Wide-field Infrared Survey Explorer (WISE)

Project Data Management Plan

Draft 2

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1 INTRODUCTION

The Wide-field Infrared Survey Explorer (WISE) is a NASA mid-class explorer (MIDEX) mission that will carry out a sensitive, digital imaging survey of the entire sky in the 3.3, 4.7, 12 and 23 μm mid-infrared bandpasses. WISE will produce and release to the world astronomical and educational communities and general public a digital Image Atlas covering the sky in the four survey bands, and a reliable Source Catalog containing accurate photometry and astrometry for approximately 300 million objects. The WISE Catalog and Atlas will enable a broad variety of research efforts ranging from the search for the closest stars and brown dwarfs to the most luminous galaxies in the Universe. The WISE science data products will serve as an important reference data set for planning observations and interpreting data obtained with future ground and space-borne observatories such as JWST.

WISE will conduct its survey using a 40cm cryogenically-cooled telescope equipped with a camera containing four mid-infrared focal plane array detectors that simultaneously image the same 47'x47' field-of-view on the sky. The spacecraft will fly in a sun-synchronous 525 km polar orbit and use a near-zenith pointing telescope with freeze-frame scanning technique to obtain multiple, independent 8.8sec exposures of each point on the sky. The number of independent exposures is typically eight on the ecliptic equator and increases towards the ecliptic poles as the orbital scan paths converge. WISE is designed to achieve a minimum point source sensitivity on the ecliptic corresponding to flux signal-to-noise ratios $\geq$5 at flux densities of 0.12, 0.16, 0.65 and 2.60 mJy at 3.3, 4.7, 12 and 23 μm, respectively, in regions of the sky not confused by Milky Way stars and diffuse emission. The astrometric precision of the WISE Source Catalog and Atlas will be $\leq$0.5" with respect to the 2MASS All-Sky PSC.

WISE is scheduled for launch in November 2009 and will have an in-orbit checkout (IOC) phase of one month, followed by a six month baseline on-orbit data acquisition operations period. A preliminary Source Catalog and Image Atlas constructed from data acquired from the first 50% of the sky surveyed will be released six months after the end of the on-orbit data acquisition phase. The final Catalog and Atlas will be released 17 months after the end of on-orbit data acquisition. WISE science data products will be distributed via the on-line and computer-compatible services of the NASA/IPAC Infrared Science Archive (IRSA).

The WISE principal investigator is Dr. Edward Wright (UCLA). Management of the WISE mission, mission systems engineering, mission assurance, and mission operations are performed by JPL/Caltech. The Space Dynamics Lab. Utah State University is responsible for the WISE payload (telescope, optics, detectors, electronics). Ball Aerospace Corp. is responsible for the WISE spacecraft and will carry out system integration. Science data processing, archiving, and distribution is performed by the Infrared Processing and Analysis Center, California Institute of Technology (IPAC). IPAC serves as the WISE Science Data Center (WSDC).

1.1 Document Scope

This Project Data Management Plan (DMP) describes project-level policies, schedules and plans for handling, processing, distribution and archiving of the science data for the Wide-field Infrared Survey Explorer.

The scope of this document covers the ground data system as it applies to the mission science data, from downlink to final archiving. This document does not apply to operating the mission or spacecraft, which is managed separately by the WISE project. The PDMP identifies the primary and supplementary science data products of WISE, systems associated with data handling, and the roles and responsibilities, and operational interfaces affecting those systems.

This document duplicates some information found in the WISE MOS/GDS Functional Design Book (JPL D-37573) and the WISE Science Data Center Functional Design Document (WSDC D-D001).

1.2 Applicable Documents

This plan conforms to the specifications in the following project documents:

WISE Project Plan (Level 1 Requirements) (JPL D-XXXXX)
WISE Level 1.5 Science Requirements Document (JPL D-XXXXX)
WISE MOS Requirements Document (JPL D-30571)
WISE Science Management Plan (JPL D-XXXXX)
MOS GDS Interface Control Document (JPL D-34372)
MOS GDS Functional Design Book (JPL D-37573)
WISE Science Data Center Function Requirements Document (WSDC D-R001)
WISE Science Data System Functional Design Document (WSDC D-D001)
the WSDC Science Data Quality Assurance Plan (WSDC D-M004)
WISE Digital Electronics Box Data Processing Description (SDL/06-070)

2 ROLES AND RESPONSIBILITIES

2.1 IPAC – WISE Science Data Center (WSDC)

The Infrared Processing and Analysis Center (IPAC) at the California Institute of Technology is responsible for WISE science data processing, distribution and archiving. IPAC works with the PI and Science Team to develop algorithms for the data processing pipeline, metrics for science data quality verification, and to develop an effective archive that is accessible to the WISE team and to the scientific user community. IPAC develops a long-term archive plan for the Level 0 science data and the main science data products from the mission. The plan describes the contents of the archives, the size of the archives, and the schedule for delivery. The final archive is to be integrated into the services and policies of the NASA/IPAC Infrared Science Archive (IRSA), NASA's designated archive center for infrared and sub-millimeter astronomy missions.

2.2 JPL - Mission Operations System (MOS)

The WISE MOS is responsible for all flight system scheduling and navigation, commanding, real-time operations and flight system health/safety monitoring, and uplink and downlink processes and coordination with WCS. The WISE MOS is responsible for managing the data holdings at WCS. MOS coordinates with WCS to receive the downlinked telemetry packets. MOS operates a High Rate Data Processor (HRP) that converts raw telemetry from each downlink session into transfer packets and transfers them electronically to the WSDC. An interim archive of raw telemetry will be maintained by the MOS at WCS for retransmission to WSDC in the event of corruption in the original transfer or ingest process at IPAC. MOS element architecture and functional roles are described in detail in the WISE MOS/GDS Functional Design Book (JPL D-37573).

2.2.1 WISE Telemetry Command and Communications Subsystem (WTCCS)

The WTCCS is the core of the MOS real time uplink and downlink system. WTCSS receives high rate science data from the TDRSS terminal and processes them using a WISE-supplied and operated high rate data processor (HRDP) at White Sands Complex (WCS). WTCCS receives low-rate engineering telemetry from the TDRSS terminal and performs frame synchronization and packet extraction. The packets are channelized for processing and display and the CFDP file data is reconstructed. High rate data science data packets are transmitted electronically to the WISE Science Data Center (IPAC). The engineering telemetry is transferred electronically to the MOS at JPL. A daily frame accountability is generated and transmitted to MOS and WSDC.

2.3 TDRSS Terminal at White Sands Complex (Ground tracking station)

The TDRSS terminal at the White Sands Complex (WSC) provides real time interfaces allowing the WISE MOS at JPL to receive both "Low Rate" S-band and "High Rate" Ku-band telemetry data and to send uplink commands to the WISE spacecraft via an S-band uplink. The TDRSS terminal performs convolutional decoding of the S-band and Ku-band telemetry. The decoded low rate telemetry is sent to the WISE MOS at JPL. The Ku-band data is transferred to the WISE HRDP at WSC for processing via a 120 Mbit/sec data stream.

2.4 Space Dynamics Laboratory, Utah State University (SDL)

SDL is responsible for design, construction and delivery of the WISE payload. The payload includes the detector instrument package, imaging optics system, telescope and optics and cryostat. SDL is responsible for on-board data processing done within the payload. This processing, which is described in SDL/06-070, is carried out by the payload's Digital Electronics Box (DEB). Four data processing boards within the DEB, one dedicated to each band of focal plane data, perform sample-up-the ramp processing and transmit processed data to the spacecraft. The DEB processing also includes the 2x2 binning of the band 4 (23μm) pixel data. The on-board payload data processing is not described further in this document.

During mission operations, SDL will participate in reviewing and trending WISE payload engineering telemetry that is sent to them from the MOS at JPL.

2.5 Ball Aerospace and Technology Corporation (BATC)

BATC is responsible for design, construction and delivery of the WISE spacecraft. The spacecraft bus includes all power and navigation facilities for the flight system, and all communication equipment. The spacecraft system contains a flash memory system that stores and stages up to three days of WISE science and stored telemetry data. On-board science data and telemetry processing is performed by the spacecraft's Mission Unique Board (MUB). This processing includes applying Rice (lossless) compression to the WISE payload data, packetizing and applying CCSDS encoding. Science and some engineering telemetry data are transmitted to TDRSS via a Ku-band high gain antenna. Command uplink and some telemetry downlink is made via S-band transceiver. The interface between the WISE flight system and ground operations is described in the WISE Flight-Ground ICD. This interface and details of on-board spacecraft data processing are not discussed further in this document.

During mission operations, BATC will participate in reviewing and trending WISE spacecraft engineering telemetry that is sent to them from the MOS at JPL.

2.6 Survey Planning Center at the Univ. of California Los Angeles

The Survey Planning Team at UCLA generates periodic survey plans that are transmitted to the MOS at JPL for translation into command sequences and uplink to the spacecraft for execution. The Survey Planning Team assesses the quality and progress of the ongoing survey using science data QA reports provided by the WSDC.

2.7 Principal Investigator and Science Team

The WISE PI and Science Team work with the WSDC to develop efficient and effective algorithms for data processing, and metrics and tests to assess downlinked science data quality. The PI and Science Team work with IPAC to validate WISE Data Products during the data processing stage, and in preparation for data product releases. The PI and Team also contribute to the preparation for the mission explanatory documentation.

3 DATA FLOW

In this section, we describe at a high level the flow of WISE science and engineering data from downlink to archiving. WISE end-to-end data flow is illustrated in Figure 1.

Compressed, encoded science data and selected engineering telemetry is transmitted via "High-Rate" Ku-band transmitted from the WISE flight system to TDRSS for relay to the TDRSS terminal at White Sands Complex (WSC). Some engineering telemetry is also transmitted to

TDRSS terminal via “Low Rate” S-band relay. Ku-band downlink occurs up to four times per day, with each contact taking approximately 15 minutes. S-band downlink occurs TBD.

The TDRSS terminal performs convolutional decoding of the S-band and Ku-band telemetry. Following each downlink contact, the Ku-band data are transferred to the WISE-provided and moperated high rate data processor (HRDP) at WSC via a 120 Mbit/sec data stream. The decoded Low Rate S-band telemetry is sent electronically to the MOS at JPL.

The WISE HRDP receives the science image data from the TDRSS terminal in the form of a stream of Reed-Solomon encoded AOS transfer frames. The HRDP performs Reed-Solomon decoding, packet extraction and stored extracted packet files by virtual channel. The HRDP generates a frame accountability report describing the overall quality and continuity of the received data (MOS/GDS Function Design Book). Following the processing of the data from each downlink, the HRDP transfers the raw data packets to the WISE Science Data Center at IPAC.

Up to 30 days of science data packet files are stored on a RAID file storage system at WSDC in the event that a retransmission to IPAC is necessary.

The WTCCS at JPL receives the S-band and Ku-band telemetry frames from the WDISC and performs frame synchronization and packet extraction. The packets are channelized for processing and display and the CFDP file data is reconstructed. A subset of engineering telemetry is forwarded to the WSDC at IPAC for merging with the raw science data. The MOS/NAV group at JPL also transmits assorted navigation products to the WSDC, including spacecraft ephemeris data and PEF. Processed spacecraft and payload engineering data are also routed to BATC and SDL for health and safety monitoring and flight system trending.

The WSDC at IPAC receives the science data packets transferred by the HRDP, validates the contents of each transfer and reports the status of the validation to MOS so that that the data can be released from the WCS interim storage, if necessary. The WSDC also receives engineering telemetry files from MOS asynchronously from the science packets.

Once each electronic transfer from the HRDP is complete, the WISE Science Data System (WSDS) Ingest subsystem decompresses the science data packets, and assembles them into raw FITS format images. Engineering telemetry is correlated with the science data using VTC time stamps, and relevant engineering parameters are added to the headers of the raw FITS images to create Level 0 FITS images. The Ingest file system then stages the Level 0 science data from pipeline processing.

Pipeline processing at the WSDC (described in Section 4), removes the instrumental signature from the raw science images, combines all images covering each point on the sky, detects and characterizes discrete sources on the images, and derives and applies astrometric and photometric calibration to the image and extracted source data. Processing image, extracted source and metadata associated with both are written to the WISE science archive.

During and following data processing, the WISE Science Data Center performs quality assurance that assesses the integrity of flight system data, the completion status of data processing, and the

derived characteristics of the science data relative to the WISE mission performance and data product requirements.

At the completion of data processing, the WSDC in collaboration with the WISE PI and Science team generates and validates the WISE Image Atlas and Source Catalog for release. These products are "delivered" to IRSA. The WISE Image Atlas and Source Catalog are distributed to the astronomical community and general public via the on-line and computer-friendly interfaces of IRSA. IRSA also provides the long-term "living" archive for the final WISE science products to insure their accessibility to the community in perpetuity.

4 SCIENCE DATA PROCESSING

4.1 The WISE Science Data System (WSDS)

Science data processing at the WSDC is carried out by the WISE Science Data System (WSDS). The WSDS is a software, operations and analysis system that converts raw WISE image data and engineering telemetry into the photometrically and astrometrically calibrated Image Atlas and Source Catalog. The design of the WSDS is described in the WSDC Functional Design Document (WSDC D-D001).

In Figure 2 is shown the functional flow of the WSDS. The WSDS is comprised of six primary subsystems: INGEST, PIPELINES, QA, EXEC, FPG, and ARCHIVE. The high level function of each subsystem is described below.

4.1.1 INGEST

The WSDS INGEST subsystem autonomously receives science data packets from the HRDP at WSC and engineering telemetry from MOS/WTCSS and assembles from them Level 0 FITS-format files. INGEST also stages Level 0 images and metadata for pipeline processing.

4.1.2 PIPELINES

The WSDS PIPELINES converts Level 0 imaging data into photometrically and astrometrically calibrated images and extracted source lists. The PIPELINES subsystem is comprised of two main components, the Scan/Frame Pipeline and the Multiframe Pipeline.

Scan/Frame Pipeline – The Scan/Frame Pipeline operates on individual f*ramesets* (images in the four WISE bands corresponding to one exposure) within one *scan* (=1/2 orbit) of WISE data. It performs basic instrumental calibration, detects and characterizes sources from individual images, and derives and applies photometric and astrometric calibration. The Scan/Frame Pipeline also identifies sources detected in the individual frames that are associated with known solar system objects such as asteroids, comets, planets and planetary satellites. The Scan/Frame functional block diagram is shown in Figure 3.

Multiframe Pipeline – The Multiframe Pipeline operates on data from more than one scan/orbit. This pipeline combines images covering the same location on the sky, detects and characterizes sources from those images and performs any updates on the photometric and astrometric calibration that are necessary. The Multiframe pipeline functional diagram is shown in Figure 4.

4.1.3 QA (Quality Assurance)

The QA subsystem generates concise reports summarizing science data quality using summary outputs from all of the other WSDS subsystems. These reports are in the tabulated in web-based compliations that provide capability to drill-down to detailed image, graphical and tabular data. QA reports are reviewed by quality assurance scientists at the WSDC. Final quality assignments for WISE data are approved by the WISE PI or his designee.

4.1.4 EXEC

The EXEC subsystem of the WSDC provides interface-related services to software wrappers and pipelines. EXEC mediates between external callers and applications, providing a uniform interface, binding execution units (modules) together into a unified pipeline

4.1.5 FPG (Final Product Generation)

The WSDC FPG subsystem constructs the WISE Preliminary and Final Image Atlases and Source Catalogs from *combined* (Level 3) image and source *Working Databases* that are produced by the Multiframe Pipeline modules. FPG is not a software subsystem, per se, but is a database and human analysis-intensive operation. The FPG system selects the subset of rows in the source Working Databases that satisfy the WISE Level 1 Requirements for Catalog reliability. For both the Image Atlas and Source Catalog, FPG assembles final formats and generates any new derived header or catalog parameters that are not already in the Level 3 image and source archives. The FPG system includes characterization, validation, and documentation of the WISE release data products.

4.1.6 ARCHIVE

The WSDC Archive subsystem is a multi-tier system that stores raw and processed mission data and metadata. The WISE Archives, described in Section 10, store and serves images, source and metadata to the operational processing system, and to the WISE project team and astronomical community. A component of the ARCHIVE subsystem is integrated into the WSDS processing system and a component is integrated into the IRSA at IPAC.

4.2 Data Processing Steps

4.2.1 Ingest

Ingest processing receives, unpacks and decompresses the science packets sent from the HRDP, and time-stamped engineering data files from MOS/WTCCS. The HRDP packets are assembled into FITS-format images. Engineering data is then matched to the appropriate science images using time coordination, and written into the image FITS headers to produce Level 0 images. Data receipts are validated for content. The Level 0 images are then staged for pipeline processing.

4.2.2 Scan/Frame Processing

4.2.2.1 Instrumental Frame Calibration

Subtract detector bias structure using the array detector reference pixels. Subtract dark response, linearize, divide by the flat field response, and subtract sky illumination correction for each image. If necessary, correct images for droop and other miscellaneous instrumental signatures. Mask bad pixels.

4.2.2.2 Source Detection and Characterization

Detect sources on individual frames for the purpose of calibrating band-to-band offsets and basic position reconstruction. Then detect sources on images in 4 WISE bands simultaneously for optimal extraction. Determine source centroids and measure brightnesses using profile-fit and multi-aperture photometry.

4.2.2.3 Artifact Identification

Identify and flag extracted sources that are associated with the predicted positions of image artifacts produced by bright sources. Artifacts include spurious detections of latent images of stars falling on preceding frames, diffraction spikes, optical and electronic ghosts, etc. Also flag real source detections that may be contaminated by proximity to image artifacts.

4.2.2.4 Position Reconstruction

Derive transformation to convert pixel coordinates to equatorial (J2000) coordinates in four bands. Transformation uses detections in each frame of 2MASS All-Sky PSC sources, which is the WISE astrometric reference. The transformation is applied to both the images (WCS information) and extracted source data.

4.2.2.5 Photometric Calibration

Derive transformation to convert brightness of sources measured in instrumental units (DN or digital units) to physical units. Photometric calibration is made relative to measurements of a network of standard stars of known brightness in the four WISE bands that are observed by WISE frequently. Photometric calibration information is applied to the individual images and to the extracted source databases.

4.2.2.6 Solar System Object Association

Sources extracted from each image frameset are associated with the positions of *known* solar system objects that are predicted to be within the boundaries of the image at the time of the WISE observation. No attempt is made to identify previously unknown solar system objects.

4.2.3 Multiple Frame Processing

4.2.3.1 Image Combination/Mosaicking

All or a subset of all individual image frames that cover a specified area (nominally the footprint of a WISE Image Atlas) are registered, resampled and optimally combined to produce a more sensitive image. Images from all four WISE bands are aligned to the same footprint and pixel scale. Images will be scaled to a common throughput level and will have backgrounds matched. Pixel combination includes outlier rejection to suppress transient events such as cosmic ray strikes, unstable or "hot" pixels and fast moving objects. The resulting combined images are Level 3 images.

4.2.3.2 Source Detection and Characterization

Sources are detected on the combined images in the four WISE bands simultaneously. The brightness of each detected source is measured using both profile-fitting and multi-aperture photometry. Brightness upper limits are derived in any band in which a source is not detected.

4.2.3.3 Artifact Identification

Identify and flag extracted sources that are associated with the predicted positions of image artifacts produced by bright sources. Artifacts include spurious detections of latent images of stars falling on "preceding" frames, diffraction spikes, optical and electronic ghosts, etc. Also flag real source detections that may be contaminated by proximity to image artifacts.

4.2.3.4 Calibration Update

If necessary, update the astrometric and photometric calibration using information derived from sources measurements in adjacent, overlapping scan/orbits. Apply this information to the extracted source lists and to the WCS header information in the combined images.

4.2.4 Quality Assurance

Perform quality analysis for image and extracted source data. This analysis verifies data integrity, processing completion status, and extracted science data quality. Science data quality is assessed by comparison extracted image and source data properties to metrics that are linked

to the WISE Level 1 and 1.5 requirements on sensitivity, photometry and astrometric accuracy, completeness and reliability. QA analyses also examine a limited number of payload parameters that may be monitored using science data, including scan-mirror/spacecraft scan rate synchronization, system throughput and detector noise properties. Concise reports summarizing the science data quality are posted in web-format for review by quality assurance scientists at WSDC, Survey Planning Team at UCLA and MOS for the purpose of tracking mission sky coverage and flight system performance.

The QA activities are described in detail in the WSDC Science Data Quality Assurance Plan (WSDC D-M004).

4.2.5 Archive

[Under Construction]

The calibrated images and source extractions produced from pipeline data processing are loaded into an Image Archive and *Working Source Database*. These archives are built within the framework of the Infrared Science Archive (IRSA) at IPAC so that the WISE Science and Team and partners can access the data using the extensive image visualization and database query tools already developed by IRSA.

The release WISE Image Atlas and Source Catalog are derived from the pipeline-processed data contained in the working archives. After validation and review, these products are served to the astronomical community via the IRSA interfaces.

4.2.6 Final Product Generation

[Under Construction]

4.3 Data Processing Levels

The terminology used to describe WISE image data during the different stages of downlink and processing is summarized in Table 1. There are corresponding extracted source tables, databases or catalogs at Levels 2b, Level 3 and Atlas Image.

Table 1 - WISE Data Processing Levels

Name	Description	Source
Telemetry	CCSDS Source Packets	MOS/HRDP
Raw	FITS, integer 2.75” pixels, band+time meta-data	WSDC/Ingest
Level 0	Raw + real pixels, add much meta-data	WSDC/Ingest
Level 1	Level-0 + instrumental, astrometric/photometric calibration	WSDC/Scan-Frame P/L

Level 1a	Level-0 + instrumental calibration applied to pixels	WSDC/Scan-Frame P/L
Level 1b	Level-1a + astrometric/photometric calibration in header	WSDC/Scan-Frame P/L
Level 2	Level-1 + upsampled and undistorted (rubber-sheeted)	WSDC/Scan-Frame P/L
Level 2a	Level-1a + upsampled and undistorted	WSDC/Scan-Frame P/L
Level 2b	Level-1b + upsampled and undistorted	WSDC/Scan-Frame P/L
Level 3	Multiple frame coadds, upsampled, undistorted	WSDC Multiframe P/L
Atlas Image	Selected FPG Level-3 products	WSDC/FPG

4.4 Two-Stage Data Processing

Data collected by WISE will be completely processed twice.

4.4.1 Preliminary Processing

Following WSDS testing and tuning to actual on-orbit performance during IOC and the first two months of on-orbit operations, the WSDC will initiate *preliminary processing* of the Level 0 WISE science data. This processing will use preliminary instrumental, photometric and astrometric calibrations that are derived from ground test and IOC data. During preliminary processing, the WSDS systems will be allowed to be updated in response to improving understanding of WISE data and processing algorithm characteristics. The WISE Preliminary Release Image Atlas and Source Catalog are generated from this preliminary processing.

4.4.2 Final Processing

Following the end of on-orbit data acquisition, all WISE science data will undergo a complete reprocessing using an updated version of the WSDS that incorporates optimal calibration and processing parameter and algorithms derived from analysis of payload, spacecraft over the life of the mission, and from analysis of the preliminary processing results. The WISE Final Release Image Atlas and Source Catalog will be derived from the output of the final data processing.

5 WISE DATA PRODUCTS

The WSDC works with the WISE PI and Science Team to produce two primary data products that enable the key scientific investigations that embody the WISE mission objectives. The products are an *Image Atlas* and an extracted *Source Catalog*. An Explanatory Supplement

describing the WISE mission, instrument and the data products will accompany the release of the Catalog and Atlas.

5.1 Image Atlas

The WISE Image Atlas consists of photometrically and astrometrically calibrated FITS images in the four bands. The images in the fours bands are registered onto a common common grid. The footprint and pixel scale of the images will be approximately 1^{o}x1^{o} and 1.375"/pix, but may be changed pending Science Team decision. The pixels from each of the frames will be combined to produce the best estimate of the flux at each position on the sky. The Image Atlas is expected to contain approximately 140,000 images. The final number will depend on the footprint and pixel scale chosen for the final export Atlas.

The photometric and astrometric calibration of WISE Atlas Images is tied to the calibration of the extracted source Catalog.

Although the WISE Atlas images will have a specific footprint and scale, users will be able to request WISE images at any specified center, pixel scale, projection and size (up to approximately 2x2 deg) using the IRSA/WISE pixel server.

5.2 Source Catalog

The WISE Source Catalog contains accurate equatorial (J2000) positions and in-band fluxes (or upper limits) measured in the four survey bands for all reliable sources detected on the combined frames from adjacent orbits for maximum sensitivity. The Catalog will contain a unique identifier for each entry, and a set of flags that encode source detection reliability and measurement quality. The Source Catalog is expected to contain approximately 300 million records.

The requirement for photometric accuracy for entries in the WISE source Catalog is 7%. Absolute positions of high SNR WISE sources are reconstructed relative to the 2MASS astrometric reference frame, and will be accurate to $\leq$0.5" RMS on each axis with respect to that frame. Lower SNR sources follow the full-width at half-maximum/SNR growth curve.

5.3 Explanatory Supplement

[Under Construction]

5.4 Ancillary Data Products

5.4.1 Atlas Image Coverage Maps

FITS format images that indicate the depth-of-coverage in each corresponsing Atlas Image. Pixel values in the coverage maps are equal to the number of pixels from individual frames that were combined to make the Atlas Image. The coverage maps will take into account fractional pixel coverage due to image reprojection and resampling, and the rejection of masked and outlier pixels.

5.4.2 Solar System Object Associations

A table will be provided that lists the WISE source information for any source found to be positionally associated with the predicted location of known asteroids, comets, planets or planetary satellites at the time of each WISE exposure. The table will also contain information for all solar system objects that are within the focal plane field-of-view during each WISE exposure but were not associated with an WISE source detection.

6 OPERATIONAL DATA PROCESSING CYCLE

[Under Construction]

WISE data processing operations cycle is shown in Figure 5.

7 DATA ACCOUNTABILITY

[Under Construction]

8 SCHEDULE AND LATENCY

8.1 Data Product Release

The objective of the WISE mission is to make the science data products available to the community as rapidly as possible. To facilitate this, data release takes place in two stages. The *Preliminary Data Release* occurs six months after the end of on-orbit data acquistion. The preliminary release consists of an Image Atlas and Source Catalog containing sources with SNR>20 in unconfused regions of the sky. The first release is drawn from the preliminary processing of the science data made while the spacecraft is operational.

The WISE *Final Data Release*, made 17 months after the end of on-orbit data acquistion, contains the final Image Atlas and Source Catalog containing sources as faint as SNR~5, and is accompanied by more extensive quality analysis, validation and documentation.

8.2 Science Data Processing

IPAC conducts *preliminary processing* of the raw image and engineering data within six days of their arrival from WSC and MOS/WTCCS. Processing is performed during on-orbit mission

operations using an automated software pipeline that uses preliminary instrumental, photometric and astrometric calibration parameters, derived during ground test and the in-orbit validation period. The preliminary Image Atlas and Source Catalog are generated from this preliminary processing.

All science data gathered during on-orbit mission operations undergoes *final data processing and validation* following the end of on-orbit mission operations and the release of the preliminary data products. Final processing incorporates optimal parameters derived from analysis of spacecraft, instrument and preliminary processing results over the life of the mission.

The WISE science data processing and archive system at IPAC is sized to be able to keep up with the data acquisition rate. The science data received twice per week from White Sands is processing, validated and loaded into the working archives within one week.

8.3 Validation

Within 3 days of their arrival at IPAC, IPAC validates the integrity of the raw science data packets sent by the HRP, and compares their contents with the manifest file provided by MOS. If the data are corrupted, contain errors in the read validation, or do not contain the data specified in the manifest report, IPAC requests a resend of the data from WSC.

8.4 Science Data Transfer

Raw science data are transmitted from the HRDP following each downlink session and processing at WSC. 24 hours of science data are expected to take approximately 15 hours to transmit to WSDC. The raw science telemetry will be archived for at least 30 days at the White Sands in an interim storage facility so that data can be resent in the event of transfer corruption or failure. Science data are released from the interim archive upon confirmation of their receipt and validation by IPAC.

8.5 Downlink and Verification

The MOS validates the integrity and content of each downlink at White Sands within 24 hours (TBD) of the contact. The results of that validation, and the content of the downlink are reported to the WISE SOC (UCLA), WSDC within 36 hours (TBD) of the downlink contact. MOS supplies a manifest of data contained in each donwlink session.

9 DATA DISTRIBUTION

9.1 Data Access Policies

Policies governing the access to WISE data prior to the release of formal data products to the community are described in the WISE Science Management Plan (JPL D-XXXXX).

WISE Data Products are released to the astronomical community and general public as rapidly as is technically feasible and scientifically sensible. There is no proprietary period on WISE data,

but the mission Data Products are not released to the archive for distribution to the community until they have undergone thorough Quality Assurance analysis by the PI and Science Team. During preliminary and final data processing and the data product validation period, the PI and Science Team have unrestricted access to the working archives for the purpose of assisting with the validation of spacecraft, instrument and data processing system performance.

9.2 Data Access

The WISE science data products are comparable in size and composition to the 2MASS Image Atlas and Source Catalogs. Thus, plans for Science Team and end-user access to WISE data follow the successful model used to enable access to the data products of 2MASS.

Primary access to the ~10 TB calibrated Image Atlas and ~1 TB Source Catalog is via the on-line services of IRSA at IPAC. Primary WISE access services currently include:

- Catalog Search (GATOR) – a web-based interface that enables complex, efficient queries of massive Catalogs and metadata tables based on any parameter or combination of parameters in the tables.
- Image Service – a web-based interface that enables both interactive and batch requests for all or parts of Atlas Images at a user specified location and size.
- Image Pixel Service – a web-based interface that enables interactive and batch requests of Atlas Images at a user specified location, size, projection and pixel scale. This may combine more than one Atlas Image if the requested footprint intersects boundaries between images.

In addition to the WISE-specific tools, because the WISE data products are integrated into the IRSA infrastructure, WISE data will automatically be visible to a number of IRSA data inventory and cross-mission data discovery services. Some of these include:

- OASIS - a Java-based service that allows image/catalog interaction and for a wide variety of Image and Catalog data sets currently served by NASA and international data centers, not limited to IRSA.
- RADAR – A service that searches all IRSA Catalog and Image holdings as well as a number of VO-accessible archives in a user –specified region and presents an inventory and portal into all available data.

WISE science data pipeline processing yields calibrated Images and Source Extractions that are loaded into working databases built within the framework of IRSA at IPAC. The WISE Science Team and project staff will access these working archives using the same on-line IRSA services. Team access to the working archives and preliminary products is restricted using password protection on the IRSA sites.

The WISE Source Catalog may also be distributed via sftp or on DVD or equivalent media, for bulk distribution. Any bulk Catalog distribution will follow the on-line IRSA distribution by several months because of the long production time for commercial DVD vendors.

9.3 Interconnectivity

Because the WISE working archives and release data products are developed with data distribution and archiving in mind, all necessary metadata and other descriptors will be in place to insure compatibility with the existing IRSA tools. This development philosophy that WISE data products are fully interoperable and extensible through the IRSA infrastructure, with related data centers and services that use XML, SOAP, WSDL and UDDI protocols being developed under the NVO initiatives sponsored by NASA and NSF.

10 ARCHIVE PLAN

The WISE Archive has two main components: the Operations archive and IRSA archive.

The Operations archive holds raw and processed data and derived metadata within the processing system. The storage is physically located close to the processing cpu's to minimize latency due to network I/O. The Operations archive serves data to the processing pipelines, QA system and FPG operations through direct file access.

The IRSA archive holds processed data and derived metadata in the infrastructure of the NASA/IPAC Infrared Science Archive (IRSA). The IRSA archive serves data to the WISE Project Team, the astronomical and educational community, and the general public via on-line interfaces, and to other archive services via machine-friendly interfaces.

10.1 Level 0 Data

Level 0 image data are stored on spinning disk in the Operations archive during mission period. Three copies of the Level 0 FITS data are written to magnetic tape. Two copies of the Level 0 data tapes are stored at IPAC, and one copy is stored in a commercial off-site secure data storage facility in the Los Angeles area. The commercial facility used is the same as is being used now by the Spitzer Science Center to archive Spitzer Space Telescope data tapes.

At the completion of WISE project activities. One copy of the Level 0 data tapes will be sent to the National Space Science Data Center (NSSDC) for long-term, deep archiving. A level of service agreement between the WSDC and NSSDC shall be developed to describe access capabilities necessary at NSSDC.

10.2 Level 1-3 Data

Level 1 and 3 intermediate images and extracted source databases will be stored in the internal WSDS Operations archive. A subset of these will be delivered to IRSA to provide access for the WISE Project Team. The Operations and IRSA archive components may share disk storage by accessing the same Level 1 and 3 image data. At present, there is no plan to release Level 1 image or source data to the public, with the exception of a list of solar system objects that are associated with sources detected on the individual exposures (Level 1).

10.3 Final Data Products

WISE Preliminary and Final Release Image Atlas and Source Catalogs will be "delivered" to IRSA. IRSA will provide long-term storage of the data products, and will provide long-term access to the data products for the astronomical community. At the completion of WISE project activities, IRSA will assume curation of the data products and Explanatory Documentation.

11 ACRONYM LIST

AOS -
BATC – Ball Aerospace and Technologies Corporation
CFDP -
CPU – Central processing unit
HRDP – High Rate Data Processor
ICD – Interface Control Document
IPAC – Infrared Processing and Analysis Center, California Institute of Technology
IRSA – Infrared Science Archive at IPAC
JPL – Jet Propulsion Laboratory
JWST – James Webb Space Telescope
LAN – Local area network
MOS – Mission Operations System
MSA – Mission Support Area (MOS at JPL)
MTBF – Mean time between failures
MTTR – Mean time to recovery
NASA – National Aeronautics and Space Administration
NSSDC – National Space Science Data Center, NASA/GSFC
QA – Quality assurance
SDL – Space Dynamics Laboratory, Utah State University
TDRSS – Tracking Data Relay Spacecraft System
UCLA – University of California Los Angeles
UTC – Coordinated Universal Time
V&V – Verification and validation
WSC – White Sands Complex
WSDC – WISE Science Data Center (IPAC)
WSDS – WISE Science Data System
WTCSS – WISE Telemetry Command and Communications Subsystem
2MASS – Two Micron All-Sky Survey

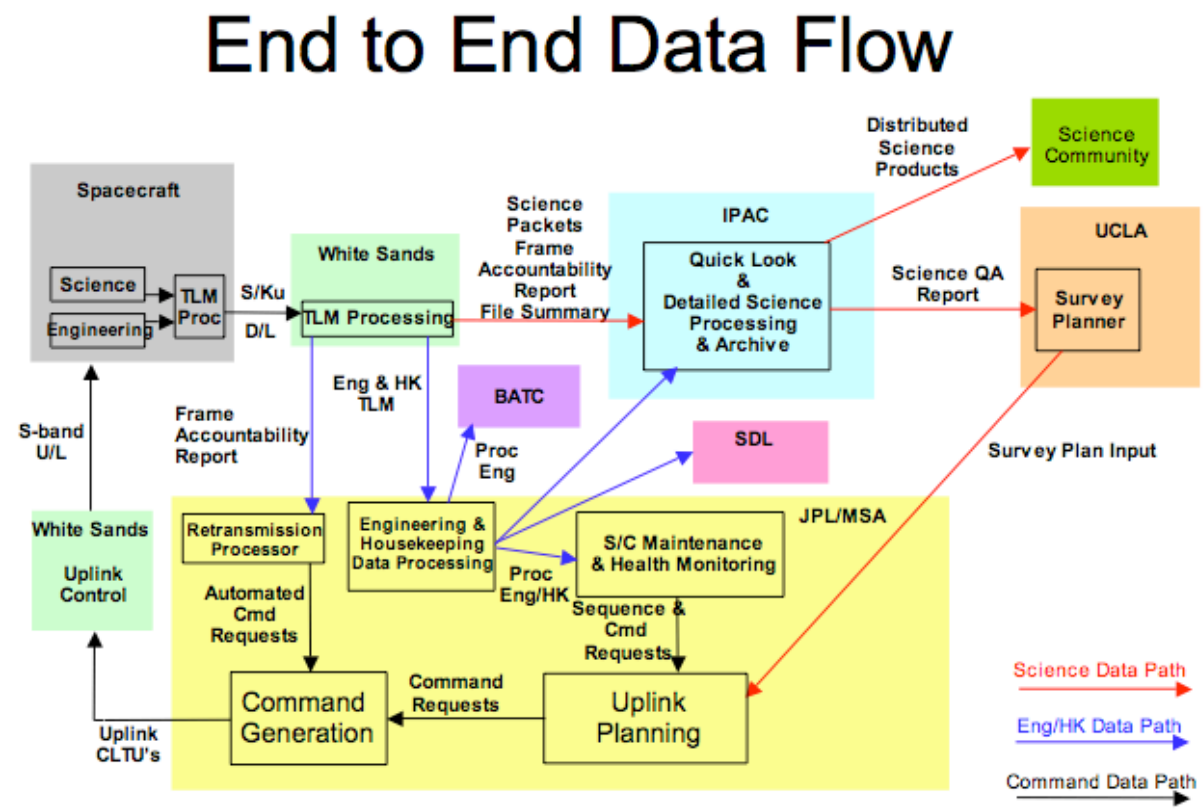

Figure 1 - WISE End-to-End Data Flow

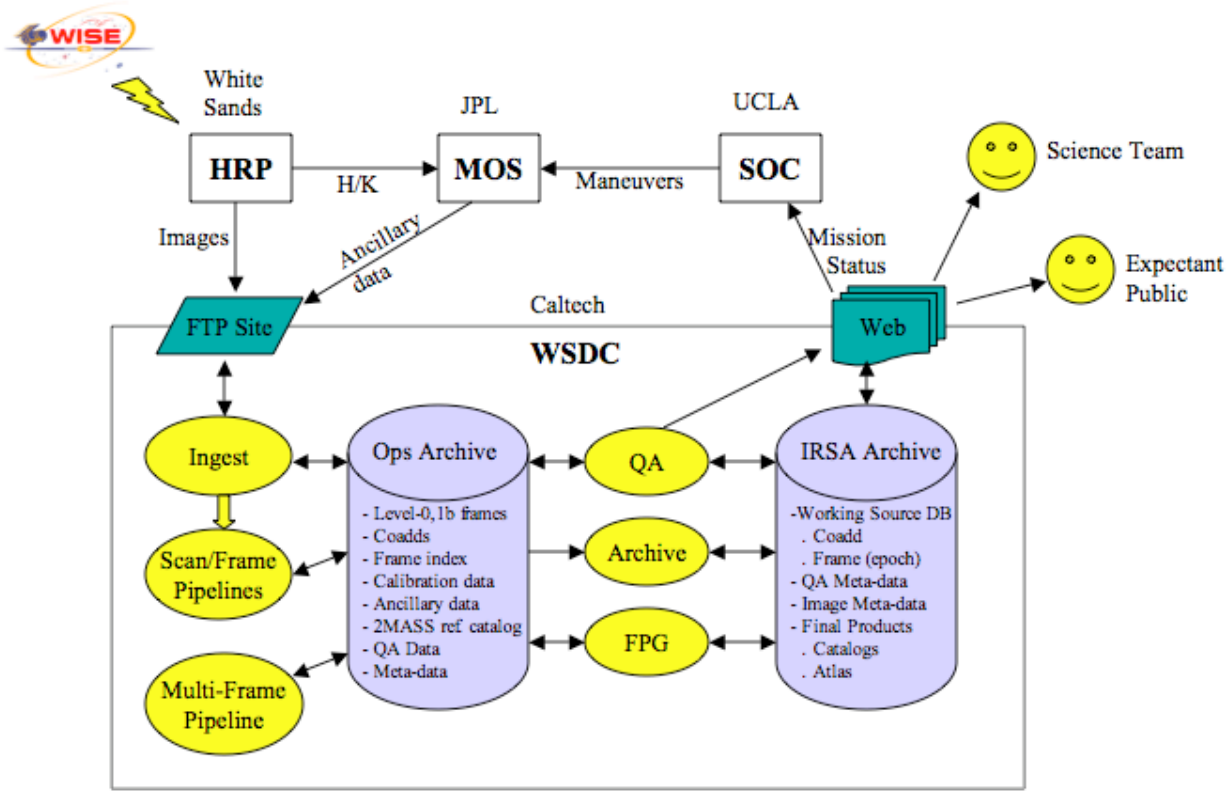

Figure 2 - WISE Science Data System Functional Data Flow

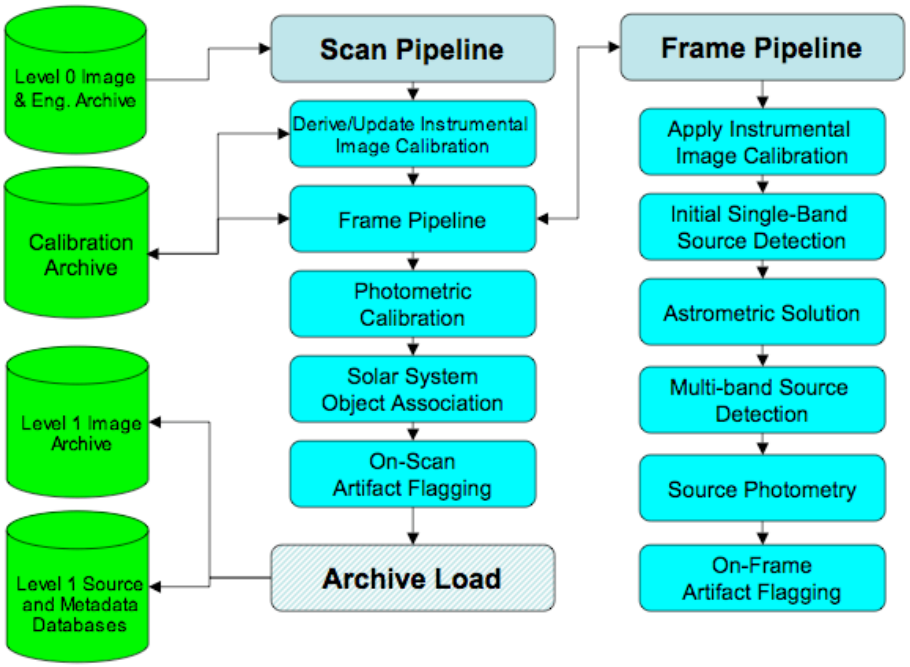

Figure 3 - WISE Science Data System Scan/Frame Pipeline Functional Block Diagram

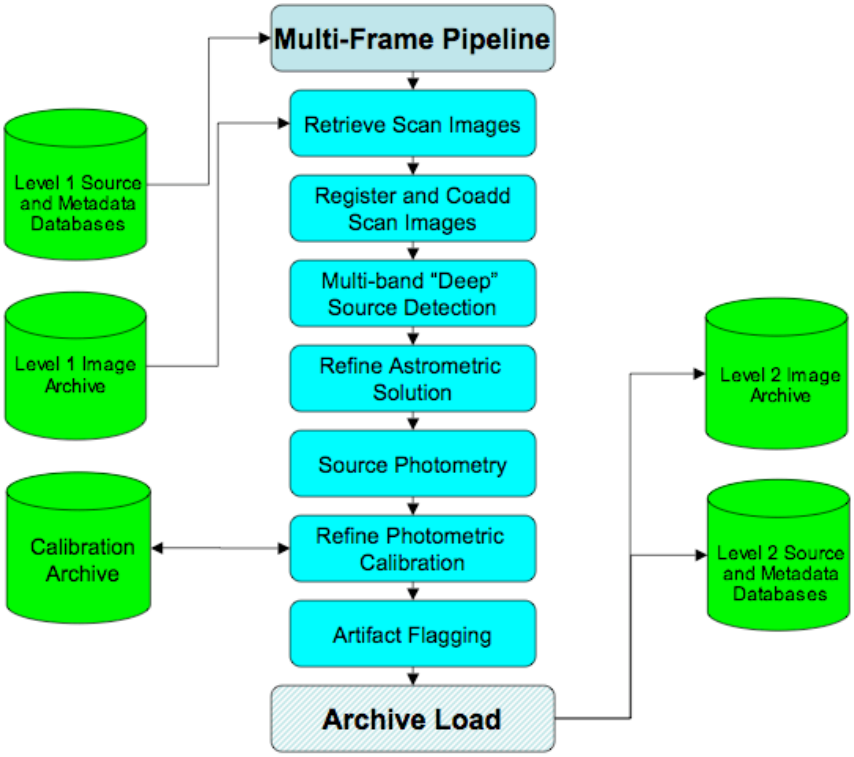

Figure 4 - WISE Science Data System Multiframe Pipeline Functional Block Diagram

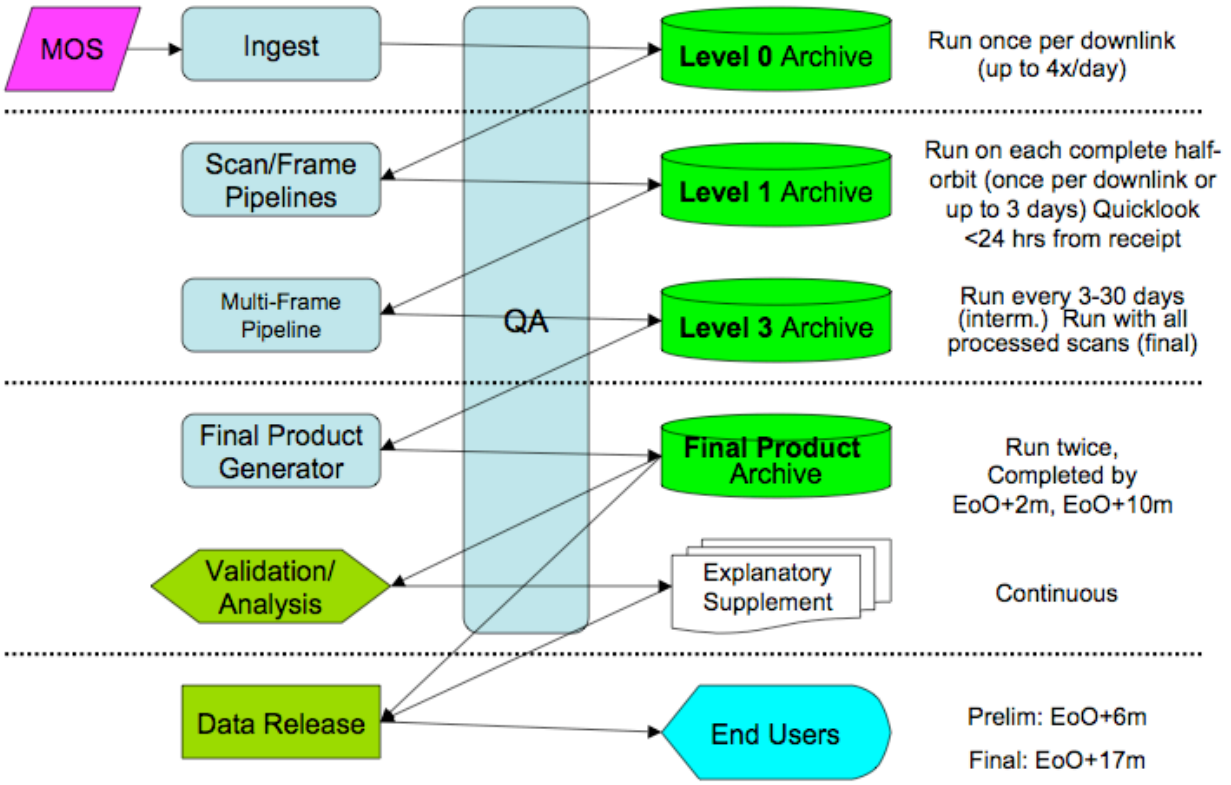

Figure 5 - WISE Science Data Processing Processing Cycle