CYGNSS Launch and Early Ops: Parenting Octuplets

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CYGNSS Mission

- Constellation of 8 μSats
- Low-cost Class D mission
- Low Earth Orbit
- 2 year primary mission duration
- Data downlinked from each μSat in 10-minute contacts nominally every 48 hours
- Investigating a new method for measuring and predicting the strength of tropical cyclones using GPS signals reflected off the ocean surface

Parenting Octuplets

- Launching and commissioning 8 µSats proved to have many parallels with raising children

- Joy, excitement, anxiety, worry, exhaustion, and pride were all experienced by the LEOps team

- The same eight µSats "raised" by the same "parents" somehow wind up with their own personalities in some respects

- It was hard not to play favorites
  - Some µSats were "loved" more than others—those that were trouble-free vs. those that misbehaved
  - Some seemed to get neglected from time to time in the planning and allocation of ground contacts

False Labor
aka Launch Delays

Success!

CYGNSS launch on December 15, 2017

A Face Only a Parent Could Love

One Born on Life Support

- First two μSats reported in on schedule, sun-pointed, and in Safe Mode

  ➔ This is going to be easier than we thought!

- Not so fast…

  – Third μSat (FM06) came up in a flat-spin 90° to the sun and a low and rapidly declining SoC

  – LEOps team spent next 14 hours working to save the 1 while largely neglecting the remaining 7 (other than quick status checks)
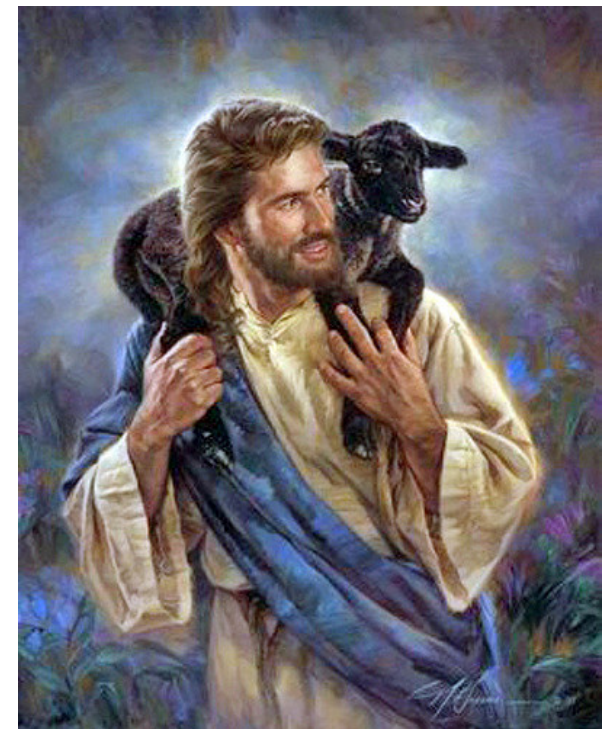
Lessons Learned

- Don't get cocky!
- Trust your design
  - Don't immediately conclude that you have to take action
  - After extensive post-analysis, FM06 would likely have found the sun 1-2 orbits sooner if left alone
  - We learned this lesson again later during commissioning
- Lies, D*%n Lies, and Statistics
  - Pre-launch Monte Carlo simulations predicted the anomaly could occur in ~1/3000 cases
  - Be prepared in case Murphy shows up

Sleepless Nights

- Caring for newborns is tiring and sleep is hard to come by

- LEOps team was divided into day-shift "Blue" team and night-shift "Green" team

- Planned 12-hour shifts (plus overlap) often turned into 16-22 hour shifts
  – Excitement & sense of responsibility made it difficult to walk away and get needed rest
  – On-console operators & off-console data analysts/ procedure developers were the same people

Interesting Trends…

- Dedicated snack room was stocked with food to keep our energy level up
- We had a whiteboard where LEOps staff could request food or drink they wanted
- The "Need List" started with things like:
  - Fruit
  - Coke & Dr. Pepper
  - Perrier
- Wish list trend is a little disturbing…

Lessons Learned

- Automation is worth the investment
  - CYGNSS MOC designed to conduct unmanned passes and automatically move and process files
  - Activated late in the 2nd week – allowed reduction to "skeleton crew" over Christmas/New Year holiday

- Other implementable LL in this area are difficult to come by
  - Training a third team for a 1-2 week LEOps period cost-prohibitive
  - Would have taken on-console time away from the two primary teams, possibly reducing their training time/competency

- Possible approaches in hindsight:
  - Aside from the brief anomaly on FM06, the entire constellation was stable in Safe Mode immediately – we could have ended the 24x7 operations earlier to provide more staff overlap
  - Rather than a complete 3rd shift, supplement the LEOps team with just 1-2 off-console staff for data analysis & procedure development

Commissioning Begins

- Constellation "coasted" cleanly into the New Year giving the LEOps team much-needed rest

- Commissioning began with the arrival of 2017

- Began formal checkout of all subsystems

- "First light" from the instrument downlinked on January 4, 2017
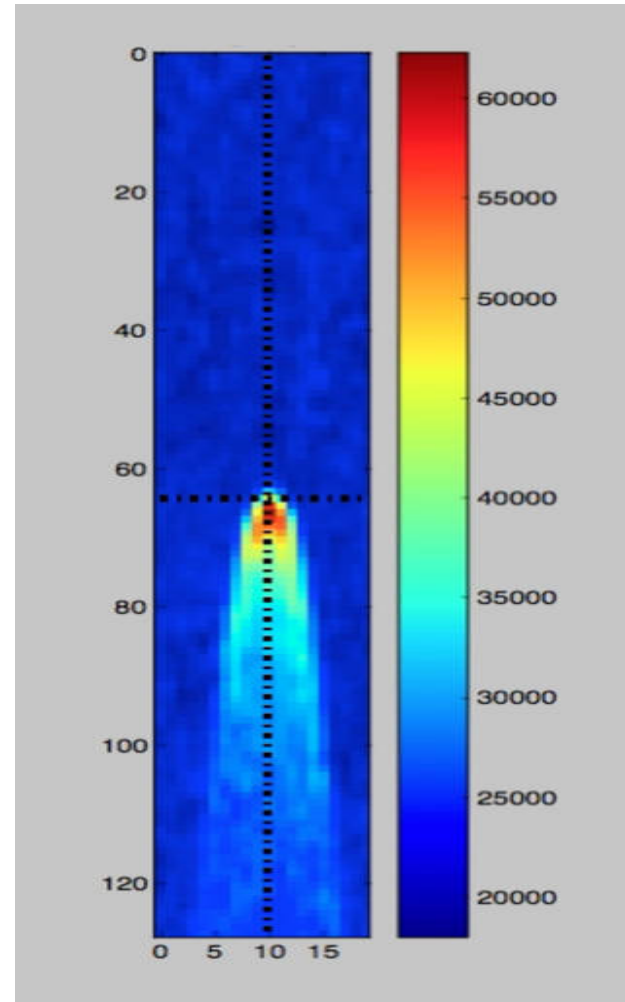
They May Look Identical, But They're Fraternal

- Like children, "identical" spacecraft and subsystems will have their own personality quirks
- Don't fall into the mindset that your mission or subsystem or component will be the exception: it won't be
  - Plan for these differences in mission operations processes & procedures, on-board table structures, etc.
- Think carefully about what could be affected by minor variances among S/C
  - Significant thought went into this on CYGNSS, but S/C-specific issues can "sneak" into unexpected places
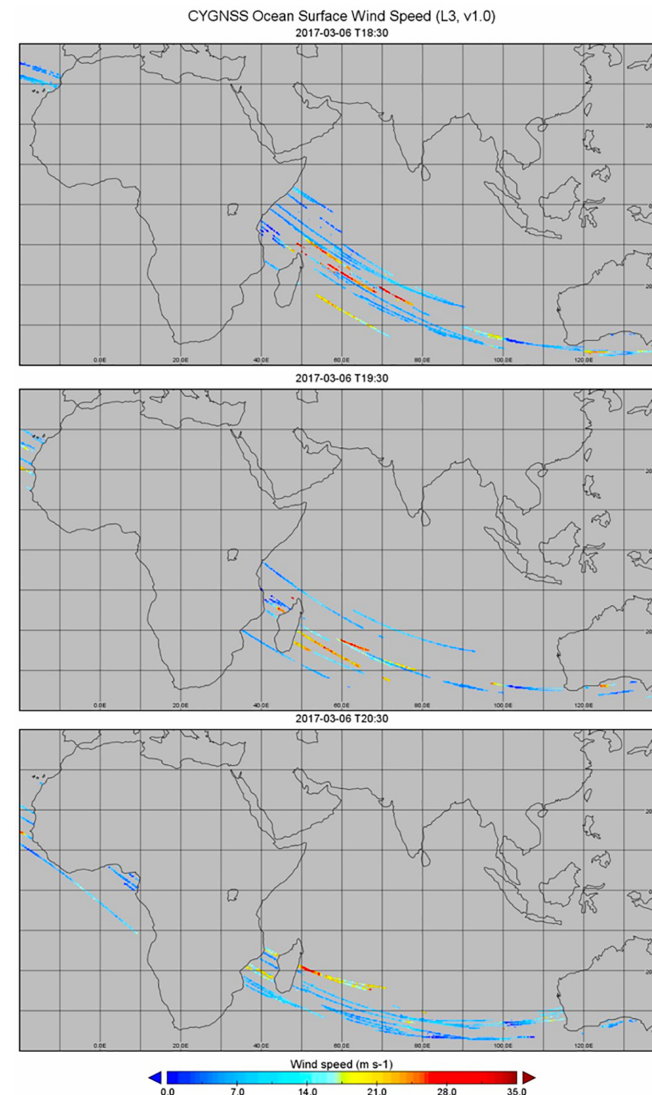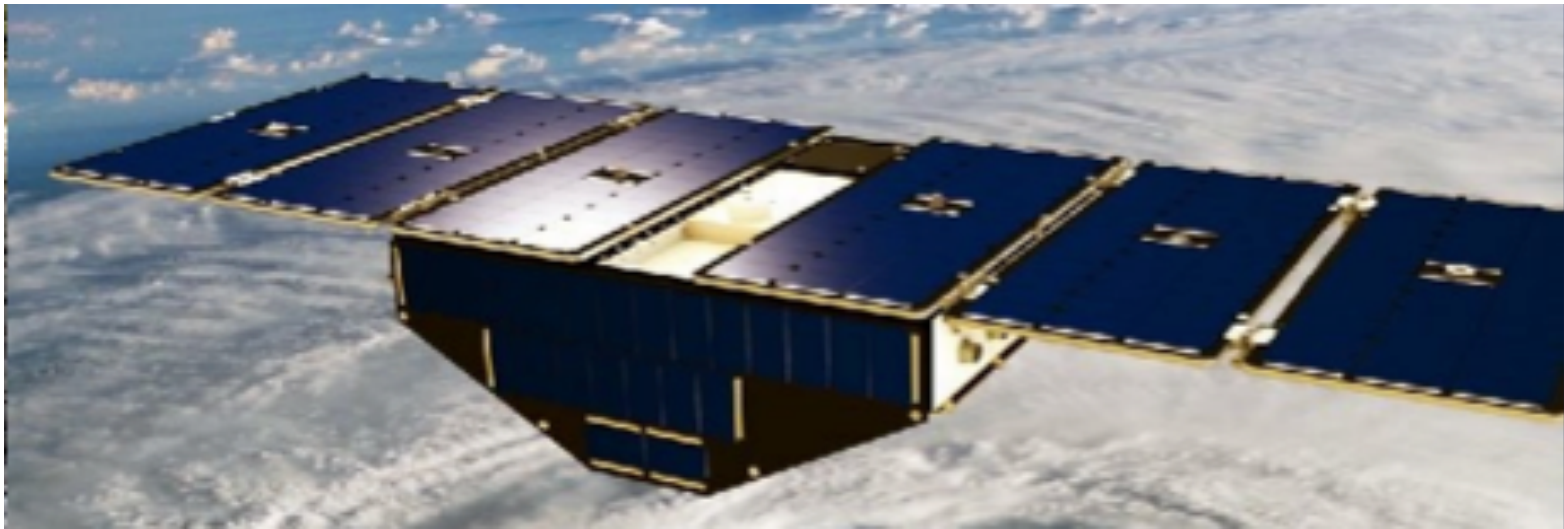
The Young Will Make Mistakes

- Low-cost, Class D mission
  - Some cubesat-class components used
    - Limited or no flight heritage
    - No radiation protection
  - CYGNSS in LEO but does fly through the SAA
- Robust on-board fault detection & correction (FD&C) is the anti-dote
  - CYGNSS treated FD&C as a subsystem with a complete Subsystem Description Document
  - Ability to modify fault thresholds & responses key in working through issues of "component youth"

Sending Them Out To Make Their Mark!

- First of CYGNSS µSats emerged from commissioning in March

- CYGNSS measured surface wind speeds from TC Enawo on March 6, 2017

- CYGNSS began regular delivery of science data to the PO.DAAC on May 22, 2017

- CYGNSS just took measurements of super-typhoon Noru Aug 5-6

CYGNSS Ocean Surface Wind Speed (L3, v1.0)
2017-03-06 T18:30
2017-03-06 T19:30
2017-03-06 T20:30
Wind speed (m s-1)

Stop by our booth #57-58

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