The Extremely Large Telescope Design Study in the Framework Programme 6 October 2003

Activity Areas

To help establish a fabric of research infrastructures of the highest level in Europe and to promote their optimum use on a European scale.

Thematic Areas

- Life sciences, genomics and biotechnology for health
- Information society technologies
- Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices.
- Aeronautics and space
- Food quality and safety
- Sustainable development, global change and ecosystems
- Citizens and governance in a knowledge-based society

Cross-cutting Research activities

- Research for policy support
- New and emerging science and technology (NEST)
- Specific SME activities
- Specific international cooperation activities
- JRC activities

Strengthening the foundations of ERA

Co-ordination of research activities

Development of research/innovation policies

Structuring the ERA

- Research and innovation
- Marie Curie Actions Human resources & mobility
- Research infrastructures
- Science and society

Nuclear Energy

Research infrastructures

- Controlled thermonuclear fusion
- Management of radioactive waste
- Radiation protection
- Other activities in the field of nuclear technologies and safety



RESEARCH INFRASTRUCTURES

* Activity areas:

- 1. Transnational access to major research infrastructures for research teams and individual researchers
- 2.1 Integrating activities combining cooperation networks with transnational access and research projects
- 2.2 Integrating activities including networking activities only
- 3. Communication network development in conjunction with thematic priority 2 (Information Society Technologies) to establish a high-capacity and high-speed communications network for all researchers in Europe (GÉANT) and specific high performance Grids and test-beds (GRIDs).
- 4. Design studies: feasibility studies and technical preparatory work for new infrastructures with European dimension
- 5. Development of new infrastructures: optimising of European infrastructures by providing limited support in duly justified cases, alongside with other funding agencies

Budget:

The indicative budget allocated to the Structuring activity Research infrastructures for the duration of FP6 is **EUR 655 million**.

- ✓ Keys: *Science* case + *Technical* case + *Business* case
- ✓ Participants: national & international institutions, industry (emphasis on SMEs)
- ✓ GRIDS a hot topic, but competition in Design Studies may be more limited.
- ✓ EC BUDGET FOR DESIGN STUDIES: 70 M€





- Feasibility studies will aim at laying the conceptual foundations of a potential new
 or enhanced infrastructure. This could consist in the basic feasibility study of a
 specific new facility or in exploring a new fundamental technology or technique
 underpinning a whole new concept. Alternatively, a feasibility study could cover
 the detailed engineering design of a proposed infrastructure, in particular in
 relation to its most technologically advanced aspects (i.e. excluding the detailed
 design of standard elements of the new infrastructure).
- Technical preparatory work will cover the development and testing of components, subsystems, materials or techniques (including dedicated software) that are critical for the future development of a new or enhanced infrastructure. Support will however not be provided for preparatory work based on existing or proven techniques or technologies, nor when it aims at reproducing available components or materials.

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European-wide preparatory work over 2004-2007 - enable design & construction of a 50 to 100-m optical/IR telescope in the 2015 horizon.

We do not want to show it is possible, we want to be ready to do it.

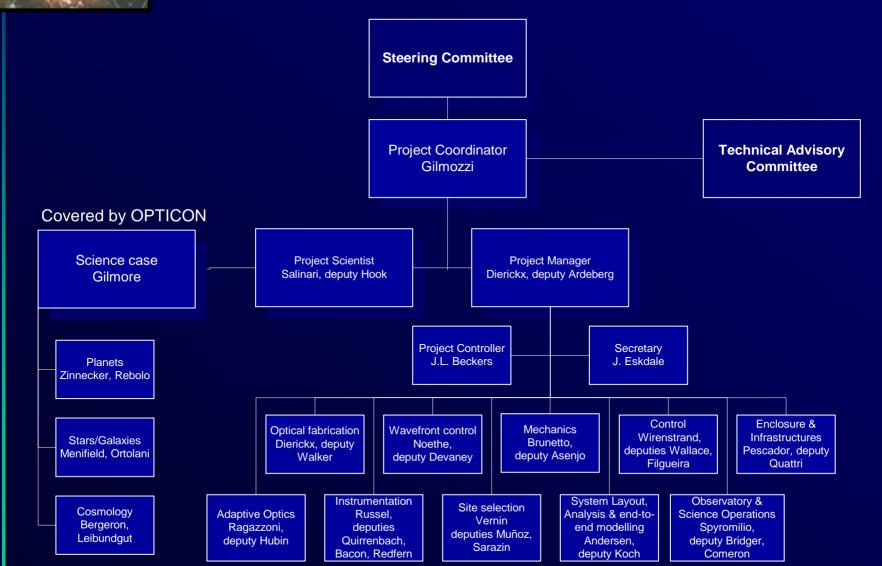
- ⇒ Focus on *enabling technologies:*
 - Technical preparatory work, development & testing of critical components, subsystems, etc.
 - Explore fundamental techniques underpinning the ELT concept (adaptive optics, phasing, wavefront control);
 - Develop design & analysis tools;
- ⇒ Clear path for crucial decisions (e.g. site);
- ⇒ Cost-consciousness and schedule as high priorities

Keep options open: mostly <u>design-independent activities</u>, <u>designs available for reference</u>.

Participation of Institutes, SMEs, major suppliers



Project Organization



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ELT Design Study: highlights

	Concepts	Technology	Tools
Adaptive optics	1st generation designs Novel AO concepts Algorithms for reconstru	Large format DM ction & control	100-m footprint measurement AO & MCAO simulations
Wavefront control	APE, MAD APE	Alignment metrology Phasing metrology Position sensors Position actuators	WEB (Wind)
Optical fabrication		Segments substrates Large Al mirrors Coatings (?)	(SiC)
Mechanics		Structural ropes Composite structural e Magnetic levitation	Breadboard friction drive elements
System layout	Analysis & modeling		Modeling tools
Site characterization	Large scale experiment Atmosphere beyond L_0		Site measuring tools Site measurements
Instrumentation	Point designs	ADCs	
Operations	Science & observatory of	pperation	
Infrastructure	Enclosure concepts		

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Work Breakdown Structure (in progress)

01000	Project coordination	08000	Enclosure & infrastructure
02000	Science requirements	08100	Enclosure concepts
03000	Project Management	08200	Construction, maintenance and operation infrast.
04000	Wavefront Control	08300	Wind studies
04100	Description & classification of WFE	09000	Adaptive optics
04200	Metrology	09100	100m-Layer WFS experiment
04300	Position actuators	09200	1st generation AO & MCAO design for ELTs
04400	Characterization of image properties	09300	Large format, high density DMs R&D
04500	Coronography		
04600	APE	09400	Novel AO concepts
04700	MAD APE	09500	AO & MCAO simulations
04800	WEB	09600	Algorithms for reconstruction & control
05000	Optical Fabrication	10000	Observatory & science operations
05100	Silicon carbide prototypes	11000	Instrumentation
05200	Aspheric surfaces	11100	Point designs
05300	Optical testing of 1.8-m Al mirrors	11200	Other design prospection
05400	Segment assemblies breadboard	11300	Atmospheric Dispersion Compensation
05500	Coating	12000	Site Characterization
06000	Mechanics	12100	Definition of parameters space
06100	Structural ropes	12200	Instruments and observations
06200	Composite structural elements	12300	Results, interpretation and discussion
06300	Magnetic levitation	12400	Large scale experiment
06400	Breadboard friction drive		
07000	Control	13000	System layout, analysis & integrated modelling
07100	APE Control System	13100	Integrated modelling – development of tools
07200	MAD APE Control Systems interfacing	13200	APE Integrated modelling
07300	WEB Control System	13300	WEB Integrated modelling
07400	SELT Control System		

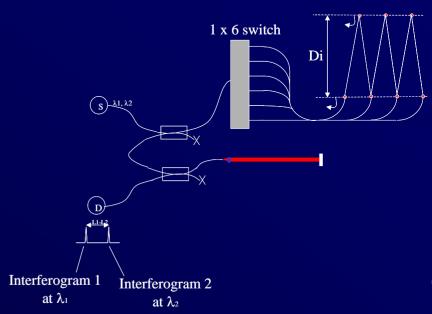


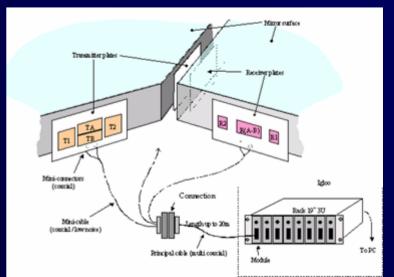
Wavefront control

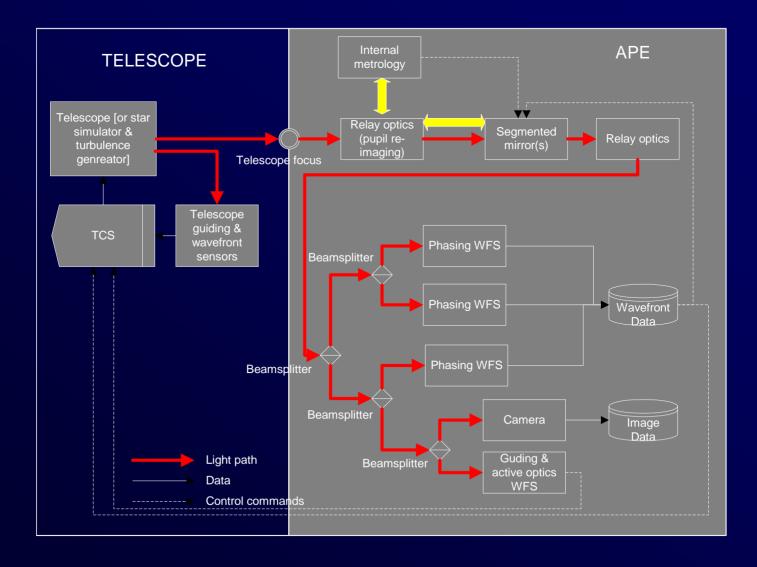
Metrology

- Internal alignment system
- Capacitive or inductance-based position sensors
- Piston-sensitive wavefront sensing
 - Mach-Zehnder (FOGALE, LAM, ESO)
 - Curvature (IAC)
 - Pyramid (INAF)

All to be tested on-sky (APE)

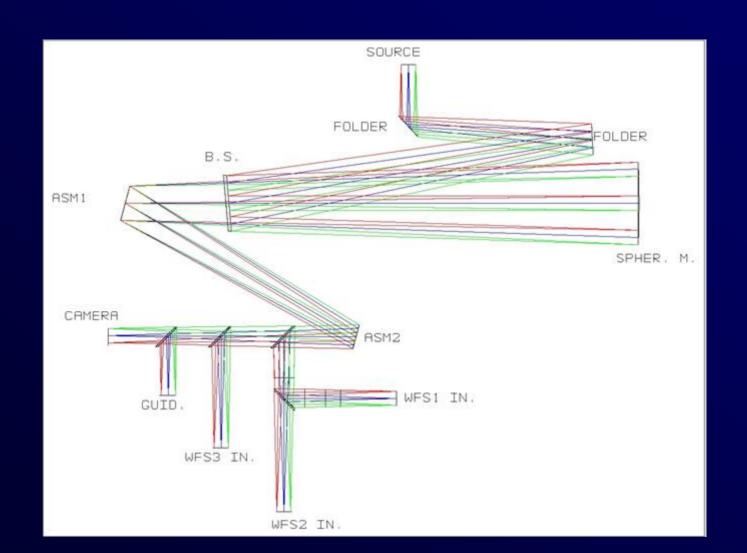








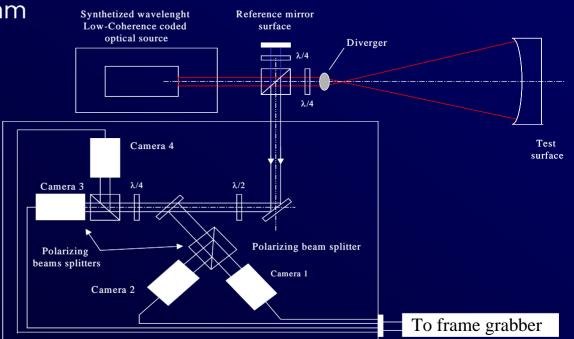
APE Optical design





APE Internal metrology

- ⇒ Verify performance of on-sky phasing sensors
- ✓ Tunable dual-wavelengths interferometer (FOGALE)
- ✓ Verify on-sky phasing sensors readings
- ✓ Expected capture range ~0.1 mm
- ✓ Expected accuracy ~nm



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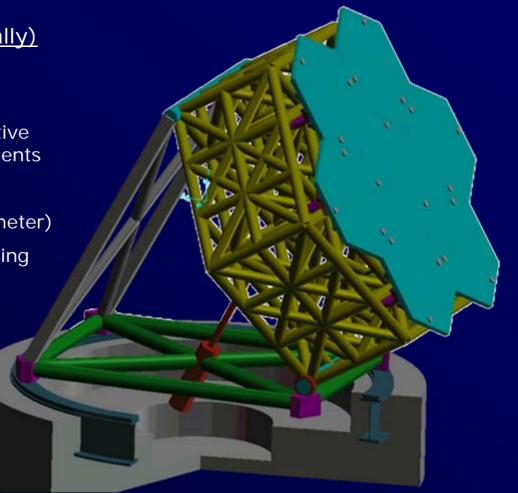
Wind Evaluation Breadboard (WEB)

7 Aluminium panels on a (manually) steerable mount

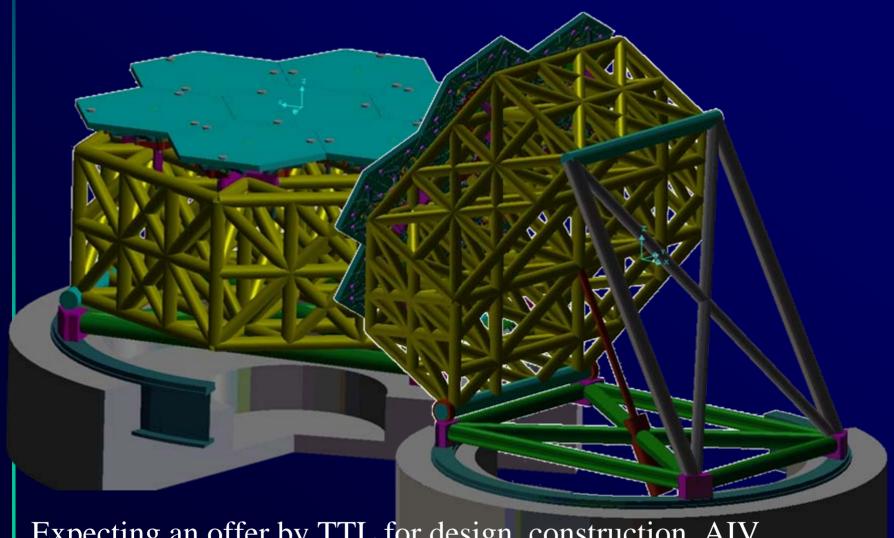
- √ 3 lightweight + 4 solid panels, mass & dimensions representative of SiC and Glass-Ceramic segments
- ✓ Position sensors & actuators
- ✓ Metrology (e.g. laser interferometer)
- ✓ Open air, control of wind buffeting

Probably installed on la Palma

Major "credibility step"



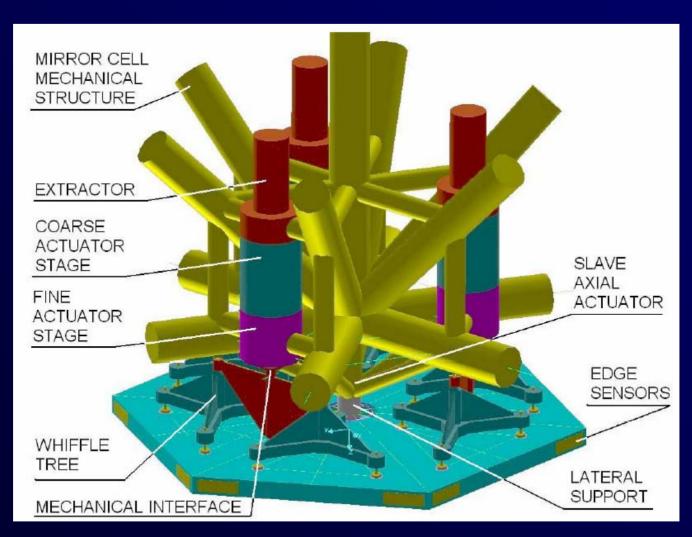




Expecting an offer by TTL for design, construction, AIV



Position actuators

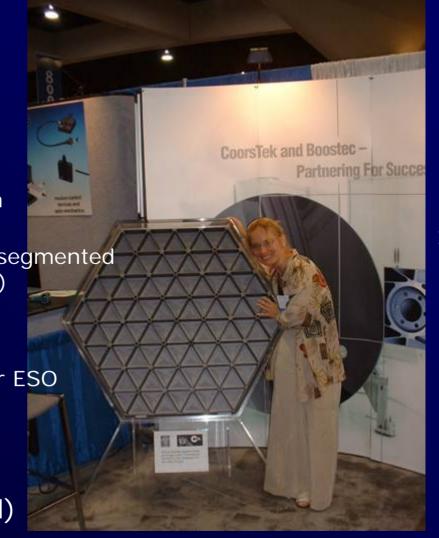




Optical Fabrication

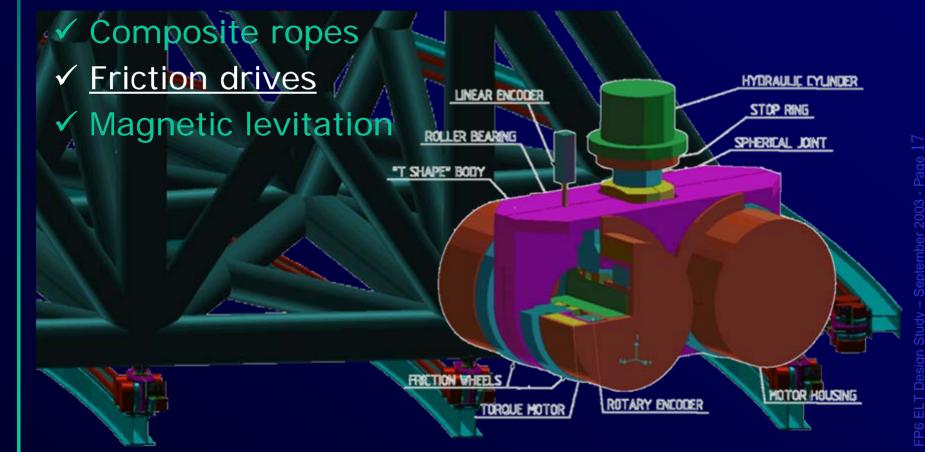
- ✓ Emphasis on substrates:
 - Silicon Carbide for segments
 - Lighter, stiffer, cheaper?
 - 4 blanks already in production (ESO contract)
 - Technology still uncertain for segmented apertures (bimetallic effects?)
 - Aluminium for large mirrors
 - 1.8-m mirrors produced under ESO contract in 1992
 - · Verify their ageing

✓ Coatings ? (still to be explored)



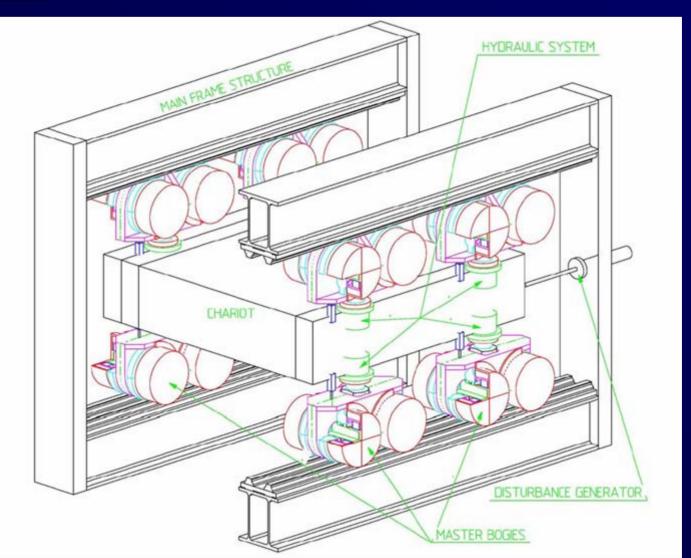


✓ Structural composite elements



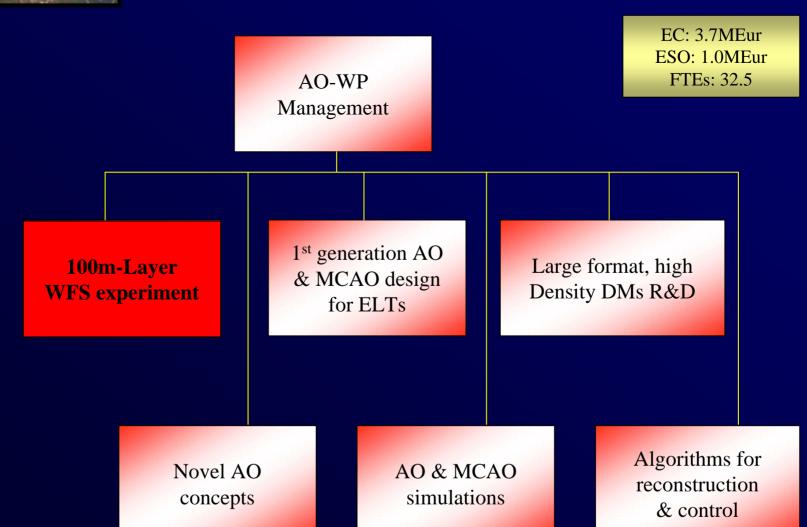


Mechanics: friction drive breadboard

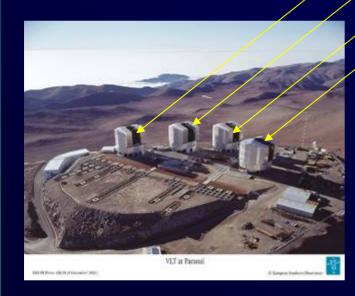




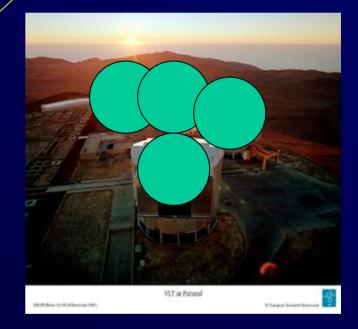
Adaptive optics



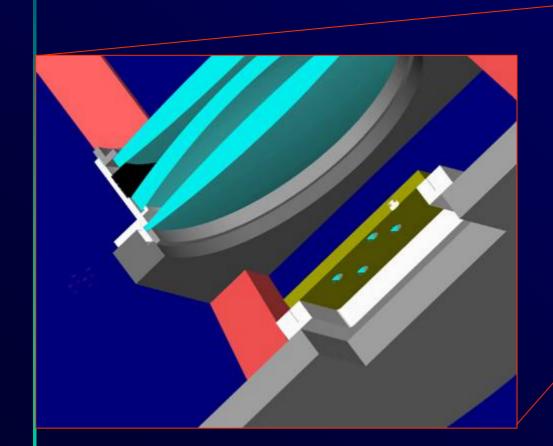
Depending upon the position on the sky the coverage of a given layer will change but, in general, it will be of the order of magnitude of size of the pupil telescopes envelope (i.e. ~100x50m)

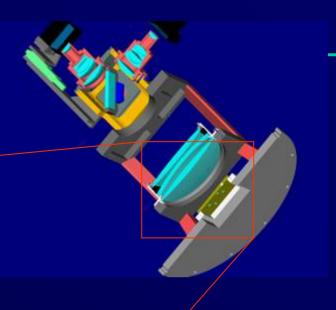


FoV ~6'



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GND layer
is accurately
measured and
numerically
removed. The
large FoV ensure
a small depth of
focus (~100m)





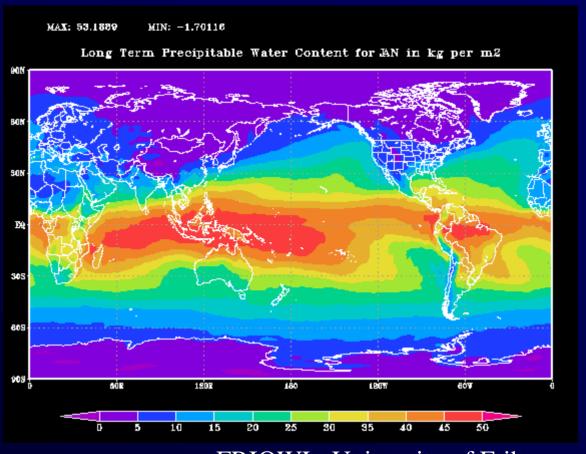
Adaptive optics: Summary

- ✓ Exhaustive information on WF deformation on spatial scales of ~50..100m
- ✓ Full conceptual design for the 1st generation AO & MCAO for ELTs, identifying any critical item
- ✓ Pursue two enabling technologies for large Deformable Mirrors
- ✓ Explore as creatively as possible novel AO & MCAO concepts for ELTs
- ✓ Support new concept with adequate simulation tools; perform end-to-end simulations for the most mature and promising ones
- ✓ Optimize and reduce computing power for AO systems



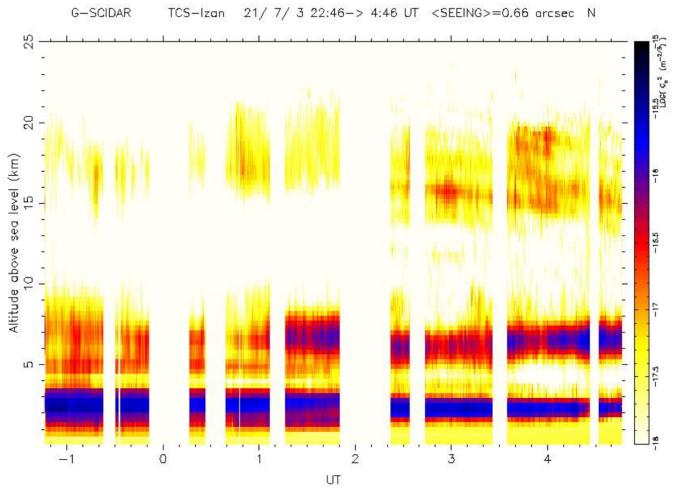


NCEP / NCAR PRECIPITABLE WATER CONTENT 1948-2001



FRIOWL, University of Fribourg

G-SCIDAR (Vernin, Avila, Fuensalida..., Dainty)



Prototype developed in collaboration IAC-LUAN/Vernin&Fuensalida Tested using ING-JKT (1m), IAC-TCS (1.5m). IAC funding.

SCIDAR to be replicated and used at ORM and Paranal. (FP6)





- ✓ WP management & system engineering
 - Incl. Astroclimatolgoy?
- ✓ Definition of parameter space,
 - I/F with other WPs:
 - mechanics,
 - · enclosure & infrastructure
 - Adaptive Optics
 - System layout & analysis
 - Complete detailed evaluation of la Palma & Paranal-N
 - Point measurements
- ✓ Instruments and measurements
 - Standardized equipment (optical properties of atmosphere)
 - Collect "other" measurements (provided by other WPs, e.g. soil properties)
- ✓ Large scale experiment (⇔ AO WP)





Institutes & European Infrastructures

- ESO
- GRANTECAN
- INAM
- Instituto de Astrofisica de Canarias
- Leiden Observatory
- Lund University
- Marseille Observatory
- National Physics Laboratory (?)
- Nice University
- Observatoire de Lyon
- UKATC
- University College London
- SALT?

Industry (TBC)

– BOOSTEC ? Mirror substrates

ECM Mirror substrates

– FOGALE Metrology, AO ?

- LZOS?

– Microgate ? AO

SAGEM Optical fab, AO,

coatings?

- SCHOTT?

SESO Optical fab, AO

- TTL?

... list still growing ...



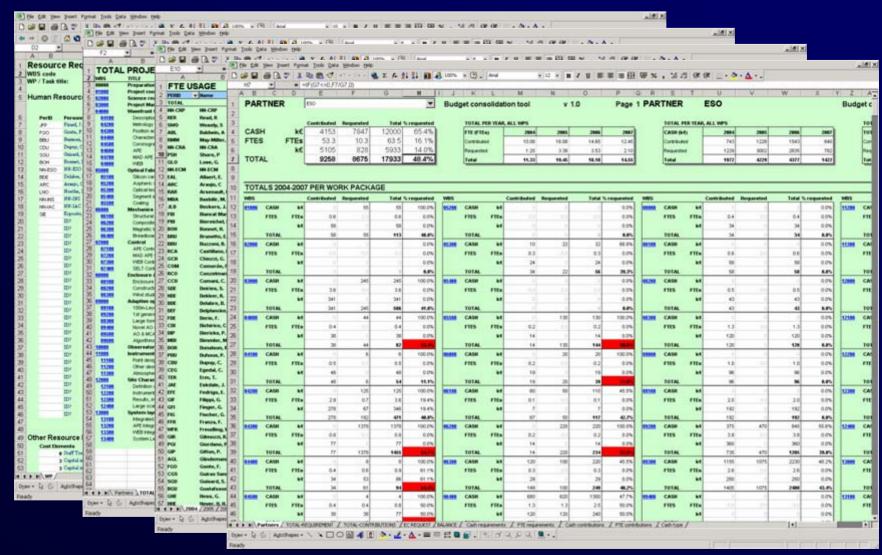


Proposal preparation

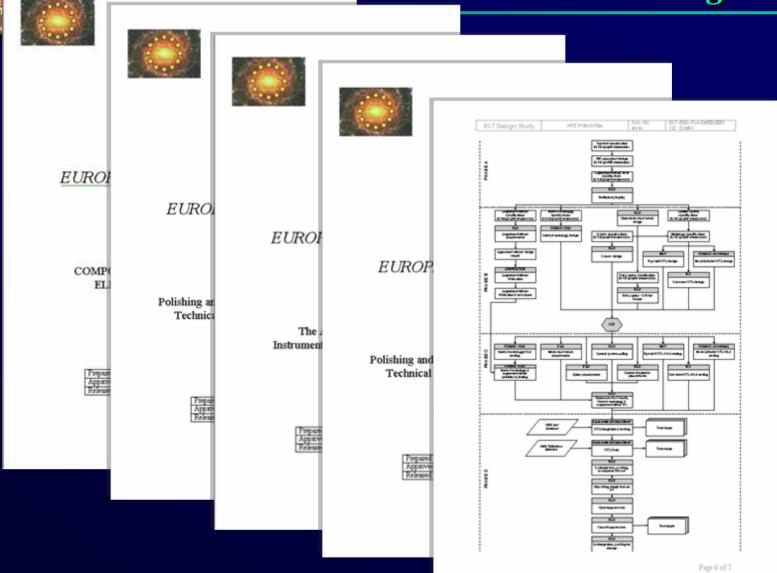
- ✓ Call for Proposal: 11 November 2003
- ✓ Deadline EC deadline 4 March 2004 Internal goal: Jan-2004; start of activities Feb-2004
- ✓ Current status
 - WBS, WP, deliverables > 90% defined
 - Major subsystems, breadboard specs & sow in progress
 - Offers received:
 - ⇒ CESIC 1-m blanks (ECM), polishing (2 offers),
 - ⇒ Position sensors (2 technologies)
 - ⇒ APE internal metrology, phasing sensors (3 technologies),
 - ⇒ Telescope alignment metrology
 - Expert consultant: meeting 1st week of September
 - Budget preparation & consolidation tools completed
 - ⇒ Readiness to address EC requirements
 - ⇒ Flexibility, fast analysis & late iteration possible



Proposal preparation



Getting ready





Deadlines & addresses

√ 11-Nov-2003 Call for proposal

✓ Early Feb-04 Submission of the proposal

√ 4-March-03 Deadline

✓ Proposal includes draft specs for major breadboards / prototypes / subsystems

No	WP	WP Manager	Host		Deputy(ies)	Host	
01000	Project coordination	Gilmozzi, R.	ESO	rgilmozz@eso.org	N/A		
02000	Science requirements	Salinari, P.	INAF	salinari@arcetri.astro.it	Hook, I	OXFORD	imh@astro.ox.ac.uk
03000	Project Management	Dierickx, P.	ESO	pdierick@eso.org	Ardeberg, A.	LUND	arne@astro.lu.se
04000	Wavefront Control	Noethe, L.	ESO	Inoethe@eso.org	Devaney, N	GRANTECAN	ndevaney@II.iac.es
05000	Optical Fabrication	Dierickx, P.	ESO	pdierick@eso.org	Walker, D.	UCL	ddw@star.ucl.ac.uk
06000	Mechanics	Brunetto, E.	ESO	ebrunett@eso.org	N/A		
07000	Control	Wirenstrand, K.	ESO	kwirenst@eso.org	Wallace, P	STARLINK	ptw@star.rl.ac.uk
08000	Enclosure & infrastructure	Pescador, G.	GRANTECAN	gpr@ll.iac.es	Quattri, M.	ESO	mqattri@eso.org
09000	Adaptive optics	Ragazzoni, R.	INAF	ragazzoni@arcetri.astro.it	Hubin, N.	ESO	nubin@eso.org
10000	Observatory & science operations	Spyromilio, J.	ESO	jspyromi@eso.org	Bridger, A	UKATC	ab@roe.ac.uk
11000	Instrumentation	Russell, A.	UKATC	apgr@roe.ac.uk	Quirrenbach, A	LEIDEN	qui@cassir.ucsd.edu
12000	Site Characterization	Vernin, J.	INSU	Jean.Vernin@unice.fr	Munoz-Tunon, C.	IAC	cmt@ll.iac.es
13000	System layout, analysis & integrated mode	Andersen, T.	LUND	torben.andersen@astro.lu.se	Koch, F.	ESO	fkoch@eso.org





ELT Design study: science requirements - I

WBS	TITLE	Input science requirements	Due
03000	Project Management & engineering	Limiting mag., resolution, FOV, wavelength range, opt. perf.	~2006 06-2004
04000	Wavefront Control	Optical quality requirements	
04100	Description & classification of WFE	Optical quality requirements (incl. contrast)	06-2004
04200	Metrology	idem	06-2004
04300	Position actuators	idem	06-2004
04400	Characterization of image properties	idem + satellites, speckles	?
04500	Coronography	idem	1-2005
04600	APE	N/A	-
04700	MAD APE	N/A	-
04800	WEB	N/A	-

NB: N/A = Not directly Applicable



ELT Design study: science requirements - II

WBS	TITLE	Input science requirements	Due
05000	Optical Fabrication	Optical quality requirements incl. contrast	end-2004
05100	Silicon carbide prototypes	idem	end-2004
05200	Optical finishing and edge control	idem (+ satellite images, speckles)	end-2004
05300	Optical testing of 1.8-m Al mirrors	N/A	
05400	Segment assemblies breadboard	Optical quality requirements incl. contrast	end-2005
05500	Coating	Wavelength range	2005
06000	Mechanics		
06100	Structural ropes	N/A	
06200	Composite structural elements	N/A	
06300	Magnetic levitation	N/A	
06400	Breadboard friction drive	N/A	

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ELT Design study: science requirements - III

WBS	TITLE	Input science requirements	Due
07000	Control	N/A	
07100	APE Control System	N/A	
07200	MAD APE Control Systems interfacing	N/A	
07300	WEB Control System	N/A	
07400	SELT Control System	N/A	
08000	Enclosure & infrastructure	N/A	
08100	Enclosure concepts	N/A	
08200	Construction, maintenance and operation infrastructures	N/A	
08300	Wind studies	Optical quality requirements incl. contrast	2005

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ELT Design study: science requirements - IV

WBS	TITLE	Input science requirements	Due
09000	Adaptive optics		
09100	100m-Layer WFS experiment	N/A	
09200	1st generation AO & MCAO design for ELTs	Optical quality requirements, wavelength range, FOV, Strehl varial	2005 pility
09300	Large format, high density DMs R&D	idem	2005
09400	Novel AO concepts	idem	2005
09500	AO & MCAO simulations	N/A	
09600	Algorithms for reconstruction & control	N/A	
10000	Observatory & science operations	Prioritized targets, λ	2005
11000	Instrumentation	idem	early 2005
11100	Point designs	idem	
11200	Other design prospection	idem	
11300	Atmospheric Dispersion Compensation	idem	

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ELT Design study: science requirements - IV

WBS	TITLE	Input science requirements	Due
09000	Adaptive optics		
09100	100m-Layer WFS experiment	N/A	
09200	1st generation AO & MCAO design for ELTs	Optical quality requirements, wavelength range, FOV, Strehl varial	2005 pility
09300	Large format, high density DMs R&D	idem	2005
09400	Novel AO concepts	idem	2005
09500	AO & MCAO simulations	N/A	
09600	Algorithms for reconstruction & control	N/A	
10000	Observatory & science operations	Prioritized targets, λ	2005
11000	Instrumentation	idem	early 2005
11100	Point designs	idem	
11200	Other design prospection	idem	
11300	Atmospheric Dispersion Compensation	idem	

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ELT Design study: science requirements - V

WBS	TITLE	Input science requirements	Due
12000	Site Characterization	λ , optical quality, FOV	early 2005
12100	Review of site parameters space	λ, optical quality, FOV	early 2005
12200	Instrumentation, measurements and mode	N/A elling	
12300	Results, interpretation and discussion	λ, optical quality, FOV	early 2007
12400	Large scale experiment	N/A	
13000	System layout, analysis & integrated modelling	s N/A	
13100	Integrated modelling – development of tools	N/A	
13200	APE Integrated modelling	N/A	
13300	WEB Integrated modelling	N/A	

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And the conclusion is, that a new generation of telescopes is needed to find evidence for extraterrestrial life.

