ISUAL Instrument Software

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Instrument Software Overview

- Command Processing
- Instrument Control
  - Camera
  - SpectroPhotometer
  - Array Photometer
- Memory Allocation, Data Compression
- Telemetry Generation
- Filter Wheel Control
- Operation Sequencing
Instrument Software Overview

- **DPU**
  - 8085 processor
  - Assembly Language, heritage from IMAGE/FUV
  - Primary purpose: Overall control and sequencing

- **DSP**
  - Fast Signal Processor
  - Software developed by NCKU
  - Primary purpose: Data Compression
Command Processing

- Commands may be received at any time and buffered in a queue.
- Commands are read from queue and executed as soon as possible.
- Echo telemetry generated for all commands, as they are executed.
- Command Echo goes out Command Status port.
- Extra enabling command required before critical commands.
- When enabling HV, command requires 4 code bytes, which are sent into the hardware.
Command Processing (cont)

- Some commands will set multiple parameters

- No automatic turn on of HV. A command is always required to turn on a HV power service

- “SAFE” command turns off HV and most other power services, and puts ISUAL in Standby mode.

- Time-tagged commands are stored in the spacecraft, and sent from there to ISUAL, when tagged time arrives

- Commands are generated by a ground station, using STOL or another procedure language
Instrument Control

- Set Parameters
- Allocate Readout Memory
- Turn on/off Power Services
- Handle Sprite Events, or Initiate scheduled readouts
Memory Allocation

- Memory for every camera readout
- Memory for every photometer group readout
- Memory for the results of data compression
- Memory for building Telemetry products
Data Compression

- All compression is done by the DSP
- Memory is shared between DSP and DPU
- DPU allocates memory and schedules jobs for the DSP
Telemetry Generation

• Telemetry products are generated as CCSDS source packets

• Packets are broken up into PVCFs and accumulated in memory until a 64 megabit Block is filled

• Block is transferred to spacecraft as a series of PVCF transmissions

• Telemetry is sent to spacecraft, primarily during Dayside transit

• Telemetry is transmitted using DMA, one PVCF at a time
Command Status

- Command Echoes and other real-time status is sent out the Command Status channel, which is different from the Telemetry channel.

- Command Status data is transmitted as CCSDS source packets, but using asynchronous serial I/O.

- A sync pattern will precede each Status packet.
Filter Wheel Control

- Stepper Motor
- Fixed number of steps between filters
- “Home” status signaled on first filter
- Motion is in one direction only
- Position is resynchronized on each passage of “Home”
Operation Sequencing

---Instruments---  --Mass memory------------  --Telemetry--

Sprite Event → Raw readout → Compressed Images → Sprite Product

Mass memory

Operation Sequencing

---Instruments---  --Mass memory------------  --Telemetry--
Data Flow - Acquisition

Camera generates a series of raw images in MM

DPU notes time of Sprite Event

Camera gets ready for another Sprite Event, using another part of MM

DPU generates readout of SpectroPhotometer and Array Photometer into MM and signals DSP

DSP

(Interrupt processing)

MM = Mass Memory

<<Sprite Event>>
DSP compresses the raw data (Sprites, Photometers), stores results in MM.

DSP signals DPU to get compressed data.

DPU converts compressed data in MM into Telemetry Products, with time stamp.

DPU generates PVCFS, sends to satellite.

DPU reallocates memory for more Sprite Events and Photometer readouts.
Operational Modes

- Standby
- Data-Taking
  - Sprite
  - Aurora
- Dayside Data Processing

Note: HV turn-on is never automatic. A command is always required.
Standby Mode

- No Data Taking
- Basic Housekeeping telemetry -- voltages, currents, temperatures
- Command Processing

Note: at any time, a SAFE command will shut off all HV and switch to Standby Mode.
Data-Taking Mode: Aurora

- Camera takes fixed-exposure at regular intervals; various filters set
- Photometer Data sampled at regular intervals
- Housekeeping Telemetry
- Command Processing
Sprite Mode

- Data taking synchronized with a Sprite Event. DPU gets an interrupt and notes the time.

- When a camera readout is complete, DPU stamps the time and passes the data on for compression and science telemetry. Same for Photometers.

- Command processing (as time is available)
Dayside Data Processing

- No Data Taking
- Data Compression from accumulated nightside raw data
- Telemetry Generation.
- Command Processing

Note: at any time, a SAFE command will shut off all HV and switch to Standby Mode.
Software Development

- Design Plan
- Development Tools & Platforms
- Test Plan
Design Plan

- Central Control by DPU
- DSP treated as a peripheral
- Inter-Module communication uses Shared Mass Memory
Development Tools & Platforms

- Heritage from IMAGE/FUV
- 8085 Assembler, Linker
- Test Pod
  - Reset and Function Switches
  - 8085 debugger
  - Upload into RAM
  - Debug display on monitoring PC
Test Plan

• Documents
  – ISUAL Requirements Document
  – Interface Control Documents

• Simulators

• Development Milestones
Simulators

- **ISUAL Simulator**
  - developed from DPU breadboard

- **Spacecraft Simulator**
  - Testing ISUAL
  - Developing Ground Data Processing Software
Development Milestones

• Established by Project Management
  – Defined Hardware Configuration
  – Defined Level of System Integration

• Formal Test:
  – list of objectives
  – specific functional requirements to be satisfied
Version Control

- CVS Software
  - Central Repository
  - Parallel Development
  - Log of changes
  - Ability to Reconstruct Previous/Alternate Versions
Software Modules

**Parameter and Mode Control Table**

- SPACECRAFT: Command, Status, Telemetry
- **Filter Wheel**
  - FWHEEL
- **Camera**
  - CAMCTL
- **Photometers**
  - SPHOT
  - APHOT
- **Data Compression**
  - DSP
- **Overall Sequence Control**
  - SEQ
- **Instrument Software**
  - C.Ingraham