# GMT Science Requirements Document

GMT Requirements Document

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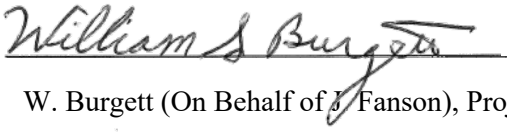

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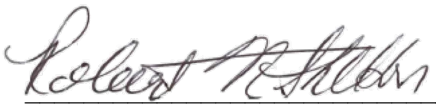

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# Revision Log

| Revision | Date | Affected Sections | Change Request # | Comments | Change Author |
|---|---|---|---|---|---|
| A | 04/03/2018 | All | GMT-CR-03216 | Authorized Release | G. Angeli |
| B | 04/06/2018 | All | None | Typo Correction (Requirement Numbers assigned & exported by and from DOORS)and corrected visible small field image quality (WAS: 0.25"/ IS: 0.3"). | A. Santana/ R. Millan-Gabe |
| C | 10/18/2018 | All | None | Minor clerical and typo corrections. Ensure TOC and DocuShare links work properly. Added DocuShare links to documents in Applicable and Reference section that were non-existent at time of Authorize Release at Rev. A | A. Kocz / R. Paredes |
| D | 10/15/2021 | All | GMT-CR-05098 | Added generalized diffraction-limited observing case. Updated astrometric variation requirements to be self-consistent. Edited off-axis image quality to be specified with each of the atmospheric resolution observing cases. Updated image quality specifications for the high angular resolution cases to all be set at 1.65 µm to be consistent with each other and the associated science cases. Updated small field visible OC sensitivity to be consistent with Rev. B IQ change. | B. Sitarski / R. Bernstein / R. Conan |

For detailed revision history in DOORs, click here.

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# 1 Scope

## 1.1 System Overview

The Giant Magellan Telescope is one of a new generation of ground-based “Extremely Large Telescopes” designed to provide unprecedented clarity and sensitivity for the observation of astronomical phenomena. The GMT will leverage cutting-edge optics technology to combine seven primary and seven secondary mirrors into a single optical system that can achieve the diffraction limit of the full diameter of the seven-segment primary mirror surface. The GMT will be located at Las Campanas Observatory (LCO). Located in the high-altitude, desert environment of the Chilean Andes, LCO is owned by the Carnegie Institution and has been operating as a world-class observatory site since 1969. The GMT is intended to execute cutting-edge scientific observations over the full optical and infrared spectrum in all fields of astrophysics with a lifetime of 50 years.

## 1.2 Document Overview

This document is one of the top-level formal documents, the "Foundation Documents," that define the GMT Observatory. These documents are projections of the Observatory's requirements database that is maintained using the DOORS software and have either been generated by or identical to the content in DOORS. As these documents are more widely accessible than the database, they constitute the formally controlled Foundation Documents of the GMT Project. The scope of each document is as follows:

- The Concept of Operations Document (ConOps, GMT-DOC-03205) expresses the stakeholders’ and owners’ intention for the Observatory. Through high-level operational objectives and constraints, it describes what the observatory is expected to do.
- The Science Requirements Document (SRD, GMT-REQ-03213) quantifies the broad observational requirements needed to address the scientific goals of the Partnership, which are described in the GMT Science Book and the science cases for the first-generation instruments. As the product of the Observatory is the data needed to execute these scientific goals, the SRD is organized into Observing Cases —the data equivalent of Science Cases.
- The Observatory Requirements Document (ORD, GMT-REQ-03214) is the response of the GMT Project to the SRD. It contains the top-level engineering requirements for the Observatory that is to be built. It transforms the data specifications for each Observing Case in the SRD into technical specifications for the Observatory Performance Modes.
- The Observatory Architecture Document (OAD, GMT-REQ-03215) captures the top-level system design, consistent with the Observatory Requirements. It defines the subsystems and their interactions as they deliver the various System Configurations that enable the Observatory to implement the Observatory Performance Modes defined in the ORD. The OAD also enumerates performance and resource allocations among the subsystems.

- The Observatory Operations Concept Document (OpsCon, GMT-OCDD-01776) describes how the Observatory design described in the OAD will be operated by the Stakeholders during operation to meet ConOps objectives and SRD/ORD specifications. It is the high-level summary of Observatory behaviors and operator interactions.

## 1.3 Strategy and Organization

Because the fundamental product of any observatory is data, the Science Requirements for the GMT Observatory have been organizing according to the characteristics of the data that are needed to execute the Observatory's scientific mission. That mission is articulated in *GMT 2012 Science Book* and the science cases for the first generation of GMT instruments. However, those documents are not intended to be an exhaustive description of the scientific questions that will be addressed over the 50 year lifetime of the Observatory. For that reason, we have developed the science requirements by focusing on the astronomical sources themselves — the characteristics that are of interest for those sources and the data quality needed to quantify those characteristics. In doing so, we have addressed the full range science cases in the documents listed above. The analysis of those documents and the development of the requirements is discussed in the Science Case Analysis Document (GMT-DOC-03227) and is not repeated in detail here.

By analogy with Science Cases, the science requirements for the GMT are organized by **Observing Cases (OC)** that describe the kinds of data that are needed to execute the scientific goals The OCs falling into three main categories according to the field of view needed for those observations (small, medium, or wide), then by wavelength (visible or infrared), and they by spatial resolution (image quality). All the requirements given for each OC must be met (simultaneously) during a corresponding imaging or spectroscopic observation. In addition to the requirements that are specific to individual OCs, there are more global scientific requirements and functional performance requirements that apply to all observations and must also be simultaneously achieved during observations characterized by any OC (See Figure 1-1).

We believe that the organization of requirements in this way has several benefits. First and foremost, it clarifies simultaneous performance and facilitates flow-down to the system and subsystem requirements. Second, because the OCs are modular, the addition of new capabilities later in the life of the Observatory can be easily added within the same framework by adding new Observing Cases. Finally, the requirements contained here describe the data quality without reference to technical implementation or techniques, as appropriate for the SRD.

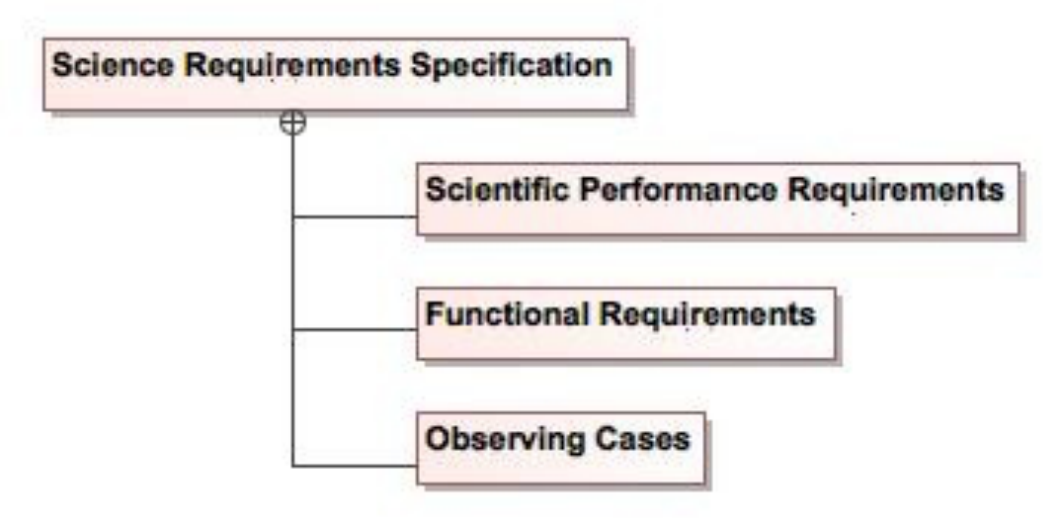


Figure 1-1: Top-Level Organization of Science Requirements

## 1.4 Definition of Requirement Terms

Throughout the document, requirements statements are shown in blue text to allow them to stand out. Statements preceded by "*Note:*" or "*Advice:"* are support text and statements preceded by *"Rationale:"* are the reasoning behind the requirements. Terms should be used as specified below:

Table 1-1: Definitions of Terms “Shall, Should & Will”

| Term | Definition |
|---|---|
| "Shall" | "Shall" denote requirements that are mandatory and will be the subject of specific acceptance testing and compliance verification. |
| "Can", "May", or "Should" | "Can", "May", or "Should" indicate recommendations and are not subject to any requirement acceptance testing or compliance verification by the supplier. The supplier is free to propose alternative solutions. |
| "Is or Will" | "Is" or "Will" indicate a statement of fact or provide information and are not subject to any requirement acceptance testing or verification compliance by the supplier. |

# 2 Definitions, Acronyms, and Reference Documents

## 2.1 Definitions

Table 2-1: Definitions

| Term | Definition |
|---|---|
| | |
| | |
| | |
| | |

## 2.2 Acronyms

Table 2-2: Acronyms

| Acronym | Description |
|---|---|
| GMT | Giant Magellan Telescope |
| | |
| | |

## 2.3 Applicable Documents

Table 2-3: Applicable Documents

| Document Number | Title | Manage Link |
|---|---|---|
| GMT-REF-00481 | GMT Scientific Promise and Opportunities (GMT Science Book) | https://bit.ly/2GDEa4U |
| GMT-DOC-03227 | Science Case Analysis Document | TBD |
| GMT-REQ-03214 | GMT Observatory Requirements Document | GMT-REQ-03214 |
| GMT-REQ-03215 | GMT Observatory Architecture Document | GMT-REQ-03215 |
| GMT-DOC-03205 | GMT Concept of Operations | https://bit.ly/3eqUjqz |
| GMT-OCDD-01776 | GMT Observatory Operations Concept | GMT-OCDD-01776 |

## 2.4 Referenced Documents

Table 2-4: Referenced Documents

| Document Number | Title | Manage Link |
|---|---|---|
| GMT-REF-00362 | GMT Project Acronyms and Glossary | https://bit.ly/3l4reUC |
| | | |
| | | |

# 3 Functional Requirements

This section describes general functional requirements for the GMT Observatory. They must be met during the observations described in all OCs.

### REQ-L1-SCI-23048: Nodding

The GMT shall enable observations that require offset sky cancellation by providing a mode for alternating between two specified positions on the sky (with or without guiding), while integrating synchronously at the endpoints with the science instrument.

### REQ-L1-SCI-23050: Non-Sidereal Tracking

The GMT Observatory shall be able to track targets moving at non-sidereal rates up to 6 arcsec/min while meeting image quality requirements for seeing-limited observations over small fields of view, with no more than an additional 0.1 * PSF image elongation.

**Notes:** There are many interesting science opportunities involving solar system targets, which move on the sky at non-sidereal rates. The range of rates range from 0.5 arcsec/min to 20 arcsec/min for the fastest moving NEOs. A non-sidereal rate of up to 6 arcseconds per minute, however, will support nearly all such targets. Observations of some distant artificial satellites can be accommodated in this range.

### REQ-L1-SCI-23053: Sidereal Targets

The GMT Observatory shall be able to meet all performance requirements while tracking targets moving at sidereal rates in all observing modes.

### REQ-L1-SCI-23055: Scanning

The GMT Observatory shall be able to uniformly sample the light from an extended source or uniformly distribute the light from a resolved source by moving the telescope at controlled rates of up to 1 arcsec/sec in any direction within a total range of motion of 60 arcsec x 60 arcsec from the initial pointing, and with a pointing accuracy equal to the PSF FWHM in seeing limited conditions.

### REQ-L1-SCI-23057: Dithering

The GMT shall support observations that require local sky determinations and averaging over detector pixels by providing a mode for stepping between positions on the sky in specified patterns and integrating with the science instrument at each step.

**Notes:** When dithering with guiding in the natural seeing mode, the telescope should move to the commanded position with an accuracy and precision sufficient to allow blind stacks and mosaics to be assembled without loss in delivered image quality.

# 4 Scientific Performance Requirements

This section describes general (non-functional) scientific performance requirements for the GMT Observatory. They must be met during the observations described in each OC.

### REQ-L1-SCI-23062: Total Sky Coverage

The GMT shall be able to access the entire southern sky and enough of the northern sky to cover key equatorial survey fields (e.g. SDSS equatorial strip, Subaru deep fields, etc.) by permitting unvignetted science observations on the sky visible from the site over the full 360 degrees range in azimuth angle and elevation angles from 30 degrees [Goal: 25 degrees] to 89.0 degrees [Goal: 89.5 degrees].

**Rationale:** Science drivers described in the Science Book require access to the Magellanic Clouds and deep survey fields on or near the celestial equator. The elevation angle range given here allows for 5 hours of integration time per night (above an airmass of 2) on targets at 20 degrees north latitude. The primary drivers for lower elevation limits are solar system targets, many of which can be observed effectively with smaller apertures.

### REQ-L1-SCI-23066: Observation Time Accuracy

The GMT Observatory shall be able to record the time of an observation with an accuracy of 10 ms.

**Rationale:** This is required for accurate timing of time-dependent phenomena, such as mutual Jovian satellite eclipses, or rapid transients.

# 5 Observing Cases and Scientific Performance Requirements

This section describes scientific performance requirements in each OC.

The OCs are organized by field of view, wavelength range, and resolution. The capability to do imaging and spectroscopy is called out explicitly in each OC. Any requirements that are unique to spectroscopy are provided within the relevant OC.

The following definitions are used for wavelength range:

- Visible: 0.32 μm ≤ wavelength ≤ 1.3 μm: The band is bounded by the atmospheric transmission at the blue end and the cut off of silicon detectors at the red end. Backgrounds are dominated by direct and scattered light from astronomical sources (e.g. moon, zodiacal light), manmade sources, and airglow.
- Infrared: 0.6 μm ≤ wavelength ≤ 25 μm: Observing Cases in this range are concerned primarily with thermal infrared wavelengths (>1.3 μm).

The following definitions are used for spatial resolution:

- Atmospheric Angular Resolution: the required spatial resolution (image quality) is limited by atmospheric turbulence.
- High Angular Resolution: the required spatial resolution (image quality) is near the diffraction limit of the telescope. Spatial resolution is higher priority than sky coverage.
- High Angular Resolution with High Sky Coverage: the required spatial resolution (image quality) is near the diffraction limit of the telescope. Sky coverage is higher priority than spatial resolution.
- Diffraction-Limited Resolution: the required spatial resolution (image quality) is at the diffraction limit of the telescope within a few arcseconds of bright stars. Here "bright" means the star can be used for image analysis on kHz timescales.
- Diffraction-Limited Resolution with High Contrast: the required spatial resolution (image quality) is at the diffraction limit of the telescope within a few arcseconds of bright stars, as above, and high image contrast can be achieved within a few λ/D (e.g., for planetary imaging).

In addition to the global functional and scientific performance requirements described in the previous sections, each OC inherits the common requirements at its field size. Some also inherit requirements from one of the more general OCs with the same field size. Note that we avoid duplication of requirements by stating only new or modified requirements for each OC. The requirements that are specific to a single OC are described last.

The currently specified OCs are as follows:

- Small Field Visible, Atmospheric Resolution
- Small Field Visible, PRV, Atmospheric Resolution
- Small Field Infrared, Atmospheric Resolution
- Small Field Infrared, High Angular Resolution
- Small Field Infrared, High Angular Resolution with High Sky Coverage
- Small Field Infrared, Diffraction-Limited Resolution
- Small Field Infrared, Diffraction-Limited Resolution with High Contrast
- Medium Field Visible, Atmospheric Resolution
- Medium Field Infrared, Atmospheric Resolution
- Wide Field Visible, Atmospheric Resolution

The requirements for each OC are given below. The following color coding is used to help clarify which requirements are inherited or unique. In general, green and blue boxes indicate reuqirements that are common to many OCs, while white boxes shown requirements that are unusual and important for that OC. In detail:

- Green boxes: requirements common to all OC.
- Blue boxes: requirements common to all OC with a given field of view (Small, Medium, or Wide).
- White box, black text: a new or modified requirement for the indicated OC.
- Grey box, black text: a requirement inherited from another OC with the same field of view. These are listed for completeness, and to emphasize commonality.
- White box, grey text: a requirement that does not apply to the indicated OC. These are listed for completeness, and so that the parallel organization of the OCs is not obscured by their absence.

## 5.1 Requirements Common to All Observing Cases

### REQ-L1-SCI-23083: Spectroscopic Resolution Range

The GMT Observatory shall not preclude observations with a spectral resolution between 10 and 150,000.

### REQ-L1-SCI-23085: Minimum Spectroscopic Stability

The GMT Observatory shall be able to perform spectroscopic observations with a minimum spectroscopic stability of 10% of the spectral resolution, when the S/N is 10 or greater, achievable with standard calibration methods and data processing applied to long exposures (~1 hour).

## 5.2 Small Field Observing Cases

### 5.2.1 Common to all Small Field Observing Cases

### REQ-L1-SCI-23090: Small Field – Minimum field of View

The GMT Observatory shall be able to perform small field visible observations with a minimum field of view of 3 arcmin.

### REQ-L1-SCI-23092: Small Field – Maximum Time to Start an Exposure

The GMT Observatory shall be able to start a small field observation in less than 600 seconds [goal 300 seconds].

**Rationale:** This requirement is intended to accommodate the need for rapid acquisition of transient sources (also called “target of opportunity” observations). The requirement includes the time to change the active instrument (receiving the telescope beam) to any other deployed instrument (an instrument installed in the telescope and available for use that night).

## 5.2.2 Observing Case: Small Field Visible (Atmospheric Resolution)

The small field visible observing case serves diagnostic observations of single or multiple objects over small fields. The targets may be unresolved, such as stars, active galactic nuclei (AGN), or transients (supernovae, gamma ray bursts, etc.), or resolved, such as galaxies or star clusters. High image quality is important, but diffraction limited spatial resolution is not required, or is less important than photometric stability.


Figure 5-1: Small Field Visible (Atmospheric Resolution) Requirements

### REQ-L1-SCI-23097: Small Field Visible – Imaging Observations

The GMT Observatory shall be able to perform imaging observations over small fields at visible wavelengths.

### REQ-L1-SCI-23099: Small Field Visible – Spectroscopic Observations

The GMT Observatory shall be able to perform spectroscopic observations over small fields at visible wavelengths.

### REQ-L1-SCI-23101: Small Field Visible – Wavelength Range Lower Limit

The GMT Observatory shall be able to perform small field visible observations with a wavelength range lower limit of 0.32 µm.

### REQ-L1-SCI-23103: Small Field Visible – Wavelength Range Upper Limit

The GMT Observatory shall be able to perform small field visible observations with a wavelength range upper limit of 1.3 µm.

### REQ-L1-SCI-23105: Small Field Visible – Image Quality On-Axis

The GMT Observatory shall be able to perform small field visible observations with an on-axis image FWHM ≤ 0.30 arcsec at 0.5 µm in a 900 sec exposure.

**Rationale:** This image quality is required to achieve the resolution and sensitivity for a variety of science cases. Extragalactic cases include observations of galaxy formation and assembly and the detection of lensed background galaxies at small impact parameters from the foreground lens source. Galactic science cases include observations of the color magnitude diagram of star clusters and dense regions of nearby galaxies.

### REQ-L1-SCI-115012: Small Field Visible -- Image Quality Off-Axis

The GMT Observatory shall be able to perform small field visible observations with image quality at all off-axis positions that degrades the as-designed image FWHM by <5%, scaled to an on-axis image quality of 0.30 arcseconds.

**Notes:** The as-designed image quality of the telescope (without the field corrector) decreases with field radius as r^2 as shown in Figure 5-2. The telescope optical design is described in GMT-DOC-00010.

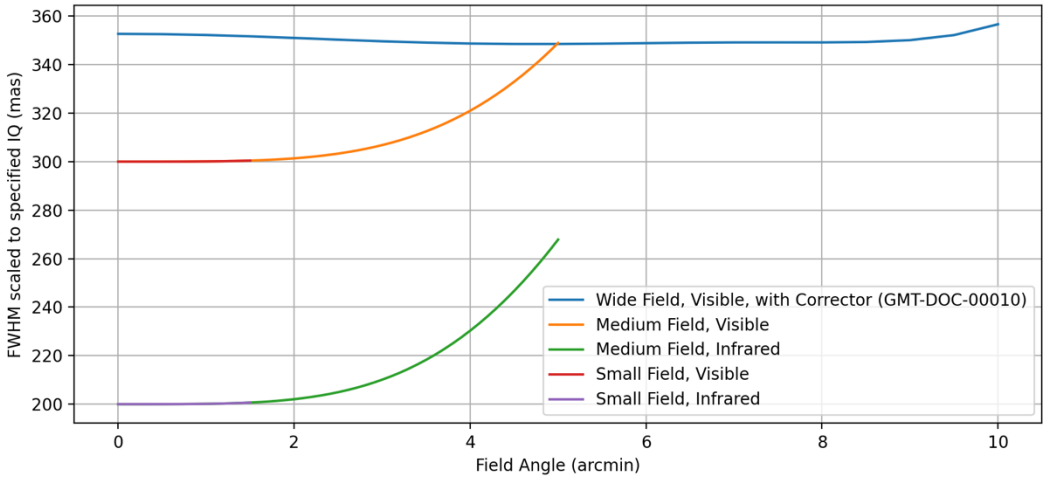


Figure 5-2: Telescope Design Aberrations

### REQ-L1-SCI-23108: Small Field Visible – On-axis Sensitivity

The GMT Observatory shall be able to perform small field visible observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

Table 5-1: Small Field Visible On-Axis Sensitivity

| U | B | V | R | I | z |
|---|---|---|---|---|---|
| 29.6 | 30.7 | 30.0 | 29.8 | 29.0 | 28.9 |

### REQ-L1-SCI-23112: Small Field Visible -- Maximum Sensitivity Variation

The GMT Observatory shall be able to perform small field visible observations with a maximum sensitivity variation over the field of view of 5%.

### REQ-L1-SCI-23114: Small Field Visible -- Absolute Photometric Accuracy

The GMT Observatory shall be able to perform small field visible observations that measure the flux of a point source with an uncertainty of ≤ 2% relative to a standard astronomical flux source.

### REQ-L1-SCI-23116: Small Field Visible – Relative Photometric Accuracy

The GMT Observatory shall be able to perform small field visible observations that measure the flux of a point sources in the field with a minimum relative photometric accuracy of 1%.

### REQ-L1-SCI-23118: Small Field Visible – Minimum Sky Coverage

The GMT Observatory shall be able to perform small field observations with a minimum sky coverage of 99%.

### REQ-L1-SCI-23120: Small Field Visible -- Maximum Astrometric Variation

The GMT Observatory shall be able to perform small field visible observations with a maximum astrometric variation (with respect to time) over the full field of 0.007% in a 900 second exposure.

**Notes:** This corresponds to 13 mas over 3 arcminutes (minimum field of view) over 900 seconds.

## 5.2.3 Observing Case: Small Field Visible Precision Radial Velocity (PRV)

Precision radial velocity measurements enable the measurement of the reflex motion of stars due to orbiting extrasolar planets. The driving science case is the measurement of the masses of earth-sized planets around solar-type stars.

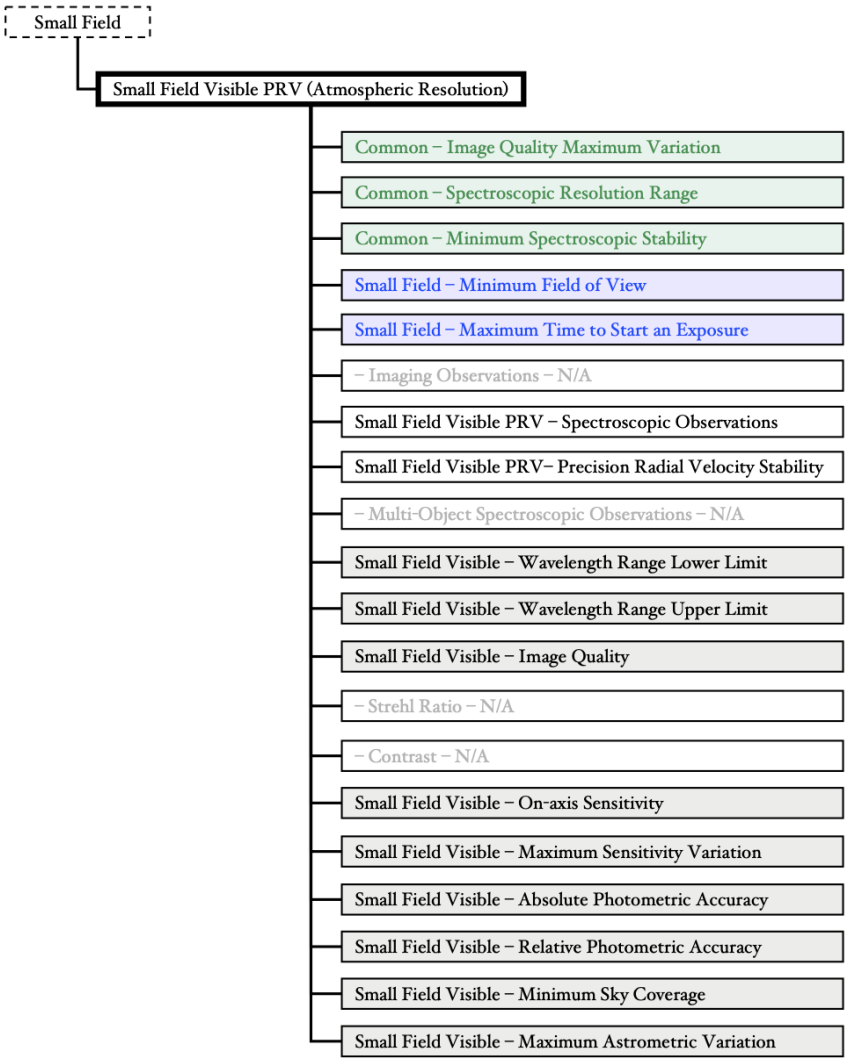


Figure 5-3: Small Field Visible (PRV) Requirements

### REQ-L1-SCI-23123: Small Field Visible PRV -- Spectroscopic Observations

The GMT Observatory shall be able to perform small field visible spectroscopic observations for precision radial velocity measurements.

### REQ-L1-SCI-23125: Small Field Visible PRV – Precision Radial Velocity Stability

The GMT Observatory shall be able to perform small field visible spectroscopic observations with a minimum radial velocity stability of 10 cm/sec [goal: 4 cm/sec].

**Note:** This observing case inherits all requirements in grey boxes in Figure Figure 5.2.3.0-2 above, namely: Wavelength Range Lower Limit (REQ-L1-SCI-23101), Wavelength Range Upper Limit (REQ-L1-SCI-23103), Image Quality (REQ-L1-SCI-23105), Off-Axis Image Quality (REQ-L1-SCI-

115012), On-axis Sensitivity (REQ-L1-SCI-23108), Maximum Sensitivity Variation (REQ-L1-SCI-23112), Absolute Photometric Accuracy (REQ-L1-SCI-23114), Relative Photometric Accuracy (REQ-L1-SCI-23116), Minimum Sky Coverage (REQ-L1-SCI-23118), and Maximum Astrometric Variation (REQ-L1-SCI-23120) requirements from the Small Field Visible Observing Case (Section 5.2.2).

## 5.2.4 Observing Case: Small Field IR (Atmospheric Resolution)

The science cases that drive this OC are similar to the Small Field Visible OC, but involve sources that are cooler, at higher redshift, or in dustier environments. Targets may be resolved or unresolved sources. High image quality is important, but diffraction limited spatial resolution is not required, or is less important than photometric stability. An OC for PRV measurement in the infrared may be added in the future.

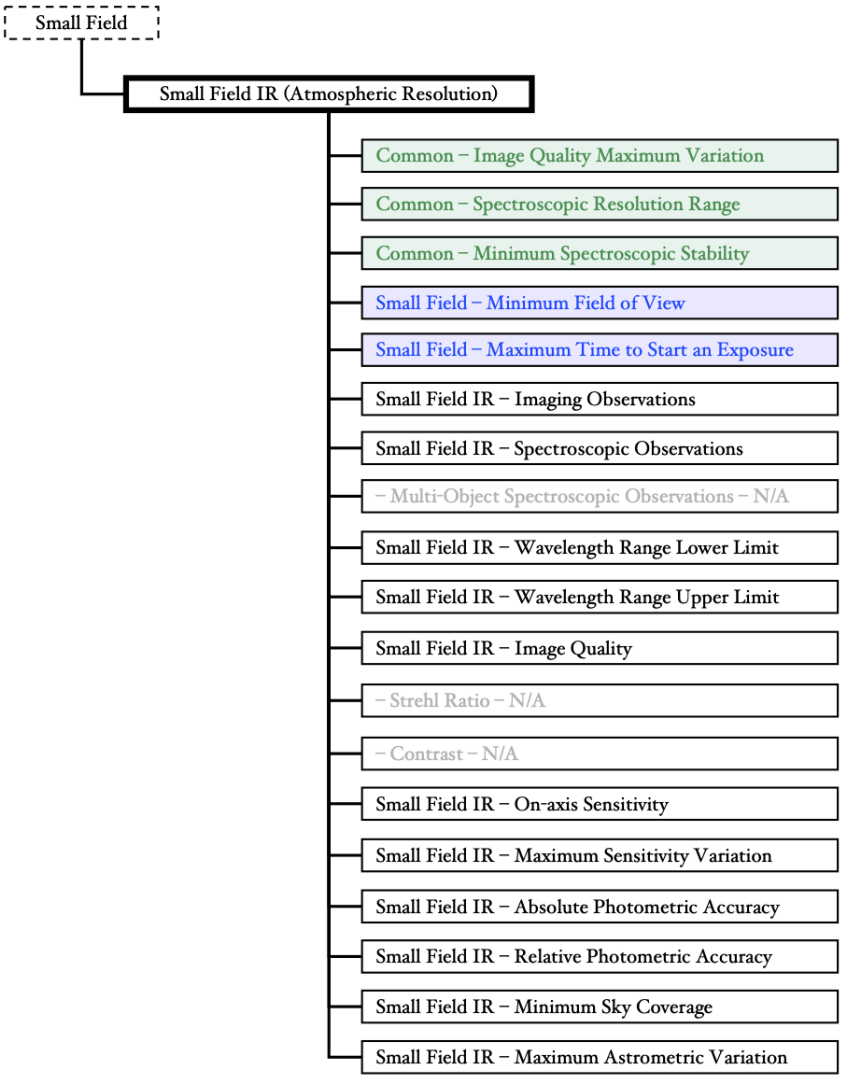


Figure 5-4: Small Field Infrared Atmospheric Resolution Requirements

### REQ-L1-SCI-23130: Small Field IR – Imaging Observations

The GMT Observatory shall be able to perform imaging observations over small fields at infrared wavelengths.

### REQ-L1-SCI-23132: Small Field IR -- Spectroscopic Observations

The GMT Observatory shall be able to perform spectroscopic observations over small fields infrared at infrared wavelengths.

### REQ-L1-SCI-23134: Small Field IR – Wavelength Range Lower Limit

The GMT Observatory shall be able to perform small field IR observations with a wavelength range lower limit of 0.8 µm [goal: 0.6 µm].

### REQ-L1-SCI-23136: Small Field IR -- Wavelength Range Upper Limit

The GMT Observatory shall be able to perform small field IR observations with a wavelength range upper limit of 25 µm.

### REQ-L1-SCI-23138: Small Field IR -- Image Quality On-Axis

The GMT Observatory shall be able to perform small field IR observations with an on-axis image FWHM ≤ 0.20 arcsec at 1.65 µm in a 900 sec exposure.

### REQ-L1-SCI-115014: Small Field IR -- Image Quality Off-Axis

The GMT Observatory shall be able to perform small field IR observations with image quality at all off-axis positions that degrades the as-designed image FWHM by <5%, scaled to an on-axis image quality of 0.20 arcseconds.

**Notes:** The as-designed image quality of the telescope (without the field corrector) decreases with field radius as r^2 as shown in Figure 5-1. The telescope optical design is described in GMT-DOC-00010.

### REQ-L1-SCI-23140: Small Field IR – On-axis Sensitivity

The GMT Observatory shall be able to perform small field IR observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

Table 5-2: Small Field IR On-Axis Sensitivity

| J | H | K | L | M | N | Q |
|---|---|---|---|---|---|---|
| 27.5 | 26.5 | 25.4 | 20.4 | 18.4 | 16.2 | 14.7 |

### REQ-L1-SCI-23144: Small Field IR -- Maximum Sensitivity Variation

The GMT Observatory shall be able to perform small field IR observations with a maximum sensitivity variation over the field of view of 5%.

### REQ-L1-SCI-23146: Small Field IR – Absolute Photometric Accuracy

The GMT Observatory shall be able to perform small field IR observations that measure the flux of a point source with an uncertainty of ≤ 3% [goal: 2%] relative to a standard astronomical flux source.

### REQ-L1-SCI-23148: Small Field IR -- Relative Photometric Accuracy

The GMT Observatory shall be able to perform small field IR observations that measure the flux of a point sources in the field with a minimum relative photometric accuracy of 2% [goal: 1%].

### REQ-L1-SCI-23150: Small Field IR -- Minimum Sky Coverage

The GMT Observatory shall be able to perform small field IR seeing limited observations with a minimum sky coverage of 99%.

### REQ-L1-SCI-23152: Small Field IR – Maximum Astrometric Variation

The GMT Observatory shall be able to perform small field IR observations with a maximum astrometric variation (with respect to time) over the full field of 0.006% in a 900 second exposure.

**Notes:** This corresponds to 11 mas over the minimum field of view (3 arcmin) in 900 seconds.

## 5.2.5 Observing Case: Small Field IR High Angular Resolution

This OC defines requirements to deliver diffraction-limited image quality as the highest priority. Driving science cases involve observations of stars, stellar disks, active galactic nuclei, or their surroundings.

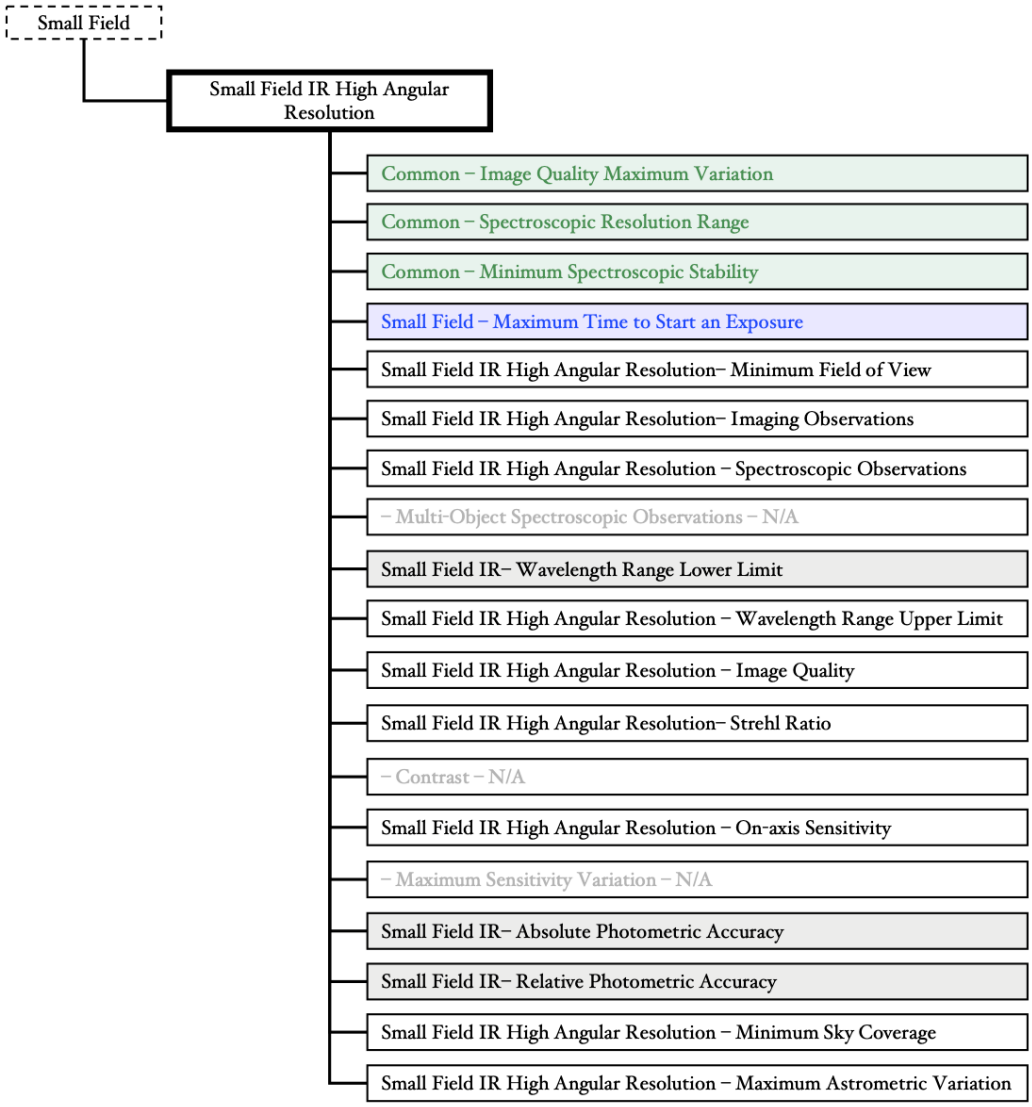


Figure 5-5: Small Field IR High Angular Resolution Requirements

### REQ-L1-SCI-23195: Small Field IR High Angular Resolution – Minimum Field of View

The GMT Observatory shall be able to perform small field IR high angular resolution observations with a field of view ≥ 0.5 arcminutes.

### REQ-L1-SCI-23156: Small Field IR High Angular Resolution – Imaging Observations

The GMT Observatory shall be able to perform imaging observations with high angular resolution over small fields at infrared wavelengths.

### REQ-L1-SCI-23158: Small Field IR High Angular Resolution – Spectroscopic Observations

The GMT Observatory shall be able to perform spectroscopic observations with high angular resolution over small fields infrared at infrared wavelengths.

**Note:** This OC inherits the Wavelength Range Lower Limit (REQ-L1-SCI-23134) requirement from the Small Field IR OC (Section 5.2.4).

### REQ-L1-SCI-23160: Small Field IR High Angular Resolution – Wavelength Range Upper Limit

The GMT Observatory shall be able to perform small field IR high-angular resolution observations with a wavelength range upper limit of 5 μm [goal 14 μm].

**Notes:** This OC has an inherited lower wavelength limit requirement which extends to 0.6 μm (goal) in anticipation of the possibility that diffraction limited performance may be available into the visible wavelength range.

### REQ-L1-SCI-23163: Small Field IR High Angular Resolution – Image Quality

The GMT Observatory shall be able to perform small field IR imaging high angular resolution observations with an image FWHM ≤ 0.02 arcsec at 1.65 μm in a 900 sec exposure.

### REQ-L1-SCI-23165: Small Field IR High Angular Resolution – Strehl Ratio

The GMT Observatory shall be able to perform small field IR imaging high angular resolution observations with a Strehl ratio ≥ 50% at 1.65 μm.

### REQ-L1-SCI-23167: Small Field IR High Angular Resolution – On-axis Sensitivity

The GMT Observatory shall be able to perform small field IR imaging high angular resolution observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

Table 5-3: Small Field IR High Angular Resolution On-Axis Sensitivity

| J | H | K | L | M | N |
|---|---|---|---|---|---|
| 27 | 27 | 26 | 20.4 | 18.4 | 16.2 |

**Note:** This OC inherits the Absolute Photometry Accuracy (REQ-L1-SCI-23134) and Relative Photometric Accuracy (REQ-L1-SCI-23148) requirements from the Small Field IR OC (Section 5.2.4)

### REQ-L1-SCI-23171: Small Field IR High Angular Resolution -- Sky Coverage

The GMT Observatory shall be able to perform small field IR imaging high angular resolution observations with a sky coverage greater than 50%.

### REQ-L1-SCI-23173: Small Field IR High Angular Resolution – Maximum Astrometric Variation

The GMT Observatory shall be able to perform small field IR high angular resolution observations with a maximum astrometric variation (with respect to time) over the full field of 0.0006% in a 120-second exposure.

**Notes:** Note: This corresponds to 0.2 mas over the minimum field of view (30 arcseconds). It is expected that, where sources are available for registration, astrometric stability will improve with exposure time (as 1/sqrt(t_exp)) and reach a floor at roughly one hour of ~40 μarcsec in crowded fields; more sparsely populated fields may require additional calibration to achieve this astrometric stability.

## 5.2.6 Observing Case: Small Field IR High Angular Resolution with High Sky Coverage

This OC is driven by science cases that require high spatial resolutions at any location on the sky, such as spatially resolved observations of galaxies at intermediate and high redshifts.

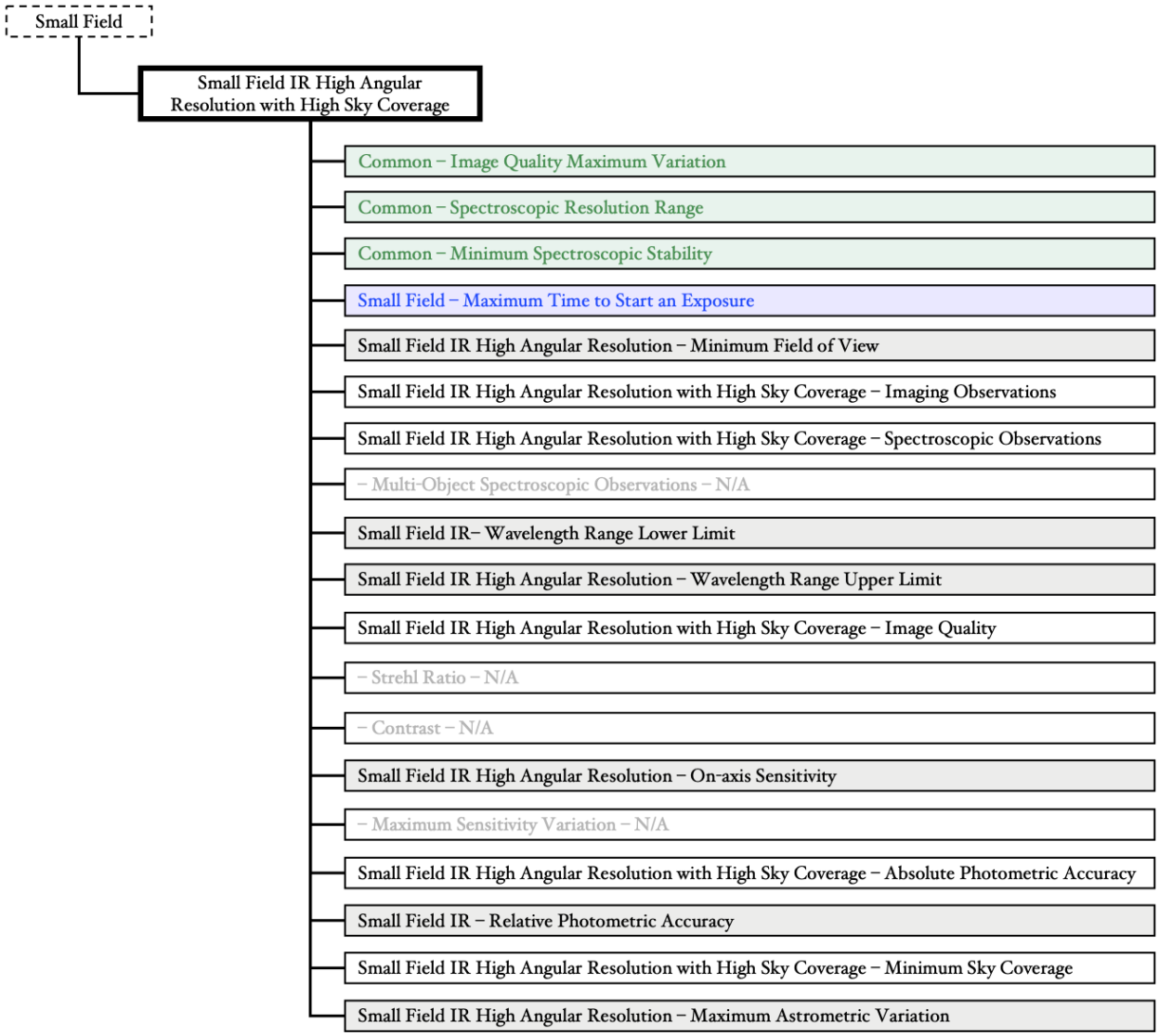


Figure 5-6: Small Field IR High Angular Resolution with High Sky Coverage Requirements

**Note:** This OC inherits the Minimum Field of View (REQ-L1-SCI-23195) requirement from the Small Field IR High Angular Resolution OC (Section 5.2.5).

### REQ-L1-SCI-23177: Small Field IR High Angular Resolution with High Sky Coverage – Imaging Observations

The GMT Observatory shall be able to perform imaging observations with high angular resolution and high sky coverage over small fields at infrared wavelengths.

### REQ-L1-SCI-23179: Small Field IR High Angular Resolution with High Sky Coverage – Spectroscopic Observations

The GMT Observatory shall be able to perform spectroscopic observations with high angular resolution and high sky coverage over small fields infrared at infrared wavelengths.

**Note**: This OC inherits the Wavelength Range Lower Limit (REQ-L1-SCI-23134) requirement from the Small Field IR OC (Section 5.2.4) and the Wavelength Range Upper Limit (REQ-L1-SCI-23160) from the Small Field IR High Angular Resolution OC (Section 5.2.5).

### REQ-L1-SCI-23181: Small Field IR High Angular Resolution with High Sky Coverage – Image Quality

The GMT Observatory shall be able to perform small field IR imaging observations with high angular resolution and high sky coverage with an encircled energy of EE50 ≤ 0.050 arcsec at 1.65 μm in a 900 sec exposure.

**Note:** This OC inherits the On-Axis Sensitivity (REQ-L1-SCI-23167) requirement from the Small Field IR High Angular Resolution OC (Section 5.2.5).

### REQ-L1-SCI-23183: Small Field IR High Angular Resolution with High Sky Coverage – Absolute Photometric Accuracy

The GMT Observatory shall be able to perform small field IR observations with high angular resolution and high sky coverage that measure the flux of a point source with an uncertainty of ≤ 5% relative to a standard astronomical flux source.

**Note:** This OC inherits the Relative Photometric Accuracy (REQ-L1-SCI-23148) requirement from the Small Field IR OC (Section 5.2.4).

### REQ-L1-SCI-23187: Small Field IR High Angular Resolution with High Sky Coverage -- Sky Coverage

The GMT Observatory shall be able to perform small field IR observations with high angular resolution and high sky coverage with sky coverage ≥ 80%.

**Note:** This OC inherits the Maximum Astrometric Variation (REQ-L1-SCI-23173) requirement from the Small Field IR High Angular Resolution OC (Section 5.2.5).

## 5.2.7 Observing Case: Small Field IR Diffraction-Limited Resolution

This OC enables observations of diffraction-limited observations of bright sources (R < 10 mag), including young stars, transients, and active galactic nuclei.

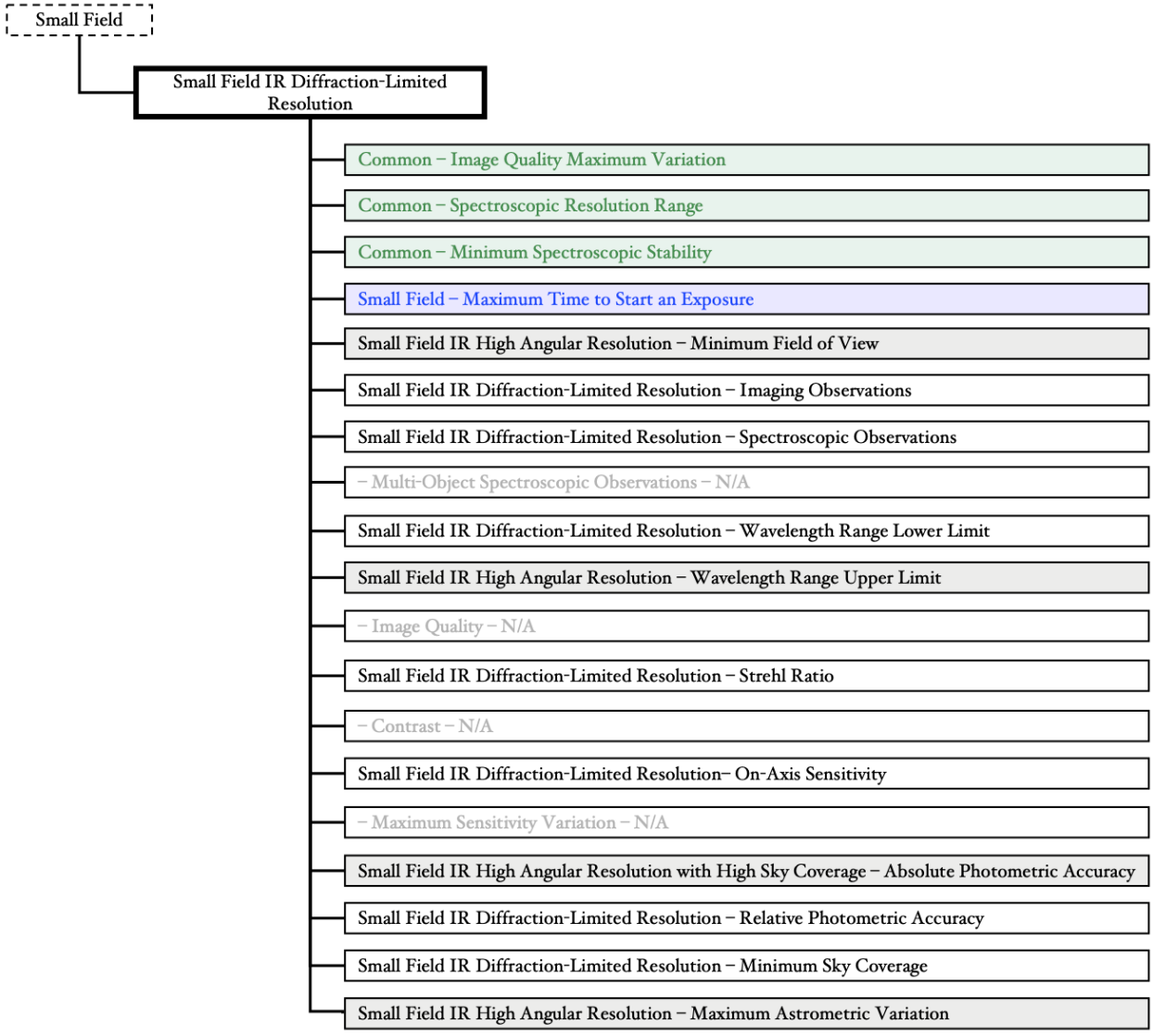


Figure 5-7: Small Field IR Diffraction-Limited Resolution Requirements

**Note:** This OC inherits the Minimum Field of View (REQ-L1-SCI-23195) requirement from the Small Field IR High Angular Resolution OC (Section 5.2.5).

### REQ-L1-SCI-102542: Small Field IR Diffraction-Limited Resolution -- Imaging Observations

The GMT Observatory shall be able to perform imaging observations at the diffraction limit over small fields at infrared wavelengths.

### REQ-L1-SCI-102543: Small Field IR Diffraction-Limited Resolution -- Spectroscopic Observations

The GMT Observatory shall be able to perform spectroscopic observations at the diffraction limit over small fields at infrared wavelengths.

### REQ-L1-SCI-23197: Small Field IR Diffraction-Limited Resolution – Wavelength Range Lower Limit

The GMT Observatory shall be able to perform small field IR diffraction-limited observations with a wavelength range lower limit of 1 µm [goal 0.6 µm].

**Note:** This OC inherits the Wavelength Range Upper Limit (REQ-L1-SCI-23160) requirement from the Small Field IR High Angular Resolution OC (Section 5.2.5).

### REQ-L1-SCI-23201: Small Field IR Diffraction-Limited Resolution -- Strehl Ratio

The GMT Observatory shall be able to perform small field IR diffraction-limited observations with a Strehl ratio ≥ 75% at 1.65 µm in a 120 sec exposure.

### REQ-L1-SCI-23205: Small Field IR Diffraction-Limited Resolution – On-axis Sensitivity

The GMT Observatory shall be able to perform small field IR diffraction-limited observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

Table 5-4: Small Field IR Diffraction-Limited Resolution -- On-Axis Sensitivity.

| J | H | K | L | M | N |
|---|---|---|---|---|---|
| 27 | 27 | 26 | 20.4 | 18.4 | 16.2 |

**Note:** This OC inherits the Absolute Photometric Accuracy (REQ-L1-SCI-23183) requirement from the Small Field IR High Angular Resolution with High Sky Coverage OC (Section 5.2.6).

### REQ-L1-SCI-23211: Small Field IR Diffraction-Limited Resolution -- Relative Photometric Accuracy

The GMT Observatory shall be able to perform small field IR diffraction-limited observations that measure the flux of a point sources in the field with a minimum relative photometric accuracy of 3%.

**REQ-L1-SCI-23213: Small Field IR Diffraction-Limited Resolution – Sky Coverage**

The GMT Observatory shall be able to perform small field IR diffraction-limited observations around all R < 10 magnitude stars within 30° of Zenith.

**Note:** This OC inherits the Maximum Astrometric Variation (REQ-L1-SCI-23173) requirement from the Small Field IR High Angular Resolution OC (Section 5.2.5).

## 5.2.8 Observing Case: Small Field IR Diffraction-Limited Resolution with High Contrast

This OC is driven by science related to observations in the immediate environment of bright sources, such as direct imaging of planets, planetary disks, and potentially the environment around active galactic nuclei. It is assumed that the desired contrast will require specialized instruments and techniques (e.g. phase apodization coronagraphy) along with specialized observing and data reduction strategies.

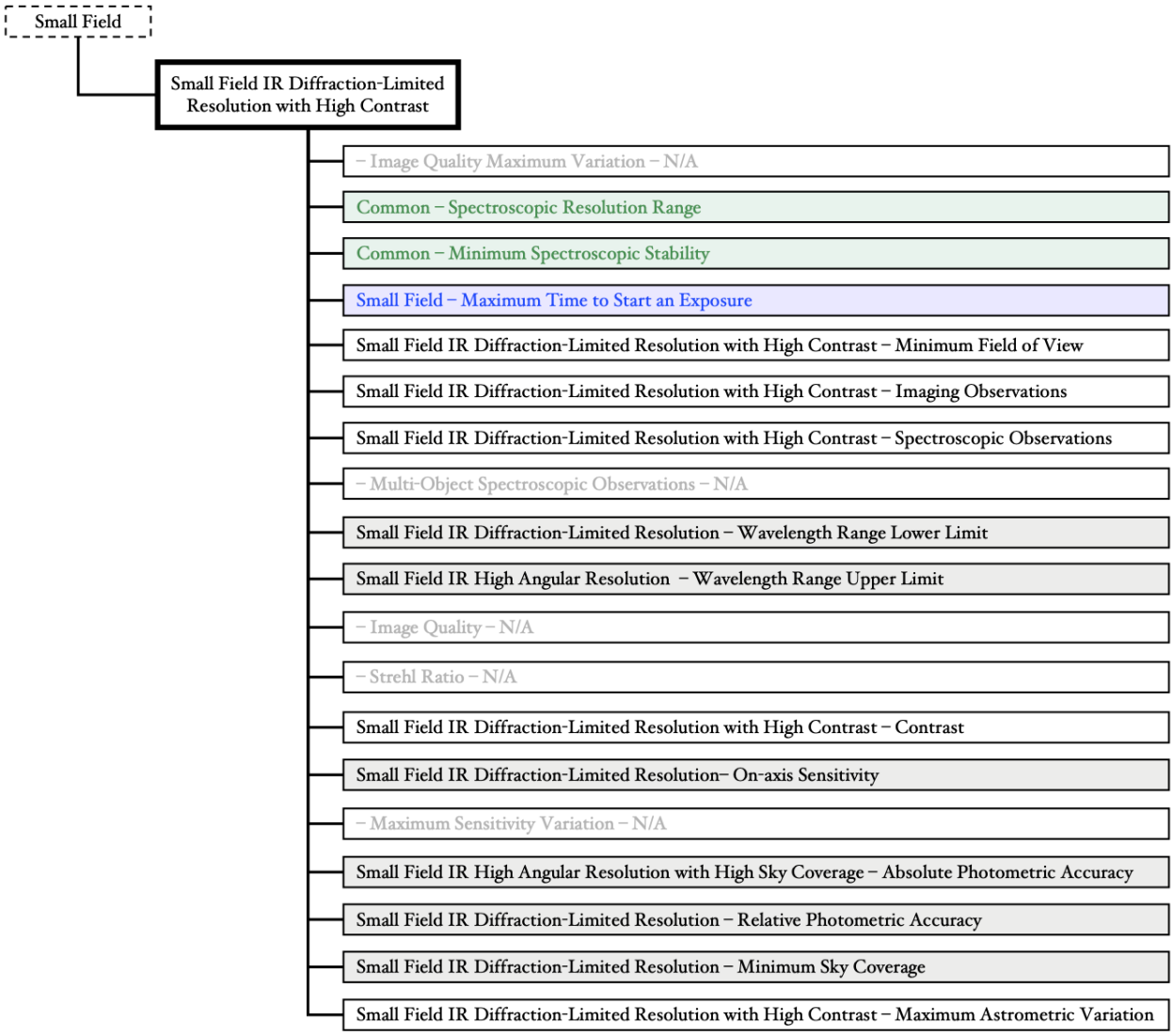


Figure 5-8: Small Field IR Diffraction-Limited Resolution with High Contrast Requirements

### REQ-L1-SCI-102547: Small Field IR Diffraction-Limited Resolution with High Contrast -- Minimum Field of View

The GMT Observatory shall be able to perform small field IR high contrast observations with a field of view ≥ 0.08 arcminutes.

**Notes:** 5 arcseconds represents the median size of the isoplanatic patch at 1 micron. the angular extent of the isoplanatic patch will grow with wavelength (size is proportional to the wavelength^(6/5)).

### REQ-L1-SCI-23191: Small Field IR Diffraction-Limited Resolution with High Contrast – Imaging Observations

The GMT Observatory shall be able to perform imaging observations with high contrast over small fields at infrared wavelengths.

### REQ-L1-SCI-23193: Small Field IR Diffraction-Limited Resolution with High Contrast -- Spectroscopic Observations

The GMT Observatory shall be able to perform spectroscopic observations with high contrast over small fields infrared at infrared wavelengths.

**Note:** This OC inherits the Wavelength Range Lower Limit (REQ-L1-SCI-23197) and Wavelength Range Upper Limit (REQ-L1-SCI-23160) requirements from the Small Field IR Diffraction-Limited Resolution OC (Section 5.2.7) and the Small Field IR High Angular Resolution OC (Section 5.2.5), respectively.

### REQ-L1-SCI-23203: Small Field IR Diffraction-Limited Resolution with High Contrast -- Contrast

The GMT Observatory shall be able to perform small field IR high contrast observations that provide a SNR > 5 detection of a faint source at a minimum separation of 120 mas [goal 60 mas] from a source that is $10^5$ [$10^6$] brighter in a 3600 second integration time composed of shorter exposures at 3.8 μm.

**Note**: This OC inherits the On-axis Sensitivity (REQ-L1-SCI-23205) requirement from the Small Field IR Diffraction-Limited Resolution OC (Section 5.2.7). This OC also inherits the Absolute Photometric Accuracy (REQ-L1-SCI-23183) requirement from the Small Field IR High Angular Resolution with High Sky Coverage OC (Section 5.2.6), and the Relative Photometric Accuracy (REQ-L1-SCI-23211) and the Minimum Sky Coverage (REQ-L1-SCI-23213) requirements from the Diffraction-Limited Resolution OC (Section 5.2.7).

### REQ-L1-SCI-23215: Small Field IR Diffraction-Limited Resolution with High Contrast – Maximum Astrometric Variation

The GMT Observatory shall be able to perform small field IR imaging high contrast observations with a maximum astrometric variation (with respect to time) over the full field of 0.0007%.

**Notes:** Note: This corresponds to 0.035 mas over the minimum field of view (5 arcseconds). See Note in REQ-L1-SCI-23173.

# 5.3 Medium Field Observing Cases

## 5.3.1 Requirements Common to all Medium Field Observing Cases

### REQ-L1-SCI-23220: Medium Field – Minimum Field of View

The GMT Observatory shall be able to perform medium field observations with a minimum field of view of 10 arcmin.

### REQ-L1-SCI-23222: Medium Field – Minimum Sky Coverage

The GMT Observatory shall be able to perform medium field observations with a minimum sky coverage of 99%.

### REQ-L1-SCI-23224: Medium Field – Maximum Astrometric Variation

The GMT Observatory shall be able to perform medium field observations with a maximum astrometric variation (with respect to time) over the full field of 0.005% in a 900 second exposure.

**Notes:** This corresponds to 30 mas over the minimum field of view (10 arcmin) in 900 seconds.

### REQ-L1-SCI-23226: Medium Field – Maximum Time to Start an Exposure

The GMT Observatory shall be able to start a medium field observation in less than 1200 seconds [goal 300 seconds].

**Notes:** This requirement is intended to facilitate scheduling and efficiency in addition to potential acquisition of transient sources (also called “target of opportunity” observations). The requirement includes the time to change the active instrument (receiving the telescope beam) to any other deployed instrument (an instrument installed in the telescope and available for use that night).

## 5.3.2 Observing Case: Medium Field Visible (Atmospheric Resolution)

Science enabled by this OC includes programs that benefit from high image quality coupled with a relatively wide field of view. Observations focus on photometry or multi-object spectroscopy to obtain statistical samples. Multi-object spectroscopy can be enabled by instruments using slit masks, single fibers, or integral field units.

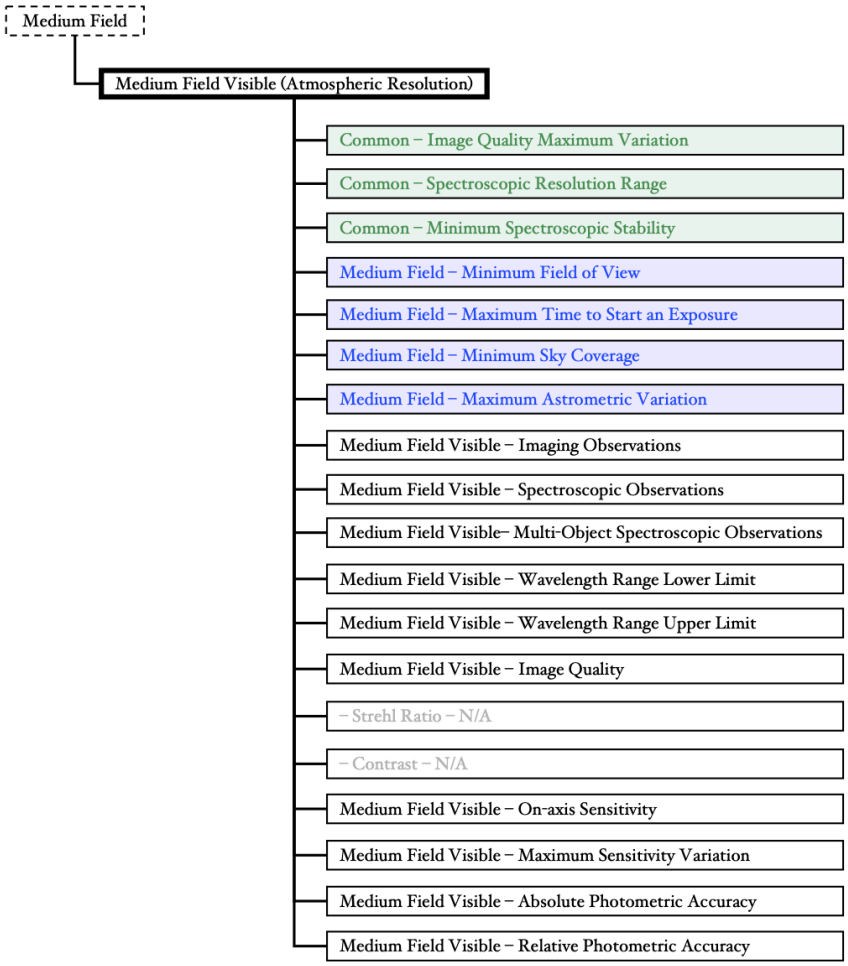


Figure 5-9: Medium Field Visible (Atmospheric Resolution) Requirements

### REQ-L1-SCI-23231: Medium Field Visible – Imaging Observations

The GMT Observatory shall be able to perform medium field visible imaging observations.

### REQ-L1-SCI-23233: Medium Field Visible – Spectroscopic Observations

The GMT Observatory shall be able to perform medium field visible spectroscopic observations.

### REQ-L1-SCI-23235: Medium Field Visible – Spectroscopic Multi-Object Observations

The GMT Observatory shall be able to perform medium field visible multi-object spectroscopic observations.

### REQ-L1-SCI-23237: Medium Field Visible – Wavelength Range Lower Limit

The GMT Observatory shall be able to perform medium field visible observations with a wavelength range lower limit of 0.32 µm.

### REQ-L1-SCI-23239: Medium Field Visible – Wavelength Range Upper Limit

The GMT Observatory shall be able to perform medium field visible observations with a wavelength range upper limit of 1.3 µm.

### REQ-L1-SCI-23241: Medium Field Visible – Image Quality On-Axis

The GMT Observatory shall be able to perform medium field visible observations with an on-axis image FWHM ≤ 0.30 arcsec at 0.5 µm (TBC) in a 900 sec exposure.

### REQ-L1-SCI-115016: Medium Field Visible -- Image Quality Off-Axis

The GMT Observatory shall be able to perform medium field visible observations with image quality at all off-axis positions that degrades the as-designed image FWHM by <5%, scaled to an on-axis image quality of 0.30 arcseconds.

**Notes:** The as-designed image quality of the telescope (without the field corrector) decreases with field radius as r^2 as shown in Figure 5-1. The telescope optical design is described in GMT-DOC-00010.

### REQ-L1-SCI-23243: Medium Field Visible -- On-Axis Sensitivity

The GMT Observatory shall be able to perform medium field visible observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

Table 5-5: Medium Field Visible On-Axis Sensitivity

| U | B | V | R | I | z |
|---|---|---|---|---|---|
| 29.5 | 30.6 | 30.0 | 30.0 | 30.0 | 29.0 |

### REQ-L1-SCI-23247: Medium Field Visible – Maximum Sensitivity Variation

The GMT Observatory shall be able to perform medium field visible observations with a maximum sensitivity variation over the field of view of 5%.

### REQ-L1-SCI-23249: Medium Field Visible – Absolute Photometry Error

The GMT Observatory shall be able to perform medium field visible observations that measure the flux of a point source with an uncertainty of ≤2% relative to a standard astronomical flux source.

### REQ-L1-SCI-23251: Medium Field Visible – Relative Photometry Error

The GMT Observatory shall be able to perform medium field visible observations that measure the flux of a point source with an uncertainty of ≤1% relative to a standard astronomical flux source.

## 5.3.3 Observing Case: Medium Field IR (Atmospheric Resolution)

Science targets for this OC are similar to those in the medium field visible case but are at higher redshifts (highly redshifted galaxies), cooler (young or low-mass stars), or obscured by dust. Like its visible counterpart, multi-object spectroscopy in this OC is enabled with slit masks, fibers, and integral field units.

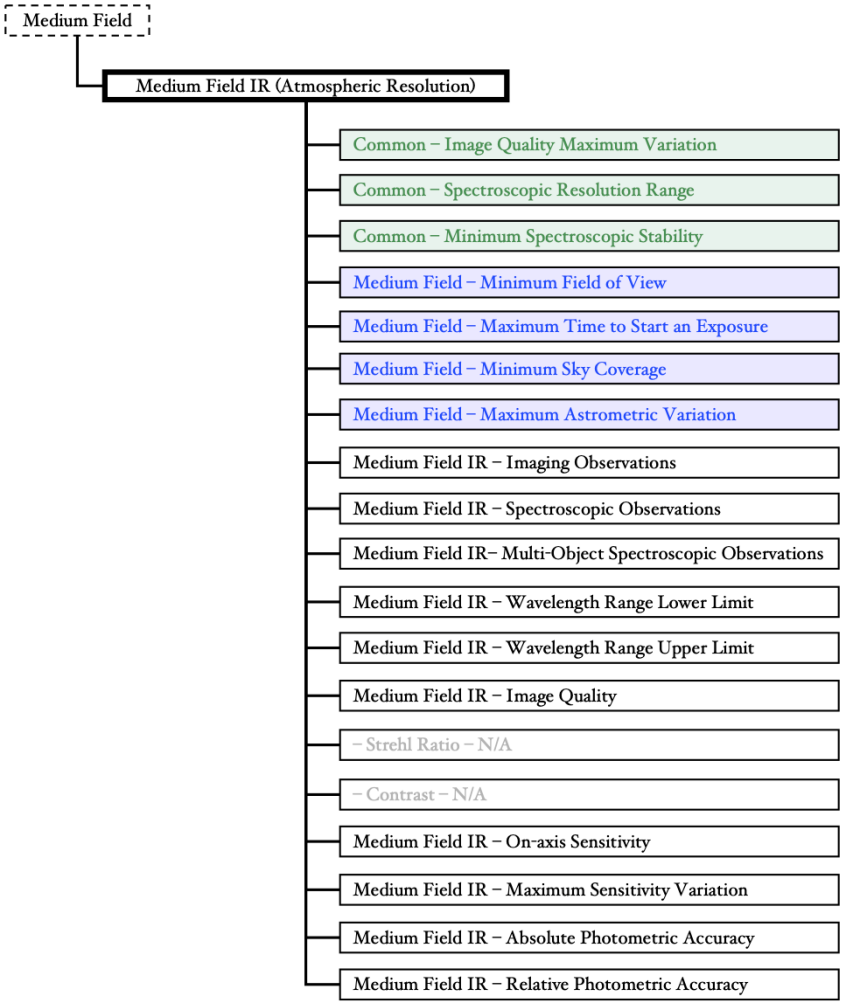


Figure 5-10: Medium Field IR (Atmospheric Resolution) Requirements

### REQ-L1-SCI-23255: Medium Field IR – Imaging Observations

The GMT Observatory shall be able to perform medium field infrared imaging observations.

### REQ-L1-SCI-23257: Medium Field IR – Spectroscopic Observations

The GMT Observatory shall be able to perform medium field infrared spectroscopic observations.

### REQ-L1-SCI-23259: Medium Field IR – Spectroscopic Multi-Object Observations

The GMT Observatory shall be able to perform medium field infrared multi-object spectroscopic observations.

### REQ-L1-SCI-23261: Medium Field IR – Wavelength Range Lower Limit

The GMT Observatory shall be able to perform medium field IR observations with a wavelength range lower limit of 0.8 µm.

### REQ-L1-SCI-23263: Medium Field IR – Wavelength Range Upper Limit The GMT

The GMT Observatory shall be able to perform medium field IR observations with a wavelength range upper limit of 25 µm.

### REQ-L1-SCI-23265: Medium Field IR -- Image Quality On-Axis

The GMT Observatory shall be able to perform medium field IR observations with an on-axis image FWHM ≤ 0.20 arcsec at 1.65 µm (TBC) in a 900 sec exposure.

### REQ-L1-SCI-115018: Medium Field IR -- Image Quality Off-Axis

The GMT Observatory shall be able to perform medium field IR observations with image quality at all off-axis positions that degrades the as-designed image FWHM by <5%, scaled to an on-axis image quality of 0.20 arcseconds.

**Notes:** The as-designed image quality of the telescope (without the field corrector) decreases with field radius as r^2 as shown in Figure 5-1. The telescope optical design is described in GMT-DOC-00010.

### REQ-L1-SCI-23267: Medium-Field IR -- On-Axis Sensitivity

The GMT Observatory shall be able to perform medium field IR observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

**Notes:** The as-designed image quality of the telescope (without the field corrector) decreases with field radius as r^2 as shown in Figure [undefined]. The telescope optical design is described in GMT-DOC-00010.

Table 5-6: Medium Field IR On-Axis Sensitivity

| J | H | K | L | M | N | Q |
|---|---|---|---|---|---|---|
| 27.5 | 26.5 | 25.4 | 20.4 | 18.4 | 16.2 | 14.7 |

### REQ-L1-SCI-23271: Medium Field IR – Maximum Sensitivity Variation

The GMT Observatory shall be able to perform medium field IR observations with a maximum sensitivity variation over the field of view of 5%.

### REQ-L1-SCI-23273: Medium Field IR – Absolute Photometric Error

The GMT Observatory shall be able to perform medium field IR observations that measure the flux of a point source with an uncertainty of ≤3% [goal: 2%] relative to a standard astronomical flux source.

### REQ-L1-SCI-23275: Medium Field IR -- Relative Photometric Error

The GMT Observatory shall be able to perform medium field IR observations that measure the flux of a point source in the field with a maximum relative photometric error of 2% [goal: 1%].

## 5.4 Wide Field Observing Cases

### 5.4.1 Wide Field Visible (Atmospheric Resolution)

Science cases that require the widest fields benefit more from areal coverage than high image quality. This includes programs that target faint sources with low surface density on the sky for which multiplexing over large sky areas is critical.

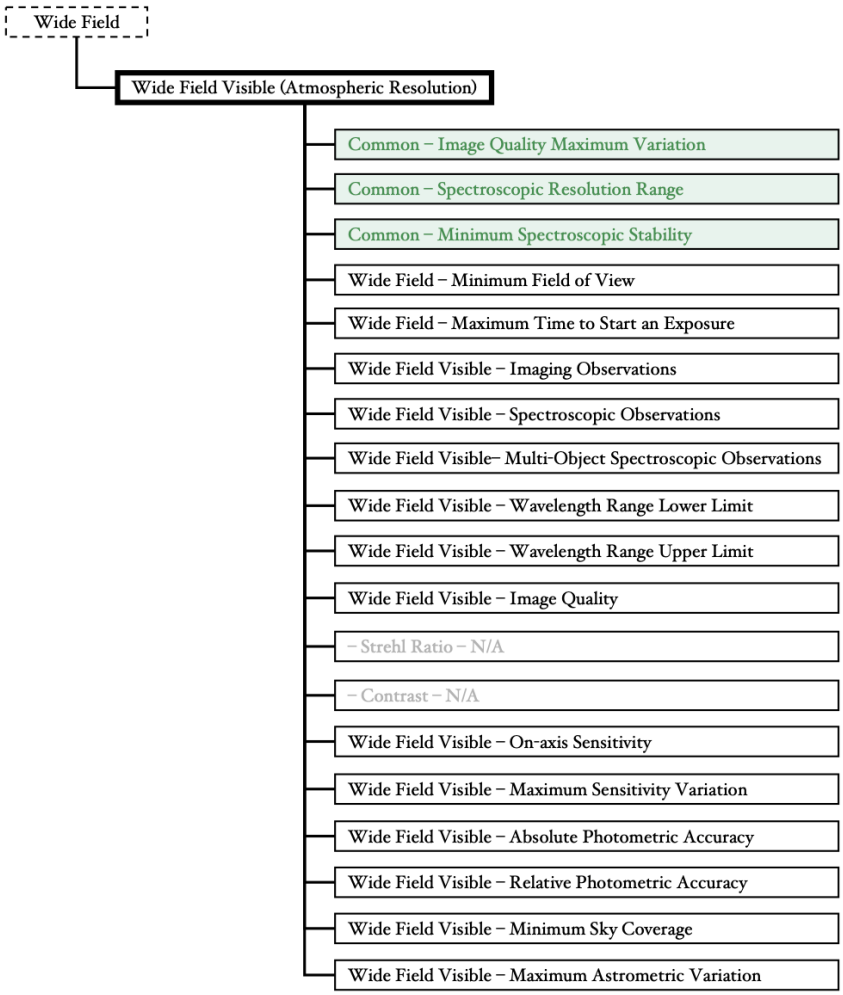


Figure 5-11: Wide Field Visible Requirements

### REQ-L1-SCI-23280: Wide Field Visible – Imaging Observations

The GMT Observatory shall be able to perform wide field visible imaging observations.

### REQ-L1-SCI-23282: Wide Field Visible – Spectroscopic Observations

The GMT Observatory shall be able to perform wide field visible spectroscopic observations.

### REQ-L1-SCI-23284: Wide Field Visible -- Spectroscopic Multi-Object Observations

The GMT Observatory shall be able to perform wide field visible multi-object spectroscopic observations.

### REQ-L1-SCI-23286: Wide Field Visible – Minimum Field of View

The GMT Observatory shall be able to perform wide field visible observations with a minimum field of view of 20 arcmin.

### REQ-L1-SCI-23288: Wide Field Visible -- Maximum Time to Start an Exposure

The GMT Observatory shall be able to start a wide field visible observation in less than 3600 sec [goal 300 sec].

**Notes:** This requirement is intended to facilitate scheduling and efficiency in addition to potential acquisition of transient sources (also called "target of opportunity" observations). The requirement includes the time to change the active instrument (receiving the telescope beam) to any other deployed instrument (an instrument installed in the telescope and available for use that night).

### REQ-L1-SCI-23291: Wide Field Visible –- Wavelength Range Lower Limit

The GMT Observatory shall be able to perform wide field visible observations with a wavelength range lower limit of 0.35 µm.

### REQ-L1-SCI-23293: Wide Field Visible – Wavelength Range Upper Limit

The GMT Observatory shall be able to perform wide field visible observations with a wavelength range upper limit of 1.3 µm.

### REQ-L1-SCI-23295: Wide Field Visible – Mean Image Quality

The GMT Observatory shall be able to perform wide field visible observations with a mean image FWHM ≤ 0.35 arcsec over the field of view at 0.5 µm in a 900 sec exposure.

### REQ-L1-SCI-115020: Wide Field Visible -- Off-Axis Image Quality

The GMT Observatory shall be able to perform wide field visible observations with image quality at all off-axis positions that degrades the as-designed image FWHM by <5%, scaled to a mean image quality of 0.35 arcseconds.

**Notes:** The as-designed image quality of the telescope (without the field corrector) decreases with field radius as r^2 as shown in Figure 5-1. The telescope optical design, including a baseline corrector and atmospheric dispersion compensator is described in GMT-DOC-00010.

### REQ-L1-SCI-23297: Wide Field Visible – On-axis Sensitivity

The GMT Observatory shall be able to perform wide field visible observations with an on-axis detection limit (SNR > 5 in 1 hour) as follows (in Vega magnitudes):

Table 5-7: Wide Field Visible On-Axis Sensitivity

| U | B | V | R | I | z |
|---|---|---|---|---|---|
| 29.2 | 30.3 | 29.7 | 29.5 | 28.7 | 28.6 |

### REQ-L1-SCI-23301: Wide Field Visible -- Maximum Sensitivity Variation

The GMT Observatory shall be able to perform wide field visible observations with a maximum sensitivity variation over the field of view of 5%.

### REQ-L1-SCI-23303: Wide Field Visible -- Absolute Photometric Error

The GMT Observatory shall be able to perform wide field visible observations that measure the flux of a point source with an uncertainty of ≤2% relative to a standard astronomical flux source.

### REQ-L1-SCI-23305: Wide Field Visible – Relative Photometry Error

The GMT Observatory shall be able to perform wide field visible observations that measure the flux of a point source in the field with a maximum relative photometric error of 1%.

### REQ-L1-SCI-23307: Wide Field Visible – Minimum Sky Coverage

The GMT Observatory shall be able to perform wide field visible observations with a minimum sky coverage of 99%.

### REQ-L1-SCI-23309: Wide Field Visible – Maximum Astrometric Variation

The GMT Observatory shall be able to perform wide field visible observations with a maximum astrometric variation (with respect to time) over the full field of 0.005%.

**Notes:** This corresponds to 60 mas over the minimum field of view (20 arcmin) in 900 seconds.

# 6 Appendix A - Observing Case Properties Summary

| Observing Cases | | | Minimum Field of View (arcmin) | Wavelength Range (µm) | | Image Quality (best, on-axis) (arcsec) | Maximum Photometry Error | | Minimum Sky Coverage (%) | Maximum Astrometric Variation (%) [arcsec over FOV in X second exposure] | Maximum Time to Start Exposure (minutes) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | Absolute (%) | Relative (%) | | | |
| Small Field | Visible | Atmospheric Resolution | 3 | 0.32 | 1.3 | FWHM < 0.30 at 0.5 µm | 2 | 1 | 99 | 0.007% [0.013 arcsecc in 900 s] | 10 (5) |
| Small Field | Infrared | Atmospheric Resolution | 3 | 0.8 (0.6) | 25 | FWHM < 0.20 at 1.65 µm | 3 (2) | 2 (1) | 99 | 0.006% [0.011 arcsec in 900 s] | 10 (5) |
| Small Field | Infrared | High Angular Resolution | 0.5 | 0.8 (0.6) | 5 (14) | FWHM < 0.02 Strehl > 0.5 at 1.65 µm in median seeing | 3 (2) | 2 (1) | 50 | 0.0006% [0.2 mas in 120 s] | 10 (5) |
| Small Field | Infrared | High Angular Resolution with High Sky Coverage | 0.5 | 0.8 (0.6) | 5 (14) | Encircled Energy 50% within 0.05 arcsec diameter at 1.65 µm | 5 | 2 (1) | 80 | 0.0006% [0.2 mas in 120 s] | 10 (5) |
| Small Field | Infrared | Diffraction-Limited Resolution | 0.5 | 1 (0.6) | 5 (14) | Strehl > 0.75 at 1.65 µm | 5 | 3 | All stars R < 10 mag within 30° of Zenith | 0.0006% [0.2 mas in 120 s] | 10 (5) |
| Medium Field | Visible | Atmospheric Resolution | 10 | 0.32 | 1.3 | FWHM < 0.30 at 0.5 µm | 2 | 1 | 99 | 0.005% [0.030 arcsec in 900 s] | 20 (5) |
| Medium Field | Infrared | Atmospheric Resolution | 10 | 0.8 | 25 | FWHM < 0.20 at 1.65 µm | 3 (2) | 2 (1) | 99 | 0.005% [0.030 arcsec in 900 s] | 20 (5) |
| Wide Field | Visible | Atmospheric Resolution | < 20 | 0.35 | 1.3 | Mean FWHM < 0.35 at 0.5 µm over the field of view | 2 | 1 | 99 | 0.005% [0.060 arcsec in 900 s] | 60 (5) |

Notes: These apply to both imaging and spectroscopic observation in all OCs. Requirements that relate to spectroscopy alone are not summarized here. Goal values are shown in parentheses. The definition of spatial resolution categories is summarized at the beginning of Section 5. Strehl ratios that are specified for High Resolution cases are indicated in the “Image Quality” column. Note that requirements that are identical in all case (i.e. global) are not repeated here. These include the “common” OC requirements (green boxes in all figures) and that the functional and scientific performance requirements. The precision radial velocity and high contrast cases are not shown as they are specialized versions of other cases listed on this table (Small Field, Visible, Atmospheric Resolution and Diffraction-Limited Resolution, respectively).