

Wallops Arc Second Pointer

Wallops Flight Facility



WASP Description

Subsystems

X-Calibur Flight

2017 Test Flight

Current Collaborations

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NASA/GSFC/Wallops

May 2017

WASP

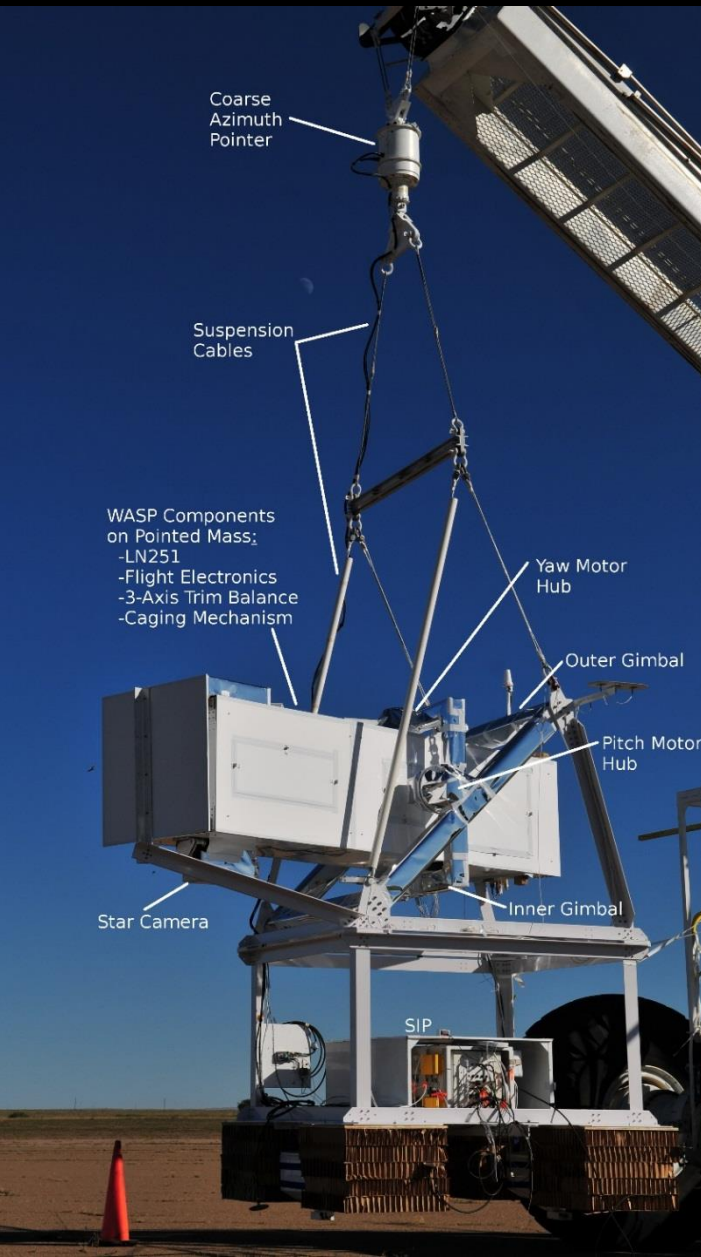
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- ❖ *WASP is a NASA developed Fine Pointing System adaptable to a variety of Science Instruments.*
- ❖ *Standardized System with Reusable Parts to Minimize the Cost to Users and NASA.*
- ❖ *Supports Multiple Science Disciplines and a wide range of Masses and Inertias.*
- ❖ *Currently Operational and Available for Science Collaborations*

WASP Functional Overview

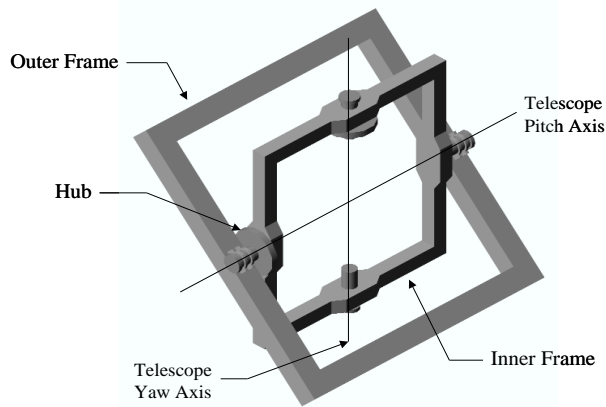
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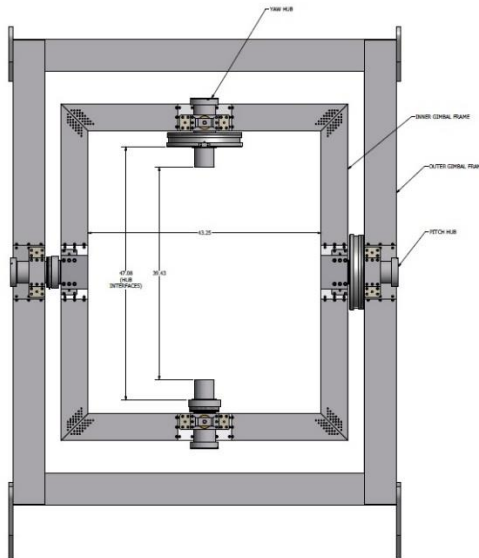
- *Rotator provides coarse azimuth pointing of gondola (to within $\sim \pm 3^\circ$)*
- *Fine instrument pointing achieved using gondola mounted pitch/yaw gimbal*
- *Two opposing gimbal hubs per axis enable sub-arcsecond stability with a design that eliminates static friction*
- *Control torque for each axis provided by large diameter brushless DC torque motor*
- *Instrument inertial attitude integrated from LN251 Fiber Optic Gyro*
- *Extended Kalman Filter (EKF) used to merge unit vectors from Star Tracker and other sources (e.g. sun sensor or science target) into integrated solution*
- *Control torques computed from modified Proportional-Integral-Derivative (PID) compensator in each axis*

WASP Standard Parts

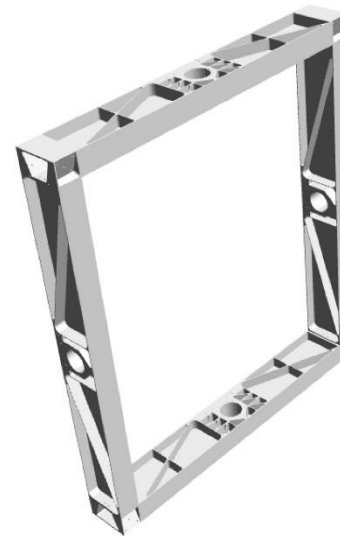
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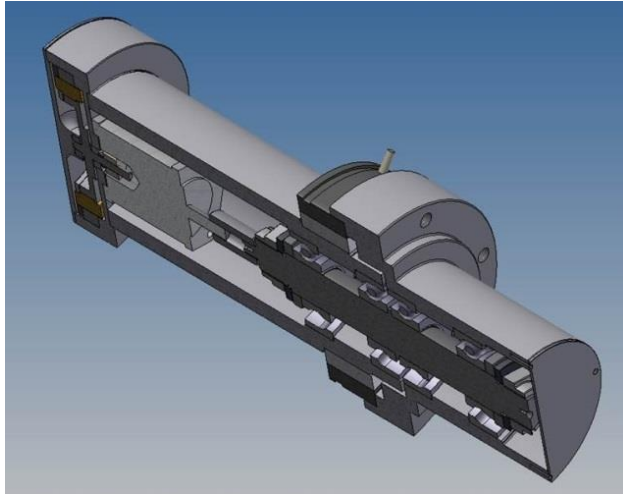
- *Gimbal Frames hold Hubs, Maintain alignment critical to minimize required torque.*
- *Outer Frame can be used as Gondola Structure.*
- *Recent Developments*
 - *Larger Inner Frame Provides full 1 meter clearance with existing Outer Frame*
 - *XL Design provides ~1.2 meter clearance and has embedded hubs to eliminate counterweights*



X-Calibur Larger Inner Frame

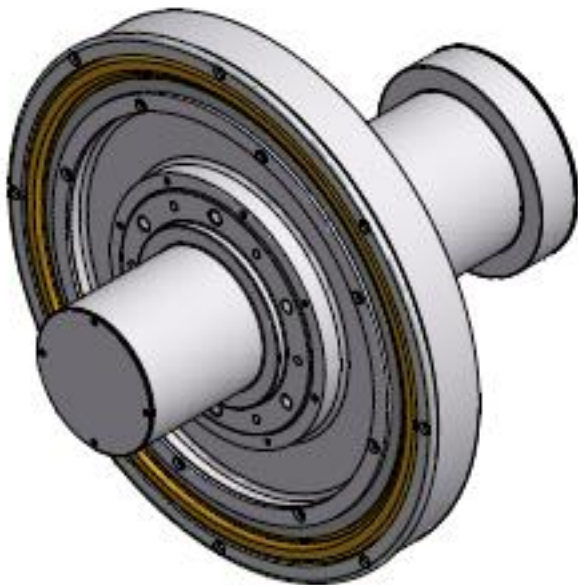


GHAPS XL Inner Frame



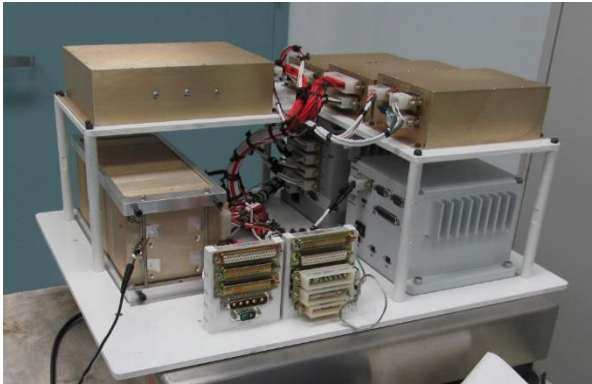
WASP Motor Hubs and Resolver Hubs

- *Each Axis uses One Motor Hub & One Resolver Hub.*
- *Constantly Rotating central shaft eliminates static friction (Stiction) when direction is reversed.*
- *Shaft Rotated with Electric Motor through Reduction Gear.*
- *Motor Hub has large diameter Torque Motor which provides the control torque.*
- *Resolver Hub has resolver which provides Angle Measurement between two halves of the Hub.*
- *Hubs support full mass of Pointed Structure and 10 G loading.*



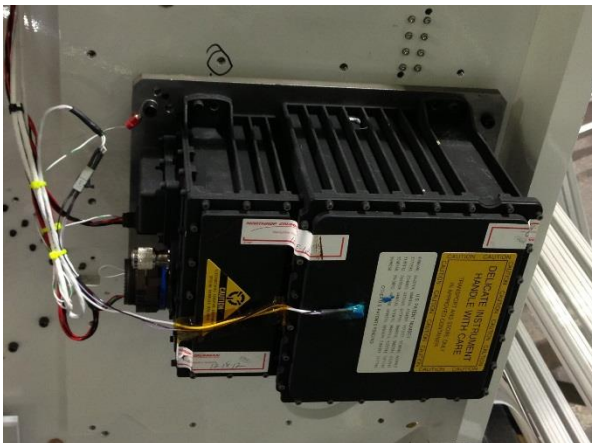
WASP Avionics Deck & Gyro

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Avionics Deck

- ~21" x ~17" aluminum deck
- *Main Flight Computer, CARDS Flight Computer, Enclosures for Resolver Interface, Power Relays, Motor Driver Interface, GPS Receiver, H-Bridge Circuits, and Housekeeping.*

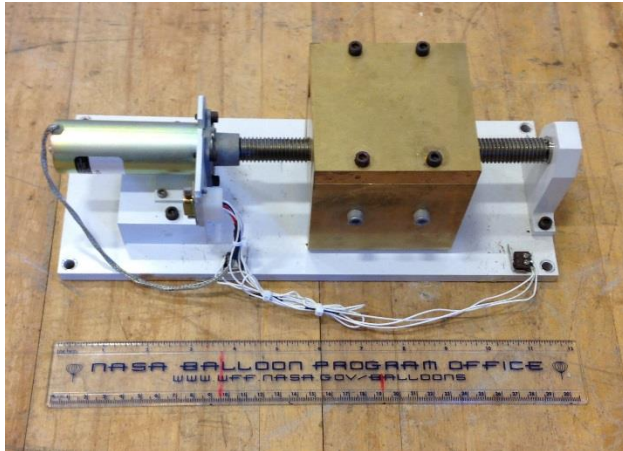


3 Axis Fiber Optic Gyro

- Northop Grumman (NG) LN-251 Inertial Navigation System
- *Used by WASP as Inertial Rate Unit (IRU).*
- *NG installed new firmware in 2016 reducing noise and improving pointing performance.*

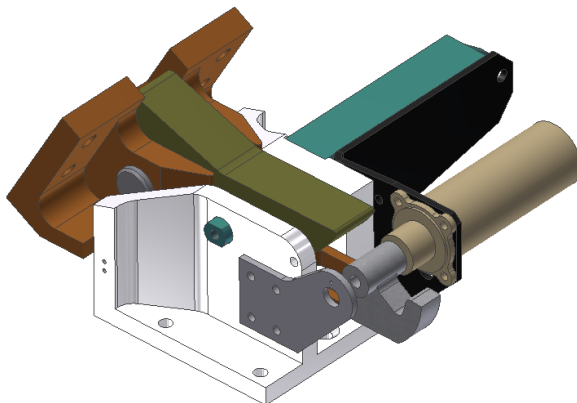
WASP Trim Weights & Latch

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Dynamic Balance Trim Weights

- *Three Dynamic Balance Trim Weights flown, one in each Axis.*
- *Commanded from Ground if needed.*
- *Brass Weight driven by small DC motor.*



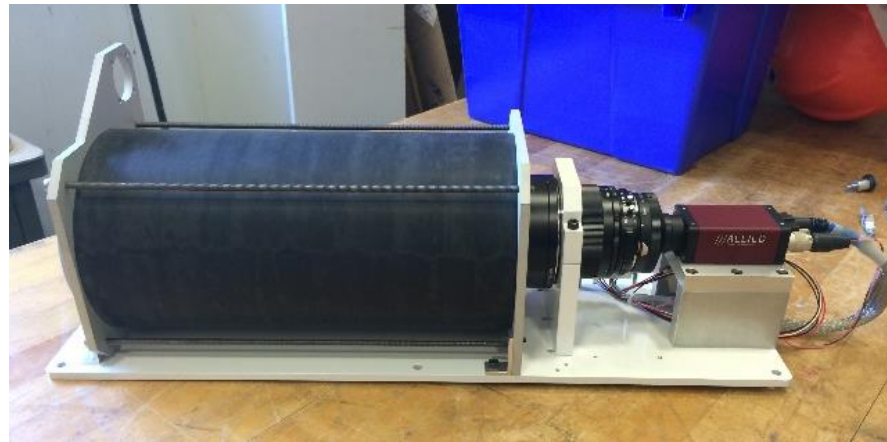
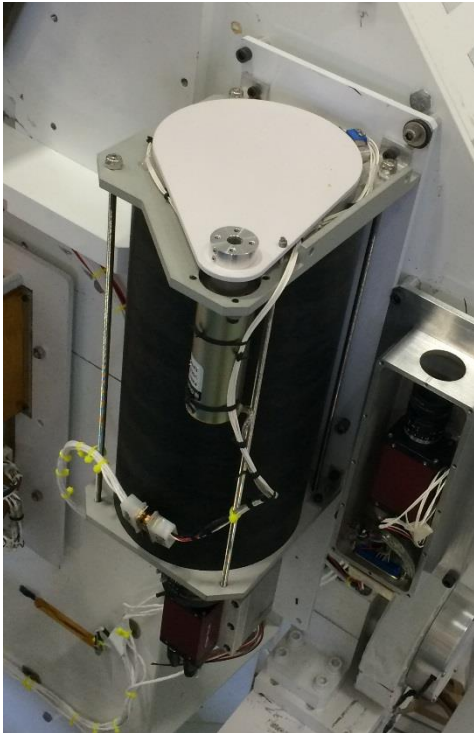
Caging Mechanism

- *Linear Actuator and electric motor driven cam provide redundant methods for releasing and recaging.*
- *Uncage - Linear Actuator shaft retracts or motor cam pushes latch hook.*
- *Cage – Shaft extended, hook spring loaded or drive into place, then extend shaft.*

WASP Daytime Star Tracker

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- **CARDS – Celestial Attitude Reference and Determination System**
 - COTS camera and processor, custom light baffle
 - Low-cost system for providing attitude inputs into WASP Control System
- **Operational specifications**
 - Point Grey Camera, 100 mm Stingray Lens, RTD flight processor
 - Field of View: 5.9 x 4.4 degrees
 - Tracking solutions: 10 Hz
 - Supplies target matched unit vectors or quaternions, depending on the application, over Async Serial or Ethernet interface



WASP Test Flights

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Test Flight 1 Gondola

- *5 Test Flights conducted between 2011 and 2014*
- *All 5 from Fort Sumner, New Mexico*
- *Three Flights included Science Instruments*
 - *2 flights with LASP Earth Science (HySICS)*
 - *1 flight with GSFC Planetary and Exoplanet Science (OPIS)*
- *All 5 demonstrated arc-second pointing*



WASP HySICS Gondola



Test Flight 2 at Float

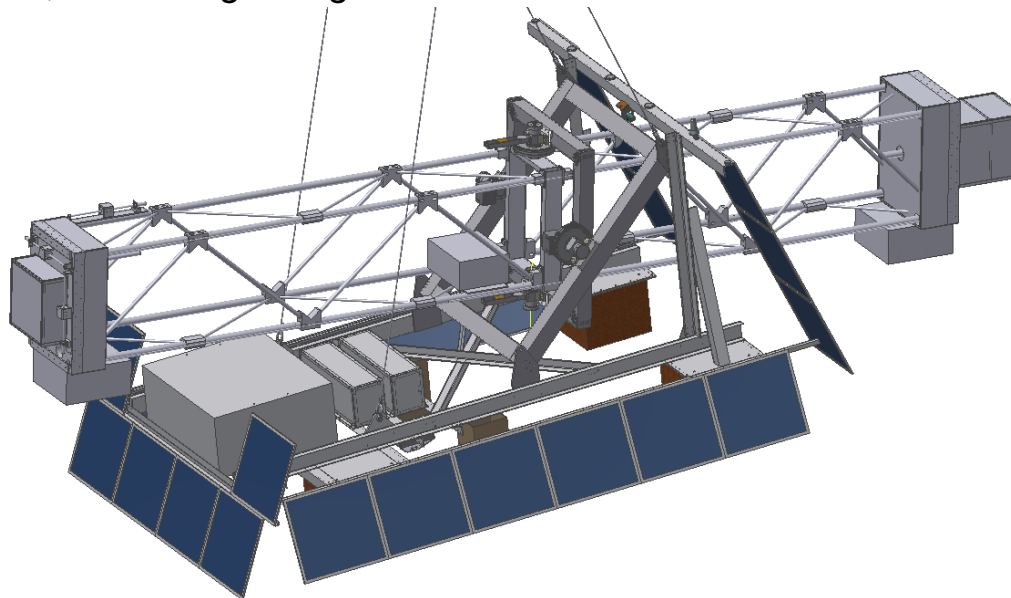


HySICS Yaw Scan Image
of Moon

X-Calibur Science Flight

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- *First Science Mission with WASP*
- *PI Henric Krawczynski, Washington University in St. Louis (WUSTL)*
 - *Measure Linear polarization of hard X-rays in the energy range of 25-70 keV.*
 - *255 shell X-ray focusing mirror and a rotating Polarimeter.*
 - *Rigid truss to maintain alignment between mirror and the detector 8 meters away*
 - *Pointing Requirements*
 - *Compute attitude with knowledge uncertainty within 30-asec (3-sigma)*
 - *Hold X-ray mirror boresight to target within 30-asec (3-sigma)*
- *September 17, 2016, flight duration 24 hours and 37 minutes*
 - *Fort Sumner, NM. Longest flight of WASP to date*



**X-Calibur Design
with Antarctic Flight
Solar Panels**

X-Calibur Science Flight

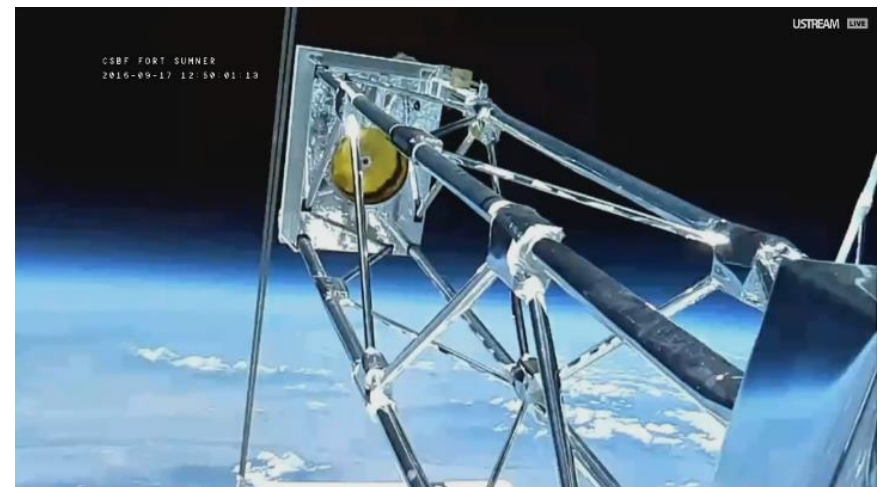
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**X-Calibur High Elevation Pointing
Test at Fort Sumner**



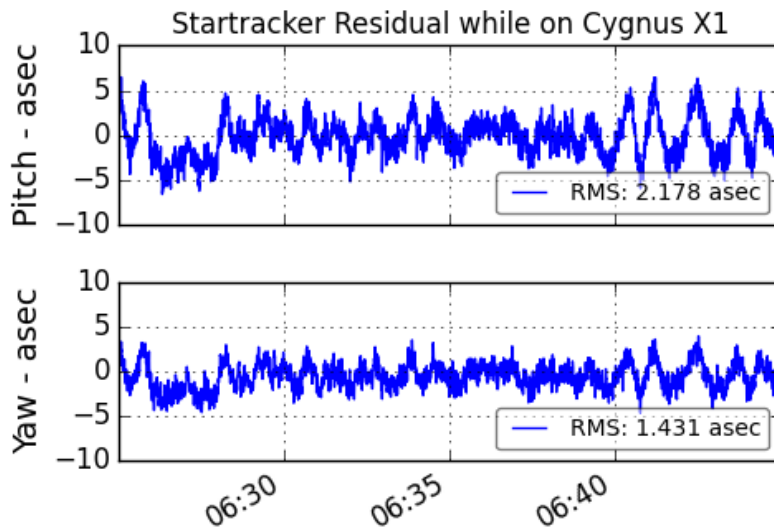
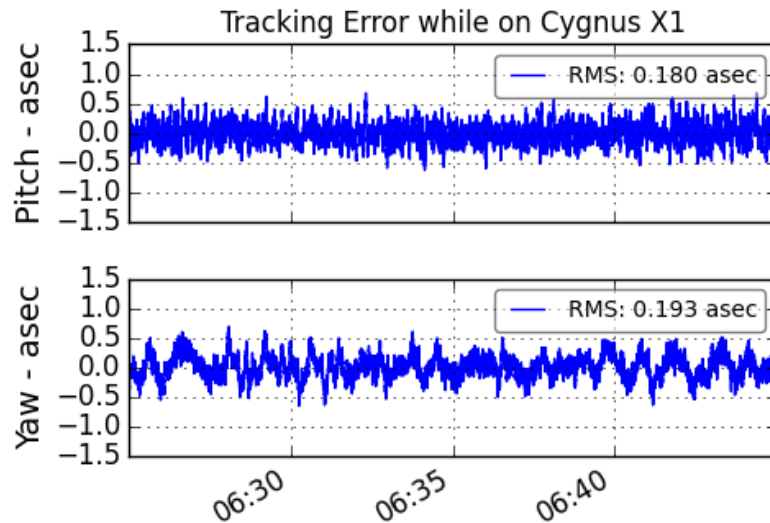
X-Calibur on Launch Vehicle



X-Calibur Pointing during Flight

X-Calibur Pointing Performance

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- Tracking errors consistent with preflight simulation and ground testing – sub-arc second.
- Star Tracker Residual provide indication of attitude estimation errors that contributes to absolute pointing error
- Roll coupling into pitch/yaw axes indicative of misalignment between Star Tracker and Inertial Rate Unit
- Able to identify misalignment by batch processing 5-10 min segments of flight data
- Post Flight Improvements
 - Misalignment correction technique ground tested that eliminates roll coupling.
 - New centroid algorithm ground tested that improves daytime performance with high ambient background levels.
 - Both to be tested on 2017 WASP Test Flight.

WASP 2017 Test Flight

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- Combined with CSBF LDB Test Systems
- Includes refurbished parts of X-Calibur, OPIS, and Test Flight Two
- Evaluate daytime Star Tracker performance improvements.
- Evaluate flight prototype GHAPS Baffle for star tracker.
- Evaluate GHAPS configuration of modified WASP Avionics mounting locations.
- Sept. 2017 Fort Sumner

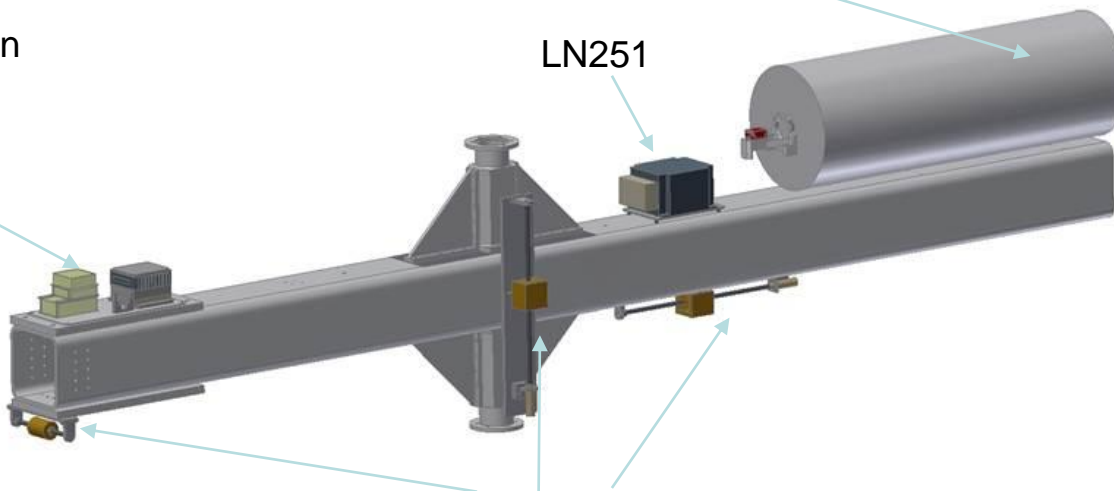
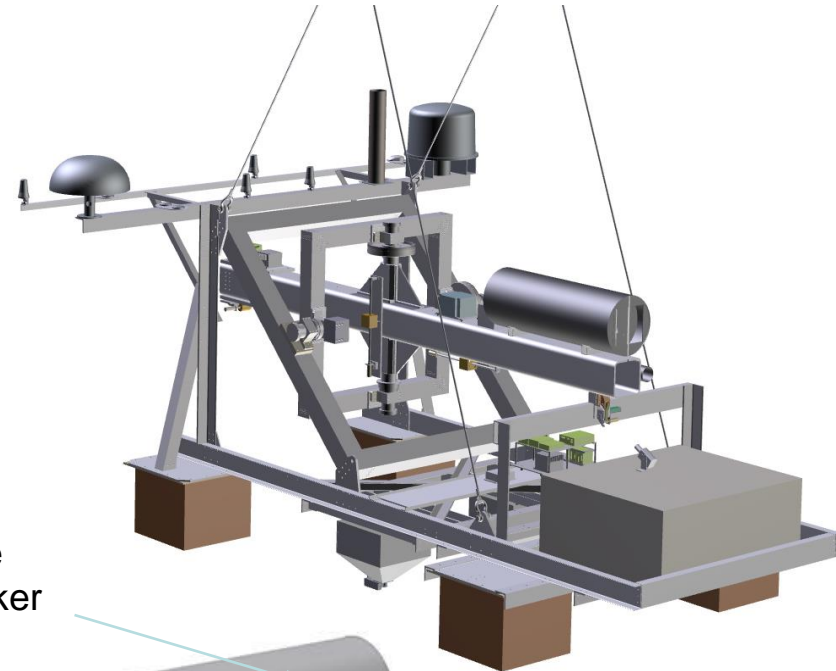
WASP Avionics in
GHAPS OTA
Configuration

GHAPS Baffle
and Star Tracker

LN251

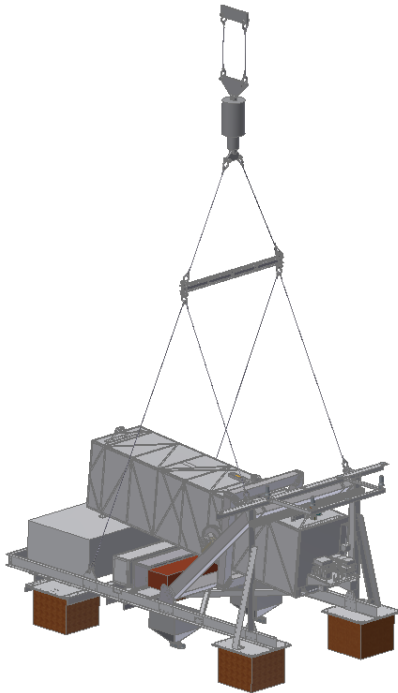
10" square steel
tube used on TF1
and TF2

Trim Weights



Current WASP Mission Support

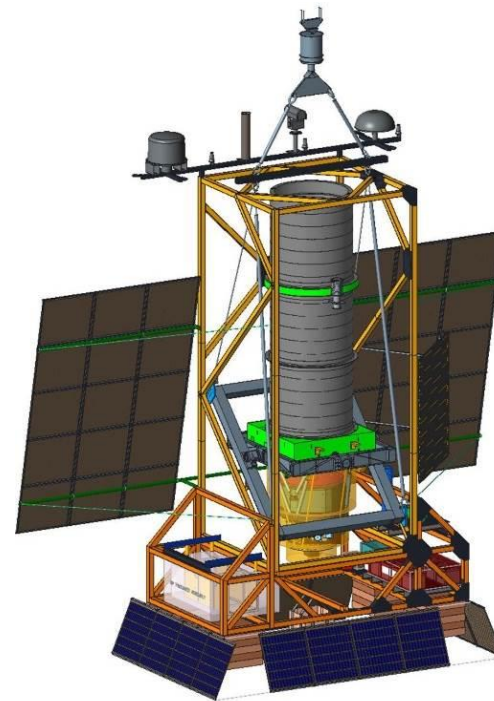
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PICTURE-C

Planetary Imaging Concept Testbed Using a Recoverable Experiment – Coronagraph

- PI Supriya Chakrabarti U Mass Lowell (UML)
- 60 cm Telescope with Coronagraph to Image Debris Disks of Nearby Systems
- Flights planned for 2018 and 2019.



GHAPS

Gondola for High Altitude Planetary Science

- NASA – GRC, MSFC, GSFC, WFF
- Developing a Reusable Gondola Platform for Planetary Science Instruments
- One Meter optical telescope, UV, IR, visible
- Initial flight planned for 2020.