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For Information

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1. **Executive Summary**

The first major achievement of the last six months was the signature and kick-off of the contract for the Dome and Main Structure (DMS) with the ACe consortium (Astaldi, Cimolai, and their nominated-subcontractor EIE). This was a major milestone to secure ESO’s current schedule targeting at First Light in 2024 and the cost-to-completion. This contract is the largest contract ever placed, not only in ESO’s history but also in the whole of ground-based astronomy.

The second main achievement over the last six months was the signature of the contract with REOSC on 6 July for the polishing of the M2. Due to its high aspheric shape, this mirror, when finished, will arguably be a true jewel among ground-based astronomical telescopes. Its early procurement was necessary to mitigate the schedule risk associated with its manufacturing challenges (in particular testing) and to secure the E-ELT First Light by the end of 2024.

A third critical milestone was the Council resolution at its June meeting to authorise the ‘placing all E-ELT Phase 1 procurements on a baseline schedule leading to first light in 2024, which might require taking up a loan from the EIB.’ This decision was needed to be able to place the M2 polishing contract at that point in time.

The second and third quarter of 2016 saw the following significant achievements:

1) Signature of the contract with the ACe consortium (Astaldi and Cimolai with their nominated subcontractor EIE Group) for the design, construction and commissioning of the Dome and Main Structure (DMS) on 25 May, followed by the kick-off meeting on 16 - 17 June;
2) Signature of the MOS and HIRES Phase A studies;
3) Approval by the FC in May to award the M2 polishing contract to REOSC and signature of the contract on 6 July;
4) Authorisation from Council to keep the baseline target of First Light for Phase 1 in late 2024, even if this might require taking up a loan at the EIB;
5) Good progress with the running industry contracts and instruments consortia agreements;
6) Completion of the contract closure negotiation with ICAFAL for the Road and Platform and completion of the additional work related to the last amendment (preparation of the Dry Coolers Platform, additional safety meshes, crash barrier and other minor works);
7) First stone event (27 May) with SAESA for the construction of the Chilean electrical grid to bring it to Armazones/Paranal, securing the planned connection date by autumn 2017;
8) Evaluation of the offers for the Medium Voltage Sub-stations (for the connection to the Chilean grid) to be submitted for FC approval in September;
9) Evaluation of the offers for the M2 and M3 Cells to be submitted for FC approval in November;
10) Evaluation of the offers for the M1 Segment polishing to be submitted for FC approval in November;
11) Evaluation of the offers for the M1 Edge Sensors to be submitted for FC approval in November.
12) Negotiation of contracts for the M3 polishing and for the M2 and M3 blanks to be submitted for FC approval in November;
13) Release of the CFT for the M1 Position Actuators (PACT);
14) Conclusion of a market investigation for the coating plants of the M1 segments and other mirrors, useful info for the planning of infrastructures, as well as to define strategies for the AIV;
15) Finalisation of the report on cross-contract risks and related logistics aspects;
16) Agreement on a new single interface for all instruments on the Nasmyth Platform (3m spacing, stiffer flanges);
17) Definition and release of the procedure for changes that affect schedule and budget within the Programme.

In summary, this semester has been rich in major milestones needed to secure ESO’s target of First Light in late 2024.

2. E-ELT Programme Organisation

Following the departure of the ELT AIV Manager, a slight reorganisation has taken place. The existing AIV team, led by a new AIV Manager, will now work under direct supervision of the Programme Engineer. In that context, an internal vacancy notice has been recently published for the position of Programme Engineer. Over the last year, this role was shared between the Programme Manager and the System Engineer. With the increasing number of running contracts and general workload, this configuration could not be maintained much longer.

Another reassignment was necessary (Edge Sensor contract management) as a consequence of the reorganisation within the Directorate of Engineering.

3. Financial Status

- confidential information -

4. ELT Construction

4.1 Programme Office

4.1.1 Programme Management

The Programme Management office continued to put high priority on supporting the procurement activities.

During this reporting period (April - September 2016), attention was first focused on the final negotiation and signature of the Dome and Main Structure (DMS) contract (the largest contract in ESO’s and even world ground astronomy’s history). The signature ceremony (25 May) was attended by the Italian Minister of Education, University and Research as well as the highest representatives of ASTALDI, CIMOLAI, EIE Group and ESO. The kick-off took place on 16 - 17 June.
Subsequently, the focus moved to Optomechanics procurement (M2 polishing, Blanks, M3 polishing, Edge Sensors, etc.). Much attention was also brought to the final negotiation and FC approval of the M2 polishing contract, arguably the most difficult polishing contract to be placed for the E-ELT. Following FC approval in May, the contract signature took place on 6 July with REOSC.

Another critical activity had been the preparation of the documents for the Council meeting in June to authorise ESO to proceed with the plan for First Light in late 2024. In its new resolution of 7 June, Council authorised the Programme ‘placing all E-ELT Phase 1 procurements on a baseline schedule leading to first light in 2024, which might require taking up a loan from the EIB.’ This decision was needed in a timely manner in order to sign the M2 polishing contract, and to proceed with the running procurement processes.

Significant effort went into negotiating the closure of the contract with ICAFAL for the Road & Platform without having to go to arbitration. An amendment was agreed with ICAFAL, and approved by FC, to complete some site preparation work needed before the DMS contractor mobilises on-site in 2017. This work is now completed.

The FTE request process was supported and completed in time. The consolidation at Programme level ended with a slight increase of FTE requests as compared to the previous plan. This is partly due to under-expenditure of FTEs in 2015. On the other hand, the AIV overall plan is now being finalised and the impact on FTEs for on-site activities is being carefully assessed.

Owing to the current perspective for additional funding for Phase 2, ESO has initiated a detailed impact analysis of a Phase 1-only Programme, not only on the science capabilities but also on the technical/engineering baseline and on managerial (schedule), contractual and operational aspects.
Other activities have included:

- Presentation of the Programme status to the round of committees (ESC, STC, FC, Council);
- First overall strategic exchange with the CTA project about potential collaboration, interfaces and synergies with the E-ELT and Paranal Observatory (e.g. logistics, rooms, etc...);
- Coordination of E-ELT participation to the SPIE conference in Edinburgh (approx. ten papers);
- Systematic review of property insurance needs to cover those items that become ESO property well before being shipped to the site;
- Follow-up of the preparation for a Construction All Risk (CAR) Insurance. Following latest negotiations with ACe, the DMS CAR insurance will remain as part of the DMS contract. A CAR for the other elements can now be prepared. The original plan for an FC approval in November is not necessary anymore as other contractors will start activities significantly later than DMS;
- Update of the Programme Management Plan and the Work Breakdown Structure (WBS) to include various minor clarifications of tasks and responsibilities, in particular in the area of contract management and follow-up;
- Participation in the first stone ceremony for the construction of the Paranal/Armazones connection to the Chilean Grid. The ceremony on 27 May was attended by Chilean authorities and the highest management representatives of ESO and SAESA;
- On-site visit with the President of Astaldi;
- Provision of E-ELT contribution to the Budget Forward Look (BFL);
- Preparation of the new format for reporting to the ESC (fact sheets);
- Initial preparation for the 3rd EMAC Meeting (1 – 2 December 2016);
- Presentation of the E-ELT Programme and its current status at the large aeronautic fair (FIDAE 2016) in Santiago, Chile end of March and at the PACMAN workshop organised in June by CERN on nanometre-level metrology and control;
- Routine meetings with the ESO Directors (oversight meeting), DOE Heads of Department and with the entire team working on the E-ELT.

4.1.2 Systems Engineering

Continuing from the previous reporting period, further work on the M1 Segments coating strategy has been done; this is connected to the M1 Edge Sensors calibration and to the number of tolerated missing segments, which depends on the science case. Moreover, the latter affects the reliability requirements of the M1 components, on which an analysis has been performed as part of RAM activities. Optimising the coating strategy considering all these aspects is under progress. Apart from this, some other system-level issues have been addressed (e.g. interface between the Main Structure and the M1 Segments, risk of failing M1 Segments, etc.).

The review of the Product Breakdown Structure (PBS) to identify any possible mismatch with the Work Breakdown Structure has been completed. As a result, a new version of the PBS is about to be released; it also incorporates some items that were not explicitly shown in previous
versions, in particular the ones for Assembly-Integration-Verification, as well as some changes in the Pre-focal Station decomposition.

Considering RAM aspects as well as budget and contractual constraints, a spares policy at Programme level has been defined and is under discussion with the Contracts & Procurements Department.

Progress has been made in linking E-ELT Level 1 Requirements to Top-Level Requirements, which is almost finished, and in connecting sub-systems specifications and technical budgets to Level 1 Requirements. Linking of requirements is of paramount importance for configuration control.

Significant effort has been devoted to the technical budgets, which are fundamental tools for allocating requirements to sub-systems. The power supply budget is ready and just waiting to complete the coolant supply and heat dissipation budgets, given the close relation among them. The system pre-setting time (after pointing to a new object) budget has been finalised. The production of two new budgets, namely the computer room space and the system start-up budget, has recently started. In addition, the performance and stroke budgets are under revision.

SE keeps defining and prioritising the PAV (Performance Analysis and Verification group) tasks. The activity in the reporting period has focussed mainly on consolidating the Pre-focal Station user requirements, providing replies to telescope performance related questions coming from instrument consortia, analysing the impact of missing M1 segments on AO performance and consolidating the wave front control strategy.

SE has led the release and setup of the M1 Edge Sensors procurement documentation package for tendering. The same applies to the M1 Positioning Actuators (PACTs). SE has played a prominent role in the review of the documents aiming to ensure consistency with the system approach and interfaces.

SE has been actively involved in the technical discussions with the DMS contractor regarding the technical specification and applicable ICDs and interface drawings. After finalising this, the complete package of the technical and managerial documents has been released.

4.1.3 Programme Science

During the reporting period, the E-ELT Programme Science provided continuous and proactive scientific input across the various E-ELT work packages, to facilitate the definition of the sub-system requirements and ensuring that the Observatory Top Level Requirements are met. In particular, the E-ELT Programme Science is supporting the definition of the requirements for the Pre-Focal Station and the Calibration strategy, as part of the Operation and Calibration strategy for the telescope and instrumentation. The E-ELT Programme Science further pursued the definition of the E-ELT requirements in terms of end-to-end science data flow and possible coordination with Paranal.

The E-ELT Programme Science continues supporting the development of the first generation instruments (MICADO/MAORY, HARMONI and METIS) during their PDR phase and attended
their science consortium meetings. The E-ELT Programme Science is also closely following the development of the Phase A study for MOS and HIRES. Substantial work has been carried out to coordinate the activities of the Project Science Team to support the Consortium science teams in defining the technical specification of the new instruments and the impact on science.

As part of the engagement with the public and the scientific community, the E-ELT Programme Science presented the status of the programme and its scientific goals to various conferences and workshops, including, among others, the ESA-Euclid annual meeting, the TMT science forum, the German/Dutch Astronomy meeting and a JWST meeting with the aim of enhancing synergies between these new facilities. The E-ELT programme was also presented at the Irish National Astronomy meeting, and received as one of the highlights and strong motivation for Ireland that it possibly joins ESO.

To enhance this engagement with the scientific community, ESO also started providing monthly updates of the E-ELT Programme via the ESO Science Newsletter and also proposed an E-ELT Symposium for the next AIU General Assembly in 2018 in Vienna.

4.2 Dome and Main Structure

The events of the past 6 months mark the positive end of the long process of tendering of the Dome and Main Structure of the E-ELT, initiated in 2012 with the issuing of the Preliminary Inquiry for the DMS, and concluded with the signature on 25 May 2016 of the contract for the “Design, Manufacture, Transport, Construction, on Site Assembly, and Verification of the European Extremely Large Telescope” with the Italian Consortium Astaldi-Cimolai and their nominated subcontractor European Industrial Engineering Group” (ACe).

As background information, that the offers for the second stage of the CFT were received in July 2015, followed by a minor update related to the recently decided chiller plant location in September 2015. The evaluation report of the offers was submitted and approved by the Contract Award Committee in November 2015. In the second half of November and during December, ESO negotiated with the winning bidder the final price and the payment plan, and started the redaction of the proposal for approval by the FC on 3 February 2016. The Finance Committee approved the award of the DMS contract to the selected bidder (ACe), and by doing this, also left open the possibility to maintain the original ESO target of achieving first light in 2024.

Astaldi is a major Italian construction company active worldwide and well established in Chile with various running projects. Cimolai is one of the top ten European steel structure manufacturers, equipped with their own sea-berth for shipment of very large assemblies, and involved in large projects like bridges, stadiums, metro stations and the likes. The European Industrial Engineering Group will act as design subcontractor and brings extensive experience in telescopes and enclosures.

The detail negotiations started shortly after the FC approval in February and extended until mid of May 2016. ESO had requested a number of modifications in the ICDs and in the specification, to take into account the evolution of the E-ELT design, the most significant one being the introduction of an optional Nasmyth interface to the instruments. In a long and complex process of face to face meetings, video and teleconferences, ACe agreed to
incorporate all changes, without effect on price, performance or delivery schedule. No change of contractual conditions, including relaxation of the specification or less than very minor changes in the statement of work were introduced in the final contractual documents. The signature of the contract took place on 25 May 2016 at ESO. The contract was signed by the presidents of both Astaldi and of Cimolai. The Italian minister of Education, University and Research attended the signature ceremony.

The kick-off meeting was held on 16 and 17 June at the Astaldi headquarters in Rome. The kick-off meeting is associated to the first payment milestone in the contract. At the kick-off meeting, the rules and procedures of interaction between the two parties were discussed and agreed as well as the planning of activities for the following months.

The first set of documents to be issued by ACe was delivered on time to ESO. ESO reviewed and commented them and is waiting for the update. A first Configuration Control meeting was held in July to agree on documentation exchange, numbering and archiving. Regarding the design, the ACe Consortium intends, in this first phase, to invest its effort in validating once more in depth the various solutions proposed in the offer, to avoid changes at a later stage. The first progress meeting took place at the designer's premises (EIE) at the end of July. At that meeting, ESO was presented in detail with the ongoing process of optimisation of the design of the DMS, starting from the bid technical proposal, and the reasons (manufacturability, easiness of assembly, etc.) justifying the study of possible alternatives. All these alternative design solutions were discussed with ESO, and will be the subject of dedicated meetings and review during the Preliminary Design Phase, spanning approximately twelve months.

In September, a joint visit was performed at the Armazones sites (ATP and ABC) to see the final status of the mountain at completion of the site work. During the spring negotiations, ESO and ACe had agreed on the exact location and on the shape of the dry-cooler platform. This work had been contracted by ESO to ICAFAL and was inspected upon its completion. Various coordination issues related to the future handover of Armazones to ACe were discussed, and are being followed, in view of the site handover in spring next year.

The second progress meeting was held at the end of September at the Astaldi premises in Rome. The most important result of the meeting was the closure of the agreement on the interface with the instruments at the Nasmyth platform. The original interface designed at the time of the FEED studies could possibly not be able to hold the loads coming from the instruments, in their most recent definition, with larger masses and higher earthquake loads. For this reason, ESO, as well as introducing an optional design of the interface in the ACe Contract, had started parallel technical negotiations with the various instruments consortia back in June, via videoconferences and face to face meetings, including one in Edinburgh at the SPIE conference. Having reached an agreement with both ACe and the Instrument Consortia, the new interface has finally been selected for the subsequent design work.

In the next period, the progress of the design work and other managerial issues will be followed in detail by ESO. A number of technical meetings as well as the next progress meeting for the whole of 2016 have been already reserved. In specific cases, ESO will also make use of their consultant Ramboll, to provide an independent and complementary opinion.
4.3 Optomechanics

The work has been very active in preparing and completing the procurements of M1, M2, and M3 Units. All tasks have been successfully completed in accordance with the planning, technical, managerial, and commercial requirements and expectations. A large portion of the optomechanics contracts will be submitted to the FC in November for approval.

The M2 Mirror polishing contract was signed, and development has started. This contract follow-up comes in addition to the other running contracts, i.e. M1 Segment Supports final design and qualification, M4 Shells manufacturing, M4 Unit design and manufacturing. Although the first difficulties are now being dealt with, the results are so far satisfying.

The procurement schedule has been kept as planned. Adjustments were required to better manage the constraints and dependencies between the different contracts and activities. The risk mitigation measures which were taken to minimise those dependencies have been successful and it was possible to reduce those risks. There are still critical items and the critical paths are well identified and focus remains on minimising the risks.

4.3.1 M1

The CFT for M1 Segments polishing was replied to by industry in June 2016, by one bidder only. A thorough review of the offer document package was followed by intensive iterations with the bidder during the period from July until September. Final negotiations were completed successfully by the end of September and the final offer is submitted to the FC in November for approval. The final offer well matches ESO's requirements and expectations, technically, managerially, and commercially.

The requirements for the supply of the M1 Segment blanks have been consolidated and have gone through a first iteration run with the supplier. A last iteration is necessary to take into account the results of the M1 Polishing contract discussions, although only minor adjustments are foreseen. So far, the first offer matches the requirements and expectations well, technically, managerially, and commercially.

Regarding the Segment Supports, the two parallel contracts for final design and qualification are not equally progressing. The design phases are either complete (VDL) or to be completed (CESA). On both sides, the manufacturing of the engineering models has started. There are risks of delay during the next phase, i.e. integration and testing of the engineering models, in both cases and in particular with CESA, although as of today, contracts completions are planned almost on time.

A Request for Information was prepared and released to prepare the procurement of the Segment Supports manufacturing, which is on the critical path. An industry day was held on that topic on 30 September. As this stage, there are no major topics to report.

As reported previously, the procurement of the M1 Edge Sensors had to be put on hold for legal issues. Following the Request for Information and Preliminary Inquiry, two bidders were qualified within the ESO Member States. However, a patent issue was putting high risk on ESO whatever the conclusion of a CFT would be. The two parties finally decided to join and
provide a common offer. A Request for Offer has been released by ESO to the newly formed legal entity. Although the schedule was tight, both ESO and the consortium worked very hard during the period from August until September to come up with a satisfactory offer. Final negotiations were held on 28 September. The best and final offer, found acceptable by all technical, managerial, and commercial teams, will be submitted to the FC in November 2016 for approval.

Having terminated the study on the prototypes of Phase B and related follow up, the procurement phase for the design, qualification, and manufacturing of the E-ELT Position Actuators (PACTs) was carried out as planned. Following the Request for Information and Preliminary Inquiry, the CFT was released on 23 September, replies being required on or before 19 January 2017. The PACTs supply contract is on track to be submitted to FC in May 2017, as planned.

Regarding the remaining E-ELT Optomechanics Phase B activities:

- The contract with OptiC Glynwr (manufacturing of Segment Prototypes) was closed, there is nothing to report any longer.

- The contract with LAM is not yet completed (Stress Mirror Polishing Demonstration, SMP). Although LAM could finally solve their problems with their Segment Warping mechanism, they discovered new serious issues with the final phase of this contract, consisting in polishing trials with their SMP fixture. ESO is discussing the way to solve the problem with them.

4.3.2 M2

The request for quote for the E-ELT M2 Mirror manufacturing (M2 Mirror polishing) was released. Very detailed and thorough discussions took place, at technical, managerial and commercial levels, until an agreement was found at the end of March 2016. The final offer was submitted to the FC in May 2016 and approved. The contract was signed on 6 July with SAFRAN-REOSC.

The first developments have started, in particular at the level of two critical aspects: the mirror mounting interfaces bonding (adhesive technology), and the technical specifications for the supply of the M2 Blank (the glass). The adhesive technology development is so far on track, and the M2 Blank specifications could be iterated with the blank supplier as scheduled. The other critical activities of this contract, as well as non-critical ones, are being addressed at the time of writing.

Being on time and not facing unsolvable difficulties in setting up the requirements for the production of the M2 Blank, iterations with the M2 Blank supplier have also been successful, technically, managerially, and commercially. The M2 Blank production offer will be submitted to the FC in November 2016 for approval.

However, last minute information from the blank supplier is worrying, as they may delay the blank casting (glass melting and in-mold pouring) for overall market demand needs. Although
they would still commit to the delivery date as required by ESO, this would be with zero margin. ESO is pushing to get the casting done as previously planned, in November 2016, i.e. with sufficient margin. The supplier has taken ESO’s request seriously into account, however the conclusions of their recovery plan are not available at the time of reporting.

The procurement phase of the M2 Cell (M2 and M3 Cells design and manufacturing) has been completed as expected. The replies to the CFT have been clarified, evaluated, and the selection process has been completed. The results are submitted to the FC in November 2016 for approval.

4.3.3 M3

The request for quote for the E-ELT M3 Mirror manufacturing (M3 Mirror polishing) was released in April (one bidder, see previous reporting) and the first offer was received by the end of June.

Very detailed and thorough discussions took place at technical, managerial and commercial levels. The negotiations were completed on 30 September 2016. The offer is submitted to FC in 2016 for approval.

Setting up the requirements for the production of the M3 Blank has been done in parallel with M2, as most of the requirements are identical. Iterations with the M3 Blank supplier (same supplier for M2 and M3 blanks) have also been successful, technically, managerially, and commercially. The offer for manufacturing the M3 Blank will be submitted to FC in November 2016 for approval.

The schedule issues reported on the M2 Blank (early casting) are nearly the same at M3 Blank level. As reported on the M2, the M3 Blank supplier is working on a recovery plan, however the conclusions are not known at the time of writing.

The procurement phase of the M3 Cell (M2 and M3 Cell design and manufacturing) was completed as expected. The replies to the CFT have been clarified, evaluated, and the selection process has been completed. The results are submitted to the FC in November 2016 for approval.

4.3.4 M4

Regarding the M4 Unit final design and manufacturing (AdOptica = ADS + Microgate in Italy) contract running since July 2015, there have been some delays during the design phase. Those delays do not affect the M4 Unit Final Design Review today, and a recovery plan has been established where necessary, however there are still schedule risks.

The design of the Reference Body, a very large Silicon Carbide lightweight structure, has been completed. The Reference Body manufacturing has started (Boostec, F).

Prototype electronics and actuators were assembled and tested successfully. Minor design adjustments are necessary, but nothing critical.
The breadboards and test plans for adhesive bonding qualification have been defined. Manufacturing has started.

The design review for the optical test set-up was successful.

Regarding the M4 Shells, all the blanks have been manufactured by Schott. Eleven blanks have been delivered to REOSC, one will be in the coming weeks. The production readiness review has been passed and REOSC started the production of the first two M4 shells. So far, the production schedule is on time, with increasing slack for the last shells (two years). The polishing of the optical surface of the first shell is planned to be finished in November 2016.

4.3.5 M5

The iterations with the potential vendors regarding the feasibility of an M5 Mirror made of brazed silicon carbide have continued. The iterations on the M4 SiC Reference Body allowed progress towards a well performing and feasible European solution for the M5 Mirror.

The procurement activities are planned to start in early 2017.

4.3.6 Lasers Projection Subunit

There is no specific work to report on the Laser Projection Subunit developments. Most of the work is performed as part of the VLT AOF development.

4.4 Optical Control

The project is preparing specifications for procured items with the main emphasis on the pre-focal stations. The PFS User requirements (TLR) have been reviewed and are close to release. A baseline set of cameras/detectors has been selected for the PFS sensor arms. The first version of the OCP management plan was released. A restructuring of the test camera with respect to the pre-focal station is being evaluated in response to a request from AIV. An area of concern remains the maturity of the wave front control requirements that will flow down to the OCP sub-system.

4.4.1 Pre-focal Stations

An updated ICD between the pre-focal stations and the dome and main structure was agreed between both sides and released. This ICD and associated drawings include the following main changes:

- Change from 23 Nasmyth attachment points to 4 Nasmyth attachment points;
- Access for personnel directly into the PFS design volume (no need to cross instrument volume any more);
- A volume allocated for a possible cable chain solution to the cable wrap.
A baseline set of cameras/detectors has been selected for the PFS sensor arms:

- Input has been provided to the specification of the wave front sensor detector to support the start of the development/procurement by the Technology Development programme;
- The imaging channel has baselined an existing detector.

A concept design of the sensor arm has started. This is needed, for example, to define design volumes and interfaces for the cameras/detectors that will be procured separately from the main system of the PFS and hosted in it.

### 4.4.2 Metrology

Coarse metrology technologies are being explored mainly in the frame of the VLT AOF project and in-house development at ESO with limited support from E-ELT. Multiline and laser tracker tests at Paranal UT4 were completed during the last period. The results show promise for this type of metrology for measuring rigid body motion of mirrors and maintaining collimation of telescopes.

### 4.4.3 Calibration Unit

User requirements for the calibration unit are pending.

### 4.4.4 Test Camera

High level requirements for the test camera are pending. The scope and organisation of the test camera are being restructured in response to a request from AIV.

### 4.5 Control System

The RFI for the Networking Infrastructure has concluded with detailed submissions from several vendors. After a round of specific questions to these vendors, a sample of the vendor's proposed networking equipment shall be benchmarked. This exercise will lead the decision on the final procurement strategy for the E-ELT Networking Infrastructure.

The Control Software development tools, models, environment and processes have been a central focus for the last six months. A suitable real-time platform has been identified, standards and tools for graphical user interfaces trialled and accepted, continuous build and test environments assembled and an iterative, agile development process (tailored to ESO’s matrixed organisation) successfully tested in-house. Further, first draft Software Configuration Management plans and Software Quality Assurance Plans were released for review.

The Core Integration Infrastructure (CII) software procurement plan is on schedule (Advanced Notice and Synopsis released) and continues in the next period with the CFT document preparation.
The M1 Local Control System final design phase has progressed well. The M1 electronics cabinet prototype now includes electronics for power distribution and control and prototype heat exchangers shown through analysis and modelling to achieve the required fan-less cooling efficiency. This is a part of the M1 Local Control System final design phase.

Contract with the University of Durham for installing a Stereo SCIDAR profiler at the focus of a Paranal AT was completed and instrument installation and acceptance at Paranal took place at the end of April 2016. A second commissioning run was performed successfully at the end of July 2016. The instrument is in position, ready for use when an AT is available.

4.6 Civil Infrastructure

The main contract aimed at building the E-ELT new road, the platform at the Armazones summit and the power trench, going from the Armazones Base Camp (ABC) to the Armazones Top Platform (ATP), was finished in October 2015.

The contract started on 3 March 2014 and was originally planned to be completed by 2 July 2015. However, during the execution of the contract, there were delays due to adverse weather conditions, but some delay was also introduced by the contractor, albeit these did not affect the contract execution negatively.

After several meetings and negotiations between ESO and Icafal, a set of additional works to develop under the so called amendment 11 were defined. The signature of the amendment was concluded in May.

The three main works built under the contract amendment were:

a. The installation of 2,489 m of metallic barriers located mainly along the spiral road, the installation of 3,728 m² of hanging mesh located along the rock cuts of the spiral road (including the Dry Coolers’ new rock cuts), the repair works on the ESO ABC offices and the improvement works of the ESO ABC offices to have them ready for the rest of the E-ELT construction phases.

b. Construction of the Storage platforms, consisting in a flat area (sloped enough to drain rainfall water) that has been separated in three platforms with a total surface of 20,000 m². Their location is North-West of the ABC and they are considered, with access roads, good enough to traffic with ramp trucks carrying 40 feet containers.

c. Construction of the Dry Coolers platform starting at km 22.27 and going until km 22.42 of the spiral road. This platform was cut into rock and has 6 m of basal width located 1.3 m above the road platform (the DC platform has the same slope as the road). Due to the nature of the equipment to be installed there, the exposed rock was coated in metallic mesh. The definitive access path to this surface is through a dirty road that starts at the road level at km 22.27 and goes up ending at platform level around km 22.31. This road is fit for access using a 4x4 pick-up truck.
The Provisional Acceptance Chile (PAC) for the totality of the contract has not been issued yet. This PAC, that includes amendment 11 works, shall be granted only once a final agreement on what will be made with the ABC camp, is reached between ESO and Icafal.

The inspection contract continues providing assistance, not just in keeping track of the last contractual topics (e.g. as built drawings), but also on other open points not directly related but which are part of the E-ELT preparatory earth works.

During this period of time, the global stability of the ATP dumps has been revised and found, by four independent reports, not to be a concern (dumps are globally stable). The last review, made by the Portuguese company ISQ, raised concerns about the rock fall phenomena that may happen under big earthquakes in the slope of the NW dump. Rock falls put drivers at risk when circulating between km 23.4 and km 23.7 of the spiral road. In order to avoid this risk, the installation of a dynamic type barrier is being studied in terms of technical feasibility and price estimate.

The E-ELT infrastructure includes also some changes to the existing Paranal observatory infrastructure that needs to be accommodated to also serve the E-ELT. The implementation of these areas is directly linked to the DMS final design, whose detailed engineering phase has just started.

Regarding the PAO new infrastructure, this considers the urbanisation of the piece of land located next to the fuel station at Paranal and the Astrotaller building with an extension of around 15,000 m². In this area, new circulation roads, new fire and potable water grids, new sewerage grid and new power and data distribution grid will need to be constructed.

In the new E-ELT PAO urban area, the construction of three new precincts is included, namely:

- The segments Storage Area;
- The E-ELT Coating Plant;
- The E-ELT Technical Building.

### 4.7 Supporting Infrastructure

Over the reporting period, the supporting infrastructure project management dealt with setting up the two new Jobs 5625 “Support Equipment” and 5626 “M4 Cooling Supply”. While for 5625, the scheduling, planning and budget requirements have been completed and are entered in Open plan, the M4 cooling is still in the process of coordinating tasks with the M4 mirror project. Together with the job manager of 5622, washing and coating, the schedule for the procurement of the M1 segment washing, stripping and coating plant was prepared.

The PM has presented two documents, enabling the programme to take decisions on:

- The supply of liquid nitrogen for the E-ELT instrumentation;
- The location(s) of the E-ELT coating facilities, mainly M1 segments here.
4.7.1 Washing and Coating (mirror maintenance)

As a result from the washing, stripping and coating (WSC) RFI for the M1 segments, it was decided:

- ESO shall aim for an integrated plant solution, placing only one contract for all process sections of the M1 segment maintenance, i.e. one prime contractor will be tasked to provide a complete process plant for washing, stripping and coating. For the ESO project team, this has strong advantages in terms of simplification of contracts, no external interfaces between different process steps, and handling can be planned as an integrated part of the complete plant;
- To be able to reduce the risk on the bidder’s side, and as such to get more solid offers, ESO will place a contract to perform a study for the coating removal process: theoretical concept, practical tests for verification, conceptual plant layout with the transfer of the chemical process into a semi-automatic plant. The offers for the corresponding CFT for this study are currently being evaluated. The project expects the final report to be ready for the CFT of the M1 segment WSC plant.

4.7.2 Power conditioning and back-up system

The connection of the Paranal observatory together with the E-ELT to the public grid is ongoing. This includes also the supply to the construction camp for the Dome and telescope erection and commissioning.

The procurement phase for electrical sub-stations at Armazones and Paranal was completed with the FC approval of the contract. During the next nine months, the sub-stations will be installed in Paranal (with higher priority due to the earlier demand) and Armazones. This will allow ESO to connect its Paranal observatory and the E-ELT construction site to the public grid.

4.7.3 Chilled Medium Plant, Compressor and Cryogenic plant

The trade-off study for the liquid nitrogen supply of the E-ELT was completed. The result of this study was analysed and a change request was issued, proposing to move from the current baseline of installing ESO’s own liquid nitrogen generation plant to supply from an industrial plant, located in the Antofagasta area.

4.7.4 M4 Cooling Supply

To supply the M4 unit with the refrigerant gas cooling, ESO will install the infrastructure, mainly consisting of the compressor unit with its auxiliary devices and the hoses to connect both systems. After gathering the initial requirements, identification of suitable industrial partners has started. The detailed project planning will continue during the next months, also to consider change requirements of the M4 unit.
4.8 Instrumentation

Progress continues on the four instruments in construction and the two Phase A studies for E-ELT Instrumentation. The instruments are:

- HARMONI, an AO-fed IFU spectrograph for the optical and near infrared;
- MICADO, an MCAO-fed near infrared imager with slit spectroscopy;
- MAORY, an MCAO module to feed MICADO and an auxiliary port;
- METIS, an AO-assisted imager/spectrometer for the thermal infrared;
- MOSAIC, an optical to NIR multi-object spectrograph (Phase A study);
- HIRES, an optical to NIR high resolution spectrograph (Phase A study).

The instruments in their construction phase are now approaching the midpoint of their preliminary design phases. The Preliminary Design Reviews are scheduled over various dates between Q2 2017 and Q3 2018. Baseline end-to-end optical designs for the instruments are largely defined and significant efforts are underway within the systems engineering teams of all instruments to flow down the requirements to the instrument sub-systems. The HARMONI consortium has fixed its basic architecture including the location of the LTAO module and its wave front sensors. METIS finalised its baseline “common fore optics” that is the backbone for the instrument and supports key functional systems (chopping mechanisms and the cold stop) as well as important scientific functions such as corona graphic masks. MICADO and MAORY have agreed on a baseline optical design and are working towards definition of the interface of the AO modules and the camera, including the control software. The guidelines of the joint development of the SCAO mode have been established and agreed by both consortia, with the detailed plan being worked on.

A series of upcoming formal and informal reviews of the instruments will mark their progress. The first of these is a review of the design of the HARMONI Laser Tomographic AO module. This post-focal AO system is included in the programme up to PDR (planned for Q2 2017); construction has been deferred to Phase 2. All of METIS, MAORY and MICADO are carrying out internal (to the consortium) System Requirements Reviews that will be supported and attended by ESO in order to ensure the clearest possible understanding of the requirements that ESO places on the instruments.

During the six months since the last report, a modification to the Nasmyth platform interface has been explored. The initial interface presented challenges in the structural design, making it hard to meet simultaneously key requirements on earthquake survivability, instrument mass and access for maintenance. A revision of the instrument attachment points and their load bearing capacity that relieves this situation was presented to the instrument teams, after discussions with the Dome and Main Structure consortium. This revision, which has had no impact on the DMS contract cost or schedule, is expected to be formally adopted by the instrument consortia in the next quarter.

The work on the Real Time Computer and Adaptive Optics wave front sensing camera was highlighted in the previous report and has continued to be a major focus of the ESO effort supporting ELT INS. Specifications for both of these systems have been further discussed.
with the instrument consortia and work is ongoing to write a unified set of requirements for these standard ESO deliverable sub-systems.

For MOSAIC and HIRES, the initial six months' work has concentrated on the task of determining the key science cases of these instruments and the instrument concepts that will support these and fall within the funding envelope announced in the Call for Proposals for the Phase A studies. This work is fully supported by the E-ELT Programme Science working with the Project Science Team.

5. **Science Data Operations**

The E-ELT science operations model assumes that E-ELT and VLT operations will be performed in an integrated environment. Therefore, the Data Flow System (DFS) will support both VLT and E-ELT operations. The evolution of the VLT-DFS is already ongoing, carefully observing new or additional requirements driven by the E-ELT infrastructure in general, and E-ELT instrumentation in particular. This process is coordinated by the end-to-end operations scientist.

A new framework for instrument-specific preparation tools and software is being introduced in the data flow deliverable specification interface document. It will serve next generation VLT instruments as well as new E-ELT instruments.

Requirement specifications for the enhancement of ESO science archive services have been consolidated. State-of-the-art archive services will allow the ESO user community to maximise its scientific return by a comprehensive exploitation of the E-ELT data holdings integrated in the ESO archive.