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für astronomische
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E-ELT PROGRAMME

E-ELT PROGRAMME - OBSERVATORY TOP LEVEL REQUIREMENTS

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Change record

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1	04.06.2008	All	First version, for phase B, in preparation for a construction proposal.
2	26.04.2012	All	Second version, for construction phase. The document has been streamlined and re-organized, Programme and System requirements have been introduced, and the Instrument section has been shortened and simplified, with the Adaptive Optics requirements moved to the Image Quality section.

Contents

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4 **Abbreviations**

See applicable document AD1 (see section 2.1 herein for references of applicable documents).

5 **Acknowledgements**

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6

1 Scope

7 This document establishes the Top Level Requirements for the European Extremely Large Telescope.

8 The Top Level Requirements are based on the needs posed by the astronomical research for which the E-ELT is being built (see RD1 - RD9).

9 The E-ELT provides the astronomers of the ESO member countries with a facility for astronomical observations at optical and infrared wavelength with a very high sensitivity and a very high angular resolution.

13

2 Related documents

14

2.1 Applicable documents

15 The following applicable documents form a part of the present document to the extent specified herein. In the event of conflict between applicable documents and the content of the present document, the content of the present document shall be taken as superseding.

16 AD1 Common definitions and acronyms;
E-ESO-SPE-313-0066 Issue 5

17

2.2 Reference documents

18 The following reference documents provide background information as to the present document. Under no circumstance shall the content of reference documents be construed as applicable to the present document, in part or in full.

19 RD1 Science Working Group final report, issue 30 April 2006

20 RD2 Instruments Working Group final report, issue 1.3, 25.4.2006

21 RD3 Site Working Group final report, issue 13 April 2006

22 RD4 Telescope Design Working Group final report, issue 3, 4 May 2006

23 RD5 Adaptive Optics Working Group final report, issue 28 Feb 2006

24 RD6 E-ELT Science Case;
E-TRE-ESO-080-0806 issue 1

25 RD7 The E-ELT Design Reference Science Plan;
E-TRE-ESO-080-0840 Issue 2

26 RD8 The E-ELT Design Reference Mission;
E-TRE-ESO-080-0717 Issue 2

27 RD9 The impact on science of the new telescope baseline;
E-TRE-ESO-257-1010 issue 1

30 RD10 E-ELT Environmental conditions: atmospheric turbulence;
E-TRE-ESO-222-1191 Issue 1

28 RD11 E-ELT Operations Plans;
E-PLA-ESO-020-0849 issue 1

29 RD12 E-ELT Science Operations Plan;
E-PLA-ESO-066-0787 issue 1

34

3 Definitions and Conventions

35 In the present document the following definitions are used:

36 E-ELT Programme: the entity, which on behalf of ESO builds and operates the E-ELT System

37 E-ELT Project: the entity, which on behalf of the E-ELT Programme designs, manufactures and delivers the E-ELT System to operation

38 E-ELT System: the entirety of the E-ELT ready to be operational

39 Sub-systems considered in this document include:

- Dome and Main Structure
- Control Systems
- Instruments
- Optomechanics
- Infrastructure
- Science Operations, Systems and Data Management

242 Seeing is defined as the integrated, long-exposure effect of the atmospheric optical turbulence across the line of sight, defined at zenith and 0.5 μm.

243 See AD1 for all other definitions.

244 Within this document, cross-references are made by referring to the paragraph number preceded by the prefix "#".

40

4 Overall Programme Requirements

41

4.1 Evolution of the Top Level Requirements

42 The present document constitutes the highest level of requirements applicable to the E-ELT and may not be superseded by any lower level document.

43 If not mentioned otherwise and applicable, the Top Level Requirements shall be met at the start of science operations. If this time scale cannot be met for a given requirement, an upgrade path must be defined.

246 The System shall be ready for science operations ten years after construction approval by the ESO Council.

247 #43 does not apply to the Top Level Requirements defined in # 107 – 111 and # 119 – 120, for which an implementation plan shall be defined.

44 The E-ELT shall be implemented in a fashion such that the Top Level Requirements are met for the duration of operations.

45

4.2 Operational Lifetime

46 The E-ELT as a System shall be designed for an operational life of at least 30 years. As a goal, its lifetime is expected to significantly exceed this figure.

47 During this lifetime, the System and its subsystems, in particular the telescope, the instruments, and the science operation systems are expected to undergo upgrades, enhancing the facility's capabilities as technology improves and science requirements evolve.

48 The E-ELT Programme shall allow for upgrades as described in #47.

49

4.3 Safety & Quality Assurance

50

4.3.1 Safety

51 The E-ELT Programme shall comply with the ESO safety policy.

52

4.3.2 Quality Assurance

53 The E-ELT Programme shall comply with the ESO policies on Product Assurance and Configuration Control.

55

4.4 Science Performance Requirements

56 The E-ELT Programme shall establish the E-ELT such that the Science envisaged is enabled in a form compatible with budget, resources and timescale. The reference for the quality of science is evaluated against (see RD1, RD2, RD6 - RD9): 1. contemporary science as described by the collection of science case documents for the E-ELT; 2. synergies with other facilities; 3. discovery potential (serendipitous discovery or planned exploration of parameter space).

57 Additional future E-ELT sub-systems, modifications, and upgrades shall not compromise the science performance individually or in combination.

58 The E-ELT System shall host a suite of instruments that guarantees a suitable scientific exploitation of all encountered atmospheric and lunar illumination conditions under which it is operated.

59

4.5 Site characteristics

60 Following the decision made by ESO Council on 2–3 March 2010, based on a report from the E-ELT Site Selection Advisory Committee, the E-ELT Telescope will be located at Cerro Armazones, Chile, about 20 km from Cerro Paranal, home of the VLT.

61 Essential site characteristics, which are referred to in this document, have been extracted from RD10 and include:

Seeing:

- Best 5-percentile 0.39 arc seconds
- Best 10-percentile 0.44 arc seconds
- Best 25-percentile 0.53 arc seconds
- Median 0.68 arc seconds

Atmospheric coherence time t_0:

- Best 25-percentile 7.9 milliseconds
- Median 5.2 milliseconds

All the above parameters refer to 0.5 μm and zenith.

Wind velocity (measured typically at 30 m):

- 75-percentile 9.2 m/s
- Median 5.7 m/s

External night-time temperature:

- Coldest 10-percentile 3.6 degrees C

62

4.6 Astronomical Site Monitoring

63 Relevant site characteristics shall be monitored in real time. These shall include all variable meteorological, astronomical, and atmospheric site parameters relevant for astronomical observations and operations (including those related to the lasers).

64 These records shall be available at the observing station and shall be included in the observing records and archived.

65 Starting with the design phase, the E-ELT Programme shall establish a policy and a plan for the preservation and improvement of its relevant site characteristics.

69

4.7 Environmental Requirements

70 Environmental specifications for the E-ELT shall be defined and the conditions monitored on site.

71 Environmental specifications shall include requirements on the operational conditions and the survival conditions for the E-ELT System and sub-systems.

72

5 System Performance Requirements

73

5.1 General Requirements

74 The System components, individually or in combination

- shall not compromise the flexibility and breadth of the envisaged E-ELT Science;
- shall not require operational support (e.g. power consumption, maintenance, logistics, science operations effort), which compromises the System's performance;
- shall not impact the performance of other components in any way (e.g. through vibrations, electromagnetic emission, light pollution, ...).

253 The System shall not generate high-energy radiation at a level of more than 10% of the natural radiation.

75

5.2 Sky Coverage

76 Science observations shall be possible over > 95% of the sky accessible to the telescope, as defined by its kinematics (# 137 – 139).

77

5.3 Moon Avoidance

78 The System shall be able to operate and provide the specified image quality as close as 25 degrees from the full moon centre.

79

5.4 Atmospheric Dispersion Compensator

80 The System shall provide atmospheric dispersion compensation.

81

5.5 Image Quality

82 The image quality criteria defined in this sub-section shall be met over the sky coverage and moon avoidance defined in #76 and #78, full field of view (FoV) defined in #157 - #161, wavelength range defined in #167, altitude angles larger than 30 degrees, a 60 minute exposure (that can be interrupted, one or more times, for a total of 3 minutes in order to meet the image quality requirements), and under the 75-percentile envelope of atmospheric parameters, unless otherwise specified.

83 To deliver the image corrections beyond those needed for seeing-limited and ground-layer modes, the System shall not need more than 3 minutes in addition to those specified in #172 and #173 for the telescope pointing and guide star acquisition.

84

5.5.1 Image Quality for seeing-limited, low-order corrections

85 The telescope shall deliver at least seeing-limited performance with natural guide star(s) for the worst 95-percentile seeing conditions.

86 For the 5-percentile best seeing conditions, the FWHM of a point source generated by an ideal telescope operated in the atmosphere shall not be degraded by the E-ELT Telescope by more than 5% during a 60 minute exposure (all wave-front errors including image motion generated by the telescope and its enclosure, with the exception of the free atmospheric turbulence, shall be taken into account).

87

5.5.2 Image Quality for ground-layer corrections

88 The System shall be able to correct for ground-layer turbulence.

89 The ground-layer correction shall be optimized for any unvignetted FoV with a diameter between 30 arcsec and 5 arcmin.

90 The ground-layer correction shall reduce, by at least a factor of 2, the FWHM of the seeing limited point spread function at a wavelength of 2 μm under median seeing conditions of the site at least during 80% of the on-sky operation time.

91 The 50% encircled energy diameter of the ground-layer corrected point spread function (PSF) shall not vary in space by more than 5% RMS over the corrected FoV.

92 Under the best 10-percentile seeing conditions, the temporal variations of the 50% encircled energy diameter of the ground-layer corrected PSF shall remain less than 50% of the temporal variations of the seeing.

93

5.5.3 Image Quality for high order corrections on a narrow field of view

94

5.5.3.1 Natural Guide Stars

95 The System shall be able to correct an on-axis FoV of up to 30 arcsec diameter using one or more natural guide stars.

96 Under the best quartile seeing conditions the System shall deliver an on-axis Strehl ratio > 0.80 at 2 μm wavelength for AO guide stars brighter than V = 12 mag and median wind conditions.

97 Under the median seeing conditions the System shall deliver an on-axis Strehl ratio > 0.70 at 2 μm wavelength for AO guide stars brighter than V = 12 mag and median wind conditions.

99 Under the best 10-percentile seeing conditions, the temporal variations of the 50% encircled energy diameter of the corrected PSF shall remain less than 50% of the temporal variations of the seeing.

100

5.5.3.2 Laser Guide Stars

101 The System shall be able to correct an on-axis FoV of up to 30 arcsec diameter using one or more laser guide stars. This shall be met over at least 50% of the observable sky and median wind conditions.

102 Under median seeing conditions the System shall deliver at 2 μm wavelength a Strehl ratio of 0.45 over 30 arcsec FoV, 0.60 over 10 arcsec FoV, and 0.70 on-axis, with a FWHM < 10mas at 1 μm wavelength. This shall be met over at least 50% of the observable sky and median wind conditions.

104 Under the best 10-percentile seeing conditions, the temporal variations of the 50% encircled energy diameter of the corrected PSF shall remain less than 50% of the temporal variations of the seeing.

105 The 50% encircled energy diameter of the corrected PSF shall not vary in space by more than 5% RMS over the corrected FoV.

106

5.5.4 Image Quality for high order corrections on several narrow fields within the field of view

107 The System shall correct several sub-FoVs of up to 10 arcsec diameter each in selected regions of the sky anywhere in the telescope FoV using one or more natural and/or laser guide stars. This shall be met over at least 50% of the observable sky and median wind conditions.

108 Under median seeing conditions in each sub-field the System shall deliver a Strehl ratio > 0.50 at 2 μm wavelength. This shall be met over at least 50% of the observable sky and median wind conditions.

110 Under the best 10-percentile seeing conditions, the temporal variations of the 50% encircled energy diameter of the corrected PSF shall remain less than 50% of the temporal variations of the seeing.

111 The 50% encircled energy diameter of the corrected PSF shall not vary in space by more than 5% RMS over the corrected sub-FoV.

112

5.5.5 Image Quality for high order corrections over a wide field of view

113 The System shall correct a contiguous FoV of up to 2 arcmin diameter using the tomographic knowledge of the atmosphere gained using natural and/or laser guide stars. This shall be met over at least 50% of the observable sky and median wind conditions.

114 Under median seeing conditions over 1 arcmin FoV the System shall deliver: at 2 μm wavelength a Strehl ratio of 0.60, at 1 μm wavelength a Strehl ratio of 0.20. This shall be met over at least 50% of the observable sky and median wind conditions.

116 Under the best 10-percentile seeing conditions, the temporal variations of the 50% encircled energy diameter of the corrected PSF shall remain less than 50% of the temporal variations of the seeing.

117 The 50% encircled energy diameter of the corrected PSF shall not vary in space by more than 5% RMS over the corrected FoV.

118

5.5.6 Image Quality for high contrast imaging

119 The System shall achieve high contrast ratios at small angular separations.

120 Under median seeing and wind conditions the contrast ratio to be achieved in the near infrared (0.9 – 1.7 μm) shall be 10^9 at 0.5 arcsec and 10^8 at 0.1 arcsec radius for the equivalent of a G-type star at 8 pc.

122

5.6 Background/Emissivity

123 During science operations the background due to the thermal radiation from the telescope (structure + mirrors) shall be less than 15% of a blackbody of temperature equal to the current nighttime temperature, assuming baffling in the instrument. The requirement shall be fulfilled down to the coldest 10 percentile of the nighttime temperature of the site.

124 At the Nasmyth focus (see # 141), under the least favourable conditions, the stray light from the telescope, at wavelength above 1 micron, should not exceed 10% of the spatially and temporally averaged zodiacal light.

125

6 Telescope Performance Requirements

126

6.1 Telescope Enclosure

127 The telescope shall be protected against adverse environmental conditions by an enclosure at all times.

128 In particular it shall close (even in case of main power supply failure) in a time guaranteeing protection, that is less than 10 minutes, with a goal of 5 minutes.

131 The maximum time to open the enclosure shall not exceed 10 minutes.

129 The enclosure shall provide a clean environment facility (class 10,000) for integration of instrumentation onto the telescope.

130 The enclosure shall provide handling facilities necessary for the maintenance of the telescope and the installation and maintenance of the instruments.

132 The movements of the enclosure shall not impose any additional loss of on-target time when pre-setting the telescope from any position of the sky to any other.

133

6.2 Telescope Aperture

134 The telescope shall have a near-annular aperture with an outer diameter of not less than 39 m.

135 The total collecting area shall not be less than 980 m^2.

136

6.3 Telescope Kinematics

137 The telescope shall be steerable from 0 to 90 degrees in altitude and over 360 degrees in azimuth.

138 The telescope shall allow science observations at altitude angles larger or equal to 20 degrees and over 360 degrees in azimuth.

139 The radius of the inaccessible area around zenith in observation mode shall not be larger than 1.5 degree.

140

6.4 Telescope Focal Stations

141 The Telescope shall provide two Nasmyth platforms.

142 It shall be possible to direct the Telescope beam to either of the two Nasmyth platforms, with a fixed focal ratio between F/15 and F/18.

143 The Telescope shall provide a coudé station, capable of hosting two coudé instruments.

144

6.4.1 Nasmyth platform and focal stations

146 Each Nasmyth platform shall provide: 1. simultaneous access for at least three instruments to the telescope focal plane

147 2. free space (in particular, back-focal distance) around the focal plane to satisfy the instruments' needs

148 3. a total surface of the platform available for instruments of at least 120 m^2

149 4. clearance of at least 7 m in height

150 5. support for instruments up to 66 metric tons in total.

151

6.4.2 Equipment at an intermediate focus

152 The Telescope shall have provision for installing calibration and instrument supporting equipment at an intermediate focus at a location in the optical path prior to any inclined reflection or high-order term deformable mirror.

248 Such equipment shall clear the optical path of the Telescope when not in use.

250 For such equipment a cylindrical volume of at least 45 m^3 capable of supporting a mass of 2.7 metric tons below the intermediate focus shall be reserved.

249 For such equipment a cylindrical volume of at least 17 m^3 capable of supporting a mass of 4.5 metric tons above the intermediate focus shall be reserved.

153

6.4.3 Coudé focal station

154 The coudé focal station shall not move with any part of the telescope.

155 The coudé focal station shall offer space for two laboratories of at least 250 m^2 each and at least 6 m in height, as well as space for associated auxiliary equipment and maintenance operations

156

6.5 Telescope Field-of-View

157 The diameter of the unvignetted field-of-view shall not be less than 10 arcmin at the Nasmyth focal stations.

158 The diameter of the unvignetted field-of-view shall not be less than 10 arcsec at the coudé focal station.

159 The central FoV with a diameter of at least 5 arcmin at each Nasmyth focal station shall be available for science without any obscuration by any telescope guide probes for normal operations, unless required by the specific mode of operations (e.g. adaptive optics mode) of the instrument.

160 The central FoV with a diameter of at least 10 arcsec at the coudé focal station shall be available for science without any obscuration by any telescope guide probes for normal operations, unless required by the specific mode of operations (e.g. adaptive optics mode) of the instrument.

161 The area of the outer FoV between 5 and 10 arcmin diameter that is not obstructed by telescope devices shall be available for science.

162

6.6 Telescope Plate Scale

163 The telescope plate scale shall have an absolute accuracy of 1%.

251 The telescope plate scale shall be stable to 1% RMS over the entire FoV.

164 The telescope plate scale shall be stable over 60 minutes.

165 The telescope plate scale shall also be reproducible on the same target at the active focal station to within an accuracy of 0.01% over the field-of-view, when the telescope is online on-sky.

166

6.7 Telescope Transmission, Wavelength Range

167 The telescope shall transmit in the wavelength range 0.3 μm to 24 μm.

168 The telescope total transmission (assuming 5 clean reflections) shall be >50% at >0.35 μm, >60 % at >0.4 μm, >70% at 0.7 μm, and >80% at wavelengths longer than 1 μm, at the Nasmyth focus.

169 The median (over an 18 month period) telescope total transmission (assuming 5 reflections) shall never be less than 45% at >0.35 μm, 55 % at >0.4 μm, 65% at >0.7 μm, and 75% at wavelength longer than 1 μm, at the Nasmyth focus.

170

6.8 Telescope Pointing and Offsetting

171

6.8.1 Pointing and Guide Star Acquisition

172 While on-line, the telescope shall acquire the telescope guide stars at any position on the sky, starting from any position on the sky (within the specified range) and be ready for a science exposure (in seeing limited and with ground-layer correction) in no more than 6 minutes.

173 The telescope shall have a pointing accuracy of better than 3 arcsec before guide stars are acquired.

174

6.8.2 Offsetting and Nodding

175 Keeping the same guide star(s), the telescope shall be able to offset to up to 10 arcsec with an accuracy of 100 mas and be ready for science observations within 10 seconds.

176 It shall also be able to recover the original position within 10 seconds time and an accuracy of 50 mas.

177 The telescope shall be able, after a nodding of 60 arcsec and back (with no image correction at the offset position), to re-acquire the guide stars and be ready for science observations within 10 seconds.

178 The telescope shall also be able, after a nodding of 15 arcmin and back (with no image correction at the offset position), to re-acquire the guide stars and meet the image quality requirement within 30 seconds.

179

6.9 Telescope Tracking

180 In closed control loop and maintaining the specified image quality, the telescope shall be able to track astronomical targets having differential velocities with respect to the sidereal rate of up to 100 arcsec/h over a period of 60 minutes (provided that the guide stars remain within the field-of-view).

181 The telescope shall also be able to track astronomical targets having differential velocities with respect to the sidereal rate of 2,000 arcsec/h (as long as the guide stars remain within the field-of-view of the target), with the goal of maintaining the specified image quality.

182

7 Instrumentation Requirements

183 In the following, the term instruments shall refer to scientific astronomical instruments making use of the telescope beam to generate signals that can be transformed into science grade products.

184

7.1 Instrumentation Plan, Complement and Exchangeability

185 The E-ELT Programme shall have, at any point in time starting from the construction phase, a valid Instrumentation Plan, describing:

- the current layout of the science instruments
- the planned (short-term) complement of science instruments
- the (mid-term) road map for instrument additions and replacements
- the long-term vision.

186 The E-ELT Instrumentation Plan shall show on average a suite of instruments that complement each other in the parameter space spanned by wavelength, spatial and spectral resolution, field-of-view/multiplexity, polarimetry and time resolution.

187 As input for operations, maintenance and other planning purposes (including science policies), the E-ELT Instrumentation Plan shall consider the trade-off between cost and scientific impact of any planned or existing instrument.

188 The E-ELT shall have a number of instruments mounted semi-permanently for long periods of time (typical time scale 5 years) and available in stand-by mode.

189 The E-ELT by design and operations planning, together with the Instrumentation Plan, shall make provisions to enable Exploratory Science by innovative use of technology, be it by either reserving some fraction of time at a focal station or by creating an Experimental Access to the Beam.

190 The E-ELT Programme shall document the design rules for the E-ELT Science Instruments enforcing the present TLRs onto the design, manufacturing and operations of these instruments, whether supplied directly by ESO or through Consortia.

191 Instrument performance shall be monitored. The operations and science operations processes shall contain appropriate measures to preserve the instrument performances.

192

7.2 Maintenance and calibration of instruments

193 Instruments shall have maintenance and calibration plans.

194 The maintenance of the instruments shall be part of the regular observatory maintenance.

195 The technical and scientific calibration of the instruments shall be embedded in the regular maintenance of the observatory and the science operations.

196

8 Site Operation Requirements

197

8.1 General

198 The operations of the E-ELT and Paranal shall be fully integrated.

200

8.2 Site Services

201 The E-ELT Project shall provide all necessary functions, logistics, facilities and spaces for the E-ELT daily operations and preventive/predictive and corrective maintenance tasks.

202 Site services shall be implemented in a way, which minimizes the impact on environmental conditions relevant to scientific quality and productivity (including image quality).

203

8.3 Telescope and Instrument Availability

204 The telescope and instruments shall be available at night with nominal image quality for on-sky operations at least between the nautical twilights.

205 The telescope and instruments shall be capable to switch from stand-by to online mode within 15 minutes.

206 The loss of on-sky science time, when switching between two instruments during a night, shall not exceed 10 minutes for instruments at the same focal station, and not exceed 20 minutes for instruments at different focal stations. This does not include the time needed to acquire the new target.

207 Over a period of one year no more than 3% of the time (10% in the first year of operation) when weather conditions permit science operations shall be lost to technical failures of the System.

208

8.4 Maintenance

209 Neither the telescope nor any instrument shall be out of science operations for maintenance reasons for more than 10 consecutive nights.

210 Neither the telescope nor any instrument shall be out of science operations for maintenance reasons for more than 5% of the time over 3 years.

211 Neither the telescope nor any instrument shall be out of science operations for upgrade reasons for more than 5% of the time over one year.

212

9 Science Operation Requirements

213

9.1 User Interaction

214 In science operations, the interaction of the users with the telescope and instrumentation shall take place by means of Observation Blocks defining the telescope preset position, instrument and adaptive optics set-up, exposure parameters, and any other parameters needed to fully characterize the execution of an observation.

215

9.2 Operation Modes

216 The operation modes of the E-ELT shall be defined such as to allow an optimal exploitation of the atmospheric conditions.

217 The operation modes shall allow a flexible short-term scheduling, that can be driven by real-time decisions.

218

9.3 On-site Science Operations

219 Routine night-time science operations shall not require more than three people to operate the telescope, instrument and short-term scheduling tools, as well as to perform very basic troubleshooting (e.g., dome status, sub-system restart) of the telescope and instrument sub-systems.

220 For each instrument mode, a fully automated data reduction pipeline shall be available to at least one operator in order to perform real-time basic quality control.

221 The instrument calibration plans shall make provision for a calibration database that can be used by the pipelines for this purpose.

222

9.4 Time Distribution

223 Observing time distribution on the E-ELT Telescope shall be based on a precise knowledge of the environmental requirements of the observing programme.

224 The long-term scheduling shall ensure the proper mixture of scientifically interesting programmes sampling the expected distribution of weather conditions.

225

9.5 Data Flow

226 All data generated by the instruments shall be in a standard format, which shall be deemed to be the most useful for the astronomical community at the time of first light.

227 These data shall contain all relevant meta-data to allow their archiving, processing and analysis.

228 The meta-data shall be standardized.

229

9.6 Data Transfer and Archiving

230 All raw data generated by the E-ELT (telescope, instruments, site monitors, ...) shall be archived.

231 All raw scientific data including calibrations obtained with the E-ELT and any of its instruments shall arrive at the ESO archive not later than 1 h after they have been obtained.

232 All science and calibration data processed by pipelines maintained by ESO that have successfully passed quality control shall also be stored in the ESO archive.

233 Both raw and pipeline processed science and calibration data shall be available to Principal Investigators as soon as they are ingested in the ESO archive, and to the community at large after the expiration of their proprietary period.

234

9.7 Data Reduction

235 The E-ELT Programme shall provide pipelines, their component recipes, and data reduction workflows for all instruments and modes for the purpose of real-time analysis, quality control and scientific application.