INSTRUMENTATION DIVISION

MACAO-VLTI

Project Management Plan & Schedule

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CHANGE RECORD

ISSUE	DATE	SECTION AFFECTED	REASON/INITIATION DOCUMENTS/REMARKS
1	March ‘00	-	First issue
2	October ‘00	All	PDR
3	February ‘01	All	FDR

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0. Scope

The scope of the present document is to describe the Management and Development plans to Design, Prototype, Manufacture, Integrate and Test in Europe, Install and Commission at the VLT, four Adaptive Optics Systems - hereafter referred to as MACAO-VLTI Systems - for the VLT Interferometer.

1. Applicable and Reference Documents

1.1. Applicable Documents

No.	Document Title	Reference	Issue	Date
AD 1	Top Level Requirements for MACAO-VLTI	VLT-SPE-ESO-15600-2082	1.2	08.03.01
AD 2	MACAO-VLTI Technical Specifications	VLT-SPE-ESO-15600-2245	1.1	09.03.01
AD 3	MACAO-VLTI List of Deliverables	VLT-LIS-ESO-15600-2246	1.1	09.03.01

1.2. Reference Documents

No.	Document Title	Reference	Issue	Date
RD 1	MACAO–VLTI System Overview	VLT-TRE-ESO-15600-2251	1.2	15.02.01
RD2	Technical Specification and SOW for studies on MACAO software specifications	VLT-SPE-ESO-15600-2301	1.0	11.09.00
RD3	MACAO-VLTI Detailed mechanical design and Analysis report of the Coude AO facilities	VLT-TRE-ESO-15600-2274	2.0	12.03.01
RD4	MACAO-VLTI Tip-Tilt mount Final design report	VLT-TRE-ODP-11640-0001	1.0	22.02.01
RD5	MACAO-VLTI WFS Optics	VLT-TRE-ESO-15600-2273	2.0	15.02.01

2. Executive Summary

2.1. MACAO-VLTI System Description

The top level requirements of MACAO-VLTI are described in AD1.

The MACAO-VLTI **System** is a 60-element curvature AO system operating at the Coudé focus of each of the VLT UTs and delivering a corrected wavefront to the VLTI delay lines after reflection off the dichroïc M9. The corrective optics consists of a deformable Bimorph mirror with 60 actuators mounted on a tip-tilt stage replacing the M8 in the Coudé miror. The Curvature Wavefront Sensor is based on a 60-element lenslet array feeding 60 APD modules. The CWFS is hosted in a WFS Assembly mounted on an X-Y table standing on the fixed rotating platform of the Coudé floor below M9. MACAO-VLTI is designed to operate only with natural guide stars (NGS). More details about the MACAO-VLTI system can be found in RD1.

A 10”x 10” VLTI acquisition camera based on VLT small standard TCCD will be included in the MACAO-VLTI WFS box. This camera will also be used as a Nyquist sampled viewing camera to allow the performance of the AO system to be monitored during daytime operations.

Although not required by the MACAO-VLTI system, the WFS Assembly will host a tip-tilt sensor –hereafter referred as STRAP system. This will permit a smooth switching between the operation of full AO and tip-tilt correction. This feature has been requested by the VLTI Group for long wavelength observations i.e. MIDI.

Moreover, we propose to deliver in advance two MACAO-VLTI WFS Assemblies (with their X-Y tables) hosting only the STRAP system and the VLTI acquisition camera, which will equip the Coudé foci of UT2 and UT4 for tip-tilt correction only, as required by the VLTI plans. The tip-tilt <u>systems</u> are not part of this Management and Development plans. These WFS Assemblies will later be equipped with the components necessary to transform them into fully-fledged MACAO Systems. This strategy reduces the cost/manpower effort required in installing the tip-tilt sensor at UT1 and UT3 at the expense of a more complex integration flow.

2.2. VLTI Group-AO department responsibilities

The present plan is based on the following assumptions concerning the sharing of work and responsibilities between the AO Department and the VLTI-Group :

The AO-Department is responsible for :

- Designing, prototyping, manufacturing, integrating and testing in Europe, installing and commissioning at Paranal (respectively at UT2, UT4, UT3 and UT1) of four MACAO-VLTI systems including the XY Tables,
- Design, procure and deliver in advance two WFS Assemblies / XY Tables only equipped with the STRAP head and acquisition camera – referred below as “Tip-tilt Boxes” - intended to be installed at UT1 and UT3.

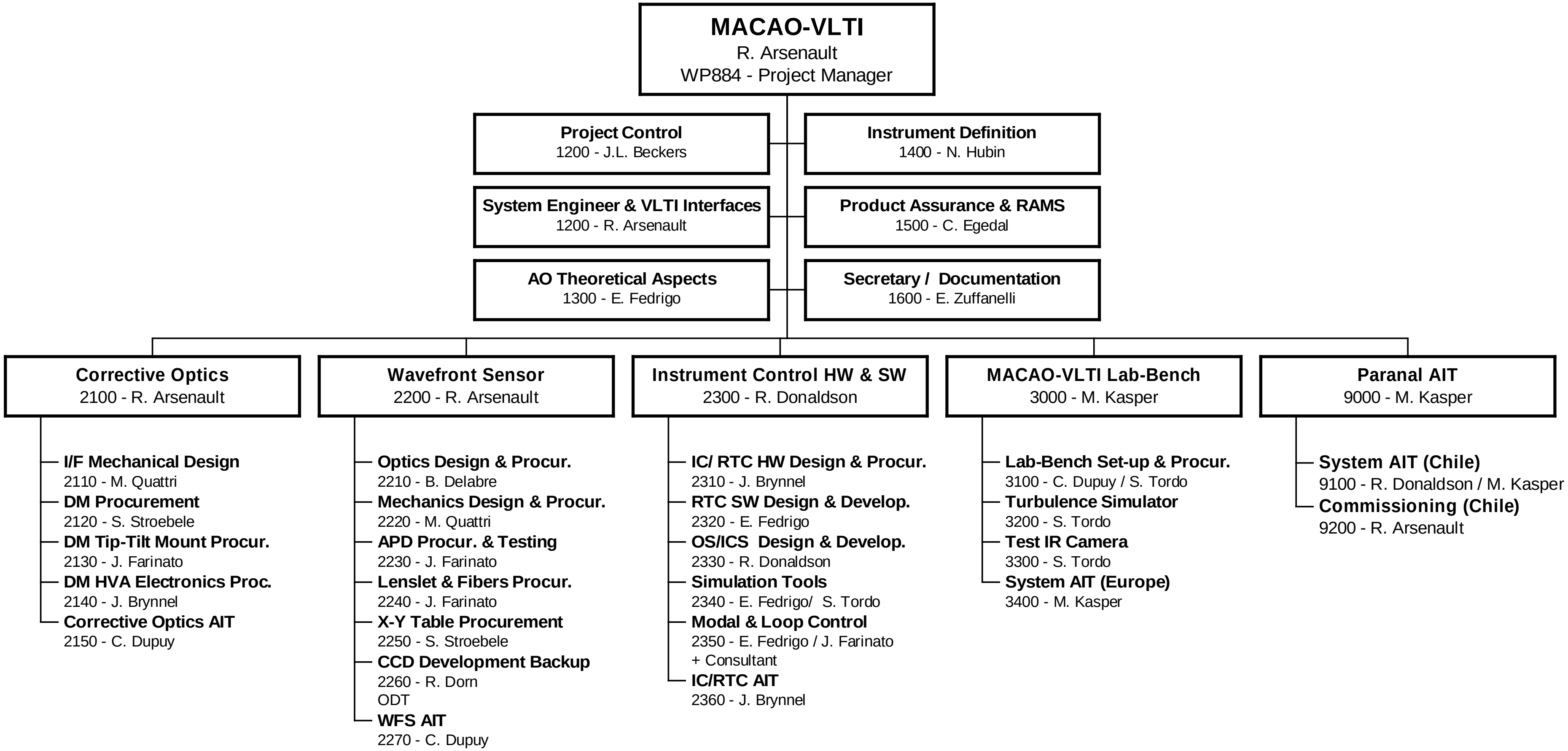
The VLTI-Group is responsible for :

- Performing the necessary activities and procurements to equip the four VLT Coudé Facilities with M9 dichroics, Telecentric Lenses (including the mechanical support) and Calibration Sources needed for the MACAO-VLTI System to operate at the Nasmyth Foci,
- Providing four small TCCD acquisition cameras and four STRAP heads (with cables) for the “Tip-tilt Boxes”. Please note that the actual implementation of the tip-tilt loop with M2 is not part of the AO-Department activity,
- Installing and commissioning the two “Tip-tilt Boxes” at UT1 and UT3 ,
- Provide support for MACAO-VLTI / Facility assembly, integration and test at Paranal.

3. Project Organisation

The MACAO-VLTI system will be designed and developed under the prime responsibility of the AO-Department within the ESO Instrumentation Division with specialised technical support provided by the Optical Detector Team, the INS Integration Group and the Technical Division (TEC).

MACAO-VLTI ORGANIZATION CHART



4. Project Development Plan

4.1. Project Milestones

Milestones	Dates
Conceptual Design Review (CDR)	24 March 2000
Incremental Preliminary Design Review	12 October 2000
Final Design Review (FDR)	March 2001
XY Tables Delivery @ Paranal	July 2001
Tip-Tilt Boxes Delivery @ Paranal	September 2001
UNIT #1 Technical Acceptance Europe (TAE1)	August 2002
UNIT #1 Release to Observatory (FAC1)	January 2003
UNIT #2 Technical Acceptance Europe (TAE2)	April 2003
UNIT #2 Release to Observatory (FAC2)	July 2003
UNIT #3 Technical Acceptance Europe (TAE3)	January 2003
UNIT #3 Release to Observatory (FAC3)	March 2004
UNIT #4 Technical Acceptance Europe (TAE4)	June 2004
UNIT #4 Release to Observatory (FAC4)	August 2004

4.2. Project Phases

4.2.1. Development Approach

Because of the short delivery time required by VLTI for the four MACAO-VLTI Systems, a "Fast Track" Development will be followed. In particular :

- Key components with long-lead delivery time have been procured after the Conceptual Design Review (see Section 4.2.4).
- Collaboration with external institutes and/or potential suppliers has been established to gain in development time without increasing the risk (see section 4.2.3).

The FDR date is mainly driven by the mechanical design and the problems encountered in the procurement of the lenslet array and X-Y tables, which led to recent modifications of the design and procurement strategies.

The X-Y tables and the Tip-tilt boxes design, procurement and AIT in Europe have a high priority in our planning to meet the delivery time required by VLTI. We assume that the VLTI group delivers four STRAP and small TCCD heads by **April 2001**.

Important: Note that five identical WFS boxes will be manufactured. Two will be delivered to Paranal as "Tip-tilt" boxes. Three will be integrated as "MACAO WFS boxes" delivered and commissioned successively at Paranal. After the third MACAO WFS System is delivered at Paranal, one "tip-tilt box" will be shipped back to Garching for MACAO WFS #4 AIT.

For the MACAO-VLTI Project we have tried to use as far as possible "on-the-shelves" products. However, MACAO-VLTI being an AO system for interferometry at the edge of the current technology, components like the deformable mirror, the X-Y table, the Tip-tilt stage and the lenslet/fibre array represent challenging custom designs. A prototyping phase for these components is therefore needed and included in the plan.

After a few evolutions the design proposed to insure a fixed pupil onto the lenslet array consists in a derotator prism in front of it. This design is definitely simpler and insures a higher reliability than the previous solutions. This means that the micro-lens assembly is no more required to rotate, nor is the APD racks. The latter will also be immobile on the Coudé platform. This means that the APD racks will not be moved in X-Y slaved according to the displacement of the Wavefront Sensor Assembly.

To avoid long commissioning periods at Paranal, it is mandatory to validate the Strehl versus flux performance of the MACAO-VLTI system in the laboratory for atmospheric conditions as close as possible to those present at Paranal (used also for the NAOS

Project). The AIT plan provides the design of the relevant test tools. An agreement is being discussed with the Observatoire de Paris to upgrade the NAOS IR WFS prototype to a test IR camera for MACAO-VLTI. This will be used in the laboratory, on the so-called Test Bench. Another IR camera will be used for the commissioning of each MACAO system at Paranal. The latter is developed by the ESO IR and integration groups, and will be VLT standard. A Technical Acceptance in Europe (TAE) will be organised at the end of the Laboratory testing phase. We believe that the development of 2 test cameras will ease the coordination of the integration and testing of the 4 MACAO-VLTI systems, SINFONI and CRIRES in Garching and in Paranal.

Important: Note that the MACAO-VLTI system testing and Acceptance in Europe is expected to be used as a training session for the VLTI and Paranal staff who will be involved later in the operation of the MACAO-VLTI systems.

Two commissioning periods are included in the plan for the first MACAO-VLTI System as we expect system tuning will be required after the first commissioning. A period of 2 months is therefore included between the two commissioning for performance analysis and system tuning. For the three remaining systems we assume no tuning will be required.

4.2.2. Internal Developments & activities

The internal activities are:

- Project Management & Control, System Engineering, Product Assurance,
- Procurement including Tendering and Follow-up,
- Reviews and Documentation,
- Overall MACAO-VLTI Design,
- Corrective Optics Design and AIT,
- WFS Design, Manufacturing and AIT,
- Real Time Computer (RTC) Design, Manufacturing and AIT,
- Instrument Control (IC) Electronics Design, Manufacturing and AIT,
- Observing and Instrument Control Software (OS/ICS) Design and Development,
- Real Time Computer (RTC) Software Design and Development,
- Tip-tilt boxes Design, Manufacturing and AIT,
- Laboratory Bench Design, Manufacturing and AIT,
- IR Cameras Design, Manufacturing and AIT (OdP, laboratory camera)
- IR Camera Design, Manufacturing and AIT (internal ESO, VLT standard)
- MACAO-VLTI System Integration, Testing and Acceptance in Europe (TAEx),

- VLTI and Paranal staff Training,
- Commissioning of the four MACAO-VLTI Systems at Paranal (FACx).

4.2.3. Key Sub-Contracting

Apart from the Key Procurements described in section 4.2.4, a contract is being negotiated with ONERA (RD2) to provide support in the field of:

- Piston removal from bimorph control
- On-line estimation of AO relevant parameters
- On-line optimisation of AO Servo parameters

Other collaborations (longer term) are being negotiated with NOVA in the field of PSF reconstruction, which will serve both SINFONI and MACAO-VLTI.

A contract has been placed with Observatoire de Paris for the design and procurement of the TTM prototype for MACAO-VLTI (RD4).

An agreement is being negotiated for the upgrade of the NAOS IR WFS prototype to a laboratory IR camera for MACAO-VLTI.

4.2.4. Key Procurements

As planned at CDR, several CFTs have been launched during the preliminary design phase. In general, the improvement of the European economy is leading to significant cost impacts and to difficulties to catch industry attention. Hereafter is the status:

- Placed contracts:
  - **APD modules:** Contract has been placed with Perkin-Elmer for the procurement of 420 APD modules (240 for MACAO-VLTI + 60 spares). As of this writing, more than 300 APDs have been received. Since the contract has been signed in US$, one may be concerned by the Dollar exchange rate w.r.t. Deutsche Mark.
  - **DM:** Contract has been placed with CILAS for the procurement of one DM prototype, 4 serial DMs + one spare. Delivery of all DMs December 2001. Note that Laplacian Optics has not sent any quotation.
  - **DM HVAs:** Contract has been placed with 4D Engineering for the procurement of 7 DM control electronics (4 +1 spare for MACAO-VLTI). Delivery of first unit May 2001.
  - **Lab bench:** The optical bench and major optics have been ordered. The lack of mechanical designer has not allowed to perform the necessary drawings required for the optics supports and M8 tower. Note that we intend to procure an additional M8 support from REOSC for the laboratory.
  - **Instrument Control & TTM electronics:** Because of the present market situation, delivery time for many electronic components is significantly increased. For that reason, several orders have been placed during the

preliminary design phase to overcome this problem and still meet the MACAO-VLTI milestones (tip-tilt boxes)

- **APD counters:** A contract has been placed with the company Shakti which has a long experience in electronics design in the field of AO. The kick-off meeting took placed at the beginning of December ’00. Counter boards should be received by late August ’01.
- **Beam Expanders:** The contract has been signed, but as said above it has involved a new design. A CFT was launched in August based on the previous design and the offers costs were high. The design has been modified to lower the cost and another CFT issued. The canadian company Applied Optics Specialties has been selected for the fabrication and assembly of the 2 off-axis parabolae system. The kick-off meeting took place on February 23rd (2001) and delivery of the 7 units is expected for November 2001.
- **Derotator Prisms:** The company Stygma Optique has been selected for the manufacturing of the derotator prisms and mounts. The kick-off meeting took place on February 16th 2001. This manufacturing is relatively simple and Stygma Optique has shown extensive credential for this type of optical components manufacturing.
- **X-Y table:** A solution has finally been found for the XY-Tables. We recall that the initial price inquiry had not been successful. The solution identified at CDR did not fulfil the specifications after further analysis with the supplier. The on-the-shelf solution was not fully satisfactory/risky from the technical point of view (see RD7) and costly. Since an X-Y table design was done in the past by ESO (which fits exactly the WFS geometry and needs), we have pursued procurement based on this design. Finhmechanika Heeze has been selected for manufacturing. As expressed before, our concern is the internal mechanical manpower support to follow up this type of contract (help with opto-mechanics, integration, tests).

- Pending CFTs:

  - **Lenslet Array**: A CFT for the procurement of the 7-lenslet arrays including fibre coupling was launched. Two answers have been received. Both offers were not acceptable for the technical and cost aspects. Two additional expected suppliers did not submit an offer (one seems to get out of business, the other did not quote because of an internal co-ordination problem!). Further investigation about the capability of this second supplier has shown weaknesses in their technology and a lack of actual experience in producing lenslet arrays. This fact was not identified before CDR. The difficulties encountered have led us to investigate design alternatives in close contact with experienced suppliers. Our best design (14-mm diameter pupil solution) is presented in RD5. The current (but confidential) information we have are very promising in all aspects (technical, risk, cost, planning). The bad side of this solution is the very recent redesign of the MACAO-VLTI WFS unit.

- **Optical Fiber Bundle**: Recent information with 2 different suppliers have led independently to very similar design solution for the 60 optical fiber interface with the 2^{nd} lenslet array. A PO has been launched with one of this company for the realisation of a prototype which should be finalised by April '01. ESO integration group will prototype the mechanical interfacing of the fiber bundle and the micro-lens (gluing or mechanical with oil index).

The design solution for these 2 subsystems is now very clear. Quotations have been sent out and shortly after the realisation of the prototype an order should be placed for several units.

- **T-Mount:** The T-Mount has not been launched yet and await FDR approval. Most of the components to be integrated on the T-Mount to complete the Tip-Tilt boxes are simple and do not require long procurement lead time. The T-Mount itself is not complex to manufacture, but must conform to several opto-mechanical interfaces and therefore is one of the latest component that can be defined in the design.

4.3. Reporting and Meetings

Our proposition for project reporting is based on the following types of reports:

- Monthly Progress Reports prepared by the Project Manager for the Instrumentation Division Head. This Progress report will be forwarded to the VLTI Group for information and for further reporting to the Telescope Division.
- Bi-Monthly Progress meeting with the VLTI group organised by the Project Manager.
- Project Review Reports. Responsible: Project Manager and Project Controller

4.3. Reviews

The MACAO-VLTI FDR is organised as it is usually done for all ESO Instruments.

The four X-Y tables (inc. LCUs) as well as the so-called Tip-Tilt boxes will go through a Technical Acceptance Europe before shipping to Paranal. The installation and operation of these X-Y tables for the Tip-Tilt systems will be transferred to VLTI after TAE.

Each MACAO-VLTI system will go through a Technical Acceptance Europe (TAE) before shipping to Paranal.

The full responsibility for the installation and commissioning of the four MACAO-VLTI Systems remains within the AO Department until the end of Commissioning phases. The VLTI group will provide support for the Installation and Commissioning of the MACAO-VLTI Systems within the VLT/VLTI environment. This support will be defined in the Commissioning plan prepared by the AO Department. At the end of the Commissioning phase, the Final Acceptance (FAC) is granted and the responsibility transferred to VLTI group for operation maintenance and further VLTI installation.

4.4 Deliveries and Documentation

Hereafter is a list of deliveries for each MACAO-VLTI Milestones:

- **PDR**
  - PDR Documentation Package

- **FDR**
  - FDR Documentation Package

- **X-Y Tables Advanced Delivery**
  - 4 X-Y Tables
  - 2 Controllers
  - 2 LCUs
  - User's Manual and Maintenance Manual
  - Technical Manuals (as provided by the supplier)

- **Tip-tilt Boxes Advanced Delivery**
  - 2 Tip-tilt boxes with Strap and TCCD heads
  - WFS Design Report
  - "as built" Drawing Set

- **TAE #x**
  - Test Procedure Report (done once)
  - Test Report for unit #x
  - Commissioning Plan (at TAE1-1month, done once for the first system)
  - MACAO-VLTI Design Documentation with "as-built" drawings for unit #x
  - User's Manual and Maintenance Manual (done once)

- **FAC #x**
  - MACAO-VLTI System #x
  - Commissioning Report for unit #x
  - Updated TAEx Documentation
  - Spares as defined at FDR (spares are delivered once with the first system)

5. Project Resources

5.1. Total Manpower

The summary of the manpower required for the Design, Development, Procurement, System AIT and Commissioning of four MACAO-VLTI units, including the advance delivery of the XY Tables and of the Tip-Tilt Boxes, is presented in the Table 1 below:

Manpower	2000	2001	2002	2003	2004	Total
FTEs	**7.1**	**8.425**	**6.95**	**5.725**	**2.4**	**30.6**

Table 1 Total Manpower

Based on the project planning (Annex A), the tasks foreseen for each Work Package of the WBS have been allocated to ESO resources.

5.2. Manpower Budgeting.

The manpower actually available during the preliminary design phase has been below the required manpower at CDR in particular in the field of Project management/system engineering and mechanical support. This explains the reason of the increase of required manpower in 2001 to perform the delayed activities. It is important to ensure that the overall manpower will be provided to avoid major delays.

5.2.1. Project Manager

The Project manager (R. Arsenault: staff position) has arrived at ESO Nov. 1st 2000.

5.2.2. AIT Responsible

The AIT responsible (M. Kasper: Paid Associate position) has arrived at ESO Nov. 1st 2000.

This is a key position for the System Integration and Commissioning of the four MACAO-VLTI units in Paranal. Given the commissioning plans, the AIT Manager is required to lead and participate to the repeated installations and commissioning at Paranal in 2002 and 2003. The AIT responsible will be supported in his task by S.Tordo (Paid Associate).

5.2.3. Other Resources

5.3. Manpower Allocation

Name	PERID	2000	2001	2002	2003	2004	Total
Balestra, A.	ABA	0.1	0.05	0	0	0	0.15
Beckers, J-L.	JLB	0.2	0	0	0	0	0.2
Quattri, M.	EBR	0.6	0.45	0.2	0.2	0.1	1.55
Brynnel, J.	BJO	0.4	0.275	0.375	0.25	0.2	1.5
Buzzoni, B.	BBU	0.15	0.1	0	0	0	0.25
Close, L.[1]	LCL	0.1	0	0	0	0	0.1
Deiris, S	SDE	0	0.025	0	0	0	0.025
Delabre, B.	BDE	0.1	0.05	0	0	0	0.15
Donaldson, R.	RDO	0.8	0.5	0.4	0.55	0.3	2.55
Dorn, R.	DRE	0.1	0	0	0	0	0.1
Dupuis, C.	CDU	0.3	0.9	1	1	0.5	3.7
Egedal, C.	CEG	0	0.075	0.15	0.15	0	0.375
Farinato, J.	JFA	0.7	0.3	0.4	0.4	0.2	2
Fedrigo, E.	EFE	0.7	0.4	0.5	0.2	0.1	1.9
Finger, G.	GFI	0	0.05	0	0	0	0.05
Fischer, G.	FIG	0	0.4	0.3	0.2	0	0.9
Guisard, S	SGU	0	0	0.2	0.2	0.1	0.5
Hess, G.	GHE	0	0.25	0	0	0	0.25
Koch, F.	FKO	0.1	0.1	0	0	0	0.2
Lizon, J-L.	JLL	0	0.1	0	0	0	0.1
Marchetti, E.	EMA	0.1					0.1
Moresmeau, J	JMM		0.1	0.1	0.1	0.1	0.4
Moureau, S.[2]	SMO	0.3	0.6	0.4	0.175		1.475
Pomaroli, E.	EPO	0.05	0.15	0.05	0.05	0	0.3
Reiss, R	RRE	0.15	0.2	0.275	0.1	0	0.725
Reyes, J.	JRE	0	0.05	0	0	0	0.05
Stroebele, S.	STS	0.3	0.2	0	0	0	0.5
Tokovinin, A.[1]	ATO	0.1	0	0	0	0	0.1
Arsenault, R	RAR	0.2	0.8	0.9	0.8	0.5	3.2
Kasper, M	MKA	0.2	0.8	0.7	0.35	0.2	2.25
Tordo, S	STO	0.75	1	1	1	0.1	3.85
Hubin, N	NHU	0.6	0	0	0	0	0.6
Draftman	NN	0.2	0.5	0	0	0	0.7
Total		**7.1**	**8.425**	**6.95**	**5.725**	**2.4**	**30.6**

Table 2 Manpower Allocation

[1] Has left ESO Nov.2000
[2] Leave ESO 2nd quarter 2001

5.4. Hardware and Contract Costs

5.4.1. MACAO-VLTI Cost Breakdown

The costs associated with the procurement and development of **four** MACAO-VLTI Systems are presented below. The number of spare units proposed for each item is also indicated.

Table 3 MACAO-VLTI Cost Breakdown (1/2)

WP	***MACAO-VLTI SUB-SYSTEMS***	***Costs***	*Qty*	***Spares***
WP2100	***Corrective Optics***	**620 KDM**		**116 KDM**
	Deformable Mirror (DM)	**620**	4	
2110	*DM*			1 Unit
2120	*DM Tip-tilt Mount*			1 Unit
2130	*Mechanical Support*			
WP2200	***Wave Front Sensor***	**3,097 KDM**		**520 KDM**
2210	Relay Optics	**282**	4	
	Beam Expander			1 Unit
	Flat & Sphere mirrors			
	De-Rotator prism			1 Unit
	Density Filters			
	Flat mirrors & BMS			1 Unit
2220	Mechanics	**869**	5	
	Functions (7)			
	Structure / Housing			
	Detailed Drawings			
2230	APDs Box	**1,113**	4	
	APD (60)			1 Unit
	Cooled Custom Box			
2240	Lenslet Array	**402**	5	
	Mount & Assembly			2 Unit
	Lenslet			2 Unit
	Fibers			2 Unit
2250	Membrane Mirror (MM)	**110**	4	
	MM Parts			1 Unit
	MM Mount			1 Unit
2260	XY Table	**321**	4	
	XY Table Structure			
	WFS Electromechanics			1 Unit
WP2300	***Instrument Control HW & SW***	**1,963 KDM**		**113 KDM**
2310	RTC LCU	**266**	4	
	PowerPC Boards(LCU)			
	PowerPC Boards(RTC)			1 Unit
	Transition module			1 Unit
	Transition module			
	TIM Board			
	MACCON Board			

	VME4SA			
	ACRO			
	HVA Fiber I/F			1 Unit
	Chassis & Power Supplies			
	ICS LCU	**258**	5	
	PowerPC Board			
	Transition module			
	TIM Board			
	MACCON Board (2)			
	VME4SA (2)			
	VMIC VMI VME			
	Chassis & Power Supplies			
2320	DM Electronics	**541**	4	
	HVA Electronics & PSU			
	DM Tip-tilt Piezzo Drive			1 Unit
	Cooled Cabinet with Cables			1 Unit
2330	APDs Electronics	**114**	4	
	Counter 60-Channel			1 Unit
2350	Software	**220**	4	
	RTAP			
	Specific AO SW (WP2350)			
2360	Others	**563**	4	
	Glue components			
	Main Rack with Cooling			
	Network Fiber-optics			
	General Cabling			
	System AIT Support (WP3400)			
	TOTAL COST (4 Units)	**5,680 KDM**		**750 KDM**

Table 4 MACAO-VLTI Cost Breakdown (2/2)

Please note that, as for VLT Instruments, the Workstations (one per system) are supposed to be delivered by the Paranal Observatory and are not included above.

5.4.2. Lab-Bench & Prototyping Cost Breakdown

The cost associated with the procurement of the Lab-Bench and with the Prototyping activities is presented below.

Table 5 Lab-Bench and Prototyping

WP	*Lab-Bench & Prototyping*	*Costs*		*Qty*	*Spares*
WP3000	***Lab-Bench & Prototyping***	***412 KDM***			
3100	HP Workstation		**44**	1	
3200	Lab-Bench Components		**88**	1	
3300	Turbulence Simulator		**52**	1	
3400	Prototyping		**229**	1	
	DM Prototype				
	DM Tip-tilt Stage Prototype				
	DM HVA Developments				
WP4000	***Test IR Camera***	**506 KDM**	**506**	1	
4100	*Data Acquisition System*				
4200	*Camera Head*				
4300	*HAWAII Detector*				
	IR Lab Camera	**83 KDM**	**83**	1	
	Read-out Electronics				
	PC & Softwares				
WP5000	***Back-up CCD & Electronics***	**496 KDM**	**496**	1	
	TOTAL	**1,497 KDM**			

The Total cost is summarised below:

Item	**COST**
4 MACAO-VLTI	5680 KDM
Lab-Bench and Prototyping	1497 KDM
Spares	750 KDM
TOTAL	**7927 KDM**

The total MACAO-VLTI cost to completion has been increase by 75 KDM following changes required by VLTI: implementation of a reflective memory and large FOV for the acquisition camera.

6. Annex A - Detailed Planning