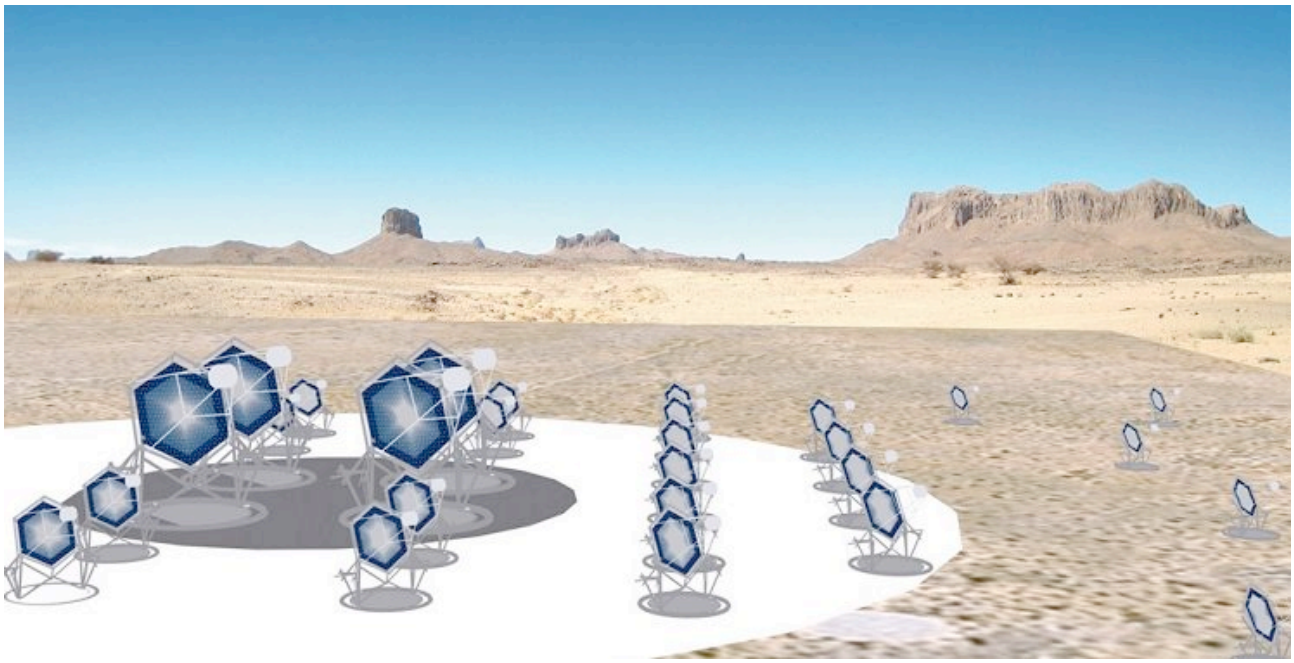
ASTRI SST design loads



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DOCUMENT HISTORY

Version	Date	Modification
1	15-12-2011	first version
2	02-04-2012	update

LIST OF ACRONYMS

CTA	Cherenkov Telescope Array
KO	Kick-off meeting
NA	Not Applicable
PO	Project Office
SLU	Stato Limite Ultimo (Ultimate State Limit)
TBC	To Be Confirmed
TBD	To Be Defined

APPLICABLE DOCUMENTS

[AD1] CTA-TC_PR1-110331 *"Level A: Preliminary CTA System Performance Requirements"*

[AD2] MAN-TPC/20120315 *"Update of CTA-TC_PR1-110331"*

REFERENCE DOCUMENTS

[RD1] P2652 email_001 *"ASTRI Project – Structural design: request for data"*

[RD2] ASTRI-SOW-OAB-3100-002 *"Statement of the Work for the engineering structural design of a dual-mirror Cherenkov telescope prototype for the ASTRI project: the Small Size Telescope of the CTA observatory"*

[RD3] ASTRI-QA-IASFMI-3400-001 *"CTA Level A & Level B Compliance Matrix"*

[RD4] ASTRI-QA-IASFMI-3400-002 *"ASTRI compliance report"*

[RD5] P2652 email_002a *"ASTRI Project – Structural design: design loads"*

[RD6] P2652 Rep. 4 Issue 2 *"AZIONI PER DIMENSIONAMENTO ORGANI MECCANICI"*

1. INTRODUCTION

This document aims to answer to the request of data by BCV and reported in [RD1]. The knowledge of this information is of fundamental importance in order to proceed with the design activities of the ASTRI telescope. Moreover, it has to be remarked that the change of the loads can have a strong impact in the dimensioning of the mechanical parts and may bring extra-costs and delays in the design. The prompt definition of the loads was also stated during the KO.

The present document is compiled on the basis of the CTA requirements reported in [AD1] and shall be considered as an update of the very preliminary and incomplete numbers reported in [RD2].

The issuing of this document should also deal the issues highlighted by the CTA compliance matrix [RD3] and ASTRI compliance report [RD4].

It worth noticing that when lack and/or missing of information are identified in [AD1] we make suggestions based on available National/International Standards (if any) and/or past experiences.

It is our intention to discuss with the CTA PO the present list of loads (together with their numerical value, coefficients and combinations) in order to obtain a formal approval. This list could become the INAF proposal for a common-frame in CTA-SST designing activities.

The present document uses the suggestions made by BCV and reported in [RD5] and [RD6]. In case of discrepancies (wrt [RD5] and [RD6]), these new values have to be considered as a replacement.

In particular the design loads for the telescope structure and for the mirrors are here summarized in separated chapters.

2. TELESCOPE STRUCTURE

2.1 Design loads

The design loads are here reported and coded in a unique way.

Load type	Load code	Value	Class*	Reference	Comments	Expected impact on design (in case of change)
Dead weight	G1	Computed on the basis of nominal dimensions and nominal densities of the materials.	Permanent (G)	EN 1991.1.1 Reference data	Weights coming from structures, mechanical components, baffles, mirrors + mirror supports and camera will be considered. No other on board equipment is considered.	NA
Wind	W50	Calculated according to $p_w = k_d * k_p * \rho_{air} * v_w^2/2$ where k_d = 1 (dynamic coefficient) k_p (pressures coefficients) are to be defined according to the shapes of the elements $\rho_{air} = \rho(T_{air}, h_{asl})$ [AD2] where T_{air} is the temperature of the air and h_{asl} is fixed to 2000 meters (see "comments" column) v_w is the peak wind velocity in m/s (for 50 – 100 – 130 km/s)	Variable (Q)	EN 1991.1.4 CNR-DT 207/2008 Technical literature [RD1]	Any telescope configuration in the full elevation and azimuth range. Used to check the optical performances. ρ_{air} = 1.11 kg/m^3	High
	W100				Any telescope configuration in the full elevation and azimuth range. Used for the structural SLU checks.	
	W130				To be analyzed just in stow configuration. Used for the structural SLU checks. ρ_{air} = 1.24 kg/m^3 The reference roughness length Z_0 is 0.2 meters [AD2]	
Snow	S	3 kN/m^2	Variable (Q)	EN 1991.1.3 Technical literature	Characteristic value at the ground. Just for the telescope in stow position.	Low (in case of stow position only)
Ice	I	5 mm thick on <u>all</u> surfaces	Variable (Q)		Adopted for the design of telecommunications antennas in Northern Europe. Just for the telescope in stow position.	Low (in case of stow position only) but depending on the load variation
Thermal	TA	15°C	Variable (Q)	[RD1]	Assembly temperature	Probably high (depending on the gradients)
	TO	-10°C / +30°C			Operative temperature range	
	TS	-25°C / +60°C			Survival temperature range	
	TG	7 °C			Temperature gradient in the structure 1 hour after the sunset.	

Seismic	E1	Horizontal peaks for OBE = 0.25g MLE = 0.34g Vertical peak is 0.67 times the horizontal ones Ground type: C Spectrum type: 1 Importance factor, γ_I: 1 Viscous damping factor: 2% Behavior factor, q: 1 No topographic amplification effects	Accidental (A)	EN 1990 EN 1998-1 [RD1]	The seismic loads are strongly site dependent. Considering that: - the Southern site of CTA has not yet been selected; - the seismic loads can have a strong impact on the cost of the telescope structure (dimensioning of the structural and mechanical components); we propose to study two opposite situations: Argentina-like (E1) and West Africa-like (E2). The design spectra to be used in response spectrum analysis (in horizontal and vertical directions) have to be computed on the basis of the rules reported in EN1998-1. Ground vertical accelerations values are derived from [RD1] and are not compliant with EN 1998-1. Combinations between the seismic effects in different directions according to EN 1998-1.	High
	E2	Horizontal peaks for OBE = 0.08g MLE = 0.05g Vertical peak is 0.67 times the horizontal ones Ground type: C Spectrum type: 1 Importance factor, γ_I: 1 Viscous damping factor: 2% Behavior factor, q: 1 No topographic amplification effects				
Fatigue		150000 slew operation with the full elevation range		EN 1993.1.9 Technical literature [RD1]	Safe life approach according to the EN 1993.1.9. γ_{Mf} = 1.35	TBD

* according to point 4.1.1 EN 1990

2.2 Loads combinations

Load combinations are used to check and validate the structural design. They are applied according to the Eurocodes EN1990 and EN1991 using the rules for buildings. In particular, they should follow the following expression:

$$\gamma_G * G \oplus \gamma_{Q1} * Q_1 \oplus \Sigma(\gamma_{Qj} * \Psi_{0j} * Q_j)$$

where ✚ means “combined with” in the sense that the signs have to be modified in order to achieve the maximum/minimum values.

Furthermore, seismic combinations goes with:

$$G \oplus A_E \oplus \Sigma(\Psi_{2j} * Q_j)$$

where ✚ means “combined with” in the sense that the signs have to be modified in order to achieve the maximum/minimum values.

The following table summarizes the coefficients to be used as reported in [AD3].

Load type	Load code	Class	γ min/max	Ψ_0	Ψ_2
Dead weight	G1	G	1.0/1.35		
Permanent	G2	G	1.0/1.35		
Wind	W(50, 100, 130)	Q	0/1.5	0.7	0.2
Snow	S	Q	0/1.5	0.6	0.0
Ice	I	Q	0/1.5	0.7	0.2
Thermal	T(A, O, S, G)	Q	TBD	TBD	TBD
Seismic	E(1, 2)	A			

3. MIRRORS

Mirrors shall be treated differently with respect to the telescope structure because of a number of reasons:

- different lifetime required (10 years vs 30 years)
- different impact on the array performances in case of failure (breakage of a single mirror vs breakage of the telescope structure)
- different impact on the cost in case of replacement (single mirror vs single telescope structure)
- different safety issues

3.1 Design loads

The design loads are here reported and coded in a unique way.

Load type	Load code	Value	Class*	Reference	Comments	Expected impact on design (in case of change)
Dead weight	G1	Computed on the basis of nominal dimensions and nominal densities of the materials.	Permanent (G)	EN 1991.1.1 Reference data	Weights coming from structures, mechanical components, baffles, mirrors + mirror supports and camera will be considered. No other on board equipment is considered.	NA
Wind	W50	Calculated according to $p_w = k_d * k_p * \rho_{air} * v_w^2/2$ where k_d = 1 (dynamic coefficient) k_p (pressures coefficients) are to be defined according to the shapes of the elements $\rho_{air} = \rho(T_{air}, h_{asl})$ [AD2] where T_{air} is the temperature of the air and h_{asl} is fixed to 2000 meters (see "comments" column) v_w is the peak wind velocity in m/s (for 50 – 100 – 130 km/s)	Variable (Q)	EN 1991.1.4 CNR-DT 207/2008 Technical literature [RD1]	Any telescope configuration in the full elevation and azimuth range. Used to check the optical performances. ρ_{air} = 1.11 kg/m^3	High
	W100				Any telescope configuration in the full elevation and azimuth range. Used for the structural SLU checks.	
	W130				To be analyzed just in stow configuration. Used for the structural SLU checks. ρ_{air} = 1.24 kg/m^3 The reference roughness length Z_0 is 0.2 meters [AD2]	
Snow	S	3 kN/m^2	Variable (Q)	EN 1991.1.3 Technical literature	Characteristic value at the ground. Just for the telescope in stow position.	Low (in case of stow position only)
Ice	I	5 mm thick on all surfaces	Variable (Q)		Adopted for the design of	Medium-High

					telecommunications antennas in Northern Europe. Just for the telescope in stow position.	(depending on the load variation)
Thermal	TA	20°C	Variable (Q)	[RD1]	Assembly temperature	High
	TO	-10°C / +30°C			Operative temperature range	
	TS	-25°C / +60°C			Survival temperature range	
	TG	3°C, TBC			Temperature gradient along the thickness of the mirror.	
Seismic	E1	Response of the telescope structure to E1	Accidental (A)	EN 1990 EN 1998-1 [RD1]	The seismic loads are strongly site dependent. Considering that: - the Southern site of CTA has not yet been selected; - the seismic loads are related to the answer of the telescope structure to the seismic input; we propose to study two opposite situations: Argentina-like (E1) and West Africa-like (E2). The design spectra to be used in response spectrum analysis (in horizontal and vertical directions) have to be computed on the basis of the rules reported in EN1998-1. Ground vertical accelerations values are derived from [RD1] and are not compliant with EN 1998-1. Combinations between the seismic effects in different directions according to EN 1998-1.	Medium or Low on M1 More significant on M2
	E2	Response of the telescope structure to E2				
Fatigue		n.c.		n.c.	n.c.	NA

* according to point 4.1.1 EN 1990

3.2 Loads combinations

In a similar way to the loads combinations rules described for the structural checks of the telescope structure, we report in the following the coefficients adopted to evaluate the mirrors.

These values could differ for the previous ones in reasons of what reported at the beginning of the Chapter 3.

Load type	Load code	Class	γ min/max	Ψ_0	Ψ_2
Dead weight	G1	G	TBD	TBD	TBD
Permanent	G2	G	TBD	TBD	TBD
Wind	W(50, 100, 130)	Q	TBD	TBD	TBD
Snow	S	Q	TBD	TBD	TBD
Ice	I	Q	TBD	TBD	TBD
Thermal	T(A, O, S, G)	Q	TBD	TBD	TBD
Seismic	E(1, 2)	A			