SNAPS – A Novel Imaging Nanosatellite

Andrew E. Kalman <aek@stanford.edu>
SNAPS Requirements

• 16-bit or better MCU
• MCU with FPU
• No deployables, including UHF antenna (i.e., be a good neighbor)
• Compatible with 3U Planetary Systems Canisterized Satellite Dispenser (CSD)
• Structure must be 3D-printable
• Can accommodate some sort of payload, e.g. a camera
• Public domain design

• Result: 1/4U-size nanosatellite (25mm thick)

• SNAPS: Stanford Nano Picture Satellite
SNAPS Architecture

- Spectrolab UTJ
- MPPT Board
- Battery Supervisor Board
- ARM MCU
- Power Management
- HackHD 1080p Camera (H.264 video stream)

Power Consumption:
- 2 x 2W
- ~95%
- ~20Wh
- 0 - ~300mW
- 300mW (1mW sleep)
- 0 - 300mW
- >95%
- ~5W
- ~5.5W
SNAPS C&DH Board

- Microcontroller
  - STM32F407 microcontroller
    - 1MB Flash, 192K SRAM, up to 168MHz
    - DSP, FPU, SPI, I2C, UART, FSMC, ADC
    - Firmware in C/C++ with IAR Embedded Workbench for ARM
    - USB communication for debug and programming

- Memory
  - 4MB SRAM, 2Mb FRAM
  - SD (dual-port interface allows MCU or Camera access)

- Radio: Lithium-1 (UHF half-duplex)

- Interfaces to Solar Cell PCBs

- Interface to Battery Supervisor, with:
  - Two Li-Ion 18650 cells + protection circuitry
  - RBF & Separation switches
  - USB 3 connector for access port comms & power
## SNAPS C&DH Software

### Application
- H.264 Decoder
- Image Ranking
- JPEG Encoder
- Packetization

### Supervisor
- SNAPS Mission Controller

### Device Driver
- FatFs
- FRAM
- SRAM
- Camera
- ADC
- Power
- Radio
- WDT
- etc...

### RTOS
- FreeRTOS

### Hardware
- ST Standard Peripheral Library

---

- Library
- Custom (complete)
- Custom (in progress)

All SNAPS embedded software is written in C using the IAR EWARM toolchain.
SNAPS C&DH Development

v0.1 (Development Mule)

v1.1 (1st flight units?)
SNAPS Structure
SNAPS Bodipole™ Antenna
SNAPS Ground Station

- Yagi Antenna on Durand Roof
- Software Defined Radio (PanCube Dongle Pro)
- Carposson
  - Carposson ground station software for Linux, controlled by Carposson.com
  - Ground Station control client, records and transmits SDR data only
- Carposson Servers
  - 1/2 data
  - 9600 baud
  - FM/QPSK
- Database
- Carposson API
- SSDL Server
  - Store, Decode, and Display packets

---

- 2013-02-22 00:22 UTC
- Packets

<table>
<thead>
<tr>
<th>Packet</th>
<th>Packet</th>
<th>Packet</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000</td>
<td>08</td>
<td>94</td>
</tr>
<tr>
<td>00000000</td>
<td>09</td>
<td>10</td>
</tr>
<tr>
<td>00000000</td>
<td>08</td>
<td>94</td>
</tr>
</tbody>
</table>

---

- 2013-02-22 00:22 UTC
- Packets

<table>
<thead>
<tr>
<th>Packet</th>
<th>Packet</th>
<th>Packet</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000</td>
<td>08</td>
<td>94</td>
</tr>
<tr>
<td>00000000</td>
<td>09</td>
<td>10</td>
</tr>
<tr>
<td>00000000</td>
<td>08</td>
<td>94</td>
</tr>
</tbody>
</table>

---

- 2013-02-22 00:22 UTC
- Packets

<table>
<thead>
<tr>
<th>Packet</th>
<th>Packet</th>
<th>Packet</th>
</tr>
</thead>
<tbody>
<tr>
<td>00000000</td>
<td>08</td>
<td>94</td>
</tr>
<tr>
<td>00000000</td>
<td>09</td>
<td>10</td>
</tr>
<tr>
<td>00000000</td>
<td>08</td>
<td>94</td>
</tr>
</tbody>
</table>
SNAPS Image Processing

Still image captured from H.264 stream

Corner detection

RGB to greyscale, resize, smooth, edge detection

CubeSat isolation via thresholding and histograms

CubeSat detected!

Proximity Filter

Still image captured from H.264 stream

Corner detection

RGB to greyscale, resize, smooth, edge detection

CubeSat isolation via thresholding and histograms

CubeSat detected!
SNAPS Further Work

• Documentation & website
• Hardware
  • Assembly & testing of C&DH board
  • Full mechanical integration w/3D-printed parts
  • First build of final structure (printed or machined)
  • Balun for Bodipole antenna
  • Final passive magstab config
• Software
  • Radio integration
  • CarpComm (beacon) and ??? (data) support, GS integration
  • Power management strategies
  • Image Capture & Processing
• Licensing
• Testing, Testing, Testing!
Alisha Babbitt, Rob Blount, John Cast, Evan Clark, David Gerson, Kaz Gunning, Rahul Gupta-Iwasaki, Greg Hall, Nathan Hall-Snyder, Theresa Johnson, Niels Joubert, Jason Kang, Vaibhav Kumar, Brian Mahlstedt, Andrew Nuttall, Max Praglin, Manu Sharma, Abishek Sheshadri, Steven Shepard, Adrian Spanu, Ben Stabler, Ana Tarano, Nathan Tardiff, Ben Todd, Mengze Yu, Andreas Zoellner