<u>All three (Europa, Pluto-Kuiper Express, and Solar Probe) Mission and Project Descriptions</u>

Modify Section 2.2.2.4, last paragraph as follows:

The spacecraft will supply regulated power between 22 and 36 VDC to the science instruments. The spacecraft has a single-point ground located within the power subsystem (i.e., no chassis return). Both power and return lines will be distributed to each load. Providing other regulated voltage levels and any high-voltage requirements will be the responsibility of the science investigation. Each switched power line will have associated telemetry reporting on/off status, trip status, current level, and output voltage.

Modify Section 2.2.2.7 Command, Control, and Data as follows:

At the end of the second paragraph (first for Solar Probe), add:

"In addition, each SFC communicates with its associated memory over a Compact PCI (CPCI) bus."

Replace the third paragraph (second for Solar Probe) with:

"Instrument command and telemetry interfaces to the Europa Orbiter avionics will be high-speed synchronous serial interfaces. Each flight computer will provide a set of command and telemetry interfaces to each instrument. The command and telemetry interfaces, together, comprise the entire data interface between a System Flight Computer (SFC) and an instrument. The interfaces with the flight computers will be provided by a System Interface Assembly (SIA). The interface is illustrated in Figure 17.5. The SIA will be a Compact PCI card in the flight computer chassis. Two SIAs on each redundant SFC string will be supplied by the spacecraft for use by the selected instruments. These SIAs will provide a total of four interfaces for science instruments to each SFC string.

The signals of the instrument data interface will be differential and conform to the TIA/EIA-422-B standard. The signal voltage levels will be 3.3 volts, nominally. The drivers and receivers on both sides of this interface will be 3.3-volt components that are being developed for JPL by Intersil (formerly Harris). These components are based on the existing Harris 5.0-volt parts, the 26C31 and 26C32. Details regarding these parts can be found in the Description of X2000 Components Available for Use in Instrument Proposals in the Outer Planets Program Library. There will be no signal common on the instrument data interface. Each of the two System Flight Computers (SFC), via its associated SIA, will provide complete data interfaces (command and telemetry), as shown in Figure 17.5, to each instrument. Connectors for the instrument data interface will be furnished by the spacecraft and are TBD.

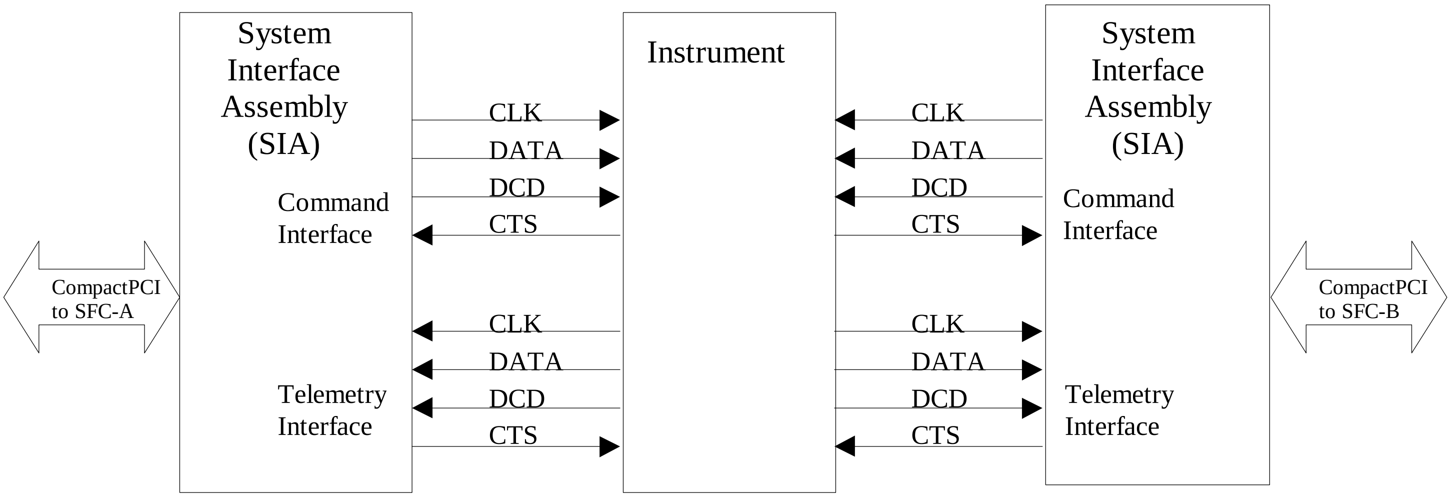


Figure 17.5. SIA/Instrument Interface

Electrically and functionally, the command and telemetry interfaces are identical except that the direction of the signals is reversed. The signals on these interfaces fall into three classifications: Timing, Data, and Control. Neither power nor ground will be provided in this interface. The signals are:

> CLK: This is the clock signal. It is generated by the data transmitter. Clock frequencies on the command interface will be less than 1 MHz. Clock frequencies up to 6 MHz will be supported on the telemetry interface.
>
> DATA: Transmitted Data. One bit of data is transmitted per clock cycle. Data are transmitted byte-wise with TBD (odd or even) parity.
>
> DCD: Data Carrier Detect is generated by the transmitting side. This signal enables/disables the receiver. DCD is active during the entire transmission of a frame of data.
>
> CTS: Clear to Send is generated by the receiving side. This signal enables/disables the transmitter.

A Binary Synchronous Communications protocol will be used on the instrument data interface. All commands and telemetry transmissions will be organized in a *transmission frame*, or simply *frame*. Each frame, whether a command or telemetry, will have the same format. The frame will include:

Frame Element Name	***Size***
Frame Sync Pattern	16 bits
Header	32 bits

Data	Telemetry: ≤ 2^{21} bytes Command: ≤ 100 bytes
Cycle Redundancy Check	32 bits
Closing Sync Pattern	16 bits

The flight computer will have the capability to control the time that a command is issued to an instrument to an accuracy better than 100 msec. The flight computer will have the capability to record the time a command is issued to an instrument with a knowledge accuracy better than 20 msec. The time base for all control and knowledge will be the spacecraft clock.

The mass, power, and cost for the SIAs will not be charged against the payload resource allocations of Table 6 (for Europa; Table 4 for Pluto or Table 7 for Solar Probe) in Section 3.1. The SIA data interface will be designed to operate with commercial off-the-shelf (COTS) support equipment (with electrical modifications to address interface isolation and signal level requirements), such as interface boards based on the Zilog 16C30 Universal Serial Controller.

Commands and software can be downloaded from the SFC into the instruments via the SIA. Any science data processing software that runs on the SFC must be supplied and budgeted by the science investigation."

2.3.1 Flight System Design and Deliveries

Modify the third paragraph as follows:

Science proposers who intend to exploit available spacecraft computer resources will need to be compatible with the MDS software architecture and design, at least for software that is resident in the Spacecraft Flight Computer (SFC). The extent to which any instrument flight software that runs on an internal instrument computer or any investigator-generated ground sequence planning, Ground Support Equipment, or data analysis software will need to adhere to MDS standards will be specified in an OP/SP Software Management Plan. Instrument proposers should plan to have at least one software expert in residence at JPL for at least 6 months prior to instrument PDR for training in the MDS methodology, development environment, and tools. MDS coding will be in C^{++}, and the operating system is VxWorks/Tornado. Software design will involve use of the Rhapsody tool.

Replace fifth paragraph (sixth for Pluto) with:

"PIs who plan to exploit the SFC to perform some of their payload processing functions must plan to develop their system recognizing that the SFC software and their hardware will not be interfaced until both are delivered to the spacecraft integrator for testing.

Science payload SFC software will have to be developed to MDS standards using an MDS Development Workstation. The PI will need to procure the workstation (e.g., mid-range Sun), software, and licenses specified by the MDS Project (these will include at least licenses for VxWorks and Rhapsody). The Project will periodically provide integrated MDS software builds and documentation to the PIs to aid in the development of science SFC software. The PI will adapt the MDS software as necessary for use by their instrument. The adapted software will be compiled and tested on their MDS Development Workstation. PIs must develop their instrument hardware to interface with the System Interface Assembly (SIA). The SIA serial interface protocol will be based on commercially available hardware. This will allow the instrument hardware to be tested with COTS hardware and software of the developer's choice to simulate the spacecraft functions. Instrument hardware and SFC software integration and testing will be performed at the spacecraft integrator's facility using the flight system test bed. The PI will need to periodically send instrument hardware, software, and development and test personnel to the spacecraft integrator's facility for integration and testing with the test bed. Test bed activities will be tied to MDS software build deliveries, the first of which will be 2/01 with subsequent deliveries on approximately six-month centers. The MDS delivery schedule for Solar Probe is TBD. Integration and test delivery milestones are specified in Section 3.6.

3.2.2.1 Science Investigators as Members of Project Teams

Modify the second paragraph as follows:

The avionics, software, and mission data system for the three missions (and other "customer" missions) will be developed in common by the X2000 First Delivery Project, based at JPL, and their numerous partners and contractors in industry, academia, and Government. Some of the electronic parts developed by X2000 will be available for use in science instruments, such as SIA drivers/receivers, memory, and power converters (see the Description Of X2000 Components Available For Use In Instrument Proposals document of the Outer Planets Program Library, available over the Internet through URL http://outerplanets.LaRC.NASA.gov/outerplanets). Each item is intended to be made available commercially and can be considered in the design of the instrument. The OP/SP Project will handle all interfaces with X2000 and will consult with PI teams as appropriate.

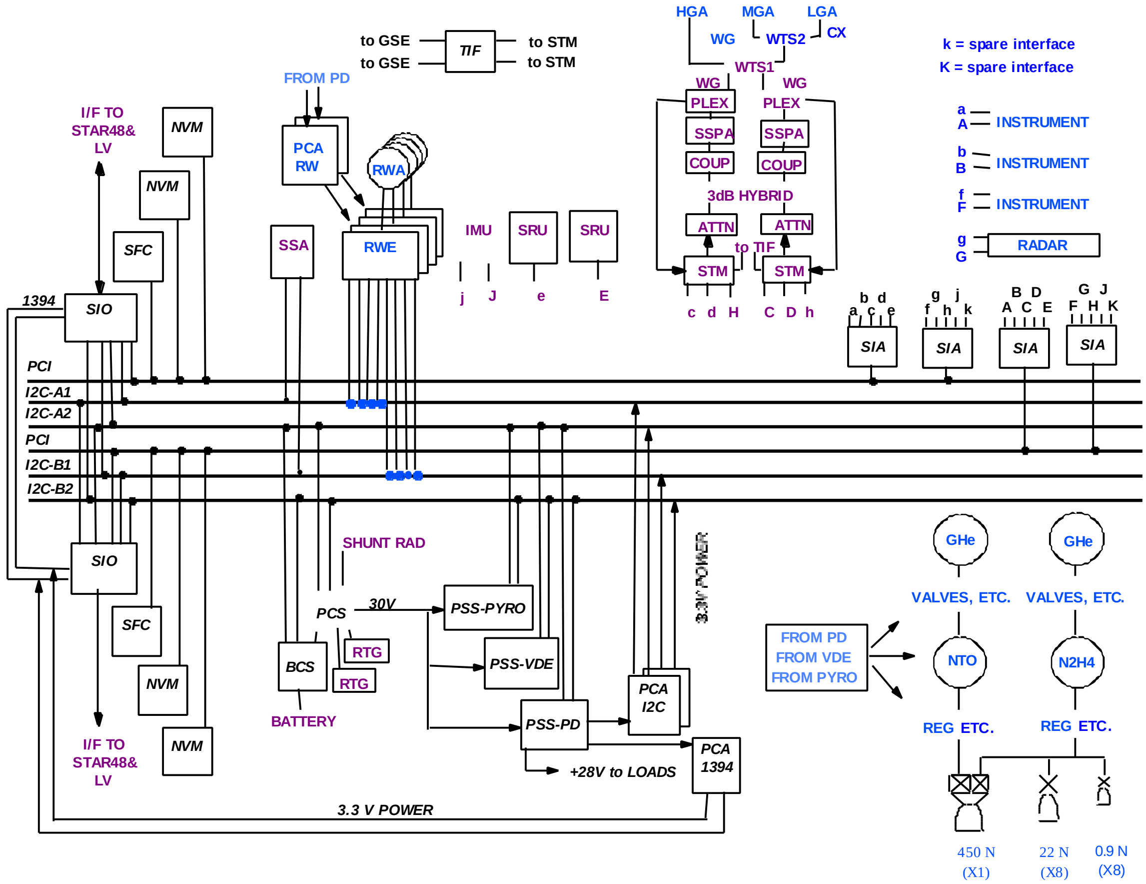
Add to list of deliverables in Section 3.3.1:

"Deliver preliminary versions of a software simulator of the instrument interface and the science adaptations of MDS SFC software."

Europa Mission and Project Description

Section 2.2.2 System Overview

Replace Figure 17 and associated acronyms with:



EUROPA ORBITER FUNCTIONAL BLOCK DIAGRAM 10-13-99

X2000 IN BLACK ITALICS

ACRONYMS & ABBREVIATIONS USED IN FLIGHT SYSTEM BLOCK DIAGRAMS

ACS - ATTITUDE CONTROL SYSTEM

ALT - ALTIMETER

ANT - ANTENNA

ATTN - ATTENUATOR

BCS - BATTERY CONTROL SLICE

CAM - CAMERAS

COUP - COUPLER

CX - COAX

GHe - GASEOUS HELIUM

GSE - GROUND SUPPORT EQUIPMENT

HGA - HIGH GAIN ANTENNA

IMU - INERTIAL MEASUREMENT UNIT

I2C - DATA BUS STANDARD

LGA - LOW GAIN ANTENNA

LV - LATCH VALVE, LAUNCH VEHICLE

MCS - MICROCONTROLLER SLICE

MGA - MEDIUM GAIN ANTENNA

N - NEWTON

NC - NORMALLY CLOSED PYROVALVE

NO - NORMALLY OPEN PYROVALVE

NTO - NITROGEN TETROXIDE

NVM - NONVOLATILE MEMORY

N2H4 - HYDRAZINE

PCA - POWER CONVERTER ASSEMBLY SLICE

PCI - DATA BUS STANDARD

PCS - POWER CONTROL SLICE

PD - POWER DISTRIBUTION

PLEX - DIPLEXER

PSE - POWER SYSTEM ELECTRONICS

PSS - POWER SWITCH SLICE

PYRO - PYRO SWITCHES

PWS - PLASMA WAVE SPECTROMETER

RAD - RADIATOR (SHUNT)

REG - REGULATOR

RS422 - DATA BUS STANDARD

RTG - RADIOISOTOPE THERMOELECTRIC GENERATOR

RWA - REACTION WHEEL ASSEMBLY

RWE - REACTION WHEEL ELECTRONICS

SB - SYSTEM BUS (PCAS SB)

S/C - SPACECRAFT

SFC - SYSTEM FLIGHT COMPUTER

SIA - SYSTEM INTERFACE ASSEMBLY

SIF - STM INTERFACE SLICE

SIO - SYSTEM INPUT/OUTPUT INTERFACE

SRU - STELLAR REFERENCE UNIT

SSA - SUN SENSOR ASSEMBLY

STAR48 - KICK MOTOR

STM - SPACE TRANSPONDING MODEM

TIF - T-ZERO INTERFACE

VDE - VALVE DRIVE ELECTRONICS

WG - WAVEGUIDE

WTS - WAVEGUIDE TRANSFER SWITCH

X - CROSS STRAPPED INTERFACE

X SSPA - X-BAND SOLID STATE POWER AMPLIFIER

3.1 Resources for the Science Investigations

Modify Table 6 as follows:

Table 6. Europa science instrument key resource allocations

Resource	Units	Allocations Non-radar	Radar	Total
Mass	kg	11	9	20
Power (average)	watts	4	20	24
Cost (real yr)	M$	21	9	30
Data storage	Gbits	1.2	1.0	2.2
Computer processing	MIPS	5	25	30
Downlink data rate	kbps	12	2	14
Data interfaces	#/string	3	1	4
Volume (internal)	cm^3	20x40x15.2	20x40x15.2	40x40x15.2
Volume (external)	cm^3	22x35x40	13100x2600x1	22x35x40*

Modify paragraph 8 as follows:

The computer processing allocation in Table 6 is for science use of the SFC.
Modify the last paragraph as follows:

To be charged to the spacecraft:
- •Instrument interface SIA;
- •Inflight purge equipment external to an instrument;
- •CPCI science electronics chassis; and
- •All RHUs (none permitted internal to instruments).

Section 3.6, add the following to the list of key delivery dates:

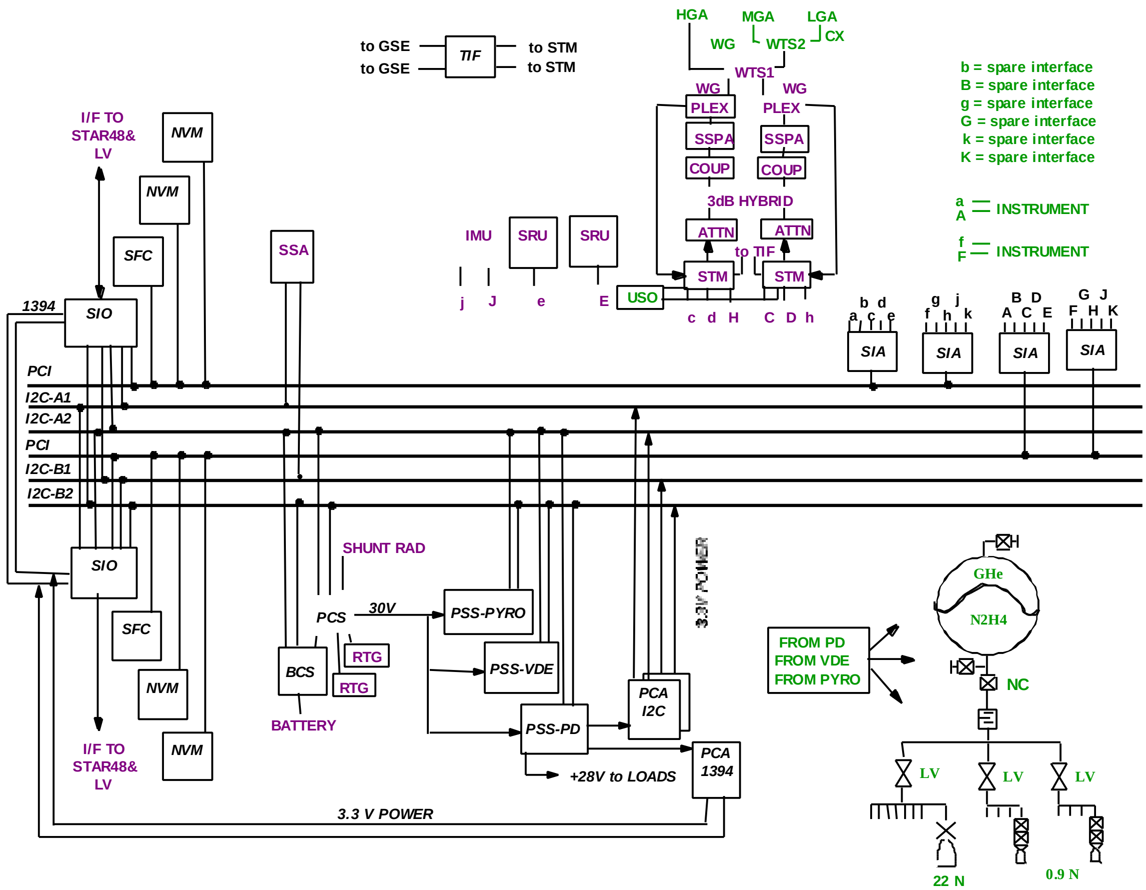
Instrument S/W SIM – preliminary	10/01
S/W test procedures – preliminary	10/01
Flight S/W for SFC – update	8/02

and change delivery date for Flight S/W for SFC – preliminary to 10/01.

Pluto-Kuiper Express Mission and Project Description

Section 2.2.2 System Overview

Replace Figure 12 and associated acronyms with:



PLUTO/KUIPER FUNCTIONAL BLOCK DIAGRAM 10-13-99

X2000 IN BLACK ITALICS

ACRONYMS & ABBREVIATIONS USED IN FLIGHT SYSTEM BLOCK DIAGRAMS

ACS - ATTITUDE CONTROL SYSTEM

ALT - ALTIMETER

ANT - ANTENNA

ATTN - ATTENUATOR

BCS - BATTERY CONTROL SLICE

CAM - CAMERAS

COUP - COUPLER

CX - COAX

GHe - GASEOUS HELIUM

GSE - GROUND SUPPORT EQUIPMENT

HGA - HIGH GAIN ANTENNA

IMU - INERTIAL MEASUREMENT UNIT

I2C - DATA BUS STANDARD

LGA - LOW GAIN ANTENNA

LV - LATCH VALVE, LAUNCH VEHICLE

MCS - MICROCONTROLLER SLICE

MGA - MEDIUM GAIN ANTENNA

N - NEWTON

NC - NORMALLY CLOSED PYROVALVE

NO - NORMALLY OPEN PYROVALVE

NTO - NITROGEN TETROXIDE

NVM - NONVOLATILE MEMORY

N2H4 - HYDRAZINE

PCA - POWER CONVERTER ASSEMBLY SLICE

PCI - DATA BUS STANDARD

PCS - POWER CONTROL SLICE

PD - POWER DISTRIBUTION

PLEX - DIPLEXER

PSE - POWER SYSTEM ELECTRONICS

PSS - POWER SWITCH SLICE

PYRO - PYRO SWITCHES

PWS - PLASMA WAVE SPECTROMETER

RAD - RADIATOR (SHUNT)

REG - REGULATOR

RS422 - DATA BUS STANDARD

RTG - RADIOISOTOPE THERMOELECTRIC GENERATOR

RWA - REACTION WHEEL ASSEMBLY

RWE - REACTION WHEEL ELECTRONICS

SB - SYSTEM BUS (PCAS SB)

S/C - SPACECRAFT

SFC - SYSTEM FLIGHT COMPUTER

SIA - SYSTEM INTERFACE ASSEMBLY

SIF - STM INTERFACE SLICE

SIO - SYSTEM INPUT/OUTPUT INTERFACE

SRU - STELLAR REFERENCE UNIT

SSA - SUN SENSOR ASSEMBLY

STAR48 - KICK MOTOR

STM - SPACE TRANSPONDING MODEM

TIF - T-ZERO INTERFACE

VDE - VALVE DRIVE ELECTRONICS

WG - WAVEGUIDE

WTS - WAVEGUIDE TRANSFER SWITCH

X - CROSS STRAPPED INTERFACE

X SSPA - X-BAND SOLID STATE POWER AMPLIFIER

2.1.5.4 Radio Science Investigation

Modify the last paragraph as follows:

The strawman PI-supplied radio science hardware consists of the ultrastable oscillator and a signal conditioning/processing unit. The signal conditioning/processing unit interfaces with both STMs for the down-converted IF signal and with the USO for the 76.5-MHz frequency reference. Signal processing for uplink radio science is accommodated within the PI-supplied instrument or by using the spacecraft main computer. A Project-supplied System Interface Assembly (SIA) slice provides a high-speed (up to 6 Mbps; see Section 2.2.2.7 for a description of the SIA) data interface between the PI-supplied instrument and the spacecraft main computer, where the data can be archived for later processing. The amounts of spacecraft data storage, bus bandwidth, and computing MIPS allocated to the radio science investigation are given in Sec. 3.1, Table 4.

3.1 Resources for the Science Investigations

Modify Table 4 as follows:

Table 4. Pluto science instrument key resource allocations

Resource	Units	Allocations Remote Sensing	 Radio Science
Cost	M$ (real yr)	22	4
Power (average)	watts	7.5	1
Mass	kg	14	1.5
Data storage	Gbits	2.1	0.1
Computer processing	MIPS	23	2
Downlink data rate	bps	200	5
Data interfaces	#/string	3	1
Volume (internal)	cm^3	$1320cm^2x12$	$440\ cm^2\ x12$
Volume (external)	cm^3	22x35x40	0

Modify the sixth paragraph as follows:

The computer processing allocation in Table 4 is for science use of the SFC.
Modify the last paragraph as follows:

To be charged to the spacecraft:

- Instrument interface SIA;
- Inflight purge equipment external to an instrument;
- CPCI science electronics chassis; and
- All RHUs (none permitted internal to instruments).

Section 3.6, add the following to the list of key delivery dates:

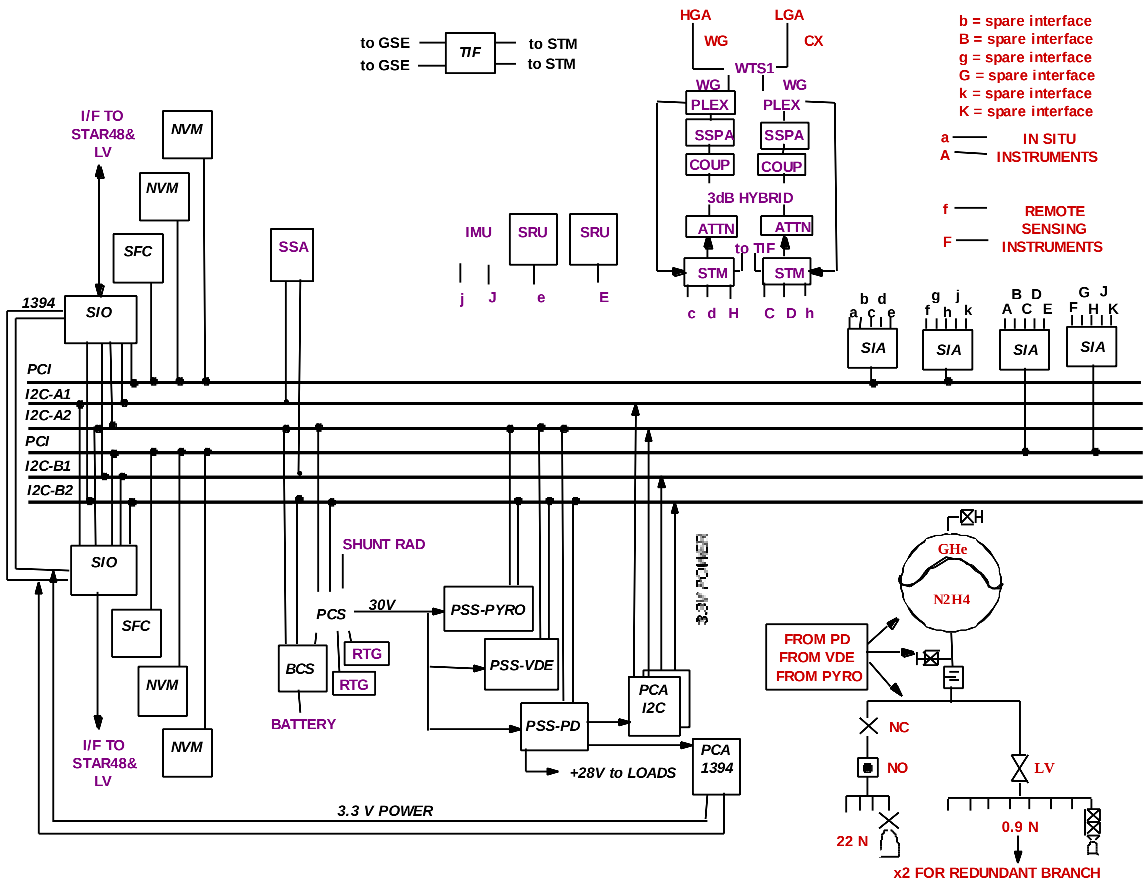
Instrument S/W SIM – preliminary	11/02
S/W test procedures – preliminary	11/02
Flight S/W for SFC – update	9/03

and change delivery date for Flight S/W for SFC – preliminary to 11/02.

Solar Probe Mission and Project Description

Section 2.2.2 System Overview

Replace Figure 7 and associated acronyms with:



SOLAR PROBE FUNCTIONAL BLOCK DIAGRAM 10-13-99

X2000 IN BLACK ITALICS

ACRONYMS & ABBREVIATIONS USED IN FLIGHT SYSTEM BLOCK DIAGRAMS

ACS - ATTITUDE CONTROL SYSTEM

ALT - ALTIMETER

ANT - ANTENNA

ATTN - ATTENUATOR

BCS - BATTERY CONTROL SLICE

CAM - CAMERAS

COUP - COUPLER

CX - COAX

GHe - GASEOUS HELIUM

GSE - GROUND SUPPORT EQUIPMENT

HGA - HIGH GAIN ANTENNA

IMU - INERTIAL MEASUREMENT UNIT

I2C - DATA BUS STANDARD

LGA - LOW GAIN ANTENNA

LV - LATCH VALVE, LAUNCH VEHICLE

MCS - MICROCONTROLLER SLICE

MGA - MEDIUM GAIN ANTENNA

N - NEWTON

NC - NORMALLY CLOSED PYROVALVE

NO - NORMALLY OPEN PYROVALVE

NTO - NITROGEN TETROXIDE

NVM - NONVOLATILE MEMORY

N2H4 - HYDRAZINE

PCA - POWER CONVERTER ASSEMBLY SLICE

PCI - DATA BUS STANDARD

PCS - POWER CONTROL SLICE

PD - POWER DISTRIBUTION

PLEX - DIPLEXER

PSE - POWER SYSTEM ELECTRONICS

PSS - POWER SWITCH SLICE

PYRO - PYRO SWITCHES

PWS - PLASMA WAVE SPECTROMETER

RAD - RADIATOR (SHUNT)

REG - REGULATOR

RS422 - DATA BUS STANDARD

RTG - RADIOISOTOPE THERMOELECTRIC GENERATOR

RWA - REACTION WHEEL ASSEMBLY

RWE - REACTION WHEEL ELECTRONICS

SB - SYSTEM BUS (PCAS SB)

S/C - SPACECRAFT

SFC - SYSTEM FLIGHT COMPUTER

SIA - SYSTEM INTERFACE ASSEMBLY

SIF - STM INTERFACE SLICE

SIO - SYSTEM INPUT/OUTPUT INTERFACE

SRU - STELLAR REFERENCE UNIT

SSA - SUN SENSOR ASSEMBLY

STAR48 - KICK MOTOR

STM - SPACE TRANSPONDING MODEM

TIF - T-ZERO INTERFACE

VDE - VALVE DRIVE ELECTRONICS

WG - WAVEGUIDE

WTS - WAVEGUIDE TRANSFER SWITCH

X - CROSS STRAPPED INTERFACE

X SSPA - X-BAND SOLID STATE POWER AMPLIFIER

3.1 Resources for the Science Investigations

Modify Table 7 as follows:

Table 7. Solar Probe science instrument key resource allocations

Resource	Units	Allocations *In situ* Package	Allocations Remote Sensing
Volume	cm	36x44 wedge w/ =1-m side boom; 15x74 aft cone	2 36x44 wedges
Cost	M$ (real yr)	17	18
Power (average)	watts	10	5
Mass	kg	12	9
Data storage	Gbits	1.0	1.2
Computer processing	MIPS	14	16
Data rate	kbps	11	14
Data interfaces	#/string	2	2
Thermal Power Dissipation	watts	28/wedge	28/wedge

Modify the fourth paragraph as follows:

The computer processing allocation in Table 7 is for science use of the SFC.
Modify last paragraph as follows:

To be charged to the spacecraft:

- Instrument interface SIA;
- Inflight purge equipment external to an instrument;
- All RHUs (none permitted internal to instruments); and
- Aft science boom.

Section 3.6, add the following to the list of key delivery dates:

Instrument S/W SIM – preliminary	1/05
S/W test procedures – preliminary	1/05
Flight S/W for SFC – update	11/05

and change delivery date for Flight S/W for SFC – preliminary to 1/05.

Description of X2000 Components Available for Use in Instrument Proposals

In Table 1, delete the description of the Generic Microcontroller. Add the following description of the System Interface Assembly data drivers/receivers:

1) TIA/EIA-422-B drivers and receivers

Command/telemetry interface drivers/receivers

Mass: 57 gm

Cost: $200/part

Size: 12 x 8 x 3 mm

Power: 23 mW for the receiver
2.5 mW for the driver

Features:

- 3.3-V versions of Harris 5-V parts 26C31 and 26C32
- 300 krad hard
- 6 Mbps maximum data rate

Earliest availability: 12/00

Contact: JPL – Shri Agarwal (818-354-5598); Intersil