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# Introduction

The NEOSTEL program will lead to the detailed design of a telescope able to fulfil the specific requirements for the survey of the Near Earth Objects. In particular, the NEOSTEL Telescope must provide the performances needed to guarantee NEO catalogue build up and maintenance, joined to accurate tracking capabilities, suitable to perform the so called “Wide Survey” observation strategy. Therefore the telescope design is focused to obtain the necessary resolution over a very wide FoV; a suitable diameter primary mirror must be provided to allow detecting NEO objects down to the required limiting magnitude.

For this purpose, an important concept is introduced, that greatly simplifies the overall optical design, consisting in the so called Fly-Eye (FY) architecture. The FY design consists in splitting the overall FoV in sub FoVs on which an array of corrector elements are placed, in form of arrayed small sized lenses. The Fly-Eye Telescope design is modular in nature, allowing for “serial” production.

## Document SCOPE and Organization

The aim of this document is to define the NEOSTEL CCD and Camera Assembly subsystem specifications.

The specification shall be submitted and reviewed by the Preliminary Design process and where necessary slightly refined taking into account Final Design review conclusions.

## Acronyms

|  |  |
| --- | --- |
| **AD** | Applicable Document |
| **CGS** | Compagnia Generale per lo Spazio (formerly Carlo Gavazzi Space) |
| **NEOSTEL** | NEO Survey Telescope |
| **RTD** | Resistance Temperature Detector |
| **IOC** | Input Output Control |
|  |  |
|  |  |

## Applicable Documents

1. Statement of Work P2-NEO-V ‘NEO Survey Telescope Detailed Design’, SSA-NEO-TEL-SOW-0001, Issue 1, 17/12/2013
2. Space Situational Awareness - NEO System Requirements Document, SSA-NEO-RS-RD-0001, Issue 1, Revision 4, 05/04/2013
3. CGS Proposal “NEO Survey TELescope Design NEOSTEL”, S14-003 Is.1, April 2014

## Reference Documents

1. TELAD Design Report, TELAD-RP-CGS-001, version 1, 25/10/2011

# REQUIREMENTS LIST AND DEFINITIONS

Requirements will be defined for each one of these items, in accordance with the sections as follows:

* Section 3.1 – CCD AND CAMERA GENERAL REQUIREMENTS
* Section 3.2 – CCD AND CAMERA FUNCTIONAL REQUIREMENTS
* Section 3.3 – CAMERA MECHANICAL REQUIREMENTS
* Section 3.4 – CAMERA MASS AND MATERIAL REQUIREMENTS
* Section 3.5 – CCD DESIGN & TECHNICAL REQUIREMENTS
* Section 3.6 – SHUTTER DESIGN & TECHNICAL REQUIREMENTS
* Section 3.7 – CAMERA DESIGN REQUIREMENTS
* Section 3.8 – CHILLER REQUIREMENTS
* Section 3.9 – SOFTWARE REQUIREMENTS
* Section 3.10 – MAINTENANCE REQUIREMENTS
* Section 3.11 – SAFETY AND HUMAN ENGINEERING REQUIREMENTS

Each requirement contained in this specification shall be verified by the previously defined verification methods. The applicable methods are indicated in the field "V.-Meth" above the requirements text.

These methods are:

* **Review of Design (R)** will be used, if technical descriptions or engineering drawings of the design can unambiguously show that the requirements concerning conceptual features, dimensions, or functionality are met, i.e. characteristics without the use of special laboratory equipment, procedures, items, or services. This includes the technical evaluation of drawings, software listings, equations, charts, graphs, diagrams or representative data. Closeout documents can be a "Review of Design Report" or existing Design Reports, which are referenced in the verification matrix.
* **Analyses (A)** will be applied when analytical techniques (such as engineering analysis, statistics, mathematical modeling, simulation) are available and provide added value, or supplement test data. When the verification method Analyses is used to predict the performance or the behavior of the item under investigation by using environmental mathematical models, these models have to be validated also by test. Analyses will be reported in the form of a Technical Note / Reports.
* **Inspection (I)** is defined as a physical measurement or visual evaluation referring to the associated documentation of the item under inspection. Inspection is used to verify construction features, document and drawing compliance, software source and object code compliance, workmanship, and physical conditions. It involves looking at an item or component, or reviewing descriptive documentation, or determination of physical dimensions. This method may require moving, turning, or partially disassembling of hardware to gain visual and / or physical access, but does not require operation of the item. Formal hardware inspections are performed in the frame of the manufacturing process as Key Inspection Points (KIP), respectively Mandatory Inspection Points (MIP) or in the frame of incoming inspections. Software code inspections are performed as part of the software qualification and acceptance process. Any inspection will be documented in an Inspection Report, if applicable including a comprehensive photographic documentation.
* **Test (T)** is defined as a method of verification wherein performance is quantitatively measured during or after the controlled application of real or simulated functional and/or environmental stimuli. In some cases, repetition of individual tests for a sufficient number of times may be required to provide a statistical level of confidence in the final results. This verification method includes all tests and measurements performed at any system level. Any analyzed data, e.g. for environmental loads, must be verified by test. Verification by test will be documented in the form of a Test Report.

The definition “Supplier” shall be understood as the company which has signed the procurement contract.

The definition “Customer” stands for CGS.

Considering that the present version refers to a Design Phase the requirements subject to TEST will be indicated in the version frozen after PDR.

# CCD and Camera Assembly requirements

## CCD AND CAMERA GENERAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CC-GR-0010 | The Supplier shall be responsible for performing the detailed design, supporting analyses and the manufacturing documentation for the camera in accordance with the requirements of this specification. |  | R |
| NEO-CC-GR-0020 | The detail design shall be documented with:   * Assembly, Interface and Manufacturing Drawings * Analysis Report (if requested) * Off the shelf part Technical Data sheet |  | R |
| NEO-CC-GR-0030 | All drawings shall be produced in electronic form. The 3D CAD-Model shall be delivered in the STEP format (\*.stp). |  | R |
| NEO-CC-GR-0040 | Deliverable documentation and drawings shall be written in English (dual language within the drawing is acceptable). |  | R |
| NEO-CC-GR-0050 | Analysis, test and inspection reports shall be established and delivered to the Customer as part of data packages. All reports shall be provided in English. |  | R |
| NEO-CC-GR-0060 | Verification of design and the workmanship of the camera shall be performed in accordance with the indicated verification methods:   * design requirements (R, A) shall be closed before start of manufacture, at internal design review; * all other requirements shall be closed during / after manufacturing and acceptance phase and recorded onto the Compliant Matrix |  | R |
| NEO-CC-GR-0070 | One review shall be performed leading to the final approved design:   * closure of design requirements * release of interface and assembly drawings * approval of analyses documentation |  | R |
| NEO-CC-GR-0080 | The Final Acceptance reviews shall be performed leading to the final acceptance:   * fulfilment of all project and contractual requirements |  | R |
| NEO-CC-GR-0090 | The design shall be compatible with the national regulations and laws of members of the European Union. |  | R |
| NEO-CC-GR-0100 | The unit system is the International System (S. I.) except for:   * Angles: Degrees (°) * Absolute Temperatures: Degrees Celsius (°C) * Accelerations: Multiples of Earth Gravity (g) * Air pressure: Bar (bar)   For the above reported units are accepted together their SI equivalent. |  | R |
| NEO-CC-GR-0110 | Any special tool, which is required for the camera set-up, operation and any other working adjustment, shall be included. |  | R |

## CCD AND CAMERA FUNCTIONAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CC-FR-0010 | The camera shall be able to fulfil all requirements with whatever angular orientation |  | R |
| NEO-CC-FR-0020 | Camera’s input, output, fluidic and power connections shall be easily grouped together in a single chain. |  | R |
| NEO-CC-FR-0030 | The camera shall be provided with a flange to the secondary optics tube. |  | R |
| NEO-CC-FR-0040 | All cables and fluidic tubes connecting the camera to external devices shall be at least 20m long (TBC). |  | R |

## CAMERA MECHANICAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CAM-MR-0010 | Camera Maximum Envelope: Ø254 x 235 mm (TBC)  **Camera Body**:  Outer Diameter: 200 mm  Height: 220 mm  **Camera External / IF Flange**:  Outer Diameter: 254 mm  Thickness: 12/15 mm |  | R |
| NEO-CAM-MR-0020 | The external IF Flange shall be provided with dedicated slots that allow the fastening of the camera to the secondary mirror structure.  Also the slots allow the rotation of the camera around its axis to adjust the CCD orientation.  Wide Angle Slot: 40 deg  Slots Position Diameter: Ø225 mm  Width Slot: 7 mm |  | R |
| NEO-CAM-MR-0030 | On the external IF flange shall be realized a milling pocket in order to show CCD PIN 1 orientation. |  | R |
| NEO-CAM-MR-0040 | On the external IF flange shall be realized a mechanical alignment (TBC) provided by the System. |  | R |
| NEO-CAM-MR-0050 | SYSTEM REQUIREMENT: The external mechanical adjustment capability shall be of at least +/- 1.0 mm from the nominal position with a +/-5 microns accuracy in tip-tilt adjustment and within +/-10microns in axis. The Camera Design shall be compatible with this requirement. |  | R |

## CAMERA MASS AND MATERIAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CAM-MMR-0010 | The camera weight shall be less than 10 Kg. The target is 5-7 Kg. |  | R |
| NEO-CAM-MMR-0020 | Camera structure material: Aluminium |  | R |

## CCD DESIGN & TECHNICAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CCD-DTR-0010 | Full Frame Transfer CCD. (State of the art low noise interface techniques shall be adopted) |  | R |
| NEO-CCD-DTR-0020 | Back Illuminated CCD (450 to 750 nm). |  | R |
| NEO-CCD-DTR-0030 | The Resolution shall be of 4096x4096 pixels. |  | R |
| NEO-CCD-DTR-0040 | The Pixel size shall be of 15x15 um. |  | R |
| NEO-CCD-DTR-0050 | Linearity shall stay within 1% in the range 100e – 95% of saturation. |  | R |
| NEO-CCD-DTR-0060 | The Dark Current shall be less than 0.1e/pix/s. |  | R |
| NEO-CCD-DTR-0070 | 100% fill factor. |  | R |
| NEO-CCD-DTR-0080 | Full well capacity depth better than 150 ke. |  | R |
| NEO-CCD-DTR-0090 | The CCD shall be positioned inside a sealed chamber filled with noble gas. |  | R |
| NEO-CCD-DTR-0100 | The sealed chamber shall be provided with a silica glass window with broad band AR coating, 5mm thick. |  | R |
| NEO-CCD-DTR-0110 | The silica glass window shall be provided with a heater. |  | R |
| NEO-CCD-DTR-0120 | The position of the CCD surface should be set as a function of the window thickness. The dimensional and positioning accuracy shall be within +-0.05mm. |  | R |
| NEO-CCD-DTR-0130 | Readout noise 10e RMS for a readout frequency of 2MHz. |  | R |
| NEO-CCD-DTR-0140 | Dynamic range: 20ke/e, 16 bit depth. |  | R |
| NEO-CCD-DTR-0150 | The readout time shall be less than 2.5 s. |  | R |
| NEO-CCD-DTR-0160 | One to four selectable readout channels shall be available. |  | R |
| NEO-CCD-DTR-0170 | Quantum Efficiency >95% peak, >75% mean. |  | R |
| NEO-CCD-DTR-0180 | Multi Phase Pinning shall be controllable by the user. |  | R |
| NEO-CCD-DTR-0190 | The CCD operative temperature shall be set to -50°C through Thermo Electric Cooling system (Peltier). |  | R |
| NEO-CCD-DTR-0200 | The readout frequency shall be selectable among 0.5, 1, and 2MHz. |  | R |
| NEO-CCD-DTR-0210 | CCD charge transfer efficiency shall be better than 99.9995% |  | R |

## SHUTTER DESIGN & TECHNICAL REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-SHU-DTR-0010 | The shutter shall have a mechanical life time of more than 106 cycles. |  | R |
| NEO-SHU-DTR-0020 | The shutter shall have a time synchronisation accuracy better than 100 us (a time offset of a few ms is acceptable). |  | R |
| NEO-SHU-DTR-0030 | The shutter synchronisation shall be both PTP and NTP compatible. |  | R |
| NEO-SHU-DTR-0040 | The shutter non-uniformity (jitter) shall be assessed below 100 us. |  | R |
| NEO-SHU-DTR-0050 | The shutter timing shall be controlled either internally or externally (RS485). |  | R |
| NEO-SHU-DTR-0060 | Trigger mode shall be user controllable, both at hardware and software level (see NEO-CAM-DR-0130). |  | R |
| NEO-SHU-DTR-0070 | The shutter design shall be such as to avoid stray-light on the FP |  | R |
| NEO-SHU-DTR-0080 | The shutter shall not introduce any vibration during operation |  | R |

## CAMERA DESIGN REQUIREMENTS

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CAM-DR-0010 | The camera shall be provided with modular architecture design. |  | R |
| NEO-CAM-DR-0020 | Camera design shall be compatible with different CCD provider choices. |  | R |
| NEO-CAM-DR-0030 | Camera operational temperature shall range -20°C to +30°C |  | R |
| NEO-CAM-DR-0040 | Camera operational altitude range shall be 0 to 4000m over sea level. |  | R |
| NEO-CAM-DR-0050 | Camera diameter shall be less then 200mm. |  | R |
| NEO-CAM-DR-0060 | Flange interface diameter shall be equal to 250mm. |  | R |
| NEO-CAM-DR-0070 | Power supply line to camera head shall be separated from TEC power supply line. |  | R |
| NEO-CAM-DR-0080 | Power supply unit shall be external to the camera. |  | R |
| NEO-CAM-DR-0090 | Communication interface: Gigabit Ethernet over optical fibre. |  | R |
| NEO-CAM-DR-0100 | The Operating system shall be Linux or Equivalent Multiprocessing Operating System with high reliability and capability to manage soft real time in particular for the control of time and trigger clock . |  | R |
| NEO-CAM-DR-0110 | Camera diagnostics shall provide at least Temperatures (operational), TEC current, CCD voltages, exposure time, pressure, camera state (idle, readout, etc). |  | R |
| NEO-CAM-DR-0120 | The camera shall have an internal real time clock with microseconds resolution , and compatible with both PTP and NTP synchronization protocols. |  | R |
| NEO-CAM-DR-0130 | A two-lines external signal shall be provided to the camera:   * Trigger signal * Gate signal |  | R |
| NEO-CAM-DR-0140 | Camera’s firmware shall be upgradeable via Ethernet |  | R |
| NEO-CAM-DR-0150 | The acquired image shall be in FITS file format. At least the following keyword will be included in the FITS header:   * Shutter open UTC timestamp * Shutter close UTC timestamp * CCD temperature * Readout parameters |  | R |
| NEO-CAM-DR-0160 | CCD control logic shall be programmable in order to be compatible with different sensors and different operation modes ( NEO-CCD-DTR-0180). |  | R |

## CHILLER REQUIREMENTS

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| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CHI-0010 | The cooling capacity of the chiller shall guarantee the proper functioning of the TEC system inside the camera within a zero to 6m height gap from chiller position. |  | R |
| NEO-CHI-0020 | The chiller shall avoid tank overflow in all operating/non-operating conditions. |  | R |
| NEO-CHI-0030 | The chiller shall provide the following alarms/interlocks functional:   * Tank Level Low * RTD Fail/Open * Fan Fail * Pump Fails |  | R |
| NEO-CHI-0040 | Temperature of the coolant shall be settable in a range that avoids water condensation on the external side of the fluidic lines. |  | R |
| NEO-CHI-0050 | The chiller unit shall be designed to provide proper heat dissipation from group of 1, 2 or 4 cameras simultaneously. |  | R |
| NEO-CHI-0060 | The chiller shall be rack mountable. |  | R |
| NEO-CHI-0070 | Difference between the set point and the actual coolant temperature shall be within +/- 1°C |  | R |
| NEO-CHI-0080 | The chiller shall work in low vibration / low noise mode. |  | R |
| NEO-CHI-0090 | Fluidic in-out lines shall be at least 20m long. |  | R |
| NEO-CHI-0100 | The protrusion of fluidic in-out lines on camera’s side shall not be more than 5cm over camera’s back-plate. |  | R |

## SOFTWARE REQUIREMENTS

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| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-CAM-SWR-0010 | The SW design standard shall be based on tailoring TT4 to ECSS-E-ST-40C included in document DOPS-ESOC-GS-TN-1002 iss3.0 shall be applied.  A further tailoring of level TT4 can be agreed with the Prime. |  | R |
| NEO-CAM-SWR-0020 | Code testing standard shall be based on MISRA C/C++ guidelines (TBC). |  | R |
| NEO-CAM-SWR-0030 | The SW design shall be in agreement with the PA plan provided by the Prime |  | R |
| NEO-CAM-SWR-0040 | Concerning camera M&C SW task, the system shall support EPICS protocol. |  | R |
| NEO-CAM-SWR-0050 | Each Camera shall have a separate camera controller connected via LAN, ETHERNET/ TCP-IP and UDP. |  | R |
| NEO-CAM-SWR-0060 | BITE (Built In Test Environment) at the boot and also bad parameter reporting to the monitoring system shall be used as failsafe algorithms for system in case of errors or other critical events. |  | R |

## RELIABILITY AND MAINTENANCE requirements

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-MR-0010 | Availability: MTBF di 8000h minimum , preferred 12000h. |  | R |
| NEO-MR-0020 | The identified HW Solution Chip-Set shall be available at least for 5 years, furthermore other strategies shall warrant the possibility to extend for further 5 years. |  | R |

## Safety and human engineering requirements

|  |  |  |  |
| --- | --- | --- | --- |
| **Requirement ID** | **Requirement Description** | **Remarks** | **Verification Method** |
| NEO-SAF-0010 | CCD and Camera systems and all related tools and external units shall satisfy CE safety mark parameters. |  | R |