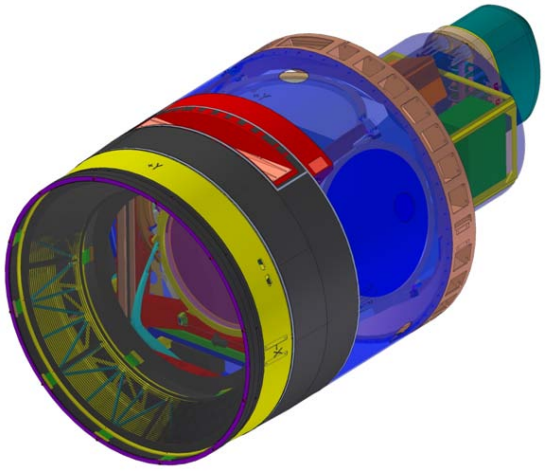
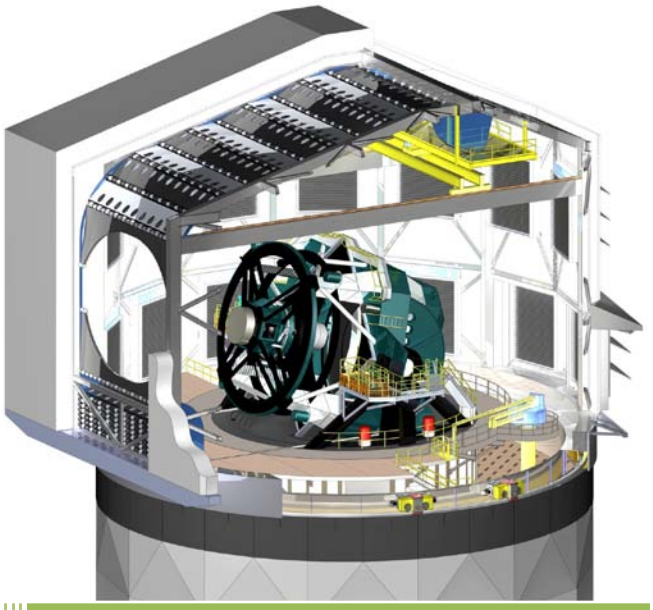
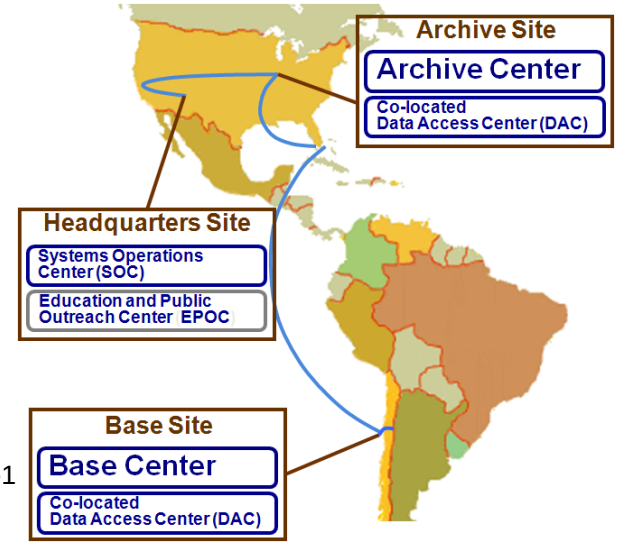
LSE-###

Science-Based LSST System Requirements







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Science Based LSST System Requirements

Project Background:

The LSST is intended to be a large-aperture, wide-field, ground-based telescope that will survey the visible sky every few nights in six photometric bands. The 10-year survey will produce a database suitable for answering a wide range of pressing questions in astrophysics, cosmology, and fundamental physics. LSST is designed to be a public facility. The images, alerts, and resulting catalogs will be made available to the community at large with no proprietary period. A sophisticated data management system will provide easy access to these data, enabling simple queries from individual users (both professionals and laypersons), as well as computationally intensive scientific investigations that utilize the entire database.

Document Scope:

This Science Based System Requirements (SBSR) document provides a comprehensive definition of the LSST Observatory system requirements. It is derived from the LSST Science Requirements document [LSST LPM-17] that describes the scientific motivations for the project, the survey capabilities and the reference science missions used to develop some detailed system specifications. This document expands on those to fully describe the specific nature of the LSST survey, final data products, and derived system finctions and specifications that must be met in the execution of the LSST project.

These requirements cover the following areas:

- Adopted survey performance parameters from the SRD
- Inherited technical requirements from the SRD
- System definitions for
  1) Optical Configuration
  2) Data collection functions and performance
  3) Data processing functions and performance
  4) Archiving and services functions and performance
- Survey planning and administration functions

Reference Documents:

1. The LSST Science Requirements Document v4.3.3
2. The Observatory Specifications
3. TBD

1 Survey Specifications

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST systen shall be designed such that the system achieves a survey with the following and scientific and performance specifications.

Discussion: The LSST SRD specifies a suite of requirements for the technical performance of the survey with minimum, design, and stretch goals. For the purpose of establishing the system design and flow down to lower level requirements and specifications a single value for these specifications must be adopted. The specifications that follow establish which specific value for each of the SRD performance parameters have been adopted within their defined ranges for the system design.

At this time the SRD design specifications have been adopted for each parameter.

1.1 Filter Set Characteristics

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST survey shall provide imaging in 6 spectral bandpasses that are defined in the follwoing specifications for the **filterComplement** and the **bandpassPerformance**.

1.1.1 filterComplement

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Discussion: The SRD specifications for internal filter exchange and change out have been moved to the Observatory Specifications Document under the Camera Dynamics and Timing requirements.

Description	Value	Unit	Attribute
The filter set to be used during the lifetime of the survey shall consist of at least 6 filters, **FC**, providing a sampling across the optical spectrum.	ugrizy		FC
The total number of filters available on a nightly basis shall be **NFilters**.	5		NFilters

1.1.2 bandpassPerformance

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The maximum out of band leakage in an 10nm interval shall be no more than **FLeak** relative to the	0.01	Percent	FLeak

Description	Value	Unit	Attribute
peak filter response outside one FWHM from the central wavelength.			
The total integrated leak shall be less than **FLeakTot** relative to the total transmission.	0.05	Percent	FLeakTot
The temporal stability of the filter bandpasses shall be sufficiently small such that the required photometric calibration specifications can be met. (quantity TBR).	TBR		temporalStability

1.2 Single Image Performance

id:
Version: 1.0 *Modified:* 2/9/2010 *Status:* Proposed

Specification: The LSST shall meet the following specifications for single image performance:

1. Delivered Image Quality
2. Photometric Performance
3. Astrometric Performance
4. Image Depth

1.2.1 r-bandRefDepth

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The reference airmass under which the depth specification shall be met is **refAirmass.**	1.0	Airmass	refAirmass
The reference exposure time for which the single image depth specifications shal be met is **refExposureTime.**	30	Seconds	refExposureTime
The reference atmospheric seeing for which the depth specifications shall be met is **refSeeing** as measured in the r-band.	0.7	ArcsecFWHM	refSeeing
The reference sky surface brightness for which the depth specifications shall be met is **refSkyBrightness** as measured in the r-band.	21	mag/SqArcsec	refSkyBrightness
The r-band 5-sigma limiting magnitude shall be no brighter than **DT1** for unresolved point sources.	24.7	ABmag	D1
The fraction of the field of view with a 5-sigma point source detection depth brighter than the depth outlier limit (**Z1**) shall be no more than **DF1.**	10	Percent	DF1
The 5-sigma point source detection depth limit shall be no brighter than **Z1**.	24.4	ABmag	Z1

1.2.2 filterDepths

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
u-band point source 5-sigma detection depth shall be no brighter than	23.9	ABmag	DB1u
g-band point source 5-sigma detection depth shall be no brighter than	25.0	ABmag	DB1g
r-band point source 5-sigma detection depth shall be no brighter than	24.7	ABmag	DB1r
i-band point source 5-sigma detection depth shall be no brighter than	24.0	ABmag	DB1i
z-band point source 5-sigma detection depth shall be no brighter than	23.3	ABmag	DB1z
v-band point source 5-sigma detection depth shall be no brighter than	22.1	ABmag	DB1y

1.2.3 imageQuality

Version: 1.0 *Modified:* 2/9/2010 *Status:* Proposed

Description	Value	Unit	Attribute
Median system delivered image quality in atmospheric seeing of 0.44 arcseconds in the r and i filters.	0.56	ArcsecFWHM	S1_0.44
Median system delivered image quality in atmospheric seeing of 0.60 arcsec in the r and i filters.	0.69	ArcsecFWHM	S1_0.60
Median system delivered image quality in atmospheric seeing of 0.80 arcseconds in the r and i filters.	0.87	ArcsecFWHM	S1_0.80
The maximum quadrature contribution from the LSST system to the atmospheric seeing referenced at zenith or airmass (sec(zd)) = 1.	0.35	ArcsecFWHM	SysIm_0
The maximum quadrature contribution from the LSST system to the atmospheric seeing referenced at zenith distance of 45 degrees or airmass (sec(zd)) = 1.4.	0.42	ArcsecFWHM	SysIm_45
The maximum quadrature contribution from the LSST system to the atmospheric seeing referenced at zenith distance of 60 degrees or airmass (sec(zd)) = 2.0.	0.52	ArcsecFWHM	SysIm_60
Delivered image quality increase factor allowed over **SF1** fraction of the field of view.	1.1	float	SX
The maximum fraction of the field of view that can exceed the delivered image size by a factor of **SX**.	10	Percent	SF1
The minimum number of pixels across the FWHM of the delivered PSF under median atmospheric conditions (0.6 arcsec FWHM) shall be	3	Pixels	PSFSample
The system image budget is allowed to degrade	0.6		ImFunc

Description	Value	Unit	Attribute
through the three reference zenith distances (zd) as sec(zd)^ **ImFunc**.			
The maximum diameter of the PSF spatial profile containing 80 percent encircled energy.	0.76	Arcsec	SR1
The maximum diameter of the PSF spatial profile containing 90 percent encircled energy.	1.17	Arcsec	SR2
The maximum diameter of the PSF spatial profile containing 95 percent encircled energy.	1.62	Arcsec	SR3

1.2.4 imageEllipticity

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The maximum median raw PSF ellipticity over the full field of view in a single 15 second exposure for bright isolated non-saturated stars.	0.04	Ellipticity	SE1
The maximum PSF raw ellipticity limit.	0.07	Ellipticity	SE2
The fraction of PSF ellipticity measurements allowed to exceed the ellipticity outlier limit for bright isolated non-saturated stars.	5	Percent	EF1
The maximum residual ellipticity correlation amplitude over 1 arcmin scales.	2.0e-4		SE3
The maximum residual ellipticity correlation amplitude over 5 arcmin scales.	5.0e-7		SE4
The maximum median residual ellipticity amplitude outlier limit on scales less than or equal to 1 arcmin.	4.0e-4		SE5
The maximum median residual ellipticity amplitude outlier limit on scales between 1 and 5 arcmin.	1.0e-6		SE6
Fraction of allowed PSF measurements of isolated bright stars to exceed the ellipticity residual correlation amplitude outlier limit.	10	Percent	EF2

1.2.5 astrometricPerformance

Version: 1.0 *Modified:* 2/9/2010 *Status:* Proposed

Description	Value	Unit	Attribute
Median error in absolute position for each axis, RA & DEC, shall be less than **AA1**.	50	mili-Arcsec	AA1
Median relative astrometric measurement error on 5 arcminute scales shall be less than **AM1**.	10	mili-Arcsec	AM1
5 arcminute outlier limit.	10	mili-Arcsec	AD1
Fraction of relative astrometric measurements on 5 arcminute scales to exceed 5 arcminute outlier limit.	10	Percent	AF1
Median relative astrometric measurement error on 20	10	mili-Arcsec	AM2

Description	Value	Unit	Attribute
arcminute scales.			
20 arcminute outlier limit.	20	mili-Arcsec	AD2
Fraction of relative astrometric measurements on 20 arcminute scales to exceed 20 arcminute outlier limit.	10	Percent	AF2
Median relative astrometric measurement error on 200 arcminute scales.	15	mili-Arcsec	AM3
200 arcminute outlier limit.	30	mili-Arcsec	AD3
Fraction of relative astrometric measurements on 200 arcminute scales to exceed 200 arcminute outlier limit	10	Percent	AF3
RMS difference between separations measured in the r-band and those measured in any other filter.	10	mili-Arcsec	AB1
The color difference outlier limit for separations measured relative the r-band filter in any other filter..	20	mili-Arcsec	AB2
Fraction of separations measured relative to the r-band that can exceed the color difference outlier limit.	10	Percent	ABF1

1.2.6 photometricPerformance

Version: 1.0 *Modified:* 2/9/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The RMS photometric repeatability of bright non-saturated unresolved point sourses in the **g**, **r,** and **i** filters.	5	mili-Mag	PA1gri
The RMS photometric repeatability of bright non-saturated unresolved point sourses in the **u**, **z**, and **y** filters.	7.5	mili-Mag	PA1uzy
Repeatability outlier limit for isolated brigh non-saturated pointsources in the **g**, **r**, and **i** filters.	15	mili-Mag	PA2gri
Repeatability outlier limit for isolated brigh non-saturated pointsources in the **u**, **z**, and **y** filters.	22.5	mili-Mag	PA2uzy
Fraction of isolated non-saturated point source measurements exceeding the outlier limit.	10	Percent	PF1
RMS width of internal photometric zero-point (precision of system uniformity across the sky) for all bands except u-band.	10	mili-Mag	PA3
The zero point error outlier limit.	15	mili-Mag	PF4
Fraction of zeropoint errors that can exceed the zero point erro outlier limit.	10	Percent	PF2
Accuracy of absolute band-to-band color zero-point for all colors constructed any filter pair except u-band.	5	mili-Mag	PA5
Accuracy of absolute band-to-band color zero-point for colors constructed using the u-band.	10	mili-Mag	PA5u

Description	Value	Unit	Attribute
Accuracy of the transformation of the internal LSST photometry to a physical scale (e.g. AB magnitudes).	10	mili-Mag	PA6
Fractional increase in the photometric error over repeated measurements for isolated bright non-saturated point sources.	10	Percent	EPErr
Percentage of image area that can have ghosts with surface brightness gradient amplitude of more than 1/3 of the sky noise over 1 arcsec.	1	Percent	GhostAF
The maximum local significance integrated over the PSF of imperfect crosstalk corrections.	3	Sigma	Xtalk
Thye maximum fraction of pixels scientifically unuseable per sensor out of the total allowable fraction of sensors meeting this performance.	1	Percent	PixFrac
The maximum allowable fraction of sensors with **PixFrac** scientifically unusable pixels.	15	Percent	SensorFraction
The maximum error in the precision of the sky brightness determination.	1	Percent	SBPrec
Maximum rms ratio of the error between resolved sources less than 10 arcsec in diameter to unresolved point sources.	2		ResSource

1.2.7 sourceBrightnessHeadroom

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The LSST shall allow for the non-saturated measurements of point sources brighter than the saturation level for the nominal single image exposure time of 15 seconds by at least	1	ABmag	sbHead

1.3 Full Survey Performance

id:
Version: 1.0 *Modified:* 2/9/2010 *Status:* Proposed

Specification: Integrated over all survey observations made over a 20 year period the LSST shall meet all specifications for **skyCoverage**, **overallElliptcitiyCorrelations**, and **dataProcessing**.

1.3.1 skyCoverage

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The total area of sky covered by the median number	18000	SquareDegre	Asky

Description	Value	Unit	Attribute
of visits shall be no less than		es	
The median number of visits for each place of the sky within the main survey area shall be at least	825	Visits	Nv1Sum
The are of sky covered with uniformly sampled time scale between 40 seconds and 40 minutes shall be at least	2000	SquareDegrees	RVA1
The total area of sky that is covered with at least 25% of the total number of visit separated by more than 5 years shall be at least	15000	SquareDegrees	RVA2
The total area of sky that is covered with at least 25% of the total number of visit spanning at least 4 calendar months shall be at least	15000	SquareDegrees	RVA3

1.3.2 overallEllipticityCorrelations

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
Median residual PSF ellipticity correlations averaged over an arbitary field of view for separations less than 1 arcmin shall be no greater than	2.0e-5		TE1
Median residual PSF ellipticity correlations averaged over an arbitary field of view for separations less than 5 arcmin shall be no greater than	1.0e-7		TE2
The outlier limit on the PSF ellipticity correlation residuals on 1 arcminute scales shall be no more than	4.0e-5		TE3
The outlier limit on the PSF ellipticity correlation residuals on 5 arcminute scales shall be no more than	2.0e-7		TE4
The fraction of PSF ellipticity correlation residuals that can exceed the outlier limits on 1 and 5 arcminutes scales over an arbitrary field of view shall be no more than	15	Percent	TF1

1.3.3 dataProcessing

Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Description	Value	Unit	Attribute
The letency of reporting optical transients following the readout of the last image of a visit shal be no more than	1	Minute	OTT1
The transient reporting capacity shall be at least **transN** alerts per visit .	1.0e4		transN

Description	Value	Unit	Attribute
The interval between standardized data releases shall be no breater than	1	Years	DRT1

2 System Capabilities

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: In order to perform a survey as defined above and present the data in a scientifically useful manor the LSST Observatory shall be a complete system that:

1. obtains survey data in the form of digital images,
2. processes, calibrates, and archives them,
3. generates source and object catalogs,
4. makes all data and data products available to a wide range of users.

Discussion: The requirements that define the system capabilities have been organized into 4 groupings that characterize the high level performance and functional requirements that must be met. The 4 groupings include:

1. **The Optical Configuration:** These requirements specify the type of optical design, filed of view, effective aperture, and overall system throughput that are derived from the SRD.
2. **Data Collection:** These requirements specify in broad terms the data collection functions the LSST system must have in order to conduct the specified survey, optimize its operation, and record knowledge of the its physical state during routine operation.
3. **Data Products & Processing:** These requirements specify the high level definition of the LSST data products to be delivered to the user community and what process must occur to create these products.
4. **Data Archiving and Services:** These requirements define the high level archiving and data delivery functions that are need to deliver the LSST data and Data Products to its intended user base. Also included are the definitions of other data processing services that will be provided by the LSST system.

2.1 Optical Configuration

id:
Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Specification: The LSST optical configuration shall be from the anastigmatic class of optical designs.

Discussion: The anastigmatic design class eliminates 3rd order astigmatism across the field of view. This need is drive primarily by the week lensing science to control the PSF shape over the full field of view.

2.1.1 Effective Aperture

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The effective light collecting area of the LSST shall be at least that of ***effAperture*** clear unobstructed circular aperture.

Description	Value	Unit	Attribute
The aperture diameter equivalent to 33.2 square meters of collecting area.	6.5	Meters	effAperture

2.1.2 Field Of View

id:
Version: 1.0 *Modified:* 2/4/2010 *Status:* Proposed

Specification: The field of view of the LSST optical system shall be at least ***fieldOfView*** in diameter.

Description	Value	Unit	Attribute
The diameter of the field of view equivalent to 9.6 square degrees of sky coverage.	3.5	Degrees	fieldOfView

2.1.3 System Etendue

id:
Version: 1.0 *Modified:* 2/11/2010 *Status:* Proposed

Specification: The LSST optical system shall have a etendue (effective collecting area integrated over the field of view * area recorded in each image) of at least ***etendue.***

Description	Value	Unit	Attribute
The effective collecting area integrated over the field of view * field of view area recorded in each image.	300	Etendue	etendue

2.1.4 Atmospheric Dispersion Correction

id:
Version: 1.0 *Modified:* 2/2/2010 *Status:* Proposed

Specification: An atmospheric dispersion corrector (ADC) is not required in the LSST system design.

Discussion: The project under took a detailed trade study during the early conceptual phase of the project to determine if an ADC is needed and if it was even feasible to design and build an ADC large enough to accommodate the LSST field of view. This trade study concluded that an ADC was feasible but was not necessary provided that the survey observations we kept above 1.4 airmasses for the science needing the most control of the PSF shape. The minimum survey area of 15000 square degrees is achievable while staying above 1.4 airmasses.

2.1.5 System Image Quality

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: At the reference atmospheric seeing of 0.6 arcsec FWHM the 10% degradation results in an allocation for the RSS system image blur of ***medainRMSBudget.***

Specification: The image degradation over the field of view shall be smooth and small compared to the atmospheric seeing such that 10 percent of the filed of view shall be allowed to exceed a total RSS system image blur budget of

10%outlierBudget_0.44 in first quartile atmospheric seeing
10%outlierBudget_0.60 in median atmospheric seeing
10%outlierBudget_0.80 in third quartile atmospheric seeing

Description	Value	Unit	Attribute
The RMS of the total RSS contribution to the atmospheric seeing from the opto-mechanical system and detectors under the median atmospheric conditions.	0.35	ArcsecFWHM	medianRMSBudget
The limiting RSS image blur that can be exceeded by 10% of the field of view in the first quartile (0.44 arcsec FWHM) atmospheric seeing conditions.	0.43	ArcsecFWHM	10%outlierBudget_0.44
The limiting RSS image blur that can be exceeded by 10% of the field of view in the median (0.60 arcsec FWHM) atmospheric seeing conditions.	0.46	ArcsecFWHM	10%outlierBudget_0.60
The limiting RSS image blur that can be exceeded by 10% of the field of view in the third quartile (0.80 arcsec FWHM) atmospheric seeing conditions.	0.52	ArcsecFWHM	10%outlierBudget_0.80

2.1.6 Stray and Scattered Light

id:
Version: 1.0 *Modified:* 2/2/2010 *Status:* Proposed

The LSST design shall minimize the effects of stray and scattered light to the extent that the overall survey performance is not compromised.

Discussion: Stray and scattered light is defined as any light that is not part of the ideal image and includes:

- diffuse scattered light,
- secondary ghost images,
- diffraction,
- structured glints.

2.1.6.1 Anti-Reflection Coatings

id:
Version: 1.0 *Modified:* 2/1/2010 *Status:* Proposed

Specification: All refractive elements in the LSST optical system shall use state-of-the-art anti-reflection coatings to minimize the surface intensity of secondary ghost images and, at the same time, maximizing system throughput.

2.1.6.2 Baffling

id:
Version: 1.0 *Modified:* 2/1/2010 *Status:* Proposed

Specification: The LSST optical system shall be baffled such that no unwanted specular path can put light onto the LSST focal plane.

2.1.7 Science Instrument

id:
Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Specification: The LSST system shall contain a single science instrument - the Camera.

Specification: The LSST system shall be capable of using any one of 5 filters of the 6 specified for the survey during the course of a single night's operation.

Discussion: By the very nature of conducting a consistent well calibrated survey the LSST will not need to support multiple instruments often found on classical telescope systems.

2.2 Data Collection

id:
Version: 1.0 *Modified:* 2/4/2010 *Status:* Proposed

Specification: The LSST shall provide a Data Collection system that is capable of providing all necessary data to meet the SRD survey specifications including science image data and all ancillary data need to calibrate the survey and to optimize operations.

2.2.1 Science Data

id:
Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Specification: The LSST survey data shall be collected in the form of pixel addressable digital images that preserve the full information content of the LSST instrument.

2.2.1.1 Standard Visit

id:
Version: 1.0 *Modified:* 2/11/2010 *Status:* Proposed

Specification: The standard "Visit" used to conduct the survey shall be defined as **nVisitexp** back to back exposures each having an exposure time of **visitExpTime** in one of the system spectral bands.

Description	Value	Unit	Attribute
The number of exposures in a standard visit shall be	2		nVisitExp
The exposure time for single images in a standard visit shall be	15	Seconds	visitExpTime

2.2.1.2 Time Interval Between Visits

id:
Version: 1.0 *Modified:* 2/11/2010 *Status:* Proposed

Specification: The *median* time between successive visits shall be less than **medianVisitInterval** over the full set of survey observations.

Specification: The *average* time between successive visits shall be less than **aveVisitInterval** over the full set of survey observations

Discussion: This requirement is derived from the total number of visits per field and the total number of fields needed to cover the defined survey area. The interval between successive visits starts when the shutter of the second exposure of the visit is fully closed, and ends when the shutter of the first exposure of the next visit opens.

Description	Value	Unit	Attribute
The median interval as defined above over all successive vist pairs over the 10 year survey.	5	Seconds	medianVisitInterval
The average interval as defined above over all successive vist pairs over the 10 year survey	10	Seconds	aveVisitInterval

2.2.1.3 System Throughput

id:
Version: 1.0 *Modified:* 2/10/2010 *Status:* Proposed

Specification: The LSST system throughput shall allow efficient collection of the science data over a wide range of wavelengths, from near the atmospheric cutoff in the blue to the band gap of silicon in the red.

2.2.1.3.1 Average System Response

id:
Version: 1.0 *Modified:* 2/11/2010 *Status:* Proposed

Specification: The average system response efficiency through in each filter measured between their respective upper and lower wavelength limits shall be at least:

1. u-band = ***uThroughputAve***
2. g-band = ***gThroughputAve***
3. r-band = ***rThroughputAve***
4. i-band = ***iThroughputAve***
5. z-band **= *zThroughputAve***
6. y-band **= *yThroughputAve***

Discussion: The system response includes the efficiency of photon detection, lens and mirror coating performances, and the transmission of the atmosphere referenced at zenith under nominal conditions found at the Cerro Pachon site.

Description	Value	Unit	Attribute
The lower wavelength limit for the system u-band response shall be	320	nm	uLambdaLower
The upper wavelength limit for the system u-band response shall be	420	nm	uLambdaUpper
The average system response efficiency measured between the upper (**uLambdaUpper**) and lower (**uLambdaLower**) u-band limits shall be at least	15	Percent	uThroughputAve
The lower wavelength limit for the system g-band response shall be	380	nm	gLambdaLower
The upper wavelength limit for the system g-band response shall be	570	nm	gLambdaUpper
The average system response efficiency measured between the upper (**gLambdaUpper**) and lower (**gLambdaLower**) g-band limits shall be at least	50	Percent	gThroughputAve
The lower wavelength limit for the system r-band response shall be	515	nm	rLambdaLower
The upper wavelength limit for the system r-band response shall be	715	nm	rLambdaUpper
The average system response efficiency measured between the upper (**rLambdaUpper**) and lower (**rLambdaLower**) r-band limits shall be at least	70	Percent	rThroughputAve
The lower wavelength limit for the system i-band response shall be	645	nm	iLambdaLower
The lower wavelength limit for the system i-band response shall be	875	nm	iLambdaUpper
The average system response efficiency measured between the upper (**iLambdaUpper**) and lower (**iLambdaLower**) i-band limits shall be at least	70	Percent	iThroughputAve
The lower wavelength limit for the system z-band response shall be	760	nm	zLambdaLower
The upper wavelength limit for the system z-band response shall be	990	nm	zLambdaUpper
The average system response efficiency measured between the upper (**zLambdaUpper**) and lower (**zLambdaLower**) z-band limits shall be at least	60	Percent	zThroughputAve
The lower wavelength limit for the system y-band response shall be	945	nm	yLambdaLower

Description	Value	Unit	Attribute
The upper wavelength limit for the system y-band response shall be	1100	nm	yLambda Upper
The average system response efficiency measured between the upper (**yLambdaUpper**) and lower (**yLambdaLower**) y-band limits shall be at least	25	Percent	yThrough putAve

2.2.1.3.2 Throughput variation with time

id:
Version: 1.0 *Modified:* 2/8/2010 *Status:* Proposed

Specification: TBD

2.2.1.3.3 Vignetting Function

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The vignetting function shall vary smoothly over the field of view with a functional form corresponding to a polynomial with an order no more than **vignettingFunc** with an amplitude of no more than **vignettingAmp**.

Discussion: The amplitude of the vignetting is less than that alowed by the survey specifcation for image depth variation to allow for additional depth variation caused by variations in image quality allowed by the SRD.

Description	Value	Unit	Attribute
The amplitude of variation across the field of view.	15	Percent	vignetingA mp
The order of functional form for the vignetting pattern across the field of view.	3		vignetting Func

2.2.2 Calibration Data

id:
Version: 1.0 *Modified:* 2/8/2010 *Status:* Proposed

Specification: The LSST shall measure and record data relating to instrumental and atmospheric transmission needed to photometrically calibrate the science data referenced to the top of the Earth's atmosphere.

2.2.3 Engineering Data

id:
Version: 1.0 *Modified:* 2/8/2010 *Status:* Proposed

Specification: The LSST Data collection system shall collect all engineering and

environmental data necessary to capture the physical state of the observatory, its components, and surrounding environment, during all modes of operation.

2.2.4 Ancillary Data

id:
Version: 1.0 *Modified:* 2/8/2010 *Status:* Proposed

Specification: The LSST system shall measure and record the needed data to provide the necessary inputs for optimizing the acquisition of survey data and a record of the environmental conditions that existed during each exposure. These data include:

1. atmospheric seeing
2. cloud cover
3. meteorological information (temperatures, wind, humidity etc..)

2.3 Data Products & Processing

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The data processing will calibrate the raw images, analyze them to generate source and object catalogs, detect and generate alerts for transient phenomena, and record the quality of the data collected and its processing provenance.

2.3.1 Calibrated Image Production

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST data processing system shall process raw image data to produce photometrically and astrometrically calibrated images.

2.3.2 Catalogue Production

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The data processing system shall process calibrated image data to produce catalogs of sources and objects.

2.3.3 Data Products

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST data processing system shall provide the means for organizing the production of three classes of data products: Level 1 (nightly cadence), Level 2 (data release cadence), and Level 3 (user-specified).

2.3.3.1 Level 1 Data Products

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: Level 1 Data Products are the result of processing of the stream of image data from the Data Collection system during normal observing.

Level 1 Data Products shall be produced and made publicly available within **L1PublicT** of the acquisition of the corresponding raw images, except for transient alerts which must meet the SRD latency requirement **OTT1**.

2.3.3.1.1 Data Quality Monitoring

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: Level 1 Data Product production shall include the production of sufficient Science Data Quality Assessment (SDQA) data, in a manner which supports feedback of observatory and observing conditions to the Observatory Control System, and alerts to observatory operators when poor quality data are detected.

SDQA data produced shall be archived in association with the corresponding raw image data.

2.3.3.2 Level 2 Data Products

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: Level 2 Data Products are the result of periodic processing of the entire archive of raw image data from the Data Collection system. The processing may additionally use as input other Level 1 Data Products corresponding to the raw images processed.

All Level 2 Data Products shall be produced in the context of Data Releases, within which a complete and consistent set of data products are generated.

2.3.3.2.1 Data Quality Monitoring

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: Level 2 Data Product production shall include the production of sufficient SDQA data to allow the determination of the scientific usability of the data products and the assessment of the large-scale progress of the survey.

2.3.3.2.2 Frequency of Data Releases

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: Data Releases of Level 2 Data Products shall be produced at intervals no less than the Survey Specifications for standardized data release interval - **DRT1**.

Data Releases will be performed more frequently during the first year of the survey.

2.3.3.2.3 Scientific Content

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The Level 2 Data Products in a Data Release shall include measurements of the properties (shapes, positions, fluxes, motions) of all detected objects, including those below the single-visit sensitivity limit, astrometric and photometric calibration of the object catalog, classification of objects based on their static properties and time-domain behavior, and deep coadded images of the full survey area on the sky.

2.3.3.3 Level 3 Data Products

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: Level 3 Data Products are the result of processing based on Level 1 and Level 2 Data Products, of a nature specified by users (by the provision of code and/or processing configuration data).

LSST data processing shall facilitate the efficient and convenient production of Level 3 Data Products, either using resources provided by the project or resources provided by the user that meet minimal specifications defined by the project.

Specification: The manner of production of Level 3 Data Products shall facilitate their federation with related Level 1 and Level 2 Data Products, when archived.

Discussion: The LSST project may promote selected Level 3 Data Products and their production to Level 2 or Level 1, subject to scientific justification and the availability of resources.

2.3.3.4 Calibrated Single Images

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: LSST data processing shall provide calibrated images from any past processing upon request.

Discussion: Calibrated image data must be available to retrieve, but may be reconstructed on demand as an alternative to its direct archiving.

2.3.3.5 Calibration Data Products

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The data processing system shall, from time to time, generate Calibration Data Products, including bias frames and flat fields, as required by the other processing functions. These will typically appear at time scales intermediate to those of the Level 1 and Level 2 Data Products.

2.3.3.6 Science Database

Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Is the metadata in the Science Database (particularly the EFD subset and the processing provenance) technically considered part of the Level 2 Data products?

2.3.4 Optical Transient Alert Generation

Id: DM-APP-DP-GR-11
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST data processing system shall detect optical transients in acquired raw images, record their detection and associated parameters, and make alerts available to external consumers.

Specification: The data processing shall differentiate between cosmic rays, moving objects and other optical transients.

2.3.4.1 Alert Generation Latency

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: Optical transient alerts shall be produced and transmitted to the distribution network for external users within the Survey Specifications for latency - **OTT1**.

2.3.4.2 Alert Generation Reliability

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: Alerts shall be transmitted within the specified latency for at least **OTR1 (98**%,

TBC) of instances where the image data contains a transient detectable by the chosen science algorithm(s). The remaining detectable transients must still be identified and recorded at the next processing opportunity.

2.4 Data Archiving & Services

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST shall archive all image, catalog, engineering, calibration, and environmental data collected during the course of the survey, and shall make this data available for analysis and distribution.

2.4.1 Raw Image Data Archiving

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST system shall archive all raw science and calibration image data, as well as all wavefront sensor data. It shall also permit the archiving of such diagnostic image data as may be needed to support the commissioning and maintenance of the observatory.

Specification: The LSST system shall archive sufficient information to permit the reliable and reproducible retrieval of calibrated image data.

Discussion: Calibrated image data must be available to retrieve, but may be reconstructed on demand as an alternative to its direct archiving.

2.4.2 Data Product Archiving

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST system shall archive all Level 1, Level 2, and Calibration Data Products.

2.4.3 Engineering and Environmental Data Archiving

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST system shall archive all engineering and environmental data collected by the observatory.

2.4.4 Data Product Open Access

Id: DM-APP-DP-LT-1
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST shall provide open access to Level 1 and Level 2 Data Products for the United States and observatory host nation scientific communities. This shall include access to all engineering, environmental, and ancillary data required for scientific interpretation of the Data Products.

2.4.4.1 Data Distribution

id:
Version: 1.0 *Modified:* 2/12/2010 *Status:* Proposed

Specification: The LSST shall permit and facilitate the bulk distribution of its public data to remote sites wishing to consume or host it, subject to the availability of resources.

Discussion: This requirement is not intended to create an open-ended obligation to add bandwidth for data distribution. In cases where remote sites wish to host a large amount of LSST public data, it is anticipated that some cost-sharing arrangement may be needed to support the installation of additional data distribution capacity.

2.4.4.2 Data Product Access Interface

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST shall provide access to all its public data products through an interface that utilizes, to the maximum practicable extent, community-based standards such as those being developed by the Virtual Observatory (VO) community, and that facilitates user data analysis and the production of Level 3 and other user-defined data products at LSST-provided facilities and at remote sites.

2.4.5 Community computing services

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST shall provide and maintain an amount of computing cpacity equivalent to at least 10% of the total LSST data processing capacity to external users for the purpose of scientific analysis of LSST data.

Discussion: The scope of this service is to be determined based on a representative set of system queries and analyses assembled from community input.

3 Survey Operation & Administration

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The Observatory shall be designed and developed to efficiently manage the execution of the survey.

Specification: In addition to the connectivity required for the science data, the observatory shall include the necessary capability to command and control the process from discrete centers and to adjust for changing environmental, technical, and scientific conditions.

Specification: The LSST project shall monitor the scientific and technical progress of the survey, communicate with the scientific user community and establish survey priorities, and adjust the survey design as needed to accomplish its goals given these priorities and achieved performance.

Discussion: The LSST Observatory will be a comprehensive project to capture, process, archive, and serve data.

3.1 Education & Public Outreach

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST Observatory shall include an Education and Public outreach program that supports Federal "broader Impacts" requirements through education resources to interface with the LSST data in formal and informal education settings, Museums, and through common internet access.

Discussion: The National Science Foundation supports programs based on intellectual merit and broader impacts. The National Science Board strives for all America citizens to have the basic scientific, technological, and mathematical knowledge to make informed personal choices, to be educated voters, and to thrive in the increasingly technological global marketplace. The National Research Council, through its development of Science Education standards supports student learning and understanding of the natural world through inquiry.

3.2 Existing Infrastructure

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST Observatory shall utilize existing infrastructure, to the extent possible, and as available, to reduce the capital and operational costs. In particular, LSST shall evaluate the use of existing NSF funded astronomical sites, DOE Astrophysics Labs, and federally funded computer centers.

3.3 Observatory Control

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The observatory shall be developed with the control centers to achieve the LSST objectives. This shall include, as a minimum, the capabilities defined here.

3.3.1 Central Administration

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: A central location shall serve as Project Headquarters for operational coordination and project interface.

Discussion: The LSST Observatory will be a distributed set of assets functioning for the specific objectives of executing the survey, serving the raw data and its data products to the public without any proprietary period. This will be a 24 hour per day operation that willl be capable of being administered and monitored from a single central location.

3.3.2 Local Administration

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: Each site in the LSST Observatory shall be capable of local autonomous control and operation. The system shall include the necessary provisions to function effectively when connections to other sites of the Observatory are interrupted.

3.3.3 Scientific Oversight During Data Collection

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST Observatory shall be developed to allow an observing scientist to have oversight of the Data Collection process. This interaction shall be enabled either locally on the summit or at remote locations. The data provided shall include all observing condition data, telemetry data to assess telescope conditions, and data quality metrics for evaluation of the data collection process. The objective is to have the observing scientist to be directly involved in the observing process.

3.3.4 Autonomous Operation

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST system shall operate in a locally supervised autonomous mode during routine survey data collection and processing with little human intervention required.

Discussion: It is not practical to expect human driven observations to keep pace of observing

cadence dictated by the LSST survey requirements.

3.4 Public Data Release

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The raw survey data and processed data products shall be made available to the public without any proprietary period.

Discussion: A necessary step in releasing the data is to do SDQA on it. However, even data prior to Data Release SDQA is available, with caveats to the user.

3.4.1 Data Quality Metrics

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The Observatory shall include the necessary infrastructure and quality assessment capabilities to serve the defined data with the defined quality metrics.

3.5 Science Priorities & Survey Scheduling

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The Observatory shall include a dynamic scheduler sufficient to achieve the survey requirements in the presence of changing observing conditions, nightly technical performance, and previous survey performance. The scheduler shall also have the following characteristics:

3.5.1 Scientific Priority

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The reference survey can be accomplished in many observing sequences that impact the scientific reach of the accumulated data. The scheduler shall provide the ability to assign additional performance metrics that exploit the technical capacity of the LSST system to optimize the image by image sequence of observation.

3.5.2 Adjustment of Survey Priorities

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST shall allow for bi-annual adjustment of the scheduler's survey priorities based on community input.

3.5.3 Survey Performance Reviews

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: LSST shall have the ability to provide periodic status of the survey to allow operations staff and the community alike, to assess the survey progress.

3.5.4 Survey Simulation

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The Observatory shall include the survey simulation tools to predict the results of the 10 year survey based on the actual survey completed to data as well as changes to the scientific priorities established in REQ-#### above. This tool set shall support planning of the survey at time scales of nightly, yearly, and the entire 10 year duration.

3.6 Overall Operational Efficiency

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST system shall meet the Section 1 Survey Specifications for number of visits and area coverage subject to the constraints of weather, system dynamics, scheduled maintenance, and unscheduled down time.

Discussion: The specifications for the allowed allocations to each of the terms for non-observable time is contained in the companion document ***the Observatory Specifications***.

3.6.1 Graceful Degradation

id:
Version: 1.0 *Modified:* 2/16/2010 *Status:* Proposed

Specification: The LSST system will be designed so that its performance degrades gracefully in the presence of adverse environmental and/or operating conditions.

Discussion: Of paramount importance is the safety of personnel, followed by safety of equipment, and then the prevention of data loss.

3.6.2 Survey Time Allocation

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: Approximately 90% of the LSST's available observing time shall be dedicated to

a community defined common survey. The remaining available time will be available for special programs (e.g. targeted deep supernova programs).

3.6.3 System Operational Lifetime

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST system shall meet all its requirements and specifications for the duration of the 10 year survey.

3.6.4 Preventive Maintenance

id:
Version: 1.0 *Modified:* 2/15/2010 *Status:* Proposed

Specification: The LSST system shall meet all its requirements and specifications for the duration of the 10 year survey by means of preventive maintenance, as opposed to replacement at failure.

Discussion: Preventive maintenance implies servicing, repairing, and replacing components and subsystems based on their expected lifetime, as opposed to their failure.