LASP
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS
UNIVERSITY OF COLORADO AT BOULDER

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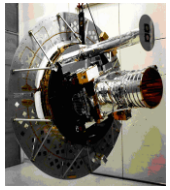
LASP Mission Operations

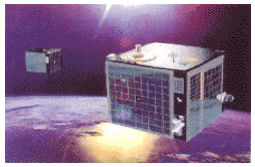
10/15/09

LASP Operations Heritage

- The Laboratory for Atmospheric and Space Physics (LASP) is a research institute at the University of Colorado, Boulder
- LASP specializes in the design, build, test and operations of instruments
- Three decades of flight operations



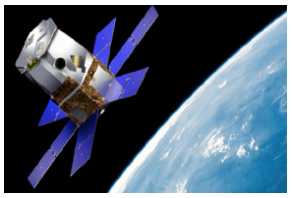
SME
(1981-1989)



STRV-1A
& STRV-1B
(1996 - 1998)

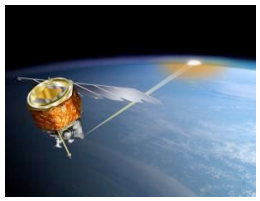
SNOE
(1998 - 2004)

QuikSCAT
(1999 - present)

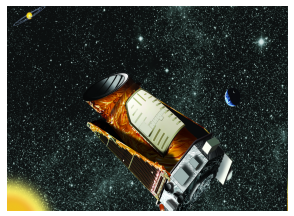


SORCE
(2003 - present)

ICESat
(2003 - present)

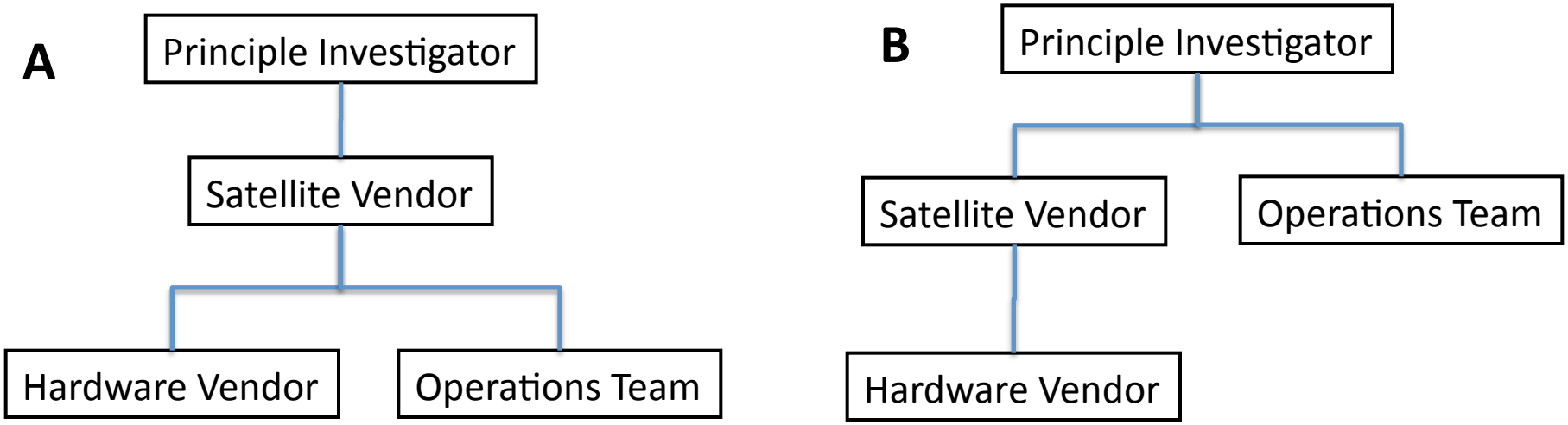


AIM
(2007 - present)



Kepler
(2009 - present)

Operations Architectures



- Operations team can be successful in both architectures
- Architecture A
  - Increased programmatic costs due to "satellite vendor in the loop"
  - Satellite vendor tends to be more active in the flight operations, this may reduce risk
- Architecture B
  - Plan needed to keep the vendor in the loop

Remote monitoring capabilities

- Satellite vendor needs the ability to view real-time telemetry
  - Critical to support anomaly resolution and recovery
  - Allows the anomaly investigation team at the vendor to remain co-located with their support team
  - Allows the anomaly investigation team to be co-located with their analysis tools
  - Efficient use of the resources

Data integrity check

- You can not have enough data integrity checks
  - Frame level
    - CRC, Turbo-code, Reed-Solomon
  - Packet level
    - CRC
    - Build packets as early as possible and include the integrity check
- Validate the contents of the data recorders
  - Compare the data delivered in real-time to the same data delivered via the real-time downlink
- Deliver all data integrity bits to the operations center
- Last commanded value vs actual value vs initial condition

Include subject matter experts

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- During anomaly investigations is is highly desirable to be able to talk directly to the component manufacturer
  - They are the experts
  - This requires regular maintenance of contact information
- Their detailed knowledge of the system, and issues on other programs is invaluable
- Having detailed anomaly reports from other programs are extremely helpful
  - Even if you do not know who program X, Y or Z is
  - Subcontractors often do not have on-orbit performance data from programs available to them, operations teams must provide this information back to them
- This interaction tends to slow the process down
  - That is generally not a bad thing
- Review the satellite operations concept with the component manufacturer

Operations team training

- Two operations concepts
  - The operations team is responsible for the day to day state-of-health monitoring with a satellite vendor providing sustaining engineering support
  - The operations team takes ownership of the vehicle on orbit and is entirely responsible for mission success
- Training needs to be geared toward the operations concept selected by the mission
  - The team taking ownership will need significantly more training
- Guidelines for long term performance monitoring needs to be included

Redundancy

- Consider selective redundancy
  - Satellites tend to come in 2 flavors, single or dual string
    - Single string vehicles only have 3 reaction wheels
      - An additional 4th wheel provides redundancy for minimal costs
    - Spare battery cells vs redundant battery vs over-sized battery
      - A redundant battery is often cost/mass prohibitive
      - If the loss of capacity is caused by the on orbit environment, then the over-sized battery may not be able to compensate – All cells equally damaged.
      - When the spare cell is "switched in" it will be mis-matched with the other cells
- We can fix it in software
  - The impact of on-orbit failures can often be mitigated by on-orbit software changes – Make sure you can get the software commands loaded
- Minimize the use of block redundancy
  - The larger the change, the less likely it is to happen

Risk vs performance

- The operations team will often continue to use a component with a partial failure because the program does not want to assume the risk/ downtime of switching to a back-up unit
  - The program will accept the reduced performance as long as requirements are met
  - The program may go to great lengths to develop an operational work-around
- Provide the ability to power up redundant units, and use one while checking out the other

Performance monitoring

- Performance monitoring is more than looking at limit violations
- Often times a degradation in performance can be seen long before a limit violation is reached
  - This allows the operations team to be proactive in preventing unexpected science loss
  - Reduces the stress on the operations team and leads to better decision making
  - Component failures on other missions may identify the need for additional
- Clearly identify on-board fault detection limits, and develop ground capabilities to monitor performance vs these limits