SPIRE

SPIRE PROJECT DOCUMENT

SPIRE SHUTTER DEVELOPMENT PLAN

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GLOSSARY

CDR	Critical Design Review
CQM	Cryogenic Qualification Model
CSA	Canadian Space Agency
DDR	Detailed Design Review
DM	Development Model
DRCU	Detector Read-out and Control Unit
ESA	European Space Agency
FS	Flight Spare
IID	Instrument Interface Document
OBS	Onboard Software
PDR	Preliminary Design Review
PFM	Proto-Flight Model
RAL	Rutherford Appleton Laboratory
TBC	To Be Confirmed
TBD	To Be Determined
USK	University of Saskatchewan

1 SCOPE OF THE DOCUMENT

This document describes the development plan of the FIRST/SPIRE shutter subsystem.

This development plan is *provisional* until it is formally agreed with the Canadian Space Agency (CSA).

2 DOCUMENTS

2.1 Reference documents

Table 1: Reference Documents.

	Title	Author	Reference	Date
RD1	Instrument Requirements Document	B.M. Swinyard	SPIRE-RAL-PRJ-000034 Iss.21	30.11.99

3 SUBSYSTEM DEFINITION

3.1 Description

In the FIRST flight configuration, the background flux on the SPIRE detectors will be limited by emission from the FIRST telescope (temperature 80 K, emissivity ~4%). The detectors will be optimised for operation in this low-background environment. This environment will be simulated in the SPIRE test facility by the use of neutral-density filters in the test cryostat. During the period between spacecraft integration and launch, however, this low background will not be available because the lid of the spacecraft cryostat will not be cooled. This makes it impossible to operate the detectors (and therefore also to carry out a wide range of other essential instrument tests) from the point of delivery to ESA until after launch, a period of nearly three years (July 2004 to April 2007).

To accommodate this situation, a cryogenic shutter will be placed into the fore-optics of the instrument. Its function will be to move a vane into the beam on command in order to block the flux from outside the instrument and provide a low background flux to the detectors. The actuator and the vane position sensor will operate at 4 K, and a temperature monitor will be incorporated into the actuator. The vane will be coated with a high-emissivity material and fitted with a heater and a temperature monitor so that the emitted flux can be controlled for calibration purposes (fig. 1).

Although the shutter is not flight-critical, a source of a repeatable and controllable flux would be extremely useful for in-orbit instrument calibration. The option of making the shutter flight-

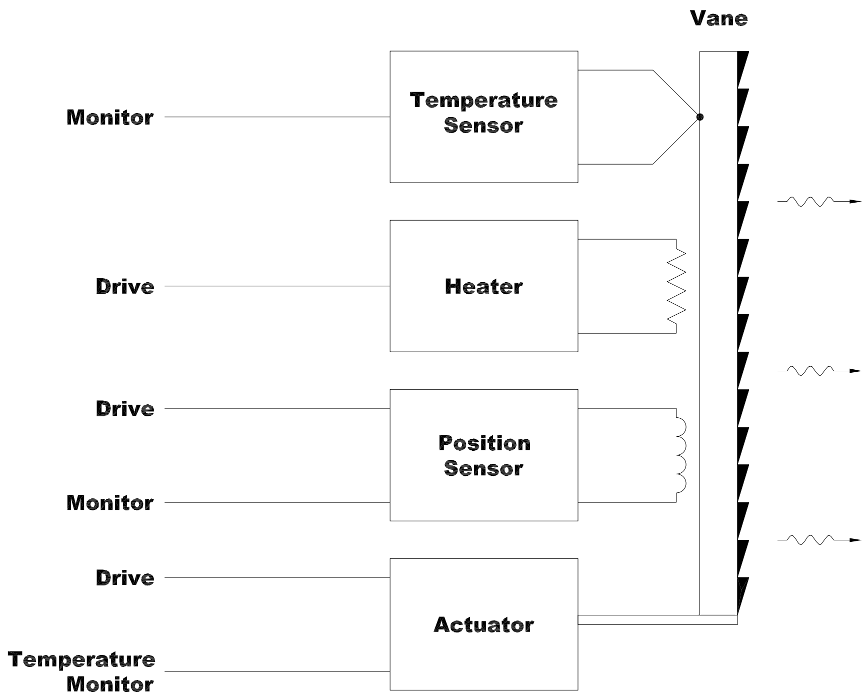

Figure 1: Block diagram of the SPIRE shutter subsystem.

capable is therefore under study. This will have important implications for reliability engineering of the design. A decision on this option will be taken following an assessment of various tradeoffs during the preliminary design phase.

3.2 Requirements

The shutter performance requirements are specified in RD1. They are repeated here for information only:

- Energy rejection: when the shutter vane is in place, the input flux shall be rejected to within TBD%.
- Vane Temperature: the temperature of the shutter vane shall be controllable within the range 5–20 K.

The shutter system requirements are also specified in RD1, and are repeated here for information only:

- Failure mode: the shutter must be engineered such that any failure of the mechanism results in the vane relaxing out of the beam.
- Operating Temperature: the actuator should function at both room temperature and instrument temperature.
- Power dissipation: the thermal dissipation of the actuator shall be less than 1 mW.
- Electrical resistance of heater: of order 10 kΩ.
- Thermal dissipation of heater: $<$5 mW.
- Nominal envelope for actuator: 45x45x45 mm.
- Nominal mass: $<$200 g.

These requirements will be developed and documented during the preliminary design phase.

3.3 Interfaces

The shutter subsystem has interfaces with nine other SPIRE subsystems. Details of these interfaces are listed in Table 2. The interfaces will be negotiated and documented during the preliminary design phase.

3.4 Deliverables

Three models of the complete subsystem shall be delivered to the SPIRE project. They are listed in Table 3. All three models will be fully flight-representative (TBC). Ground support equipment and supporting documentation will also be delivered with each model as required.

Table 2: Interface descriptions.

Interface	Description
DRCU	The analogue electronics to control and monitor the subsystem will be contained within the DRCU. The electronics design will be based on specifications to be provided by USK.
OBS	The software to control and monitor the subsystem will be contained within the OBS. The software design will be based on specifications to be provided by USK.
Analogue Simulator	The Analogue Simulator will contain a hardware/software simulation of the shutter subsystem. The simulation will be based on specifications to be provided by USK.
Instrument Simulator	The Instrument Simulator will contain a hardware/software simulation of the shutter subsystem. The simulation will be based on specifications to be provided by USK.
IID	The IID will contain wiring specifications pertaining to the shutter.
Structure	The shutter subsystem will physically attach to the instrument structure. This interface will specify the attachment details, volume, mass, etc. It will also specify the wiring harness from the subsystem to the connector plate.
Thermal	The thermal characteristics of the shutter subsystem will be provided through this interface.
Optics	The shutter interfaces with the optical system since its purpose is to reject the incoming beam and illuminate the detectors with a known and controlled flux. The location of the shutter vane will be specified through this interface.
Baffles	The shutter interfaces with the baffle system to ensure that stray light is adequately rejected whether the shutter vane is in or out of the beam.

Table 3: Model deadlines.

Model	Date
Cryogenic Qualification Model (CQM)	March 2002
Proto-Flight Model (PFM)	November 2003
Flight Spare (FS)	November 2004

4 WORK DESCRIPTION

4.1 Organisation

All aspects of the shutter subsystem design, development, manufacture and test will be undertaken in Canada. The work will be a partnership between the University of Saskatchewan (USK; the SPIRE Co-I institute), the Canadian Space Agency (CSA) and an industrial partner to be selected through a competitive process. The CSA will provide financial support and will issue and manage contracts to both USK and the industrial partner.

Until the industrial partner is selected, the allocation of work between the sites cannot be finalised. Subject to this caveat, it is anticipated that USK will:

- formulate and document the technical requirements for the shutter subsystem;
- negotiate and document the shutter interfaces;
- assist and advise the industrial partner on the shutter design;
- formulate and document the verification requirements;
- participate fully in the subsystem verification programme.

4.2 Preliminary design phase

The industrial partner will undertake a preliminary design of the shutter subsystem. All of the relevant tradeoffs which affect the feasibility, performance, reliability, risk and cost of the subsystem will be evaluated. At the conclusion of this phase, a shutter-specific PDR will be convened to assess the results and to make design selections. The critical issue of whether to make the shutter flight-capable will be resolved during this review.

In parallel with this activity, USK will develop and refine the technical requirements, interfaces and verification requirements. Close coordination with the industrial partner will be required so that the preliminary design is fully informed. These items will be finalised in advance of the shutter-specific PDR.

4.3 Detailed design phase

Following on from the design decisions taken at the shutter PDR, the industrial partner will undertake a detailed design of the subsystem. A detailed design of the associated control system will also be produced during this period, either by the industrial partner or by USK (TBD). This phase will conclude with the SPIRE Detailed Design Review.

4.4 CQM manufacture and test

Two models of the shutter subsystem will be manufactured in parallel: the development model (DM) and the CQM. The DM will not be deliverable and will be used to verify the design through a comprehensive series of qualification and life tests. The CQM will be assembled after the DM tests and will undergo verification at subsystem level in agreement with the requirements. The CQM will be delivered to RAL and integrated into the SPIRE CQM for further verification. This phase will conclude with the SPIRE CDR.

4.5 PFM and FS manufacture and test

Any design changes mandated by the CDR will be critically evaluated before final approval. Following manufacture by the industrial partner, the PFM shutter subsystem will be verified by a series of acceptance and characterisation tests before delivery to RAL.

Manufacture and test of the FS will follow, although the piece parts may be fabricated in parallel with the PFM. It is TBD whether the FS will be the refurbished CQM or manufactured from scratch.

4.6 Development schedule

The milestones are listed in Table 4. The shutter subsystem development plan up to the SPIRE CDR is presented in Fig. 2.

Table 4: Development schedule.

Date	Action
Jun 2000	SPIRE Delta-PDR
Jul 2000	Issuance of Co-I contract to USK and commencement of work
Jul 2000	Issuance of preliminary design contract to industrial partner
Jul 2000 - Sep 2000	Preliminary design phase
Sep 2000	Shutter PDR
Oct 2000	SPIRE Interface Review
Oct 2000 - Feb 2001	Detailed design phase
Feb 2001	SPIRE DDR
Mar 2001 - Feb 2002	CQM manufacture and test phase
Mar 2002	Delivery of shutter CQM to RAL
Nov 2002	SPIRE CDR
Dec 2002 - Oct 2003	PFM manufacture and test phase
Nov 2003	Delivery of shutter PFM to RAL
Dec 2003 - Oct 2004	FS manufacture and test phase
Nov 2004	Delivery of shutter FS to RAL

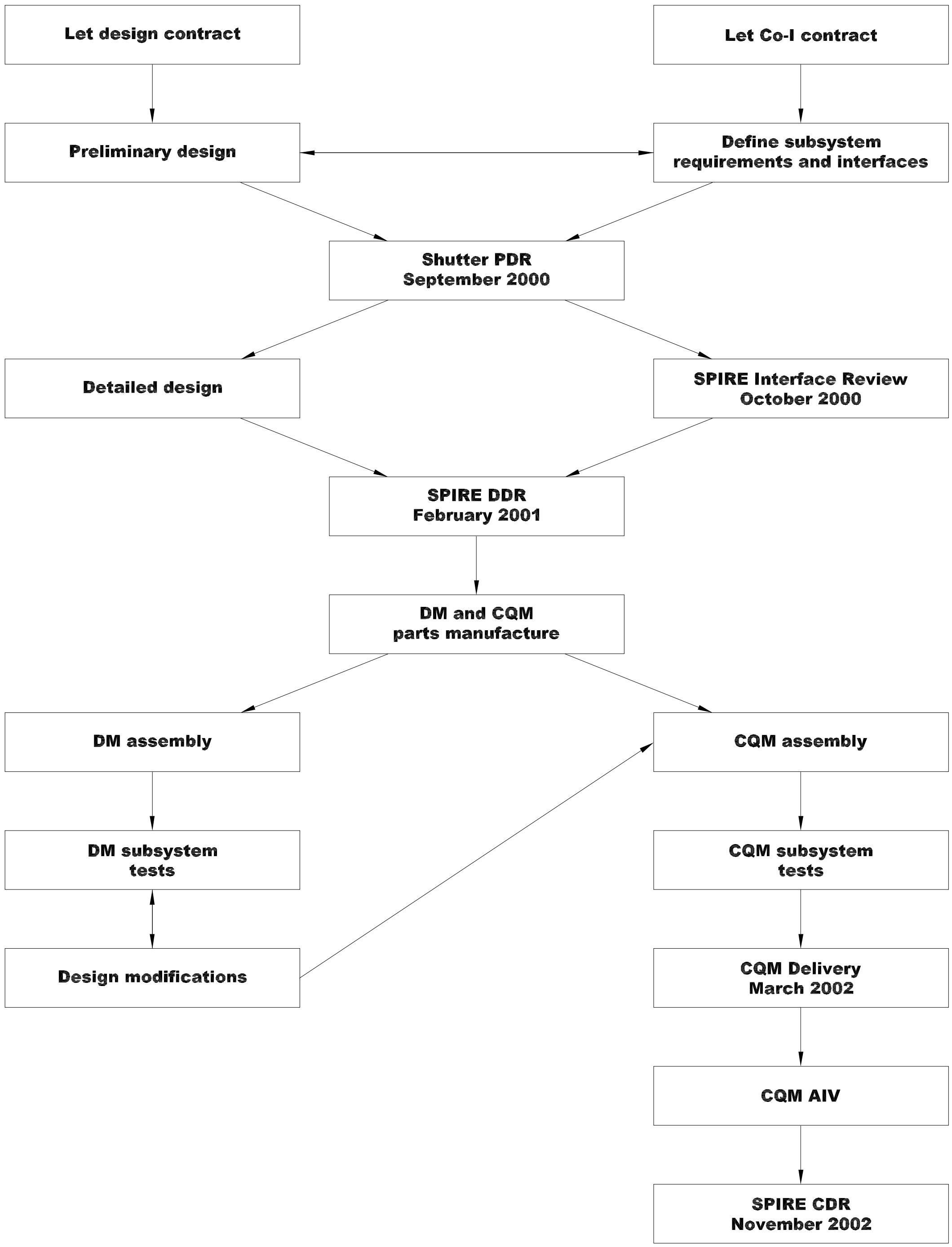

Figure 2: Shutter subsystem development plan.