Facility visit SPIRE-RAL-MOM-002419
PFM 1 perf
SPIRE schedule
Need for clearances
DM 300 k vibration Nov. 04
Development logic
CNES key points
DM thermal tests Jan-Mar –05
Mechanism modelling
Modified latch
Vibration specs
DM 300 K vibration Apr. 05
Discussion on life test conditions
AOB and planning

SPIRE SMEC meeting, LAM, April 14 2005

1. SPIRE Test schedule (Eric Sawyer)

- PFM1 campaign just completed – warming up at the moment
- Warm electronics delivered to Astrium for EQM
- Next step = configure full flight instrument. All parts available.
- Will install existing CQM SMEC
- PFM2 to start mid-June (paced by arrival of DRCU)
- Swap out CQM SMEC ASAP when it's available –but must be before "summer holidays" = end July
- PFM SMEC needed for cold vibration
- Final test and calibration
- Delivery of PFM in Feb. 06

2. SMEC performance in PFM 1

- Spectral distribution of speed fluctuation
- Std dev for speed in 0.3-25 Hz = 9.25 um/s (10) and 41 nm (100)
- Speed stabilisation and dead time < 10% even for low res
- 3. Top = SCAl, then SCAL enc. Then SMEC
- SMEC temp goes up at max OPD by about 0.1 K
- Peak power dissipation = 3.x mW
- 4 = calibration of optical encoder wrt laser – good agreement
- General problem with saturation by room background (maybe out in more ND?)

3. SMEC Latch (Dominique)

- Thijs: Concern about need to use different materials for pin and its guiding cylinder to avoid cold welding. Otherwise will have to prove that it's going to be OK after vibration. Vespel is hard enough (but has high shrinkage)
    - Dominique: We will take this into account in reviewing the latch design.
- DM warm vibrations Nov. 2004
    - Some differences wrt FM
    - All three axes low level sine vibration

- Y-axis (vertical): no shocks, but shocks in Z-axis
- 0.2-mm clearances too great – decided needed to be reduced to 30-40 um p-p

4. CNES Key Point objectives (Karine Mercier)

- (Dec. 1) meeting/review
- Verify qualification and performanc eof pivots
- Verify SMEC perf wrt specifications
- DM test plan and warm vib test results
- Differences between various models
- Risk analysis and mitigation
- FM fabrication authorisation

- Work/Action plan defined with these key elements:
  - Confirm FM pivot purchase order: Done in Dec.
  - Step-by-step DM vibration plan: In progress
  - Quality actions to ensure pivot supply:
    - Monitoring of each manufacturing step and improvements of integration tool; additional characterisation of FM pivots planned (angular and radial stiffness)
  - Improvement of latch design:
    - Thermal tests confirm design; some modifications planned
  - Securing the FM SMEC manufacture
    - Optimisation of pivot orientation in the FM to match the centre shift
    - Development of pivot back-up solution

5. Development logic (Dominique)

- Limitation of clearances to 30 um p-p
- Thermal testing needed to verify feasibility of this
- Therma l tests carried out in Jan.
  - 20 K per hr.
  - Measured relative displacement of actuator wrt baseplate – see VG 25
  - Displacements > goal (45-65 um)
- Feb. test done with reduced rate of change of T (5 K/hr)
  - Max displacement about 27 um during warm-up (VG 29)
  - This is within the goal
  - Additional sensors included in next test to understand the differences between warm-up and cool-down behaviour
  - Test done but needs to be redone
- Conclusion: Down to about 55 um p-p
- Expect thatt blackening will allow goal to be reached
- Eric: Are any constraints from the latches allowed?
- Dominique: No

6. Pivot analysis (Guy Turzot)

- Critical point for pivots is buckling of the blade
- Initial analysis (Dec. 2004)
  - Buckling analysis showed negative margin on both axes – buckling at 50% of load (whatever the random axis)

- Improvements in modelling
  - Conclusions not much different – 0.1 mm blades not sufficient
- Design modifications
  - Theoretical calc indicated that 0.12 mm would be OK
  - Analysis showed that buckling at 85% of limit load
  - But change to 0.12 mm difficult due to manufacturing constraint, unless the diameter of the pivot is changed
- Back-up solutions
  - Increase in pivot diameter impacts on SMEC design
- Braze blades into casing
  - Long dev. Time; not qualified
- Glue blades into casing
  - To be qualified
  - Would need 6 months to develop and qualify

7. SMEC modified latch (Dominique)

- Summary of modifications introduced for DM tests

8. Vibration specifications (Berend)

- SMEC will only see flight levels during instrument cold vibration tests
- SPEC can be cut back as much as possible to protect SMEC from overtest
- Instrument is qualified although some changes –mainly instrument supports (separate qualification programme)
- Flight instrument will be vibrated to acceptance levels
- Thijs: If SPIRE considers it safe that acceptance levels are OK for the sub-unit, then that's OK for ESA. Qualify to same level seen at instrument-level qualification
- Avoid exceeding 10 grms anywhere
- Yesterday's tests
  - SMEC has large response in the high frequency range (even up to 4 kHz) due to shock-loads caused by pin rattling with no damping
  - Getting high accelerations (up to 20 grms) even at – 6dB wrt the random levels
  - Discussion between Thijs and Berend on significance of high-frequency modes
    - Berend is concerned about 700 Hz-1 kHz region in case it's associated with strut flexing that might stress the pivots. Berend and Thijs will discuss offline.
    - Differences in pre- and post-low-level sweeps in X-direction (larger play created by surface damage?).
    - Dominique:
      - Evidence of internal blade warping in at least one of the pivots.
      - And some shift seen in the mechanism position.
  - Conclusions
    - Analysis is of limited use due to non-linear behaviour
    - Need to decide how to deal with the shock load energy distribution observed when SMEC hard mounted
    - Reducing play further is not possible
    - Possible options:
      - Use softer/springier material
      - Introduce some slip friction – possibly introduce blade spring friction at the latch location
    - Accept current guidelines of 10g-rms during cold vibration – questionable since the pivots used in the CSL qual test were not flight-like.

- Overall: tweaking the current design (to introduce some friction) looks as though it could be a good solution

9. Summary of April 05 warm tests (Dominique)

- See VG 43 etc.
- Tests stopped when pivot damage seen.
- Analysis and further inspections to be done to assess all possible damage and determine when the above blade degradation occurred.
- Conclusion: SMEC not qualified yet.

10. SMEC design parameters

- Impact of pivot stiffness on power consumption
- Max actuator force = 1.77 N – assume 1.6 N with 10% margin
- CQM needs only 0.8 N
- SMEC travel is up to 32 mm for high res
- Assuming 67% of time in high res. (with total of 1800 hrs)
- Mean power dissipation is about 4 mW
- Rises to 10 mW with twice the stiffness
- Present pivot stiffness is 0.05 Nm/rad
- Changing to 0.12 mm will double the stiffness
- If we keep the current power dissipation and double the stiffness then max resolution is 240
- Currently max power is 7 mW
- Doubling the stiffness would increase that to 30 mW
- Conclusion:
    - Changing the pivots affects either power dissipation or achievable resolution

11. DM and FM planning

- DM
    - Keep the current BE system pivots
    - Thermal test with blackened parts
    - Vibration tests with flight-batch pivots
    - Cryovibrate and life tests
    - End of DM program = end Oct. 2005-04-14
- FM:
    - Moving parts made
    - Flight pivots to be delivered end May
    - Start manufacture mid-May (with latch improvements based on tests/mods over the next few weeks)
    - PFM higher priority than DM
    - With present BE system pivots, delivery mid-Oct. 2005
    - Success-orientated programme – no guarantee that FM will be properly qualified
    - No significant margins included here
    - If back-up pivot solution then add 6 months

- Impact on SPIRE schedule:
    - 3-month slip wrt currently assumed installation of SMEC

    - Could maybe save 1 month by extending PFM2 first cooldown to carry out more calibrations, so estimated minimum impact of 2 months on PFM delivery
    - Action: Eric and Matt to examine SPIRE ILT plan and estimate possibility of programme to minimise interval between SMEC delivery and SPIRE FM delivery.
    - SPIRE FM delivery would then slip to early May.
- Options for recovering schedule within the LAM programme
    - Carsten:
        - Significant delay to SPIRE instrument delivery schedule
            - Could any of the activities be speeded up or parallelised, or extended shift-working implemented.
- Matt: to what extent might this be a non-problem: are the vibration levels too extreme with respect to the actual launch environment.
- Thijs: My models indicate that the 10-g rms is comfortable. We could at this stage agree that notching to limit at 10g-rms at low frequencies is acceptable. The question is can we safely ignore the energy in the higher-frequency range (i.e., assume that these features don't contribute much loading).
- Conclusion: 10 g-rms limitation up to 600 Hz with steep (details TBD by Berend). Then assessment will be made of how close mechanism is to being qualified based on tests done already.
- Karine: CNES/LAM will analyse the test data and consider whether this is feasible.
- Torlon may be a better option than Vespel for "soft" material

12. Life-test conditions

- Plan is to do on DM after cold vibration
- Number of cycles and length has been calculated (based on high and med-res scans)
- 273000 cycles at high res and 15E6 at med res
- Requires about 3 months
- LAM consider that room temp. better (fatigue limit is higher)
- RAL (and Berend) consider that 4-K is preferable (and standard for cryo-mechanisms).
    - Acceptable to break the test at times for warm-up and inspection

13. Some planning for the immediate future

- Pivot inspection week of 18 April
- CQM thermal tests week of 25th
- Functional tests of CQM at RAL week of May 2
- Vibration test with vespel or torlon: week of May 9 (if minimum pivot damage)
- Dominique will produce detailed planning week after next after discussion with CNES

Meeting conclusions and actions

Conclusions

1. The scientific performance of the SMEC CQM in SPIRE PFM 1 is excellent and compliant with its main specifications.

2. Based on test results available to date, the SMECm cannot be regarded as mechanically qualified.

3. The success-orientated programme to deliver the FM in October 2005 is the only option compatible with getting working SMEC in SPIRE on a "credible" schedule (even though it imposes another delay in SPIRE FM delivery wrt the formally required date).

4. It is considered advisable to develop the back-up solution (stiffer pivots), but noted that this solution is very late with respect to Herschel schedule (and would likely require reduction in the max. FTS spectral resolution - from ~ 1000 to ~ 2-300)

5. The qualification levels will be modified (notching allowed to limit to 10 grms up to 600 Hz), and assessment made of performance wrt revised levels

6. Some "softening" of the latch pin-restraint parts is needed to reduce the shock loads. There is very limited time available to make these modifications: within next 6 weeks.

Actions:

1. Dominique: produce more detailed planning and identify milestones for tracking progress of revised development plan in the regular telecons etc.

2. Eric and Matt: examine SPIRE ILT plan and outline a programme that would minimise the interval between SMEC delivery and SPIRE FM delivery.

3. Berend: assess and summarise implications of revised qual. levels.

4. Berend: provide Torlon mechanical properties to LAM.

5. Eric: send some samples of Torlon to Dominique.

6. Next telecon: Tuesday 26 April 14:00 UK time (15:00 CET)