



WISE Science Data System Frame Co-addition Peer Review: Introduction and Overview

R. Cutri and the WSDC Team @ IPAC



Review Panel



- Sean Carey (IPAC/SSC)
- Nick Gautier (JPL/WISE Science Team)
- John Good (IPAC/IRSA)
- Russ Laher (IPAC/SSC)
- Dave Shupe (IPAC/NHSC)



Charge to Panel



The peer review panel is asked to comment on the following specific questions:

- Does the design of Frame Co-addition program address the requirements on the system?
- Are the Frame Co-addition algorithms suitable and appropriate to carry out the system functions?
- Is the design robust to circumstances that will be encountered with the WISE data?

In addition, comments are welcome on other aspects of the design.





What Is WISE?



- A NASA Medium Explorer (MIDEX) Mission
- The Wide-field Infrared Survey Explorer (WISE)
 - An all-sky survey at 3.3, 4.7, 12 & 23 μm with 3 to 6 orders of magnitude more sensitivity than previous surveys
 - A cold 40 cm telescope in a sun-synchronous low Earth orbit
 - 6'' FWHM (12'' at 23 μm)
 - Enabled by Megapixel infrared detector arrays
- WISE will deliver to the scientific community
 - An Image Atlas containing $\sim 500,000$ calibrated, rectified images covering the whole sky in 4 infrared bands
 - A Source Catalog of $\approx 5 \times 10^8$ objects seen in these 4 IR bands



WISE Milestones



- WISE was initially proposed as NGSS in 1998
 - Selected for Phase A study, but not flight
- Re-proposed in 2001
- Initial Confirmation Review 2004 August 25
- Mission Confirmation Review 2006 October 13
- Mission CDR 2007 June 18 - 21
- MOS CDR 2007 July 18-19
- Launch November 2009
 - 1 month IOC
 - 6 months survey (baseline - 12 months Phase F)
- Final catalog 17 mos. after end of survey



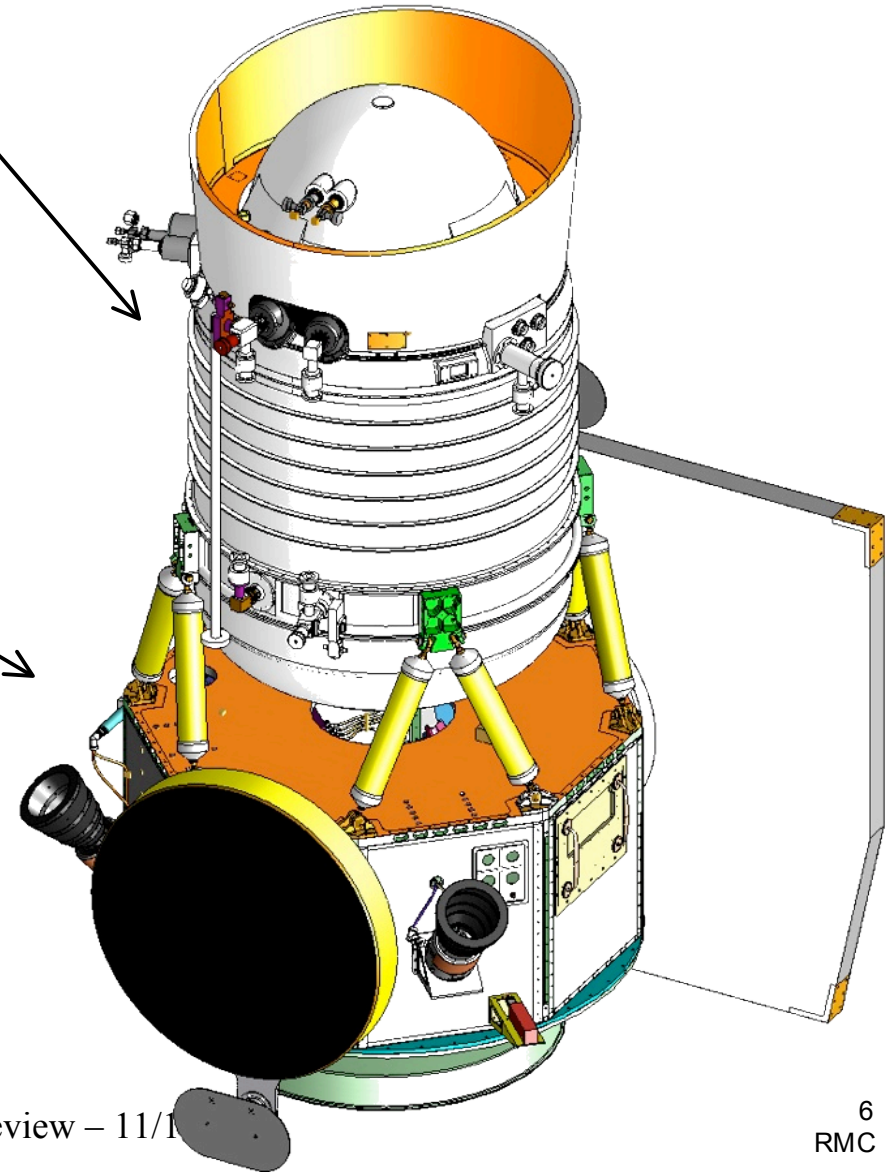
Flight System

Payload (Space Dynamics Lab)

- 2-Stage Solid H₂ cryostat
 - 13.5 months life time (7 required)
- All aluminum reflective optics: <17K
 - 40-cm telescope
- Dichroic beamsplitters separate wavelengths onto four 1024² pixel arrays (2.75"/pix)
- 2 HgCdTe detectors: 3.3, 4.7 microns (32K)
- 2 Si:As detectors: 12, 23 microns (7.8K)
- 3 electronics boxes (mounted in spacecraft)

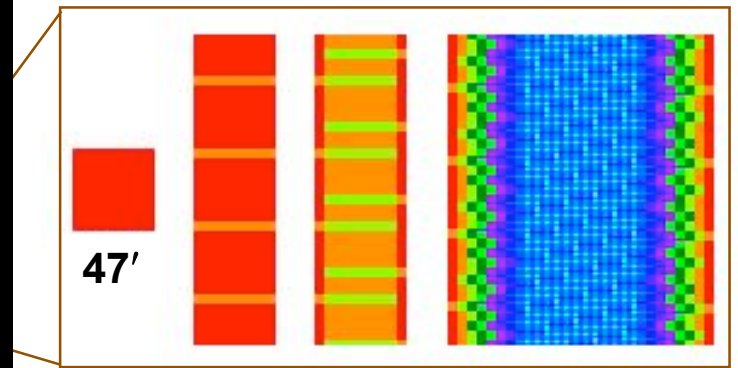
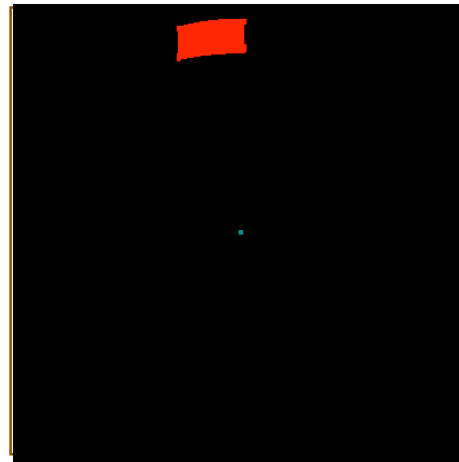
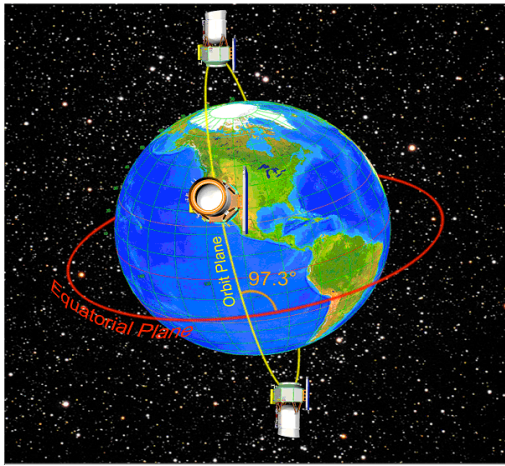
Spacecraft (Ball Aerospace)

- Orbital Express architecture
- Augmented single string
- No mechanisms, no deployables, no propulsion
- 3-axis stabilized
- Pointing stability/accuracy: ~ 1"/~1'
- Ku band science data link: 100Mbps
- 3.5 days (96 GB) of science data storage





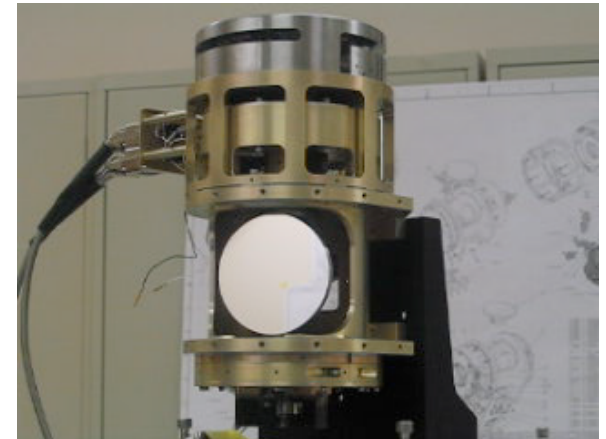
Simple Mission Design



1 frame 1 orbit 2 orbits Many orbits

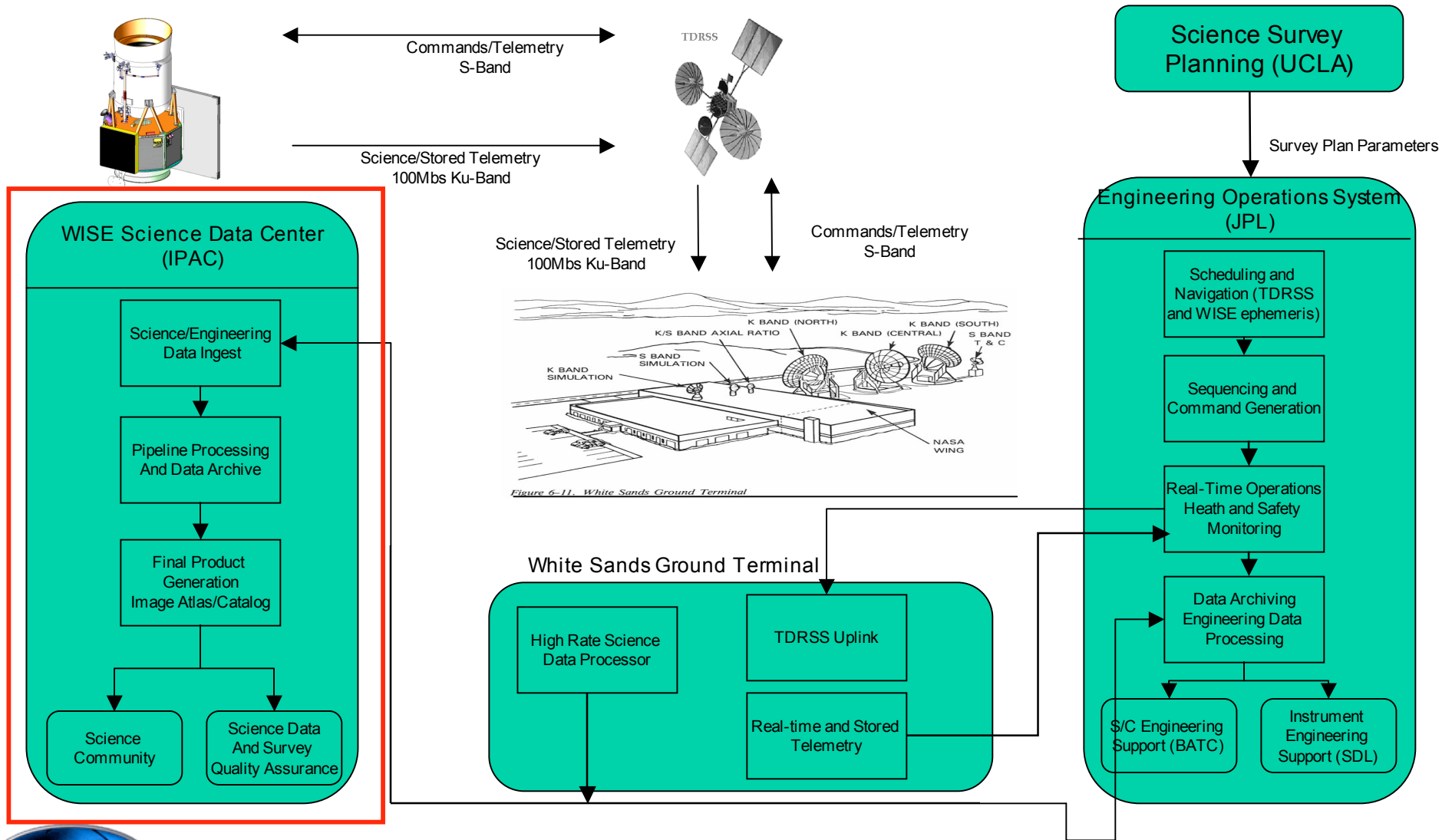
- Delta 7320 launch – WTR
- 523 km, circular, polar sun-synchronous orbit
 - Nodal crossing time 6:00 PM
 - One month of checkout
 - 6 months of survey operations
- One simple observing mode – half orbit scan

- Scan mirror “freezes” orbital motion enabling efficient mapping
 - 8.8-s exposure/11-s duty cycle
 - 10% frame to frame overlap
 - 90% orbit to orbit overlap
- Expect to achieve at least 8 exposures/position after losses to Moon and SAA
- Uplink, downlink, calibrations at poles
 - 4 TDRSS tracks per day





MOS Architecture





Data Product Requirements



WISE Source Catalog Requirements		
Reliability	>99.9%	SNR>20; unconfused
Completeness	>95%	SNR>20; unconfused
Photometric Accuracy	<7%/band	SNR>100; unconfused
Photometric Sensitivity	3.3 μ m: 0.12mJy 4.7 μ m: 0.16mJy 12 μ m: 0.65mJy 23 μ m: 2.6mJy	SNR=5
Astrometric Accuracy	0.5'' RMS wrt 2MASS PSC	

WISE Image Atlas Requirements	
Coverage	Constructed by combining all available images in each band
Band Registration	Four bands resampled to common pixel grid and scale
Calibration	Tied to Source Catalog
Format	Standard FITS





IPAC is the WISE Science Data Center (WSDC)



- **Science Data Processing**
 - Convert raw imaging and engineering data into a photometrically and astrometrically calibrated Image Atlas and extracted Source Catalog
 - Compile Explanatory Supplement to the WISE Data Products
 - Generate ancillary data products to support mission requirements
- **Science Data Quality Assurance**
 - Quicklook QA feedback for on-orbit performance (i.e. scan mirror synch)
 - Overall science data QA for survey planning, data product generation and characterization
- **Science Data Archiving and Distribution**
 - Raw data (Level 0) archive during mission
 - Long-term “living” archive for primary and intermediate data products
 - Serve WISE science data products to project team, astronomical community and general public along with user’s guide documentation and descriptive analysis

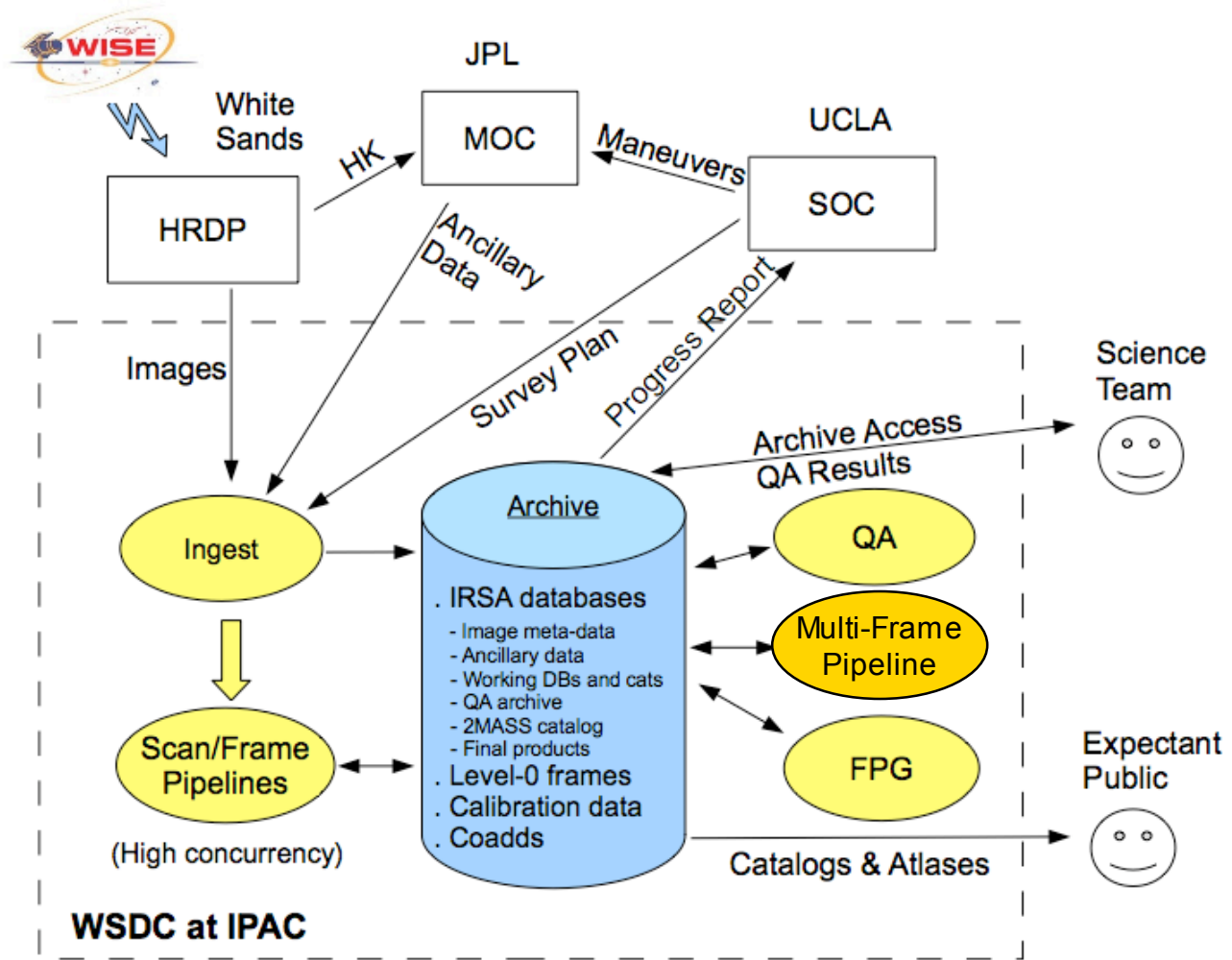




WISE Science Data System (WSDS) Executes Functions of the WSDC



WSDS Functional Block Diagram





WSDS Consists of Six Key Subsystems

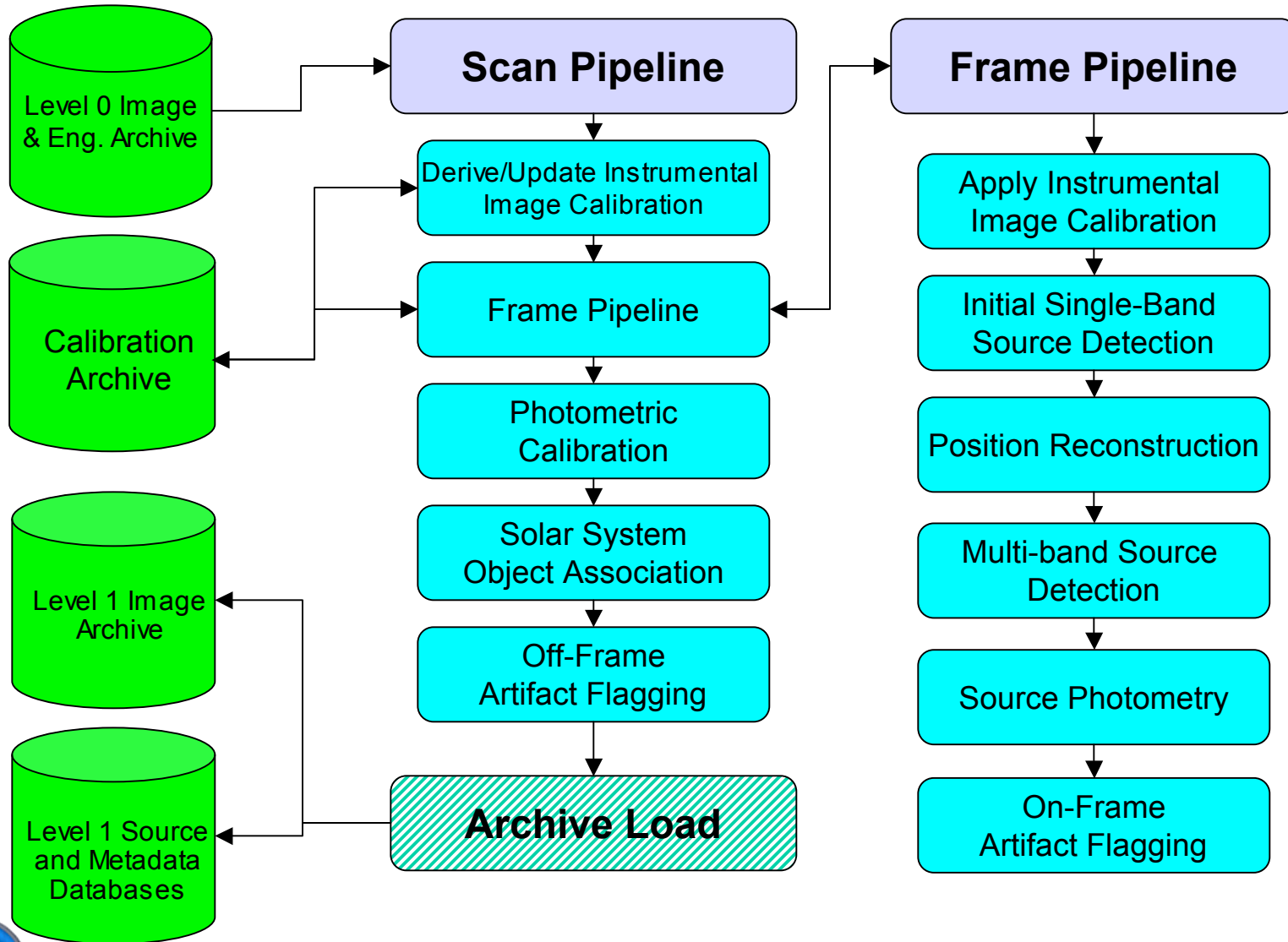


- **INGEST**
 - Autonomous receipt of science data packets and engineering telemetry from MOS, decompresses and assembles Level 0 FITS-format files. Stages Level 0 images and metadata for pipeline processing.
- **Data Reduction PIPELINES**
 - Highly automated conversion of Level 0 imaging data into calibrated *Image Archives* and extracted source *Working Databases*
 - **Frame/Scan pipeline** operates on individual frames within one “scan” (=1/2 orbit)
 - **Multi-frame pipeline** combines and operates on data from multiple orbits
- **Quality Assurance (QA)**
 - Tracks and summarizes science data quality using summary outputs from other subsystems. Concise, web-based reports with capability to drill-down to detailed image, graphical and tabular data
 - Reports reviewed by QA scientists at WSDC. Final quality assignment approved by PI or designee
- **EXEC**
 - Pipeline initiation, management and monitoring
 - Application wrappers, parameter interfaces, process status, error handling
- **ARCHIVE/Distribution System**
 - Archives raw and processed mission data and metadata.
 - Provides interface to *Image Archive*, *Working Databases* and metadata for WISE Project Team, and Image Atlas, Source Catalog and mission metadata for astronomical community.
 - Integrated into Infrared Science Archive (IRSA) at IPAC
- **Final Product Generator (FPG)**
 - Constructs WISE Preliminary and Final Image Atlas and Source Catalog from coadded *Image Archive* and source *Working Databases*. Includes validation, characterization and documentation



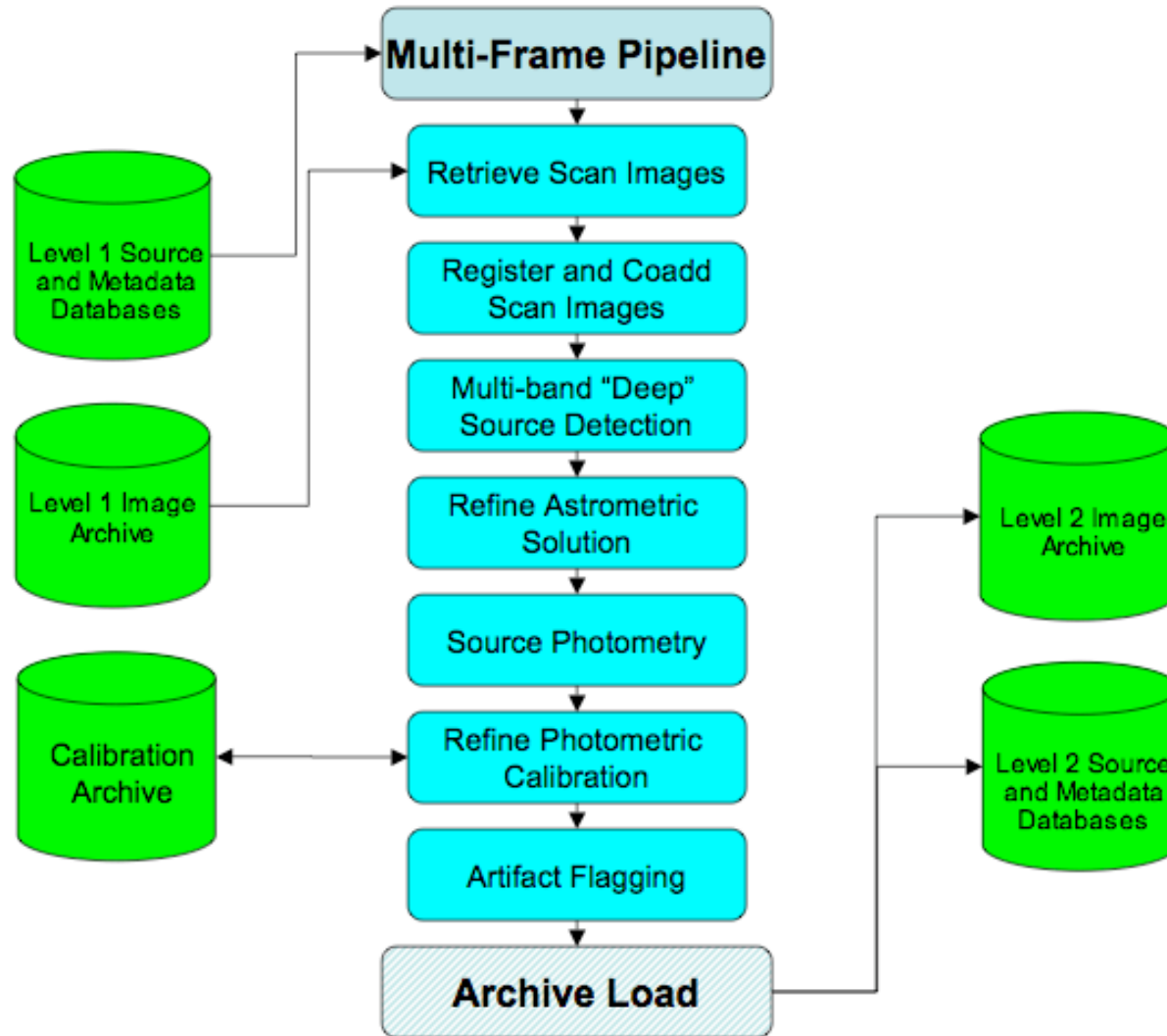


Scan/Frame Pipeline Reduces Data From Each Half-Orbit



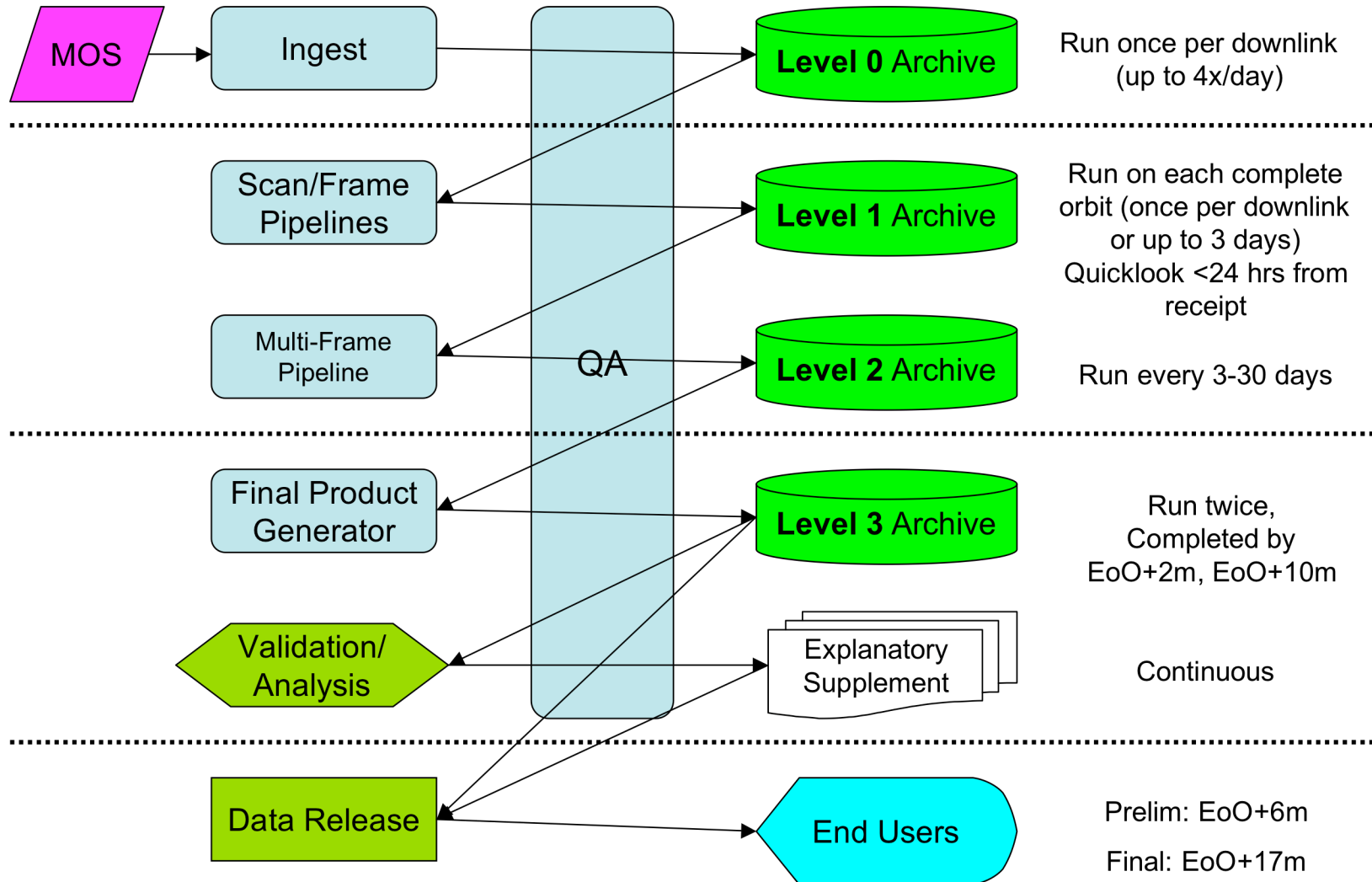


Multi-Frame Pipeline Combines Data From Multiple Scans/Frames





WSDS Data Flow and Operational Cycle





National Aeronautics and Space
Administration
Jet Propulsion Laboratory
California Institute of Technology



Back-up Slides





Level 1 Requirements



Baseline Minimum Requirement
Four bands centered within 10% of 3.3, 4.7, 12, and 23 microns Three bands between 2.2 and 50 microns
At least 4 independent exposures in each filter over at least 95% of the sky 2 exp. over 90 %
SNR 5 on 0.12/0.16/0.65/2.6 mJy at 3.3/4.7/12/23 microns
Digital image atlas combining multiple exposures at each sky position same
Catalog of sources associated with image atlas same
Reliability > 99.9% for SNR > 20 same
Completeness > 95% for SNR > 20 > 90%
<7% relative photometric accuracy for SNR > 100 <10 %
Position error <0.5" wrt 2MASS for SNR > 20 < 1.0"
Include sources to SNR 5 in any band, characterize completeness and reliability at all flux levels
Image atlas and catalog publicly available via IRSA within 17 months of end of on-orbit data collection
Survey sky for at least 6 months following checkout
~500 km Sun Synchronous 6am/pm Polar Orbit via Delta II 7320
Launch any day of year; launch readiness in November 2009
Compatible with data return through TDRSS
\$299.3 M RY\$ project funding
Use WTR, GSFC, TDRSS, IRSA
Conduct an E/PO program
Images available for outreach purposes within 1 month of start of normal operations





Level 1.5 Science Requirements



- **Bandpasses:**
 - 2.8 (but up to 3.2) to 3.8 μm
 - 4.1 to 5.2 μm
 - Centered at 12 μm ; bandwidth 6 to 9 μm
 - 20 to > 25 μm
- **Out of band response** $< 1\%$ of in-band response for
 - All bands for A0 star (goal B0), 800K BD (Band 1), and Class 2 circumstellar disk (Bands 2 and 3)
- **Sensitivity allocations:**
 - Effective confusion noise: 63/62/344/950 μJy in bands 1/2/3/4
 - Payload: 102/147/551/2420 μJy in bands 1/2/3/4
- Time interval between first and last exposure at a sky position > 30 minutes
- Image Atlas registered to $0.5''$ relative to 2MASS
- Image Atlas photometric calibration tied to catalog
- **Saturation** $> 0.11/0.06/0.25/0.3$ Jy in bands 1/2/3/4
- Preliminary Catalog (first 50% of survey to SNR 20) within 6 months of end of survey

