Wide-field Infrared Survey Explorer (WISE)

WSDC Quality Assurance Plan

Version 1.1

05-March-2008

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WSDC D-M004

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Revision History

Date	Version	Author	Description
01 March 2007	0.1	D. Kirkpatrick	Initial Draft
14 December 2007	1.0	D. Kirkpatrick	Preliminary Version
05 March 2008	1.1	D. Kirkpatrick	Revised Version

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1 INTRODUCTION

The WISE mission will produce a large volume of imaging data over a very short time span. The processing pipelines at the Wise Science Data Center (WSDC) will create products from these data for eventual use by the scientific community. Because of the data volume and the short timescale on which data are to be made available to the general public, rapid processing is required. Quick and efficient data quality assurance is vital to success.

The objective of science data quality assurance is to assess data through each stage of processing, to identify and flag data that may not meet WISE science requirements, and to alert SOC, MOS, and WSDC of these cases. Data meeting the science requirements will be characterized so that after their public release they can be correctly interpreted by the scientific community.

This science data QA is not responsible for primary flight system health monitoring, which is the responsibility of MOS. Some of the WSDC quality assurance products may however supplement health monitoring of the primary instrument and spacecraft.

Some parameters that affect data quality will be tracked by the processing pipeline subcomponents, but others parameters can be assembled only after all subcomponents are run, particularly when overall comparisons to previous data sets are needed. In this vein, a comprehensive quality assurance (QA) system in which all of the data quality parameters are tracked and assembled is necessary. It is vital that this system be as automated as possible so that the final arbiter of quality (the human reviewing the data) can quickly assess and bless those data meeting the project's specifications, while spending most of his/her time on the small fraction of data most needing detailed scrutiny. The QA system will also provide an interface for this detailed follow-up so that the QA scientists can efficiently analyze and troubleshoot issues and feed this knowledge back into the automated system.

The QA system will collect summary reports for all of the data processing subsystems and compile them into a single concise report to be reviewed by the QA scientist. These summaries consist of software completion status reports, statistical analyses, and other tabular and graphical material on which data quality can be judged. The QA system collects parameters, compares them to concise metrics, and presents the results in a web-based form.

This document serves as an overview of the components comprising the QA system. QA activities during normal operations are described in section 2, followed by in-orbit checkout QA in section 3. A V&V matrix mapping WSDC requirements into specific QA checks is given in section 4. A plan for anomaly alert and resolution is discussed in section 5. The document concludes with a breakdown of QA operations staffing in section 6.

2 QA ACTIVITIES DURING NORMAL OPERATIONS

2.1 Overview of WSDC Quality Assurance

WISE data will pass through several different processing stages as described in the WSDS Functional Requirements Document (#WSDC D-R001), and quality assurance (QA) will be performed as an integral part of each of these. The flow diagram below demonstrates how the QA subsystems interact with the rest of the pipeline data flow, as implemented in the WSDS Functional Design Document (WSDC D-D001).

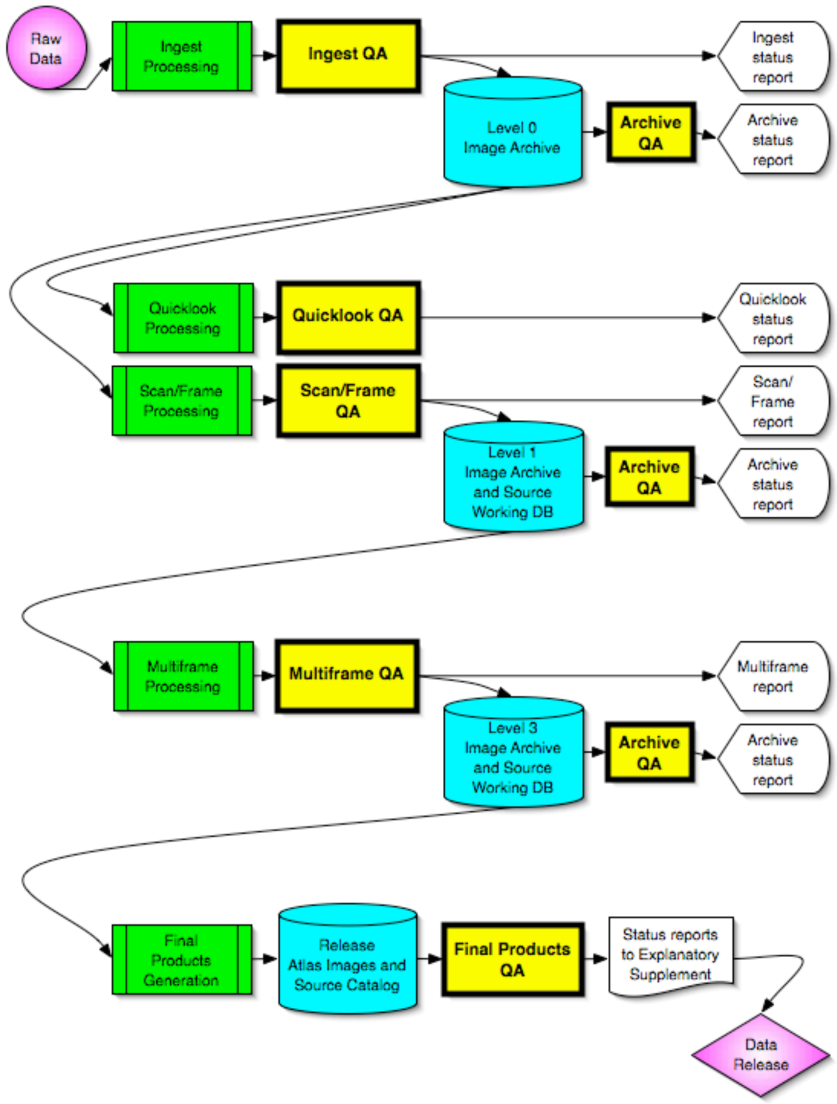

Figure 1: WSDS data flow diagram with QA subcomponents highlighted in yellow.

The data flow diagram of Figure 1 pertains to data processing during on-orbit operations ("first-pass" processing). First-pass processing will produce a Preliminary Image Atlas and Preliminary Source Catalog for public release.

Knowledge gleaned from first-pass processing of the entire WISE data set will be used to refine the QA algorithms and thresholds used in "second-pass" processing. Second-pass processing will begin at the Level 0 Archive, skipping only the Quicklook Processing and Quicklook QA steps. The goal of second-pass processing is to produce the Final Image Atlas and Final Source Catalog for public release.

The purpose of each of the QA subsystems is listed below along with the timescale on which the QA is to be performed (during first-pass processing) and the actions resulting from each QA assessment:

A. Ingest QA
   a. Purpose:
      i. To check compliance with the FITS standard.
      ii. To verify that all Level 0 images have been created.
      iii. To compare the input manifest from White Sands to actual data received.
   b. Timescale: Following each data transfer (up to 4 times per day).
   c. Action: WSDC to inform MOS/EOS and SOC of status and anomalies.

B. Quicklook QA
   a. Purpose: To check key system performance parameters (on 3% of data) for each downlink via an abbreviated processing pipeline. This will include but not be limited to monitoring of scan synchronization, system throughput, and image backgrounds and noise.
   b. Timescale: Within 24 hours of end of data transfer to WSDC.
   c. Action:
      i. WSDC to post report to web page; SOC to review report.
      ii. Text based summary report e-mailed to MOS.

C. Scan/Frame QA
   a. Purpose:
      i. To check for successful completion of Scan/Frame processing pipeline.
      ii. To scrutinize output of processing pipeline.
      iii. To compare achieved performance to metrics tied to mission science requirements.
   b. Timescale: Within 6 days of receipt of data at IPAC.
   c. Action: WSDC to assign quality scores to each scan and produce QA report; PI or his designee responsible for signing off.

D. Multiframe QA
   a. Purpose:
      i. To check for successful completion of Multiframe processing pipeline.
      ii. To scrutinize output of processing pipeline.
      iii. To compare achieved performance to metrics tied to mission science requirements.
   b. Timescale: Within 15 days for multi-orbit runs with >8 coverages.
   c. Action: For ultimate (not intermediate) coadds, WSDC to assign quality scores to each coadd and produce QA report; PI or his designee responsible for signing off.

E. Archive QA
  a. Purpose:
    i. To validate accuracy of source/metadata database loadings.
    ii. To verify integrity of database tables and images (using, e.g, checksums and RTB queries).
  b. Timescale:
    i. After each database load (roughly once per week).
    ii. Run periodically on static tables.
  c. Action: WSDC reports status of checks and responds to problems (in concert with IRSA, where applicable).

F. Final Products QA
  a. Purpose:
    i. To assess properties of the Atlas Images and Source Catalogs relative to mission Level 1 and 1.5 science requirements.
    ii. To check integrity of the products via range checking on all parameters.
    iii. To give overall characterization of public data products.
  b. Timescale: After Final Product Generation but before public release.
  c. Action: WSDC and Science Team to provide analyses; final release approval given by PI.

2.2 Functional Overview

Each component of the QA subsystem will encompass a number of individual tests relevant to that point in the data processing pipeline. The specific QA tests to be run during each of these stages are detailed below:

A. Ingest QA
  a. Check that assembled images meet the FITS standard.
  b. Compare input manifest to resulting output to check for completeness.
  c. Verify that all Level 0 images were successfully created.
  d. Verify that housekeeping telemetry data and PEF were successfully mated with the correct images.
  e. Summarize QA findings for MOS and SOC.

B. Quicklook QA
  a. Scan synchronization and image quality
    i. Generate matrix of composite star images detected on each frame in each band, where each element is the average star image formed by combining the images of all stars in the corresponding region of the frame.

ii. Measure image second moment ratios and position angles for each composite star image in the matrix.
iii. Generate table and plot showing the means of these values for all frames in a half-orbit.
iv. Trigger warning messages when image elongation has exceeded a predetermined threshold related to the Level 1.5 specifications for image quality. Threshold values are to be determined prior to launch using simulated image data.

b. Photometric zero point and system throughput (needs ecliptic polar data for primary and secondary standard star checks.)
i. Tabulate the mean and RMS differences between a priori "true" and measured instrumental magnitudes for standard stars observed in the polar frames.
ii. Generate a table and plot showing the mean and RMS of these values for each orbit.
iii. Trigger a warning message if the zero point offset in any band falls outside a threshold range. The threshold range will be derived pre-launch and updated during IOC.

c. Image backgrounds and noise (needs ecliptic polar data to use as bellwethers of background level)
i. Compute the mean pixel values along with total and point-source-filtered noise values for each frame.
ii. Generate a table and plot of mean pixel values and noise levels for each frame in a half-orbit and for each quadrant (for Si:As arrays) or stripe (for HgCdTe arrays).
iii. Compare the measured mean pixel values and noise values in each frame to threshold values, band by band.
iv. Trigger a warning message if the mean pixel values and noise values exceed predefined thresholds. These thresholds will be determined pre-launch and updated during IOC.

d. Visual checks
i. Generate jpegs of a few frames in each band and check by eye. Purpose is to look for unexpected fixed pattern artifacts, odd noise signatures, and other oddities not predicted a priori.
ii. Generate three-color jpegs of a few registered framesets (if possible) and check by eye.

C. Scan/Frame QA

a. Summary of input data
i. Report log file and results of Ingest QA.
ii. Report QA results for quicklook processing.

b. Instrumental image calibration
i. If new flat fields computed, compare flat-fields to ground flats.

    ii. Monitor dynamic bad-pixel masks – changes in masks, # of pixels masked.
    iii. Flag outlying noisy frames; plot noise histograms.
    iv. Flag outlying point-source-filtered noisy frames; plot histograms.

c. Scan synchronization
    i. Monitor point source shape, scan mirror synchronization.

d. Bandmerging
    i. Monitor percentage of sources seen in all bands vs. single-band missing sources, two-band missing, etc.

e. Astrometric calibration
    i. Plot histograms of astrometric deltas between WISE-computed and 2MASS All-Sky PSC positions; scrutinize outliers.
    ii. Modulo solar system object identifications, tabulate and follow up
        1. Sources (at least in W1 and W2) with no 2MASS match
        2. 2MASS sources lacking a WISE counterpart.
    iii. Tabulate/plot mean/RMS differences between stars in this orbit and those observed in previous overlapping orbits (trending via other Level 1 data).
    iv. Tabulate/plot mean astrometric offsets from in-scan overlaps.

f. Photometric calibration
    i. Monitor mean aperture photometry curves-of-growth.
    ii. Tabulate/plot mean/RMS differences between truth and derived photometry for standard stars in the orbit.
    iii. Tabulate/plot mean/RMS differences between stars in this orbit and those observed in previous overlapping orbits (trending via other Level 1 data).
    iv. Tabulate/plot mean photometric offsets from in-scan overlaps.
    v. Plot number of objects with noted source confusion as function of galactic latitude; spot check image data for selected clean and confused sources.
    vi. Plot saturated star mag/flux estimates against ramp saturation flag.
    vii. Compare color-color diagrams for objects saturated in any band and compare against fiducial color loci to check saturated mag estimates.

g. Artifact identification -- Perform semi-automated visual spot checks of a few examples of each of the following:
    i. Latents.
    ii. Dichroic/filter glints.
    iii. Diffraction spikes.
    iv. Bright star halo contamination.
    v. Optical ghosts.
    vi. Electronic ghosts.
    vii. Non-uniform stray light.
    viii. Scattered light patches from bright objects.
    ix. Radiation hits (?).

h. Frame statistics
    i. Plot log(N)-log(S) and check against mean frame noise level.
    ii. Measure frame-to-frame overlap to assure overlap is sufficient.

i. Solar system object identification
    i. Plot number of solar system objects vs. ecliptic latitude.
    ii. Perform checks to make sure that identifications include asteroids, comets, planets, and planetary satellites.
    iii. Inspect color-color plots of identified objects.
    iv. Check detection fraction vs. visual magnitude?
    v. Plot ecliptic latitude distribution for identified minor planets as a function of predicted distance above the ecliptic plane and of predicted distance from the Earth.

j. Completeness and reliability
    i. Determine fraction vs. magnitude of detected "truth" sources in ecliptic polar fields.

k. Astrophysical checks
    i. Plot color-color and color-mag diagrams of "good" sources.

l. QA summary
    i. Report successful/unsuccessful processing completion.
    ii. Provide web-accessible page with tables and plots listed above.
    iii. Generate auto-filled QA report along with quality scores as starting point for human review.
    iv. Review by QA scientists to finalize report.

D. Multiframe QA (same as Scan/Frame QA with the following additions/deletions)

a. Summary of input data
    i. Summarize QA grades for each scan considered for image stacking.

b. Source characterization
    i. Perform semi-automated visual checks of registered coadds.

c. Astrometric calibration
    i. Plot deltas with respect to 2MASS and individual scan astrometry; scrutinize sources with large deltas.
    ii. Plot astrometric error per axis as function of source SNR

d. Photometric calibration
    i. Tabulate/plot zero-point differences for scan-to-scan overlaps.
    ii. Plot Level-1 photometry vs. deep coadd photometry to check for photometric self-consistency and depth of extractions.

e. Frame statistics
    i. Plot log(N)-log(S) and check against mean frame noise level.
    ii. Measure scan-to-scan overlap to assure overlap is sufficient.

f. Artifact identification
    i. Check additional artifact flagging from extra-scan info.

g. Solar system objects identification (none needed)

E. Archive QA

a. Perform checksums on the following:
    i. Working databases.
    ii. Source catalogs.
    iii. Image archives.
    iv. Image metadata.
    v. Any ancillary archives such as QA score archive or calibration archive.

b. Perform range checking of the same databases, catalogs, and archives.

c. QA summary
    i. Report status of each check.
    ii. Provide web-accessible page with summarized results.

F. Final Products QA

a. Source Catalog
    i. Plot histogram of N-out-of-M (N/M) statistics for multiple epochs for internal checks of completeness and reliability; scrutinize cases with low N/M values.
    ii. Check photometric variability statistics; scrutinize outliers.
    iii. Check astrometric variability statistics (moving objects); scrutinize outliers.
    iv. Perform cross-correlations with other catalogs; scrutinize sources in each catalog that have no association in the other.
    v. Perform range checking on all columns.
    vi. Using deeper Spitzer Space Telescope data at similar wavelengths (IRAC-ch1, IRAC-ch2, IRAC-ch4/IRS-blue-PU, and IRS-red-PU/MIPS-24um) and multi-repeat WISE scans at the ecliptic poles, determine completeness of catalog as a function of SNR and check with respect to science requirements.
    vii. Using the same data sets as above, determine reliability of catalog as a function of SNR and check with respect to science requirements.
    viii. Plot log(N)-log(S) against mean scan noise level or SNR.
    ix. Plot saturated star mag/flux estimates against ramp saturation flag.
    x. Compare color-color diagrams for objects saturated in any band and compare against fiducial color loci to check saturated mag estimates.
    xi. Plot astrometric error per axis as function of source SNR.

b. Image Atlas (data images, depth-of-coverage mags, noise maps)
    i. Confirm FITS standard.
    ii. Confirm that photometric zero points are correct.
    iii. Overlay images on outside image source data (2MASS All-Sky Atlas Images) to check astrometry.
    iv. Perform range checking on header values; check that pixel grid is the same for all images and all wavelengths.

v. Determine areal coverage for 8+-deep coverage areas and check against science requirement. Build up survey coverage statistics.
vi. Using header info, determine epoch difference between first and last observation and check against science requirement.

c. Summarize reports of QA analyses for Explanatory Supplement.

3 QA ACTIVITIES DURING IN-ORBIT CHECKOUT

Although some of the data acquired during IOC will be non-standard with respect to normal operational data, QA tasks will be needed on resultant data products as the integrity of both the data and the pipelines is tested. These will largely be manual activities using custom software and analysis tools. The checks below are broken into both cover-on and cover-off activities and are guided by the document entitled "In-Orbit Check-out Plan" (JPL-D-38048) dated 17 Jul 2007:

3.1 Cover-on: Before the cover is released, the temperature of the inner shield of the aperture cover will be high enough that data in W3 and W4 should be saturated. Nonetheless, there are tests that can be made for W1 and W2 data, and generic checks on the ability to ingest data can also be performed. The ingest pipeline and its associated QA system can be tested on these data. Parts of the QA system for the single-orbit pipeline can also be exercised. These are detailed below:

a. Test Ingest QA pipeline.
b. Test those portions of the Scan/Frame QA Pipeline that monitor darks, hot pixel masks, and frame noise (for W1 and W2 only).
c. Test saturation pixel flagging (for W3 and W4 only).
d. Check noise characteristics in W1 and W2 for orbits with SAA passages to determine noise thresholds to use during routine QA.

3.2 Cover-off: After the cover is ejected, a series of planned tests will evaluate the performance of the instrument to actual astronomical sources. These data will allow (a) threshold checking needed for nominal QA operations, (b) collection of inputs needed for pipeline tuning, and (c) thorough testing of the scan synchronization monitor:

a. Scan Synchronization monitor
    i. Test fully.
    ii. Derive warning thresholds for QA.
b. Detector calibration

        i. Derive fiducial on-orbit flats. Derive and monitor "low-frequency" flat/responsivity.
        ii. Derive fiducial on-orbit masks (low-response pixels + hot pixels).
    c. Photometric calibration initialization
        i. Monitor orbit-to-orbit pole passages to check zero-point stability of standard stars.
        ii. Monitor photometric stability using orbit-to-orbit overlaps.
        iii. Verify that each standard is still appropriate for use.
        iv. Derive linearity correction and check/refine against ground calibration.
        v. Check/refine saturation limits and on-board thresholds.
    d. Source detection initialization
        i. Determine optimal SNR thresholds for detections to meet completeness requirements.
        ii. Set deblending parameters.
    e. Bright source artifact mapping
        i. Set thresholds for flagging latents, diffraction spikes, dichroic glints, electronic ghosts, and optical ghosts.
    f. Annealling characterization
        i. Check image statistics before and after anneals.
        ii. Check behavior of latents before and after anneals.
    g. Avoidance limits
        i. Determine practical background limit for processing data near the Moon.
        ii. Determine SAA charge rate limits for W3 and W4.

4 MAPPING OF QA CHECKS TO REQUIREMENTS

The following tables list the requirements that will be checked by WSDC Quality Assurance. Specifically, Table 1 lists requirements that will be checked at intermediate stages of the QA process. Tables 2 and 3 are reserved for those requirements that pertain directly to the ultimate deliverables, the Source Catalog and Image Atlas. These requirements are listed with their IDs (from the next highest Level document) as extracted from the following sources:

- WISE Science Requirements Document, JPL D-30563, dated 02-Mar-2006 (Level 1.5).
- WISE Facility Requirements Document, JPL D-30564, dated 02-Mar-2006 (Level 2).

- WISE Mission Operations System Requirements Document, JPL D-30571, dated 15-Jul-2005 (Level 3).
- WISE Science Data Center Functional Requirements Document, WSDC D-R001, dated 25-Nov-2007 (Level 4).

The QA checks pertaining to each requirement are noted by their designations in section 2.2 of the current document.

Table 1: Requirements Checked During General Quality Assurance

ID	**REQUIREMENT**	**QA CHECK(S)**
	Quicklook QA	
L4WSDC-065	**Data Sampling:** A sample of 3% of the science imaging data returned to the ground each day processed in an expedited way to produce a Quicklook report that monitors the routine performance of the flight system as can be determined from the science data, and identifies problems that may require prompt action by WISE Science or Mission Operations.	**B**
L4WSDC-032	**Timescale:** Within 24 hours after receipt, the WSDC shall ingest at least 3% of the science data from each downlink, and process it through a quick turn-around version of the WISE pipeline. It shall produce processing reports and quality summaries to a WISE internal web-site and stage sample FITS data to a WISE FTP site at the same time, from which the other MOS partners can fetch the data for evaluation.	**B**
L4WSDC-035	**Validation:** The WSDC shall ingest and validate the Level 0 science data for readability and completeness of content.	**B,** **E** (on Level 1 archive)
L4WSDC-066	**Scan Synchronization:** The WSDC shall provide a monitor of the synchronization between the flight-system and scan mirror rates to achieve and maintain required image quality as part of Quicklook QA.	**B.a**
	Scan/Frame QA	
L4WSDC-062	**Data Sampling:** The WSDC shall perform quality analysis of all WISE science data and make reports available on a regular basis.	**C**
L3MOS-345	**In-scan Frame Overlap:** During routine survey operations the MOS shall ensure that the Frame-to-Frame overlap of image frames in in-scan direction is	**C.h.ii**

ID	REQUIREMENT	QA CHECK(S)
	greater than 5%.	
L4WSDC-027	**Solar System IDs:** The WSDC shall identify and compile a listing of known solar system objects that are positionally associated with source extractions in the WISE single-epoch image frames.	**C.i**
L4WSDC-028	**Scope of Solar System IDs:** The solar system objects associated with WISE single-epoch extractions shall include asteroids, comets, planets, and planetary satellites.	**C.i.ii**
L4WSDC-043	**Source Detection Threshold:** The WSDS Pipeline processing shall detect sources down to a threshold of at least five time the image noise for the calibrated image frames, and the combined Atlas Images.	**C.h.i**
L4WSDC-048	**Artifact Flagging:** The WSDC shall identify spurious extractions of image artifacts and transient events in the source lists for the purpose of eliminating them from the WISE Source Catalog.	**C.g**
L4WSDC-049	**Data with Missing Bands:** The WSDS subsystems shall be robust to data missing from one or more bands.	**C.d.i**
	Coadd QA	
L3MOS-347	**Cross-scan Frame Overlap:** During routine surve operations the MOS shall ensure that the Frame-to-Frame overlap of image frames in cross-scan direction is greater than 85%.	**D.e.ii**
L4WSDC-043 (also given above)	**Source Detection Threshold:** The WSDS Pipeline processing shall detect sources down to a threshold of at least five time the image noise for the calibrated image frames, and the combined Atlas Images.	**D.e.i**
	Final Products QA	
L4WSDC-063	**Requirements Check:** The WSDC shall work with the WISE Science Team to validate that the Image Atlas and Source Catalog satisfy WISE science requirements prior to their release.	**F**
L4WSDC-064	**Explanatory Supplement:** The WSDC shall work in collaboration with the WISE Science Team to characterize and document the overall data product quality relative to the mission requirements. This documentation shall be included in the WISE data product explanatory supplement.	**F.c**

Table 2: Requirements on the (Final/Preliminary/Both?) Source Catalog

ID	REQUIREMENT	QA CHECK(S)
	Completeness & Reliability	
L4WSDC-009 and 011	**Level of Completeness:** The (final/preliminary) WISE Source Catalog shall be at least 95% complete for sources detected with SNR>20 in at least one band, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.	**C.h.i, D.e.i, F.a.vi**
L4WSDC-080	**Level of Reliability:** The (final) WISE Source Catalog shall have greater than 99.9% reliability for sources detected in at least one band with SNR>20, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.	**C.g, D.f, F.a.vii**
L4WSDC-010	**Characterization:** The final WISE Source Catalog shall include sources down to SNR=5 in any band, and the completeness and reliability of sources in the Catalog shall be characterized at all flux levels.	**F.a.vi-vii**
L4WSDC-020	**Artifact Flagging:** The WISE Source Catalog shall contain one or more quality flags for each object entry that indicate if the detection of that object may be a spurious detection of an image artifact or transient event.	**C.g, D.f**
	Photometricity	
L4WSDC-015	**Flux Measures and Upper Limits:** The WISE Source Catalog shall contain the measured in-band fluxes or flux upper-limits in the four WISE bands for objects detected in at least one band in the WISE Atlas Images.	**C.d.i, D, F.a.v**
L4WSDC-016	**Flux Uncertainties:** The WISE Source Catalog shall contain uncertainties in the flux measurements (one sigma) in all bands for which a source is detected.	**F.a.v**
L4WSDC-019	**Flux Quality Flag:** The WISE Source Catalog shall contain one or more quality flags for each object entry that indicate if a flux measurement may have been contaminated due to the proximity of the source to an image artifact or another nearby source.	**C.g, C.f.v, D, F.a.v**
L4WSDC-012	**SNR=5 Limits:** Flux measurements in the WISE Source Catalog shall have a SNR of five or more for	**D.e.i, F.a.viii**

	point sources with fluxes per band as listed below, assuming 8 independent exposures and where the noise is limited to flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources: 0.12 mJy at Band 1 0.16 mJy at Band 2 0.65 mJy at Band 3 2.6 mJy at Band 4	
L4WSDC-013	**RMS Error:** The root mean square error in relative photometric accuracy in the WISE Source Catalog shall be better than 7% in each band for unsaturated point sources with SNR>100, where the noise flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that superimposed on an identified artifact.	**D.e.i, F.a.viii**
L4WSDC-085	**Photometry in Saturated Bands:** The WISE Source Catalog shall as a goal contain flux estimates for sources in any band in which the object has saturated the WISE image data.	**C.f.vi-vii, D, F.a.ix-x**
L1.5SRD-45 & 58	**Saturation Limit:** The relative photometric accuracy requirement shall be achieved for inertial point sources no less bright than: 0.11 Jy for Band 1 0.06 Jy for Band 2 0.25 Jy for Band 3 0.3 Jy for Band 4	**D.e.i, F.a.viii**
L4WSDC-038	**Near-Moon Performance:** The WISE science data processing shall be designed to meet image and catalog quality requirements for data taken as close as 15 deg. to the moon, assuming adequate stray light performance of the flight system, and assuming that all other elements of the WISE system satisfy their performance requirements.	**(unsure how to check this on coadded data that correspond to different moon distances)**
	Astrometry	
L4WSDC-017	**Positional Measures:** The WISE Source Catalog shall contain equatorial (J2000) coordinates for objects detected in at least one band.	**F.a.v**
L4WSDC-018	**Positional Uncertainties:** The WISE Source Catalog shall contain uncertainties in the coordinates	**F.a.v**

	measurements for each object.	
L4WSDC-014	**RMS Error:** The root mean square (1σ) error in WISE catalog positions with respect to 2MASS All-Sky Point Source Catalog positions shall be less than 0.5" on each axis, for sources with SNR > 20 in at least one WISE band.	**D.c.ii, F.a.xi**

Table 3: Requirements on the Image Atlas

ID	REQUIREMENT	QA CHECK(S)
	Image Atlas Specifications	
L2FRD-339	**Sky Coverage:** The WISE survey shall be designed to provide at least 8 repeat observations over 99.25% of the sky, exclusive of unplanned safing or anomalous events.	**F.b.v**
L4WSDC-026	**Coverage Maps:** The WSDC shall generate and archive coverage maps that show the number of independent observations that go into each pixel of the Image Atlas images in each band. The coverage numbers shall take into account focal plane coverage and losses due to poor quality data, low responsivity and/or high noise masked pixels, and pixels lost because of cosmic rays and other transient events.	**F.b**
L3MOS-351	**Time Sampling:** The MOS shall generate survey plans that ensure that the time interval between the first and last exposures at each position on the sky be at least 30 minutes.	**F.b.vi**
L4WSDC-021	**Common Pixel Grid:** The images in the final WISE Image Atlas shall be re-sampled to a common pixel grid at all wavelengths.	**F.b.iv**
L4WSDC-022	**Photometric Calibration:** The photometric calibration of the final WISE Image Atlas shall be tied to the photometric calibration of the final WISE Source Catalog.	**F.b.ii**
L4WSDC-023	**FITS Standard:** The WSDC shall make all WISE image data available in accordance to the Flexible Image Transport (FITS) astronomical data standard	**F.b.i**
L2FRD-115	**Image Quality:** The average WISE flight system image quality, across the FOV excluding the corners shall be no greater than the numbers specified below (in noise pixels), assuming a 2.75 arcsecond pixel: 14.5 at Band 1	**(unsure how to test this)**

	18.2 at Band 2 48.4 at Band 3 136.0 at Band 4. The worst case image quality across the optical FOV excluding corners shall not exceed the average image quality requirement by more than 20%.	

The following tables illustrate how QA analyses during Scan/Frame QA (Table 4), Multiframe QA (Table 5), and Final Product Generation QA (Tables 6-7) map into science requirements imposed on the final source catalog and image atlas. As these tables show, every requirement has one or more associated QA checks.

Table 4:V&V Matrix for Scan/Frame QA

	Source Catalog															**Image Atlas**						
Requirement → **QA check↓**	Completeness	Reliability	Characterization	Artifact Flagging	Flux Meas/Upper Limits	Flux Uncertainties	Flux Quality Flag	Phot. SNR=5 Limits	Phot. RMS Error	Saturated Photometry	Saturation Limit	Near-Moon Performance	Astrometric Measures	Astrometric Uncertainties	Astrom. RMS Error	Sky Coverage	Coverage Maps	Time Sampling	Common Pixel Grid	Photometric Calibration	FITS Standard	Image Quality
SCAN/ FRAME QA												X										
Band detection statistics					X																	
Source confusion vs. galactic latitude							X															
Saturation vs. ramp flag										X												
Color-color plots										X												

Artifact ID checks		X		X			X															
Log(N)-log(S) plots	X																					

Table 5: V&V Matrix for Multiframe QA

	Source Catalog															**Image Atlas**						
Requirement → **QA check↓**	Completeness	Reliability	Characterization	Artifact Flagging	Flux Meas/Upper Limits	Flux Uncertainties	Flux Quality Flag	Phot. SNR=5 Limits	Phot. RMS Error	Saturated Photometry	Saturation Limit	Near-Moon Performance	Astrometric Measures	Astrometric Uncertainties	Astrom. RMS Error	Sky Coverage	Coverage Maps	Time Sampling	Common Pixel Grid	Photometric Calibration	FITS Standard	Image Quality
MULTI-FRAME QA																						
Scan detection statistics					X																	
Astrometric error vs. SNR															X							
Source confusion vs. galactic latitude							X															
Saturation vs. ramp flag										X												
Color-color plots										X												
Artifact ID checks		X		X			X															
Log(N)-log(S) plots	X							X	X		X											

Table 6: V&V Matrix for Final Products QA (Source Catalog)

	Source Catalog															Image Atlas						
Requirement → **QA check↓**	Completeness	Reliability	Characterization	Artifact Flagging	Flux Meas/Upper Limits	Flux Uncertainties	Flux Quality Flag	Phot. SNR=5 Limits	Phot. RMS Error	Saturated Photometry	Saturation Limit	Near-Moon Performance	Astrometric Measures	Astrometric Uncertainties	Astrom. RMS Error	Sky Coverage	Coverage Maps	Time Sampling	Common Pixel Grid	Photometric Calibration	FITS Standard	Image Quality
FINAL PRODUCTS QA – Source Catalog																						
Range checking of columns					X	X	X						X	X								
Completeness via truth fields	X		X																			
Reliability via truth fields		X	X																			
Log(N)-log(S) plots								X	X		X											
Saturation vs ramp flag										X												
Color-color plots										X												
Astrometric error vs. SNR															X							

Table 7: V&V Matrix for Final Products QA (Image Atlas)

	Source Catalog															Image Atlas						
Requirement → **QA check↓**	Completeness	Reliability	Characterization	Artifact Flagging	Flux Meas/Upper Limits	Flux Uncertainties	Flux Quality Flag	Phot. SNR=5 Limits	Phot. RMS Error	Saturated Photometry	Saturation Limit	Near-Moon Performance	Astrometric Measures	Astrometric Uncertainties	Astrom. RMS Error	Sky Coverage	Coverage Maps	Time Sampling	Common Pixel Grid	Photometric Calibration	FITS Standard	Image Quality
FINAL PRODUCTS QA – Image Atlas																	X					
Confirm FITS standard																					X	
Photometric zero point check																				X		
Range checking of headers; pixel grid check																			X			
Build survey coverage stats																X						
Compute epoch difference via headers																		X				

5 TRACKING QA RESULTS

The QA subsystem will maintain two tables, one for individual scans and one for coadds, that summarize QA results. These tables will contain concise data on (a) basic scan information such as ID and observation date, (b) telescope telemetry such as detector temperature, (c) characterizations of the data such as point source shape parameters and mean source density, and (d) quality assessments and final quality scores.

These tables will be used to perform trending analyses (such as background noise vs. detector temperature) and to decide which scans to include/exclude from further processing.

6 ANOMALY RESPONSE PLAN

During the QA process, anomalies and problems will be detected that may need response from the EOS, MOS, SOC, WSDC, or WISE Science Team. The procedure for anomaly announcements, the tracking of further analysis, and the successful resolution of each reported problem are discussed for each of the QA processes below. All web-accessible reports and summaries will be password protected and available only to WISE personnel:

A. Ingest QA
   a. Action: WSDC to inform MOS/EOS and SOC of successful Ingest runs or anomalies via web-accessible report.
   b. Tracking: (TBD) MOS/EOS and/or SOC to acknowledge receipt of anomaly report via web form; results of subsequent analyses to be archived by WSDC and made web accessible.
   c. Resolution: WSDC will note anomalies on web summary pages; issues may need to be closed with MOS/EOS and/or SOC.

B. Quicklook QA
   a. Action: WSDC to inform MOS/EOS and SOC of Quicklook runs or anomalies via web-accessible report.
   b. Tracking: MOS/EOS and/or SOC to acknowledge receipt of anomaly report via web form; results of subsequent analyses to be archived by WSDC and made web accessible.
   c. Resolution: WSDC will close the issue and note it on web summary pages once parties agree that resolution has been reached

C. Scan/Frame QA
   a. Action: WSDC to report anomalies as part of the normal assigning of scan/frame QA grades. This report will be posted on the web for review by the PI and SOC.
   b. Tracking: On the web summary pages, WSDC will mark reviews having outstanding issues and add subsequent analyses by WSDC or SOC to the QA review for curation.
   c. Resolution: WSDC will close the issue and note it on web summary pages once the PI or designee concurs that resolution has been reached.

D. Coadd QA
   a. Action: WSDC to report anomalies as part of the normal assigning of coadd QA grades. This report will be posted on the web for review by the PI and SOC.
   b. Tracking: On the web summary pages, WSDC will mark reviews having outstanding issues and add subsequent analyses by WSDC or SOC to the QA review for curation.
   c. Resolution: WSDC will close the issue and note it on web summary pages once the PI or designee concurs that resolution has been reached.

E. Archive QA
   a. Action: WSDC to report problems on web summary pages and to assign action items to internal WSDC or IRSA personnel via those project's ticket systems.
   b. Tracking: Tracking will be handled by each project's existing ticket systems.
   c. Resolution: WSDC will close issue and note it on web summary pages after concurrence of WSDC/IRSA personnel.

F. Final Products QA
   a. Action: WSDC to report anomalies to WSDC/IRSA via ticket systems or to SOC via e-mail.
   b. Tracking: WSDC to note status of anomaly checking via ticket systems (for WSDC/IRSA-related issues) and via web summary pages.
   c. Resolution: WSDC will close the issue and note it on web summary pages once the PI or designee concurs either that a solution has been found or that the anomaly should be characterized and documented for the Explanatory Supplement.

G. Anomaly Collection Via Other Routes
   a. From the WISE Science Team: Capture/track/resolve anomalies via a WISE Help Desk, set up through IRSA's Ticket Tracker.
   b. From the Astronomical Community: Same as above.

7 STAFFING PLAN

Personnel for Quality Assurance operations will have the following roles:

- QA operations will be overseen by the QA Lead Scientist. The QA Lead Scientist will produce a WSDC Quality Assurance Plan (this document) in preparation for the WSDC CDR. The QA Lead Scientist will then direct the continued progress of the QA system from development through final handoff of the data products to IRSA.
- The bulk of the code for the QA system will be written by the QA System Development Engineers. Other pieces of the code, such as specific analysis modules, are expected to be contributed by the QA Scientists or WISE Science Team members.
- QA Scientists, who are experienced in the analysis and interpretation of near-infrared astronomical images and astronomical catalogs, will serve as the arbiters of data quality for day-to-day processing. These QA scientists may include postdoctoral scholars.
- QA operations also require the services of a Documentarian/User Support Scientist for collecting, standardizing, and in some cases writing the final user documentation. The Documentarian will oversee both an explanatory supplement to the data products as well as in-depth analysis reports. The User Support Scientist will oversee the response to user questions on WISE data products prior to final hand-off to IRSA.

The timescale for this staffing is envisioned as follows:

QA Lead Scientist

- 0.5 FTE from the present until ~6 months after final data release

QA System Development Engineer

- 0.5 FTE starting ~1.5yr before launch.
- Ramps up to 1.0 FTE at ~6 months before launch.
- Ramps back down to 0.5 FTE at ~2 months after end of on-orbit operations.
- Ends at final data release.

QA Scientists (numbers may include up to three postdocs)

- 5.0 FTEs phased in between ~6 to ~9 months before launch and continue through final data release.

- Ramps down to zero at ~6 months after final data release.

Documentarian and User Support

- 0.2 FTE starting ~3 months before launch.
- Ramps up to 0.5 FTE at ~5 months after end of on-orbit ops (i.e., the start of final data processing).
- Ends at ~6 months after final data release.

8 DEVELOPMENT SCHEDULE

- Version 1.0 (July 17, 2008)
  - Ingest QA prototyped
  - Quicklook QA prototyped
  - Parts of Scan/Frame QA prototyped
  - Scan synchronization monitor in preliminary state
- Version 2.0 (February 28, 2009)
  - V1.0 pieces matured
  - Parts of Multiframe QA prototyped
  - Archive QA prototyped
- Version 3.0 (August 10, 2009)
  - Ingest QA ready for launch
  - Quicklook QA ready for launch
  - Scan/Frame QA ready for launch
  - Multiframe QA ready for launch
  - Archive QA ready for launch
- Version 3.5, post-launch (January 26, 2010)
  - Post-launch tune-ups of the five QA subsystems directly above
  - Final Products QA prototyped
- Version 4.0, post-cryo (October 18, 2010)
  - Final versions of all six QA subsystems mature

9 ACRONYM LIST

2MASS	Two Micron All-Sky Survey
2MASS PSC	Two Micron All-Sky Survey Point Source Catalog
CDR	Critical Design Review
EOS	Engineering Operations System
FITS	Flexible Image Transport System
FOV	Field of view
FTE	Full-time employee
IOC	In-orbit checkout
IRSA	NASA/IPAC Infrared Science Archive
JPL	Jet Propulsion Laboratory
log(N)-log(S)	Logarithm of the number of sources (N) as a function of the logarithm of the flux density (S)
MOS	Mission Operations System
NEP	North ecliptic pole
PEF	Predicted Events File. The PEF is a MOS product that shows the spacecraft activities, particularly scan start, scan end, SEP/NEP crossings, orbit numbers, and SAA boundary crossings.
PI	Principal investigator
QA	Quality assurance
RMS	Root mean square
RTB	Regression test baseline
SAA	South Atlantic anomaly
SEP	South ecliptic pole
SNR	Signal-to-noise ratio
SOC	Science Operations Center
V&V	Verification and validation
W1	WISE channel 1
W2	WISE channel 2
W3	WISE channel 3
W4	WISE channel 4
WISE	Wide-field Infrared Survey Explorer
WSDC	WISE Science Data Center at the Infrared Processing and Analysis Center