ELT DESIGN STUDY

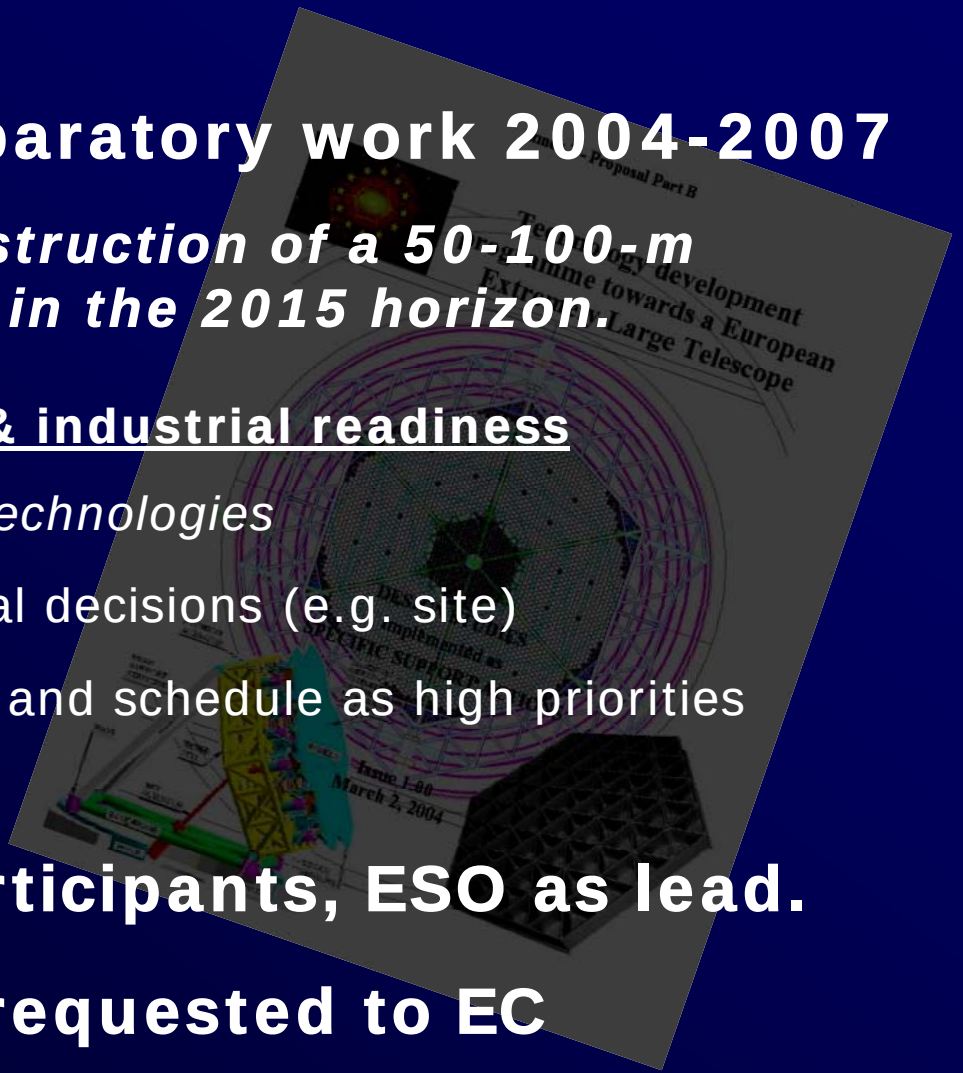
A European(...+) R&D effort towards ELT enabling technologies

ELT Design Study

European-wide preparatory work 2004-2007

⇨ ***enable design & construction of a 50-100-m optical/IR telescope in the 2015 horizon.***

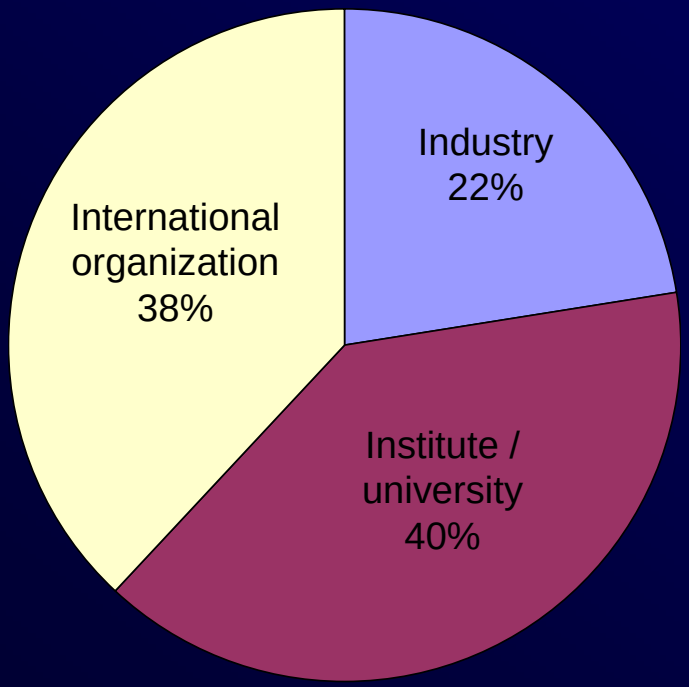
- **<u>Foster academic & industrial readiness</u>**
- Focus on *enabling technologies*
- Clear path for crucial decisions (e.g. site)
- Cost-consciousness and schedule as high priorities

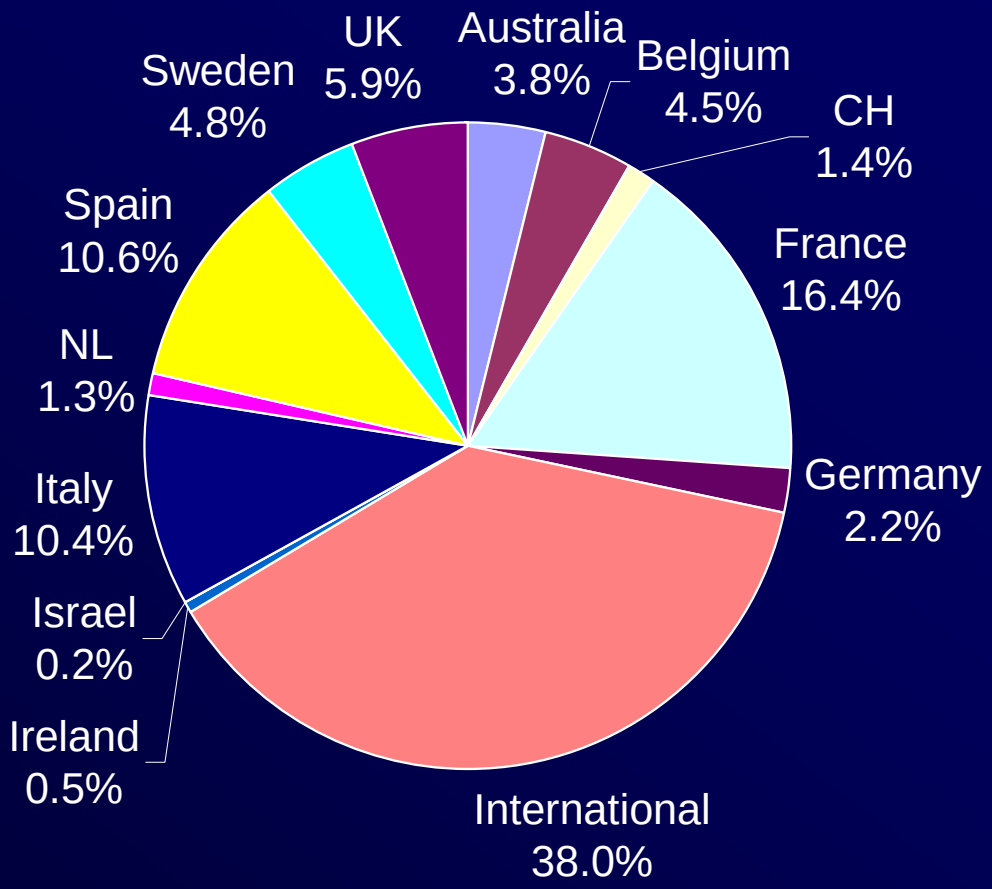


13 countries, 39 participants, ESO as lead.

42 M€ total, 22 M€ requested to EC

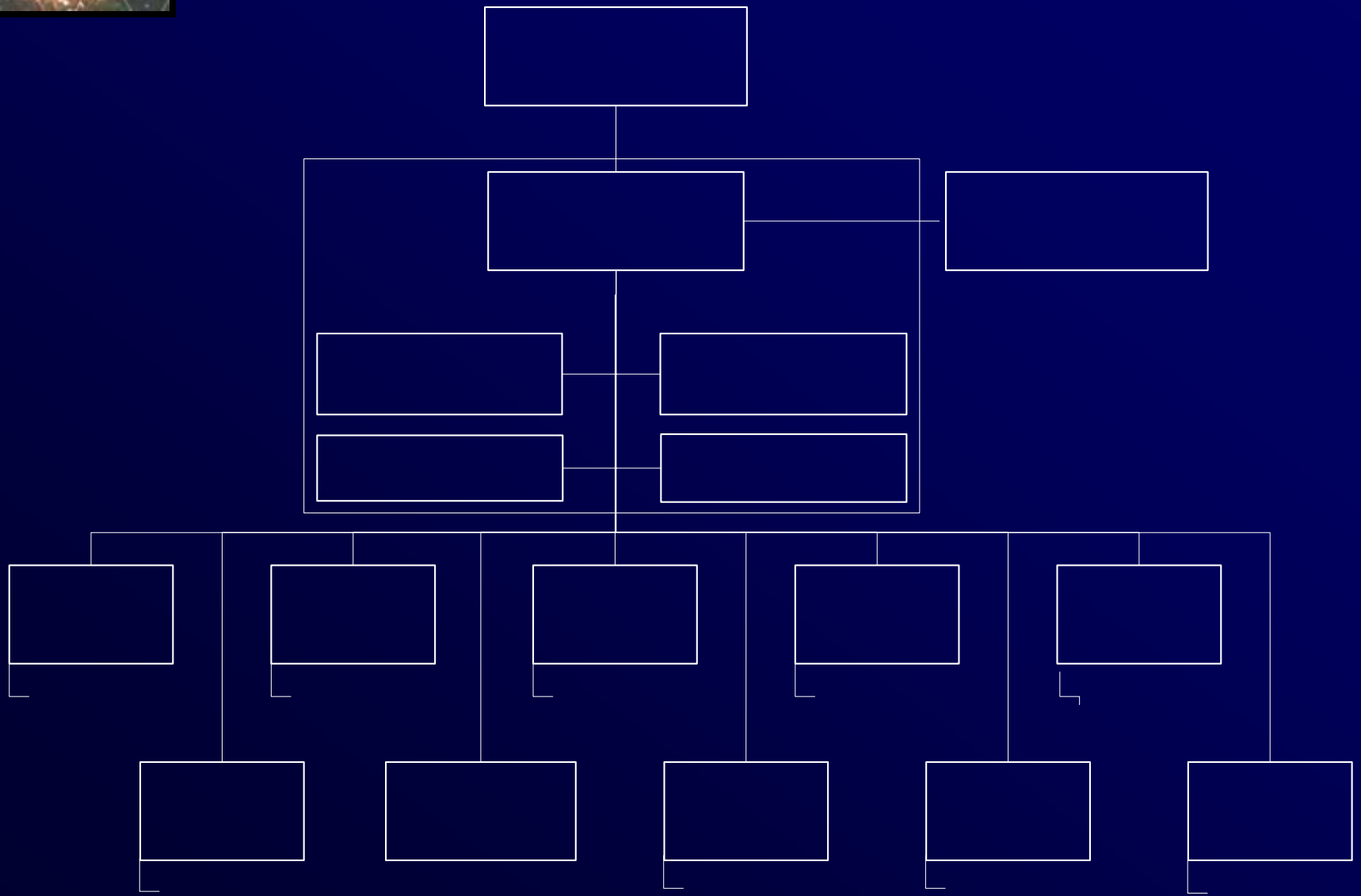
Shares, in % of total estimated budget



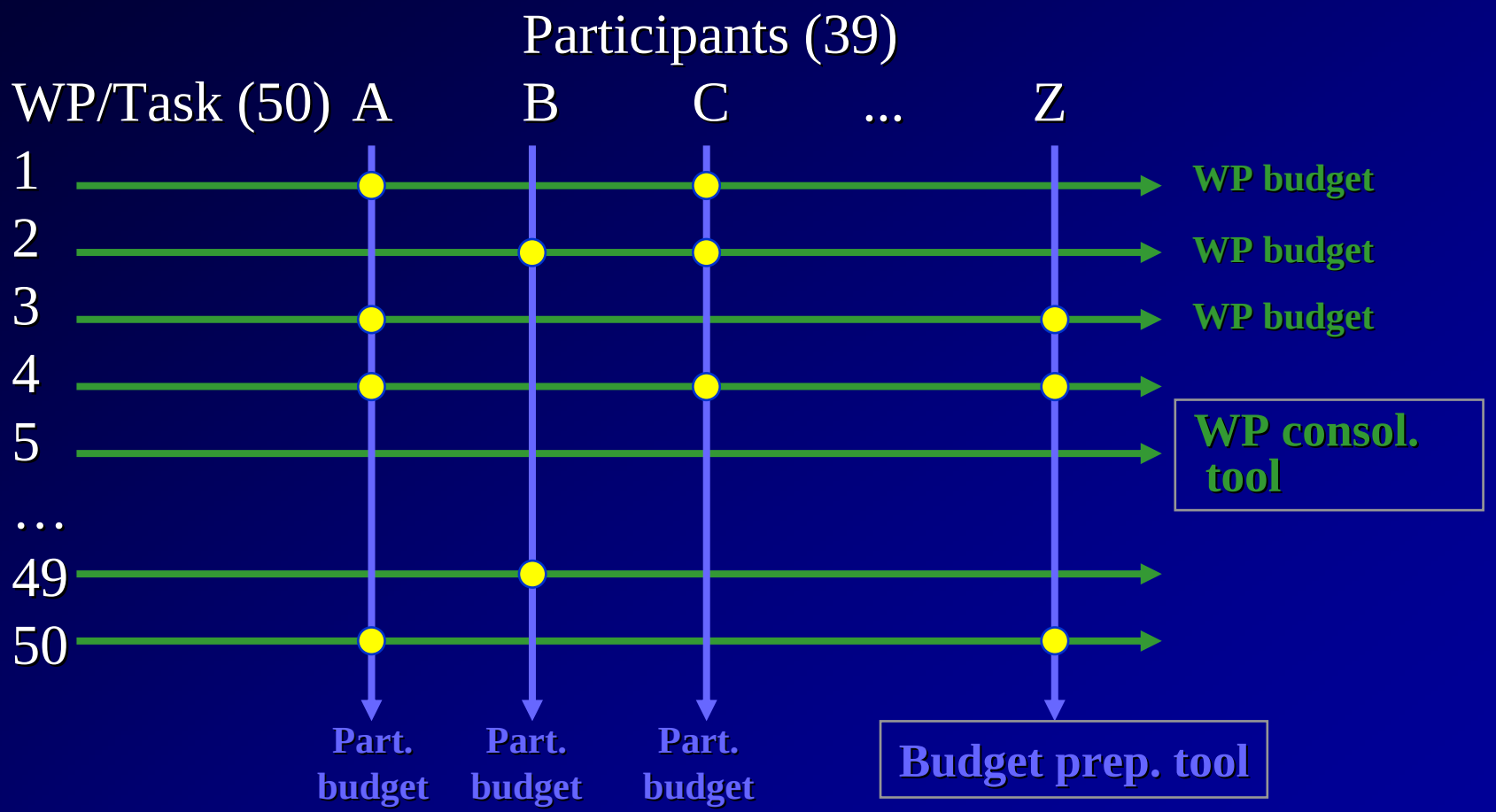


18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Contributed
Requested to EC
ESO
INAF
IAC
FOGALE
LUND Univ.
AMOS
Australia National University
SAGEM
SESO
INSU-LAM
JUPASA
UKATC
Universite de Nice
INSU-CRAL
UCL
EPFL-STI-IPR-LAI
MPIA
CRANFIELD
GRANTECAN
ECM
MEDIA C. I.
CIMNE
Durham Univ.
University of New South Wales
ITER
Observatoire Paris-Meudon
ASTRON
Galway University
Politecnico di Milano
Oxford Univ.
Dutch Space
AAO
LEIDEN Obs.
Technion
TNO TPD
ZEEKO
Universidad Politecnica Catalunia
University Padova
INSU-LAOG

Project Organization



Project organisation



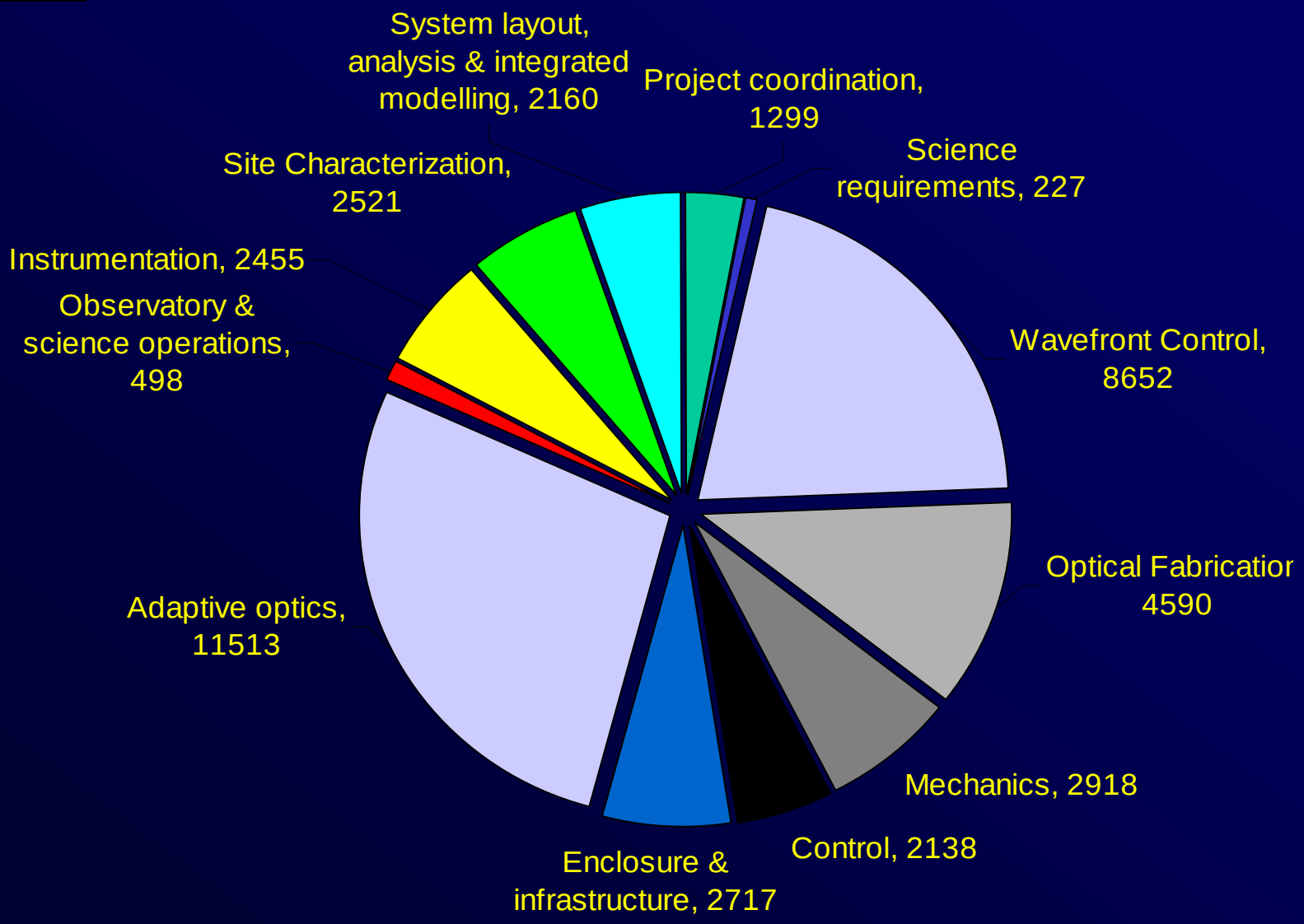
Added complexity: sensitive information

⇨ cross-participants confidentiality !

ELT Design Study: highlights

WORK PACKAGES	Concepts	Technology	Tools
Adaptive optics	*1st generation designs* *Novel AO concepts* *Algorithms for reconstruction & control*	*Large format DM*	*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 (SiC)* *Large Al mirrors* *Coatings*	
Mechanics		*Structural ropes* *Composite structural elements* *Magnetic levitation*	*Breadboard friction drive*
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 operation*		
Infrastructure	*Enclosure concepts*		

Total cost per WP, k€



STUDIES, PROTOTYPES AND BREADBOARDS.

WP 4100: Description and classification of wavefront errors
WP 4200: Metrology
WP 4300: Position Actuators
WP 4400: Characterization of image propoerties
WP 4500: Coronography
WP 4600: Active Phasing Experiment (APE)
WP 4800: Wind Evaluation Breadboards (WEB)

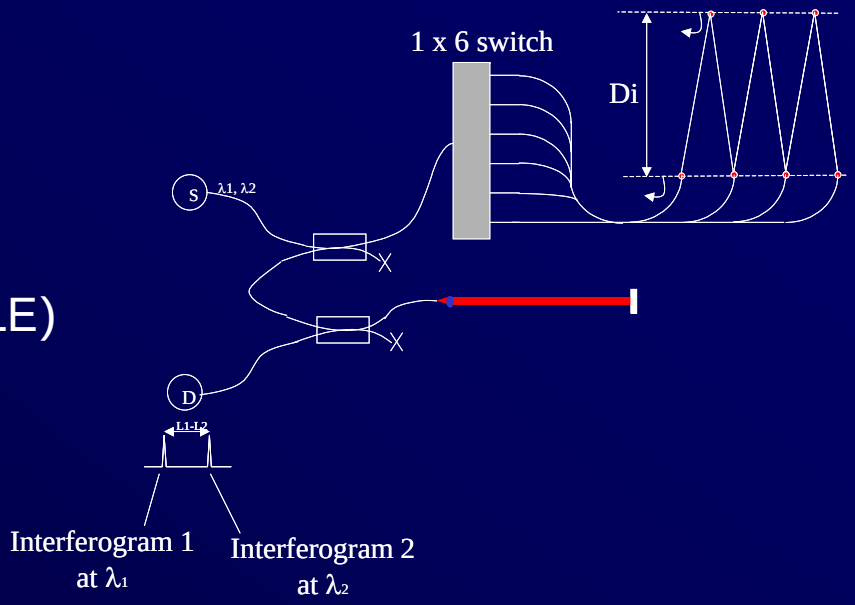
WP Manager: L. Noethe (ESO)
WP Deputy: N. Devaney (GRANTECAN)

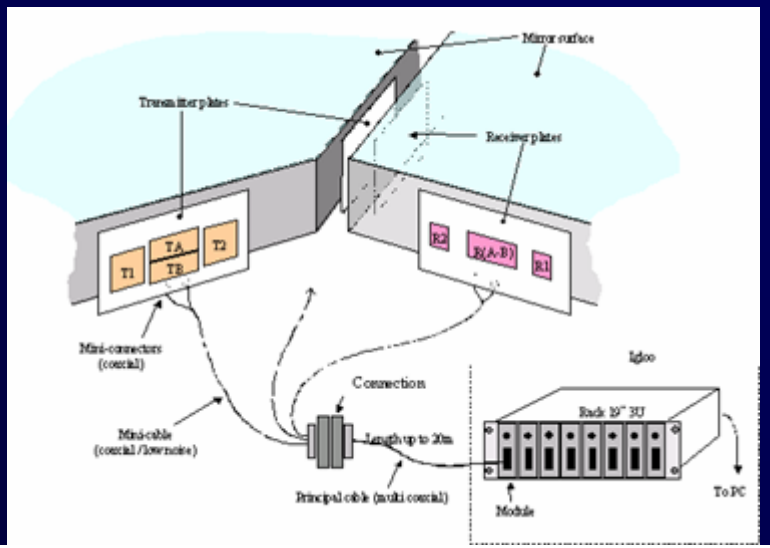
Wavefront control

Metrology

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

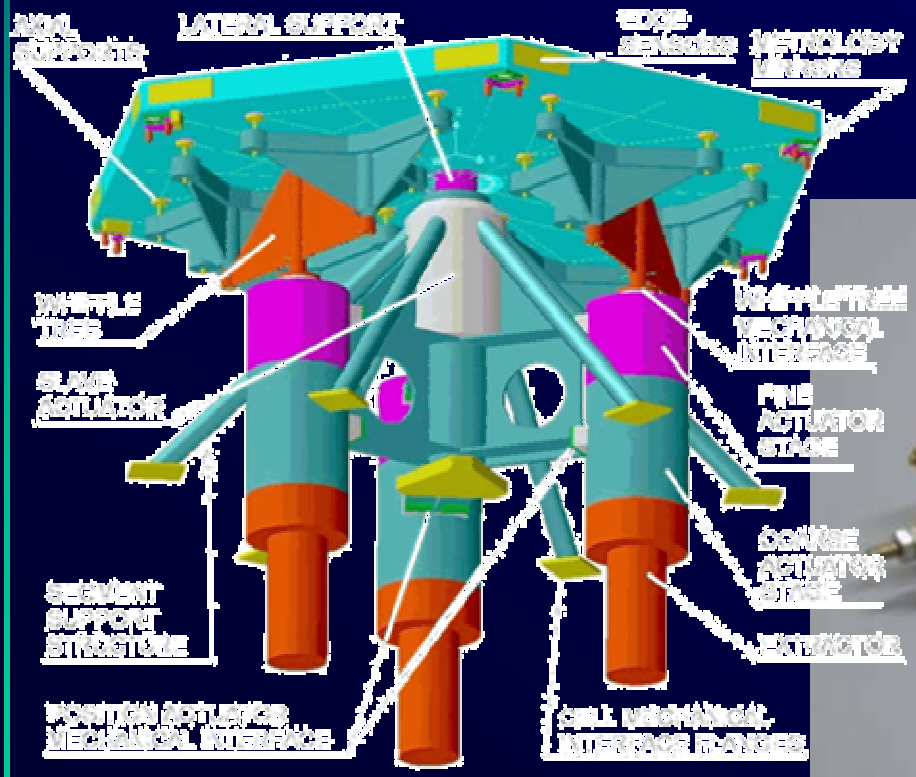
All to be tested on-sky (APE)

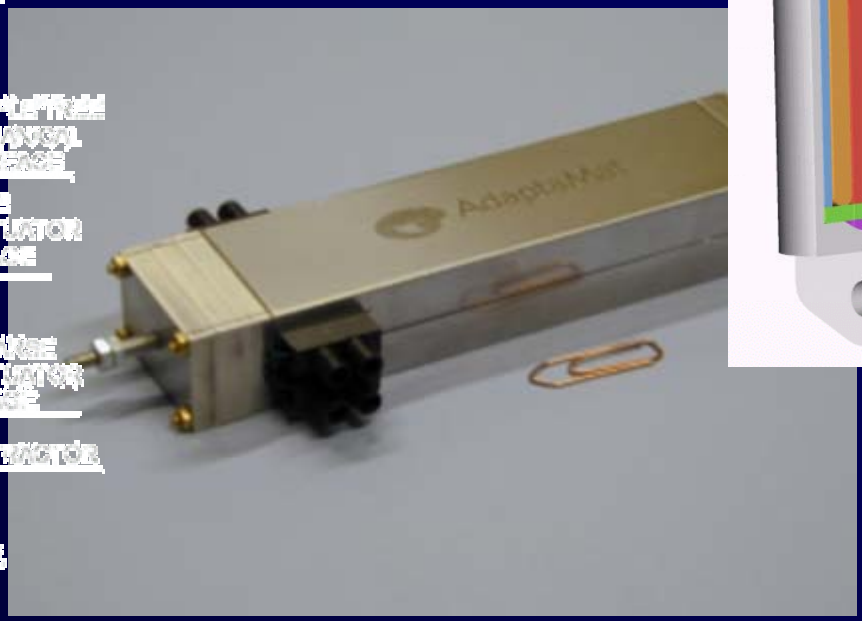


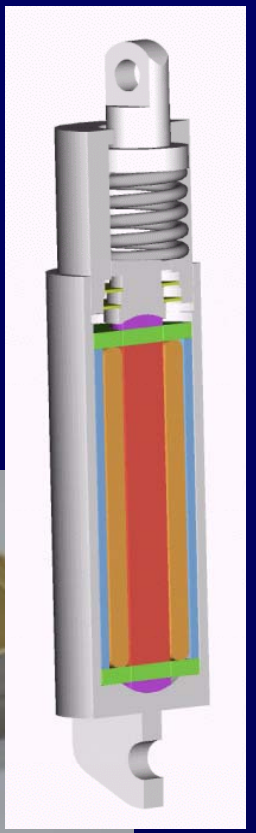


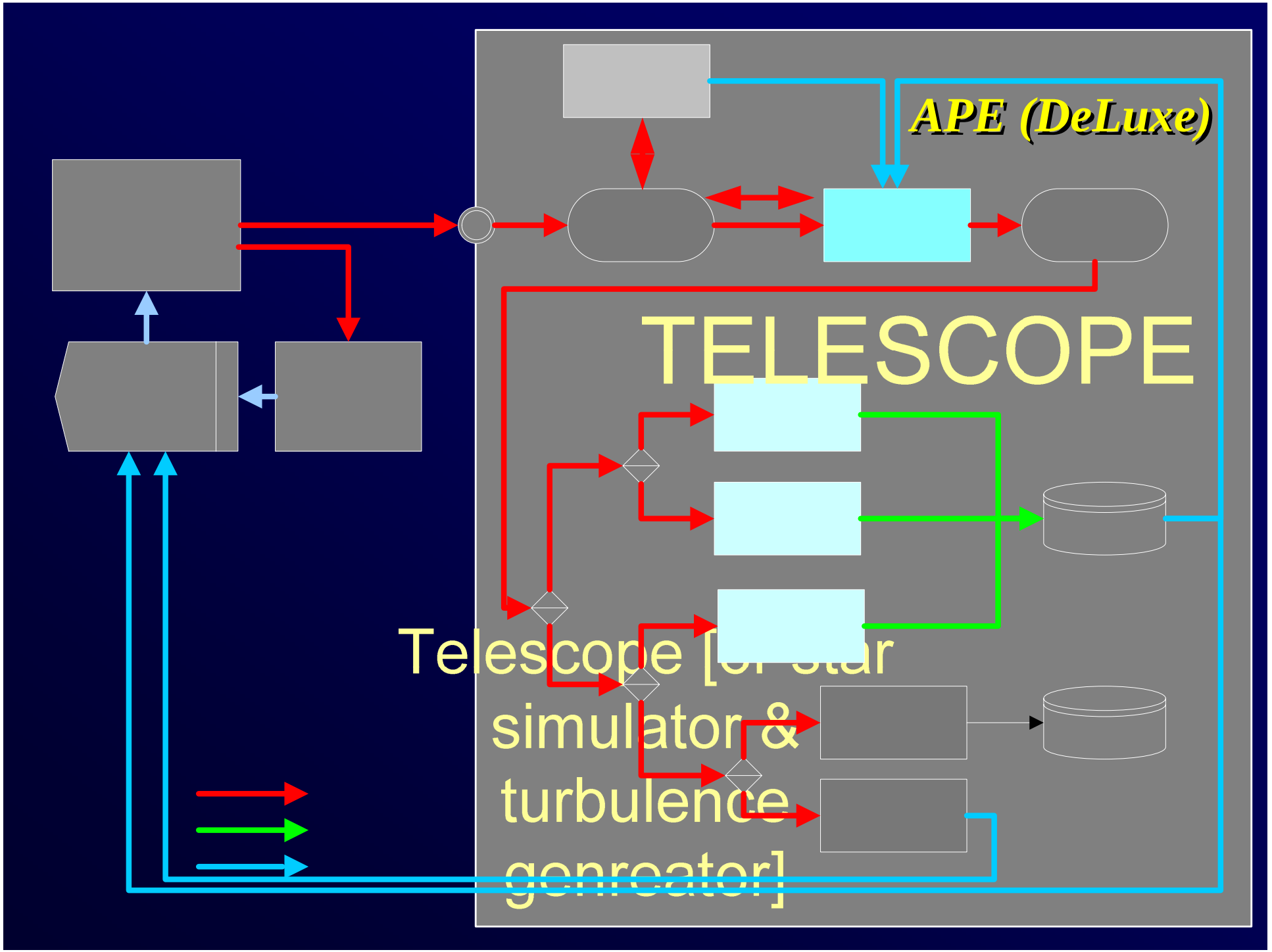
Position actuators

- ✓ Position actuators for WEB (subcontract)
- ✓ Alternative design / prototyping (Dutch Space)







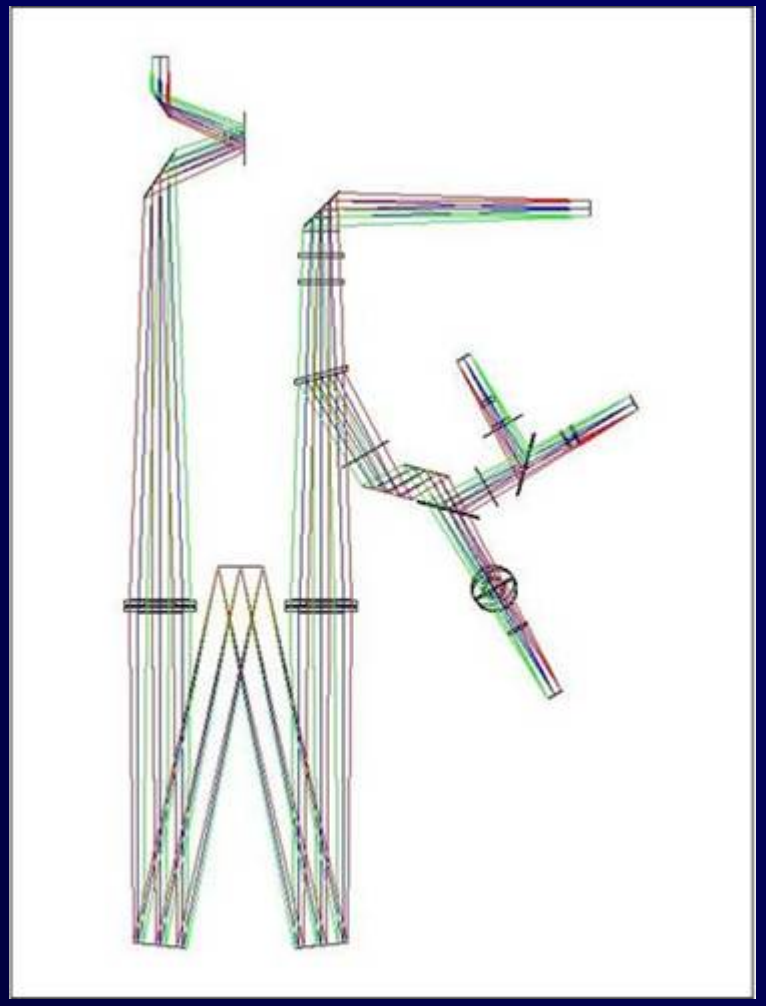

APE (DeLuxe)
TELESCOPE
Telescope [or star
simulator &
turbulence
genreator]

APE (DeLuxe)

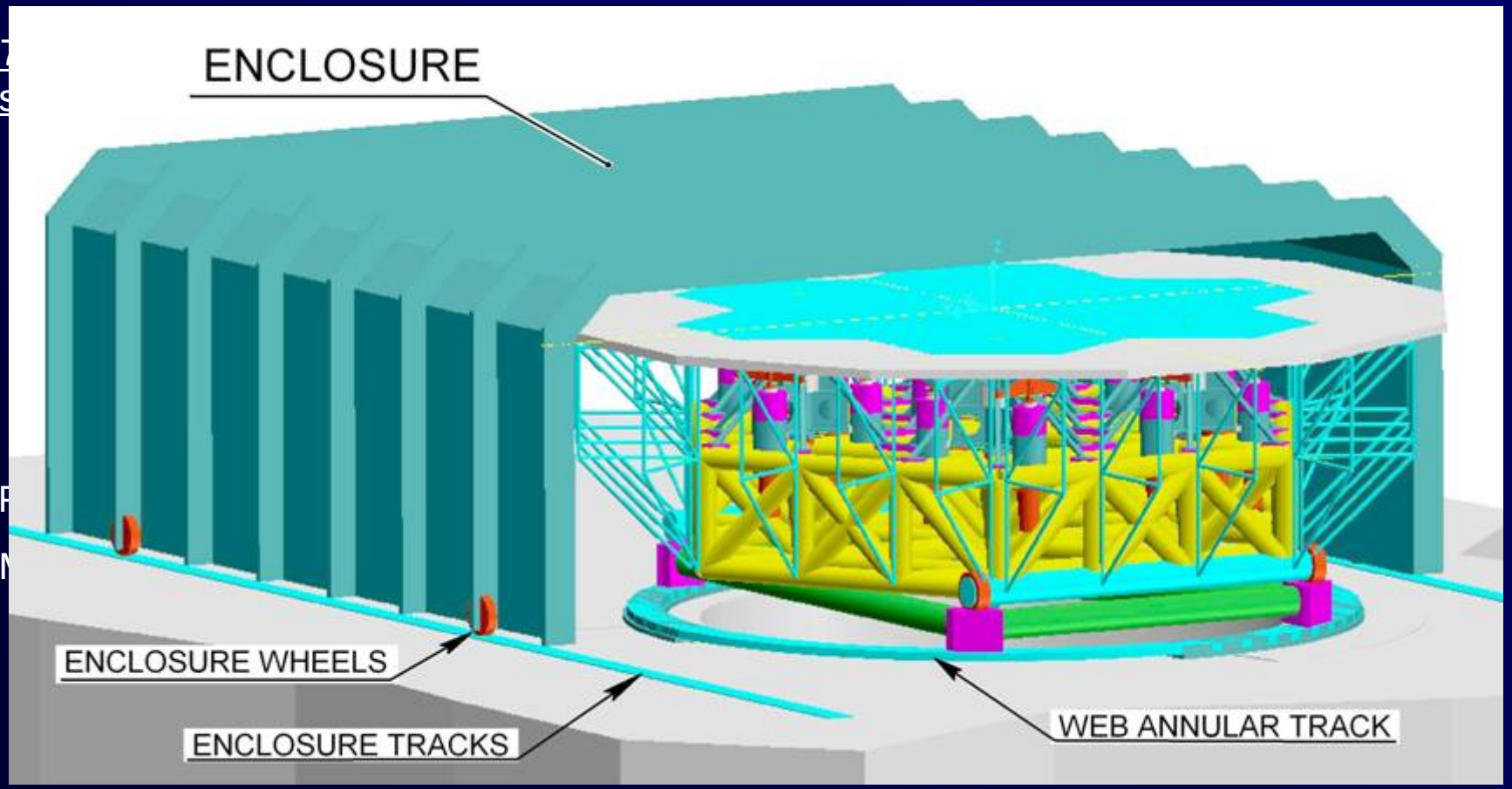
GOALS

- ✓ Compare the performance of 3 types of wavefront sensors :
  - Curvature
  - Mach-Zehnder
  - Pyramid
- ✓ Test the control of combined active optics & segmentation
- ✓ Design & test control software

For control systems, an alternative to an “intermediate step”



Wind Evaluation Breadboard (WEB)



OBJECTIVES (TASKS 05100 TO 05400)

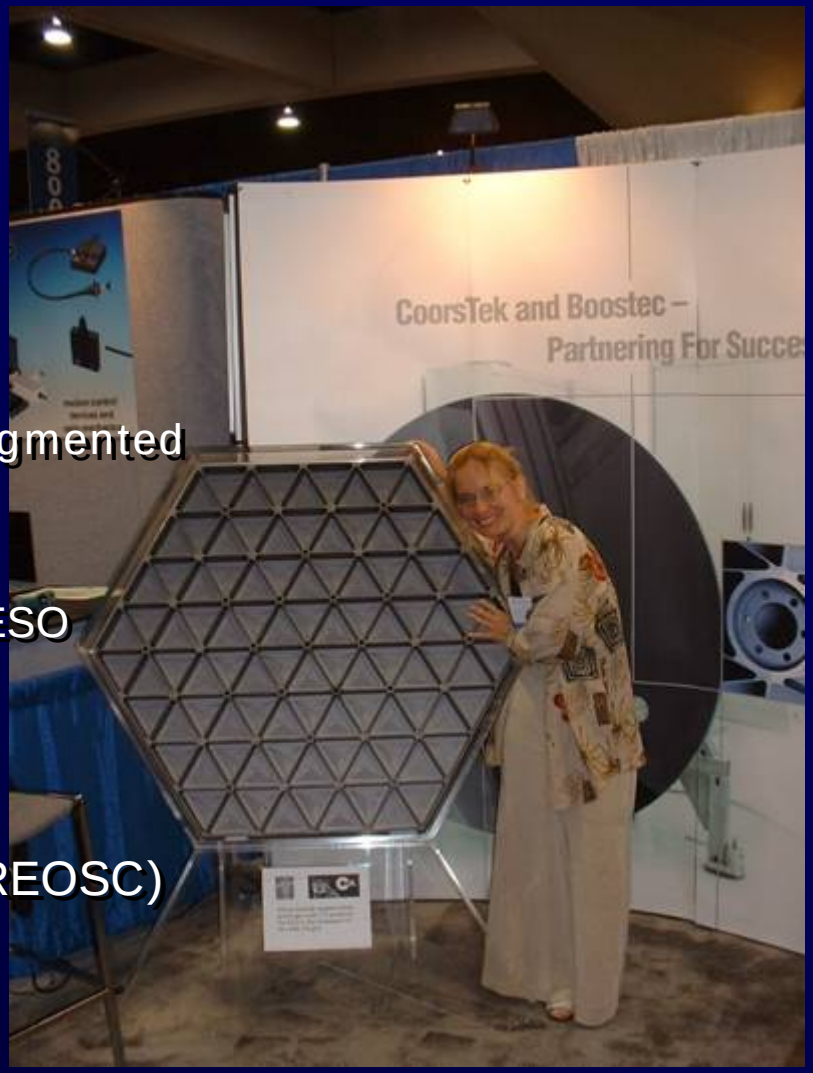
- ✓ Development & verification of potentially cost- and performance-effective materials and processes (e.g. SiC)
- ✓ Optical finishing and edge control
- ✓ Verification of CTE homogeneity of large Aluminum mirrors
- ✓ High performance reflective coatings

WP Manager: P. Dierickx (ESO)

WP Deputy: D. Walker (UCL)

Optical Fabrication

- ✓ Substrates:
  - – Silicon Carbide for segments
    - • Lighter, stiffer, cheaper ?
    - • 4 blanks already produced (ESO contract)
    - • 4 additional by ECM
    - • 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
- ✓ Polishing & testing
  - – SiC segments + edges (SESO, REOSC)
  - – Edge control (UCL)
- ✓ Coatings (study + samples)



STUDIES, PROTOTYPES AND BREADBOARDS.

WP 6100: Structural ropes application for ELT.
WP 6200: Composite structural element for the ELT.
WP 6300: Magnetically levitated systems & linear drives.
WP 6400: Characterization of the friction drive & bearing.

WP Manager: Enzo Brunetto (ESO)
WP Deputy: N.N.

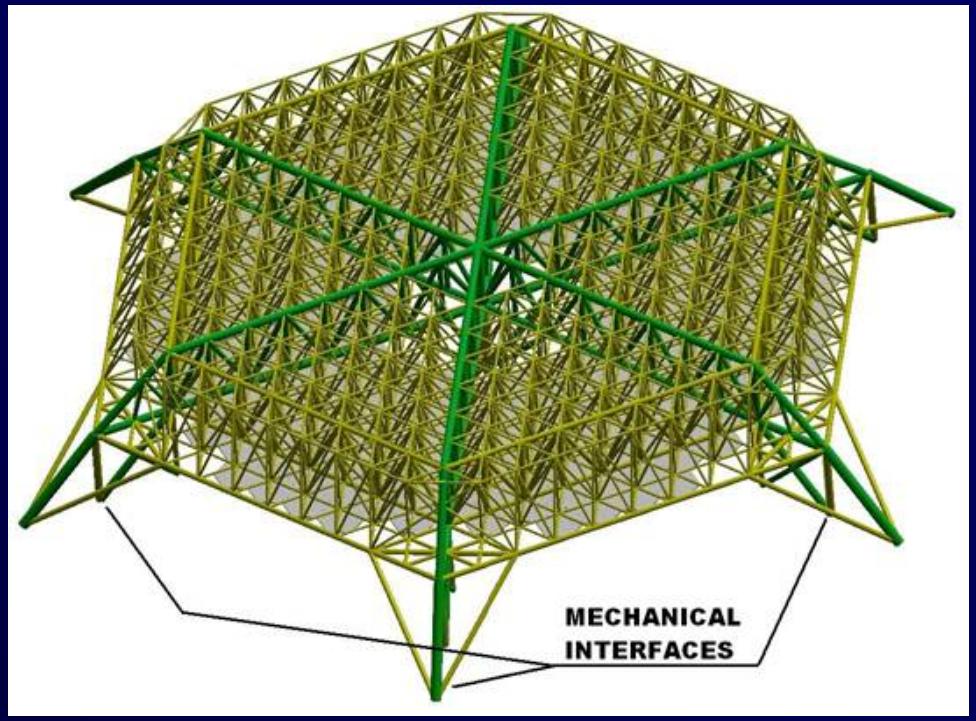
WP 6200 - Composite structural elements

WHY ?

- ✓ All ELT concepts benefits from the reduction of mass of structural elements on critical areas.

SCOPE OF THE STUDY.

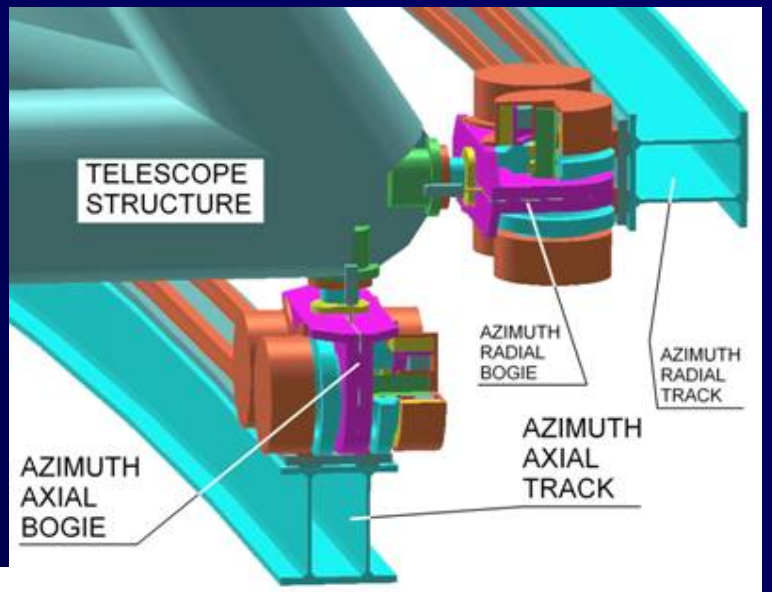
- ✓ Define alternative material to steel cylindrical pipes.
- ✓ Define fittings and mechanical interfaces.
- ✓ Define manufacturing and installation methods.
- ✓ Define maintenance criticality and concept.
- ✓ Define suppliers and costs.

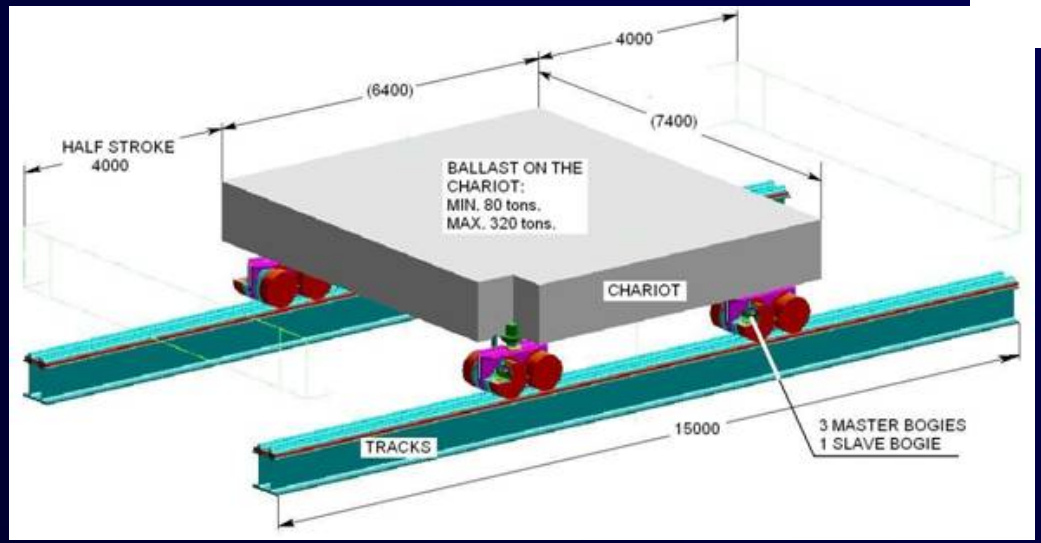


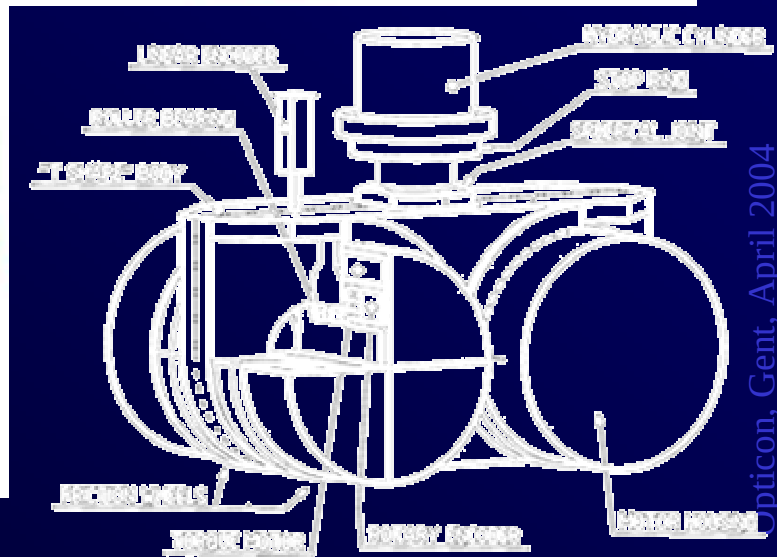
Mechanics

- ✓ Friction drives

  (AMOS, ESO)







Adaptive optics

AO-WP Management

100m-Layer WFS experiment

1st generation AO & MCAO design for ELTs

Large format, high Density DMs R&D

Novel AO concepts

AO & MCAO simulations

Algorithms for reconstruction & control

Schedule-deliverables WP 9200

	4Q-04			1Q-05			2Q-05			3Q-05			4Q-05			1Q-06			2Q-06			3Q-06			4Q-06			1Q-07			2Q-07			3Q-07			4Q-07		
SSAO																																							
Kick-off	M																																						
SMD Phase			V			M			M																														
CD Phase												V			V																								
CDR																M																							
Seeing-Reducer																																							
Kick-off	M																																						
SMD Phase			V			M			M																														
CD Phase																M				V			V																
CDR																								M															
MCAO-K																																							
Kick-off	M																																						
SMD Phase			V			M			M																														
CD Phase																								M				V			V								
CDR																															M								
HSAO-NK																																							
Kick-off	M																																						
SMD Phase			V			M			M																														
CD Phase																															M			V			V		
CDR																																						M	
LGS provisions																								M				V			M			V				M	
Post Focal AO									M			V				M				V				M															
	To	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38

Configuration — Input Meeting — Des. Phase — CDR — Meeting M — Videoconf. V

10000 - Observatory & science ops

- ✓ **The current generation of 8-m class facilities explores new operations paradigms from those of classical observatories.**
- ✓ **Upcoming large, unique facilities (ALMA) will already enforce further evolution of such paradigms.**
- ✓ **Technical and scientific operations of an ELT are expected to involve further significant differences.**

- ✓ ***An integrated approach to problems is proposed to ensure that operations exploit the full capabilities of telescope and instrumentation at the highest efficiency.***
- ✓ ***The goal is to generate level one requirements for the telescope based on the astronomical goals and the needs of the auxiliary instrumentation.***

11000 Instrumentation

3 POINT DESIGN STUDIES (PDSs: €433k)

- ✓ WFSPEC – Wide Field (5 – 10 arcmin) seeing-limited (or boundary-layer corrected) SPECtrometer (Lyon)
- ✓ MOMSI – Optical /NIR Multi-Object & Multi-field Spectrometer & Imager (1-2 arcmin MCAO-corrected FOV) (UK ATC + Durham)
- ✓ MIDIR – MID-IR diffraction-limited high-resolution spectrometer/imager (1-2 arcmin MCAO-corrected FOV) (Leiden + MPIA)

and....

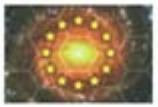
…and 6 Small Studies (SSs: €82k)

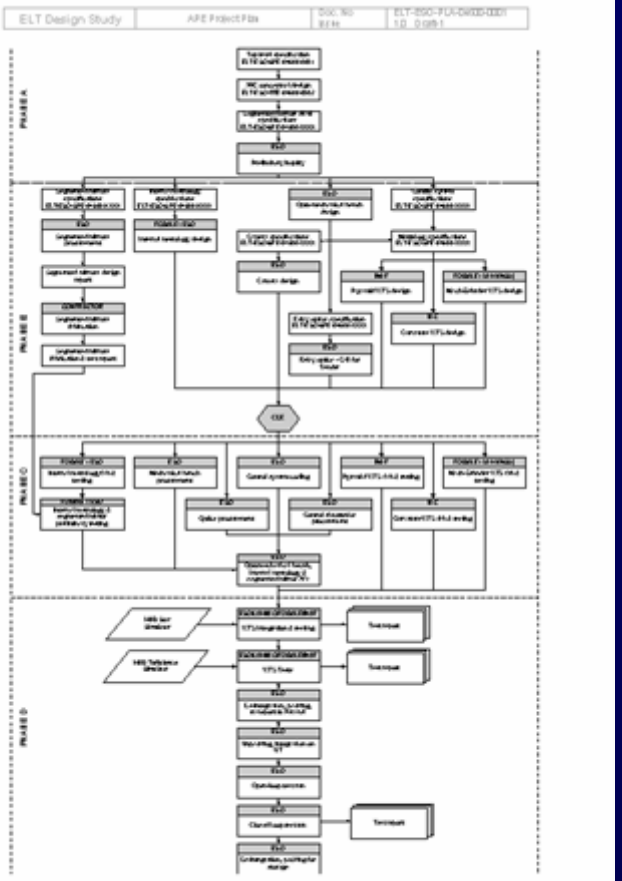
- ✓ Planet Finder – High dynamic-range (coronagraphic) imager/spectrometer (UKATC + Durham, ANU: higher level)
- ✓ HISPEC – O/NIR high spectral resolution instrument (AAO+ ANU higher level?)
- ✓ HiTRI – High Time Resolution Instrument (UIG)
- ✓ GRB-Catcher – Fast-response broad-band imaging spectrometer for transients (AAO)
- ✓ SCUBA-3 (alias SCOWL) – Submm imager (UKATC)
- ✓ ADC: Atmospheric Dispersion Correction – Basic Study of "AO" aspects of ADC (UK ATC + Durham + AO WP Gp)
- ✓ Innovative instrument designs search (Durham + Oxford)
  - * ALSO: Meudon group seeks to study "Falcon" AO button WF facility

And more …

- ✓ Top level ELT requirements (Salinari, Hook)
- ✓ Enclosure & infrastructure concepts (Pescador, Quattri)
- ✓ Standardized site testing equipment & measurements, environmental impact study (Vernin, Munoz, Sarazin)
- ✓ System modeling, development of software tools (andersen, Koch)

Getting ready





…we'll know more in June / July