GLAST Large Area Telescope

Instrument Flight Software
Flight Unit Design Review
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Spacecraft Interfaces

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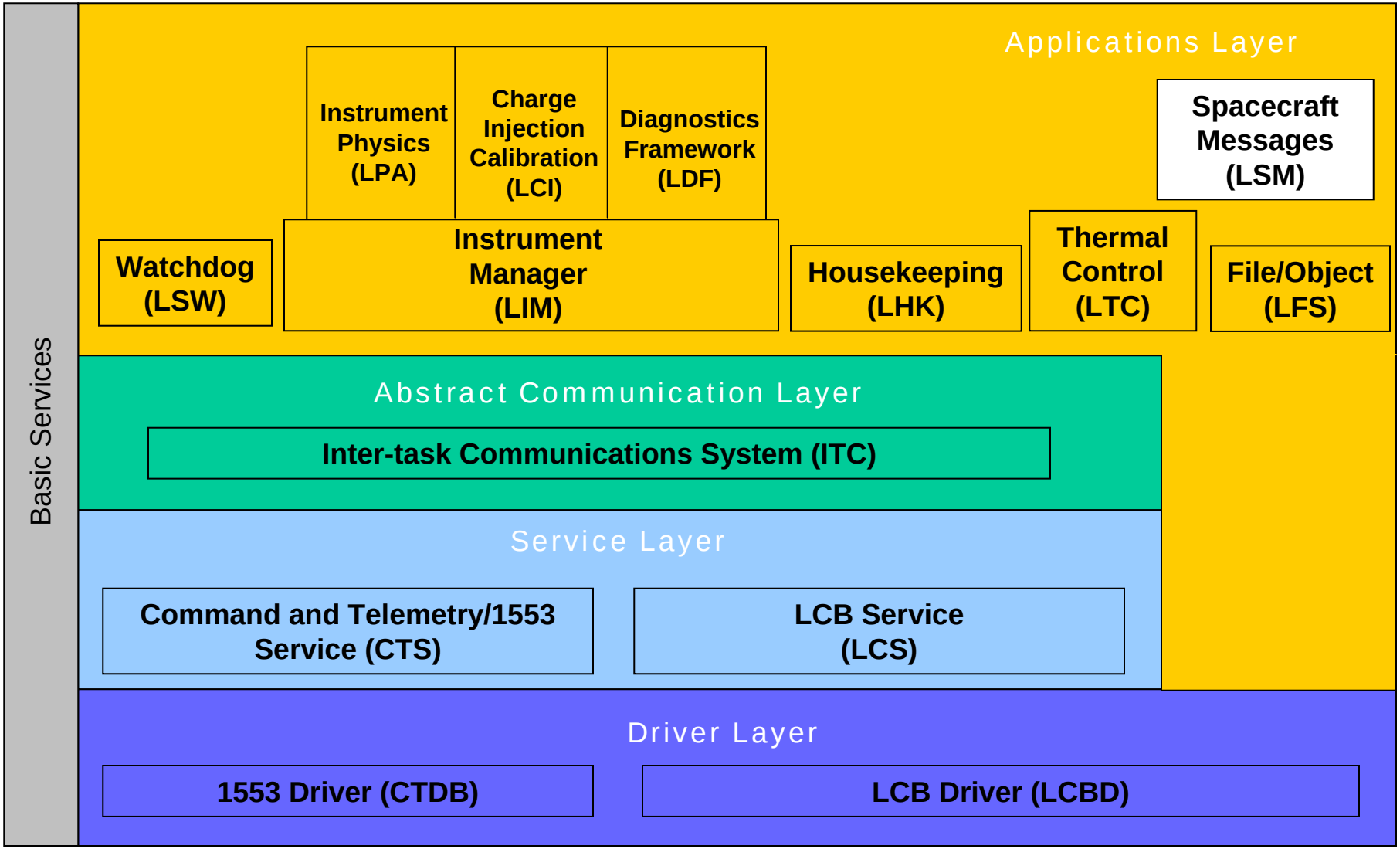
Spacecraft Interface Requirements

- **Flight Software General Requirements:**
  - **Discrete Signals (5.2.2.2, 5.2.2.3, 5.2.2.4, 5.2.3.1)**
    - **The SIU shall support up to 4 primary and 4 redundant discrete input signals from the SC for configuration and power control of the LAT.**
      - **Upon receipt of the appropriate command, the SIU shall transition between the primary and redundant signals**
    - **The SIU shall be capable of generating up to 2 primary and 2 redundant monitor signals to the SC for communicating status.**
    - **The SIU shall be capable of receiving up to 1 primary and 1 redundant pulse monitor signals from the GBM.**
  - **Time Services (5.3.4, 5.3.4.1, 5.3.4.2, 5.3.4.3, 5.3.4.4, 5.3.4.5)**
    - **FSW shall process external time signals from the Spacecraft and an internal time signal from the LAT. The goal of this processing is to generate an accurate and verified time stamp that can applied to event data.**
    - **The time accuracy of event time measurements shall be better than 10 µsec relative to spacecraft time. The goal is to achieve time accuracy of better than 2 µsec relative to spacecraft time.**
    - **The time signals to be processed are:**
      - **A 1 Hz GPS "time hack" on a discrete signal line from the Spacecraft**
      - **A 1 Hz GPS time message over the 1553 interface from the Spacecraft**
      - **A 20 MHz LAT internal clock signal**

Spacecraft Interface Requirements (cont'd)

- **Flight Software General Requirements:**
  - **Receive Attitude Data (5.3.11.3.2)**
    - **The SIU FSW shall receive spacecraft attitude data packets from the SC, delivered at the 5 Hz SC attitude control loop rate, via the CTDB.**
  - **Ancillary Data from SC (5.3.14, 5.3.14.1, 5.3.14.2, 5.3.14.3, 5.3.14.4)**
    - **The SIU FSW shall receive and process the following ancillary data packets from the SC delivered at 1Hz via the CTDB:**
      - **SSR Usage**
      - **LAT In or Out of SAA**
      - **GPS Status**
      - **Transmitter Status**

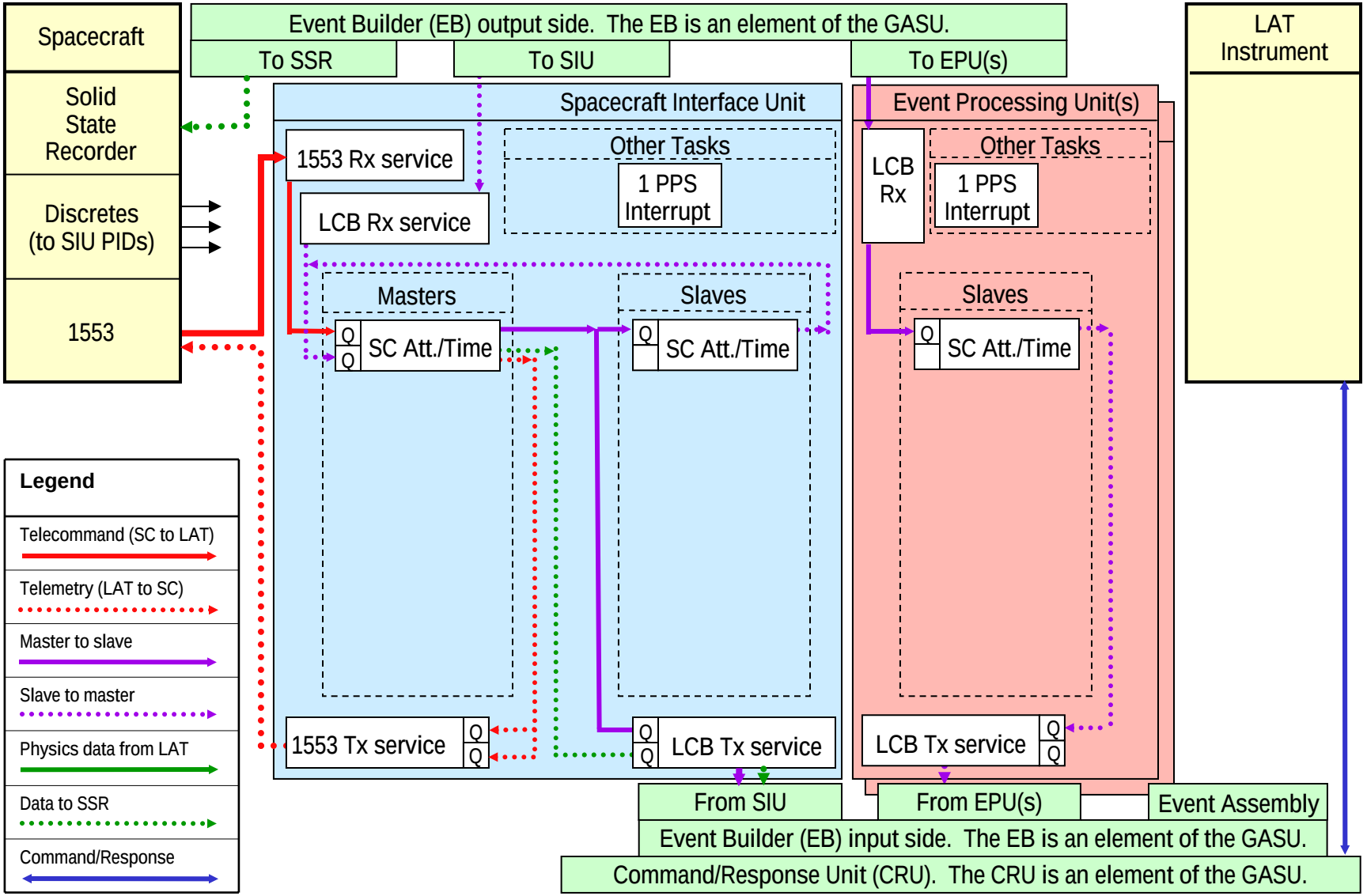
FSW Layer Architecture



Functional Components

- **Functional Inputs**
  - A 1 Hz GPS “time hack” signal from the Spacecraft over a discrete line
  - Time tone messages via CTDB from the Spacecraft at 1 Hz
  - Ancillary data messages via CTDB from the Spacecraft at 1 Hz
  - Attitude data messages via CTDB from the Spacecraft at 5 Hz
  - LAT internal clock signal at 20 MHz
- **Functional Processing**
  - The Attitude/Time function performs an internal integrity check of the input GPS time hack to verify consistency with the expected internal clock behavior.
  - The Attitude/Time function shall generate a mapping of external time (UTC) to the LAT internal 20 MHz clock.
  - The Attitude/Time function is required to tabulate time data that can be used to tag all photon events
  - The Attitude/Time function tabulates attitude data to support repoint requests
- **Functional Outputs**
  - The Attitude/Time function shall send the LAT a 1 Hz GPS "time hack" on a discrete signal line, which the LAT will use to generate a correlation between the GPS time hack and the LAT internal 20 MHz clock.
  - FSW time-tags and logs all incoming messages and makes these logs available to the ground

LAT FSW Architecture (Attitude/Time and PPS Specific)

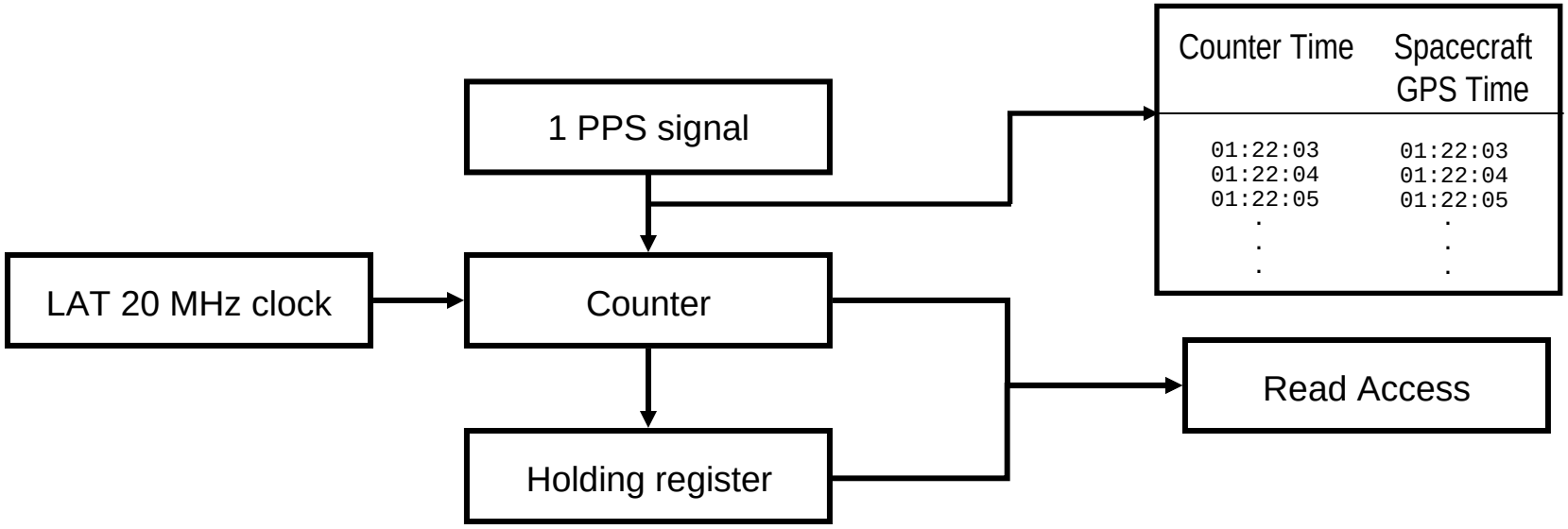


SC Attitude/Time and PPS Architecture (cont'd)

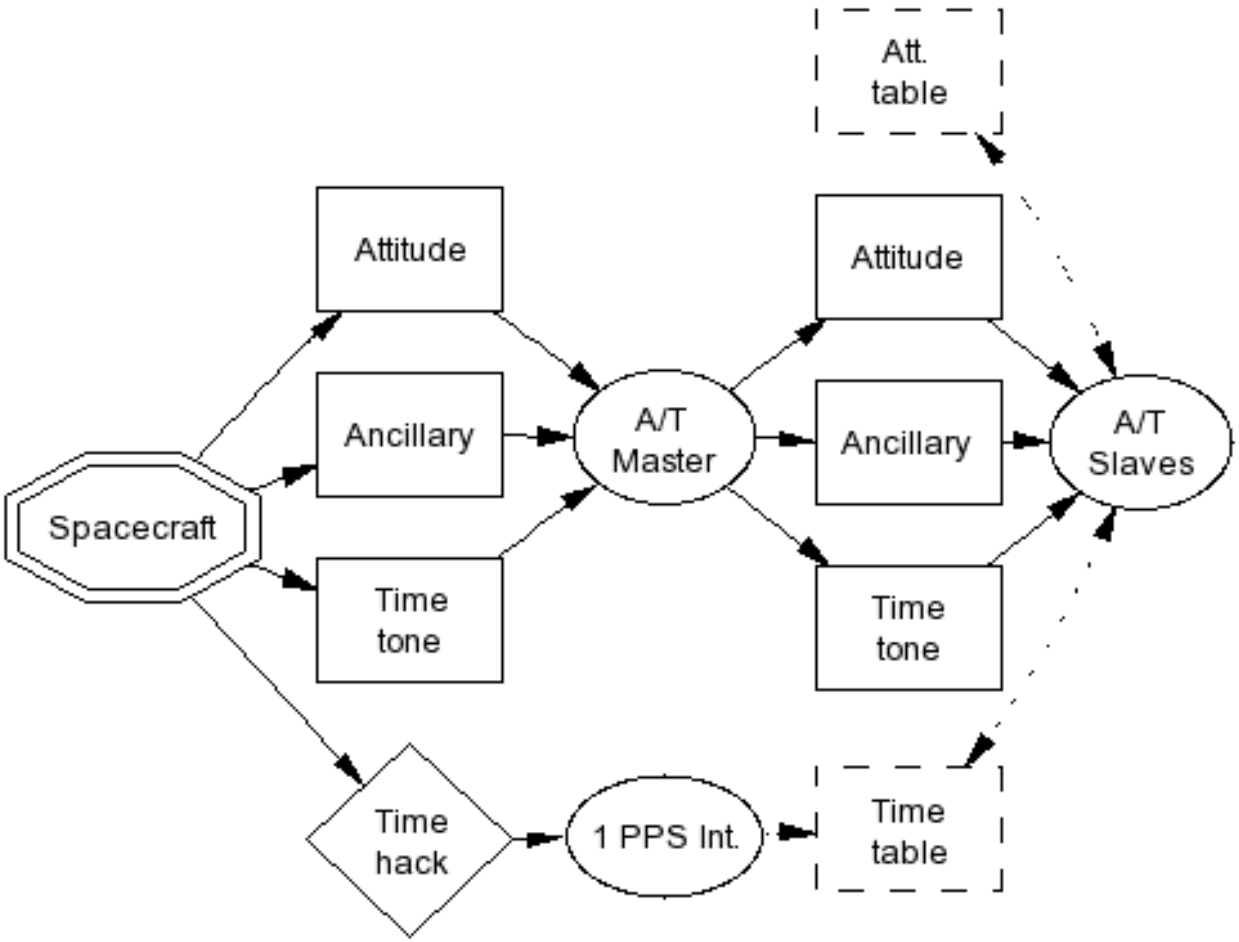
- The 1-PPS task, when awakened by the time hack interrupt from the Spacecraft, updates the processor's local time value.
  - It works cooperatively with the Spacecraft Attitude/Time slave task (shared memory structure) to build time interpolation tables.
- The Attitude/Time master task has the following duties:
  - Receive seven messages per second from the spacecraft: 5 attitude, 1 time-tone, 1 ancillary.
  - The master task redistributes these messages to slave tasks on all CPUs.
- The Attitude/Time slave tasks perform the following:
  - Build time tables for interrogation by other tasks/functions
  - Build attitude tables. Attitude tables can be interpolated to give spacecraft attitude at a requested time.
- Time tone messages, combined with time hacks (also distributed to all CPUs) provide wall clock time throughout the system, accurate to ~200 nanoseconds.

Wall Clock Time: Principal of Operation

- Drive a counter from the LAT 20 MHz clock
- Strobe the current value of this counter into a holding register with the spacecraft 1 PPS signal
- Reading the counter provides “current time” (in counter units)
  - Stamp this value into triggered events
- CPU uses 1 PPS signal interrupt to read strobed values in holding registers, using the data to build tables of wall clock time (provided by the Spacecraft messages) against counter value
- Counter time can be converted to wall clock time by interpolating/extrapolating through these tables



Time, Ancillary, and Attitude Data Flow Paths



- **Attitude table construction is analogous:**
  - **Spacecraft attitude messages enter at 5 Hz**
  - **The Attitude/Time master forwards these messages to the slaves**
  - **The Attitude/Time slaves time-tag the attitude data and store to Attitude table**

Discrete Signal Processing

- The Spacecraft and SIU are connected via discrete lines. The SIU provides its end of the connection through Programmable I/O Discretes (PIDs) mounted on the RAD750 board
  - 4 incoming primary lines and 4 redundant lines per SIU
  - 2 outgoing primary lines and 2 redundant lines per SIU
  - 1 primary and 1 redundant signal from the GBM to LAT
- FSW currently handles the following discrete signals to and from the Spacecraft:
  - GPS time hack (SC to SIU)
    - Discussed above
  - Reboot signal (SIU to SC)
    - Primary Boot addressed in a separate presentation
  - GBM interrupt (SC to SIU)
    - FSW has no requirement as yet to perform processing in response to this interrupt
    - At a minimum, FSW will log the time the interrupt signal was received
  - Unused discrete lines available for expansion

- All inbound discrete signals are processed in the same way:
  - 1) The discrete signal causes an interrupt
  - 2) In response to the interrupt, FSW reads a PID register on the RAD750
  - 3) Receipt of the signal is linked to time information and logged into the appropriate table

Using the Ancillary Data Messages

- All ancillary messages incoming at 1 Hz.
  - Time-tagged and sent to the science data interface
  - The contents of these messages are used primarily by the Instrument Physics and Instrument Manager FSW tasks.
- SSR Usage
  - Used by Instrument Physics
  - FSW will record basic usage statistics the number of bytes written to the SSR, percent “fullness” of the SSR, etc.
- LAT In or Out of SAA
  - This message is used by the Instrument Manager task as part of instrument mode control
    - Mode control is covered in a separate presentation
- GPS Status, Transmitter Status
  - These routine messages are time-tagged, stored, and made available for downlink
    - The ground may use these messages for troubleshooting

Attitude/Time and Spacecraft Messages: Telecommands and Telemetry

- **Telecommands**
  - **None**

- **Telemetry**
  - **Message indicating any discrepancy between the GPS time hack and the LAT internal clock**
  - **All data from the attitude, time, and ancillary tables is sent to the ground via the Science Data Interface**

Forward Work

- Coding to begin October 2004
- Generation of time and attitude tables will be demonstrated in November 2004
- Coding and unit test complete 11/15/04