TASA 國家太空中心 Taiwan Space Agency

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FORMOSAT-8F
Spacecraft Bus to Science Payload Interface Requirement Document

Taiwan Space Agency

國 家 太 空 中 心

Revision/Change Record
改版/變更記錄

Revision 版次	Author 作者	Authorization Date 核可日期	Revision / Change Description 改版/變更說明	Pages Affected 影響頁次
01	薛創維		New Issue	All

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1. Introduction

This document describes the requirements for the interface between the FORMOSAT-8F spacecraft bus and science payload.

1.1. Purpose

This document defines the interface requirement between FORMOSAT-8F spacecraft bus and science payload.

1.2. Scope

This document applies to the interface requirement between FORMOSAT-8F spacecraft bus and science payload only.

This document contains the interface requirements for procurement of science payload for the FORMOSAT-8 mission, specifically confined to FS-8F.

2. Related Documents

2.1. Applicable Documents

FS8-REQ-0001	FORMOSAT-8 System Requirement Document
FS8-SPEC-0017	FORMOSAT-8 Component Environmental Specification

2.2. Referenced Documents

NA

3. Requirements

This interface requirements between FORMOSAT-8F spacecraft bus and the science payload are defined in each section.

3.1. System

3.1.1. Configuration

Figure 1 defines the configuration of science payload.

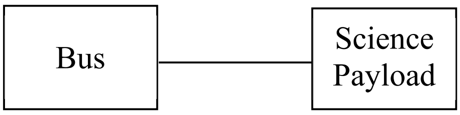

Figure 1 Science payload configuration

All communication and power lines to science payload shall go through OBC. OBC will provide electrical power to science payload for normal operation. OBC will also provide necessary command and telemetry interface to science payload. OBC to science payload harness will be provided by TASA. Any science payload internal harness shall be provided by contractor.

3.1.2. Operation Modes

Operation modes shall be POWER ON and POWER OFF. The science payload shall operate autonomously in normal operation.

3.1.3. Operation Requirements

The operation of science payload shall not interfere with RSI imaging and regular satellite normal operation.

3.1.4. Mission Life

The mission life of science payload for FS-8F shall be at least 5 years in orbit subsequent to one year of ground testing and four years of storage. (TBC)

3.1.5. Orbit

The FS-8F mission orbit is at 510 km altitude with inclination 97.44 degree as a sun-synchronous orbit. The equatorial descending time is between 10:00 to 11:00 am local time for FS-8F. The mission orbit might be changed by TASA due to program need.

3.2. Physical

3.2.1. Location Dimensions

There are two location and dimension options for science payload. The science payload shall select only one option for the design.

Option 1: The science payload shall be installed on +Z panel as shown in Figure 2 and 3.

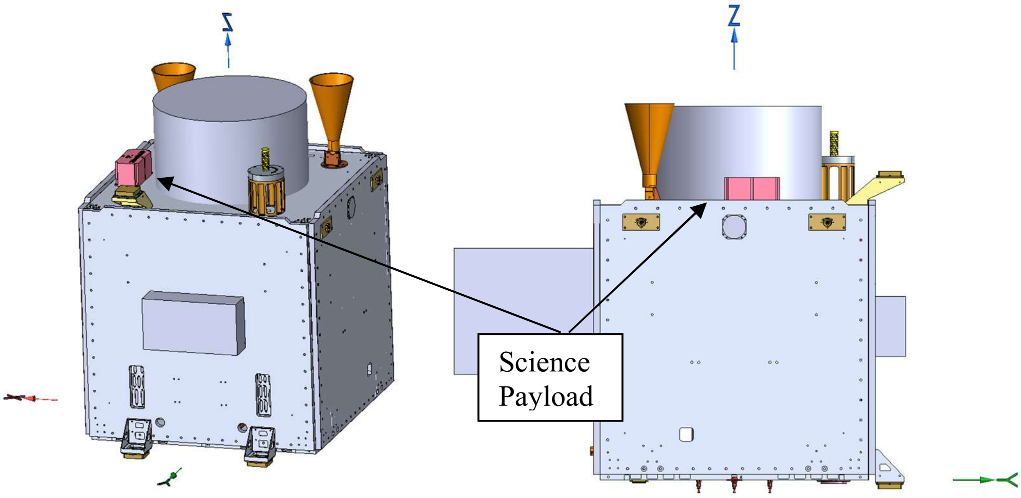

Figure 2 Science payload on +Z panel

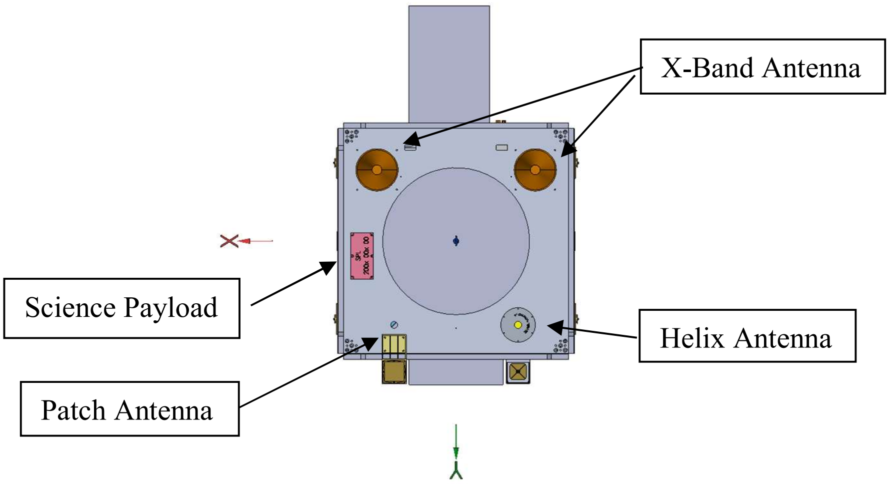

Figure 3 Science payload on +Z panel

The dimension of science payload shall not exceed 200(L)x100(W)x100(H) mm. The footprint of science payload shall follow Figure 4.

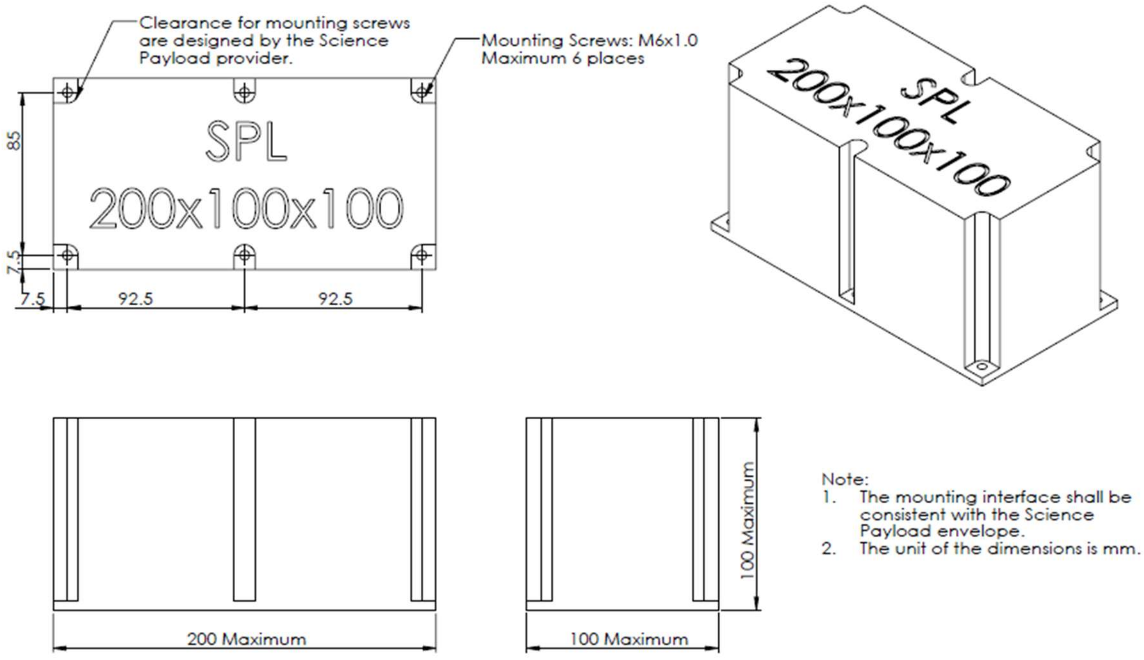

Figure 4 Footprint of science payload on +Z panel (mm)

Option 2: The science payload shall be installed on +Y (Plus Y direction) panel as shown in Figure 5.

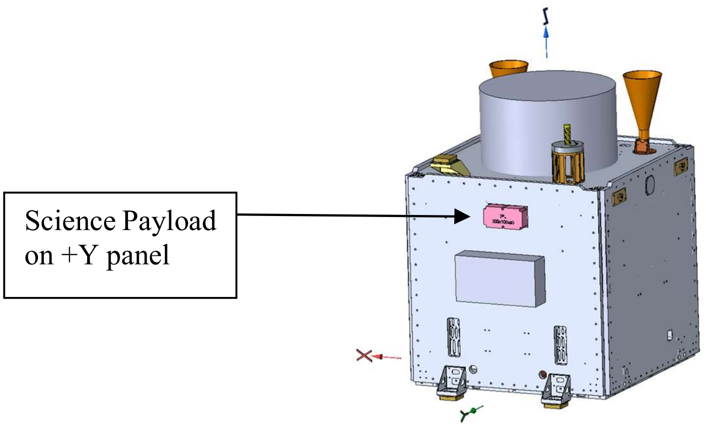

Figure 5 Science payload on +Y panel

The dimension of science payload shall not exceed 200(L)x100(W)x60(H) mm for each location. The footprint of science payload on each location shall follow Figure 6.

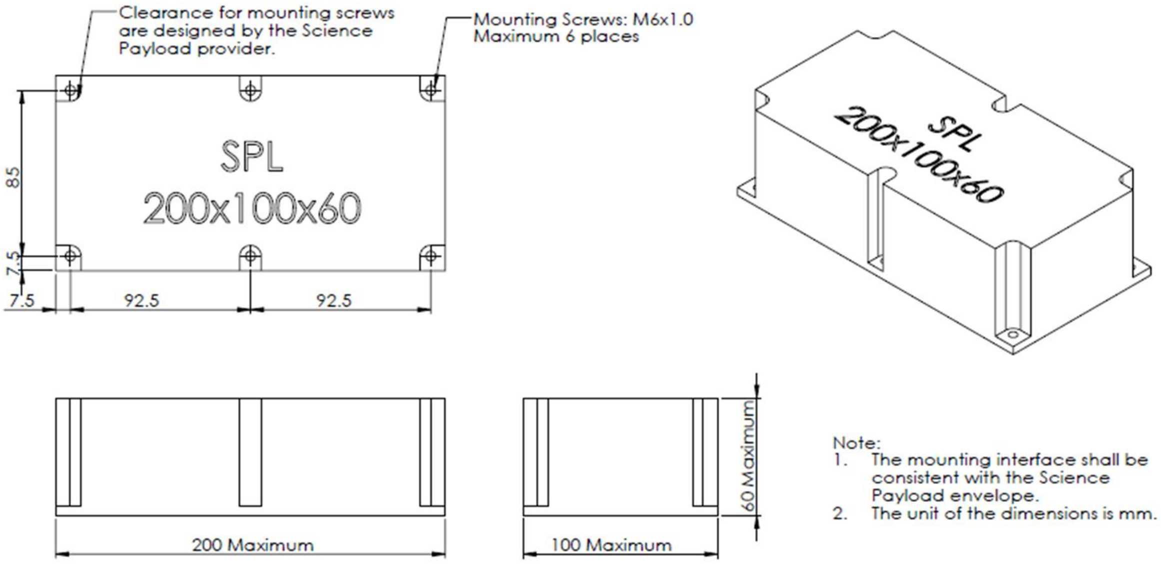

Figure 6 Footprint of science payload on +Y panel (mm)

3.2.2. Mass

Science payload including any hardware needed shall be less than 2kg (TBC).

3.2.3. Center of Gravity

The center of gravity of science payload shall be within 5% of the geometric center of the envelope.

3.2.4. Field of View

TASA will provide the field of view information based on the science payload location after the contract is awarded.

3.2.5. Deployment

No deployment mechanism in any form shall be allowed in science payload.

3.2.6. Alignment

If alignment is necessary, alignment cube shall be included on science payload design.

3.2.7. Mounting

Science payload shall have a flat mounting surface that conducts electrically and thermally to the spacecraft bus.

3.2.8. Grounding

Science payload shall be grounded in accordance with the spacecraft bus grounding scheme.

3.3. Attitude Control

3.3.1. Pointing Accuracy

The spacecraft bus will maintain the pointing accuracy less than 0.026 degree in pitch, roll and yaw axes. All values are 3 sigma.

3.3.2. Pointing Knowledge

The spacecraft bus will maintain the pointing knowledge less than 0.012 degree in pitch, roll and yaw axes. All values are 3 sigma.

3.3.3. Positioning Knowledge

The spacecraft bus will provide on-board position knowledge better than 25m(3-sigma) for each axis.

3.3.4. Operation of Science Payload

The nominal attitude of satellite is local-vertical-local-horizontal(LVLH) except during RSI imaging, ground communication and sun-pointing. The operation of science payload shall not interfere with RSI imaging and regular satellite normal operation. The science payload shall coordinate with TASA for science payload mission operation planning.

3.3.5. Pointing Stability

The spacecraft bus will provide pointing stability better than 0.147 arc second per 2.296 ms per axis.

3.4. Power

3.4.1. Orbit Average Power

The science payload shall consume less than 2W orbit average power.(TBC)

3.4.2. Input Voltage

The spacecraft bus will provide DC input voltage for +15V, -15V and +5V.

3.4.3. Peak Current Draw

The science payload current draw shall not exceed 0.2A for +15V, 0.2A for -15V and 1.5A for +5V. Spacecraft will cut off power supply to science payload if over-current protection is triggered.

3.4.4. Electrical Power Interface

Two electrical power lines will be provided to science payload for redundancy. Science payload shall provide two interface circuits and connectors as shown in Figure 7 for power interface.

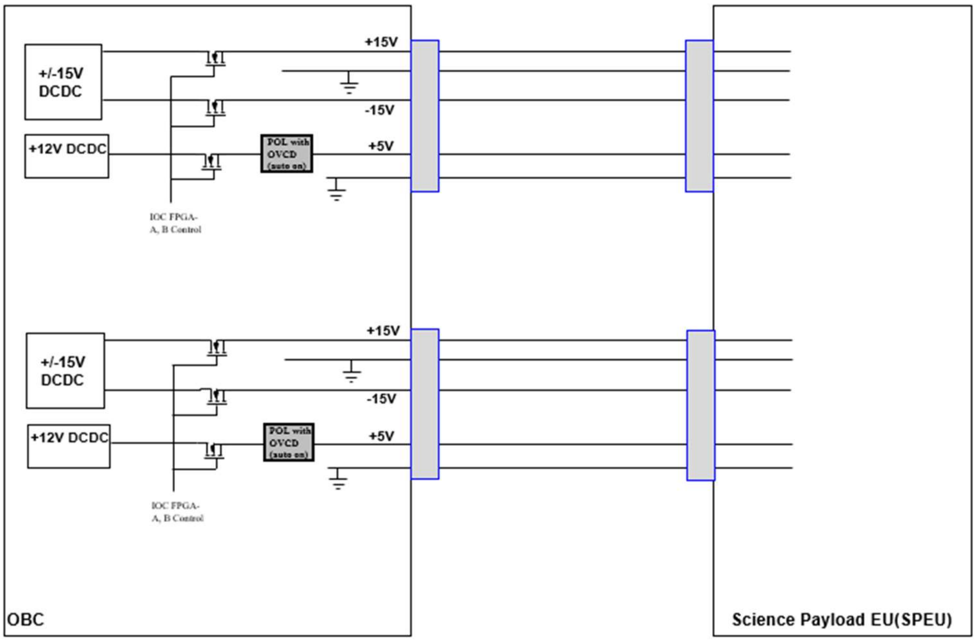

Figure 7 Electrical Power Interface

3.4.5. Connector

Science payload shall design pin assignment of the connectors according to the definition listed in this section.

J01	(15P High Density D-type)
1	+15V POWER
2	+15V POWER
3	-15V POWER
4	-15V POWER
5	TBC
6	+15V POWER RETURN
7	+15V POWER RETURN
8	-15V POWER RETURN
9	-15V POWER RETURN
10	TBC
11	+5V POWER
12	+5V POWER RETURN
13	+5V POWER
14	+5V POWER RETURN
15	CHASSIS GND

J02	(15S High Density D-type)
1	UART RX RS422+
2	UART TX-A RS422+
3	UART TX-B RS422+
4	PPS-A RS422+
5	PPS-B RS422+
6	UART RX RS422-
7	UART TX-A RS422-
8	UART TX-B RS422-
9	PPS-A RS422-
10	PPS-B RS422-
11	CHASSIS GND
12	TBC
13	TBC
14	TBC
15	CHASSIS GND

J03	(9S Micro D-type)
1	SPL_A_SPW_DIN+
2	SPL_A_SPW_SIN+
3	Inner shield
4	SPL_A_SPW_SOUT-
5	SPL_A_SPW_DOUT-
6	SPL_A_SPW_DIN-
7	SPL_A_SPW_SIN-
8	SPL_A_SPW_SOUT+
9	SPL_B_SPW_DOUT+

J04	(9S Micro D-type)
1	SPL_B_SPW_DIN+
2	SPL_B_SPW_SIN+
3	Inner shield
4	SPL_B_SPW_SOUT-
5	SPL_B_SPW_DOUT-
6	SPL_B_SPW_DIN-
7	SPL_B_SPW_SIN-
8	SPL_B_SPW_SOUT+
9	SPL_B_SPW_DOUT+

3.5. Command and Telemetry

3.5.1. Command and Telemetry Interface

The spacecraft bus will provide two RS422/PPS interfaces to science payload for science payload command and telemetry. The interface shall be RS422, UART at 115.2 kbps. Science payload shall provide two interface circuits and connectors as shown in Figure 8 and 9 for command, telemetry and PPS interface.

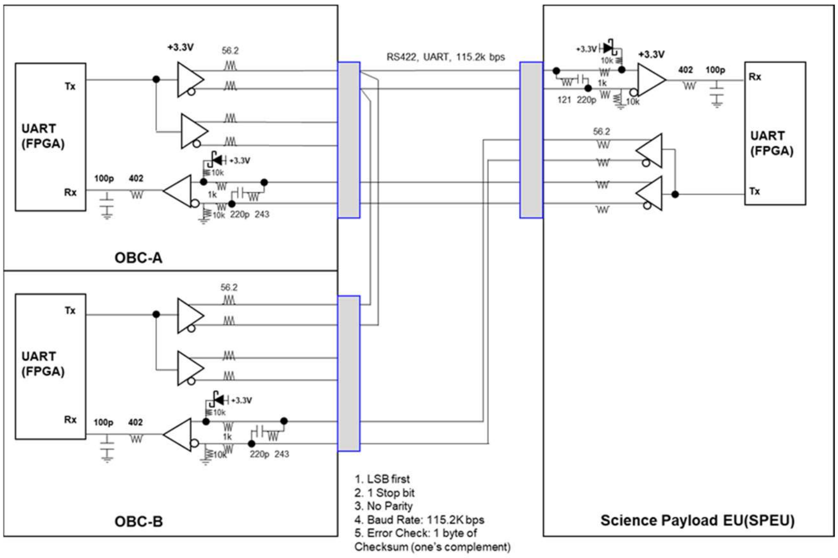

Figure 8 Command and Telemetry Interface

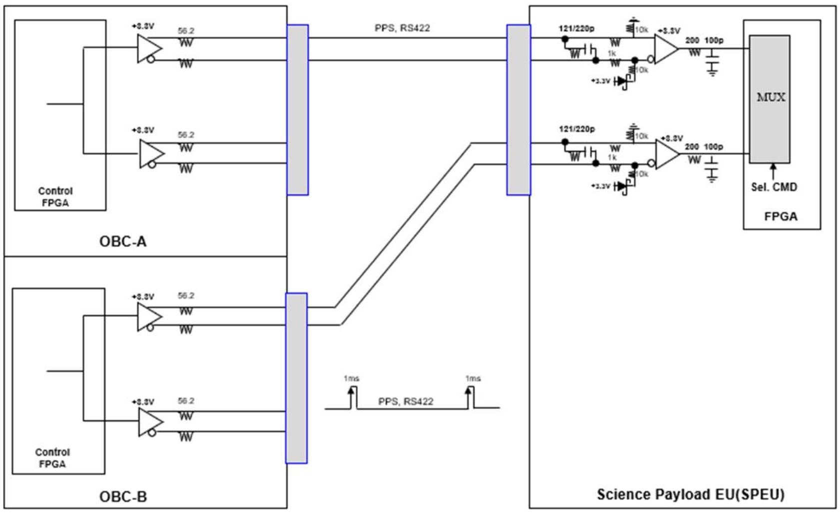

Figure 9 PPS Signal Interface

3.5.2. Connector

N/A.

3.6. Science Data

3.6.1. Science Data Interface

The spacecraft will provide two SpaceWire interfaces to science payload for science data transmission. The science data transmission rate shall not exceed 1Mbps. Science payload shall provide two sets of interface circuits and connectors as shown in Figure 10 for science data.

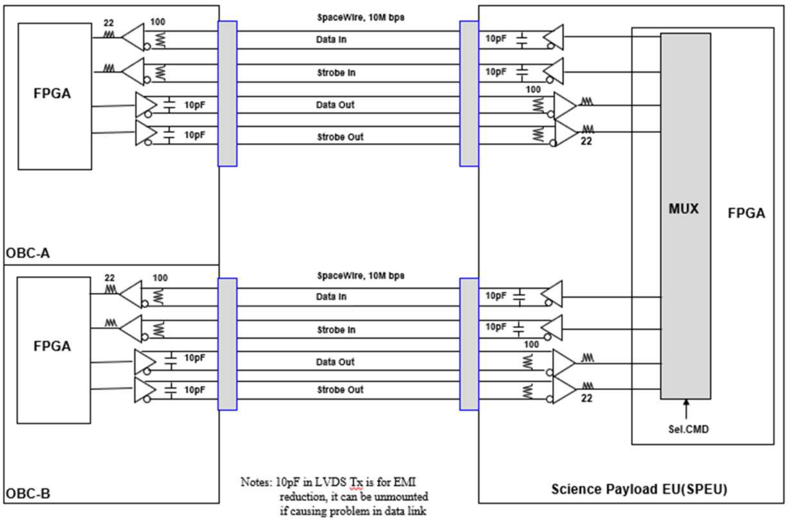

Figure 10 Science Data Interface

3.6.2. Connector

N/A.

3.6.3. Data Storage

The spacecraft bus will provide data storage capacity for science data plus EDAC data from science payload up to 2 Gbits (TBC) per day.

3.7. Thermal

3.7.1. Thermal Control

The science payload shall provide thermal control by itself if necessary. Any necessary heater or thermal monitor devices for science payload operation and non-operation stage shall be provided by science payload.

3.7.2. Thermal Power Dissipation

The science payload can be thermally conductively to spacecraft bus structure to dissipate thermal power if necessary.

3.8. Magnetic Cleanliness

Wherever possible, non-magnetic material shall be used and the utilization of permanent magnets shall be avoided.

3.9. SOCC/SDC Interface Requirement

The SOCC supports the TASA FORMOSAT-series satellite missions. The SDC interacts with SOCC and the SDC science team to plan and perform the science operations. The SDC is responsible for the science payload operation support, science data management, processing, analyzing and archiving. The SDC is also responsible for distributing the data and algorithms. Furthermore, the SDC will actively communicate with research and education communities to promote maximum usage of the science data. Figure 11 shows the data interface between SDC and SOCC.

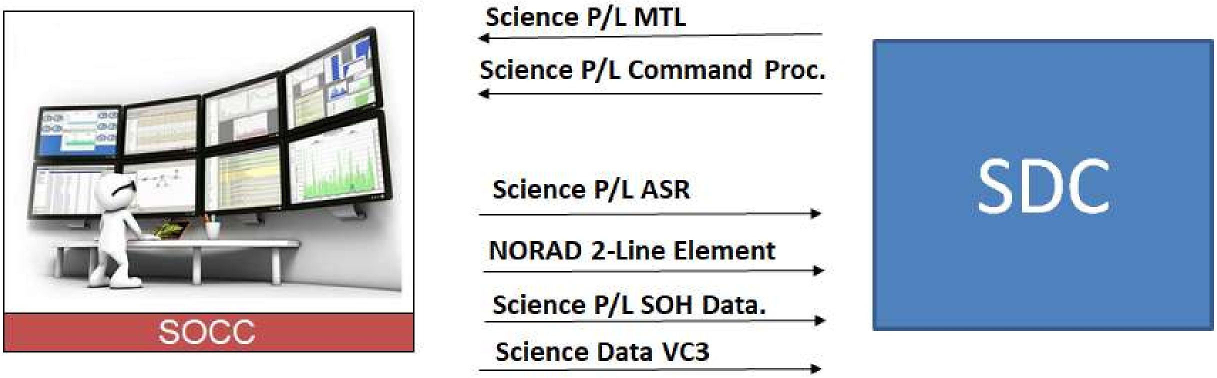

Figure 11 Data interface between SOCC and SDC

3.9.1. Science P/L MTL

	Science Payload Mission Timeline
Purpose/Description	The Mission Timeline contains sequence of on-board events regarding desired activities, including command procedure.
Originator	SDC
Destination	SOCC
Frequency/Volume	One to five times per week (TBR) / Variable data volume
File name/E-mail Subject Convention	SDC_yyyymmdd_timeline.txt (yyyy: 4 digits of year, mm: months, dd: days) Date of file name represents the date to perform measurement. For example: SDC_20191214_timeline
Data Link Interface	Internet
Transport Interface	TCP/IP SFTP
Comments	

All fields are left adjusted.

Line Number	Type/Size	Field Name	Contents/Format and Unit/Range of Values
1	string/8 bytes	LABEL_1	"SOURCE: "
1	string/variable	SOURCE	Author of File / "SDC"
2	string/13 bytes	LABEL_2	"DESTINATION: "
2	string/variable	DESTINATION	Destination of File / "SOCC"
3	string/11 bytes	LABEL_3	"FILE NAME: "
3	string/variable	FILE_NAME	file name / "SDC_20191214_timeline"
4	string/11 bytes	LABEL_4	"DATE TIME: "
4	string/19 bytes	DATE_TIME	Time to generate this file in the format of "yyyy/mm/dd hh:mm:ss"
5	string/12 bytes	LABEL_5	"SPACECRAFT: "
5	string/variable	SPACECRAFT	Satellite ID / "FS8"
6	string/12 bytes	LABEL_6	"INSTRUMENT: "
6	string/variable	INSTRUMENT	Instrument ID / "SDC"
7	string/16 bytes	LABEL_7	"REQUEST_WINDOW: "
7	string/variable	REQUEST_WINDOW	"yyyy/ddd 00:00:00– yyyy/ddd 00:00:00"
8	string/5 bytes	LABEL_8	"EVENT"/leading label of EVENT column
8	string/3 bytes	LABEL_9	"UTC" / leading label of UTC column
8	string/2 bytes	LABEL_10	"DUR" / leading label of DUR column
8	string/2 bytes	LABEL_11	"Q1"/leading label of Quaternion_1 column
8	string/2 bytes	LABEL_12	"Q2"/leading label of Quaternion_2 column
8	string/2 bytes	LABEL_13	"Q3"/leading label of Quaternion_3 column
8	string/2 bytes	LABEL_14	"Q4"/leading label of Quaternion_4 column
8	string/9 bytes	LABEL_15	"Procedure" / leading label of Procedure column for Command Procedure
9	string/2 byte	Event	The number of the requested event count
9	string/17 bytes	UTC	UTC time when the activity commences, in "yyyy/ddd hh:mm:ss" format / year, day, hour, minute, second / 2000:2050, 001:365, 00:23, 00:59, 00:59
9	string/2 bytes	DUR	Execution time of the activity in second "ss" format

Line Number	Type/Size	Field Name	Contents/Format and Unit/Range of Values
9	string/8 bytes	Q1	Quaternion_1 of satellite attitude in “sd.ddddd” format / +1.00000:-1.00000, or “NA”
9	string/8 bytes	Q2	Quaternion_2 of satellite attitude in “sd.ddddd” format / +1.00000:-1.00000, or “NA”
9	string/8 bytes	Q3	Quaternion_3 of satellite attitude in “sd.ddddd” format / +1.00000:-1.00000, or “NA”
9	string/8 bytes	Q4	Quaternion_4 of satellite attitude in “sd.ddddd” format / +1.00000:-1.00000, or “NA”
9	string/19 bytes	Procedure	The name of the Command procedure “SDC_PROCyydddFn.prc” yy:year, ddd:day of year, n:the nth command procedure of the same day or “NA”
10	same as line 9	Same as line 9	Same as line 9
11	same as line 9	Same as line 9	Same as line 9
Last	string/13 bytes	LABEL_16	“END OF REQUEST”

Sample Science P/L Mission Timeline

```
SOURCE:        SDC
DESTINATION:   SOCC
FILE NAME:     SDC_20191214_timeline
DATE TIME:     2019/12/08 19:40:00
SPACECRAFT:    FS8
INSTRUMENT:    SDC
#
REQUEST_WINDOW: 2019/348 00:00:00 - 2019/349 00:00:00
#
Event  UTC                   DUR  Q1 Q2 Q3 Q4   Procedure
1      2019/348 00:19:16     180  NA NA NA NA   SDC_PROC19348F1.PRC
2      2019/348 01:58:35     180  NA NA NA NA   SDC_PROC19348F2.PRC
3      2019/348 03:37:54     180  NA NA NA NA   SDC_PROC19348F3.PRC
4      2019/348 05:17:12     180  NA NA NA NA   SDC_PROC19348F4.PRC
5      2019/348 06:56:31     180  NA NA NA NA   SDC_PROC19348F5.PRC
6      2019/348 08:35:50     180  NA NA NA NA   SDC_PROC19348F6.PRC
7      2019/348 10:15:08     180  NA NA NA NA   SDC_PROC19348F7.PRC
8      2019/348 11:54:27     180  NA NA NA NA   SDC_PROC19348F8.PRC
9      2019/348 13:33:45     180  NA NA NA NA   SDC_PROC19348F9.PRC
10      2019/348 15:13:04     180  NA NA NA NA   SDC_PROC19348FA.PRC
11      2019/348 16:52:23     180  NA NA NA NA   SDC_PROC19348FB.PRC
12      2019/348 18:31:41     180  NA NA NA NA   SDC_PROC19348FC.PRC
13      2019/348 20:11:00     180  NA NA NA NA   SDC_PROC19348FD.PRC
14      2019/348 21:50:19     180  NA NA NA NA   SDC_PROC19348FE.PRC
15      2019/348 23:29:37     180  NA NA NA NA   SDC_PROC19348FF.PRC
```

3.9.2. Science P/L Command Proc.

	Science Payload Command Procedures
Purpose/Description	This file contains command mnemonics and the arguments and the time tag corresponded to the command procedure activity requested in the Science Payload Mission Timeline.
Originator	SDC
Destination	SOCC MCC
Frequency/Volume	variable / variable data volume
File name/E-mail Subject Convention	SDC_PROCyydddFn.prc (SDC: instrument name, yy: last 2 digits of year, ddd: day of year, n: the nth Command Procedure of the same day. For example: SDC_PROC19348F1.prc
Data Link Interface	Internet
Transport Interface	TCP/IP SFTP
Comments	1. The content of the Command Procedure will follow the XPSOC command format beginning with relative time tag “CMD” in each line.

Sample Science Payload Command Procedures

```
00:01:05.000- # Select
00:00:00.000^ CMD P SELPWR "A" SRC=TTQ

00:01:00.000- #   Power up on
00:00:00.000^ CMD C ESWION SRC=TTQ

00:00:55.000- # Delete file0 if existed, before Start record 30 sec
00:00:00.000^ CMD DCDSFILEDEL FILE_NAME = 'File_0' SRC=TTQ

00:00:40.000- # Create file [file0], before Start record 15 sec
00:00:00.000^ CMD DCDSFILECRE FILE_CAPACITY = 4 FILE_DEVICE = 'SPL_1' FILE_NAME = 'File_0' FILE_TYPE = 'Linear' SRC=TTQ

00:00:25.000- # Start record [file0]
00:00:00.000^ CMD DCDSSTARTREC FILE_NAME = 'File_0' SRC=TTQ

00:00:15.000- #   Sensor on
00:00:00.000^ CMD S SENSON SRC=MPQ

00:00:10.000- #   IDMIT mode
00:00:00.000^ CMD S IDMIT SRC=MPQ

00:00:05.000- #   switch to [safe mode]
00:00:00.000^ CMD S SAFE SRC=MPQ

00:00:00.000  #   switch to [fast mode]
```

3.9.3. Science P/L ASR

	Science Payload Acquisition Schedule Report
Purpose/Description	This file contains conflict-free activities including on-board events and ground events.
Originator	SOCC
Destination	SDC
Frequency/Volume	Once per day / Variable data volume
File name/E-mail Subject Convention	SDC_yyyymmdd.sch (yyyy: 4 digits of year, mm: months, dd: days) For example: SDC_20191214.txt
Data Link Interface	Internet
Transport Interface	TCP/IP SFTP
Comments	

All fields are left adjusted.

Line Number	Type/Size	Field Name	Contents/Format and Unit/Range of Values
1	string/8 bytes	LABEL_1	"SOURCE: "
1	string/variable	SOURCE	Author of File: "SOCC"
2	string/13 bytes	LABEL_2	"DESTINATION: "
2	string/variable	DESTINATION	Destination of File: "SDC"
3	string/11 bytes	LABEL_3	"FILE NAME: "
3	string/variable	FILE_NAME	file name / "SDC_20191214.sch"
4	string/11 bytes	LABEL_4	"DATE TIME: "
4	string/19 bytes	DATE_TIME	Time to generate this file in the format of "yyyy/mm/dd hh:mm:ss"
5	string/12 bytes	LABEL_5	"SPACECRAFT: "
5	string/variable	SPACECRAFT	Satellite ID / "FS8"
6	string/12 bytes	LABEL_6	"INSTRUMENT: "
6	string/variable	INSTRUMENT	Instrument ID / "SDC"
7	string/19 bytes	LABEL_7	"UTC" / leading label of UTC column
7	string/7 bytes	LABEL_8	"DUR" / leading label of DURATION column
7	string/10 bytes	LABEL_9	"Q1" / leading label of Quaternion_1 column
7	string/10 bytes	LABEL_10	"Q2" / leading label of Quaternion_2 column
7	string/10 bytes	LABEL_11	"Q3" / leading label of Quaternion_3 column
7	string/10 bytes	LABEL_12	"Q4" / leading label of Quaternion_4 column
7	string/23 bytes	LABEL_13	"Procedure" / leading label of Procedure column
8	string/19 bytes	UTC	UTC time when the event commences, in "yyyy/ddd hh:mm:ss" format / year, day, hour, minute, second / 2000:2100, 001:365, 00:23, 00:59, 00:59
8	string/7 bytes	DUR	Elapsed duration of the event, in second / second / 000.1:999.9
8	string/10 bytes	Q1	Quaternion_1 of satellite attitude in "sd.ddddd" format / +1.00000:-1.00000, or "NA"
8	string/10 bytes	Q2	Quaternion_2 of satellite attitude in "sd.ddddd" format / +1.00000:-1.00000, or "NA"

Line Number	Type/Size	Field Name	Contents/Format and Unit/Range of Values
8	string/10 bytes	Q3	Quaternion_3 of satellite attitude in "sd.ddddd" format / +1.00000:-1.00000, or "NA"
8	string/10 bytes	Q4	Quaternion_4 of satellite attitude in "sd.ddddd" format / +1.00000:-1.00000, or "NA"
8	string/19 bytes	Procedure	The name of the command procedure "SDC_PROCyydddFn.prc" yy: year, ddd: day of year, n: the nth command procedure of the same day.
9	Same as line 8	Same as line 8	Same as line 8
10	Same as line 8	Same as line 8	Same as line 8
-	"	"	"
11	string/22 bytes	LABEL_14	"Unscheduled Request"
12	string/25 bytes	LABEL_15	"Activity" / leading label of Activity column
12	string/19 bytes	LABEL_16	"UTC" / leading label of UTC column
12	string/9 bytes	LABEL_17	"Error_MSG" / leading label of Error_MSG column
13	string/25 bytes	Activity	"SDC_PROCyydddFn.prc"
13	string/19 bytes	UTC	UTC time when the activity should commence, in "yyyy/ddd hh:mm:ss" format / year, day, hour, minute, second / 2000:2050, 001:366, 00:23, 00:59, 00:59
13	string/variable	Error_MSG	The reason of the request not being scheduled
14	Same as line 13	Same as line 13	Same as line 13
14	Same as line 13	Same as line 13	Same as line 13
Last	String/13 bytes	LABEL_18	"END OF REPORT"

Sample Science P/L ASR

```
SOURCE:              SOCC
DESTINATION:         SDC SDC
FILE NAME:           SDC_20191214.sch
DATE TIME:           2019/12/12 06:03:07
SPACECRAFT:          FS8
INSTRUMENT:          SDC
UTC                  DUR  Q1        Q2        Q3        Q4        Procedure
2019/348 00:19:16    180  NA        NA        NA        NA        SDC_PROC19348F1.PRC
2019/348 01:58:35    180  NA        NA        NA        NA        SDC_PROC19348F2.PRC
2019/348 03:37:54    180  NA        NA        NA        NA        SDC_PROC19348F3.PRC
2019/348 05:17:12    180  NA        NA        NA        NA        SDC_PROC19348F4.PRC
2019/348 06:56:31    180  NA        NA        NA        NA        SDC_PROC19348F5.PRC
2019/348 08:35:50    180  NA        NA        NA        NA        SDC_PROC19348F6.PRC
2019/348 10:15:08    180  NA        NA        NA        NA        SDC_PROC19348F7.PRC
2019/348 11:54:27    180  NA        NA        NA        NA        SDC_PROC19348F8.PRC
2019/348 13:33:45    180  NA        NA        NA        NA        SDC_PROC19348F9.PRC
2019/348 15:13:04    180  NA        NA        NA        NA        SDC_PROC19348FA.PRC
2019/348 16:52:23    180  NA        NA        NA        NA        SDC_PROC19348FB.PRC
2019/348 18:31:41    180  NA        NA        NA        NA        SDC_PROC19348FC.PRC
2019/348 20:11:00    180  NA        NA        NA        NA        SDC_PROC19348FD.PRC
2019/348 21:50:19    180  NA        NA        NA        NA        SDC_PROC19348FE.PRC
2019/348 23:29:37    180  NA        NA        NA        NA        SDC_PROC19348FF.PRC
Unscheduled Requests:
Activity             UTC                 Error_MSG
#END OF REPORT
```

3.9.4. NORAD 2-Line Element

	NORAD 2-Line Element
Purpose/Description	FORMOSAT-8 orbital parameters for SDC to compute the satellite trajectory. It is in the standard NORAD 2-line element format.
Originator	SOCC FDF
Destination	SDC
Frequency/Volume	Once per 3 days. [TBR] / 160 Bytes
File name/E-mail Subject Convention	SSSS_yyyymmdd_hhmm.nor (SSSS: S/C name in capital, yyyy: 4 digits of year, mm: months, dd: days, hh: hours, mm: minutes) For example: FS8_20151203_0232.nor
Data Link Interface	Internet
Transport Interface	TCP/IP SFTP
Comments	SOCC as the data server, SDC to retrieve the data via SFTP. SOCC: Gateway-PC, username/passwd: xxx/xxx (TBD)

Lines 1 and 2 are the standard format of Two-Line Orbital Element Set identical to that used by NORAD and NASA. The format description is:

Byte	Field Name	Description
Byte 1	Record Number	Line 1. One integer digit: Always 1
Byte 2	Blank	ASCII Space
Bytes 3-7	Satellite Number	Five integer digits: right justified with possible leading blank character.
Byte 8	Classification	One alphabetical character for classification
Byte 9	Blank	ASCII Space
Byte 10-11	Launch Year	Last two digits of launch year
Bytes 12-14	Launch Number of Year	Three integer digits.
Bytes 15-17	Piece Number	Three alphabetical characters with possible trailing blanks.
Byte 18	Blank	ASCII Space
Bytes 19-20	Epoch Year	Two integer digits: last two digits of year
Bytes 21-32	Epoch Day	xxx.xxxxxxxx: Epoch (Julian day and fractional portion of the day-12 digits including decimal point at byte 24).
Byte 33	Blank	ASCII Space
Byte 34	Sign of First Time Derivative of Mean Motion (rev/day^2)	space or -: space = positive, - = negative
Bytes 35-43	Value of First Time Derivative of Mean Motion (rev/day^2)	.xxxxxxxx (nine characters including decimal point at byte 35
Byte 44	Blank	ASCII Space
Byte 45	Sign of Second Time Derivative of Mean Motion (rev/day^3)	space or -: space = positive, - = negative
Bytes 46-52	Value of Second Time Derivative of Mean Motion (rev/day^3)	(.)xxxxx-x (seven characters; the decimal point is implied)
Byte 53	Blank	ASCII Space
Byte 54	Sign of BSTAR Drag Term (for SPG4 Theory) or Radiation Pressure Coefficient (for SDP4 Theory)	space or -: space = positive, - = negative
Bytes 55-61	Value of BSTAR Drag Term (for SPG4 Theory) or Radiation Pressure Coefficient (for SDP4 Theory)	(.)xxxxx-x (seven characters; the decimal point is implied)
Byte 62	Blank	ASCII Space

Byte	Field Name	Description
Byte 63	Ephemeris Type	One integer digit: 0 = SGP4 Theory, 3 = SDP4 Theory
Byte 64	Blank	ASCII Space
Bytes 65-68	Element Number	
Byte 69	Check Sum (Modulo 10)	letters, blanks, periods, plus signs=0; minus signs = 1
Bytes 70-80	Blank	ASCII Spaces
Byte 81	Record Number	Line 2. One integer digit: Always 2
Byte 82	Blank	ASCII Space
Bytes 83-87	Satellite Number	Five integer digits: right justified with possible leading blank character.
Byte 88	Blank	ASCII Space
Byte 89-96	Inclination (deg)	xxx.xxxx (eight characters including decimal point at byte 92)
Byte 97	Blank	ASCII Space
Byte 98-105	Right Ascension of Ascending Node (deg)	xxx.xxxx (eight characters including decimal point at byte 101)
Byte 106	Blank	ASCII Space
Byte 107-113	Eccentricity	[.]xxxxxxx (seven characters, the decimal point is implied)
Byte 114	Blank	ASCII Space
Byte 115-122	Argument of Perigee (deg)	xxx.xxxx (eight characters including decimal point at byte 118)
Byte 123	Blank	ASCII Space
Byte 124-131	Mean Anomaly (deg)	xxx.xxxx (eight characters including decimal point at byte 127)
Byte 132	Blank	ASCII Space
Byte 133-143	Mean Motion	xx.xxxxxxxx (eleven characters including decimal point at byte 135)
Byte 144-148	Revolution number at epoch (revs)	
Byte 149	Check Sum (Modulo 10)	
Bytes 150-160	Blank	ASCII Spaces

Sample NORAD 2-Line Element

```
Data for each satellite consists of two lines in the following format:
1 NNNNNU DDLLLppp YYddd.dddddddd +.tttttttt +sssss-s +uuuuu-u T EEEEc
2 NNNNN iii.iiii rrr.rrrr eeeeeee www.wwww MMM.MMMM mm.mmmmmmmmnnnnnx
```

3.9.5. Science P/L SOH Data

	Science Payload SOH Data
Purpose/Description	This file contains the SOH telemetry data packets from Command and Telemetry Channel generated by the SDC instruments, and is extracted from XPSOC dump file.
Originator	SOCC SCC
Destination	SDC
Frequency/Volume	Whenever data is available/ variable
File name/E-mail Subject Convention	SDC_yyyydddhhmmss_ppp.dmp (yyyy: last 2 digits of year, ddd: day of year, hh: hour, mm: minutes, ss:second, ppp:packet APID) For example: SDC_2015302120103_70D.dmp
Data Link Interface	Internet
Transport Interface	TCP/IP SFTP
Comments	SOCC: Gateway-PC, username/passwd: xxx/xxx

3.9.6. Science Data VC3

	Science Data VC3
Purpose/Description	This file contains the telemetry packets of science data from Science Data Channel as generated by the SDC instruments.
Originator	SOCC SCC
Destination	SDC
Frequency/Volume	Whenever data is available/ 1.5 Gbits per day
File name/E-mail Subject Convention	yyyydddhhmmssxx.vc3 (TBD) (yyyy: digits of year, ddd: day of year, hh: hour, mm: minutes, ss:second, xx:version) For example: 201512809323101.vc3
Data Link Interface	Internet
Transport Interface	TCP/IP SFTP
Comments	SOCC: Gateway-PC, username/passwd: xxx/xxx (TBD)

FORMOSAT-8 Telemetry is compliant to CCSDS/ECSS standards.

The telemetry emission interface executes the following functions:

- The "HOUSE KEEPING" telemetry storage before transmission to the ground (playback/backup telemetry).
- SSR interface, used to dump the SPL data from the DS
- CCSDS protocol management and encoding of the frames (master frame count

management, Reed Solomon check code computation, scrambling and marker insertion).

- Virtual channels allocation to the different sources.

The VCM function (Virtual Channel Multiplexer) multiplexes the virtual channels, manages the priority between these different channels and generates Reed-Solomon check codes. The defaulted virtual channel IDs are:

- VCID = 011b, scientific data

4. Environmental Design Requirements

The science payload shall be designed to comply with FORMOSAT-8 Component Environmental Specification (FS8-SPEC-0017). The environmental specification might be changed by TASA due to program need.

5. Requirements Verification

The requirements shall be in accordance with the methods indicated in the Requirement Verification Matrix. The methods selected for verification are described below.

Inspection

Verification by inspection is a process which may be used in lieu of or in conjunction with testing to verify design features. Inspection is the process of physically measuring, examining or comparing an article to the design drawings, schematics, or other records to assure requirements compliance. This method also includes the validation of records to ascertain that correct parts, materials and processes were used.

Demonstration

Demonstration shall be the determination of properties and performance of an item involving proof-by-doing such as service and access, transportability and human engineering.

Analysis

Verification by analysis is a process used in lieu of or in addition to testing to verify compliance to specification requirements. The selected techniques may include systems engineering analysis, statistics and qualitative analysis, computer and hardware simulations, and analog modeling. Analytical techniques may be used in lieu of tests for such things as reliability assessment, life, storage, failure analysis, safety, interchangeability, and other performance requirements which are difficult or impractical to test. Analysis associated with qualification by similarity is included in this method.

Test

Test shall be the determination of properties and performance of an item by mechanical, electrical and environmental functional measurements. Tests shall be classified as follows:

Performance Testing: Comprehensive verification that the Bus meets the performance characteristics defined in Section 3 and identified in the Verification Cross Reference Matrix under both nominal conditions and environments.

Environmental Testing: Any testing performed under conditions other than the ambient environment.

Acceptance Testing: The environmental, electrical, mechanical, and other tests which all items intended for flight must pass. The tests are designed to verify proper workmanship and to demonstrate that the Bus will operate as specified when subjected to the expected worst case environmental conditions.

Protoflight Testing: The environmental, electrical, mechanical, and other tests required to verify that the Bus components will comply with design and performance requirements under anticipated operational regimes and environments. The environment of protoflight tests shall be harsher than the predicted operational environment, but below the design safety factor level so that the components need not be refurbished prior to flight. Exposure time is based on the use cycle and/or type of flight item. When several units of the same component are manufactured, only one shall be protoflight tested. Protoflight testing applies only to those component types identified below.

i. New designs
ii. Modified designs
iii. Existing designs with qualification levels that do not meet FORMOSAT-8 requirements

5.1. Requirements Verification Cross-Reference Matrix (VCRM)

VCRM of the Science Payload IRD is described in Appendix-B.

Appendix-A Acronym

AIT Assembly, Integration and Test

AUT Antenna under Test

BW Bandwidth

CCB Configuration Control Board

CCU Camera Control Unit

CDMU Command and Data Management Unit

CDR Critical Design Review

CE Conducted Emission

CFRP Carbon Fiber Reinforced Plastic

CMOS Complementary Metal Oxide Semiconductor

CS Conducted Susceptibility

CVCM Collected Volatile Condensable Material

DC Direct Current

ECR Engineering Change Request

EEE Electro mechanic, Electric and Electronic

EICD Electrical Interface Control Drawing

EIDP End Item Data Package

EMC Electromagnetic Compatibility

ESD Electrostatic Discharge

FM Flight Model

FMECA Failure Mode Effects and Criticality Analysis

HK Housekeeping

H/W Hardware

ICD Interface Control Document/Drawing

I/F Interface

I/O Input/Output

GPS Global Positioning System

LET Linear Electron Transfer

LISN Line Impedance Simulation Network

LV Launch Vehicle

MDRP Marine Data Relay Payload

MICD Mechanical Interface Control Drawing

MMU Memory Management Unit

MS Margins of Safety

NCR Non-Conformance Report

PA Product Assurance

PCB Printed Circuit Board

PCDU Power Control Distribution Unit

PFR Problem/Failure Reporting

PIND Particle Impact Noise Detection

PSLV Polar System Launch Vehicle

QA Quality Assurance

QPL Qualified Parts List

RCS Reaction Control Subsystem

RD Reference Document

RE Radiated Emission

RHCP Right Handed Circular Polarization

RS Radiated Susceptibility

RSI Remote Sensing Instrument

RMS root mean square

SCOE System or Special Check-Out Equipment

S/C Spacecraft

SEB Single Event Burnout

SEE Single Event Effect

SEGR Single Event Gate Rupture

SEL Single Event Latch-up

SEU Single Event Upset

SOCC/SDC Satellite Operation Control Center/Science Data Center

SRS Shock Response Spectrum

TB Thermal Balance

TBC To be confirmed

TBD To be defined

TC Thermal Cycling

TML Total Mass Loss

TV Thermal Vacuum

VSWR Voltage Standing Wave Ratio

Appendix-B Science Payload IRD Requirements Verification Cross-Reference Matrix (VCRM)

Requirement		Verification						Traceability
		Level	Method					
Paragraph	Title		n/a	tt	aa	ii	dd	
3	Requirements	C	X					SRD Section 3.2.4
3.1	System	C	X					Title
3.1.1	Configuration	C	X					SRD Section 1.2
3.1.2	Operation Modes	C				X		SRD Section 1.2
3.1.3	Operation Requirements	C				X		SRD Section 3.5.1.5.2
3.1.4	Mission Life	C				X		FS5 heritage
3.1.5	Orbit	C	X					General description
3.2	Physical	C	X					Title
3.2.1	Location Dimensions	C				X		SRD Section 3.5.1.5.2
3.2.2	Mass	C					X	SRD Section 3.5.1.5.2
3.2.3	Center of Gravity	C			X			FS5 heritage
3.2.4	Field of View	C	X					General description
3.2.5	Deployment	C				X		General description
3.2.6	Alignment	C	X					General description
3.2.7	Mounting	C				X		General description
3.2.8	Grounding	C	X					General description
3.3	Attitude Control	C	X					Title
3.3.1	Pointing Accuracy	C	X					General description
3.3.2	Pointing Knowledge	C	X					General description
3.3.3	Positioning Knowledge	C	X					General description
3.3.4	Operation of Science Payload	C	X					General description
3.4	Power	C	X					Title
3.4.1	Orbit Average Power	C			X			SRD Section 3.5.1.5.2
3.4.2	Input Voltage	C		X				SRD Section 3.5.1.5.2
3.4.3	Peak Current Draw	C		X				SRD Section 3.5.1.5.2
3.4.4	Electrical Power Interface	C				X		SRD Section 3.5.1.5.2
3.4.5	Connector	C				X		General description

3.5	Command and Telemetry	C	X					Title
3.5.1	Command and Telemetry Interface	C				X		SRD Section 3.5.1.5.2
3.5.2	Connector	C				X		General description
3.6	Science Data	C	X					Title
3.6.1	Science Data Interface	C		X				SRD Section 3.5.1.5.2
3.6.2	Connector	C				X		General description
3.6.3	Data Storage	C	X					SRD Section 3.5.1.5.2
3.7	Thermal	C	X					Title
3.7.1	Thermal Control	C	X					General description
3.7.2	Thermal Power Dissipation	C				X		General description
3.8	Magnetic Cleanliness	C				X		General description
3.9	SOCC/SDC Interface Requirement	E		tt				FS5 heritage
4	Environmental Design Requirements	C	X					FS5-SPEC-0017

Requirement: List out paragraph number and title of the requirement
Traceability:

1. Flowed-down requirements: list out doc/paragraph number of the parent doc
2. Heritage requirements: spell out the heritage (i.e. FS5 or …)
3. Newly created/derived requirements: list out the released memo/doc which records how the requirements were derived or created.

Verification:

6. Verification Levels

Level	Abbr	ID
Component	CMP	C
Subsystem	SUB	U
Engineering Dev. Model	EDM	D
Support Equipment	SE	E
Scientific Instrument	SI	I
Spacecraft Bus	S/C	S
Remote Sensing Instrument	RSI	R
Satellite	SAT	F
Ground Segment	GS	G
Image Signal Processing	ISP	P

7. Verification Methods

Method	**Abbr**	**ID**
Not Applicable	N/A	n/a
Test	TT	tt
Analysis	AA	aa
Inspection	II	ii
Demonstration	DD	dd