CloudSat
Safety Operations
at Vandenberg AFB

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CloudSat Project Overview

Aqua (Formation Partner)

CloudSat Spacecraft Radar instrument built at JPL S/C Bus built at Ball Aerospace

Aqua's Orbit = The "A-Train"

CALIPSO (Launch & Formation Partner)

S-Band SGLS Compatible

Ground System

S-Band SGLS Compatible

SAFB

OAS

Ground System

Telemetry Stream

Commands

RSC KAFB

Albuquerque, NM

AFSCN

Delta II (7420-10c) Launch from VAFB

June 27, 2006

JPL Pasadena, CA

Science Data Processing System

CIRA

Fort Collins, CO

Spacecraft Contractor

Ball Aero, Boulder, CO

Project Office
Vandenberg Ground Operations

CloudSat arrives from Boulder - May 3, 2005

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Processing at Astrotech, Vandenberg AFB

Launch at SLC-2

CALIPSO arrives from France - May 13, 2005
• Co-manifested launch with Calipso-CENA
• Delta II (7420-10C) vehicle
• Dual Payload Attach Fitting (DPAF) to accommodate two spacecraft
• CloudSat in lower DPAF attach position
• Launch from Vandenberg Air Force Base (VAFB)
• Launch vehicle mass performance
  Mass to orbit capability = 1003 kg
  CloudSat Measured Mass = 847.6 kg
• Launch time: 03:02:17 PST
The A- Train

The Afternoon Constellation is comprised of Aqua, as the leading satellite, followed by CALIPSO, CloudSat, Parasol, and Aura.

All are in a sun- synchronous orbit at 705 km and \( \approx 13:30 \) hours local time.
System Safety Management

- CloudSat/CALIPSO dual manifest resulted in extensive operational and hazards communications coordination between NASA JPL, KSC, LaRC, GSFC, Range Safety, CNES (French Space Agency), & Boeing

- Two spacecraft with different operational and test requirements
  - CloudSat - 94Ghz Radar instrument
  - CALIPSO - LIDAR (Laser) instrument

- Processing initially started in separate, adjoining high bays

- Post fueling, both spacecraft resided in the same high bay

- Once both spacecraft were co-located in the same bay, and mated, they were treated as a single spacecraft with respect to safety system implementations
• **CALIPSO - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation**
• **Joint NASA and CNES Spacecraft Mission**
  – Instrument built by Ball Aerospace under contract to GSFC
  – S/C bus built by Alcatel under contract to CNES
• **NASA provided Range Safety interface, System Safety oversight**
  – Flagged propulsion system design as not meeting Range Safety requirements
    • Prop system was designed with AN threaded fittings, not a welded system
    • Single fault tolerant to inadvertent thruster leakage
  – Coordinated hazards assessment, NASA waiver, and enhanced mitigation measures
• Enhanced Hydrazine Monitoring
  – Primary monitoring resides within the facility
  – Secondary monitoring provided by NASA
    • Zelwegger portable gas monitoring system
    • Sensitive to 1 ppb
    • To be placed as close as practical to the fueled S/C

• Enhanced Hydrazine Leak Checks
  • Two person entry into the High Bay, at the beginning of each 8 hour shift
  • Use of Interscan 4000 handheld leak monitor sensitive to 0.1 ppm for hydrazine

• Enhanced Hydrazine Training
  • PPE and SLC-2 evacuation exercises
  • Hydrazine familiarization for all operations personnel
    – Basic hydrazine hazards
    – Leak Detector Sensors
    – Alarm Systems
    – Evacuation Procedures
    – Exposure Symptoms

• Single Safety Lead - Ground Operations Safety Program Lead (GOSPL)
  • Overall NASA responsibility for CALIPSO/CloudSat post fueling
  • Ensures that all supplemental safeguards are implemented
  • All project safety organizations report to the GOSPL
Joint System Safety Operations

CloudSat/CALIPSO fueled - Aug ‘05
CloudSat DPAF encapsulation - Aug ‘05
CALIPSO stacked upper DPAF - Sept ‘05

• Continuous hydrazine leak detection since fueling due to CALIPSO threaded fittings concern - No leaks detected
• KSC GOSPL maintained constant presence at VAFB - coordinated all CloudSat/CALIPSO hazardous operations
• Changing launch date resulted in potential for concurrent hazardous operations
• All NASA centers and CNES worked with KSC and Range Safety to coordinate concurrent hazardous operations during the flight preparations
• Range Safety allowed concurrent hazardous operations to occur with the following constraints:
  – Continuous KSC GOSPL support maintained
  – Consider the two S/C as one hazardous system
  – Maintain a 1 meter clear area around hazard zones as specified in haz-op procedures.
Extended Stand-down

• 1st launch attempt planned for Oct. 2005
  – Delayed due to USAF high priority launches

• 2nd launch attempt planned for Nov. 2005
  – Delayed due to Boeing labor dispute (beginning Nov. 3, 2005)

• 3rd launch attempt planned for Dec. 2005
  – Delayed due to continuing labor dispute and Range shutdown for maintenance

• 4th launch attempt planned for Feb. 2006
  – Delayed due to continuing labor dispute (settled March 3, 2006)
  – Concerns raised over limited life components and S/C command software

• 5th launch attempt planned for April 2006
  – Arrived at SLC-2 April 8
  – Launched successfully on April 28
Launch Delay Safety Concerns

- Fueling and pressurization completed for both S/C Aug. 2005
- No pressure or temperature monitoring after fueling planned for CloudSat
  - Electrical GSE specific to CloudSat was relocated to the launch complex in Sept. 2005 in preparation for launch
  - No plan to return EGSE to Astrotech as delays continued
  - Resulting concern raised over hydrazine pressure and temperature post fueling
    - Limited data set available post fueling
    - JPL conducted an analysis on the post fueling data set
      - Conclusion reached that potential for increasing pressure and temperature risk was low
    - Range Safety accepted JPL’s conclusions
  - Plan to continue as configured was based in part on the continuous secondary hydrazine monitoring and enhanced training due to the CALIPSO waiver
• GSE proof tests and calibration dates expired during the stand-down.
  – MGSE and EGSE proof/calibrations required recertification during the time of extended stand-down
    • Required GSE to be returned to Ball Aerospace, Boulder, Colo. for recertifications
    • Could have resulted in loss of use for potential contingency
    • Critical equipment required for S/C lifting and emergency fuel off-loading was maintained at Vandenberg, in climate controlled facilities, dedicated to our project
    • Range Safety accepted out-of-date certs for critical equipment with the understanding that they were dedicated
    • All other GSE returned to Vandenberg within 30 days
Launch Delay Safety Concerns

- Vandenberg Tracking Station (VTS) range radar and tracking systems in periodic use - supporting USAF launch and space operations
  - Periodic CloudSat receiver lock-ups occurred resulting in the inability to verify S/C system status
  - Could have resulted in additional launch delays if occurrence coincided with a launch attempt
  - NASA and Project Mgmt worked with VTS to establish sector blanking where possible, and advanced notifications of pending VTS operations
  - Communication between NASA and VTS helped assure successful launch
Lessons Learned

- The extended stand-down raised several safety concerns complicated by:
  - Two fueled and pressurized S/C
  - Additional safety mitigations resulting from the CALIPSO prop system design waiver
- CloudSat EGSE redeployed to SLC-2, no post fueling temperature and pressure monitoring capability
- Proposed re-verification of S/C powered systems was severely restricted due to our fueled condition
- Limited life components can cause unexpected change-outs, retest, and servicing which would result in removing inhibits from a fueled propellant system
- Expiring GSE certifications result in need to re-certify, potentially making this equipment unavailable for contingency operations

Be prepared for the unexpected to happen