CII Data Guidelines

Ben Bornstein
NASA CII Team

Interface Assumptions

- During the matching process, detailed parameters of the data interface will be negotiated. The Data Interface Control Document (DICD) will record those parameters and decisions.
- The instrument is autonomous, in particular the instrument includes:
  - an onboard processor
  - packet processing
  - telemetry monitoring
  - command and data handling
  - stored command sequences
  - (science) data storage, compression, and playback
- The spacecraft acts largely as a passive relay of instrument commands and engineering and science data
- Autonomous instruments and passive relay spacecraft require far fewer changes to spacecraft flight software, ground software, and mission operating systems.

Data L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.2	Data Interface	[LEO] The Instrument-to-Host Spacecraft data interfaces *should* use RS-422, SpaceWire, or MIL-STD-1553B.	RSS-422, SpaceWire, and MIL-STD-1553 are commonly accepted spacecraft data interface.
2.2.3	Data Accommodation	[LEO] The Instrument *should* transmit less than 10 Mbps of data on average to the Host Spacecraft. Data may be transmitted periodically in bursts of up to 100 Mbps.	NICM Database analysis provides 10 Mbps upper bound. Total data volume is shared and *may* be used for burst transmission when negotiated with Host Spacecraft.

<u>CII Workshop Feedback</u>

Led to increased burst data rate

Data L1 Guidelines

ID	Function	Guidelines	Rationale/Comment
2.2.2	Data Interface CMD / TLM	[GEO] The Instrument *should* use MIL-STD-1553 as the command and telemetry data interface with the Host Spacecraft.	The use of MIL-STD-1553 for command and telemetry is nearly universal across GEO spacecraft buses.
2.2.3	Data Accommodation CMD / TLM	[GEO] The Instrument *should* utilize less than 500 bps of MIL-STD-1553 bus bandwidth when communicating with the Host Spacecraft.	Shared data bus; total resource budget **Command** 250 bps – 2 Kbps **Telemetry** ≤ 4 Kbps

Data L1 Guidelines

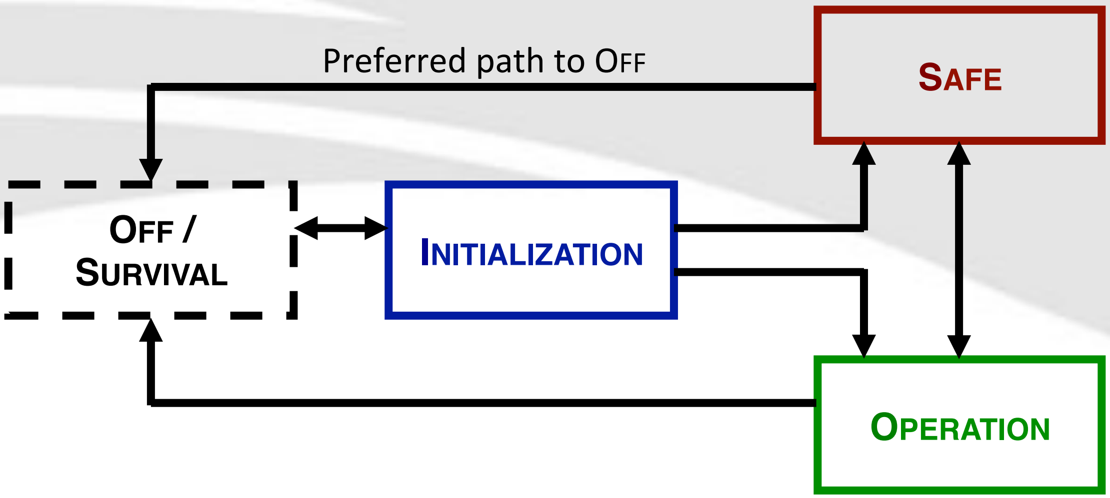
ID	Function	Guidelines	Rationale/Comment
2.2.2	Data Interface Science	[GEO] The Instrument *should* send science data directly to its transponder via an RS-422, LVDS, or SpaceWire interface.	Direct transponder interface for high volume payload data is common.
2.2.3	Data Accommodation Science	[GEO] The Instrument *should* transmit less than 60 Mbps of science data to its transponder.	Transponder bandwidth varies based on lease cost and hardware; 30–80 Mbps is common.

Data L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
4.2.1	Data Interface CMD / TLM	The Instrument Provider *should* provide a **command dictionary** to the Host Spacecraft Manufacturer, the format and detail of which will be negotiated with the Host Spacecraft Manufacturer.	Best practice and consistent with DICD.
4.2.2	Data Interface CMD / TLM	The Instrument Provider *should* provide a **telemetry dictionary** to the Host Spacecraft Manufacturer, the format and detail of which will be negotiated with the Host Spacecraft Manufacturer.	Best practice and consistent with DICD.

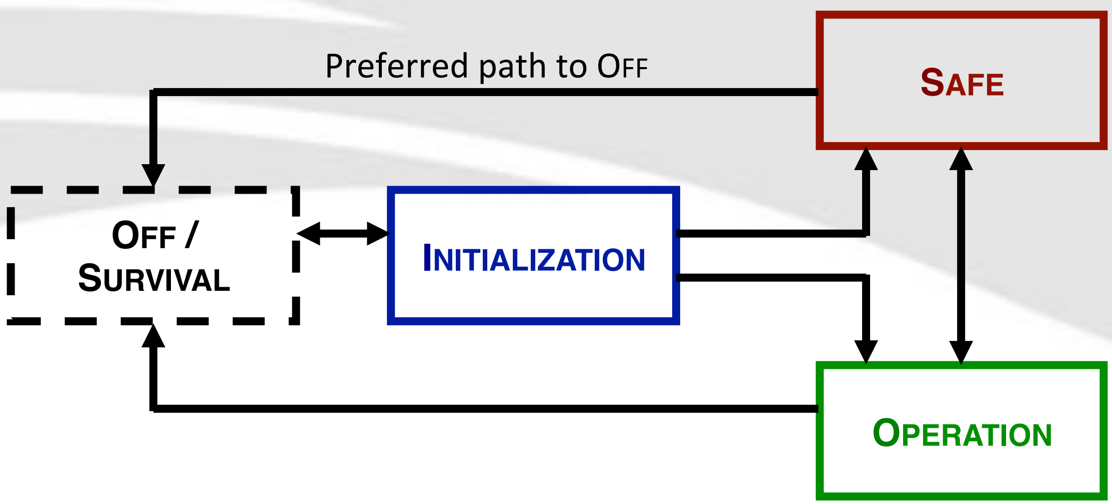
Data L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
4.2.3	Data Interface CMD / TLM	The Instrument *should* provide a SAFE mode.	Preserve Instrument and Host Spacecraft under anomalous conditions.



Data L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
4.2.4	Data Interface CMD / TLM	The Instrument *should* enter SAFE mode when commanded either directly by the Host Spacecraft or via ground operator command.	Preserve Instrument and Host Spacecraft under anomalous conditions.



Data L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
4.2.5	Data Interface CMD / TLM	The Instrument *should* respond to commands to suspend and resume the transmission of Instrument telemetry and Instrument science data.	Fault Detection, Isolation, and Recovery.
4.2.6	Data Interface CMD / TLM	The Instrument *should* acknowledge the receipt of all commands, in its telemetry.	Fault Detection, Isolation, and Recovery.

CII Workshop Feedback

Led to Data Flow-Control

Data L2 Guidelines

ID	Function	Guidelines	Rationale/Comment
4.3.1	Data Accommodation Science Storage	The Instrument *should* be responsible for its own science data onboard storage capabilities.	Fewer impacts on Spacecraft; [GEO] Consistent with direct to transponder interface.

From GEO RFI Response

"Ideal hosted payload is as self-contained as possible with no need for spacecraft computer interaction beyond passing low rate commands, macros, telemetry, and memory loads (no changes to platform flight software)."

From GEO RFI Response

"The SB shall not store, buffer, and/or process HPL data. The HPL shall provide all required data storage internally."

Data Best Practices

ID	Function	Guidelines	Rationale/Comment
9.1.1	Data CCSDS	The Instrument *should* transmit and receive all packet data using Consultative Committee for Space Data Systems (CCSDS) primary and secondary headers for packet sequencing and control.	Common across aerospace flight and ground data systems.

CCSDS Primary Header						
	Packet Identification			Packet Sequence Control		
Packet Version Number	Type	Secondary Header Flag	ApID	Sequence Flags	Sequence Count	Packet Length
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	16 bits
2 bytes				2 bytes		2 bytes

CCSDS Secondary Header								
CCSDS Unsegmented Time Code (CUC) Field								
P-Field		T-Field						
Default	Extended	Coarse Time				Fine Time		
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

Field	Length (bits)	Value	Comments
Packet Version Number	3	0b001	CII Packet Version 1
Packet Type	1	0b	CII SpaceWire-CCSDS packet
Secondary Header Flag	1	0b1	Indicates the CII-CCSDS secondary header is present
Application Process Identifier	11	0–2048	Reserved for instrument use
Sequence Flags	2	0b11	Indicates packet is unsegmented
Sequence Count	14	0–16383	Specifies the packet sequence count. The packet count begins at zero and resumes at zero after 16384 packets have been sent.
Packet Length	16	0–236	Specifies the length of the packet data field in bytes.

Data Best Practices

ID	Function	Guidelines	Rationale/Comment
9.1.2	Software Update (Full)	Instrument control flight software *should* be updatable on orbit through ground command.	Best practice; Facilitates updates and workarounds.
9.1.3	Software Update (Partial)	Individual memory addresses of instrument control software *should* be updatable on orbit through ground command.	Best practice; Facilitates updates and workarounds.

Data Best Practices

ID	Function	Guidelines	Rationale/Comment
9.1.4	Communication Infrastructure	Instrument Developers *should* consider utilizing the communication infrastructure provided by the Host Spacecraft and Satellite Operator for all of the Instrument's space-to-ground communications needs.	Size, mass, and power may not allow separate communications equipment; Long lead times for spectrum approval; onerous interference management

Summary of Data Guidelines

2.0 Level 1 Design Guidelines
- 2.2.2 Command / Telemetry / Science Data Interface (LEO/GEO)
- 2.2.3 Command / Telemetry / Science Data Accommodation (LEO/GEO)

4.0 Data Level 2 Guidelines
- 4.2.1 Command Dictionary
- 4.2.2 Telemetry Dictionary
- 4.2.3 SAFE Mode
- 4.2.4 Command (SAFE Mode)
- 4.2.5 Command (Data Flow Control)
- 4.2.6 Command (Acknowledgement)
- 4.3.1 Onboard Science Data Storage

9.0 Reference Material / Best Practices
- 9.1.1 CCSDS Data Transmission
- 9.1.2 Flight Software Update
- 9.1.3 Flight Software Update (Partial)
- 9.1.4 Use of Preexisting Communication Infrastructure