Minutes of meeting
SMEC Latch Power Unit (LPU) Design Review
10/07/07
SPIRE-RAL-MOM- 002945

Attendance:
Karine Mercier
Yvan Blanc
Dominique Pouliquen
Guy Doubrovik,
Carsten Scharmberg
Eric Sawyer
Gerard Rousset
Christophe Cara
Jean Fontignie
Siegmund idler, by phone, part time.

Aims of the meeting
Agree a baseline design for the launch latch box, mechanical, electrical.
Give the go ahead for manufacture.
Agree the documentation to be supplied.
Agree a development plan
Agree a schedule.
Agree divisions of responsibilities.

For this we need available:
Detailed mechanical drawings.
Electrical schematics.
Mechanical and electrical interface documents (at least in draft)
Proposed schedule

Presentation by Dominique.

A shorting plug will be required to allow operation of the box without the LPU present.
Redundancy discussed. Hot or cold?
Baseline is hot redundancy. One circuit should give 20% margin.
Hot redundancy avoids the possibility to completely loose power to the latch, as both relays would have to open simultaneously under vibration.

Components.
It is not clear what is the difference between level B and C relays. (clarified by phone call to ESA PA- the two types are identical but B has additional documentation. Either type would be acceptable but the preference is for level B for flight)
Diodes are available from the SPIRE spares at LAM.
Connector backshells are required for EMC purposes on the latch side.
LAM have sufficient connectors for all their deliverables, but not sufficient to supply Astrium.
Shorting plug will be a flight connector, with appropriate links. But should have a backshell, probably conductive tape would be ok, as it is non flight item.

Savers are available at LAM.

Heaters. Current density is about half the max recommended by Minco. This follows the normal guidelines.

Mechanical design.
Screw fixings on the FCU should also be abraded to provide electrical groundings.
LAM to provide provision for ground strap, probably on the top face between the two middle connectors. This is as a back up to the abrasion above, in case this can not be achieved.
Large margin on mechanical strength.
Large margins on thermal design.
Dominique confirms that the unused pins are not connected within the MCU.

Documents.
(see Dominique's list) +
Integration procedure.
Include design calculations as presented today.
Failure modes table discussed see presentation.
Minimum of two failures required to loose latch function.

Glue.
Two types are being considered, decision after tests.

Model philosophy and testing
No shock test planned.
Relays have been shock tested at component level.
Shock occurs during fairing jettison, still waiting for info from Arianespace.
Vibration will be powered on with relays monitored
FM will not be glued for tests, a jig will be designed.
No thermal planned for QM.
Temperatures of thermal tests agreed during the meeting.
Use +45 for in air test..
Levels for thermal cycles, -45 to +70 powered 4 cycles. TBC.
LAM to check all components for these temperatures.
If lower temperatures are desirable, a justification will be required.

Questions for Astrium telecon.

Backshells for harness 9 way. Could not be answered today.
Connector availability for harness. Insufficient at Astrium, probably some at Thales, but probably not the backshells.
Access to grounding stud on the PSU. Astrium to check the access when Carsten is at Friedrichshafen this week.
Abrasion of the mounting holes. LAM to send Astrium a sketch and they will asses
Thermal analysis, Exact location of heat source in the model. Node number. To be supplied to Alcatel. **ACTION RAL**

Schedule,

Two periods, one for abrasions, one for fitting, both could be done in August but box will not be ready. Abrasion and harness mods should be done by end August, this is when the panel is scheduled to be closed. There is not a planned opening of the panel after end August. Integration of the LPU will require a dedicated opening of the panel.
Astrium to inform SPIRE and ESA if any information is missing, that may be preventing the start of harness manufacture.
Dominique to update his interface document to include the abraded areas and location of grounding stud.
HDD to be reissued?? ECR required.
RAL to manufacture shorting plug.
RAL to investigate manufacture of boxes and internal wiring.
Possibly a climatic chamber could be used in place of thermal vacuum.
New development plan to be prepared by LAM when information about manufacturing facilities are available.
Investigate a very shortened test campaign for the FM.

Responsibility.
Harness, RAL to specify, Astrium to procure.
Box manufacture, SPIRE. (LAM or RAL)
Integration, SPIRE with Astrium support.
Testing, environmental – LAM. After integration onto Spacecraft, SPIRE and Astrium
Proposal by Guy, LAM expert to visit Astrium and discuss the details of the gluing.

Telecon Friday 13th July, 10:00UK/11:00CET

Summary.
Review of the aims of the meeting

- Agree a baseline design for the launch latch box, mechanical, electrical. **Baseline agreed**
- Give the go ahead for manufacture. **Go ahead for manufacture given**
- Agree the documentation to be supplied. **Documentation list agreed as presented plus integration procedure and inclusion of design calculations as presented at this meeting.**
- Agree a development plan. **An outline plan was agreed as presented and amended during the meeting, this may change depending upon available manufacturing failities.**
- Agree a schedule. **Baseline schedule presented attempts by LAM and RAL to accelerate the schedule will be made.**
- Agree divisions of responsibilities. **Division of responsibilities agreed in principle, RAL may do some manufacture to accelerate the schedule.**

Summary of actions.

Astrium to check the access of the grounding stud when Carsten is at Friedrichshafen this week.	Astrium/ESA	13/7/07
LAM to send Astrium a sketch of the	LAM	13/7/07

abraded areas and they will asses		
Exact location of heat source in the model. Node number. To be supplied to Alcatel.	RAL	20/7/07
Astrium to inform SPIRE and ESA if any information is missing, that may be preventing the start of harness manufacture	Astrium	20/7/07
RAL to manufacture shorting plug.	RAL	30/7/07
RAL to investigate manufacture of boxes and internal wiring.	RAL	13/7/07

Annex A
Dominique's presentation.

Eric Sawyer
11/7/07

Latch power Unit

10 July 2007

Contents

- Subsystem requirements
- Electrical design
- Mechanical and thermal design
- I/F
- Documentation
- Development plan & schedule

LPU requirements

The LPU must be able to

- Function “latch”: Deliver a continuous current to the latch coil to maintain the latch latched..
- Function “Switch to MCU”: Allow for normal operation of the latch when not in use i.e. unlatching/latching at ambient or cryogenic temperature through the MCU.
- Function “Isolate the harness”: Not link any non SPIRE harness to the FPU when not in use

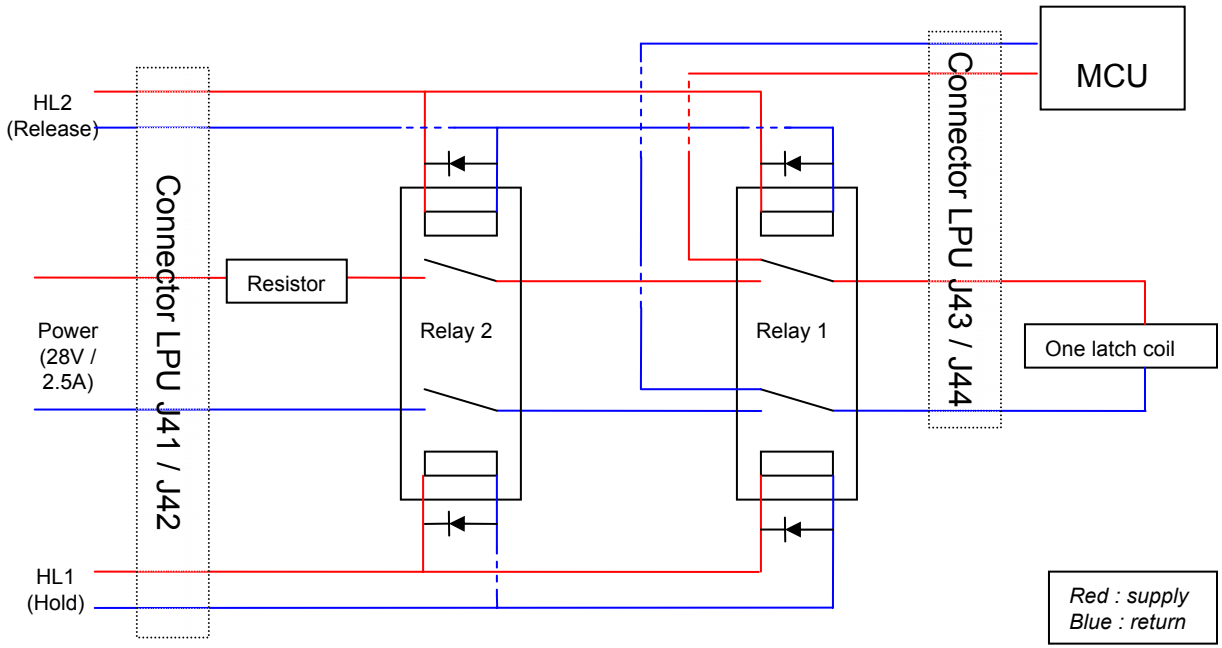
The design of the LPU must

- Be used during vibrations or acoustic tests and from atmospheric pressure to vacuum.
- Respect the prime and redundant philosophy
- Not induce a modification of the existing MCU boards
- Not require a de-integration of the SPIRE warm electronic unit nor of the SPIRE FPU
- Avoid having to put ON the SPIRE warm electronic during the satellite tests and the launch.
- Ensure that its temperature when used does not exceed that of the FCU in flight (storage temperature = +65°C)

The LPU must be delivered and integrated at least (much) before the satellite test campaign.

LPU Electrical design

LPU electrical design: the scheme



Two identical circuits

Hot redundancy

Function “Latch”

- Nominal when both coils are powered
- Degraded if only one coil is powered
- Lost if both coils are unpowered. For this to happen, 2 failures are needed: one relay does not switch to the “hold” position on each channel

Function “Switch to MCU”

- Nominal when both PRIME and RED are switched to the release position
- Degraded if only one is switched to the “release” position
- Lost if both remain in the hold position. For this to happen, 2 failures are needed: relay 1 does not switch to the “release” position on each channel

Function “Isolate the harness”

- Nominal when both PRIME and RED SPIRE harness are isolated from the satellite lines
- Lost if relays 1 and 2 of any one channel remain in the “hold” position.
- No degraded mode

Relays: bistable

- SCC360201911C datecode 0411C (5 available) => QM quality level
- SCC360201911B datecode 0411B (8 available) => FM quality level

Diodes:

Resistors: heaters MINCO, Kapton type, to be ordered

Connectors: SubD 9 pins or sockets 7 9P and 7 9S available

LPU electrical design: latch current and heater resistance (1/2)

A margin of 25% is desirable when only one coil is powered, in the design worst case conditions.

The latch magnetic force is equivalent to a 250 mA current in one coil.

The 0 margin current is estimated at 300 mA.

So the 25% margin is for a 125 mA current in one coil.

The design worst case conditions are *(current output lowest)*:

- Launch latch at 80K *(resistance = 13 Ohms)*
- Resistor at +60°C
- Resistor value = catalog + 10%
- U satellite = 26V

=> With 26V, the circuit resistance = 208 Ohms in these conditions.

LPU electrical design: latch current and heater resistance (2/2)

The nominal resistance of the circuit is 156 Ohms.

Nominal design conditions are:

- Launch latch at 4K *(resistance = 4 Ohms)*
- Resistor at +20°C
- Resistor value = catalog
- U satellite = 28V

As the harness resistance is 5 Ohms and the 4K coil resistance 1 Ohm, the nominal resistance of the heaters is 150 Ohms.

- MINCO catalog

  2 heaters HK5164R78.4L12A in series with each coil

  (Size for each heater = 25.4 x 50.8 mm)

  => catalog resistance = 157 Ohms

  => achieved design worst case margin = 23%

  => acceptable

LPU: mechanical design

LPU mechanical design

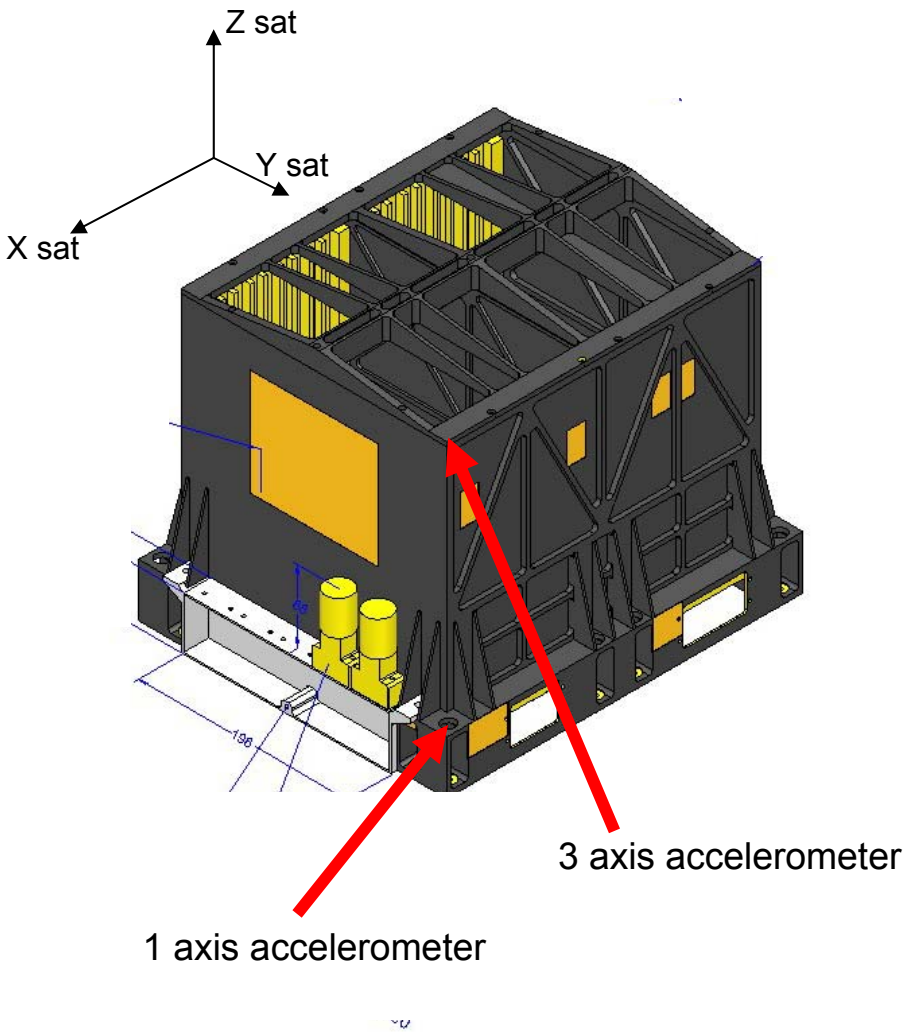
The LPU is

- fixed on two access holes of the FCU
- glued on the FCU +Xsat face
- mass about 0.36 kg.
- material = Al 6082 (as the FCU)

Surface treatment:

- Black anodisation inside and outside
- Alodine for the components IF (connectors and relays)
- Alodine for the lid/box I/F
- Alodine for the LPU-FCU I/F

LPUmechanical design: FCU vibrations levels



From the Q results of the FCU vibrations tests, we can check if the screws are Ok and calculate the glue area needed for mechanical purpose.

X_sat excitation (7.63 g RMS)
FCU X meas: 14 g RMS
PSU X meas: 8.3 g RMS

Y_sat excitation (7.63 g RMS)
FCU Y meas: 19.2 g RMS
PSU Y meas: 8.2 g RMS

Z_sat excitation (10.8 g RMS)
FCU X measure: 12.3 g RMS
FCU Y measure: 6.0 g RMS
FCU Z measure: 16.5 g RMS
PSU Z measure: 12.4 g RMS

Response at the top of the FCU taken for the design (upper values)

LPU Glue and screws: mechanical dimensioning

- The shear directions are the Ysat and Zsat directions
- The maximum measured is on the Zsat direction, 19.2 g RMS
- With the LPU mass, the shear force is **254 N** (1.25 safety margin included)

GLUE

- The candidate glue is 3M 2216 or DP490.
- Its shear modulus is **3 MPa** at +82°C (no figure between +24 and 82°C)
- So the surface needed is about **85 mm²** - This is about 100 times less than the available glueing surface.

SCREWS

- The screws are M5.
- With one screw, the elastic margin is 24% and the ultimate margin 93%.

The LPU mechanical design is Ok

LPU: thermal aspects

Worst case for the dissipated power = highest current

- Satellite power at 29V
- Launch latch at 4K: low resistance
- Resistor = catalog – 10% (141 Ohms) but at +11°C (minimum launch temperature??) => 136 Ohms
- Both coils powered
- The satellite under vacuum. (no convection)

=> This leads to a current of 204 mA in each coil.
$\Rightarrow$ For one circuit, the power is 5.7 W and for both circuits, **11.4 W**.

Note: max power density = 0.22 W/cm²

LPU thermal aspects: LPU-FCU

- The candidate glue (3M 2216 gray) has a thermal conductivity of 0.4 W/m.K (DP490's is about the same)
- If the full surface is glued (83 cm²) and a glue thickness of 0.2 mm chosen, the thermal conductance between the LPU and the FCU is 16.6 W/K.
- In fact, due to glueing constraints, it is wiser to not use the full glueing surface to avoid the making of air bubbles.
- The real glued surface will be less than 100% of the available area but will be above 50% of that area.

The thermal conductance LPU - PSU is > 8.5 W/K

With 11.4 W dissipated inside the LPU and under vacuum,

- the LPU temperature will be less than 2°C above the temperature of the FCU

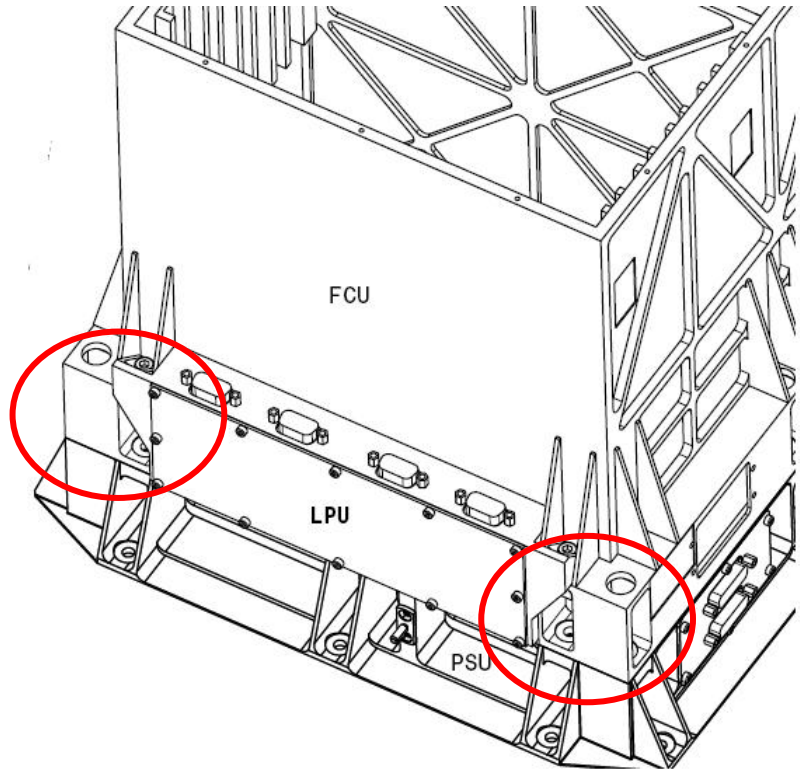
- *Thermal conductance through the 2 LPU screws is neglected.*
- *Radiative exchanges are neglected*.

LPU thermal aspects: FCU – PSU - Platform

- During thermal tests, temperature of the FCU box < PSU + 5°C with 21W consumed (about 15W dissipated in the MCU)
- The FCU is fixed to the PSU through 12 screws, of which 8 evacuates directly the MCU power.
- This means that each screw has a thermal conductance of about 0.38 W/K.
- Below the LPU, there are 4 FCU/PSU fixation points => 1.5 W/K
- The PSU is fixed to the platform by 12 screws, among which 5 are below the LPU => 1.9 W/K
- The thermal conductance between the FCU and the platform is 0.84 W/K

With 11.4W, the FCU temperature is 14°C above the platform temperature

Note: If one takes into account only the radiative exchanges between the FCU +X face (minus the LPU), this face evacuates the LPU's11.4W with a surface temperature of 51°C when the environment is at +35°C (.



With 11.4 W dissipated inside the LPU and under vacuum,

- the LPU temperature will be less than 2°C above the temperature of the FCU.
- The FCU temperature will be less than 14°C above the platform temperature

=> the LPU temperature will be less than +16°C above the platform temperature

- As the LPU maximum allowed temperature is +65°C (storage temperature), the maximum temperature for the platform would have to be at +49°C.

- The maximum platform launch temperature being +35°C (??), the LPU box will not go above **+51°C**, which is lower than the flight acceptance temperature FCU ON.

LPU: I/F

- See MICD and proposal for the pin allocation documents
- Bonding?

LAM
LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE

LPU documentation

LPU ADP documentation

1	Shipping document	Yes
2	Procedure for transport and handling	Yes
3	C of C / Delivery review boar and AI list	Yes
4	Qualification status list	Yes
5	Top level drawings	Yes
6	Interface drawings	Yes
7	Functionnal diagram (Block Diagram)	Yes
8	Electrical circuit diagram	Yes
9	As built configuration status list	Yes
10	Serialised conponent list	Yes
11	List of waivers	Yes
12	Operational manual	Yes?
13	Historical record	Yes
14	Log book	Yes
15	Operating Time / Cycle record	Yes
16	Connector mating record	Yes
17	Age sensitive Item record	N/A
18	Pressure vessel history	N/A
19	Calibration data record	N/A
20	Temporary installation record	N/A
21	Open Work / Deferred work / Open tests	Yes
22	List of Non Conformance records	Yes
23	Test Reports	Yes
24	Proof load certificates	N/A
25	Reference list of lower level ADP	N/A
26	Mass records / Power Budget	Yes
27	Cleanliness statement	Yes
28	Compliance matrix	Yes

L.P.U. development plan

LPU: models

Due to the gluing of the LPU on the FCU,

- 2 models of the mechanical parts to be built: a QM and a FM.
- 3 models of the cabling to be built: a QM and 2 FMs

QM :

- identical to the FM (mechanical+cabling) except for the connectors which will be of commercial grade *(not enough connectors available)*
- Used to verify the gluing I/F and the relays versus vibrations (Q profiles)
- Check the first eigen mode (one accelerometer on the lid, one inside the box (TBC))

FM: tested before delivery to check everything is Ok

- Vibrations: acceptance levels
- Thermal test: cycled powered in the expected temperature range and cycled unpowered to the usual WE FM specs

LPU: tests specification

Vibrations: (IID-A)

- Sine Q: X-Y:20g / Z:25g 10mm 0-p then level up to 100Hz 2oct/min
- Random Q: X-Y: 7.63 g RMS / Z:10.8 g RMS
- Acceptance levels applied on the FM
- Shocks: not needed because no impact on the SMECm + same type of relays already shocked in the MCU

Thermal (IID-A & LPU I/F spec & MCU specs) proto-flight => applied on the FM

- Atmospheric pressure test: 3 hours at +45°C, powered
- 4 cycles between -45 and +70°C, powered (TBC)

LPU Tools

To test the LPU, an EGSE will have to be built to:

- Provide the power (26V to 32V)
- Provide the relays commands
- Simulate the launch latch: 2 resistors (1 for each coil) adjustable from 1 to 14 Ohms
- Check the position of the relays

To check the glue procedure, dimensioned plates (2 sets)

To manufacture the cabling, a simplified box is to be built geometrically representative of the I/F between the components and the box.

To vibrate the models:

- One vibration I/F plate on which the QM is glued
- One vibration I/F tool to maintain the FM during the vibrations (the 2 screws + a clamp)

LPU Schedule

Mechanical manufacture (subcontracted)

- Cabling tool available end of August
- Boxes available mid September at LAM

Cabling (subcontracted): duration = 1 week => available mid September (TBC)

Gluing procedure test: 1st two weeks of September

Test tools (subcontracted): ready for mid September

EGSE (in house, TBC): ready by mid September

Then,

- One week for integration, controls, tests, etc…
- QM gluing: 7 days
- QM Vibrations: 2 days (no problem encountered)
- FM vibrations: 2 days
- FM thermal test: 1.5 week (1 day for powered test, remaining time for cycles)

FM Delivery beginning of 3rd week of October