STATEMENT OF WORK FOR THE PRELIMINARY DESIGN OF THE ADAPTIVE SECONDARY MIRROR FOR THE EUROPEAN SOLAR TELESCOPE

WORK-PACKAGE (DELIVERABLE NR)

M2 : M2 ASSEMBLY
## AUTHORS LIST

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Project Role</th>
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<tbody>
<tr>
<td>Miguel Núñez Cagigal</td>
<td>IAC</td>
<td>EST System engineer</td>
<td>09/12/2019</td>
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## APPROVAL CONTROL

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<tr>
<td>Revised</td>
<td>Angel Mato Martínez</td>
<td>IAC</td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td>Approved</td>
<td>Mari Barreto Cabrera</td>
<td>IAC</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Authorized</td>
<td>Manuel Collados Vera</td>
<td>IAC</td>
<td>Principal investigator</td>
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## DOCUMENT CHANGE RECORD

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LIST OF ABBREVIATIONS

AIV Assembly, Integration and Verification
AD Applicable Documents
CDS Conceptual Design Stage
CFD Computational Fluid Dynamics
CIDL Configuration Item Data List
CO Contractor
CRE Change Request
DI Delivery Item
DL Deliverable
EAST European Association for Solar Telescopes
EMC Electro-Magnetic Compatibility
EST European Solar Telescope
EST-PO European Solar Telescope Project Office
FEM Finite Element Model
FDR Final Design Review
IAC Instituto de Astrofísica de Canarias
ICD Interface Control Document
KM Key Milestone
KOM Kick-Off Meeting
LW Lightweight
M1 Primary Mirror
PDR Preliminary Design Review
PDS Preliminary Design Stage
PHA Preliminary Hazard Analysis
PO Project Office
RAMS Reliability, Availability, Maintainability and Safety
RD Reference Documents
RID Review Items Discrepancies
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<td>Work Breakdown structure</td>
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1. INTRODUCTION

1.1 Summary

This document defines the SoW for the preliminary design of the M2 assembly of the European Solar Telescope with the main objective of consolidating the baseline design and specifications to allow to start the detailed design and construction of this subsystem.

1.2 Background

The European Solar Telescope (EST) is a next generation large-aperture solar telescope. This 4-metre telescope will be optimised for studies of the magnetic coupling between the deep photosphere and upper chromosphere. The European Association for Solar Telescopes (EAST), currently formed by solar physicists from 18 European countries, fully supports the project and intends to develop, construct and operate EST. The Conceptual Design Study of the EST project started in February 2008 and finished in July 2011.

The EST Preparatory Phase (PRE-EST), started on April 2017 and funded under the H2020 Framework, will review the 2011 concept and will define the detail design specifications for the Construction Phase of the key systems and will provide the detail plan for the detail design and constructions of the telescope.

Figure 1. EST.

EST is a 4-metre class solar telescope with an on-axis Gregory configuration, aiming at superb polarimetric performance. It will have a main instrumentation station at the Coudé focus with three types of instruments, each one composed of different channels to observe different wavelengths:
broad-band imagers, narrow-band tunable filter spectropolarimeters and grating spectropolarimeters. The telescope includes active and multi-conjugate adaptive optics integrated in the telescope optical path between the primary mirror and the instrument focal plane in order to maximize the telescope throughput and provide a corrected image at the Coudé focus for the three types of instruments simultaneously. The active optics system is composed of M1, M2. The adaptive optics system is composed by a deformable secondary mirror conjugated to pupil and 4 attitude deformable mirrors.

The M2 Assembly is one of the main subsystems of EST with the primary mirror and the Structure.

During the EST Conceptual Design (2008-2011) a rigid secondary mirror was proposed with only active optics functionality. At that time, the adaptive optics system was also included in the telescope and previous to the science focal plane delivered to the instruments. In the Conceptual Design, a potential upgrade of the secondary mirror to an Adaptive Secondary Mirror (ASM) was foreseen. Hence, the telescope optical design concept defined the stop of the system at M2.

Since the EST conceptual design stage, several night-time astronomical facilities have successfully assembled ASMs. In view of this, the EST PO decided in 2019 updating the EST baseline design to assemble an ASM. It reduced by half the number of optical elements (of the current EST conceptual design) from the main telescope up to the Coudé focus. However, as consequence of the feedback coming from ASM suppliers and from the current EST concept review also, the EST PO foresees that any alternative for M2 is open. Besides, the EST PO foresees that as result of the interaction with ASM suppliers, the parameters of M2 could change slightly.

1.3 Definitions

1.3.1 Client

EST Project Office is the client. Throughout the documentation EST-PO will be understood also as EST Project Office or Client. The EST Project Office is at the IAC headquarters in la Laguna. Tenerife (Canary Islands- Spain)

1.3.2 EST-PO contract manager

Contact person at the EST Project Office for any issue related to the contract. This person will define
the EST-PO persons to contact depending on the different needs.

1.3.3 Contractor

Company or association of companies selected by EST-PO or EST Partners to execute the work described in this SOW.

1.3.4 Site

Place selected for the construction of the EST Telescope. It will be located in the Canary Islands Observatories, Spain. The final site will be selected between Roque de los Muchachos Observatory or Teide Observatory.

1.3.5 Bidder

Any Company or association of Companies who submit a proposal for the execution of the Work described in this SOW.

1.3.6 Telescope coordinate system

The telescope origin corresponds to the elevation axis coordinate system origin, which is defined in the applicable document EST Coordinate Systems, AD 1.

2. RELATED DOCUMENTS

2.1 Applicable documents

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

- AD 1: Technical specifications for the preliminary design of the adaptive secondary mirror for the European Solar Telescope. EST-0M2-EPO-SPE-0022v1

2.2 Other referenced documents

- RD 1: EST Conceptual Design Study Final Report RPT/EST/0001_1A
- RD 2: Secondary mirror preliminary design RPT/GTC/5001_1A
- RD 3: EST M2 Unit Phase III Report RPT/NTE/3001_1A
- RD 4: EST Error Budgets RPT/EST/3005_1A
3. PRODUCT DEFINITION

The EST adaptive secondary mirror assembly is composed of a deformable glass ceramic mirror supported by a structure, which includes the mirror support, actuators, thermal control and control electronics to interface with the telescope control system. It also includes at least a second stage based on a hexapod. The mirror support provides also the interface which fix the M2 assembly to the telescope structure.

The thermal control system controls the temperature of the mirror that will receive solar radiation during the telescope operation.

In addition to the M2 assembly, all the tools and handling equipment required for the installation, calibration, operation and maintenance of the M2 assembly are part of the M2 auxiliary equipment which is also included in the scope of this preliminary design.

4. PROJECT DEFINITION

4.1 Scope

The scope of this project is the Preliminary Design of the EST adaptive secondary assembly, according to the requirements defined in AD1, with the main objective of consolidating the baseline design, including specifications, production and AIV plan and budget to allow to start the detailed design and construction of this subsystem.

This document specifies the tasks to be performed during the M2 Assembly Preliminary Design including:

1. Design of the M2 assembly and its auxiliary equipment required for handling, maintenance, calibration and operation, and validation of the design by modelling and analysis.
2. Verification of the key components of the M2 assembly by a test campaign on breadboards and prototypes.
3. Definition of a production plan and schedule for the M2 assembly, including detailed design, manufacturing and AIV.
4. Definition of a production cost estimate for the M2 assembly, including detailed design, manufacturing and AIV.

The Contractor shall develop his own Front-End Engineering and Design of the M2 Assembly assuming the requirements defined in AD1.

The design concepts for the M2 assembly developed during the conceptual design study of EST are included in the RDs. These documents may be used as initial reference but keeping in mind that in the conceptual design the baseline was a rigid M2, while this preliminary design is for an adaptive
M2.

At the end of this Contract, EST-PO shall be the owner of all the results (design, specifications as well as all the intellectual and industrial property developed during the preliminary design contract).

4.2 Project Phases

The project development during the contract has been organized in the next phases: Phase 1, Phase 2 and Phase 3. The last phase includes the review of the whole preliminary design (PDR).

4.2.1 Phase 1

The main objective of the Phase 1 is to obtain a baseline design. In order to achieve it, there will be a revision and consolidation of the specifications, exploration of the current solutions, performing trade-offs at conceptual level and proposing a baseline design to be approved by EST-PO.

EST-PO shall deliver the update version of the specifications after the sign of the contract and before the Kick-Off Meeting. During the Kick-Off Meeting, the differences between the specifications published in this tender and the updated one will be reviewed and the new version of the specification will be agreed and released. In case that the new version is not agreed, the previous version will remain applicable, being considered the new version as a goal. The update of the specifications document, AD 1, will be kept under EST-PO control.

During the Phase 1 the Contractor shall:

1. Consolidate the following topics, that had been presented in the offer to win the bid, previously to the contract sign:
   a. Review EST M2 Technical specifications, AD 1, checking that the requirements are complete and they do not contain excessive risks. EST-PO shall deliver the update version of the specifications after the sign of the contract and before the Kick-Off Meeting. During the Kick-Off Meeting, some specifications updates shall be agreed between PO and CO. In the cases where there is no agreement the specifications originally published for this bid will be applied and the new version will be kept as goals. The update of the specifications document, AD 1, will be kept under EST-PO control.
   b. Identify critical requirements in terms of performance, safety and potential complexity.
2. Explore alternative solutions concepts, performing trade-offs and propose a baseline design. This phase must include, at least, the following trade-off:
   a. Thermal control strategies.
   b. Strategies to achieve the required distance between actuators.
   c. Routing of cables for the required amount of actuators.
3. Propose a baseline solution for different subsystems, based on the results of trade-offs. The final decision will be taken by the EST-PO.
4. Attend to the Phase 1 Review Meeting to present the result of the different trade-offs and the baseline proposed previously to the meeting. The final decision will be taken by the EST-PO.
5. Review risks, hazards, costs estimation and schedule for the manufacturing and assembly of the subsystem in the different configurations under trade-off.
6. Deliver the documentation specified in the Phase 1 Data Package.

The baseline design of the project at this phase shall be addressed with a detail level adequate to:

1. Include a quantitative comparison in the trade-off presented, based on the critical requirements.
2. Consolidate the specifications for the next phases of the design.
3. Analyse the proposed solution to the level where the critical factors in the error budget can be estimated.
4. Develop the design of the unit and each subsystem to the level of proposal with a plan developed for each one.

**Phase 1 starts:** at T_0 at the same time that the Kick-Off Meeting.
**Phase 1 ends:** acceptance by EST-PO of the Phase 1 Data Package during Phase 1 Revision Meeting and closure of open actions.

### 4.2.2 Phase 2

The Phase 2 focuses on designing based on consolidated requirement specifications and the baseline adopted at the end of the previous phase, up to the point where the design is validated with respect to the requirements. The fulfilment of the requirements will be checked using models at subsystem level, M2 assembly as a whole, and also developing analyses that allows filling all the elements in the error budget with a bottom-up approach.

A fundamental task of this phase is designing of key prototypes and definition of the test plan for them. The minimum amount of prototypes shall allow verifying the requirements related with:

1. Distance between actuators.
2. Thermal control for electronics.
3. Mirror Thermal Control shall include the required hardware and a breadboard of the proposed control system to test the functionalities and performance of the proposed design of the Mirror Thermal Control controlling the temperature of the Mirror Blank prototype in traceable conditions to the telescope operational conditions.

It is accepted that several of the previous functionalities can be implemented and tested in a single prototype.

This phase will include also the design of the interfaces with the telescope, and the fabrication plans.
Within the framework of Phase 2, the CO shall:

1. Produce the complete set of requirement specifications for each item of the M2 Assembly so that suppliers of main components can produce an offer.
2. Design in detail the prototypes and launch the manufacturing or procurement of all the parts.
3. Develop the different subsystems, select components and interact with the providers.
4. Define the interfaces that are external to the scope of this preliminary design and prepare the following Interface Control Document (ICD) between:
   a. M2 assembly and the telescope structure.
   b. M2 assembly and the telescope services: power supply, digital data, cooling supply.
5. Define the M2 assembly interfaces that are internal to scope of this preliminary design items and prepare the Interface Control Documents (ICD).
6. Report the performed analyses and simulations, including FEM, CFD, Thermal, EMC and Control Simulations.

The baseline design of the Project at this phase shall be addressed in such a level that:

1. The item level requirements that will be tested with the prototypes and the M2 assembly level requirements that will be influenced in the bottom-up propagation.
2. Define requirements for the defined prototypes.
3. Prepare a Test Plan for the defined prototypes.
4. Based on the requirements in point 2 and Test Plan in point 3, prototypes are designed up to the point where they can be manufactured. In order to start the manufacturing, the designed prototypes shall be approved by EST-PO.
5. All the subsystems shall have consolidated analyses and simulation models.
6. Refining the proposal design solutions.
7. The contribution of each part within error budget in a bottom-up strategy. In bottom-up strategy, the lowest level values of the error budget must be linked with the product tree components which affect that value. Analysis will be made from engineering magnitudes and for specific conditions to produce values at the lowest values of the error budget. The analysis will be parametrized so that it is possible to play with the parameters and observe the influence on the error budget.

**Phase 2 starts:** at the completion of the Phase 1.

**Phase 2 end:**

1. Holding the interfaces consolidation meeting and acceptance by EST-PO of the associated deliverables and the closure of associated actions.
2. Submission of Phase 1 Data Package.
3. Revision of Phase 1 Data Package in Phase 1 Review Meeting and acceptance by EST-PO of the associated deliverables and the closure of associated actions.

**4.2.3 Phase 3**

The main objectives of Phase 3 are: finishing the production of the prototypes, define test procedures for the prototypes, testing the prototypes and validate the design with the results of the performed
tests. Phase 2 also includes the submission of all the documentation for the PDR and its modification after the PDR meeting.

Within the framework of the Phase 3, the CO shall:
1. Conclude the production of the prototypes.
2. Prepare the detailed Test Procedures for the prototypes.
3. Carry out the tests with the prototypes.
4. Validate and update the design incorporating the results from the performed tests.
5. Report all plans from the manufacturing to the commissioning.
6. Report the main facilities required for manufacturing and commissioning the system.
7. Report the selection of the main commercial components.
8. Prepare the specifications for a future tender of M2 assembly detailed design and construction.
9. RAMS analysis must be included at preliminary design level.

The works in Phase 3 shall be finished for PDR in such a level that the next tender of detailed design and construction can be addressed. This must include:

1. The consolidated specifications for the future tender of detailed design and construction ready to be published.
2. The analysis of the models must be updated and finished with the inputs of the prototypes. The discrepancies between prototypes and models must be corrected or accurately argued.
3. The M2 assembly Preliminary Design. It must be at a level that the fulfilment of all the requirements can be verified by analysis, design or test in prototypes.
4. Specifications for new prototype that will be defined during this phase in order to cover the verification of the requirements not successfully covered previously, if any.
5. The Final Error Budget. It must include all its components filled with values developed with bottom-up analysis.
6. Design and/or Selection of all parts of the subsystem with a preliminary design level, including the design of the interfaces.

After the PDR meeting, there shall be a last submission with an update of all documents after closing all the defined actions.

**Phase 3 starts:** at the completion of the Phase 2.

**Phase 3 end:** with the PDR meeting and when all actions of the PDR meeting are closed.

### 4.3 Project Schedule and Key Milestones

The time estimated for the development of the PDS shall not exceed the 78 weeks from the start of the contract to the reception of all deliverables and pass the PDR.
## Statement of Work for the preliminary design of the adaptive secondary mirror for the European Solar Telescope

**Code:** EST-0M2-EPO-SOW-0019

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Statement of Work for the preliminary design of the adaptive secondary mirror for the European Solar Telescope

**Code:** EST-0M2-EPO-SOW-0019

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**Table 1 Project Schedule & Key Milestones**

All the video-conference meetings will be recorded to guarantee that the information under discussion will be accessible by both parts if it's needed. The records will be kept at the PO.

### 4.3.1 Kick-Off Meeting

The objective of the Kick-Off meeting is to confirm the understanding of the scope of work specified by both sides. It includes the update of the applicable specifications at this time, to clarify and confirm the plans for the execution of the contract.

On the side of client, the EST-PO shall:
1. Introduce key resource of his team and contact person.
2. Present the status of the project, presenting the update baseline design and specifications.
3. Present the main guidelines for the development of the design.

And the Contractor shall:
1. Present his project plan, schedule and work breakdown structure.
2. Introduce key resource of this team.
3. Make a technical presentation of the project.

EST-PO and the CO shall:
1. Review all the requirements.
2. Review and agree the differences between the requirements published for the tender and the new version delivered by EST-PO, if any.

The CO shall take the minutes of the meeting and record the actions items.

### 4.3.2 Progress Meetings

The optimal development of the project requires that Contractor and EST-PO keep in touch frequently to follow the potential drifts from this statement of work. For this reason, progress meetings will be held in the periods when there are no others meetings.

The progress meetings will be held by teleconference or in the CO premises. This is a decision to be
taken by EST-PO. In the case that EST-PO decides to hold one the meetings in the CO premises it will be communicated 1 week in advanced to the date of the meeting.

Two days in advance to the progress meeting date, the Contractor shall provide a Progress Report. It will include the evolution of the tasks mentioned in this SOW and the open actions items from previous meetings.

The Contractor shall take the minutes and Action Items List, keeping it updated. The Action Items List shall be regularly updated and attached to the minutes. In addition, the minutes shall be signed by both parts.

4.3.3 Review meetings

These review meetings conclude the activities of the defined milestone.

There must be a closed and regular interaction between the CO and EST-PO. These will allow building up the documentation that the CO will have to produce within the framework of Phase 0 and Phase 1, in a progressive and coordinated way. To this end, the CO is encouraged to submit to EST-PO drafts or outlines of said documents as soon as they are reasonably complete, for comments and feedback.

The procedure for Review Meetings applies to the review meetings of all the milestones shall be as follows:

**The review panel:** the review chairperson shall be appointed by the EST_PO. The reviewers will be nominated by the chairperson. EST-PO has the right to add, in his review panel, external experts on opto-mechanics or other disciplines.

**Four weeks** before the review meeting, the Contractor shall seek EST-PO approval of the final list of documents that will be part of the Phase Data Package. **Two weeks** before the Review Meeting, the Contractor shall deliver the data package to EST-PO. EST-PO Review board members shall review said documents and submit to the Contractor Review Items Discrepancies (RID), not later than **1 week** before the Review Meeting. The Contractor shall provide answers to the RID in written form at least **3 working days** before the Review meeting.

The agenda of the Review Meeting shall be agreed upon between the CO and the EST-PO. The Review Meeting shall include, as a minimum, the following items.

1. A concise presentation of the baseline design and of the analysis and trade-offs supporting it.
2. In the case of the Phase 1 Review Meeting, it will be particularly focus on the different trade-offs and their pros and cons with respect to the requirements that will be agreed by CO and EST-PO during launch trade-off meeting.
3. The CO’s answers to all RID shall be presented at the Review Meeting. EST-PO reserves the right to accept or reject each answer to the RID.
4. The detailed planning for the subsequent project phases.

Minutes of the Review meeting shall be taken by the CO and signed by both parts.

The Review Meeting milestone is successfully met when all actions are closed.

4.3.4 Interface Consolidation Review

This review consolidates the external and internal interfaces of the M2 assembly. Draft version of the ICDs of all the related interfaces shall be delivered in DL.2.

During the meeting, the proposed interfaces shall be presented by the CO.

After the meeting, the agreed interfaces will be approved by the EST-PO and the ICDs shall be used by other COs of other subsystems of the telescope until the end of the PDS.

The Interface Consolidation Review is successfully met when all actions are closed.

4.3.5 Prototype Test Readiness Review

In this milestone, the status of the prototypes and the test procedures will be reviewed before starting the test campaign.

4.3.6 Prototype Test Review

In this milestone, the results from the prototypes test campaign will be reviewed.

The EST-PO shall witness, in the CO premises, a total or partial repetition of the tests carried out and documented in the Prototype Test Report. The tests to be witness will be chosen by the EST-PO.

4.3.7 Preliminary Design Review Meeting

The PDR at the end of the Phase 3 is particularly important and it is described in this section. It includes the review of the PDR Data Package, this review concludes the activities of the Phase 3 and closes the preliminary design of the M2 Assembly.

The Review Meeting shall include, as a minimum, the following items:

1. A concise presentation of the preliminary design and of the analysis supporting it and the prototype test results. As well as all the technical aspect of the design.
2. Presentation of the preliminary design solutions and the compliance of the detailed specification matrix.
3. Presentation of the requirements specifications for the future tender that shall include detailed design and construction.

4. Presentation of schedule for the future tender that shall include detailed design and construction.

5. Presentation of cost estimation (detailed design, construction, integration and maintenance and operation)

6. Presentation of the M2 Assembly error budget.

7. Presentation of the subsystem interfaces.

8. Presentation of the production, assembly, integration and verification in the factory and in the telescope.

9. Presentation of RAMS and FMEA analysis and PDR level.

10. The Contractor’s answers to all Review Item Discrepancies shall be presented at the Review Meeting. EST-PO reserves the right to accept or reject each answer to the Review Item Discrepancies.

### 4.4 Deliverables

#### 4.4.1 Deliverables List

All the hardware produced by the CO shall be property of the CO, with the exception of the prototypes, which ownership shall be of the EST-PO at the end of the contract.

The Deliverable Item List includes documentation and prototypes. See section 4.3 for the definition of the Key Milestones.

<table>
<thead>
<tr>
<th>Nº</th>
<th>Description</th>
<th>Delivery event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Progress Report</td>
<td>2 working days earlier than the corresponding progress meeting.</td>
</tr>
<tr>
<td>DL.1</td>
<td>Phase 1 Data Package</td>
<td>KM. 2</td>
</tr>
<tr>
<td>DL.2</td>
<td>Interface Proposals</td>
<td>KM. 4</td>
</tr>
<tr>
<td>DL.3</td>
<td>Phase 2 Data Package</td>
<td>KM. 6</td>
</tr>
<tr>
<td>DL.4</td>
<td>Prototype Test Procedures</td>
<td>KM. 8</td>
</tr>
<tr>
<td>DL.5</td>
<td>Prototype Test Report</td>
<td>KM. 10</td>
</tr>
<tr>
<td>DL.6</td>
<td>PDR data package</td>
<td>KM. 12</td>
</tr>
<tr>
<td>DL.7</td>
<td>Final Documentation</td>
<td>KM. 14</td>
</tr>
<tr>
<td>DL.8</td>
<td>Submission of the prototypes</td>
<td>KM. 15</td>
</tr>
</tbody>
</table>

Table 2. Deliverables and the key milestone associated.
4.4.1.1 Progress Reports

Progress reports shall provide a brief account of the progress of the work done by the CO, encompassing all aspects, in accordance with the requirements provided in AD 1 and within the time frame specified herein.

Progress Reports shall be delivered to the EST-PO in electronic format. The Configuration Item Data List updated at the time of release of a progress report shall be attached to said progress report.

Progress reports shall include the draft agenda of the corresponding, forthcoming progress meetings.

4.4.1.2 DL1: Phase 1 Data Package

The Phase 1 Data Package shall cover all activities undertaken in the Phase 1. Its objectives are to document the baseline design, the trade-off carried out and the first model of the proposed design. The Phase 1 Data Package shall include at least the following deliverables:

1. A set of change request to the EST-PO specifications.
3. Risk Register. Identifying the most risky requirements.
5. Reports for each trade-off carried out.
6. Filling Error Budget most critical contributions based on analysis.
7. Compliance matrix specifications status.
8. Updated Risk Matrix.
9. All source code files used for design, analysis modelling and whatever files are needed to fully reproduce the results included in the data package documentation.

4.4.1.3 DL2: Interface Proposals

This Data Package shall include proposals and draft versions of the ICDs for all the external and internal interfaces of the M2 assembly.

4.4.1.4 DL3: Phase 2 Data Package

The Phase 2 Report and Data Package shall cover all activities undertaken in this Phase. The data package shall include at least the following deliverables:

1. Phase 1 design and analysis Report.
   a. Design Proposal for the M2 assembly and auxiliary equipment.
   b. FEM.
   c. Thermal Analysis.
d. Control analysis & Simulation (including Simulink models).
  e. Preliminary EMC analysis.
2. M2 assembly subsystems specifications.
3. M2 assembly external and internal ICDs.
4. Preliminary construction proposal
5. Preliminary operation plan.
6. Updated compliance matrix.
7. Updated error budget with bottom-up values from the design and analysis report.
8. Update Risk Matrix.
   a. Prototypes specifications.
   b. Prototypes Design.
   c. Prototypes Manufacturing Plan.
   d. Prototypes Test Plan.
10. All source code files used for design, analysis modelling and whatever files are needed to fully reproduce the results included in the data package documentation.

4.4.1.5 DL4: Prototype Test Procedures

This Data Package shall include detailed procedures for the execution of the prototypes test campaign defined in the Prototypes Test Plan.

4.4.1.6 DL5: Prototype Test Report

This Data Package shall include the prototypes test reports including at least the following documents:
1. Test Results Summary.
2. Test Campaign Logbook.
3. Test results, including raw data and post processed files.
4. Test results compliance matrix vs prototypes specifications.

4.4.1.7 DL6: PDR Data Package

This Data Package shall include at least the following deliverables:
1. Final version of the Preliminary Design report including Analysis Report.
   a. FEM.
   b. Thermal Analysis.
   c. CFD Analysis.
   d. Control analysis and Simulation (including Simulink models).
   e. Preliminary EMC analysis.
2. RAMS Analysis.
4. Risk Matrix.
5. Construction proposal.
6. Operation plan.
7. Preliminary Design Error Budgets with bottom-up values from the design and analysis report consolidated by the results of the prototypes test campaign.
9. External and internal ICDs.
10. Detailed design, Manufacturing and AIV plan including schedule and cost estimation.
11. All source code files used for design, analysis modelling and whatever files are needed to fully reproduce the results included in the data package documentation.

4.4.1.8 DL7: Final Documentation

Update of all the documentation in DL.6 according to the actions defined in the PDR meeting.

The documents in the Final Documentation Package that will be used for the next tender for detailed design and construction such as the specifications shall follow the format template strictly described by EST-PO.

All the updated source code files used for design, analysis modelling and whatever files are needed to fully reproduce the results included in the final documentation.

4.4.1.9 DL8: Submission of prototypes

At the end of the contract the prototypes shall be delivered to the EST-PO by the CO. The responsibility of the CO is to package and transport the prototypes and deliver them in the EST-PO facilities in Tenerife.

5. **PROJECT MANAGEMENT**

1. The Contractor shall implement a Project Management Plan to control the project.
2. The Project Management Plan shall have an organisational structure of the project including responsibilities and the authority of each function in the organigram. This organisational structure must include the subcontractors.
3. The principal point of contact shall be the Contractor’s Project Manager.
4. The Contractor’s Project Manager shall have full authority to deal with all matters relate to the contract, including but not limited to technical matters.

5.1 **Project Plan**

1. Along the lines of the Work Breakdown Structure, the CO shall implement a Project Management Plan.
2. Deviations from the Project Management Plan shall be reported to EST-PO, for approval insofar as such deviations may affect the contractual timeline, for information if not.
3. The Project Management Plan shall be updated or reconfirmed with each Progress Report.
4. The Contract shall establish a detailed planning, including detailed networks, dependencies, bar charts, milestones, resource allocation, etc.

5.2 Documentation

5.2.1 General
The following general rules shall be followed by the CO:

1. The CO shall set and operate a centralized documentation system.
2. The CO shall maintain documentation lists of all documents generated or received.
3. The lists shall be accessible to EST-PO.
4. The document numbering system shall comply with the EST-PO codification.
5. The ESP-PO establishes English as the language for the documentation of deliveries, unless Spanish is explicitly specified for a particular document in this SOW.
6. All deliverable documents shall be delivered in electronic format to EST-PO at the Instituto de Astrofísica de Canarias headquarters.
7. The Final Documentation Package in paper format shall be delivered in duplicate.

5.2.2 Files format
The files delivered by the Contractor must fulfil the following formats:

1. CAD models: Format must be PTC/Creo native format, version 5.0 or earlier. It is also acceptable STEP format (ISO 10303).
2. FEM/CFD models: Format must be compatible with ANSYS, version 19.0 or earlier (preferably ANSYS native format).
3. Drawings model: Format must be DRW (PTC/Creo native format, version 5.0 or earlier). It is also acceptable DWG format. In any case, a copy in PDF format must also be provided.
4. The optics analysis must be done with OpticStudio by Zemax.
5. Control simulation model and scripting:
   a. Matlab R2010b or compatible.
   b. Simulink 7.6 or 100% equivalent.
   c. Python 2.7.
6. Documents can be chosen between the following options:
   a. PDF format
   b. Microsoft Word 2013 or 100% compatible.

5.2.3 Templates
Document templates shall be developed starting from the EST Project templates and getting to an agreement between CO and EST-PO. Drawings templates shall be developed starting from EST-PO
templates.

The template shall contain at least:
1. The EST Project identification (logo).
2. The EST code (to be provided by the EST-PO).
3. The date and the revision number.
4. The status of the document.
5. The changes control table.
6. The applicable and reference documents table.
7. Table of contents.
8. A hierarchy numeration of the sections of the document in order to be easily referenced.

The documents in the Final Documentation Package that will be used for the next tender for detailed design and construction, such as the specifications, shall follow the format template strictly described by EST-PO.

The ICDs shall follow the internal structure and template provided by EST-PO.

5.2.4 Design reports

The design reports shall include at least the following sections:

The design reports shall include at least the following sections:

1. Scope
2. Applicable documents
3. Assumptions
   a. Design constrains
   b. Environmental conditions others than specified in AD 1.
   c. All calculations methods
   d. Maintenance constrains (if applicable)
   e. Access constrains (if applicable)
4. Materials. A list of the main materials used in the design and their physical and mechanical properties.
5. Design description. A complete description of the design addressing all the requirements in the specifications AD 1.
6. Calculations and analysis. This section can be divided in a separated report if it becomes too large.
   a. Assumptions
      i. For the model.
      ii. Defining the boundary conditions
      iii. Defining the material properties.
      iv. Defining load and loading cases.
      v. Used in processing the results.
      vi. Methods.
   b. Model
      i. The geometry.
ii. Type of elements used.
iii. Correspondence between the model and the actual modelled component.
   c. Loading cases
   d. Results. Comparing the results with the specifications that the model must fulfil.
7. Conclusions. The compliance of the results must be stated in this section.

5.2.5 Units
The Contractor shall use the international system of units (kilogram, meter, second, ampere) with multiples and submultiples.

5.2.6 Dates
The date system shall follow the format: day-month-year.

5.2.7 New editions of documents
Every new edition of any document or drawing shall be clearly identified by the CO.

6. CONFIGURATION MANAGEMENT

6.1 General
The following general rules shall be followed by the CO:
1. The CO shall develop a configuration control system, to make sure proper configuration control is implemented.
2. The Configuration Control Plan will document it and may form part of the Management Plan.
3. The Configuration Management, including but not limited to specifications, must ensure that the configuration of the deliverable items is in-line with the pertinent documentation.
4. Identifying each document, drawings, subsystem or part, establishing the item configuration and relation to the hardware and software at any time in the project;
5. To ensure that all personnel who use, write, authorise, process and distribute documents and changes to documents are aware of the impact of changes and their evaluation;
6. To ensure that all the data are received, coded, recorded, and released in an orderly, centralized and consistent manner at one central point.

6.2 Configuration Item Data List (CIDL)
1. The CIDL is a basic document for configuration control. It shall contain the list of all documents that define and describe the M2 system.
2. The CIDL shall list all documents from the following categories:
   a. Requirements
   b. Definition of hardware and software, product tree.
   c. Design and analysis documentation
   d. Interface control documents
   e. Lists (parts, material, components)
   f. Manuals and handling procedure
3. The CIDL shall be updated with each progress report, if there are changes.
6.3 Change and waiver procedures

6.3.1 General

Definitions applying:
1. A Change is a modification of a contractual clause, such as schedule, cost, delivery, specification.
2. A Change Request (CRE) is the formal request made by EST-PO or the CO proposing a Change to the Contract or any of its applicable documents.
3. A Request for Deviation (RFD) is a formal request by the Contractor to EST to allow an exceptional deviation (non-compliance) from a requirement to the contract.
4. Approval by EST of a Request for Deviation constitutes a one-off acceptance of the subject deviation and shall not be considered as a precedent for subsequent deviations.

The Contractor shall use EST-provided forms for CREs and RFDs.

6.3.2 Change Request (CRE)

1. EST-PO or the CO may propose at any time a change to be introduced into the contracted scope of work. Such change may cover contractual conditions, schedule, or performance.
2. In this case, the initiator (the CO or EST-PO) submits a Change Request (CRE) to the other party. Justification for such change shall be included. Technical, cost and schedule implications to EST shall be provided in a concise and quantitative manner. The receiving party shall respond to any such Change Request within 3 weeks of its receipt.
3. When preparing a Change Request, the proposed change shall be thoroughly investigated and EST-PO provided with all information needed for a decision, including, but not necessarily limited to:
   a. The reason for the change.
   b. Assessment of the technical and performance impacts on the total system/other subsystems.
   c. The affected documents. The necessary modifications of the contractual documents (Spec., SOW, ICDs etc.) shall be clearly indicated by quoting the old and proposed new versions of the text or the drawing.
   d. Schedule impact on key milestones (including detailed schedule of the change implication).
   e. Total cost impact (giving detailed information on the manpower, material, cost etc., and reflecting the differential cost for changes in work packages).
   f. Other related factors such as reliability, safety/integrity, maintenance, etc.).
   g. Additional documents as needed to justify the change.
4. Each Change Request shall be identified by an individual and unique number, which shall be used in all subsequent correspondence.
5. Implementation of the requested changes shall not begin before the written authorisation by the receiving party.
6. The Contractor shall maintain a change status list, which shall track all initiated CREs with their status (approved, rejected, pending) and provide an update together with the regular reports.
6.3.3 Request for Deviation

1. The CO may submit to EST-PO a Request for Deviation (RFD) in order to obtain exceptional relief from a contractual obligation.
2. A RFD shall not be used to request changes to contractual requirements. A RFD can cover only one or a limited and specified set of requirements.
3. Any RFD shall be supported by a Non Conformance Report.
4. A RFD shall include at least the following information:
   a. The reference of the items to be covered by the RFD.
   b. The consequence of the discrepancy on the contract conditions, schedule and performance of the unit.
   c. The consequence of the discrepancy on the safety, reliability and performance of the item(s) concerned and of the higher assemblies into which it is to be incorporated.
   d. The corrective actions taken by the Contractor to prevent recurrence.
5. Each RFD shall be identified by an individual and unique number, which shall be used in all subsequent correspondence.
6. The decision to reject or accept a RFD is under EST-PO’s responsibility, and be taken after assessment of the information provided in the RFD.
7. EST shall reply to a RFD within 2 weeks.

6.4 Safety

The Contractor shall implement and maintain through all project phases a quality assurance and safety approach. In addition to the specified safety requirements and where not explicitly stated otherwise the Contractor shall fulfil also all national safety laws and legislation applicable to the design, development, manufacturing, installation and operation of the contracted item.