CTA - CHERENKOV TELESCOPE ARRAY
INAF – ASTRI SST-2M PROTOTYPE

Galbiati Group
Engineering & Machining

EIE GROUP

Engineering, Design & Analyses

The Project

PROJECT NAME	Cherenkov Telescope Array (CTA), Astrofisica con Specchi a Tecnologia Replicante Italiana (ASTRI), Small Size Telescope (SST)
LOCATION	Serra La Nave (CT), Etna mountain, Sicily, Italy
SITE ALTITUDE	1735 m a.s.l.
TIMELINE	18/11/2013 – 17/10/2015
CUSTOMER	INAF, National Institute for Astrophysics – Astronomy Observatory of Brera
CONSTRUCTOR	GEC Consortium (Galbiati Group, EIE GROUP)
ACTIVITIES	Mount Assembly Re-Design, Electrical System Design, Detailed Design, Manufacturing, Factory Pre-Assembly, Packing & Transport, On Site Erection, Commissioning, Acceptance and Testing

Technical Specifications

NUMBER OF UNITS	1 + 3
OBSERVATION TYPE	High gamma-ray energy region
OPTICAL DESIGN	Dual-mirror Schwarzschild-Couder
MOUNTING	Altitude-Azimuth
HOUSING	None, telescopes in open air
PRIMARY MIRROR	18 Segment mirrors
SECONDARY MIRROR	Monolithic mirror ∅1.8 m
AZ ANGULAR STROKE	± 270°
EL ANGULAR STROKE	-0° up to +91°
SURVIVAL OBE	0.26 g
SURVIVAL MLE	0.49 g
OPERATING TEMPERATURE RANGE	-15 to +40 C
OPERATING AND OBSERVING RELATIVE HUMIDITY RANGE	2% to 95%
OPERATING WIND CONDITIONS	50 km/h (average over 10 minutes)
OBSERVING WIND CONDITIONS	20 km/h (average over 10 minutes)
AZ AND EL MINIMUM EIGENFREQUENCY	>2.5 Hz
ABSOLUTE POINTING ACCURACY	<12 arcsec RMS
RELATIVE POINTING ACCURACY	<70 arcsec RMS
TRACKING ACCURACY	<6 arcmin RMS
MAX AZ ANGULAR VELOCITY	4.5°/s
MAX AZ ANGULAR ACCELERATION	1°/s^2
MAX EL ANGULAR VELOCITY	2°/s
MAX EL ANGULAR ACCELERATION	1°/s^2
LIFETIME	30 years

Telescope Description

The first CTA ASTRI SST Prototype is installed on a concrete foundation.

The telescope is made of three major parts:

- the Mount Assembly, composed of the Base Structure and the Azimuth Fork;
- the Optical Support Structure, composed of the M1 Dish and eighteen M1 Segment mirrors, the Central Tube with the Camera, the four Mast, the M2 Structure with the M2 Mirror and the Balancing Counterweights;
- the Electrical and LPS Systems.

The Base is cylindrical conical-shaped with 24 anchor points. At the top of the Base it is installed a Slewing Bearing with external gear for the AZ rotation. The AZ Fork is mounted on this bearing. The AZ rotation is provided by two gearmotors installed outboard on the AZ Fork.

Two couple of bearings and an EL Ball Screw Jack operated by a gearmotor have been foreseen between the AZ Fork and the M1 Dish for the EL rotation.

The eighteen M1 segments are installed on the M1 Dish through the M1 Segment Supports equipped with three Actuators each. A Central Tube is installed on the centre of the M1 Dish in order to house the Camera. Four Must Legs are attached on the M1 Dish in order to support the M2 Back Up Structure with its M2 Mirror and the related actuation system made up of three Loadspreaders.

The telescope is also provided with the following subsystems: Telescope Control, AZ Incremental Tape Encoder, EL Absolute Encoder, Grounding & Lightning Protection, EL Bumpers, AZ and EL Stow Pins, AZ and EL Limit Switches, UPS and Electrical Installations, AZ Cable Drape, EL Cable Wraps, Counterweights, M1 Shields, Optical Baffle & M2 Shield.

Base and Azimuth Fork Structures Re-Design

GEC Consortium was responsible for the manufacturing and the erection of the ASTRI SST, based on the design proposed by another company.

As per agreement with INAF, the Base and Azimuth Fork structures have been re-designed by GEC consortium to improve the accessibility, the maintainability and the safety of some subsystems and major components, e.g. the Azimuth Encoder and the Azimuth Motors.

The adopted cross roller bearing has allowed to use only one bearing instead of the two roller bearing proposed by the previous design.

Mechanical, Electrical and Servo-System Design

GEC Consortium has developed all the mechanical/structural components with the aid of CAD and Finite Element Analysis tools to achieve the best compromise in terms of safety, performance and maintainability.

The electrical system has been realized mainly according to the site environmental conditions (outdoor solutions) and the electromagnetic compatibility constraints (shielded cables, EMC cable glands, filters, etc.). Additionally, an external LPS system has been implemented to guarantee the best protection for the telescope devices and its delicate parts (e.g. bearings) in case of lightning strikes.

The mount control software implements algorithms to minimize the backlash of the azimuth axis pinion-rack transmission. The AZ axis is provided with an incremental tape encoder that has to be initialized to know the absolute position, while the EL axis uses an absolute encoder. GEC Consortiumhas developed all the algorithms to initialize the measurement system.

Analysis of the New Design

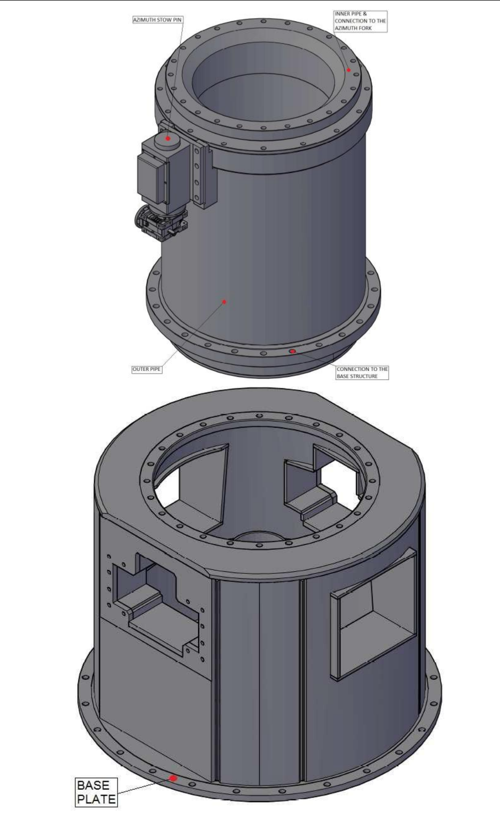
In order to check the new design under survival loads and to compare the performances of the two designs under operational loads, in particular w.r.t. the pointing error and the modal behaviour, both the designs have been modelled via FEM.

Final Results

The performances are equivalent for both the designs.

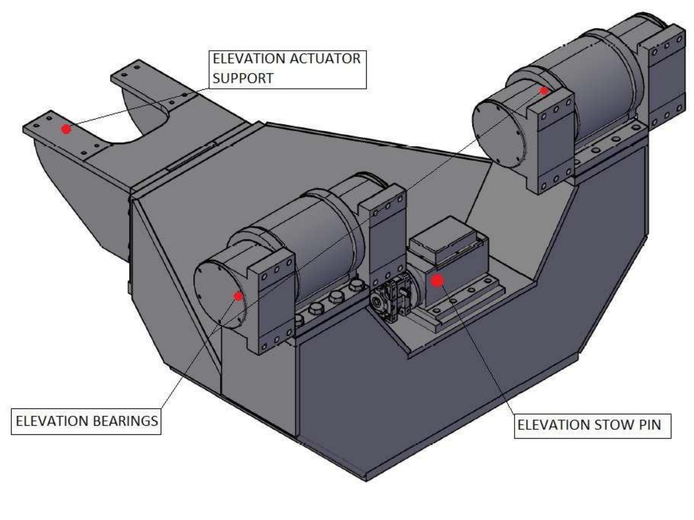
The new design structure has been verified under survival loads.

The new design is 5000 kg lighter (19600 kg vs 24700 kg), 20% less.

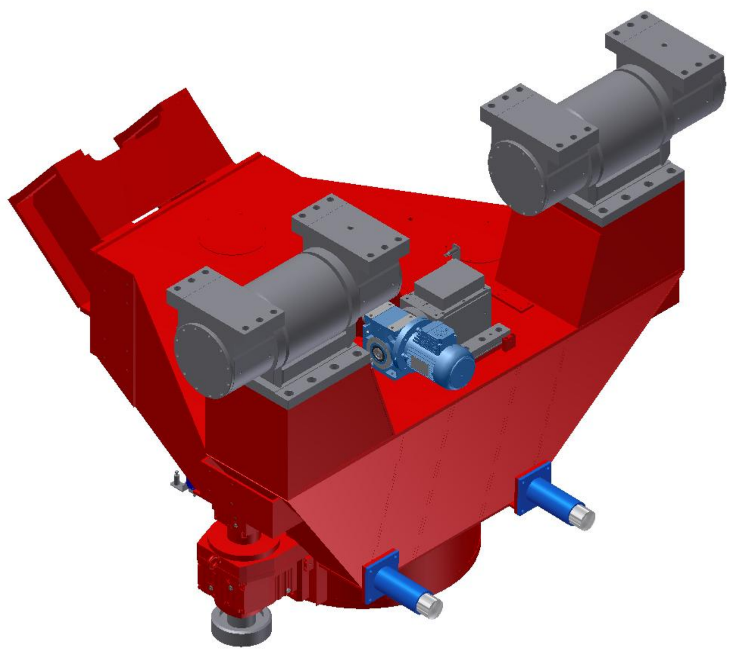


Base and Azimuth Column
Previous Design

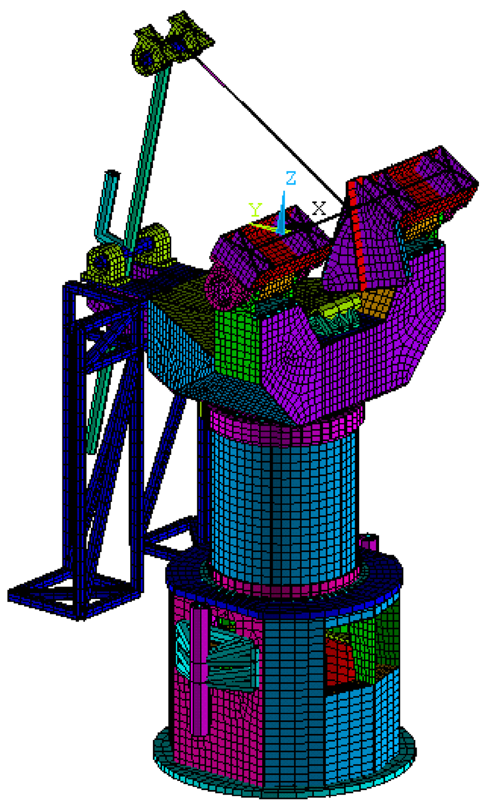
Base
GEC Re-Design



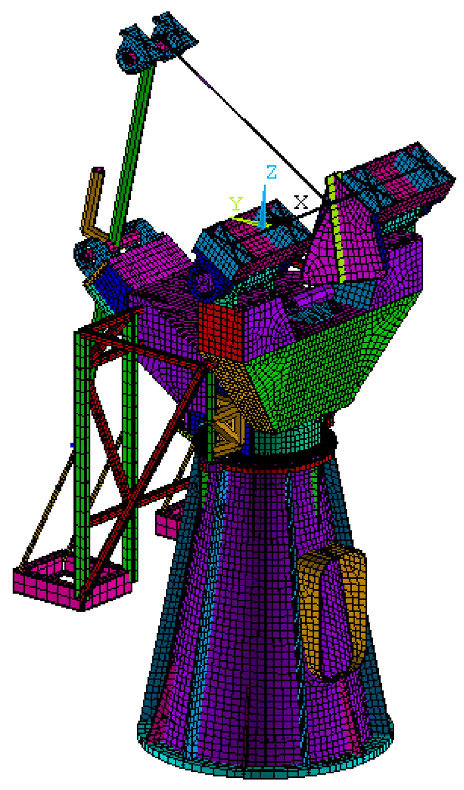
Azimuth Fork
Previous Design



Azimuth Fork
GEC Re-Design



FEM
Previous Design



FEM
GEC Re-Design