Wide-field Infrared Survey Explorer science payload overview

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ABSTRACT

The Wide Field Infrared Survey Explorer is a NASA Medium Class Explorer mission to perform and all-sky survey in four infrared wavelength bands. The science payload is a cryogenically cooled infrared telescope with four 1024^2 infrared focal plane arrays covering from 2.8 to 26 microns. Advances in focal plane technology and a large aperture allow an all-sky survey to be performed with high sensitivity and resolution. Mercury cadmium telluride (MCT) detectors, cooled to 32 K, are used for the two midwave channels, and Si:As detectors, cooled to < 8.3 K, are used for the two long wavelength channels. Cooling for the payload is provided by a two-stage solid hydrogen cryostat providing temperatures <17K and < 8.3K at the telescope and Si:As focal planes, respectively. The science payload supports operations on orbit for the seven month baseline mission with a goal to support a 13 month extended mission if available. This paper provides a payload overview and discusses instrument requirements and performance.

Keywords: Infrared, Cryogenic, Astronomy, WISE, Space-Telescope

1. INTRODUCTION

1.1 WISE mission

The Wide-field Infrared Survey Explorer (WISE) is a cost-capped MIDEX program funded by NASA's SMD Universe Division, managed by the Jet Propulsion Laboratory (JPL), and led by Principal Investigator Edward Wright from UCLA[1]. The WISE mission will map the entire sky with unprecedented sensitivity from 2.8 to 26 µm. With over 500,000 times the sensitivity of Cosmic Background Explorer (COBE) at 3.5 and 4.7 µm, and a thousand times that of Infrared Astronomical Satellite (IRAS) at 12 and 25 µm, WISE will establish an essential database for testing theories of the origins of planets, stars, and galaxies, and is a precursor for the James Webb Space Telescope (JWST).

The sky mapping makes use of the sun synchronous orbit precession, which essentially scans the orbit over the six-month data- taking mission lifetime. Each field of view is overlapped by 10% between frames and overlapped 90% between orbits. The overlaps and planned outages for the moon, SAA, data downlink, and miscellaneous outages are estimated to give a minimum coverage of eight observations of each area of the sky. Each frame of data has an 8.8 second integration time on the detectors, with data collected using a sample up-the-ramp technique. To allow for readout time and scan mirror fly-back, each frame is 11 seconds in length. Mission elements include a science payload, spacecraft, mission operation and data processing. The flight system consists of the science payload and spacecraft elements together. This paper focuses on the science payload that enables the highly sensitive sky survey in the four infrared bands.

1.2 Flight system

The 750-kg WISE Flight System (Figure 1) will be launched into a 500-km, sun-synchronous orbit in June 2009. Utah State University/Space Dynamics Laboratory is providing the science payload and Ball Aerospace Technology Center is providing the spacecraft bus. The science payload consists of the IR instrument, cabling, aperture shade, and payload electronics. Payload to spacecraft integration is a straightforward process with limited interfaces to allow parallel development and testing. As seen in Figure 1, the payload instrument mounts directly to the top of the spacecraft bus. The instrument is structurally attached and thermally isolated through the composite bi-pod support structure.

Electronics specific to the payload reside within the spacecraft bus and cabling connects the electronics to the instrument. The aperture shade protects the <17 K open aperture from environmental heat loads from the sun, earth, and albedo. A deployable cover is ejected approximately two weeks after launch to allow the solid hydrogen-cooled cryostat to be processed on the ground and to allow the spacecraft outgassing and on-orbit checkout to occur. This

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instrument has strong legacy to previous solid hydrogen-cooled infrared instruments built at SDL such as SPIRIT III[7] and WIRE[5,6] and will apply lessons learned from these programs.

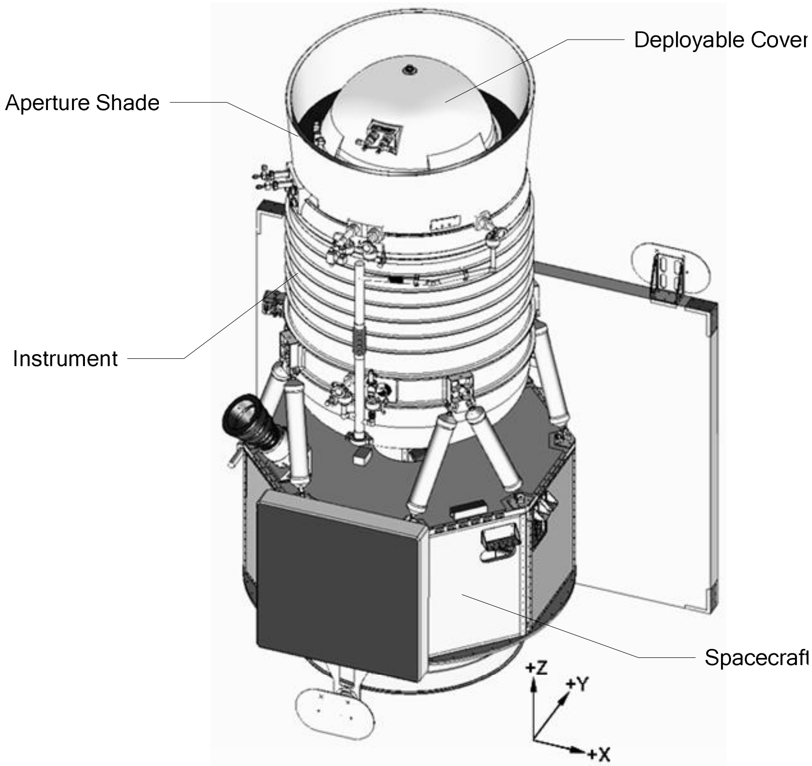

Figure 1: WISE Flight System including the science payload and Spacecraft Bus

WISE is designed to perform a four-band infrared all-sky survey over the course of its six-month data collection mission. Although the six-month mission allows a full sky coverage, there is a goal of providing 12 months of data collection if the operations are funded and the flight system is operating correctly. The WISE IR bands are shown in Table 1.

Table 1: WISE FPA bands

BAND	CHANNEL
1	2.8-3.8 µm
2	4.1-5.2 µm
3	7.5-16.5 µm
4	20 µm to detector cutoff (~28 µm)

The WISE survey will provide over one million calibrated, rectified images covering the whole sky and catalogs of over half a billion objects in the four WISE IR bands. These images will be used to study the nature and evolutionary history of ultra-luminous IR galaxies and identify the most luminous galaxies in the universe. WISE data will also be used to measure the space density, mass function, and formation history of brown dwarf stars near our sun. WISE data will form the primary catalog used for the James Webb Space Telescope.

2. PAYLOAD DESCRIPTION

The science payload is a cryogenically cooled infrared-imaging instrument which covers 4-infrared bands centered at 3.3, 4.7, 12, and 23 µm. The hardware consists of a 40-cm afocal telescope, a scan mirror, an all-reflective imager, and four focal plane arrays (FPAs) to capture data in four mid-infrared channels. The optical subsystem is contained within a two-stage solid-hydrogen cryostat that provides the appropriate temperatures over the desired mission life. Figure 2 shows a cut-away view of the major components. Images are frozen on the sky while data are collected by offsetting the spacecraft motion with the payload scan mirror. Warm electronics mounted within the spacecraft are used to control the scan mirror, process data, and monitor system health and telemetry. In the following subsections, we describe the optical subassembly, the focal planes, the cryogenic support system, and the electronics.

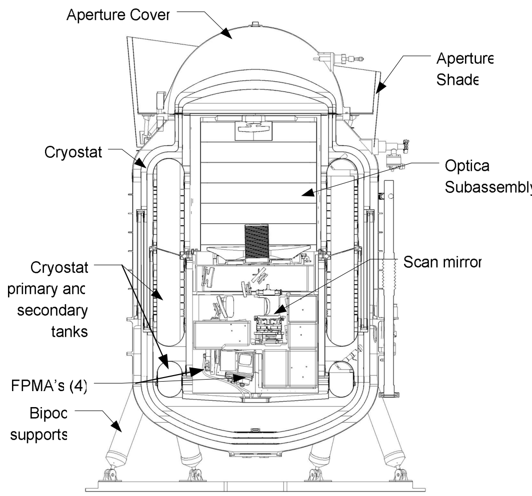

Figure 2: Payload cut-away view showing major components

2.1 Optical subassembly

The WISE optical subassembly[2] (see Figure 3) includes an afocal telescope, a scan mirror, imaging optics, and a beamsplitter assembly containing three beamsplitters and four filters. The afocal telescope, scan mirror, and imaging optics are provided by SSG Inc. The optical subassembly fits into the cryostat and is structurally and thermally tied to the cryostat via the mounting ring. The scan mirror is placed in collimated space between the afocal optics and the imaging optics, and is used to hold the image steady on the sky as the spacecraft rotates in its orbit.

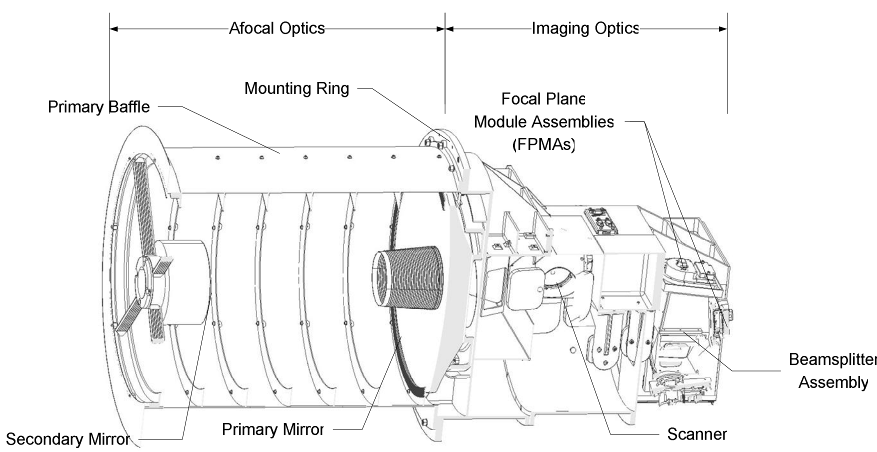

Figure 3: Optical Subassembly

The optics will be built with an aluminum structure and bare-polished aluminum mirrors (with a reflective gold overcoat), thus providing an inherently athermal system that will not require any cryo-nulling or cryo-figuring. The optics are designed to operate at a temperature of less than 17 K. The modularity of the optical subsystem allows the afocal optics, the imaging optics, the beamsplitter assembly, and the scan mirror to be developed in parallel. The scan mirror is placed where the exit pupil of the afocal optics coincide with the entrance pupil of the imaging optics to reduce beam-walk and allow for a smaller scan mirror.

The optical system has a 40 cm aperture, a field of regard that is 83 arcminutes by 47 arcminutes to cover the detector field of view plus the scan angle, and an effective focal length of 1.35 m, resulting in a pixel instantaneous field of view of 2.75 arcseconds.

2.1.1 Scan mirror

The scan mirror is a flat mirror placed in the collimated space between the afocal and imaging optics. During data collection, the scan mirror counters the orbital motion, holding the image of the sky stable over the entire integration time of the focal plane arrays. After the integration time, the scan mirror returns to its original position in 1.1 seconds. As the only movable component in the payload, the scanner includes redundant position sensors, motors, and electronics, and is required to meet its specifications at temperatures less than 17 K.

2.1.2 Afocal optics

The afocal optics are designed to have a Cassegrain-like objective in an in-plane folded package with a three-mirror relay and are made up of five powered mirrors — an ellipsoid, a hyperboloid, and three aspheres — and a fold flat. The primary design drivers for the afocal optics include the aperture size, which is 40 cm, good image quality, and low distortion. Because the afocal optics are in the optical path before the scan mirror, this low distortion is necessary to avoid streaking of point sources as the scanner freezes the image on the sky. The 8x afocal magnification was selected to balance the imaging optics size with the field of view and the scan range of the scan mirror.

2.1.3 Imaging optics

The imaging module is an all reflective imager for all channels and includes five powered mirrors and one fold flat. It has an entrance pupil diameter of 5 cm, and a design level wavefront error of less than 0.065 waves RMS at 3.3 µm. It interfaces to the scanner, the afocal optics, and the beamsplitter assembly and has an effective focal length of just under 16.9 cm.

2.1.4 Beamsplitter assembly

The beamsplitter assembly is an aluminum structure that attaches to the imaging optics. Three beamsplitters are used to separate the light into the four bands. It also serves as the physical interface to the focal planes. Beamsplitter 1 reflects bands 1 and 2 and transmits bands 3 and 4. An InSb substrate is used to allow good transmission through 26 µm. Beamsplitter 2, made of silicon, reflects band 1 and transmits band 2. Beamsplitter 3, also InSb, reflects band 3 and transmits band 4.

The focal plane module assemblies are mounted to the beamsplitter assembly. Focal planes 1-4 are mounted identically. A composite thermal isolator is used between the mount and beamsplitter assembly for bands 3 and 4. This provides the thermal isolation needed to achieve the lower temperatures for these two FPAs mounted to the primary hydrogen tank.

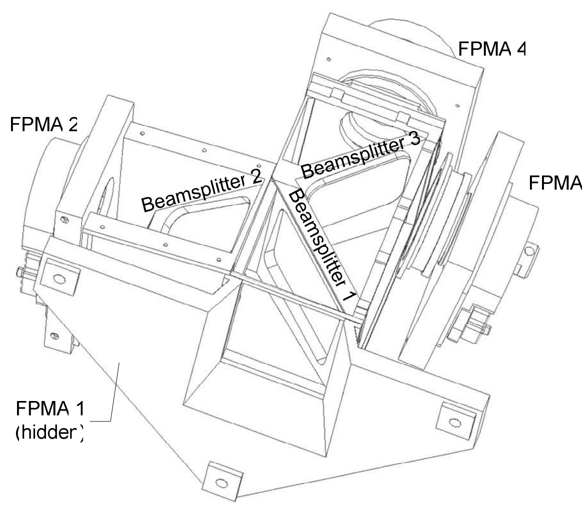

Figure 4: Beamsplitter Assembly

The filters will be mounted as close as possible to the focal plane to reduce ghosting and the Stierwalt effect. Filters for bands 1 and 2 use a sapphire substrate. The band 3 filter uses ZnSe, and Band 4 will be filtered using Si.

2.2 Focal planes

WISE uses four focal plane arrays to capture data in its four IR bands. These advanced devices are the technology that allows the sensitive high resolution all sky survey. DRS Sensors and Targeting Systems, Inc. provides the four focal plane module assemblies, cables, and electronics to SDL for integration. Bands 1 and 2 use MCT arrays produced by Rockwell Scientific and bands 3 and 4, the long-wave bands, use arsenic-doped silicon blocked impurity band arrays (Si:As), produced by DRS. All four of the focal planes have a 1024 x 1024 format with a pitch of 18 µm. Given the optical subsystem, this results in a 2.75 arcsecond instantaneous field of view. Because of diffraction, this resolution is not needed for band 4, so to reduce the data rate, band 4 is binned by the flight processing electronics to 512x512 pixels with an effective pitch of 36 µm.

2.2.1 Si:As focal plane module assemblies

The Si:As arrays use a 1024x1024 readout integrated circuit (ROIC) designed for and funded by the WISE project. The devices provide low-power and low noise operation at the 7.8 K nominal operating temperature. Measurements taken to this point indicate a measured read noise of approximately 44 e^- , in correlated double sample mode. The Si:As detector material provides a red cut-off of approximately 27 µm, a dark current of less than 100 e^-/s, and a measured in-band quantum efficiency of better than 65%.

This substrate mounts to a G10 thermal isolator as shown in Figure 5. Heaters and temperature monitors located under the molybdenum substrate are used to control the temperature to 32 K. The Si:As arrays mount to a focal plane module assembly for mechanical integration. The arrays mount to an aluminum stage connected to the aluminum base structure. Cooling is provided through a beryllium-aluminum shrink-fit thermal connector which is attached to the primary tank of the cryostat through copper thermal straps.

2.2.2 MCT focal plane module assemblies

The MCT arrays were grown on a single crystal cadmium-zinc-telluride substrate, and have a red cutoff of approximately 5.4 µm. The MCT arrays mount in a similar fashion as the Si:As arrays to keep the mounts identical for integration simplicity. The stage assembly is different for the MCT arrays to account for array mounting requirements and thermal isolation. The stage uses a G10 isolator to provide enough thermal isolation to allow a small heater to control the array to its 32 K nominal operating temperature.

These arrays are predicted to have a read noise of less than 15 e-, and at the operating temperature of 32 K, are expected to have a dark current much less than 1 e-/s. They have a measured Quantum Efficiency (QE) before anti-reflection coating of greater than 66% in both bands 1 and 2, and a predicted QE after anti-reflection coating of greater than 75% in bands 1 and 2.

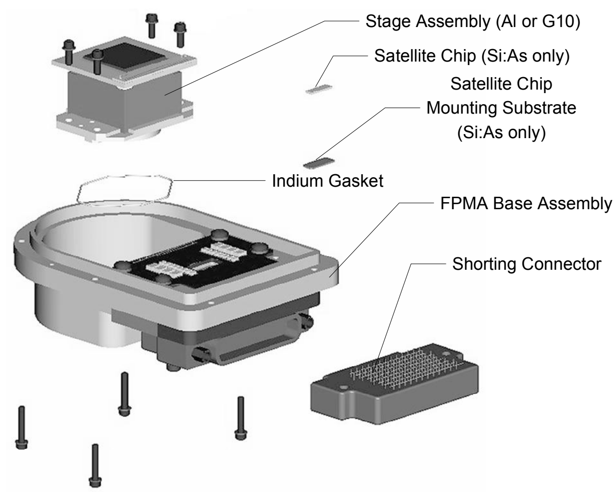

Figure 5: FPMA Construction

2.3 Cryogenic support system

2.3.1 Cryostat

The WISE cryostat[3] being provided by Lockheed-Martin is a dual-stage solid hydrogen design consisting of the primary hydrogen tank and a secondary hydrogen tank, housed within an outer vacuum shell. The vacuum space is sealed on the ground with a deployable aperture cover. Plumbing mounted internally and externally support ground processing and on-orbit venting of the subliming hydrogen. The dual-stage design provides two separate cooling zones. The secondary tank provides <17 K cooling to the optical subsystem and absorbs the parasitic heat loads from the outer shell.

The primary tank is mounted off the secondary tank and only cools the Si:As focal plane module assemblies. The heat loads and vent line sizing out to the vacuum of space define the vapor pressure and temperature of each cryogen tank.

The cryogen tanks are structurally supported and thermally isolated from the vacuum shell by three concentric fiberglass epoxy tubes. Spaced between two of the tube sections are two vapor cooled shields. These shields utilize the hydrogen vent gas to remove additional parasitic heat loads.

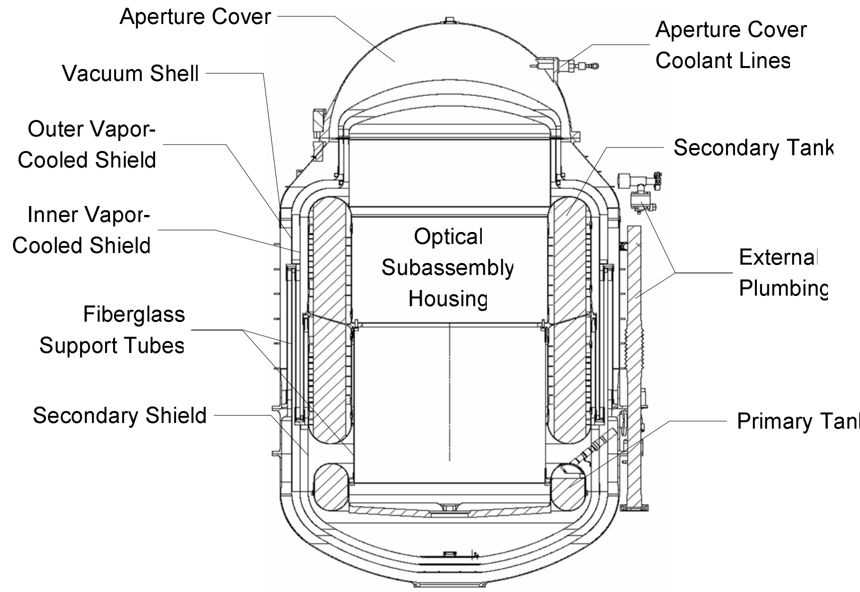

Figure 6: WISE Cryostat

The design type and criteria have been used on previous cryostats including CLAES, SPIRIT III, and WIRE. The cryostat interior and the optical subassembly will be protected during ground and launch operations by an aperture cover that will be jettisoned once WISE is on orbit. The attachment is made through three pyrotechnic separation nut devices. These are actuated on orbit using electronics contained within the payload electronics. The aperture cover contains a cooling loop to allow cooling of the inner shield for dark measurements during ground functional tests once the payload is delivered. Each tank also contains a vent valve that is actuated with pyrotechnic initiators identical to the separation nuts. Once opened the tanks vent to space with the large flow rate of the secondary tank being vented through the spacecraft center of mass to limit torques imparted to the spacecraft.

As part of the overall cryogenic support system, the vacuum shell will operate at < 200 Kelvin on orbit. This is made possible by taking advantage of the sun synchronous orbit and insulating the sun facing side of the instrument with MLI blankets and leaving the space facing side open to radiate to space. By utilizing a high emissivity / low absorptivity coating on the outside of the blanket, the design is able to achieve lower shell temperatures than using the solar array to block the sun. The predicted cryogen life on orbit is currently 16.3 months.

2.3.2 Aperture shade

WISE is designed with an aperture shade to reduce the impact of environmental heat loads on the open aperture and support limited pointing capability for the flight system to allow shifts around the moon and support TDRSS downlinking of the science data. The WISE keep out zone requirements state that WISE will never get closer than 83.25 degrees to the vector running through the center of the sun and 10 degrees from the edge of the earth. The aperture shade is designed and positioned to block direct impingement of earthshine and solar heat loads within these keepout zones. As seen in Figure 1, the shade has a slight angle, 8 deg, to allow limited pointing toward the sun. When tilting toward the earth, the angle of the shade is such that the rays coming in are reflected back out. The dual stage shade contains a radiator on the inner stage to provide radiative cooling to approximately 100 K. The inner part of the shade is gold coated to limit the self radiated heat back into the open aperture of the cryostat.

2.3.3 Bipods

The WISE Payload is supported off the Spacecraft top deck by four composite bipods. These provide not only the structural support but also thermally isolate the payload from the spacecraft. A simple mounting pad at the cryostat and a clevis foot at the spacecraft deck provide straightforward integration of the bi-pod fixtures. Rod end bearings at each end of the struts eliminate moment transfer at the interfaces making a very efficient structural design.

2.4 Electronics

WISE Payload electronics control the focal planes and the scan mirror, process data, monitor system health and telemetry, and fire the Payload pyro devices. The electronics are housed in three boxes, mounted to the Spacecraft walls. The three boxes are the Monitor Electronics Box (MEB), Focal Plane Electronics Box (FEB), and Digital Electronics Box (DEB).

The MEB monitors Payload health, controls the scanner, focal plane annealing heaters, and pyrotechnic devices for releasing the aperture cover and opening the orbit vents. The FEB controls the focal planes and digitizes raw focal plane data. The DEB performs sample up-the-ramp processing on the digital focal plane data from the FEB and transmits the processed data to the Spacecraft. A functional block diagram of the payload is illustrated in Figure 7.

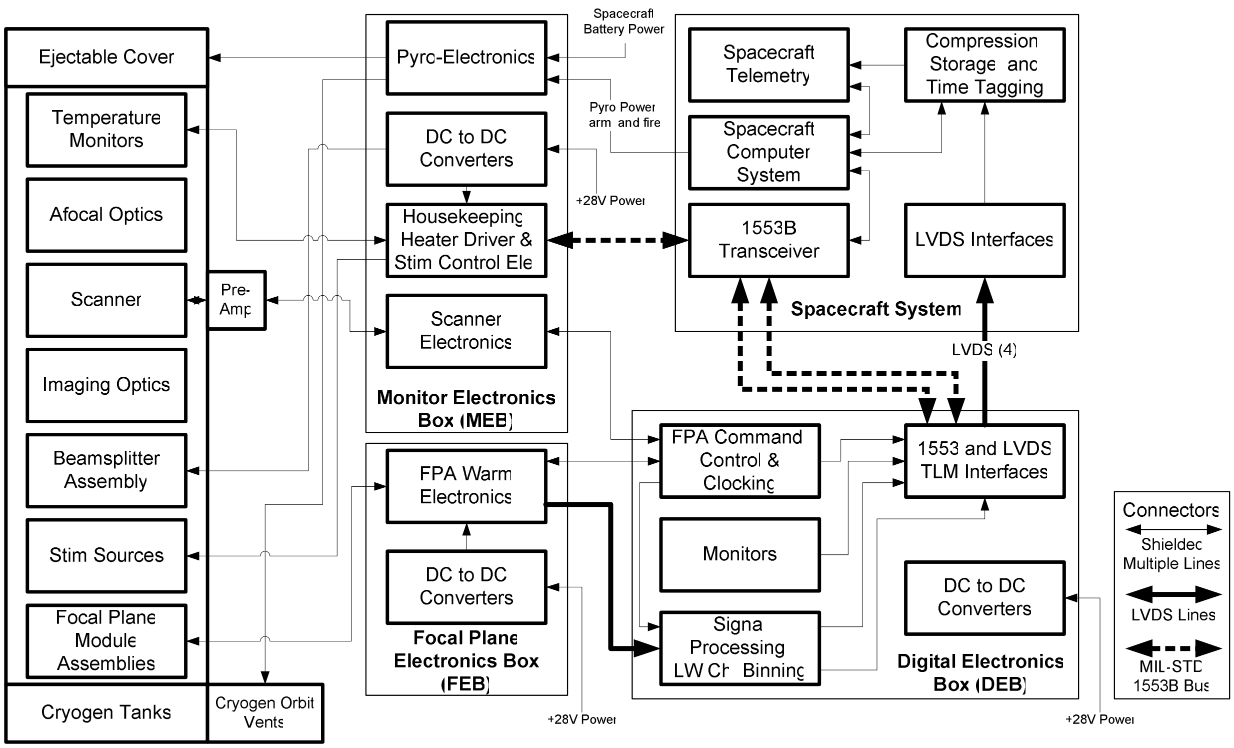

Figure 7: Payload Block Diagram

2.4.1 Sample up-the-ramp

WISE employs a "sample up-the-ramp" (SUTR) algorithm to estimate the flux on a pixel[4]. The purpose of this algorithm is to estimate the slope of the integrated signal on a pixel, the line labeled "pixel charge" in Figure 8. Correlated double sampling can be thought of as a special case of SUTR, where the number of samples up-the-ramp, N, is 2. For WISE, $N = 9$ was chosen for efficient data collection and to keep the data rate low. Figure 8 illustrates the method for data collection. First, the scanner ramp is started, then, when the scanner velocity is linear, the focal plane is reset, and the first sample after reset is obtained. This first sample and the eight subsequent samples are non-destructively read. Then, during the scan mirror retrace, the focal plane is reset and read. The sample collected during scanner retrace is not kept, and the process is repeated. The nine samples up-the-ramp are processed using the sample up-the-ramp algorithm.

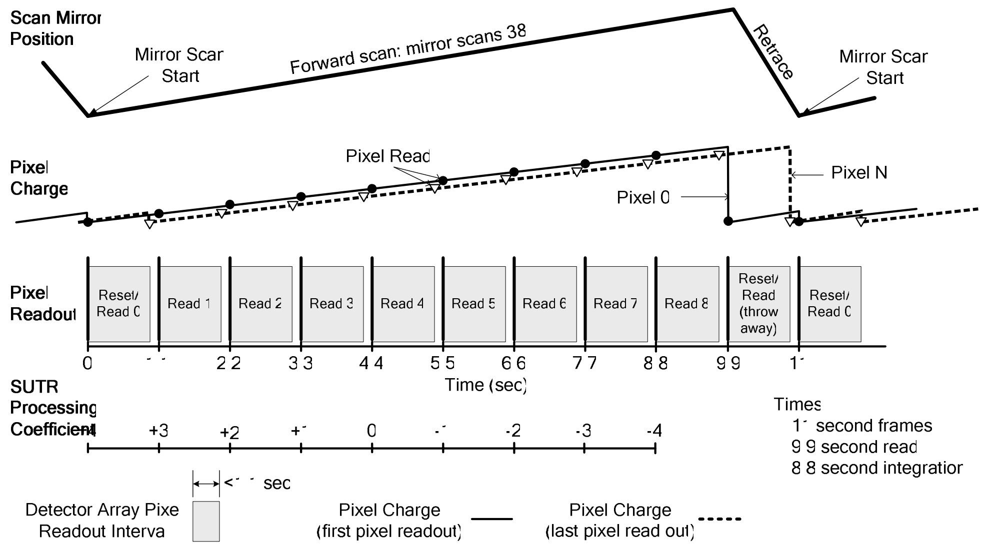

Figure 8: Sample up-the-ramp data collection method

The algorithm calculates the best fit to the slope of the ramp. The least squares fit can be calculated using

$$m = \frac{1}{\alpha}\sum_{i=1}^{N} y_{i-1}\left(i - \frac{N+1}{2}\right), \tag{1}$$

where $\alpha = \frac{T_{\text{int}} N(N^2-1)}{12}$, y_i is the i^{th} data sample, and N is the number of samples[4], in this case 9. On-orbit processing will use a simplified equation

$$m_{onboard} = 4y_0 + 3y_1 + 2y_2 + y_3 - y_5 - 2y_6 - 3y_7 - 4y_8\,. \tag{2}$$

This equation allows the on-board processor to use integer arithmetic; the non-integer scale factor is applied during ground processing. The resulting slope is transmitted to the spacecraft for downlink. The advantage of the sample up-the-ramp algorithm is that it decreases noise relative to correlated double sampling at low background and signal levels by a ratio of

$$\frac{\sigma_{SUTR}}{\sigma_{CDS}} = \sqrt{\frac{6(N-1)}{N(N+1)}}\,.. \tag{3}$$

3. KEY PERFORMANCE REQUIREMENTS

Key performance requirements for the science payload are listed in Table 2 below. From these driving requirements, suballocations are made to subsystems. This flowdown process is illustrated in Figure 9. The key driving requirements for the payload are discussed below.

Table 2: WISE key requirements

Parameter	Requirement
Mass	376 kg
Power	152 W
FOV	47 arcminutes
FOR	47 x 83 arcminutes
Cryogen Life	> 7 months
FPA cooling	7.8 +/-0.5 K for Bands 3,4 32.+/-2. K for Bands 1,2
Optics Cooling	<17 K
Image Quality	Band 1=11.8 Noise Pixels Band 2=15.4 Noise Pixels Band 3=43.3 Noise Pixels Band 4=131 Noise Pixels
Sensitivity *based on minimum of 5 passes on ecliptic	3.2-3.8 μm =120 μJy 4.2-5.2 μm =160 μJy 9.-15 μm =650 μJy 20-26 μm =2600 μJy

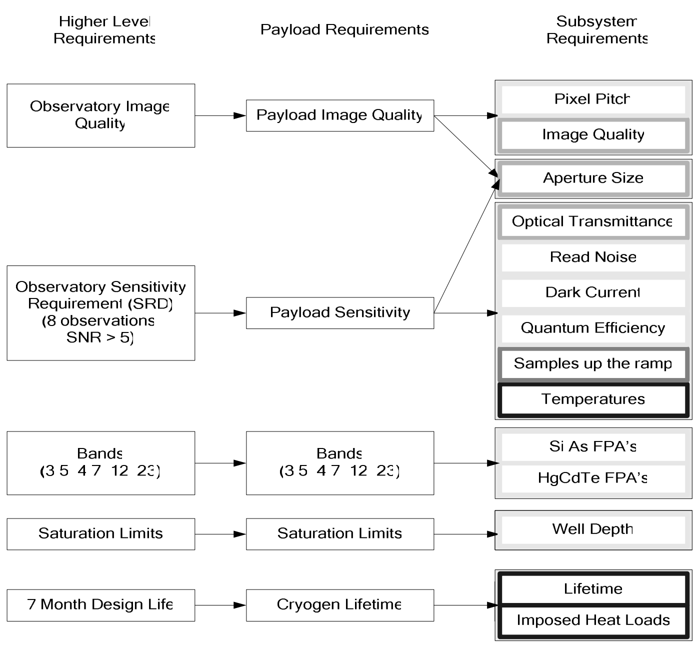

Figure 9: Illustration of requirements flow from high level requirements through subsystem requirements

3.1 Image quality

Of interest in any imaging system is image quality. Several metrics are commonly used to measure image quality, however for WISE, the figure of merit is noise pixels. The noise pixel metric was chosen because it relates directly to the uncertainty in the estimate of the irradiance of a point source. Because the noise pixel is not widely used, the following is a discussion for understanding the noise pixel requirement. Define a region $\Re_S$ of the WISE detector array. Given measurements of a source S_i over $\Re_S$, the least squares estimator of irradiance F is given by a matched filter

$$F = \frac{\left(\sum_i \frac{1}{\sigma_i^2} S_i \phi_i\right)\left(\sum_j \phi_j\right)}{\sum_i \frac{1}{\sigma_i^2}\phi_i^2}, \tag{4}$$

where ϕ_i is the point spread function (PSF) and σ_i is the noise on pixel i. Assuming the noise is equal for all pixels, $\sigma_i = \sigma_S$, the uncertainty in F can be written

$$\sigma_F^{\ 2} = \sigma_S^{\ 2} n_p , \tag{5}$$

where

$$n_p = \frac{\left(\int \phi(\Omega) d\Omega\right)^2}{\Omega_{\det} \int \phi(\Omega)^2 d\Omega}, \tag{6}$$

is the image quality, measured in noise pixels, and $\Omega_{\det}$ is the pixel instantaneous field of view solid angle, (2.75 arcseconds)^2 for WISE. Since the modulation transfer function (MTF) is the Fourier transform of the system PSF, (5) and (6) can be re-written in terms of the MTF.

$$n_p = \frac{1}{\Omega_{\det} \int\int (\Phi(f_x, f_y))^2 df_x df_y} . \tag{7}$$

The payload image quality requirements are shown in Table 2. Analysis was performed of the image quality and allocations made to various subsystems. Each subsystem relates the noise pixel requirement and flows them down further to native engineering units for designing components. An illustration of this process is shown in Figure 10 for Band 1. Other bands are similar but are increasingly dominated by diffraction effects. Sub-allocations to the scanner and optical subsystems are described in *Cryogenic telescope, scanner, and imaging optics for the Wide-field Infrared Survey Explorer (WISE)*[2].

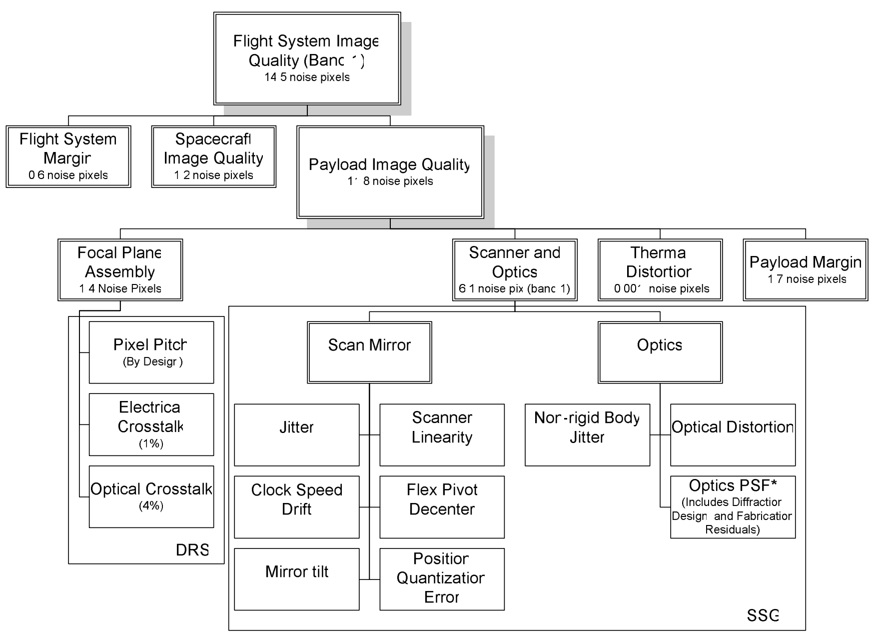

Figure 10: Allocation of image quality to subsystems.

The current best estimates for payload image quality roll up to the value shown in Table 3. These results indicate that the preliminary design is adequate and has sufficient margin for a non-stressing detailed design.

Table 3: WISE science payload Image Quality Performance vs. Requirements

	MEAN IMAGE QUALITY (NOISE PIXELS)			
	BAND 1	BAND 2	BAND 3	BAND 4
PREDICTED PERFORMANCE	7.2	9.9	30.7	108.8
REQUIREMENT	11.8	15.4	43.3	131

3.2 Sensitivity

A major goal for WISE is to identify a 200 K brown dwarf nearer than the nearest known star, and also to identify brown dwarfs at temperatures cooler than 1000 K at larger distances. These two goals drive the sensitivity requirements for bands 1 and 2. Identifying ultraluminous infrared galaxies (ULIRGs) drives the requirements for bands 3 and 4. The sensitivity requirements are shown in Table 4. The sensitivity is based on the minimum expected number of observations of a star during the mission life, which is 8, and a signal to noise ratio for detection of 5.

The sensitivity requirement drives several detector and optics parameters. The allocations for the various components are shown in Table 4. These allocations include the worst-case zodiacal background, also included in the table. Together these allocations result in a sensitivity margin between 51% and 11% against the requirement. Based on predicted performance of the subsystems, the expected sensitivity has a margin between 73% and 14% against the requirement.

Table 4: Subsystem requirements and estimated performance with those requirements

	Parameter	Unit	Band			
			1	2	3	4
Assumptions	Center Wavelength	μm	3.3	4.65	12	23
	FPA QE	%	70	70	60	60
	Optical Transmittance	%	50	50	50	50
	Image Quality	Noise Pix.	14.5	18.2	48.4	34.0
	Background Radiance	W/cm^{2}sr	4.45E-12	9.11E-12	5.48E-10	2.42E-10
	Background Current	e-/s	5	13	1773	6261
	Read Noise (after SUTR)	e-	10	10	31	61
	Dark Current	e-/s	1	1	100	400
	SNR for detection		5	5	5	5
	Number of Frames		8	8	8	8
Results	Predicted Sensitivity	μJy	59	104	465	2322
	Sensitivity Requirement	μJy	120	160	650	2600
	Margin against requirement		51%	35%	28%	11%

3.3 Thermal

The thermal system is designed to provide cooling for the FPAs and optics for the specified mission lifetime. As described previously, the cryogenic cooling is provided by a dual stage solid hydrogen cryostat. The secondary tank intercepts the majority of the parasitic and instrument loads while the primary tank cools only the Si:As FPMAs. A copper thermal strap attaches each FPMA to the primary tank. A dual-stage aperture shade limits heat loads from the environment into the open aperture.

Lifetime for the solid hydrogen is driven by a 200 Kelvin vacuum shell temperature, which is achievable based on analysis of the external thermal design and consistent with the shell temperature achieved in other LEO missions. While not discussed specifically, the electronics are passively cooled and are mounted within the spacecraft. The key thermal requirements for the payload are listed in Table 5. Preliminary analysis of the thermal design indicates that the thermal requirements can be met. The temperature predictions are listed in Table 5 next to the requirement.

Table 5: Payload Temperature Requirements

SUBSYSTEM	THERMAL	PREDICTED	REASONING
Vacuum Shell	< 200 K	196 K (hot case)	Limits parasitic heat loads into the hydrogen
Aperture Shade Inner shield	<110 K	93 K	Limits self emitted heat into the open aperture
Optics	< 17 K	9.5 K	Necessary to avoid background in longer bands
Si:As Detectors	7.8 ± 0.5 K	7.5 K	Necessary to achieve low dark current Stability better than 150 mK over an orbit
MCT Detectors	32 ± 2 K	32 K; temp. controlled	Temperature above 30 K allows existing low-noise multiplexers to be used; low temperature makes the dark current small
Electronics Boxes	-20° to +40° C	Meets requirements	Operational temperature range

3.3.1 Cryogen life

WISE has been designed to meet the thermal requirements over seven months of on-orbit operations—one month of on-orbit checkout and six months of data collection. The current 16.3 month cryogen life prediction supports the program goal. This substantial margin provides the risk mitigation for the primary mission. Additionally, the remaining cryogen may be used for additional data collection.

4. SUMMARY

The preliminary design of the science payload satisfies the requirements with appropriate margins. The cost constrained program is enabled by technologies developed on other programs such as SPIRIT III and WIRE. Additionally, no new technologies are required. The combination of focal plane, optical, and cryogenic technologies provides an instrument design that will satisfy the needs for the sensitive all sky survey. The instrument detailed design is progressing as planned. Launch is scheduled for June, 2009.

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