IMAGE/FUV

DPU Requirements

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1. INTRODUCTION

This document describes the functional requirements of the IMAGE/FUV Data Processing Unit (DPU), which is part of the IMAGE/FUV Main Electronics Package (MEP)

The IMAGE/FUV instruments observe the Earth from a satellite, which spins once every 120 seconds (0.5 rev/sec). The satellite has a 1.66 day orbit, with apogee at (radius) 8 Re and perigee at 1.15 Re.

2. DERIVATION OF REQUIREMENTS

The *UCB* **FUV Instrument Specification** describes what IMAGE/FUV is to do overall, and how it is put together.

The Data Processing Unit (**DPU**) is an 8085 microprocessor. The DPU I/O interfaces are described in detail in the *UCB* **DPU Interface Control Document**.

The spacecraft is controlled by the Common Instrument Data Processor (**CIDP**). The interface to the CIDP is given in the *SWRI* **CIDP Interface Control Document .**

Data products and their management is generally described in the *NASA* **IMAGE MIDEX Mission - Project Data Management Plan**.

3. REQUIREMENTS

3.1 Time

The IMAGE mission runs on Mission Elapsed Time (MET).
MET is delivered from the spacecraft once per spin, on the Nadir mark.
Time format is described in the CIDP ICD:

- 32 bits of coarse time, representing 0.1 second resolution
- 9 bits of fine time, representing a fraction of 0.1 second (195 microsecond resolution)

The DPU keeps internal time within spins. The DPU time resolution is a **frame**, which will be about 1/30 second. The exact duration of a **frame** is TBD, but will be close to 1/30 second.
Time-stamps recorded in the output data shall be 6 bytes: 4 of coarse, 2 of fine (lower 9 bits significant)

3.2 Instrument Control

The DPU starts the WIC and SI detectors gather data once per spin. The start time and duration depend on the spin rate and the distance of the satellite from earth. At the end of the data collection period, the DPU commands successive readouts of the MEP image memories
The DPU contains counters which are incremented by pulses from the GEO photometers. The DPU reads out these counters and resets them, at regular intervals.

3.3 Power Control

Once each spin, the DEP turns the high-voltage power on before activating the MEP, and off after data collection is complete.

3.4 Housekeeping

Voltages, Current and temperature values are by the DPU. A set of mux channels are set and an A/D converter is read. In some cases, an additional “remote mux” needs to be set. The housekeeping muxes are described in the DPU ICD.
Housekeeping data is transmitted in a special data package, once per spin.

3.5 CDIP Interface

3.5.1 Telemetry

Data transmitted to the ground goes to the CIDP via an RS-422 serial interface.
The detectors are commanded to read out on some schedule.
Header information is sent out directly from the DPU.
Output to the CIDP is in the form of "data packages", which are specified in the CIDP ICD.

3.5.2 Commands

Commands from the ground come from the CIDP directly to the DPU.
The form of commands is described in the CIDP ICD.
The DPU either executes a command itself, or passes the command through to the Command Data Interface (CDI).
The commands themselves are TBD, but will include:

- FUV Mode settings
- Spacecraft Time-set
- Attitude, Radius, Spin-rate data
- Table loads and patches
- Set Sun-sensor high voltage levels
- Set instrument threshholds
- Modify distortion correction LUTs

3.6 Motion Correction

3.6.1 TDI Concept

Each spin produces three output images: one each from WIC, SI-12 and SI-13. Each image is a summation of pixels over the sweep past the earth.

Each pixel in an output image is intended to be the sum of detector pixels which were pointing in a particular direction. This is called Time-Delay Integration (**TDI**). It is important that each detector pixel be summed to the proper output pixel, in order to get a sharp sum-image.

The SI and WIC detector images are transformed into summed output images by:

- Correcting for geometric distortion in the detector
- Removing 'hot' detector pixels.
- Correcting for the spin of the satellite, and orbital motion.
- Correcting for the tilt of the spin plane from the body plane, and any tilt of the instrument itself from the body plane.

The WIC generates a detector image once per frame (about 1/30 sec). The MEP steps through the detector coordinates, generating output image coordinates and adding each pixel to the summed output.

Each SI event results in a pair of detector coordinates. The MEP generates the corresponding output image coordinates, and increments the proper accumulation pixel.

For WIC, the accumulator cell array is 256x256; for SI, the accumulator cell array is 128x128.

Each accumulator cell is 16 bits.

3.6.2 Calculating the Rates

Every **frame**, the TDI electronics step the X and Y coordinates to compensate for the spin and orbital motion. The values of **xrate** and **yrate** are calculated from the spin rate, and the total tilt.

The combined effects of the tilt of the body axes from the true spin axes, and the tilt of the instrument with respect to the body, yield an angle **Alpha**.

Alpha is the angle between the rows of the output image, and the true spin plane.

P is the spin-period, converted to frame units.

Width is the number of columns in the output image (256 for WIC).

FOV is the horizontal field of view of an instrument (30 degrees for WIC).

The sweep past the earth goes from where the left side of the detector touches the right side of the output image, to where the right side of the detector image touches the left side of the output image. The angle of the sweep is **FOV*2.**

The number of pixels swept out by any pixel in the detector array is:

NP = Width*2

Adjusted for tilt:

NP = Width*2/cos(Alpha)

The sweep duration **D**, in time-steps, is given by:

D = P * (2*FOV)/360

Near perigee, D is adjusted for the effect of orbital motion, from a table of factors for ranges of radius:

D = D * factor

From this, **N** the number of pixels stepped per time-step is:

N = NP/D

Applying the tilt gives:

xrate = N * cos(Alpha)

yrate = N * sin(Alpha)

These numbers must be scaled to a 256x256 address space, showing 12 bits of fraction. The values will be small, so the result fits in a 16-bit word (4 bits before the binary point).

3.7 Faults

The DPU software should be able to handle faults -- exceptional conditions, which may be caused by hardware malfunction, improper commanding or software error.
The general guideline is to quickly return the instruments and interfaces to a “safe” condition.
Faults shall be reported in housekeeping.
Faults include:

- Missing Nadir Pulse Fault -- detected by: more than N seconds since the last nadir pulse
- CIDP Input Fault -- detected by: more than 2 seconds without “all is well” message from the CIDP.
- Code Checksum Fault – executable flight software fails checksum
- DLUT Checksum Fault – WIC Distortion LUT stored in EEPROM fails checksum