Minutes of the SPIRE Detector Group meeting, Caltech, March 20-22 2000

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6 April 2000

The objectives of the meeting were:

- To reach decisions on the design of the detector subsystem and its associated electronics.
- To examine the options available to the consortium for warm electronics funding and provision.
- To agree a development programme, an integration and test plan for the CQM and PFM models and schedule.

1. Detector Readout Electronics (Presentation by Viktor Hristov)

Analogue part:

- There will be one LIA for each bolometer (same for photometer and spectrometer) produces an output already band-limited to 30 Hz (3-dB 29 Hz; -18 dB/octave). The cut-on is at ~ 30 mHz. This is scientifically preferable to 100 mHz, but not a requirement.
- The bias frequency is nominally 200 Hz
- There will be one bias line per JFET module (24 channels)
- In-flight adjustability of the bias frequency should be incorporated to allow the ability to steer clear of troublesome microphonic or EMI.

Digital part:

- The low-pass filter requirements for the FTS are more stringent than for photometer, but it may be simplest to implement the same module for each.
- The details of the digital interfaces are still subject to revision.
- It is highly desirable to be able to do AC-biased load curves on all or a few channels

- **Summary of requirements on the rate at which the subsystem electronics sends data to the master controller or the DPU**

  Photometer:
  - 280 detectors + 8 additional channels
  - Detector sampling frequency requirement is 15 Hz or greater
  - TM rate is 15 Hz at 16 bits
  - Electronics bandwidth: 5 Hz
    Note: the detectors will be faster than this - so the electronics will determine the roll-off (OK - provides uniformity)

  Spectrometer
  - 56 detectors + 8 additional channels
  - Sampling rate at 80 Hz; 16 bits
  - Electronics bandwidth: 25 Hz

  Implications of these requirements are to be to be studied by the JPL and Saclay electronics teams

  Temperature measurement
  8 channels to be sampled at 15 Hz with 16 bit resolution (this does not mean that the temperature control system will have to operate this rapidly)

  Additional channels
  Eight additional channels are assumed for other purposes (chopper position etc.)

2. DRCU Architecture

2.1 Presentation by Christophe Cara

- The DRCU could have two basic parts: a Readout Control Unit (RCU) for the detectors and a subsystem Control Unit (SCU) the rest of the system
- The SCU also includes DC/DC converter and power distribution system
- A controller in SCU would have limited functionality and could be based on an already designed microprocessor.
- The interfaces between the RCU and SCU can be very limited
- The RCU and SPU can thus be developed separately and can have simple integration and testing procedures.
- **Comment from BMS:** It's not certain that the 115 kbs link will be fast enough - it may be necessary to use the HIFI-type fast/slow interface.

2.2 Presentation by Bruce Swinyard (see attached document)

- There is no need for high-performance processor in DRCU
- There is no very fundamental differences between Christophe's and Bruce's concepts
- It is necessary to study the implementation in more detail - it will depend on the division of work, testing and development plan, etc.

3. RF filter module and JFET box Dustin Crumb

- RF filter modules:
  - Two sets in one module: 34 x 66 mm with two 37-way MDM connectors
  - Can bolt to 4-K wall of instrument
  - Filters are mounted on both sides of circuit boards to save space
  - The RF filters should be added to the list of not-yet-qualified components

- JFET modules:
  - Two 12-channel modules now used (to increase yield)
  - 16 such 24-channel units
  - A light wall prevents radiation from getting into the 4 K box

- Issues:
  - Length of thermal isolation 4 - 10 K for cables
  - Cable routing to JFET box
  - Serviceability (ability to remove and replace cables)
  - GSE to support JFET box from instrument during transport?
  - Location of RF filter modules
  - Requirements in the IID-A

- Total mass estimates: 1.5 kg for RF filter modules
  3.8 kg for JFET module (doesn't include structure ~ another 2 kg)

Discussion:

- The interfaces might be simpler for JPL if the interface for the JFET box were to be same as for the RF filter box.
- Modal analysis - not done yet. Making the legs stumpier would help here.
- Currently, the JFET box needs to be on "stilts" to get above cooling pipes (0.75 kg mass) Vespel tube with removable cover for 4-K to 10-K link
- It should be assumed that there is no requirement to open the unit in situ
- Interface at end of Vespel tube: Terry and Dustin to suggest something. It would be nice to have something that accommodated all compliance on the JPL side.
- JPL will be responsible for the cables from the FET box to the arrays

4. Buffer Amplifier Unit status

A discussio9n of the pros and cons resulted in a decision to delete the BAU, subject to assessment of what modifications to the cryoharness definition will be necessary or desirable to make sure that the detector signals can be sent along 5 metres of cable between the FPU and the DRCU.

5. Thermal straps and temperature control

- Jamie's simulations indicate that about two orders of magnitude rejection will be needed to be able to cope with a 1000 sec. observation.
- One order of magnitude may be available from the thermal straps.
- The specification on the cooler would then need to be about 10 times lower than the IRTS fridge performance.
- Conclusions:
  - Implement readout of thermometers at control node
  - Jamie and Terry to continue to work on improving the thermal circuit
  - Lionel is going to do tests on use of pump heater for control
  - Redundant heaters should be baselined for the control node

6. CQM Functionality

6.1 CQM tests required

- **Instrument-level (cold FPU):**

- Thermal balance/performance
- Scientific performance
- Observing mode check-out
- Qualification
  - CoG requirement; mass; mechanical etc.
  - Vibration
  - Bakeout

- **Thermal tests**

- Flight-like fridge
  - Correct thermal load
  - Correct thermal architecture (straps to dummy arrays with heaters if nesc
- JFET module
  - Flight-like (mass, power, wires etc.)

- Correct thermal load
- Correct interfaces
- Correct architecture

Temperature control
- Flight-like hardware
- Control loop implemented

Thermal environment:
- Cryostat should produce thermal environment like FIRST (but we can't simulate the real thing - it's too complicated and difficult)

- **Scientific performance:**

- Detector performance and characterisation
- Optical performance and characterisation (alignment, fov and beams, stray light, focus, spectral response, optical efficiency; crosstalk, etc.)
- Microphonics
- Spectrometer performance
- BSM performance
- Calibrator performance and characterisation
- Shutter performance
- Performance vs. thermal loading

- **Observing mode checkout:**

- Test in-flight procedures for calibration
- Set up functional tests that need to be done at system-level tests and in-orbit checkout
- Define performance tests for system level integration
- Test AOT procedures
- End-to-end AOT tests

6.2 Implications for the detector provision

Detectors:
- Externally structurally representative
- Correct mass
- Correct interfaces and thermal behaviour

JFETs
- Externally structurally representative
- Thermally representative

Thermometers:
- Flight-like (at least for temp. control parts)
- Internal harness and connectors fully representative
- All signal lines should have signals

Spectrometer:
LW: Fully populated with 19 detectors but they don't all need to be good feedhorns
SW: Minimum of centre and 4 corners

Photometer:
500 μm: Fully populated but don't need to be all scientifically optimised.
350 μm: 8 detectors
250 μm: 8 detectors

7. Schedule

- The CQM schedule does not allow time for proper prototyping of the arrays and feedhorn manufacture
- Building five structurally representative modules is OK
- An additional six months at least would be needed to do a proper job on the array prototyping, manufacture and testing
- Major risk is to feedhorn manufacture
- PFM manufacture must start before the results of CQM testing are available.

8. Warm electronics provision

An informal discussion document was presented by MJG and discussed.

- Conclusions

- The favoured options were 2 (Saclay provision of detector readout electronics in parallel with PACS participation) and 4 (Canadian provision of all or part of the detector readout electronics)
- The Canadian possibilities to be investigated
- JPL estimates of the costs are
  - LIA : $425k per flight-like unit
  - Digital unit : $850k per flight-like unit
  - Bias circuit : $325k per flight-like unit
- These figures should be multiplied by ~ 2.5 for the total cost

- There are some worries about the feasibility of Option 2: e.g.,
  - Funding/schedule
  - WE development programme at SAp is still large and complex
  - SPIRE/PACS prioritisation
  - Loss of SPIRE Warm Electronics System Engineer
  - Need for EMI grounding expertise

  These will need to be raised at the meeting with CNES on March 27.

- The warm electronics management is to be done by Ken King at RAL, reflecting the simplification of the DRCU to the extent that it can now be regarded as a subsystem.

- The BSM electronics can probably to be done at LAS - the details and the test programme need to be established by ATC and LAS.

9. Cold Units Development Plan

9.1 Thermal straps:

Design and provision of the thermal straps is a difficult area for which responsibility is ill-defined at present. After some discussion it was decided that:

- Lionel Duband would need to define the specification, including constraints on overall strap length and provide preliminary design of strap supports, required connection impedances.
- Terry Cafferty could then to do thermal modelling based on this information
- A useful approach might be to take one strap into each 2-K box
- A thermal strap team (including JPL, MSSL, CEA Grenoble) would be coordinated by Bruce

10. Array Module Qualification Programme (Presentation by Jamie)

1. Characterisation:
   - Focal Plane Structure
     - Cryogenic shake
     - Mechanical motion
   - JFET unit

2. Development unit
   - FPS
     - Kapton cables
     - Load resistor packs
     - Thermometry
     - Mechanically representative array
     - Light seal and thermal strap
   - JFET unit
     - RF filters, boards, module

3. Feedhorn programme (in parallel with 1 and 2)
   - Design and characterisation

4. Development of test dewars (also in parallel)

5. Fabrication of CQM arrays, JFET unit, and temperature control hardware
   - Focal plane structure qual testing
   - Then put arrays in
   - Then CQM environmental testing
   - JFET structure qual testing
   - JFET module env. tests
6. Noise tests on CQM arrays
7. CQM optical testing
8. JFET characterisation

- Radiation testing: need to coordinate with Planck
- QMW and JPL test programme: to be discussed at splinter meeting tomorrow

11. Warm Electronics Development Plan (Presentation by Ken King)

AVM
- AVM = DPU and DRCU simulator
- Must check that Stockholm are happy with increase in speed and number of interfaces
- Need to know from each subsystem the list of telecommands that are required with description of the status conditions - needed to implement simulator
- Need to review and complete all templates/information as given at WE Review.
- Stockholm need description of interface between DPU and DRCU
- Bruce will produce a document describing the requirements on the simulator

CQM:
- QM = AVM DPU + QM interconnect harness + QM DRCU + CQM FPU + FPU simulator (+ EGSE?)
- Could we produce a < 100% equipped DRCU?
- SAp plan is to produce 2 QMs QM1 and QM2
- QM1 compatible with CQM FPU for instrument level testing (gets delivered to ESA); doesn't need to have complete redundancy

- QM2 as close as possible to FM, used for qualification and environmental tests, fully redundant (not for delivery)(needs to be tested by CDR)
- BMS: Would like to do a thermal range test also, using QM1
- BMS: UK environmental testing - no impact on schedule
  Earlier delivery to UK if UK doing DPU/DRCU integration
- KJK: Want to discuss later whether integration at RAL or CEA
- WIH to be shared with Italy (still proposed by SAp - no answer from Italy yet)

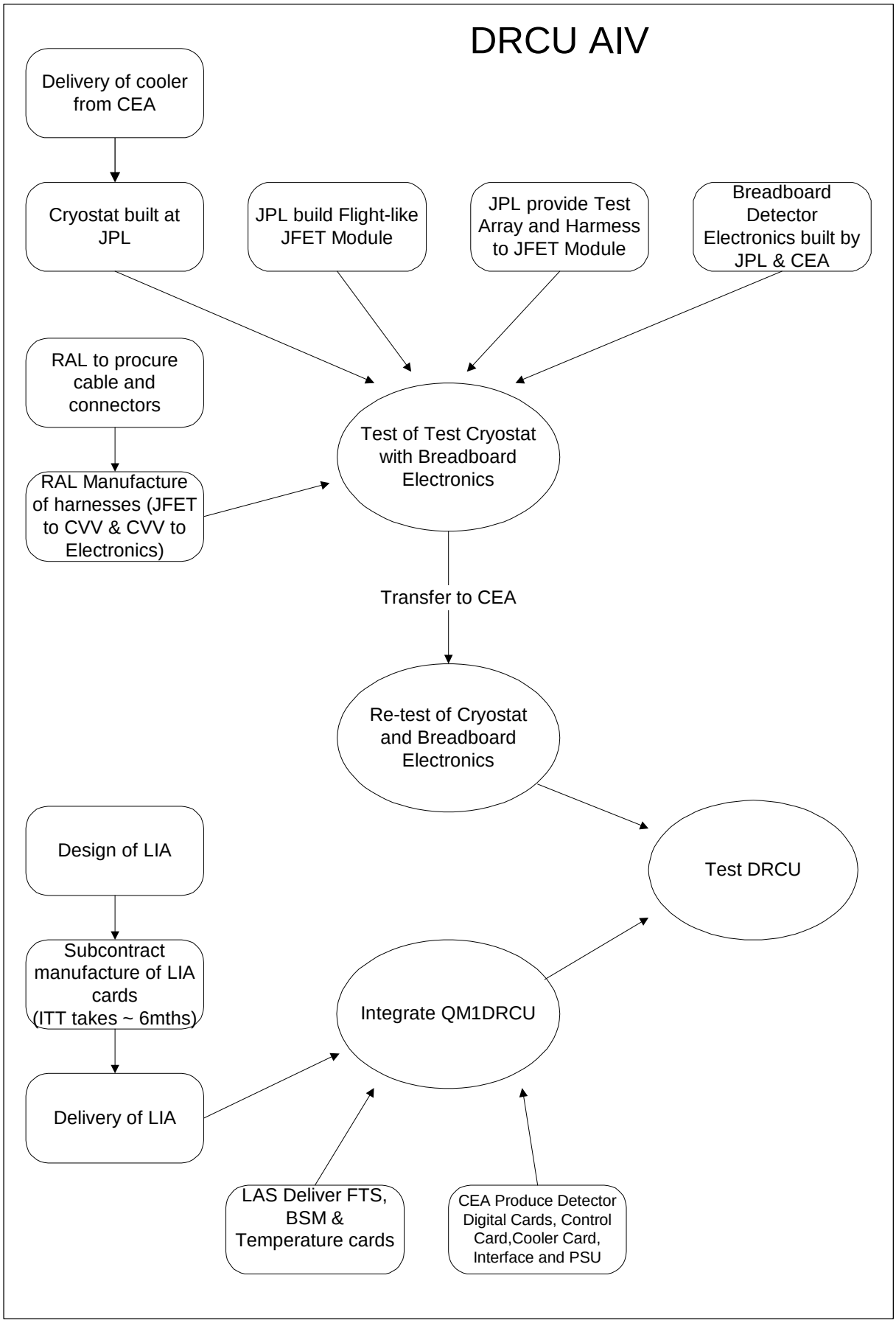
PFM:
- Must be flight-like
- It is desirable to have break-out boxes for the harnesses for integration checks
- It will be necessary to measure the cryoharness for noisy contacts etc.

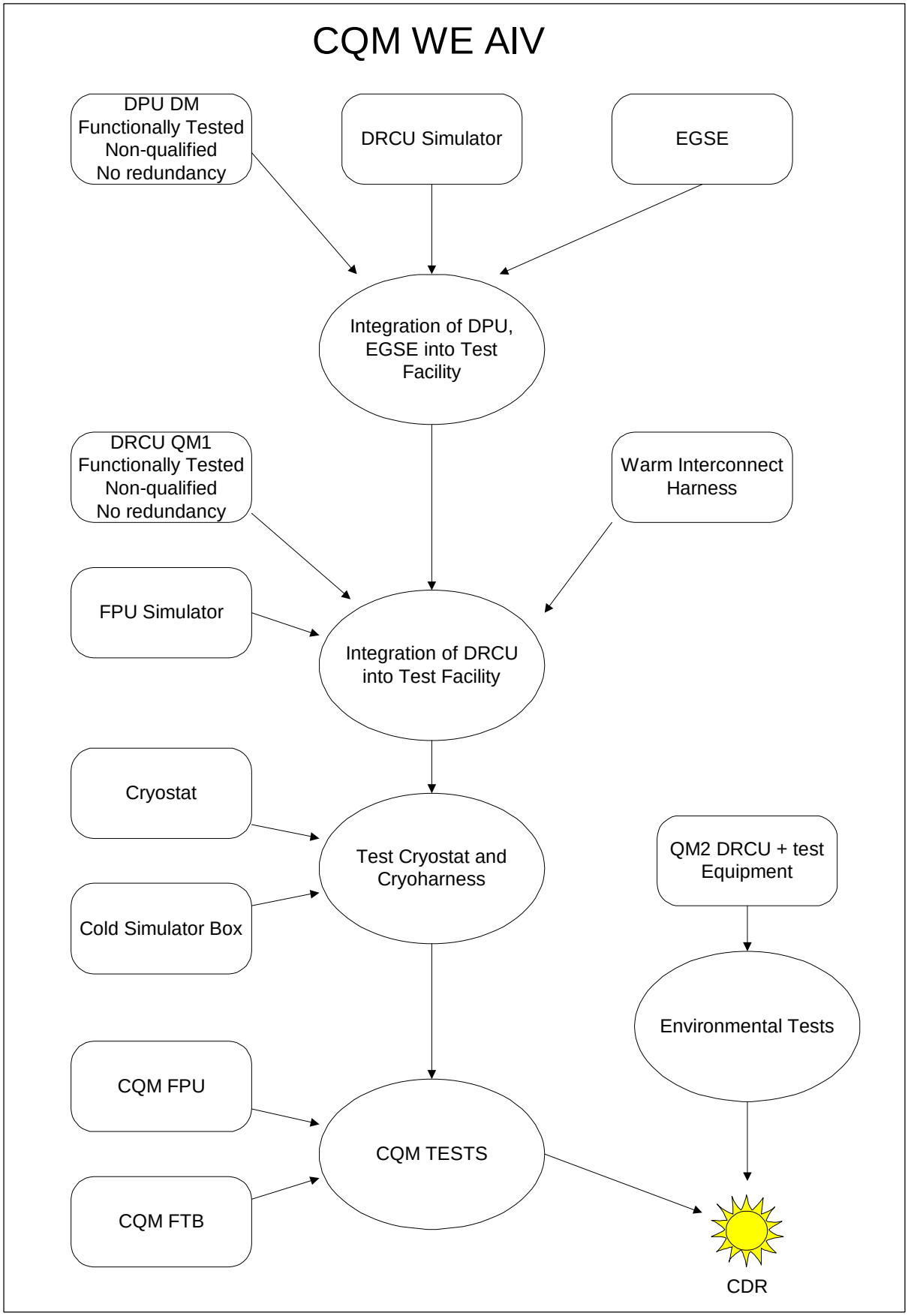
FS:
- SAp are proposing to provide a full flight spare DRCU rather than replacement boards. This goes beyond what ESA require.

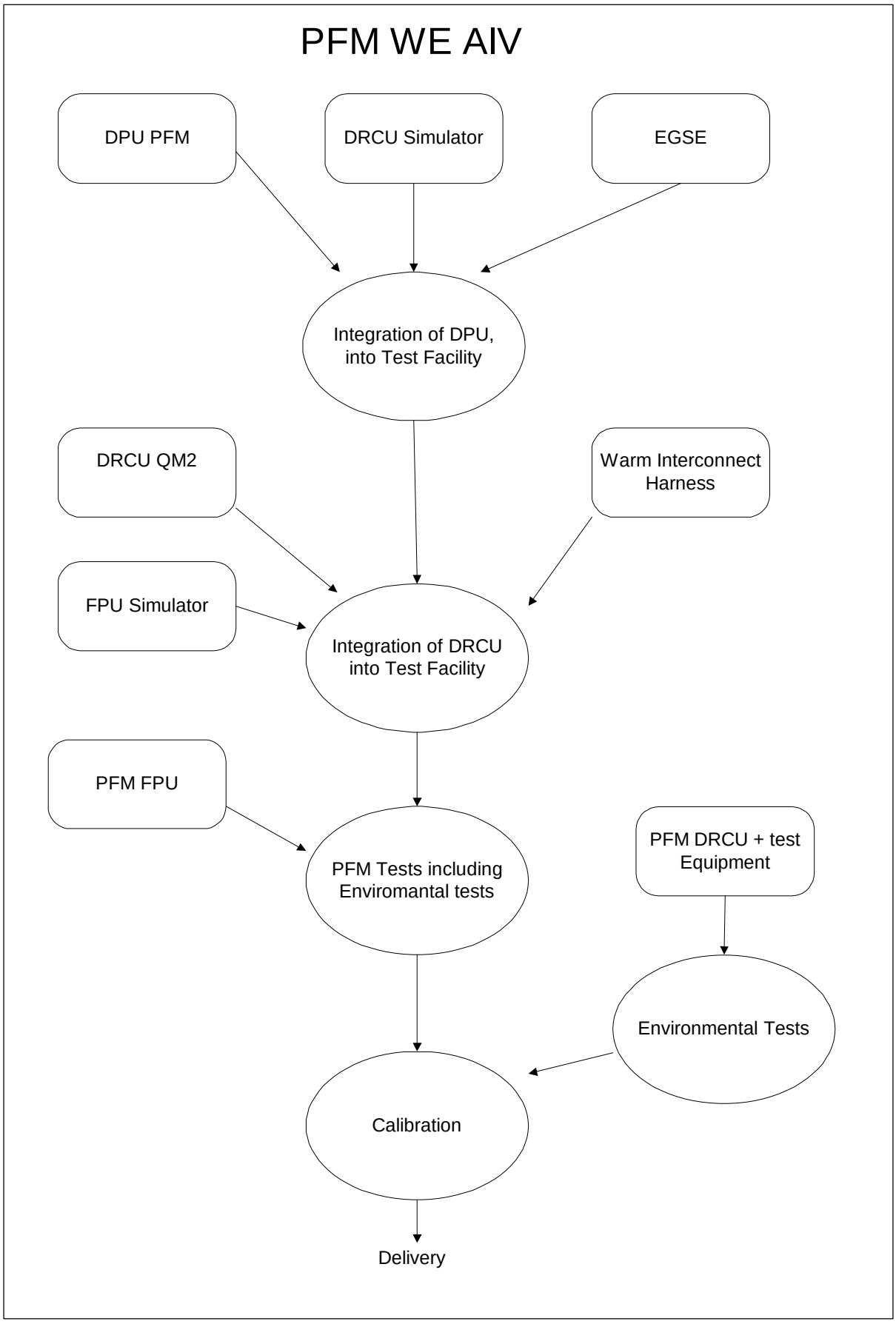
12. Warm electronics AIV

- The plan to implement a test cryostat at Saclay is supported by JPL
- JPL will provide the cryostat and deliver it to SAp, together with a flight-like JFET module + harness, and a test array
- JFET - CVV and CVV - WE harnesses: single procurement (by RAL?) could save costs.
- RAL will need the cable by Autumn 2001 in any case
- JPL and CEA will collaborate on a breadboard model of the readout electronics that will be tested at JPL
- Design and procurement of the QM will go on in parallel (the LIAs will be subcontracted - maybe to Canada to save cost?). As the LIAs will be subcontracted, the design must be defined soon (the ITT cycle takes 6 months to issue ITT in the Saclay system)
- LAS will do the BSM and FTS control electronics + the thermometry card. SAp will just do basic electrical tests on these.
- SAp will do the cooler control card.

13. WE integration (KJK viewgraphs drawn up in real time)


DRCU AIV
Delivery of cooler from CEA
Cryostat built at JPL
JPL build Flight-like JFET Module
JPL provide Test Array and Harmess to JFET Module
Breadboard Detector Electronics built by JPL & CEA
RAL to procure cable and connectors
RAL Manufacture of harnesses (JFET to CVV & CVV to Electronics)
Test of Test Cryostat with Breadboard Electronics
Transfer to CEA
Re-test of Cryostat and Breadboard Electronics
Design of LIA
Subcontract manufacture of LIA cards (ITT takes ~ 6mths)
Delivery of LIA
Integrate QM1DRCU
Test DRCU
LAS Deliver FTS, BSM & Temperature cards
CEA Produce Detector Digital Cards, Control Card,Cooler Card, Interface and PSU


CQM WE AIV
DPU DM
Functionally Tested
Non-qualified
No redundancy
DRCU Simulator
EGSE
Integration of DPU, EGSE into Test Facility
DRCU QM1
Functionally Tested
Non-qualified
No redundancy
Warm Interconnect Harness
FPU Simulator
Integration of DRCU into Test Facility
Cryostat
Test Cryostat and Cryoharness
QM2 DRCU + test Equipment
Cold Simulator Box
Environmental Tests
CQM FPU
CQM TESTS
CQM FTB
CDR



This scheme will be further discussed at the next Warm Electronics Group meeting.

14. Schedule

- There is a 9-months discrepancy between the current schedule and the SAp delivery schedule for the warm electronics - we need to work on bringing them together. The simplification of the DRCU should help in this respect.

- The FIRST and Planck instrument teams are to present their funding and schedule status to the ESA Director of Science on 23 May at a meeting designed to assess their readiness and compatibility with the project schedule. The SPIRE approach to this will be:

  - to present a schedule incorporating delivery of the PFM six months later than the current schedule (i.e., at the end of 2004);
  - to present the disadvantages of following the current schedule
    - high level of risk as the schedule contains no margin
    - need to commence FM manufacture before QM testing is complete

15. Manpower support for instrument testing at RAL:

- JPL and SAp will provide support equivalent to one full-time person for testing and calibration at RAL
- The IAS (through Francois Pajot) are also interested in participating, and some support from LAS may also be available.

16. Reviews

16.1 SPIRE PDR plan

- This will be a review of the detailed documentation rather than viewgraph presentations
- The final phase of the PDR will be on 26, 27 June at Saclay
- Documents must be ready and approved by 1 June
- Some will be required earlier for ISVR
- There will now be only one OBS URD (none for the DRCU)
- Ken King will coordinate the preparation of the documentation

16.2 SPIRE DDR plan

- This has been outlined in the e-mail from Ken King.
- There was some concern that the format of the mini-reviews of the detailed design could hamper the establishment of a proper overview of the instrument
- With suitable attention to the format, the overall review in October to freeze the interfaces should be the best form for taking an overview of the complete instrument. The purpose of the later mini-reviews would then be to look at the detailed designs of the subsystems in the context of clear and documented interfaces.

16.3 Forthcoming funding agency reviews:

France: Following SPIRE detector selection and the proposal to use the CEA arrays in PACS, it will be essential to convince CNES and CEA of the viability of the SPIRE programme (Saclay and LAS).

A review is being set up by requested by CNES. CEA must be involved as SAp are asking for more resources. It will be a combined review of participation in PACS and SPIRE. Laurent would like to

invite relevant people from SPIRE. CNES and CEA will define the format. The date is uncertain (around the end of April or the beginning of May). The purpose is to approve the idea and define the funding envelope (not to review the design of PACS etc.)

USA: JPL will hold yearly reviews of FIRST/Planck. Two reviews will take place this year: peer review (June 14 at JPL) and PDR (4 weeks later). Ken King will be invited to attend the peer review.

UK: A SPIRE project review will be held in the in the UK to examine and revise the distribution of work and resources that was originally formulated 18 months ago. It will be a SPIRE project review, but with PPARC oversight, and they will have to agree any significant changes. The overall budget for SPIRE in the UK will remain fixed at the current level. The date of the review is TBD (possibly early June).

17. Splinter meeting reports

17.1 WE splinter report

- Viktor's design for the readout electronics was discussed
- Cost and availability and capacitor for the AC cutoff are a concern - could the ac coupling be removed?
- The phase shift vs. frequency requirement for the FTS needs to be examined
- Christophe will look at design vs. cost etc and suggest design changes
- Viktor will give Christophe a set of requirements on gain and stability

17.2 Feedhorns splinter report

- A horn working group has been set up (Jason, Matt, Bruce, Anthony Murphy, Jamie)
- The initial goals and schedule for design and prototyping established
- Will involve JAM modelling, and testing at QMW/UCol
- Jason and Matt will write up notes and programme
- Fortnightly telecons will be held
- A progress meeting/workshop on detailed CQM planning is planned for July

17.3 JPL/QMW testing splinter

- Identical test cryostats will be built up at JPL and QMW following the BACUS tradition
- Peter Hargrave will visit JPL in about six weeks to formulate the detailed plan and cryostat design with the JPL team
- It will need to have 150 channels to measure full the 250 array (maybe only 50 channels for the CQM).
- Division of work:

- The cryostat and He-3 fridge specification and procurement will be agreed by JPL and QMW, with each institute purchasing one dewar and fridge.
- The fridge must be capable of getting to 300 mK or lower.
- JPL will provide the JFET modules and warm electronics and QMW will provide filters, optics etc.
- The exact plans for provision of connectors, thermometers etc. will need to be worked out.
- A LabView-based PC system can be adopted for data acquisition
- QMW will organise the BACUS-type procurement
- It would be useful if some parts (e.g., connectors, wiring) could be the same as in the RAL calibration facility

- Tests to carry be done:

- BACUS type tests (list to be defined)

- It would be very useful if the system were compatible with testing of the thermal strap concept
- Division of testing work between JPL and QMW is TBD - with two systems we can be flexible about this. The test programme and procurement schedule should be defined when Peter Hargrave visits Pasadena in May.

- Timescale:
- The systems need to be operational within about one year.

19. SPIRE extragalactic science capabilities

Presentations were made by Jamie and George Helou, pointing out, inter alia, the potential benefits of "stretching" the photometer wavelength coverage to provide somewhat larger separation between the bands. Extending the longer wavelength band to, say, 600 μm would allow greater ability to discriminate between sources at different redshifts and greater sensitivity to the S-Z increment. Matt Griffin made a presentation of the current survey capabilities of SPIRE and PAS, and an assessment, based on Michael Rowan-Robinson's models, of the possible source counts and redshift distributions. Andrew Lange presented the possibilities for S-Z science, including the potential of the long wavelength band of the FTS.

Following discussion it was agreed that:

- It is worth considering changing the wavelength bands of the photometer, subject to the constraint that the design of the rest of the instrument does not change significantly (including no in crease in the total number of detectors).

- Jamie will write an outline case for extending the long wavelength band to a nominal 600 μm by 20 April

- Bruce will look at the possibilities for limited polarisation capability

- Bruce and Matt will examine the impact on sensitivity and optical performance of extending to 600 μm. (Martin Caldwell will need to look at beam clipping and vignetting at 600 μm)

20. Conclusions of the meeting

1. The BAU is deleted (TBC). A proposal to ESA involving request for extra resources (cold power, cryoharness shielding etc.) will be made at the April meeting.

2. The DRCU master controller is deleted

3. The CQM array requirements have been defined

4. We should work towards Option 2 (Saclay) or Option 4 (Canada) for detector warm electronics provision

5. There are some worries about the feasibility of Option 2
   - Funding/schedule
   - WE development programme at SAp is still large and complex
   - SPIRE/PACS prioritisation
   - Loss of SPIRE Warm Electronics System Engineer
   - Need for EMI grounding expertise

6. The possibilities of shifting warm electronics environmental test, integration, vibration, limited EMC, to the UK will be investigated (these are all TBC depending on cost)

7. The warm electronics management to be at RAL, reflecting the simplification of the DRCU to the extent that it can now be regarded as a subsystem.

8. The BSM electronics can probably to be done at LAS - the details and the test programme need to be established by ATC and LAS.

9. Many uncertainties over consortium responsibilities are now being revealed (e.g., System Engineering effort, thermal straps), and the overall AIV plan is in serious need of clear definition

10. In-flight adjustability for detector bias frequency should be implemented.

11. Overall schedule (for presentation at Bonnet meeting at end of May):
    - SPIRE will present schedule with 6-months later PFM delivery as the "sensible" approach
    - Compromises/risks involved in meeting the existing schedule are to be listed

21. Summary of actions

SPIRE Detector Group Meeting, Pasadena, March 20 - 22 2000			
Action Number	**Description**	**Responsible**	**Due Date**
AI-DET-0000-01	BMS/MJG specify what the detection bandwidth should be for the photometer (is 30 mHz to 5 Hz OK? Or should it be a little higher?) .	Griffin, Swinyard	March 29
AI-DET-0000-02	Present JFET module design at ESTEC meeting on April 11 meeting; discuss options for improving design (e.g., shorter stilts)	Swinyard	April 11
AI-DET-0000-03	Produce revised version of his JFET box ppt presentation without any need to replace modules in situ	Crumb	March 29
AI-DET-0000-04	Allocate thermal budget for load on 4 K from the 10-K level.	Swinyard	April 7
AI-DET-0000-05	Suggest design to Bruce for the Vespel tube interface.	Cafferty, Crumb	April 14
AI-DET-0000-06	Provide wish list of cryoharness parameters that would allow BAU to be eliminated	Bock	March 29
AI-DET-0000-07	Ask Lionel Duband to provide early information on results of prototype fridge tests (inc. open loop performance)	Swinyard	April 7
AI-DET-0000-08	Specify reasonable thermal conductance for contacts at each end of the thermal straps	Duband	April 7
AI-DET-0000-09	Define the specification, including constraints on overall strap length and provide preliminary design of strap supports, required connection impedances. Also indicate fridge stability.	Duband	April 14
AI-DET-0000-10	Investigate the option of getting RAL effort for thermal modelling and discuss with Matt and Colin Cunningham	Swinyard	April 7
AI-DET-0000-11	Produce electrical grounding diagram of Faraday cage for Bruce	Bock	April 7
AI-DET-0000-12	Produce full FPU grounding diagram: cooler, JFET box etc. etc.	Swinyard	April 14
AI-DET-0000-13	Write note on requirements for CQM detectors	Swinyard	April 7
AI-DET-0000-14	Raise issue of schedule pressure at the technical meeting with ESA	Griffin	April 11
AI-DET-0000-15	Send updated cost estimates that would allow Gary Davis to use to assess what Canadians could do.	King	March 24
AI-DET-0000-16	Draw up schedule for thermal strap design work and coordinate MSSL, JPL, CEA, to arrive at a preliminary design by May 15.	Swinyard	April 7
AI-DET-0000-17	Produce document outlining requirements on the simulator	Swinyard	
AI-DET-0000-18	Provide document template to Ken King for the Subsystem Definition Document based on the viewgraph template	Augueres	April 7

AI-DET-0000-19	Produce Subsystem Definition Document based on Jean-Louis's template to be provided	All subsystem managers	April 30
AI-DET-0000-20	Ask this question at ESA technical meeting: Do we have to deliver some EGSE with the CQM or will ESA be providing the S/C simulator?	King	April 11
AI-DET-0000-21	Find out what the arrangement is for the WIH provision for the other instruments	King	April 14
AI-DET-0000-22	Discuss best solution for FPU simulator (later this week) and report to Bruce	Bock, Cara, Pinsard	March 27
AI-DET-0000-23	Devise solution to problem of ensuring that bias frequency doesn't coincide with microphonic resonance of the cryoharness (which could be different in flight)	Hristov	April 14
AI-DET-0000-24	Raise harness definition and absence of spacecraft contractor as problem on April 11 (our QM will need to be tested with a harness so this constrains the flight harness)	Swinyard	April 11
AI-DET-0000-25	Write detailed AIV programme for the DRCU	Augueres	April 14
AI-DET-0000-26	Investigate possibilities for getting EMI modelling expertise within JPL	Lilienthal	April 3
AI-DET-0000-27	Coordinate definition of schedule incorporating additional 6 months (subsystem managers to indicate recommended approach to saving 6 months).	King	May 1
AI-DET-0000-28	Provide grounding scheme for detectors and readout electronics to SAp	Bock	April 7
AI-DET-0000-29	Include the above in the overall grounding scheme	Cara	April 21