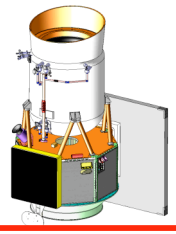
WISE Mission Operations System CDR

WISE Science Data Center

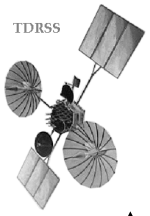
R. Cutri - IPAC
WISE Science Data Manager
Tim Conrow - IPAC
WSDC Lead Engineer

MOS Architecture



Commands/Telemetry
S-Band

Science/Stored Telemetry
100Mbs Ku-Band



Science/Stored Telemetry
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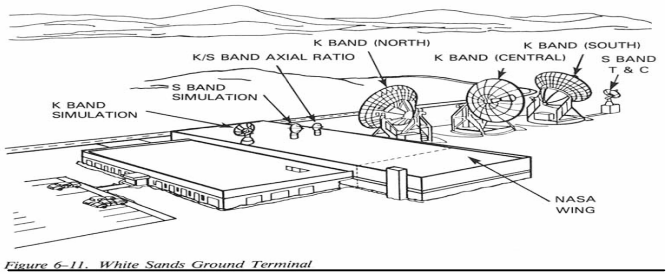


Figure 6-11. White Sands Ground Terminal

Science Survey Planning (UCLA)

Survey Plan Parameters

Engineering Operations System (JPL)

- Scheduling and Navigation (TDRSS and WISE ephemeris)
- Sequencing and Command Generation
- Real-Time Operations Heath and Safety Monitoring
- Data Archiving Engineering Data Processing
  - S/C Engineering Support (BATC)
  - Instrument Engineering Support (SDL)

WISE Science Data Center (IPAC)

- Science/Engineering Data Ingest
- Pipeline Processing And Data Archive
- Final Product Generation Image Atlas/Catalog
  - Science Community
  - Science Data And Survey Quality Assurance

White Sands Ground Terminal

- High Rate Science Data Processor
- TDRSS Uplink
- Real-time and Stored Telemetry

WSDC Responsibilities

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

Implementation - 1

- The WSDC is an independent *task* at IPAC
  - Analogous to 2MASS, NHSC, IRSA, NED
  - IPAC/WISE Task Lead reports to IPAC Executive Director and works with IPAC Manager to organize staff and resources to perform task
  - Administrative, facilities and common infrastructure cost shared with all IPAC projects
  - WSDC will use dedicated hardware that is integrated into IPAC network structure
  - Resources and expertise shared with other IPAC tasks along with SSC, MSC which reside under a common administrative umbrella at IPAC

- Results in a substantial savings and improved quality because of access to expertise and synergy with other IPAC projects, including the Spitzer and Michelson Science Centers

Implementation - 2

- Science Data Processing/Archiving/Distribution integrated into WISE planning and design from the outset
  - WSDC task lead participates in WISE management meetings, telecons
  - Task lead, lead engineer and lead QA scientist participate in MOS, MSET, V&V meetings, telecons
  - WSDC personnel participate in Calibration WG, analysis of test data

- On-going interaction with WISE Science Team during all phases of the project
  - Five WISE co-Investigators are IPAC staff members (Cutri, Jarrett, Kirkpatrick, Lonsdale, Padgett) that provide strong scientific oversight for WSDC activities
  - "Cognizant" Science Team member will be assigned to each data processing pipeline subsystem and will work closely with WSDC cognizant engineer to develop and validate algorithms, and analyze on-orbit data (adopted from 2MASS)
  - Science Team will be heavily involved with development of data reduction algorithms, analysis of on-orbit data, validation of preliminary and final WISE data products, and in writing explanatory documentation

WSDC Status

- WSDC staffing and activity has been kept at minimal level until start of Phase C/D
- Staff is beginning to build up and will be ready for the WSDC CDR 1/29-30/2008
- Work to date has focused on management, design and key data and operational interface definition
  - Project management activity support, requirements definition, flow-down
  - Top level system design and implementation planning (cost, schedule)
  - Key external interface definition in conjunction with MOS
- Prototyping in conjunction with MOS
  - Science data INGEST capability has been developed to support spacecraft MUB testing starting in April 2007
  - Scan synchronization monitor component of Quicklook Quality Assurance subsystem demonstrated

Driving Requirements - 1

Higher Level Requirement	Level 4 Requirement	Compliance	Verification Method
L3MOS-366 (L1PP-8)	**Image Atlas:** The WSDC shall produce a digital Image Atlas that combines multiple survey exposures at each position on the sky.	By design	Demonstration
L3MOS-374 (L1PP-9)	**Source Catalog:** The WSDC shall produce a Source Catalog derived from the WISE digital Image Atlas.	By design	Demonstration
L3MOS-366,374 (L1PP-34)	**Data Release:** The WSDC shall release to the public an image atlas and source catalog covering the full survey area within 17 months after the end of on-orbit data collection.	By design	Demonstration
L3MOS-355, 363 (L1.5SRD-50)	**Preliminary Data Release:** The WSDC shall release to the public a preliminary image atlas and source catalog covering at least 50% of the surveyed area within 6 months after the end of on-orbit data collection	By design	Demonstration
L3MOS-417 (L1PP-010)	**Catalog 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.	By design	Test: Comparison with external "truth tables"; detection confirmation
L3MOS-363, 418 (L1PP-011)	**Catalog Completeness**: The final WISE Source Catalog shall be at 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.	By design	Test: Detection repeatability in deep coverage areas (e.g. the ecliptic poles)

Driving Requirements - 2

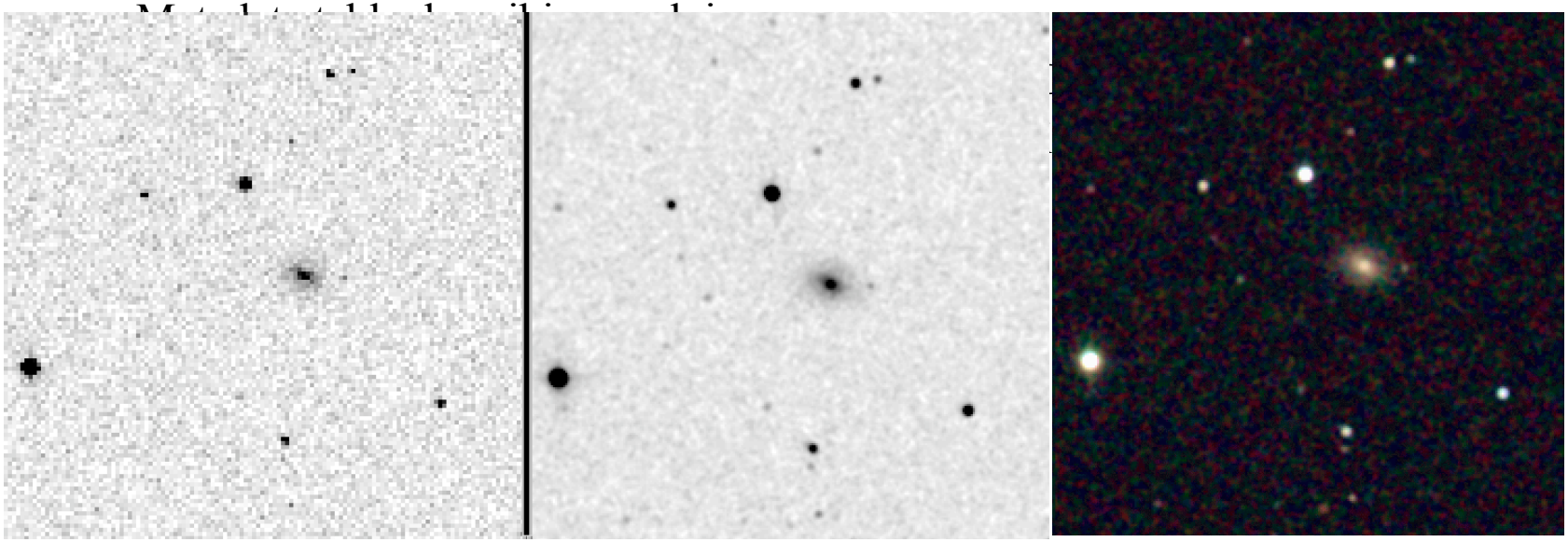
Higher Level Requirement	Level 4 Requirement	Compliance	Verification Method
L3MOS-376 (L1PP-012)	**Photometric Accuracy:** The root mean square error in relative photometric accuracy in the WISE Source Catalog shall be better than 7% in each band for unsaturated point sources with SNR>100, where the 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.	By design	Test: Photometric repeatability; stellar color stability over sky
L3MOS-370 (L1PP-013)	**Astrometric Accuracy:** 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	By design	Test: Comparison with 2MASS PSC and other astrometric catalogs (e.g UCAC)
L3MOS-420 (L1PP-4)	**Photometric Sensitivity:** Flux measurements in the WISE Source Catalog shall have a SNR of five or more for point sources with fluxes of 0.12, 0.16, 0.65 and 2.6 mJy at 3.3, 4.7, 12 and 23 micrometers, respectively, assuming 8 independent exposures and where the noise flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources.	By design	Test: Photometric repeatability; Colors of normal stars, galaxies
L3MOS-272	**Quicklook Quality Assurance:** Approximately 3% of the science data from each orbit shall be processed and data quality summary reports posted to the WISE internal web site within 24 hours of receipt at the WSDC.	By design	Demonstration

Driving Requirements - 3

Higher Level Requirement	Level 4 Requirement	Compliance	Verification Metho d
L3MOS-286	**Single Orbit Data Processing Latency:** Within 3 days of receipt of a given data set, the WSDC shall process all single orbit data through the first stage of pipeline processing .	By design	Demonstration
L3MOS-387 (L1PP-34)	**Archive Longevity:** The WSDC shall make the Image Atlas and Catalog products accessible to the astronomical community in collaboration with the NASA/IPAC science archive infrared to ensure long-term availability beyond the end WISE missions operations and data processing phase, and insure interoperability with other NASA mission archives.with other NASA mission archives.	By design	Demonstration

WSDC Mission Deliverables - 1

- WISE Image Atlas
  - FITS format, all exposures registered and combined, resampled to 1/2 raw pixel scale (1.375”/pix), 4 bands registered



WSDC Mission Deliverables - 2

GATOR STATUS PAGE

http://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-query

Apple (14) .Mac News (574) WISE 2MASS Roc's 2MASS Pages Amazon EarthLink

dist	ra	dec	err_maj	err_min	designation	j_m	j_msigcom	h_m	h_msigcom	k_m	k_msigcom
6.465670	132.832875	11.810451	0.07	0.07	08511989+1148376	15.084	0.0426	14.508	0.0477	14.445	0.0672
14.368325	132.836275	11.808737	0.07	0.07	08512070+1148314	15.468	0.0479	14.843	0.0658	14.562	0.0744
20.978402	132.830069	11.807475	0.07	0.07	08511921+1148269	15.151	0.0416	14.600	0.0542	14.312	0.0598
29.256208	132.840081	11.817353	0.07	0.07	08512161+1149024	13.780	0.0229	13.368	0.0281	13.279	0.0301
33.213040	132.842251	11.807739	0.07	0.07	08512214+1148278	14.011	0.0252	13.530	0.0281	13.441	0.0301
36.974720	132.838481	11.821186	0.25	0.25	08512123+1149162	16.807	0.1594	15.961	0.1667	15.720	0.2101
41.378972	132.845475	11.813716	0.07	0.07	08512291+1148493	11.612	0.0205	11.360	0.0202	11.313	0.0198
43.387251	132.830112	11.823437	0.07	0.07	08511922+1149243	12.748	0.0229	12.468	0.0216	12.427	0.0212
44.930420	132.827257	11.822631	0.07	0.07	08511854+1149214	11.506	0.0217	11.229	0.0216	11.145	0.0169
45.717732	132.823341	11.804540	0.11	0.11	08511760+1148163	14.616	0.0230	11.767	null	11.455	null
49.095066	132.846987	11.807363	0.07	0.07	08512327+1148265	12.714	0.0217	12.238	0.0188	12.133	0.0198
50.388077	132.829927	11.798506	0.07	0.07	08511918+1147546	12.566	0.0205	12.247	0.0202	12.182	0.0198
51.324129	132.845675	11.820311	0.07	0.07	08512296+1149131	12.365	0.0217	12.155	0.0202	12.076	0.0198
52.004229	132.821257	11.804460	0.07	0.07	08511710+1148160	8.140	0.0270	7.526	0.0184	7.385	0.0210
54.553848	132.847936	11.818291	0.07	0.07	08512350+1149058	14.468	0.0263	13.904	0.0330	13.816	0.0426
56.224454	132.818667	11.816701	0.07	0.07	08511648+1149001	15.289	0.0448	14.562	0.0520	14.419	0.0702
56.385021	132.832042	11.827520	0.07	0.07	08511969+1149390	14.096	0.0263	13.683	0.0330	13.577	0.0393
57.017689	132.845000	11.800464	0.07	0.07	08512280+1148016	8.560	0.0227	8.075	0.0325	7.942	0.0241

WSDC Mission Deliverables - 3

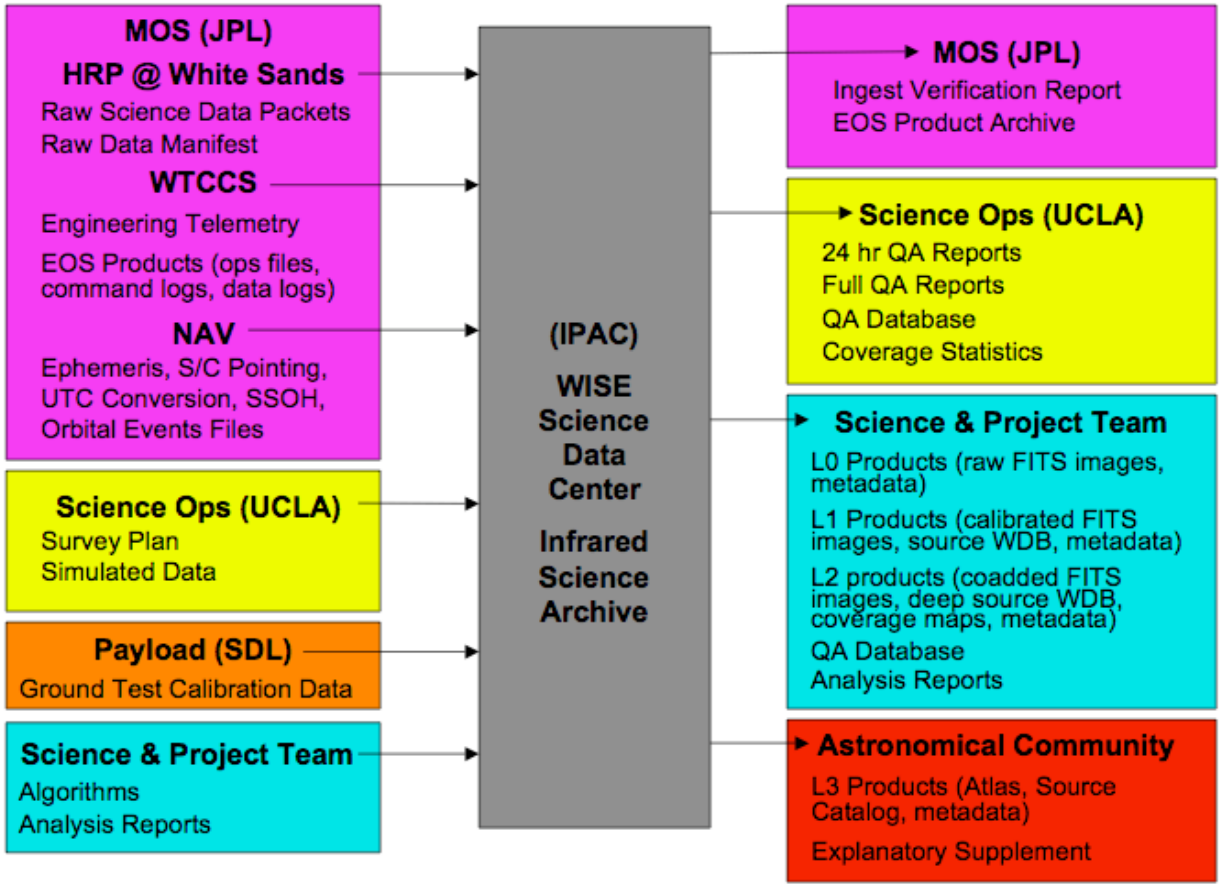
- WISE Explanatory Supplement
  - Mission and data product description,
  - User's guide (*e.g.* data formats, access modes)
  - Cautionary notes

- Ancillary Products
  - Not specified in higher level requirements. To be developed as resources and schedule allow
  - Atlas Image coverage maps
  - Solar system object association list (derived from single-epoch images)

Data Product Delivery

- Preliminary Image Atlas and Source Catalog
  - Derived from first 50% of sky surveyed
  - Release 6 months after end of on-orbit operations (12/2010)
- Final Image Atlas and Source Catalog
  - Derived from all survey data
  - Release 17 months after end of on-orbit operations (11/2011)
- Data Access Mode (project, science community and general public)
  - On-line services of NASA/IPAC Infrared Science Archive (IRSA)
  - IRSA will host Level 1,2 and final product archive
  - Option to provide bulk distribution of Source Catalog
- Level 0 Data Archive
  - At IPAC and off-site during mission
  - Permanent Level 0 Data Archive at NSSDC (Letter of agreement to be arranged by end of FY07)

External Interfaces - 1



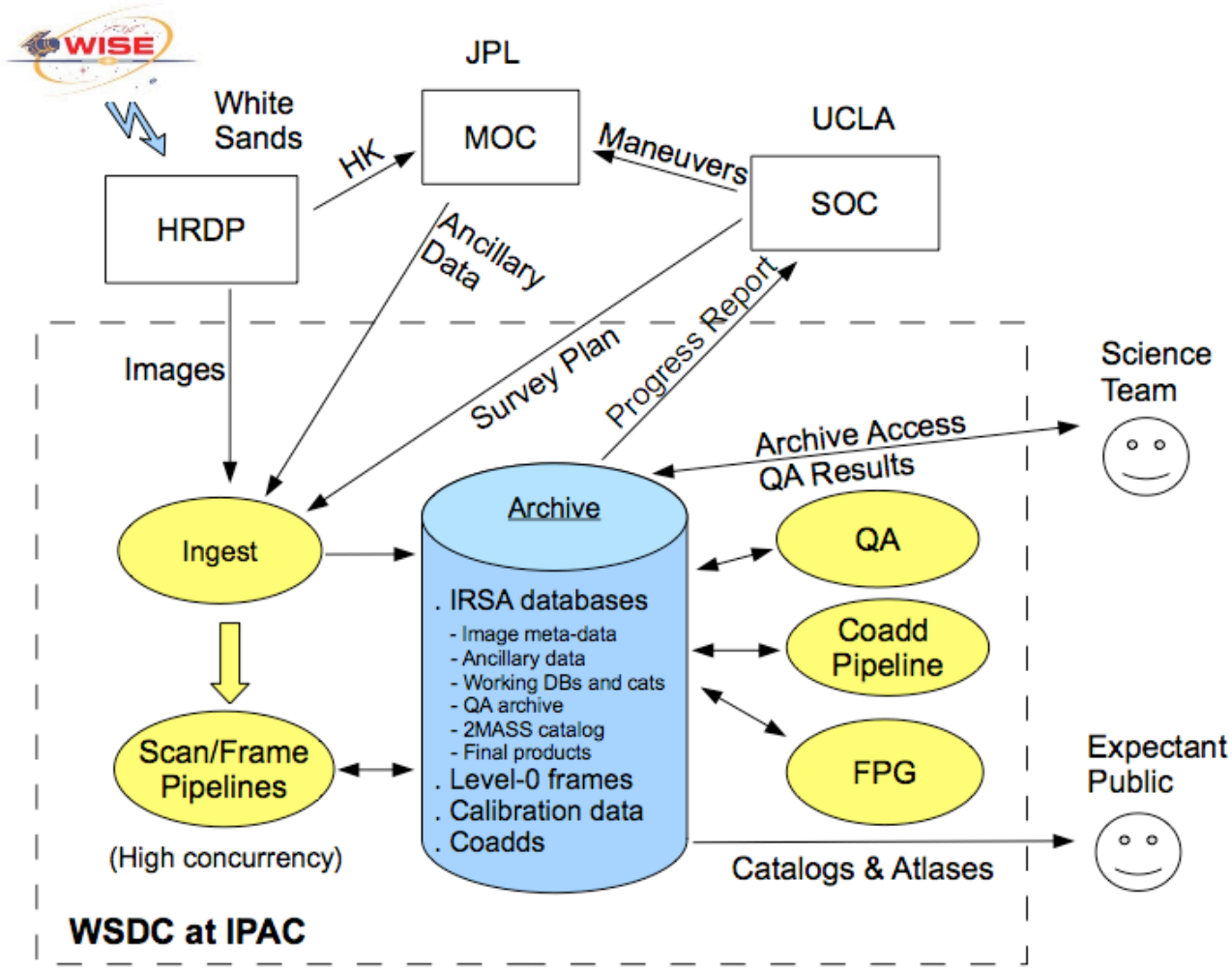
External Interfaces - 2

- MOS/WTCCS & NAV (receive and acknowledge)
  - Receive Spacecraft ephemeris, pointing, VT-UTC conversion telemetry files
  - Receive Selected stored-state-of-health files
  - Receive Orbital Events files
- MOS/HRDP@White Sands (receive and acknowledge)
  - Receive High-rate science data
  - Receive Science data manifest
- Science Operations (receive and send)
  - Receive Science observation plan
  - Send Science data processing QA report to close loop on survey planning (on-line)
- Project Team (send and receive)
  - Send Intermediate processed data products and working databases
  - Send Science data processing QA reports
  - Receive data processing algorithms
  - Receive science data analysis reports and contributions for Explanatory Supplement
- Astronomical Community (send)
  - Image Atlas, Source Catalogs, ancillary products
  - Data product documentation (on-line Explanatory Supplement)

WISE Science Data System (WSDS)

- Software and operations system to execute WSDC functions
- Five primary Subsystems
  - INGEST, PIPELINES, FPG, ARCHIVE, QA
- Based closely on systems used for 2MASS and other IPAC projects
  - Highly automated, "industrial strength" data processing software system designed for high-throughput, reliable operation
  - Extensive use of automated QA reporting
  - Modular system to facilitate parallel development, unit-testing
  - Extensive use of parameter control files to allow "tuning" for actual on-orbit performance
- Planned two-stage data processing and data release
  - "Can't get it right the first time"
  - Allows incorporating best knowledge of actual instrument performance, calibration and sky
  - Gets data out as rapidly as possible, and uses community as "beta-testers"
- Design from outset with product development and distribution in-mind
  - Source and image databases/archives developed within IRSA
  - Empower Science and Project Team by enabling easy access to intermediate and final data products

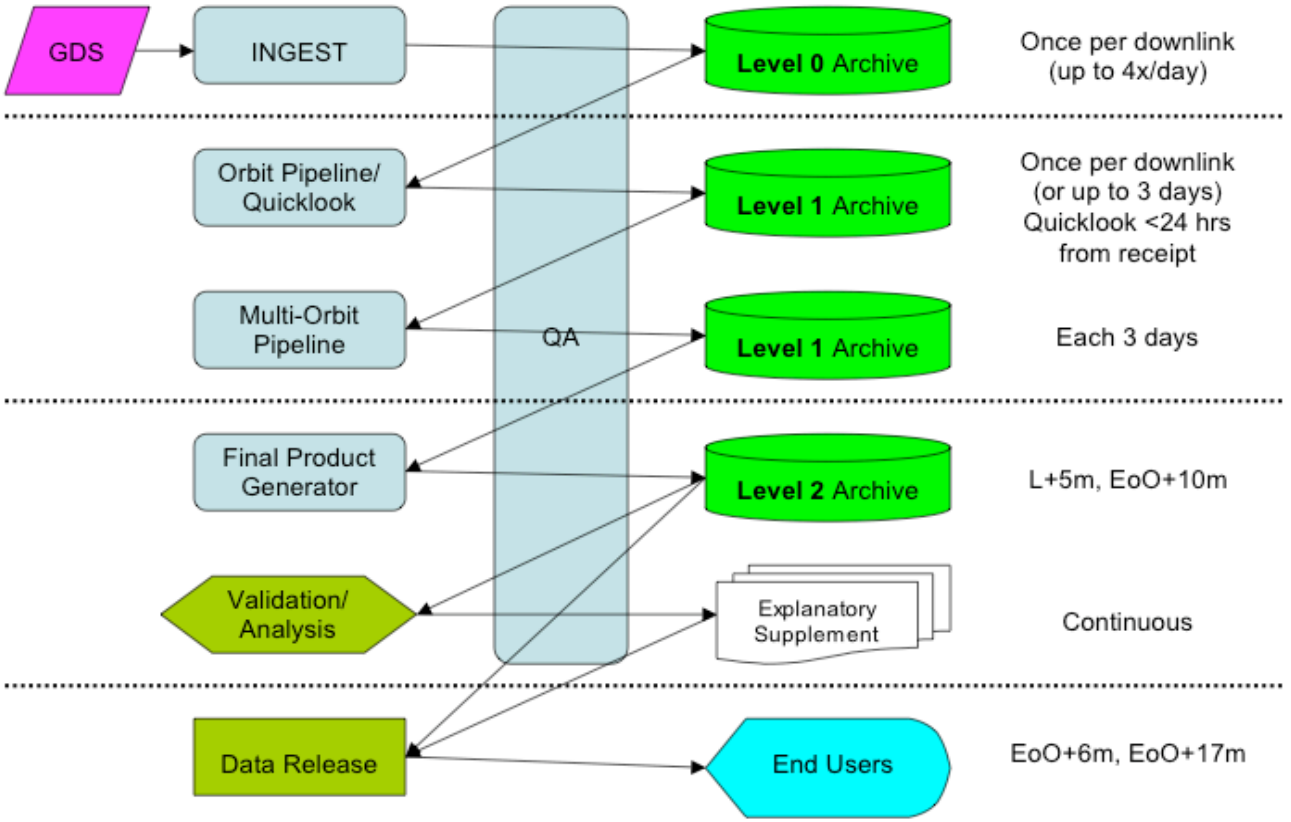
WSDS Functional Block Diagram



WSDS Key Subsystems

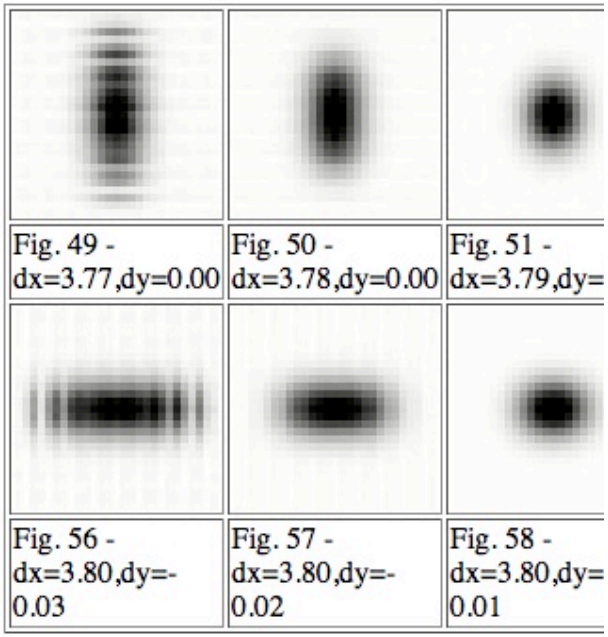
- INGEST
  - Receives science data packets and engineering telemetry from MOS and assembles Level 0 FITS-format files. Stages Level 0 images and metadata for pipeline processing.
- Data Reduction PIPELINES
  - Converts Level 0 imaging data into calibrated images and extracted source *Working Databases*
  - **Frame/Scan pipeline** operates on individual frames within one "scan" (=1/2 orbit)
  - **Coadd pipeline** operates on data from multiple orbits
- 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
- 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 Atlas and Source Catalog from *Combined* image and source *Working Databases*. Includes validation, characterization and documentation

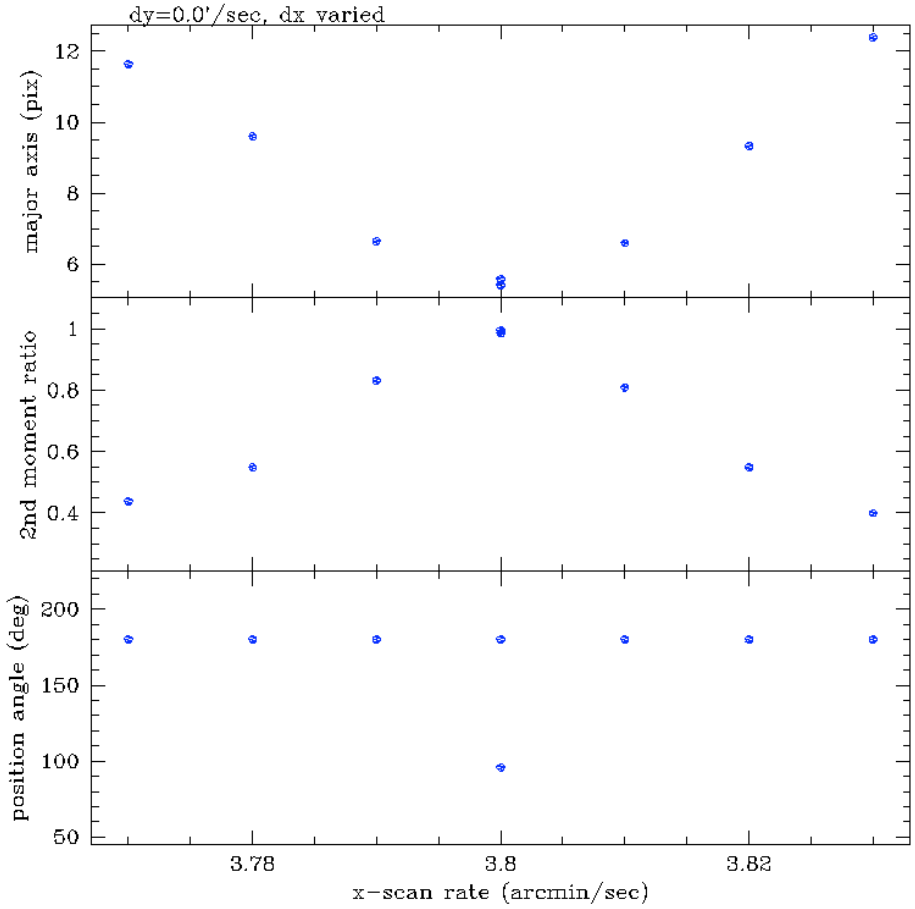
Internal Data Flow and Operational Cycle



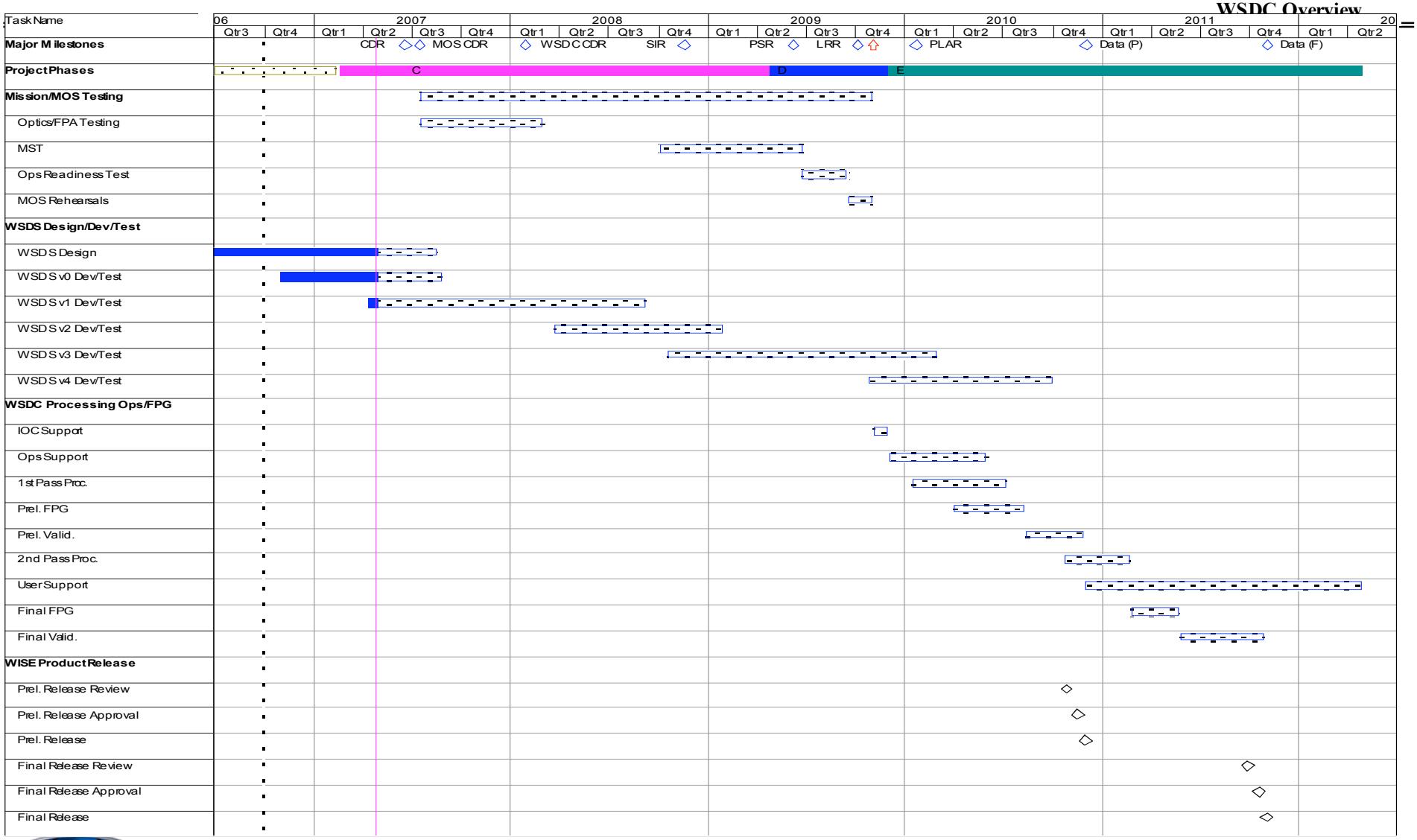
Scan Synchronization Monitor Demo

- Image quali
  monitored a
  pipeline QA
- Same tool w
  task to sync
  rates
- Demonstrat
  data showin
  provided by
- Composite
  high SNR p
  or more ima
- PRF "shape" characterized, plotted as a function of frame, scan rate, etc.
- Optimal image shape occurs when scan rates are matched





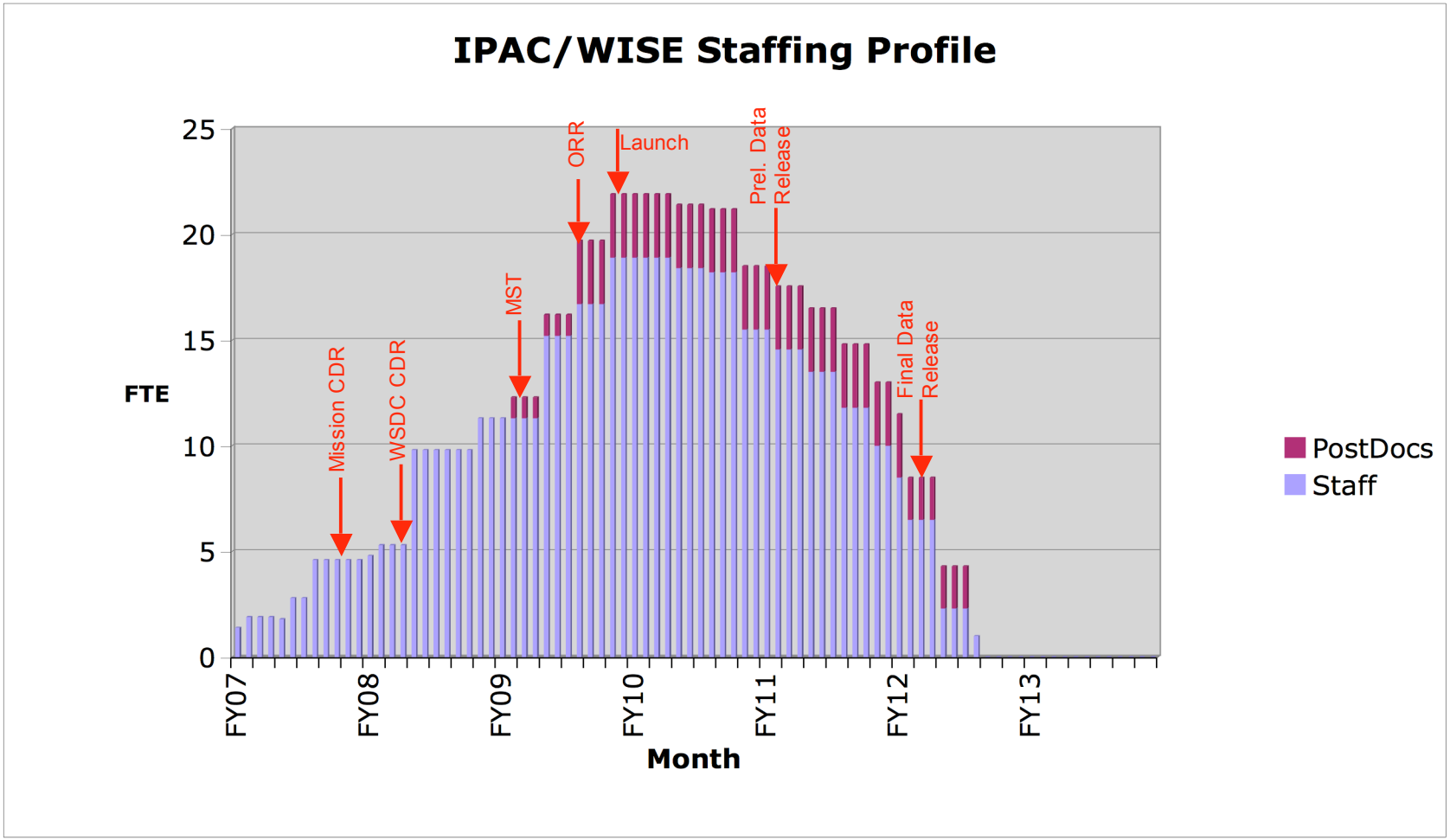
WSDC Dev/Ops Schedule



WSDC WBS and Task Plan

Fiscal Year	FY07	FY08	FY09	FY10	FY11	FY12	FY13	Total
Month								
Phase	B/C	C	C/D	D/E	E	E	E	
Project Lead								
Lead Scientist	0.60	0.73	0.80	0.80	0.80	0.50	0.00	4.79
Lead Engineer	0.50	0.50	0.50	0.50	0.50	0.17	0.00	3.08
Lead QA/Analysis Scientist	0.30	0.50	0.50	0.50	0.50	0.31	0.00	2.91
Subystem Development Engineers								
Pipeline Executive/Config. Mgmt./I&T	0.13	0.81	1.00	0.92	0.29	0.00	0.00	3.15
Data Ingest System	0.18	0.47	1.00	0.58	0.00	0.00	0.00	2.23
Instrumental Calibration	0.00	0.50	0.50	0.50	0.22	0.00	0.00	1.72
Image Construction/Mosaicing	0.21	0.83	1.00	1.00	0.54	0.17	0.00	3.75
Source Detection	0.21	0.50	0.50	0.50	0.29	0.00	0.00	2.00
Source Photometry	0.21	1.17	1.50	1.50	1.08	0.17	0.00	5.63
Position Reconstruction	0.58	0.83	1.00	0.92	0.50	0.17	0.00	4.00
Bandmerge	0.00	0.33	0.50	0.42	0.00	0.00	0.00	1.25
Artifact Identification	0.21	0.50	0.83	1.00	0.54	0.10	0.00	3.19
Photometric Calibration	0.00	0.33	0.83	1.00	0.88	0.08	0.00	3.13
Known Solar System Object ID	0.00	0.00	0.27	0.28	0.00	0.00	0.00	0.55
Quality Assurance System Development	0.00	0.33	0.71	0.92	0.46	0.02	0.00	2.44
Operations, QA, Analysis, Support								
Pipeline Operations	0.00	0.08	1.00	2.00	1.58	0.04	0.00	4.71
Instrument Characterization Scientists	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quality Assurance Scientists	0.00	0.00	1.08	2.00	2.00	0.33	0.00	5.42
Documentation and User Support	0.00	0.00	0.03	0.20	0.48	0.31	0.00	1.02
Archive								
Archive Interface/Load	0.00	0.04	0.42	0.50	0.26	0.07	0.00	1.29
Archive Support (DBA,Metadata Mgmt,Tool Dev)	0.00	0.04	0.92	2.00	2.00	0.56	0.00	5.52
Total Staff (FTE)	3.13	8.51	14.89	18.03	12.92	2.99	0.00	61.75
PostDoctoral Analysts (FTE)	0.00	0.00	1.75	3.00	3.00	1.25	0.00	9.00
Total Workforce by Month (FTE)	**3.13**	**8.51**	**16.64**	**21.03**	**15.92**	**4.24**	**0.00**	**70.75**

WSDC Staffing Profile



Steps to the WSDC CDR

- WSDC CDR scheduled for 1/29-30/2008
- Final scrub of WSDC Functional Requirements (FDD - currently in v1)
- Advance all major documents to version 1 or higher
  - PDMP, FDD, SMP, SDS templates, SIS templates, etc.
- Complete top-level design of key INGEST and PIPELINE components
- Peer reviews of major components in November and December
- Deliver WSDS v0
- Continue prototyping activities using simulated data
  - H/K data ingest, mating to Level 0 science data
  - Multi-band source detection
  - Position reconstruction (astrometry)
  - Source photometry
- Baseline data product schemata (image specifications/headers, catalog columns)
- Support detector/instrument testing to further our knowledge of FPA performance

WSDC Concerns

- Surprises in actual on-orbit instrument performance

  Mitigation: Modular S/W system with extensive parameter file control. Close involvement with payload ground test design discussion. Take advantage of lessons learned from Spitzer (Si:As). Lien for additional instrument characterization scientists.

- Baselined aperture photometry algorithm may not yield measurements that satisfy sensitivity requirements

  Mitigation: Lien to implement profile-fitting photometry. Hired cognizant engineer for photometry subsystem who developed profile-fitting software for 2MASS.

- Aggressive preliminary release schedule allows very little time for validation

  Mitigation: Relaxed requirements for preliminary release. Design for automated QA concurrent with processing, tied to science metrics (2MASS heritage).

- Handling deliveries of fragmented, out-of-order, and/or incomplete data frames

  Mitigation: Design for expected fragmentation. Working with MOS to insure that sufficient information to reassemble fragmented files will be provided.

Summary

- WISE data processing, archiving and distribution tasks are challenging, but we know how to do them
- The WSDC processing and archiving system design is based closely on proven systems
  - Scope and functionality of WISE data processing, quality assurance, final product generation and archiving tasks are similar to those of 2MASS.
  - 2MASS photometric/astrometric accuracy, completeness and reliability requirements were more stringent than those for WISE, and all were met or surpassed.
  - WSDC Level 0 data ingest system design draws upon operational GALEX system (not strictly an IPAC institutional activity, but supported by IPAC staff detailed to GALEX)
- Assembling staff now to carry out task and prepare for WSDC CDR in January 2008.