WISE Science Data Center Overview

R. Cutri - IPAC

October 7-8, 2009
WSDC Responsibilities

• Data Ingest
  – Receive raw science image packets from White Sands and engineering telemetry from MOS
  – Decompress and assemble image data into Level 0 FITS format, and mate with engineering telemetry

• 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
  – Provide rapid QA feedback for selected on-orbit performance (i.e. scan mirror synch)
  – Overall science data QA for survey assessment and data product generation and validation

• Science Data Archiving and Distribution
  – Archive raw data (Level 0) during mission, deliver to NSSDC at end of mission
  – Provide an operational archive to store and serve intermediate data products and metadata to project team during mission
  – Provide a long-term “living” archive that stores and serves WISE science data products to the astronomical community and general public along with user’s guide documentation and descriptive analysis
WISE Primary Science Data Products

• **WISE Image Atlas**
  - Formed by combining all image frames covering each point on the sky
  - ~73,000 calibrated, FITS format, 4 bands registered, 4kx4k pix @ 1.375”/pix.
  - Metadata describing each Atlas Image including depth-of-coverage and noise maps

• **WISE Source Catalog**
  - ~300 million entries containing attributes of each object detected on combined (Atlas) images
  - Positions and uncertainty error ellipses, fluxes, uncertainties and flux upper limits
  - Source detection and measurement quality flags and parameters (e.g. detection statistics, reliability estimate, photometric quality, confusion and contamination)
  - Additional information to enhance usability (e.g. association with 2MASS)

• **Explanatory Supplement**
  - Mission and data product description
  - User’s guide (e.g. data formats, access modes)
  - Cautionary notes
WISE Science Data System (WSDS)
Comprised of Six Subsystems

• **INGEST**
  – Receives science data packets, engineering telemetry and NAV products from MOS and assembles Level 0 FITS-format files. Stages Level 0 images and metadata for pipeline processing.

• **Data Reduction PIPELINES**
  – Converts Level 0 imaging data into calibrated images and extracted source *Working Databases*
    • **Frame/Scan pipeline** operates on individual frames within one “scan” (=1/2 orbit)
    • **Multi-Frame pipeline** operates on data from multiple scans

• **Quality Assurance (QA)**
  – Generates concise reports summarizing science data quality using summary outputs from other subsystems. Web-based report, 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**
  – Provides interface-related services to wrappers and pipelines. Mediates between external callers and applications, providing a uniform interface, binding execution units (modules) together into a unified pipeline

• **ARCHIVE/Distribution System**
  – Archives raw and processed mission data and metadata. Serves Image Atlas, Source Catalog and mission metadata to WISE project team and astronomical community. Integrated into Infrared Science Archive (IRSA) at IPAC.

• **Final Product Generator (FPG)**
  – Constructs WISE Preliminary and Final Image Atlases and Source Catalogs from *combined* image and source *Working Databases*. Includes validation, characterization and documentation.
Operational Data Processing Phases

• Provisional
  – IOC to L+3m
  – WSDS v3.2.x
  – Uses pre-launch calibration and instrument characterization
  – Supports IOC activities, early mission ops, Quicklook QA

• First Pass
  – L+3m to End of on-orbit ops+6m
  – WSDS v3.5
  – Uses initial on-orbit calibration and instrument characterization
  – Support Mission ops, Quicklook QA, FPG for Preliminary Data Release

• Second Pass
  – End of on-orbit ops+5m to End of on-orbit ops+17m
  – WSDS v4
  – Uses best calibration and instrument characterization derived from first-pass processing
  – Supports FPG for Final Data Release
WSDC Top-Level Schedule

Operational Readiness Review – October 7-8, 2009
WSDC IOC and Operations
Functional Assignments

Management
Lead – Cutri
Financial – Kennedy
IRSA – Teplitz, Groom
ISG - Burt

IOC/Early Ops
Coordinators – Wachter, Masci
Boresight – Grillmair, McCallon
Scan Rate Cal – Kirkpatrick, Gelino, Fajardo-Acosta
Anneal – Padgett
Linearity – Kirkpatrick, Masci
Inst. Cal. – Masci, Padgett, Wachter
PSF Determ. – Marsh, Grillmair
Distortion – McCallon, Fowler
Latent Char. – Padgett, Liu, Alles
Phot. ZP – Wheelock, Cutri

Pipeline Tuning/Dev
Lead – Conrow
INGEST - Conrow
ICAL – Masci, Fowler
MDET – Marsh
PREX – McCallon, Fowler
WPHOT – Marsh, Jarrett. Evans
PCAL – Wheelock
ARTID – Alles
SSOID – Fowler, Tholen
NEOWISE – Dailey, Bauer
QA – Brandenburg, Lungu

Ingest/Processing Operations
Coordinator – Beck
Team – Barba, Lungu, Wyatt

QA Operations
Lead – Kirkpatrick
QA Thresholds – Gelino, Fajardo-Acosta
Ops – Bauer, Dailey, Fajardo-Acosta, Gelino, Grillmair, Hoffman
Kirkpatrick, Liu, Padgett, Tsai, Wachter

Archive
Lead – Yan
DB Prep – Evans, Wheelock
DBA – Rey
Interfaces – Monkewitz, Paredes, Zhang

Hardware System
Coordinator – Brandenburg
Conrow

Science Analysis/Validation
Coordinator – Cutri
Team – Bauer, Gelino, Grav, Fajardo-Acosta, Grillmair, Hoffman
Jarrett, Kirkpatrick, Liu, Marsh, Masci, Padgett, Tsai, Wachter,
Tools – Evans, Wheelock

• Presenting today
• IPAC management
Changes Since CDR

- **Ground test data archive** established for deposit and retrieval and storage of payload ground test data and large simulations.
- **Profile fitting photometry** fully implemented into WSDS for source characterization
- **Instrument characterization scientists** added to staff to conduct analyses of payload ground test and on-orbit data
- **Revised launch date**
- **Extended mission operations period** and corresponding increase in storage and processing capacity to accommodate expanded data volume
- **NEOWISE** augmentation to develop solar system-friendly archive and new moving object identification (no direct impact on baseline mission activities)
WSDC Will Be Ready to Support Dec. 7 Launch

- Staffing completed this month, IOC/Ops staff assignments made
- Required WSDS functionality in place to support IOC and nominal survey operations
  - Performance validated with high-fidelity simulations of sky data combined with detector characteristics from payload testing
  - Final Product Generator process defined and implementation to start in February
- IOC and Survey Ops interfaces and operations tested in conjunction with Project
- Final processing system hardware upgrade this month
  - Processing performance demonstrated to meet survey ops needs
- Archive system design complete; hardware implementation underway; query interfaces prototyped and operational version deliveries scheduled
- Operations procedure document drafts in place
- External and internal interfaces in place and tested
- Requirements, design, interface documents up to date
Data Processing Status

- Pipeline and algorithm design and operations are being tested using WISE data simulations provided by PI Ned Wright
- Evolving fidelity
  - Realistic sky scenes based on Spitzer source counts, asteroids, zodiacal background, cirrus emission, rad hits, satellites
  - Latest instrumental characteristics based on SDL payload testing (e.g. dark images, responsivity, detector noise, latent decay)

- Simulations:
  - “70 frameset” – full-depth coverage in one coadd area (~3deg2)
  - 30 orbit simulations – represent two days of survey image data with realistic flight system maneuvers
  - Smaller, focused simulations for analysis of fixed-pattern noise, IOC testing (scan-rate synchronization, linearity, etc)
Data Processing Status

• ORT-2 – Aug. 28, 2009
  – IOC test – simulated boresight alignment and scan-rate calib. tests
  – Ingest, Quicklook QA, IOC analysis tests completed
  – Processed C-kernel problems identified and corrected

• ORT-3 – Sep. 21, 2009
  – Survey ops test – two days of nominal operations
  – 8 MOS/HK and Science Image data transferred
  – Ingest, Quicklook QA, Scan/Frame Processing and QA
  – Survey coverage reports sent to SOC/MOS

• End-to-end Data Transfer Testing – ongoing
  – Test transfer from HRP to WSDC of data sets of various sizes
  – Interface and transfer rate testing
Science Performance Status
Instrumental Calibration

Band 3

Raw

Dark Calibration

Dark-subtracted

Responsivity Map

Final Frame
Science Performance Status
Image Coaddition

Single W1 frame  Coadded W1 Region  Depth-of-coverage Map
Photometric residuals with respect to Simulation Input Catalog

Photometric accuracy as a function of Simulation Input Catalog flux
Science Performance Status
Astrometry

2MASS–WISE Residuals
Coadd 1991m106
(\(\alpha, \delta = 199.13^\circ, -10.584^\circ\))

\(\sigma_{\text{RA}} = 0.24''\) \(\sigma_{\text{Dec}} = 0.21''\)
Science Performance Status Completeness

Detection completeness as a function of Simulation Input Catalog flux (W3)
Final Product Generation

Human analysis and database-intensive activity to generate, characterize and validate release Source Catalog and Image Atlas from L3 source Working Database and Coadded Image archive (not a discrete software subsystem)

• Required for preparation of Preliminary and Final Release data products, but not required for support of IOC or on-orbit operations
  – Implementation and testing begin 2/10 using flight data processing results

• FPG performed prior to data releases:
  – Begins 6/10 for Preliminary Release; 7/11 for Final Release

• Procedure has been defined
  – Follows prescription developed for 2MASS
  – Will be amended as necessary in response to WISE on-orbit performance
Final Product Generation Procedure

• Select frames/scans to include in Data Release based on data quality scores, sky coverage considerations

• Run Multi-Frame pipeline on selected images
  – Generate coadded (L3 - Atlas) images, extracted source Working DB, metadata
  – Source WDB contains detections of real sources as well as spurious detections of noise, image artifacts, residual transients

• Source Catalog tasks
  – Select subset of entries in WDB that satisfies reliability requirement (SNR, artifact flagging, N/M, chi-squared)
  – Define final Catalog schema and derive new columns, if necessary

• Image Atlas tasks
  – Define final FITS headers, image metadata and derive new parameters, if necessary

• Stage products in WISE/IRSA public access area
• Characterize and validate release products relative to mission requirements
• Prepare user documentation

Operational Readiness Review – October 7-8, 2009
WSDC Document Status

• WSDC Document tree accessible on-line at:
  
  http://web.ipac.caltech.edu/staff/roc/wise/docs/wsdc_document_tree.html
  

• L4 Requirements up to date
• Management plan documents at v1.0 or later (PDMP, SMP, QA Plan, Archive Plan)
• All Subsystem Design documents at v1.0 or later
• 60 Subsystem Interface Specs in place
• Ops Procedure documents in draft
Key Tasks Remaining Before Launch

- WSDS v3.2 deployment
- Artifact identification modules in scan/frame and multi-frame pipelines
- Finalize all ops procedures documents
- Finalize filtering criteria to exclude from processing data taken during maneuvers and when in SAA
- Exercise raw telemetry back-up and off-site storage
- Continue data transfer testing from HRP
- Continue to exercise IRSA archive loading operations
Backup Slides
WSDC is Part of MOS Architecture

Operational Readiness Review – October 7-8, 2009
WISE Will Also Produce Several Ancillary Products

• **Known Solar System Object Association List**
  - Asteroids, comets, planets and planetary satellites, known at time of WISE launch, predicted to be within each WISE image FOV
  - Positions and fluxes of WISE detections positionally associated with predicted object positions

• **Moving Object Tracklets (NEOWISE)**
  - Position/time pairs of candidate moving objects identified by linking non-inertial detections in individual WISE image frames
  - Published to Minor Planet Center within ~20 days of mid-point of WISE observations for initial orbit determination

• **WISE Single-Epoch (Level 1b) Images (NEOWISE)**
  - Calibrated single-exposure frames in 4 WISE bands
  - ~5.7e6 FITS format images, 1kx1k pix @ 2.75”/pix; intensity, noise and bit-mask images

• **WISE Single-Epoch Detection Database (NEOWISE)**
  - ~1.5e10 entries containing basic attributes of objects detected on single-exposure WISE images
  - Useful for time-domain studies such as source variability, motion, solar system object precovery
Science Performance
Photometry

Operational Readiness Review – October 7-8, 2009
Science Performance
Photometry

W3

WPRO multi-frame
(Nblend = 1)
(Nblend > 1)

WPRO multi-frame
WAPPco multi-frame
Requirement (N=8 & 12; 5-σ)

Operational Readiness Review – October 7-8, 2009
Science Performance Status Completeness

W1 1991m106_Z_ORT3 Cumulative Completeness, 3" match radius

SNR = 20

95% Completeness

Operational Readiness Review – October 7-8, 2009
Science Performance Status Completeness

W2 1991m106_Z_ORT3 Cumulative Completeness. 3'' match radius

95% Completeness

SNR = 20

Operational Readiness Review – October 7-8, 2009
Science Performance Status
Completeness

W3 1991m106_ZORT3 Cumulative Completeness, 3'' match radius

95% Completeness

SNR = 20

Operational Readiness Review – October 7-8, 2009