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<th><strong>Revision:</strong> Rev. C</th>
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Signature on File
R. Shelton, President
04/03/2018
## Revision Log

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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 operations 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 organized 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 (GMT-REF-00481) 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 of 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 fall 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 then by spatial resolution (image quality). All the requirements given for each OC must be met (simultaneously) during a corresponding 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. 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](image)
2 Definitions, Acronyms, and Reference Documents

2.1 Terms and Definitions

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 2-1: Acceptable Requirement Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Shall&quot;</td>
<td>&quot;Shall&quot; denotes requirements that are mandatory and will be the subject of specific acceptance testing and compliance verification.</td>
</tr>
<tr>
<td>&quot;Can&quot;, &quot;May&quot;, or &quot;Should&quot;</td>
<td>&quot;Can&quot;, &quot;May&quot;, or &quot;Should&quot; indicate recommendations and are not subject to any requirement acceptance testing or compliance verification by the supplier. &quot;Should&quot; is the preferred word to use to express a suggestion over &quot;Can&quot; or &quot;May&quot;. The supplier is free to propose alternative solutions.</td>
</tr>
<tr>
<td>&quot;Is or Will&quot;</td>
<td>&quot;Is&quot; or &quot;Will&quot; indicate a statement of fact or provide information and are not subject to any requirement acceptance testing or verification compliance by the supplier.</td>
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</table>

2.2 Referenced and Applicable Documents

Table 2-2: Reference and Applicable Documents

<table>
<thead>
<tr>
<th>Document Number</th>
<th>Title</th>
<th>DocuShare Link</th>
</tr>
</thead>
</table>
3 Functional Requirements

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

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.

Note: 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 track 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.

Note: 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].

Note: Science drivers laid out 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.

**Rationale:** Science drivers laid out in the Science Book require access to the Magellanic Clouds and deep survey fields on or near the celestial equator. 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.

Note: 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 for the GMT and its instruments that are specific to distinct types of data, or “Observing Cases.”

In addition to the basic organization by field of view, wavelength range, and resolution, all data falls into one of two categories: imaging or spectroscopy. Because forming an image in the focal plane of the telescope is a prerequisite to both, the requirement in all OCs are explicitly imaging requirement that must be met also for all spectroscopic observations. Note that the capability to do imaging and spectroscopy is called out explicitly in each OC. Requirements that are unique to spectroscopy are given within each OC as relevant to that Case.

The following definitions of wavelength ranges apply to all of the Observing Cases described below.

- **Visible:** $0.32 \mu m \leq \text{wavelength} \leq 1.3 \mu m$; this is the regime where thermal emission from the telescope and sky does not dominate the background flux or observing strategy.

- **Infrared:** $0.6 \mu m \leq \text{wavelength} \leq 25 \mu m$; this is the regime in which thermal emission from the telescope and sky does dominate the background flux. Note that Observing Cases that are primarily concerned with infrared wavelengths (nominally longer than 1 \mu m) may be extended to include the visible range without altering the requirements of the OC; the lower limit of the range has been extended to 0.6\mu m to anticipate this possibility.

The following definitions are used to distinguish spatial resolution cases.

- **Atmospheric Angular Resolution:** the required spatial resolution (image quality) may be limited by atmosphere.

- **High Angular Resolution:** the required spatial resolution (image quality) is at or near the diffraction limit of the telescope for a limited range of astronomical targets, as specified.
• High Angular Resolution and High Sky Coverage: spatial resolution (image quality) at or near the diffraction limit of the telescope must be achieved for any astronomical target within the pointing range of the telescope, as specified.

• High Contrast: the required spatial resolution (image quality) is at or near the diffraction limit of the telescope for a limited range of astronomical targets, as specified.

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.

Figure 5-1 shows the complete set of currently-specified OCs. A summary figure for each OC contains its full set of requirements. The following color coding applies to all figures to help clarify which requirements are inherited or unique.

• 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.
Figure 5-1: Organization of Observing Cases and Common Requirements

5.1 Requirements Common to All Observing Cases

REQ-L1-SCI-23081: Image Quality Maximum Variation
The GMT Observatory shall be able to perform observations with a maximum image quality variation of 5% of the FWHM over the observing field of view.

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].

Note: This requirement is intended to accommodate the need for rapid acquisition of transient sources (also called “target of opportunity” observations).
5.2.2 Observing Case: Small Field Visible (Atmospheric Resolution)

Figure 5-3: 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 \( \mu \text{m} \).

REQ-L1-SCI-23105: Small Field Visible – Image Quality
The GMT Observatory shall be able to perform small field visible observations with an image FWHM \( \leq 0.3 \) arcsec at 0.5 \( \mu \text{m} \) 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-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>
<thead>
<tr>
<th></th>
<th>U</th>
<th>B</th>
<th>V</th>
<th>R</th>
<th>I</th>
<th>z</th>
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<td>30.2</td>
<td>30</td>
<td>29.2</td>
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</tr>
</tbody>
</table>

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 \( \leq 2\% \) 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%.
5.2.3 Observing Case: Small Field Visible Precision Radial Velocity (PRV)

REQ-L1-SCI-23123 : Small Field Visible PRV
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 – 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].

Figure 5-4: Small Field Visible (PRV) Requirements
5.2.4 Observing Case: Small Field IR (Atmospheric Resolution)

Figure 5-5: Small Field Infrared High Angular 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 \( \mu m \) [goal: 0.6 \( \mu m \)].
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
The GMT Observatory shall be able to perform small field IR observations with an image FWHM ≤ 0.20 arcsec at 1.65 µm in a 900 sec exposure.

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>
<thead>
<tr>
<th>J</th>
<th>H</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.5</td>
<td>26.5</td>
<td>25.4</td>
<td>20.4</td>
<td>18.4</td>
<td>16.2</td>
<td>14.7</td>
</tr>
</tbody>
</table>

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 – 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%.
### 5.2.5 Observing Case: Small Field IR High Angular Resolution

#### 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.

#### 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 $\mu$m [goal 14 $\mu$m].

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**Figure 5-6: Small Field IR High Angular Resolution Requirements**

<table>
<thead>
<tr>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Field IR High Angular Resolution — Imaging Mode</td>
</tr>
<tr>
<td>Small Field IR High Angular Resolution — Spectroscopy Mode</td>
</tr>
<tr>
<td>— Multi-Object Spectroscopic Mode — N/A</td>
</tr>
<tr>
<td>Small Field — Maximum Time to Start an Exposure</td>
</tr>
<tr>
<td>Small Field — Minimum Field of View</td>
</tr>
<tr>
<td>Small Field IR — Wavelength Range Lower Limit</td>
</tr>
<tr>
<td>Small Field IR High Angular Resolution — Wavelength Range Upper Limit</td>
</tr>
<tr>
<td>Small Field IR High Angular Resolution — Image Quality</td>
</tr>
<tr>
<td>Common — Image Quality Maximum Variation</td>
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<tr>
<td>Small Field IR High Angular Resolution — Strehl Ratio</td>
</tr>
<tr>
<td>— Contrast Ratio — N/A</td>
</tr>
<tr>
<td>Small Field IR High Angular Resolution — On-axis Sensitivity</td>
</tr>
<tr>
<td>— Maximum Sensitivity Variation — N/A</td>
</tr>
<tr>
<td>Small Field IR — Absolute Photometric Accuracy</td>
</tr>
<tr>
<td>Small Field IR — Relative Photometric Accuracy</td>
</tr>
<tr>
<td>Small Field IR High Angular Resolution — Minimum Sky Coverage</td>
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<tr>
<td>Small Field IR High Angular Resolution — Maximum Astrometric Variation</td>
</tr>
<tr>
<td>Common — Spectroscopic Resolution Range</td>
</tr>
<tr>
<td>Common — Minimum Spectroscopic Stability</td>
</tr>
</tbody>
</table>
Note: That this OC has an inherited lower wavelength limit requirement which extends to 0.6 µm 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

<table>
<thead>
<tr>
<th>J</th>
<th>H</th>
<th>K</th>
<th>L</th>
<th>M</th>
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<tr>
<td>27</td>
<td>27</td>
<td>26</td>
<td>20.4</td>
<td>18.4</td>
<td>16.2</td>
<td>14.7</td>
</tr>
</tbody>
</table>

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% at any galactic latitude greater than 30 degrees.

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 0.001%.
5.2.6 Observing Case: Small Field IR High Angular Resolution with High Sky Coverage

Figure 5-7: Small Field IR High Angular Resolution with High Sky Coverage Requirements

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.
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 \( \leq 0.050 \) arcsec and an image FWHM \( \leq 0.02 \) arcsec at 1.65 \( \mu \)m in a 900 sec exposure.

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 \( \leq 5\% \) relative to a standard astronomical flux source.

REQ-L1-SCI-23185: Small Field IR High Angular Resolution with High Sky Coverage – Relative 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 sources in the field with a minimum relative photometric accuracy of 2\% [goal: 1\%].

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 \( \geq 80\% \).
5.2.7 Observing Case: Small Field IR High Contrast

Figure 5-8: Small Field IR High Contrast Requirements

REQ-L1-SCI-23191: Small Field IR 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 High Contrast – Spectroscopic Observations
The GMT Observatory shall be able to perform spectroscopic observations with high contrast over small fields infrared at infrared wavelengths.
REQ-L1-SCI-23195 : Small Field IR 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 $\geq 0.5$ arcminutes.

REQ-L1-SCI-23197 : Small Field IR High Contrast – Wavelength Range Lower Limit
The GMT Observatory shall be able to perform small field IR high contrast observations with a wavelength range lower limit of 1 $\mu$m [goal 0.6 $\mu$m].

REQ-L1-SCI-23199 : Small Field IR High Contrast – Image Quality
The GMT Observatory shall be able to perform small field IR high contrast observations with an image FWHM $\leq 0.040$ arcsec at 3.8 $\mu$m in a 120 sec exposure.

REQ-L1-SCI-23201 : Small Field IR High Contrast – Strehl Ratio
The GMT Observatory shall be able to perform small field IR high contrast observations with a strehl ratio $\geq 90\%$ [goal: 95$\%$] at 3.8 $\mu$m in a 120 sec exposure.

REQ-L1-SCI-23203 : Small Field IR 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 10E5 [10E6] brighter in a 3600 second integration time composed of shorter exposures.

REQ-L1-SCI-23205 : Small Field IR High Contrast – On-Axis Sensitivity
The GMT Observatory shall be able to perform small field IR high contrast observations with an on-axis detection limit (SNR $> 5$ in 1 hour) as follows (in Vega magnitudes):

<table>
<thead>
<tr>
<th>J</th>
<th>H</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>27</td>
<td>26</td>
<td>20.4</td>
<td>18.4</td>
<td>16.2</td>
<td>14.7</td>
</tr>
</tbody>
</table>

REQ-L1-SCI-23209 : Small Field IR High Contrast – Absolute Photometric Accuracy
The GMT Observatory shall be able to perform small field IR high contrast observations that measure the flux of a point source with an uncertainty of $\leq 5\%$ relative to a standard astronomical flux source.

REQ-L1-SCI-23211 : Small Field IR High Contrast – Relative Photometric Accuracy
The GMT Observatory shall be able to perform small field IR high contrast 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 High Contrast – Sky Coverage
The GMT Observatory shall be able to perform small field IR high contrast observations with a sky coverage $\geq 50\%$ at zenith angles $\leq 35\,$ deg.
REQ-L1-SCI-23215 : Small Field IR 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 0.001%.

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%.

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 TBD seconds].

Note: This requirement is intended to facilitate scheduling and efficiency in addition to potential acquisition of transient sources (also called “target of opportunity” observations).
5.3.2 Observing Case: Medium Field Visible (Atmospheric Resolution)

Figure 5-10: 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
The GMT Observatory shall be able to perform medium field observations with an image FWHM ≤ 0.3 arcsec at 0.5 μm (TBC) in a 900 sec exposure.

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>
<thead>
<tr>
<th></th>
<th>U</th>
<th>B</th>
<th>V</th>
<th>R</th>
<th>I</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>29.5</td>
<td>30.6</td>
<td>30.0</td>
<td>30.0</td>
<td>30.0</td>
<td>29.0</td>
</tr>
</tbody>
</table>

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)

Figure 5-11: 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 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
The GMT Observatory shall be able to perform medium field IR observations with an image FWHM ≤ 0.2 arcsec at 1.65 μm (TBC) in a 900 sec exposure.

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):

<table>
<thead>
<tr>
<th></th>
<th>J</th>
<th>H</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27.5</td>
<td>26.5</td>
<td>25.4</td>
<td>20.4</td>
<td>18.4</td>
<td>16.2</td>
<td>14.7</td>
</tr>
</tbody>
</table>

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 Photometry 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 Photometry 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)

Figure 5-12: 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].

Note: This requirement is intended to facilitate scheduling and efficiency in addition to potential acquisition of transient sources (also called “target of opportunity” observations).

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 – Image Quality
The GMT Observatory shall be able to perform wide field visible observations with an image FWHM ≤ 0.35 arcsec at 0.5 µm in a 900 sec exposure.

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):

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>B</td>
<td>V</td>
<td>R</td>
<td>I</td>
<td>z</td>
</tr>
<tr>
<td>29.2</td>
<td>30.3</td>
<td>29.7</td>
<td>29.5</td>
<td>28.7</td>
<td>28.6</td>
</tr>
</tbody>
</table>

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 Photometry 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%.
### Appendix A  Observing Case Properties Summary

Table 5-8: Executive Summary of Requirements Describing Imaging Performances

<table>
<thead>
<tr>
<th>Observing Cases</th>
<th>Field of View min. [arcmin]</th>
<th>Wavelength Range min [µm]</th>
<th>Wavelength Range max [µm]</th>
<th>Image Quality, best FWHM</th>
<th>Photometry Maximum Error absolute [%]</th>
<th>Photometry Maximum Error relative [%]</th>
<th>Sky Coverage min [%]</th>
<th>Sky Coverage max [%]</th>
<th>Astro-metric Variation max [%]</th>
<th>Time to Start Exposure, maximum [Minutes]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible Atm. Res.</td>
<td>3</td>
<td>0.32</td>
<td>1.3</td>
<td>FWHM &lt; 0.3 @ 0.5 µm</td>
<td>2</td>
<td>1</td>
<td>99</td>
<td>0.007</td>
<td>10 (5)</td>
<td></td>
</tr>
<tr>
<td>Atm. Res.</td>
<td>3</td>
<td>0.8</td>
<td>25</td>
<td>FWHM &lt; 0.20 @ 1.65 µm</td>
<td>3 (2)</td>
<td>2 (1)</td>
<td>99</td>
<td>0.006</td>
<td>10 (5)</td>
<td></td>
</tr>
<tr>
<td>High Angular Resolution</td>
<td>3</td>
<td>0.8 (0.6)</td>
<td>5 (14)</td>
<td>FWHM &lt; 0.02 Strehl &gt; 0.5 @ 1.65 µm in median seeing</td>
<td>3 (2)</td>
<td>2 (1)</td>
<td>50 @</td>
<td>b</td>
<td>&gt; 30 deg</td>
<td>0.001</td>
</tr>
<tr>
<td>High Ang. Res. High Sky Cov.</td>
<td>3</td>
<td>0.8 (0.6)</td>
<td>5 (14)</td>
<td>FWHM &lt; 0.02 Encircled energy 50% w/in 50 mas diameter at 1.65µm</td>
<td>5</td>
<td>2 (1)</td>
<td>80</td>
<td></td>
<td>0.001</td>
<td>10 (5)</td>
</tr>
<tr>
<td>High Ang. Res. High Contrast</td>
<td>0.5</td>
<td>1 (0.6)</td>
<td>5 (14)</td>
<td>FWHM &lt; 0.04 Strehl &gt; 0.90 (0.95) @ 3.8 µm in medium seeing Contrast: &lt;10^7 (10^6)</td>
<td>5</td>
<td>3</td>
<td>50% @</td>
<td>ZA</td>
<td>&lt; 35 deg</td>
<td>0.001</td>
</tr>
<tr>
<td>Visible [see lim]</td>
<td>10</td>
<td>0.32</td>
<td>1.3</td>
<td>FWHM &lt; 0.3 @ 0.5 µm</td>
<td>2</td>
<td>1</td>
<td>99</td>
<td>0.005</td>
<td>60 (5)</td>
<td></td>
</tr>
<tr>
<td>Infrared [see lim]</td>
<td>10</td>
<td>0.8</td>
<td>25</td>
<td>FWHM &lt; 0.2 @ 1.65 µm</td>
<td>3 (2)</td>
<td>2 (1)</td>
<td>99</td>
<td>0.005</td>
<td>60 (5)</td>
<td></td>
</tr>
<tr>
<td>&lt; 20</td>
<td>0.35</td>
<td>1.3</td>
<td>FWHM &lt; 0.35 @ 0.5 µm</td>
<td>2</td>
<td>1</td>
<td>99</td>
<td>0.005</td>
<td>60 (5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.