench but this is not mandatory
Tools:	All the appropriate hand tools and measuring devices
Masses:	These will be necessary to load blades flat. Note: this is not part of this procedure

2.1 Upper structure build [22]

TOP STAGE

1. Install empty upper structure on the gazebo, attach with at least 16 dog clamps (4 per side, with 2 per corner).
2. Install all four top stages in place. Check the tips are central, and the location holes align.
3. Ensure all blade tips are held well down with blade stops. Target is that the tips are 2mm below nominal (108mm from the optic table to the blade top).

TABLE CLOTH AND TOP MASS

4. Lie 2 off 36mm cross bars across the lower structure bottom ring and rest the two top masses approximately in place (the upper structure removable braces work well)
5. Assemble the tablecloth side plates in place with no OSEMs/ECD assemblies. Install all the dowels to locate it nominally WRT to the structure.
6. With the stops raise the top masses into place . Position nominally in x and y using dowels and approximately 10mm too high in z (do this by inserting the stops too far).
7. Connect the top two masses to the top stage bolting the top wire clamps to the top blade tips and the top mass. The top plate of the top masses can be removed to make this easier.
8. Lower top two masses to nominal position, note the top stage blade tips may need to be pushed down for this.

2.2 Lower structure

TOOLING REQUIRED:

- Lower structure assembly tooling
- Wire jig

1. Assemble both halves of the lower structure assembly tooling side by side on either the floor or a low table. Note when viewed from above they should look something like: ⊓ ⊔ ideally with the rear of the penultimate mass easily accessible.
2. Install the respective halves of the lower structure into the tooling.

REACTION CHAIN

Note the test and reaction chains are subtly different approaches, either is acceptable, the only reason they are different is that they are more-representative of the glass procedure.

3. Add the reaction UI mass into place on fully retracted vertical stops, this puts the masses 10mm below nominal (nominal is UIM base plate bottom 70.2mm from lower structure cross member top).Note: OSEMS should be in place.
4. Add the Penultimate reaction mass in to a position in its nominal position WRT lower structure (on fixed PFA440HP pads); set roll (approximately) Note: OSEMS should be present and in the approximately correct position.
5. Add the reaction test mass ~3mm above nominal (use #1 spacers); approximately set roll by eye.

6. Add the UIM-PenRe-TestRe wire assemblies to both sides. Roll test mass and Pen mass as required
7. Lower test reaction mass to its nominal position (use #2 spacers) note the mass will initially have to be lifted to remove the #1 spacers
8. Raise the UI mass to its nominal position on the vertical stops taking care to keep it horizontal.
9. Raise the UI mass further to lift the PenRe mass and remove the PFA440HP pads below the PenRe mass. Lower the UI mass to get the PenRe mass back into its original position.
10. Remove the stops from below the test mass to ensure everything hangs stabaly and with no gross pitch.
11. Lock all three masses in their nominal positions (leaving the wires all in tension).

TEST CHAIN

12. Add the test UI mass into place on partially retracted vertical stops 10mm below nominal.
13. Add the Penultimate test mass in its nominal position WRT lower structure with magnets omitted (on fixed PFA440HP pads); set roll by eye.
14. Add the test mass 3mm (using #1 spacer) above nominal.
15. Approximately set the roll.
16. Add the UIM-Pen-Test wire assemblies and attach to all 3 masses, note the UIM blade tips may need to be worked up and down for this
17. Raise the UI mass to its nominal position on the vertical stops taking care to keep it horizontal.
18. Lower and release the test mass from all its stops.
19. Slightly raise the UIM mass allowing the penultimate mass to raise and remove its PFA440HP pads (upper stops need to be retracted). Note, at this point all masses should be suspended for the first time so care should be taken that no unexpected pitches occur although it is quite unlikely. Lower the UIM to its nominal along with penultimate mass suspending it.
20. All masses can now be locked in place. The simplest thing to do is to lock them in their nominal positions. A more representative thing to do is to raise the test mass 8mm as it will be when there is glass. For now nominal positions is recommended.

FINAL LOWER STRUCTURE ASSEMBLY

21. Ensure all 6 masses are in their nominal positions and are secured with stops that are wrench (not finger) tightened.
22. Use the genie to manipulate the two structures so that they are face to face. This may involve moving one or both of them.
23. Bolt two halves of the lower structure together, also bolt the two halves of the lower structure assembly tooling together with the connection plates (4 off)
24. Unlock test and penultimate masses in both chains and verify that the penultimate masses are parallel, and that the test reaction mass is hanging at the correct angle. Also verify that there is no differential yaw in each chain. Correct if required (locking the round masses, releasing the UIM masses and manipulating them is the recommended method).

2.3 3 in 1 assembly

1. Lift lower structure and tooling on to the 5 axis table, ensure that is correctly centred, and that the table will go low enough that the lower structure will fit under the upper, bolt down with dog clamps (8 min).
2. Wheel trolley and lower structure under upper structure on gazebo.
3. Raise lower structure as far as it will go (~28mm above nominal), so that the legs of the lower structure pushes up against the upper structure, note the lower structure must be correctly orientated, (test mass on test chain side).
4. Use the slack in the UI wires to connect to them to the top masses. Note that the top masses are in their nominal positions WRT the upper structure and the UI masses are in their nominal position WRT the lower structure. If necessary lower the blades on top mass using the stops in order to allow the wires to be connected.
5. Let down the Lower structure into its nominal position, (28mm gap)
6. Insert implementation shim and connect lower and upper structures, 8 bolts.

2.4 Suspension

7. Ensure reaction top mass is horizontal and in its correct position.
8. Release test reaction mass and then pen re mass, check the blade tips are still at the correct height in the UI reaction mass and then release the UI reaction mass.
9. Release test mass and then pen test mass, check the blade tips are still at the correct height in the UI test mass and then release the UI test mass.
10. There should now be two triples suspended side by side.
11. Retract the blade stops in the top reaction mass and check the tip heights are correct.
12. Retract the blade stops in the top test mass and check the tip heights are correct.
13. Retract top stage blade stops.
14. Carefully retract the stops on the top test mass, only retract them a little at a time and watch for pitch at all times. If the suspension appears stable and un-pitched then it is likely the blade tip stops are holding one of the blade tips down.
15. ref appendix A on fixing problems.
16. As 14 but for the reaction mass.

2.5 Completion

1. Balance and align the quad to the point where both chains are at the correct height and are correctly pitched, and yawed. Note; alignment of the OSEMs will effect the pitch.
2. Add the front and back plates to the tablecloth omitting the ECD and OSEM mounts. [2.2.2.7]

3. CLEAN METAL WITH CONTROL AT LASTI

3.1 Mass and OSEM alignment procedure. (Clean metal at LASTI)

See T07???? For alignment procedure

Note: this procedure will need to be repeated once the real masses have been installed but is being rehearsed at this stage before the most delicate components are present.

4. CLEAN GLASS (OUTLINE PROPOSAL FOR WIDER DISCUSSION)

Need to define when and where we do ESD tabs. See doc from BT & CIET

Strip down of clean metal

1. Disconnect electrical wiring to lower structure and masses.
2. Lock all masses
3. Lock and overload blade UIM blade tip by 3mm and lock top stage and top mass blades.
4. Remove X braces and sleeve.
5. Offer up tooling with carriages and remove implementation shim lowering lower structure slightly.
6. Raise lower structure
7. Disconnect UI-Pen mass wires
8. Remove lower structure
9. Separate halves of lower structure
10. Wheel structure to non-metal mass assembly area.

Real clean glass assy

Note: We must double check at this point that all the metal masses we will be removing at this point are identical in mass to the glass being installed. If discrepancies are found corrections should be made to metal masses and re alignment of metal masses trial assembly.

Reaction chain

11. Unclamp dummy reaction test mass and lift 10mm on stops.
12. Remove wires from UIM to reaction test mass stage.
13. Remove reaction test mass.
14. Add UIM to pen-re mass wires and then Pen-Re to test mass wire loop.
15. Install glass reaction mass ensuring wire loops loop under test reaction mass and seat in groves. Note; the test reaction mass will have to be inserted high and then lowered to enable this, and the task may be further simplified by keeping one end of the wire loop free.
16. Lower the test rection mass allowing the wires to partially tension.
17. Wire in the ESD and cable to top of reaction chain lower structure.
18. Abandon reaction chain on stand.

Test chain

19. Lock UIM blade tips and over load by ~2mm, lower test UIM to release tension in Bottom wires.
20. Unclamp dummy test mass, raise, detach the wires and remove.

21. Remove the UIM to test mass wires.
22. Unclamp and remove dummy test penultimate mass.
23. Install lever arm clamp, test mass jack, and assembly stops, with high position welding spacers in place.
24. Add the wire loop from the UIM
25. Add the Penultimate test mass into loops from UI mass; set roll. Note: Magnets should be absent, they will be added later.
26. Lift the UI mass, tensioning wires to 25% load. Ensure loops on Pen mass are correctly in grooves
27. Add the test mass 8mm above nominal; set roll.
28. Wheel assembly to welding rig and bolt in position. Note trolley will require turntable and z adjustment to allow structure to be adjusted for welding.
29. Prepare structure for welding operations, add baffles etc…
30. Weld ribbons.
31. Switch the welding spacers for the stress reliving spacers.
32. Lower test mass ~1mm hard against stretching spacers and relieve stress on ribbons.
33. Raise test mass with test mass jack, and remove stress reliving spacers. Fit nominal spacers
34. Suspend test mass by progressively lowering the jack, it will barely suspend
35. Use test mass jack to lift the test mass and remove the nominal spacers.
36. Fit overload spacers.
37. Suspend test mass by progressively lowering test mass jack. Once suspended verify that that pitch and roll are acceptable.
38. Use lever arm clamp to overload fibres, make sure that the test mass jack is never a long way from the mass as the fibres are overloaded.
39. Remove the spacers and fit the transport stops.
40. Remove lever arm clamp and test mass jack.
41. Raise main UI mass to nominal position.
42. Stop UI mass blade tips down form nominal.
43. Raise test mass to 1mm below slack fibre position ~12.5% tension.
44. Lock all glass masses down with UHV polymer stops.
45. Separate lazy Susan/lower structure from welding table and return structure to mass assembly area.
46. Recombine structures, as above. Note test mass is too high and test mass must be lowered prior to suspending masses.
47. Re-connect all wiring including ESD, and tidy pig tales.

4. INSTALL INTO TANK

This will need to be worked on in conjunction with LASTI closer to the time. It should be noted that we know that all parts of the quad can be fitted into the tank through the door where ever the quad is on the optics table so no significant problems are imagined.

5. REPAIR SENARIOS

These repair scenarios are not intended as a step by step repair guide (that will come with the final article). They are more “broad brush” concepts intend to convey the potential to make the repair rather the exact detail.

Failure	Repair description
Ribbon snaps/ ear bond fails	• Open tank • Lock ALL masses and the blade tips in present positions (many will be in the wrong places) • Remove the sleeve • Extract or retract the OSEM cans in the Pen Re mass • Remove the ESD cabling • Add the lower structure support tooling and take the weight of the lower structure (this may be on the articulated arm) • Remove the implementation ring • Lift the lower structure and disconnect the bottom wires from the UI mass • Lower the lower structure until it is free from the upper. • Remove the lower structure from the tank • Raise the reaction test mass with the mass jack • Lower the UI masses to 10mm below nominal • Lift the masses one by one and swap in the appropriate stops, do so in the following order: Test mass, reaction test mass, penultimate mass, Pen Re mass • Inspect all masses for damage • Inspect all stops for damage and replace as required • Check all OSEMs and ECDs at all stages for damage (theoretically impossible but good practice) • Rebuild lower structure as described above.
Replace a local control OSEM	• Open the tank • Find the appropriate OSEM and rack it back as far as possible (off the end of the screws). • Unplug the pig tail • Remove the faulty OSEM body • Put in the replacement OSEM body • Advance it forward • Plug in pig-tail • Align It is likely that it will be felt blasé that the chain has not been locked. We are not touching either suspended chain throughout this operation however and the risk of damage should be weighed against the risk of damage from locking down and unlocking the two chains.
Replace a global control OSEM (UI	• Open the tank • Find the failed OSEM and photograph the position of the flags within all four OSEMs on the mass. • Lock down the reaction and test UI masses. (We may find the this should say

mass)	"lock down both chains" as we work with the noise prototype) • Check you have not moved the mass by cross referencing the four photos just taken with what you now see. If there is a sufficient discrepancy release the UI masses and repeat. • Unplug the OSEM • Rack back the flag on the test chain UI mass • Remove the flag on the test chain UI mass • Unbolt the OSEM mount bracket from the UI mass. • Swap the new OSEM onto the mount bracket • Replace the OSEM and bracket to the UI mass. • Connect the OSEM and wind in the flag • Check the OSEM is still aligned as per the photograph • Release the chains (carefully checking from problems)
Replace a global control OSEM (Pen Re mass)	• Open the tank • Find the failed OSEM and photograph the position of the flags within all four OSEMs on the mass. • Lock down the Pen re and Pen masses. (We may find the this should say "lock down both chains" as we work with the noise prototype) • Check you have not moved the mass by cross referencing the four photos just taken with what you now see. If there is a sufficient discrepancy release the Pen masses and repeat. • Unplug the OSEM • Unbolt the OSEM can from the pen re mass • Slide out the OSEM can from the pen re mass • Dismantling the can as much as is required replace the OSEM taking care not to adjust the z,y adjuster. • Slide the OSEM can back into the pen re mass looking through the back of the OSEM and checking the magnet at all times. • Check the OSEM is still aligned as per the photograph • Release the chains (carefully checking from problems)
Wire replacement (any wire, generic procedure)	Since there are a lot of different wires in a suspension each with a subtly different replacement scenario it is very hard to write a generic procedure. What is written below is more a declaration of intent rather than a outline procedure, and in some cases will be a very long winded way of replacing a wire. It is intended to show that it is possible rather than to be a procedure to follow. • Open the tank • Lock all the masses and blade tips down in their present positions starting at the bottom and taking care not to make anything worse. • Remove the sleeve • Remove or retract all OSEMs and flags

	• Following the ribbon repair scenario remove the lower structure from the tank • Return all masses to their nominal positions in the safest way possible • Work back through the assembly procedure to get enough slack in the damaged wire to allow the installation of the replacement • Install the new wire • Rebuild the suspension as per the assembly procedure, take care that the new wire clamps have not affected the trim etc • Re-install the lower structure and final align optics and OSEMs.