# SPIRE

**SUBJECT:** **Systems Budgets**

**PREPARED BY:** **Colin Cunningham**

**DOCUMENT No:** **SPIRE-ATC-PRJ-000450**

**ISSUE:** **2.0** **Date:** **12-Apr-01**


**CHECKED BY:** **Bruce Swinyard** **Date:** **……**

**APPROVED BY:** **Ken King** **Date:** **……**
**Matt Griffin**
**John Delderfield**

# Distribution

| | |
|---|---|
| Matt Griffin | QMW |
| Ken King | RAL |
| Bruce Swinyard | RAL |
| Berend Winter | MSSL |
| Gerald Lilienthal | JPL |
| Dominique Pouliquen | LAM |
| Lionel Duband | CEA |
| Peter Hargrave | QMW |
| Riccardo Cerruli | IFSI |
| Jean-Louis Augueres | CEA |
| Ian Pain | ATC |
| Don Peterson | USK |

# Change Record

| ISSUE | DATE | |
|---|---|---|
| 1.0 | 11-Jun-00 | First Issue following IID meeting with ESA |
| 1.1 | 14-Jun-00 | Change to JFET box allocation |
| 2.0 | 12-Apr-01 | Revised following interface review |

# Table of Contents

# Glossary

| | |
|---|---|
| SPIRE | Spectral and Photometric Imaging REceiver |
| HOB | Herschel Optical Bench |
| SVM | Service Module |
| TBW | To be written |

# References

## Applicable Documents

AD1 IID-B
AD2 LOOM.KD.SPIRE.2000.002-DRAFT Optical error Budgets

## Reference Documents

RD1 Structure Mass Estimates Spreadsheet v1.3
RD2 Budgets and Estimates Spreadsheet v3.2

# 1. INTRODUCTION

This document shows the systems budgets for the SPIRE instrument. It includes mass on the HERSCHEL Optical Bench (HOB), mass on the Service Module (SVM), thermal loads on the HERSCHEL cryostat levels and SVM, and data rates in all operating modes. Budgets for system noise and crosstalk are in preparation. Optical error budgets are given in AD2.
Budgets are assigned to subsystems. Contingency is held by the SPIRE systems team, and will only be released following detailed justification. As the designs reach maturity, contingency is being reduced for each subsystem.

# 2. MASS BUDGETS

## 2.1 Mass on HERSCHEL Optical bench

| **Mass Budget HOB** | V3.2 | **03-Apr-01** | | Custodian: | Colin Cunningham | | |
|---|---|---|---|---|---|---|---|
| All subsystems include fasteners & their harness in mass estimates, except detector boxes | | | | | | | |
| **Items** | **Respons-ible** | **Temp. K** | **Mass Estimate** | **Allocation** | **Difference** | **Contingency %** | **Inc Contingency** |
| **Photometer** | | | | | | | |
| Mirrors | LAM | 4 | 1019 | 1020 | 1 | 10 | 1122 |
| Mirrors | LAM | 2 | 348 | 350 | 2 | 10 | 385 |
| Filters | QMW | 4 | 8 | 10 | 2 | 10 | 11 |
| Filters | QMW | 2 | 539 | 540 | 1 | 20 | 648 |
| Detectors | JPL | 2 | 1680 | 1500 | -180 | 20 | 1800 |
| Thermal Straps | MSSL | 4 | 0 | 0 | 0 | 0 | 0 |
| Thermal Straps | MSSL | 2 | 282 | 285 | 3 | 20 | 342 |
| Cooler | CEA | 4 | 1400 | 1400 | 0 | 10 | 1540 |
| Cooler Straps | MSSL | 2 | 235 | 235 | 0 | 20 | 282 |
| Baffles | MSSL | 4 | 2420 | 2420 | 0 | 20 | 2904 |
| Baffles | MSSL | 2 | 0 | 0 | 0 | 0 | 0 |
| Calibration Source | QMW | 4 | 30 | 30 | 0 | 20 | 36 |
| Detector Harness | JPL | 4 | 1275 | 1300 | 25 | 0 | 1300 |
| BSM (& support) | ATC | 4 | 1100 | 1100 | 0 | 20 | 1320 |
| Shutter | USK | 4 | 200 | 200 | 0 | 20 | 240 |
| Non- bolometer RF Filters & Box | JPL | 4 | 1720 | 1720 | 0 | 0 | 1720 |
| Cover | MSSL | 4 | 7640 | 7650 | 10 | 15 | 8797.5 |
| Detector Box | MSSL | 2 | 1840 | 1850 | 10 | 15 | 2127.5 |
| Mounts,clamps | MSSL | | 1310 | 1310 | 0 | 15 | 1506.5 |
| TOTAL | | | **23046** | **22920** | -126 | | **26082** |
| | | | | | | | |
| **Spectrometer** | | | | | | | |
| Mirrors | LAM | 4 | 1312 | 1320 | 8 | 10 | 1452 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Filters | QMW | 4 | 65 | 65 | 0 | 10 | 71.5 |
| Filters | QMW | 2 | 2 | 2 | 0 | 10 | 2.2 |
| Detectors | JPL | 2 | 897 | 1000 | 103 | 20 | 1200 |
| Baffles | MSSL | 4 | 0 | 0 | 0 | 0 | 0 |
| Harness | JPL | 4 | 200 | 200 | 0 | 0 | 200 |
| Mechanism | LAM | 4 | 1100 | 1100 | 0 | 20 | 1320 |
| SMECp | LAM | 4 | 200 | 200 | 0 | 20 | 240 |
| Cover | MSSL | 4 | 6880 | 6880 | 0 | 15 | 7912 |
| Detector box | MSSL | 2 | 1350 | 1350 | 0 | 15 | 1552.5 |
| Mounts,clamps | MSSL | | 860 | 860 | 0 | 15 | 989 |
| Calibration Source | QMW | 4 | 200 | 200 | 0 | 20 | 240 |
| TOTAL | | | **13066** | **13177** | 111 | | **15179** |
| | | | | | | | |
| **Common Structure** | | | | | | | |
| Optical Bench | MSSL | 4 | 8000 | 9000 | 1000 | 15 | 10350 |
| Mounting | MSSL | 4 | 540 | 540 | 0 | 15 | 621 |
| RF seal | MSSL | 4 | 0 | 0 | 0 | 0 | 0 |
| Cooler I/F | MSSL | 4 | 100 | 100 | 0 | 20 | 120 |
| Strap Baffles | MSSL | 4 | 500 | 500 | 0 | 20 | 600 |
| JFET I/F structure | MSSL | 4-11 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | | | **9140** | **10140** | **1000** | | **11691** |
| **TOTAL FPU** | | | **45252** | **46237** | **985** | | **52952** |
| Request to ESA (8/6/00) | | | | **45000** | | 20 | **54000** |
| Offer by ESA (8/6/00) | | | | **42000** | | 20 | **50400** |
| | | | | | **Variation from ESA budget** | | **2552** |
| **JFET Boxes** | | | | | | | |
| JFET Modules | JPL | 11 | 5490 | 5500 | 10 | 10 | 6050 |
| JFET Structures | MSSL | 11 | 1500 | 1500 | 0 | 20 | 1800 |
| JFET - FPU Interface | MSSL | 4-11 | 300 | 300 | 0 | 20 | 360 |
| **TOTAL FTB** | | | **7290** | **7300** | | | **8210** |
| Request to ESA (8/6/00) | | | | **6500** | | 20 | **7800** |
| Offer by ESA (8/6/00) | | | | **6000** | | 20 | **7200** |
| | | | | | **Variation from ESA budget** | | **1010** |

## 2.2 Mass on Service Module

| Mass Budget SVM | V3.2 | All in grammes | | | | Custodian: | Colin Cunningha |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| Items | Work-package | Respons-ible | Mass Estimate | Allocation | Difference | Contingency % | Inc Contingency |
| Digital Processing Unit | DPU | IFSI | 6621 | 7000 | 379 | 20 | 84 |
| Detector Read-out & Control Unit | DRCU | CEA | 23000 | 23000 | 0 | 20 | 276 |
| Warm Interconnect Harness | WIH | CEA | 2000 | 2000 | 0 | 20 | 24 |
| TOTAL | | | **31621** | **32000** | | | **384** |
| Request to ESA (8/6/00) | | | | **30000** | | | |
| Offer by ESA (8/6/00) | | | | **30000** | | | |
| | | | | | **Variation from ESA budget** | | **84** |

# 3. THERMAL BUDGETS

## 3.1 Thermal loads on HOB

**Thermal Loads on HOB** V3.2

21-03-01

Loads in mW

| Stage | Item | Mode | Estimate | Allocation | Contingency | Inc Contingency |
|---|---|---|---|---|---|---|
| | | | Update | | % | |
| Level 2 | JFET Box | Standby | 49.5 | **33** | 50 | 49.5 |
| | | OFF | 0 | **0** | 0 | 0 |
| | | PHOT | 49.5 | **33** | 50 | 49.5 |
| | | SPEC | 14.1 | **9.4** | 50 | 14.1 |
| | | RECYCLE | 49.5 | **33** | 50 | 49.5 |
| Level 1 | Wires | Standby | 1.339 | 1.1 | 20 | 1.32 |
| | | OFF | 0.649 | 1.1 | 20 | 1.32 |
| | | PHOT | 1.31 | 1.1 | 20 | 1.32 |
| | | SPEC | 0.767 | 1.1 | 20 | 1.32 |
| | | RECYCLE | - | | | |
| | Radiation | Standby | 0.088 | 0.1 | 0 | 0.1 |
| | | OFF | 0.027 | 0.1 | 0 | 0.1 |
| | | PHOT | 0.088 | 0.1 | 0 | 0.1 |
| | | SPEC | 0.04 | 0.1 | 0 | 0.1 |
| | | RECYCLE | - | | | |
| | Mechanisms & calibrators | Standby | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | OFF | 0 | 0 | 0 | 0 |
| | | PHOT | 4.1 | 4.1 | 0 | 4.1 |
| | | SPEC | 8.4 | 8.4 | 0 | 8.4 |
| | | RECYCLE | - | | | |
| | Structure | Standby | 10.934 | 6 | 100 | 12 |
| | | OFF | 5.289 | 6 | 100 | 12 |
| | | PHOT | 10.689 | 6 | 100 | 12 |
| | | SPEC | 6.345 | 6 | 100 | 12 |
| | | RECYCLE | - | | | |
| | Total | Standby | 12.361 | **7.2** | - | **13.42** |
| | | OFF | 5.965 | **7.2** | - | **13.42** |
| | | PHOT | 16.187 | **11.3** | - | **17.52** |
| | | SPEC | 15.552 | **15.6** | - | **21.82** |
| | | RECYCLE | - | | | |
| | **HERSCHEL L1 Cryostat Strap Load** | **Standby** | **9.063** | | | |
| | | **OFF** | **4.116** | | | |
| | | **PHOT** | **12.229** | | | |
| | | **SPEC** | **11.951** | | | |
| | | **RECYCLE** | **7.222** | | | |
| Level 0 | Wires | Standby | 0.452 | 0.1 | 100 | 0.2 |
| | | OFF | 0.253 | 0.1 | 100 | 0.2 |
| | | PHOT | 0.538 | 0.1 | 100 | 0.2 |
| | | SPEC | 0.486 | 0.1 | 100 | 0.2 |
| | | RECYCLE | - | | | |
| | Dissipation - cooler | Standby | 0 | 5 | 0 | 5 |
| | | OFF | 0 | 5 | 0 | 5 |
| | | PHOT | 0.2 | 5 | 0 | 5 |
| | | SPEC | 0.2 | 5 | 0 | 5 |
| | | RECYCLE | 2.54 | 5 | 0 | 5 |
| | Cooler Parasitics | Standby | 0.031 | 0 | 0 | 0 |
| | | OFF | 0.016 | 0 | 0 | 0 |
| | | PHOT | 0.038 | 0 | 0 | 0 |
| | | SPEC | 0.034 | 0 | 0 | 0 |
| | | RECYCLE | - | 0 | 0 | 0 |
| | Cooler Switch supports | Standby | 0.61 | 1 | 20 | 1.2 |
| | | OFF | 0.37 | 1 | 20 | 1.2 |
| | | PHOT | 0.714 | 1 | 20 | 1.2 |
| | | SPEC | 0.661 | 1 | 20 | 1.2 |
| | | RECYCLE | - | | | |
| | Strap Feed Throughs | Standby | 1.237 | 1.5 | 0 | 1.5 |
| | | OFF | 0.678 | 1.5 | 0 | 1.5 |
| | | PHOT | 1.496 | 1.5 | 0 | 1.5 |
| | | SPEC | 1.356 | 1.5 | 0 | 1.5 |
| | | RECYCLE | - | | | |
| | Structure | Standby | 0.968 | 1.1 | 20 | 1.32 |
| | | OFF | 0.532 | 1.1 | 20 | 1.32 |
| | | PHOT | 1.172 | 1.1 | 20 | 1.32 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | SPEC | 1.064 | 1.1 | 20 | 1.32 |
| | | RECYCLE | - | | | |
| | Total | Standby | 3.298 | **8.7** | - | **9.22** |
| | | OFF | 1.849 | **8.7** | - | **9.22** |
| | | PHOT | 4.158 | **8.7** | - | **9.22** |
| | | SPEC | 3.801 | **8.7** | - | **9.22** |
| | | RECYCLE | - | | | |
| | **HERSCHEL L0 Cryostat Strap Load** | **Standby** | **3.298** | | | |
| | | **OFF** | **1.849** | | | |
| | | **PHOT** | **4.14** | | | |
| | | **SPEC** | **3.78** | | | |
| | | **RECYCLE** | **15.167** | | | |
| 300 mK | Detector Modules-kevlar | PHOT | 4.46 | 8 | uW | |
| | | SPEC | 4.36 | 8 | uW | |
| | Detector Modules-harness | PHOT | 3.20 | | uW | |
| | | SPEC | 3.11 | | uW | |
| | Cooler Parasitics | PHOT | 11.64 | 12 | uW | |
| | | SPEC | 11.14 | 12 | uW | |
| | Busbar Supports | PHOT | 1.51 | 2 | uW | |
| | | SPEC | 1.48 | 2 | uW | |
| | Temperature Control Headroom | PHOT | 0.00 | 0 | uW | |
| | | SPEC | 0.00 | 0 | uW | |
| | TOTAL | PHOT | 20.81 | 22 | uW | |
| | | SPEC | 20.09 | 22 | uW | |

Note that there is no contingency on the 300mK loads. Any excess load translates to shorter cooler hold time.

## 3.2 Dissipation on SVM

| Unit | Item | Mode | Estimate | Allocation | Contingency | Inc Contingency |
|---|---|---|---|---|---|---|
| HSDRC | Detector Read-out and Control Unit | All | 67 | **71** | 20 | 85.2 |
| HSDPU | Digital Processing Unit | All | 24 | **15** | 20 | 18 |
| HSWIR | Warm Interconnect Harness | All | | **0** | 0 | 0 |
| TOTAL | | | | **86** | | **103.2** |

Note that the DPU estimates are over budget, and we do not have an agreed level of contingency from ESA

## 4. DATA TRANSMISSION

**Data Transmission** V3.2
All in kbps

| Function | Mode | Estimate | Allocation |
|---|---|---|---|
| DCU Science | Phot | 80 | |
| MCU Science | Phot | 11 | |
| SCU Science | Phot | 1.5 | |
| DPU Science | Phot | 1.1 | |
| Housekeeping | Phot | 2 | |
| Total | | 95.6 | 100 |
| DCU Science | Spec | 79 | |
| MCU Science | Spec | 15.8 | |
| SCU Science | Spec | 1.5 | |
| DPU Science | Spec | 1.1 | |
| Housekeeping | Spec | 2 | |
| Total | | 99.4 | 100 |

## 5. OPTICAL ERROR BUDGET

See AD 2. Budget is held and controlled by LAM.

## 6. SYSTEM NOISE BUDGET

TBW

## 7. CROSS-TALK BUDGET

TBW