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HiSOLO

Windproof Simulation Report



BIGLUX INNOVATION LTD

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1/HiSOLO Anti-overturning check calculation under working state

1.1 HiSOLO Mainly composed of wind-bearing components

HiSOLO Mainly composed of the lower car box (including the control box, frame, axle, wheels and the battery, electrical parts, side shake jack), lifting rod (composed of six sections, complete the working state of extension), CCTV box, CCTV box camera and related functional parts, solar panel bracket and solar panel components. Overall weight: 1158 KG; total working height: 7.53 m

HiSOLO Component weight distribution table

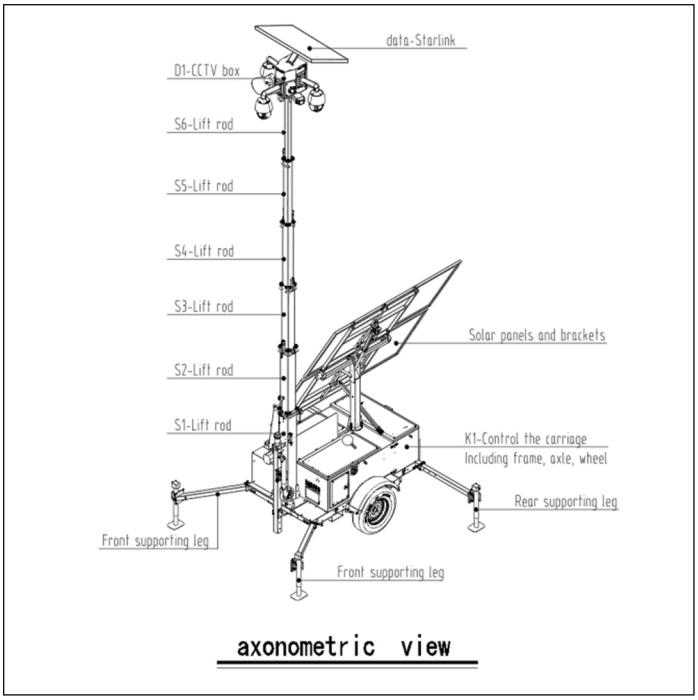
order number	component	Part Weight: KG	remarks
1	Control the box	200.76	
2	Rack, axle	267.38	
3	wheel	40	
4	lifter	160	
5	CCTV box	30	
6	CCTV box camera	30	
7	Solar panel bracket	67.73	
8	solar panel	41.8	
9	cell	226	
10	Electrical parts in the compartment	50	
11	The side shake jack	45	
12	Vehicle weight	1158.67	

HiSOLO Working status diagram

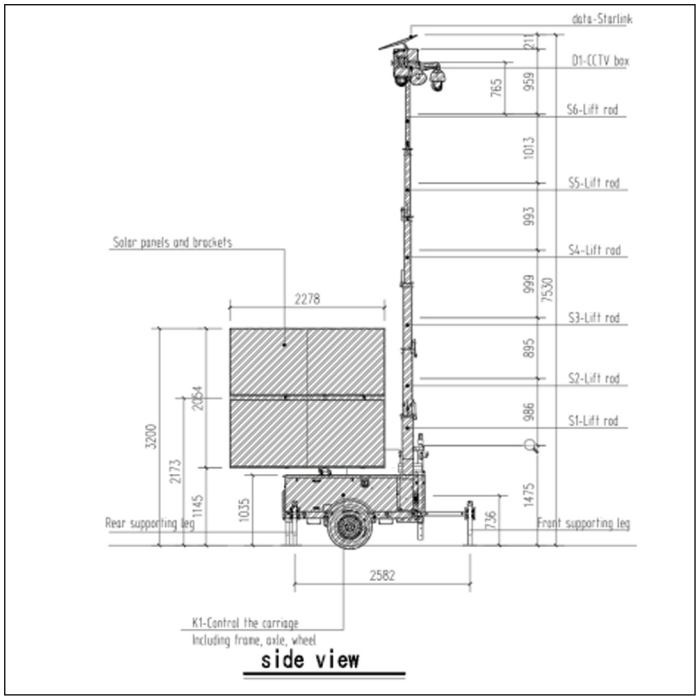


Post-deployment condition (total height 7.53 m)

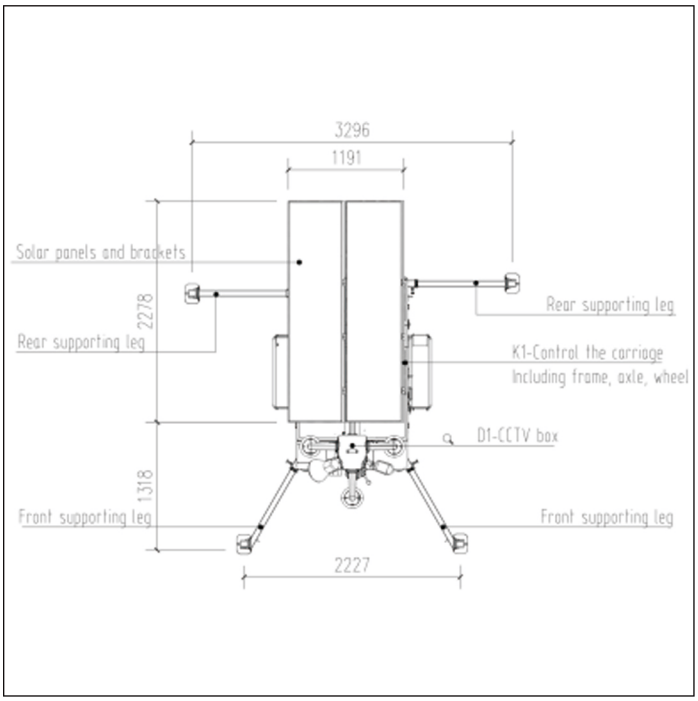
HiSOLO Size diagram of each equipment under working condition



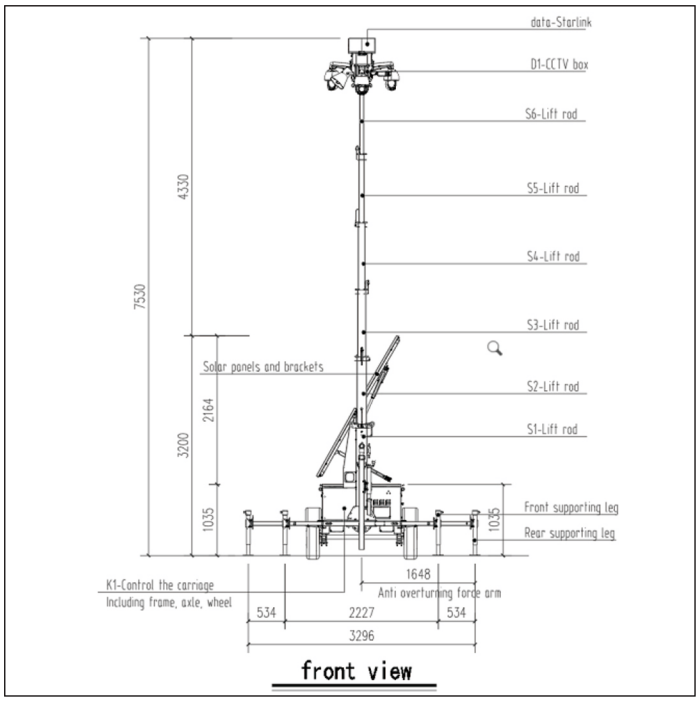
HiSOLO axonometric view



HiSOLO Side view dimension drawing (main wind surface)



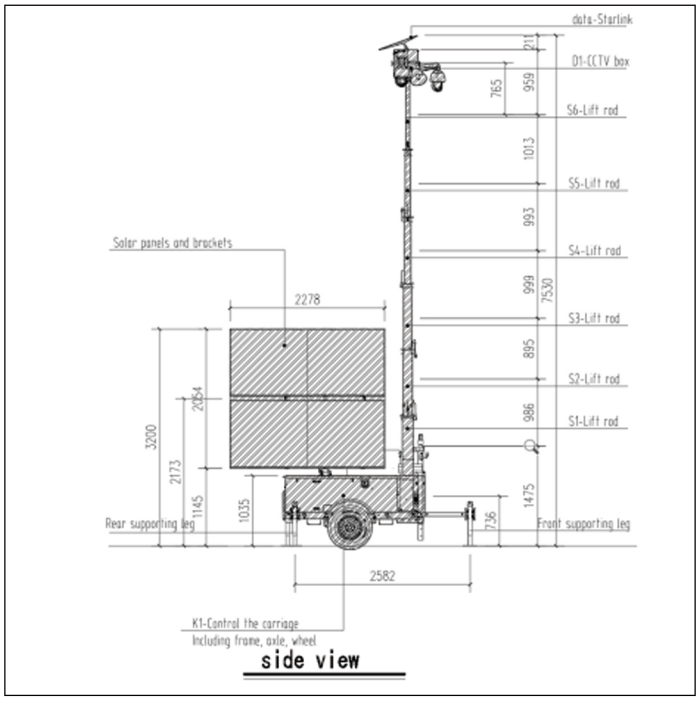
HiSOLO Top dimension view



HiSOLO front view

1.2 HiSOLO Main wind surface analysis

According to the characteristics of HiSOLO equipment, the main wind surface is in the front face and the side view. Because the solar panels are installed on the side and the wind area is the largest, it can be determined that the side is the most affected by the wind, and the side wind surface is the main wind surface



Maximum wind surface

Statistical table of the maximum wind surface area size

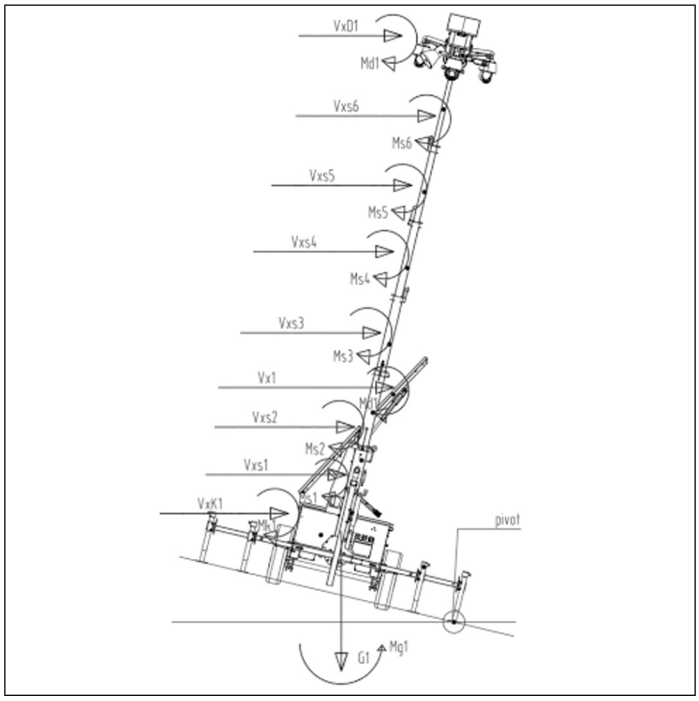
order number	component	wind Area (m2)	Center-point elevation (m)
1	K1-Control the carriage (Including frame, axle, wheel)	1.6	0.736
2	S1-Lift rod	0.14	1.475
3	S2-Lift rod	0.136	2.461
4	S3-Lift rod	0.117	3.356
5	S4-Lift rod	0.098	4.355
6	S5-Lift rod	0.081	5.348
7	S6-Lift rod	0.062	6.361
8	D1-CCTV box (Including data Starlink)	0.294	7.32
9	Solar panels and brackets	4.68	2.173

1.3 HiSOLO Wind-dependent analysis

Considering that HISOLO is an outdoor mobile equipment, combined with the characteristics of the equipment, the wind resistance analysis of the maximum working height and the maximum expansion range of the 8 wind force, including the anti-overturning stability analysis of the body and the strength analysis of the body components under the 8 wind force;

HiSOLO Anti-overturning calculation in working condition:

（1）HiSOLO The unstable state under the working state is mainly generated by the horizontal wind force, According to the characteristics of composition and composition, Respectively, by K1-Control the carriage (Including frame, axle, What), S1-Lift rod, S2-Lift rod, S3-Lift rod, S4-Lift rod, S5-Lift rod, S6-Lift rod, D1-CCTV box, (Including data Starlink) and Solar panels and brackets, The resulting horizontal force codes are simplified as VxK 1, Vxs 1, Vxs 2, Vxs 3, Vxs 4, Vxs 5, Vxs 6, VxD 1, The resulting overturning moments are presented, namely Mk 1, Ms1, Ms2, Ms3, Ms4, Ms5, Ms6, Md 1, Mx 1, As shown below:



Brief diagram of force analysis under overturning state

（2）The overturning moment generated by horizontal wind (the sum of Mk1, Ms1, Ms2, Ms3, Ms4, Ms5, Ms6, Md1, Mx1) is balanced by the resisting moment Mg1 generated by the vehicle's own weight. When the resisting moment Mg1 generated by the vehicle's own weight is greater than (the sum of Mk1, Ms1, Ms2, Ms3, Ms4, Ms5, Ms6, Md1, Mx1), the working state is effective, otherwise the equipment cannot work normally;

（3）According to the BILUX Limited data:

Wind speed: 20.7 m/s (Grade 8)
Wind pressure calculation: wp = 0.5 p v 2
Wind pressure: 280 N / m2
HISOLO Dead weight: 1158.67kg;
Gravity acceleration: 9.8 m/s2;

Main load-bearing components materials (control body, lift rod, solar panel bracket): Q235B carbon steel, yield strength 235 MPa.

（4） Wind load calculation

The standard value of wind load perpendicular to the HiSOLO surface shall be determined according to the following provisions:

1) When calculating the main force structure of HISOLO, calculate the following equation:

Wk=ßzμsμzWo,
Where: Wk one one wind load standard value (kN/m2);
Wind vibration coefficient at ß z-height z;
μ S. One wind load size coefficient;
μ z One is the change coefficient of wind pressure height;
Wo- -Basic wind pressure (kN / n2).

2) Check the specification: HiSOLO the wind surface is a plane rectangular structure, the wind load body coefficient is valued as 1.3, the wind pressure is valued according to 0.28 KN/m2 (the maximum wind pressure value of force 8 wind), in class B field, the change coefficient of wind pressure at 10m and below is calculated as 1.0, and the wind vibration coefficient is calculated as follows:

According to the specification, the influence of wind pressure pulsation on the structure should be considered.

The spatial correlation coefficient of the pulsating split air load is determined:

According to the specification, the horizontal correlation coefficient is ρ x=1 for towering structures with small width of the windward side

Correlation coefficient in the vertical direction

$= \rho z = \frac{10\sqrt{H + 60e^{-H/60}} - 60}{H}$ 0.8427

Background component factor $Bz = kH^{a1}\rho x \rho z \frac{\phi z}{\mu z}$ of the pulsating wind load

For towering structures where the width of the windward and sidewind surfaces varies along the height, it shall be multiplied by the correction factor

$\frac{B(H)}{B(0)}$ = 0.447, =1.$^{\theta_v}$ 928, press $\theta_B = \frac{B(z)}{B(0)}$ the table to determine:

Table 1. Correction coefficient θ_B

z	B(z)	B(0)	θB
1	529	560	0.945
3	498	560	0.889
5	467	560	0.834
7.25	436	560	0.779
10.025	405	560	0.723
12	374	560	0.668

Table 2 Background component factors of the Bz pulsating wind load

z	H	K	a1	ρx	ρz	ψz	uz	Bz1	θB	θv	Bz
1	30	0.91	0.218	1	0.843	0.02	1	0.032	0.945	1.928	0.059
3	30	0.91	0.218	1	0.843	0.06	1	0.097	0.889	1.928	0.166
5	30	0.91	0.218	1	0.843	0.14	1	0.225	0.834	1.928	0.362
7.25	30	0.91	0.218	1	0.843	0.23	1.052	0.352	0.779	1.928	0.528
10.025	30	0.91	0.218	1	0.843	0.34	1.13	0.484	0.723	1.928	0.675
12	30	0.91	0.218	1	0.843	0.46	1.19	0.622	0.668	1.928	0.801

Resonant component factor of the pulsating wind load

$$R=\sqrt{\frac{\pi}{6\xi_1}\frac{x_1^2}{\left(1+x_1^2\right)^{4/3}}}$$

$$x_1=\frac{30f_1}{\sqrt{k_w w_0}},\ x_1>5$$

R=2.876

The vibration coefficient at z height is β_z shown in the table below:

Table 3. Value of wind vibration β_z coefficient

Bz	R	I	g	βz	height
0.059	2.876	0.14	2.5	1.125	1m
0.166	2.876	0.14	2.5	1.353	3m
0.362	2.876	0.14	2.5	1.772	5m
0.528	2.876	0.14	2.5	2.126	7.25m
0.675	2.876	0.14	2.5	2.439	10.025m

3) Under the wind load state of force 8, the horizontal force and generating torque of each wind surface are calculated in the following table

order number	component	wind area(m2)	Center-point elevation (m)	Wind Load Standard value Wk (KN)	Horizontal wind force (KN)	overturning moment (KN.m)
1	K1-Control the carriage(Including frame, axle, wheel)	1.6	0.736	0.4925	0.6	0.486
2	S1-Lift rod	0.14	1.475	0.4925	0.07	0.11
3	S2-Lift rod	0.136	2.461	0.4925	0.067	0.165
4	S3-Lift rod	0.117	3.356	0.4925	0.058	0.195
5	S4-Lift rod	0.098	4.355	0.645	0.063	0.275
6	S5-Lift rod	0.081	5.348	0.645	0.053	0.285
7	S6-Lift rod	0.062	6.361	0.774	0.048	0.305
8	D1-CCTV box(Including data Starlink)	0.294	7.32	0.774	0.237	1.735
9	Solar panels and brackets	4.68	2.173	0.4925	2.31	5.02
amount to					3.566	8.575

4) HiSOLO The calculation of the dead weight to the fulcrum

Mg = Fg (HiSOLO weight) * L (force arm) * 0.8 (, imbalance coefficient of front and rear leg distribution) * 0.8 (HiSLO set imbalance coefficient of core distribution) = 11.58KN*1.648m*0.8*0.8=,12.214KN.m (maximum resistance bending moment)

1.4 Stability analysis conclusion in HiSOLO 80Km/h wind state

At 80Km/h wind state, HiSOLO by the wind surface total overturning moment of 8.575 KN. m <HiSOLO dead capacity of resistance bending moment 12.214KN.m, HISOLO work normally, considering the flatness of the ground of the ground and the body installation complete state, suggest that horizontal wind above level 8 or 8, should be lowered, solar panels and bracket pack and tighten, equipment suspended.

2/HiSOLO Analysis of windproof strength of components

2.1 Introduction of the finite element method and the engineering simulation software

2.1.1 Basic knowledge of the finite element method

In engineering, the finite element method (FEM) is a numerical method to solve the boundary value problem of partial differential equations. The problem domain is divided into simpler parts, called finite elements. Using the variational method, the error function is minimized to obtain a stable solution. Similar to using circles with small straight segments, finite element combine equations on small domain (finite element) to estimate more complex equations on large fields. The domains that solve the problem are divided into many interconnected subdomains, each assuming a simpler solution. This yields an approximate solution rather than an exact solution. The finite element method is particularly effective for complex shapes that are difficult to obtain conventional analytic solutions.

1.2 Basic steps for solving the problem by using the finite element method

The elastic finite element method includes the following steps that are usually similar regardless of the specific physical properties or mathematical model:

1.2.1 Problem classification

The first step in solving a problem is to identify and analyze it. What is the deeper physical problem that it contains? For example, is it static or dynamic, does it include non-linearity, does it require an iterative solution, and what are the results obtained from the analysis? The answers to these questions will deepen the knowledge and understanding of the questions, which will directly affect the future modeling and solution choices.

1.2.2 Model

Previously conducting finite element discretization and numerical solutions, we design a computational model to analyze problems, including deciding which features are the focus of the problem discussion in order to ignore unnecessary details and decide which theoretical or mathematical formulas are used to describe the behavior of the results. Therefore, we can ignore the geometrical irregularity and argue that some loads are concentrated while some supports are fixed. Materials can be idealized as linear elastic and isotropic. According to the dimensionality of the problem, the load, and the theoretical boundary conditions, we can decide whether to use beam theory, plate bending theory, plane elasticity theory, or other analytical theory to describe the structural properties. Analytic theory is used to simplify and model the problem.

1.2.3 Continuum Discrete

The continuum discretization, often referred to as a finite element network partition, is that the continuum divides into a finite number of units, where two adjacent units are connected to each other only by multiple points, and each connected point is called a node. The setting, nature, and number of cell nodes should depend on the nature of the problem, the need to describe the deformation, and the computational accuracy. Discretization is a process of converting a continuum with infinite degrees of freedom into a discretization with finite degrees of freedom, which necessarily produces errors. There are two main categories: modeling error and discretization error. Modeling error can be reduced by improving the model, and discretization error can be reduced by increasing the number of cells. Therefore, when the number of grouped meta-components is large and the model is closer to the reality, the obtained analysis results will be closer to the actual situation.

1.2.4 Cell analysis

(1) Selection of displacement mode In the finite element method, node displacement is selected as basic unknown is called displacement method; node force is selected as force method; partial force and partial node displacement as basic unknown amount is called hybrid method. The displacement method has the advantage of easy computer automation, so it is the most widely used method in the finite element method. If the displacement method is used, the physical quantities within the cell, such as displacement, stress and strain, can be described by the node displacement. In the finite element method, displacement within a cell is first expressed as a cell node displacement function, called displacement function or displacement mode, usually a polynomial and in the simplest case a linear polynomial.

(2) The mechanical properties of the analytical unit According to the material properties, shape, size, number of nodes, displacement and the meaning of the unit, and the geometric and physical equations in elastic mechanics are used to establish the node load and node displacement equations, and derive the stiffness matrix of the unit. Let the node load vector represent the node load vector, and the node displacement vector represent it, then the relationship between the unit load and the displacement equation is

$$\overset{e}{F} = \overset{e}{K}\,\Delta^{e}$$

Is the $\overset{e}{K}$ cell stiffness matrix

(3) Calculation of equivalent node load After the continuum is scattered, the force is transferred from one unit to another through the node. However, in the actual continuum, the force shifts from one cell to another, so that the surface, volume, or concentration forces acting on the cell boundary should be moved equally to the node, that is, the equivalent node force should be used in place of the force on the cell.

1.2.5 The entire system of equations constituting the object

By integrating the known unit stiffness matrix with the unit equivalent node load matrix, the total stiffness matrix and the structural load matrix of the whole structure are obtained to establish the relationship equation between the whole node load and the node displacement. Let the total stiffness matrix be K, the load vector be F, and the node displacement vector be, then the equilibrium equation of the whole structure is

$$F = K\Delta$$

After obtaining the equilibrium equation of the whole structure, we also need to consider its boundary conditions or initial conditions to solve the above equations.

1.2.6 Solving the finite element equation and the interpretation of the results

Solve the structural equilibrium equation described above. The result of the solution is an approximation of the state variables at the unit node and will assess the quality of the calculated results and the need for duplicate calculations will be determined by comparison with the allowable values provided by the design guidelines.

In conclusion, FEA can be divided into three stages: preprocessing, solution and postprocessing. The preprocessing is to build the finite element model and complete the cell grid division; the post-processing is to capture the results of the solver analysis, so that the user can easily extract the information and understand the calculation results.

1.3 Introduction of solid engineering simulation software

Solid engineering simulation is an integrated simulation optimization design analysis system. It provides a unified screen solution for stress, frequency, torsion, thermal analysis, and optimization analysis. With the support of a fast solver, it can quickly solve big problems. There are a variety of different software packages to meet different analysis requirements.

In this report, HiSOLO was analyzed by using the 2025-A12 professional system provided by BIGLUX INNOVATION LTD.

2 Product simulation calculation

2.1 Model description

HiSOLO Mainly composed of the lower car box (including the control box, frame, axle, wheels and car in the battery, electrical parts, side shake jack), lifting rod (composed of five sections, complete the working state of extension), CCTV box, CCTV box camera and related functional parts, solar panel bracket and solar panel components. Overall weight: 1158 KG; total working height: 7.53 m; both front and rear legs are installed to protect the stability in the working condition.

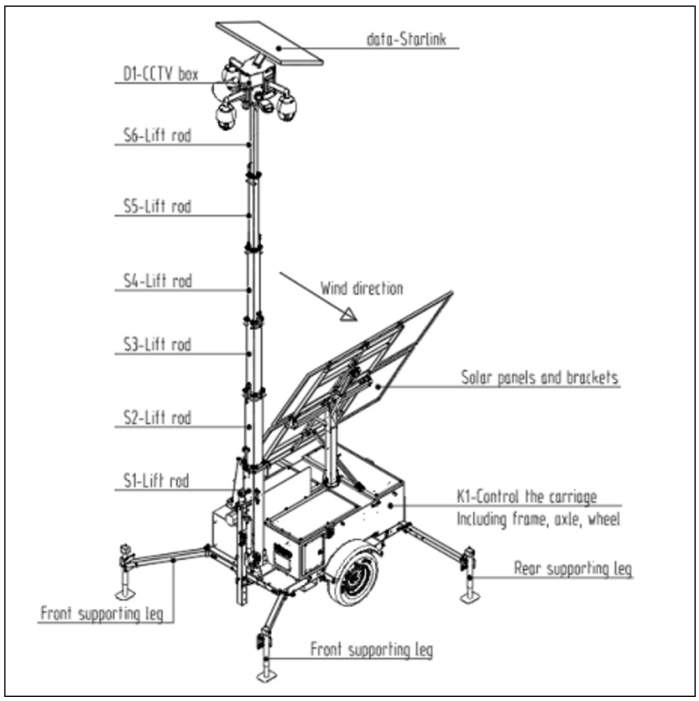


Figure 1 Figure HiSOLO assembly Fig

The FE model after the grid is shown in Figure 2:

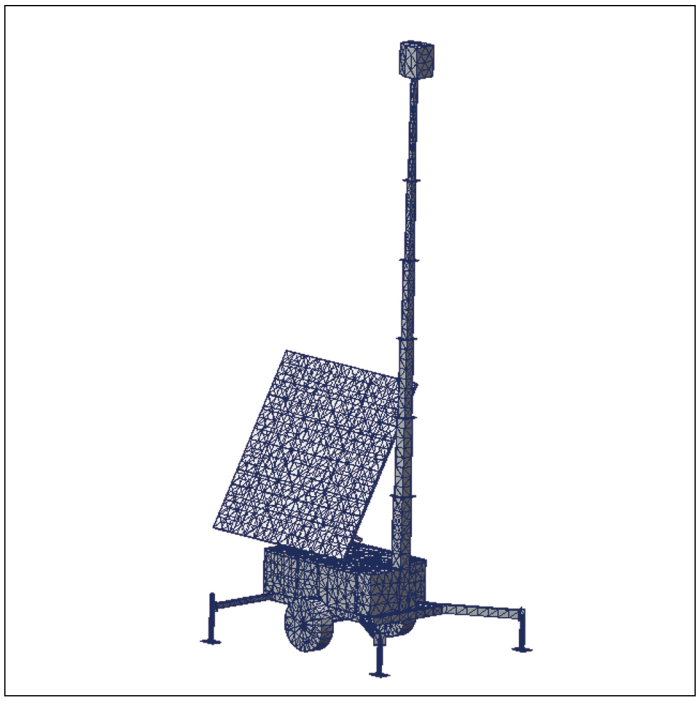


Figure Figure 2 A. The HiSOLO grid

2.2 Loading condition

According to the data provided by BILUX Limited:

Wind speed: 20.7 m/s (Grade 8)
Wind pressure calculation: wp =0.5 **p v** 2
Wind pressure: 280 N / m2
HiSOLO Dead weight: 1158.67kg;
Gravity acceleration: 9.8 m/s2;

Main load-bearing components materials (control body, lift rod, solar panel bracket): Q235B carbon steel, yield strength 235 MPa.

According to the above boundary conditions, the maximum wind area of HISOLO is analyzed static, that is, when the wind direction is fully facing the solar energy.

2.3 Computing result

When the HiSOLO side is windy, For the K1-Control the carriage (Including frame, axle, While), S1-Lift rod, S2-Lift rod, S3-Lift rod, S4-Lift rod, S5-Lift rod, S6-Lift rod, D1-CCTV box (Including data Starlink), applied on all windshield sides of Solar panels and brackets, Dedeformation and stress results were obtained by static analysis of simulations, As shown in Figures 3 and and 4. To observe the deformation, the deformation was magnified by 50 x.

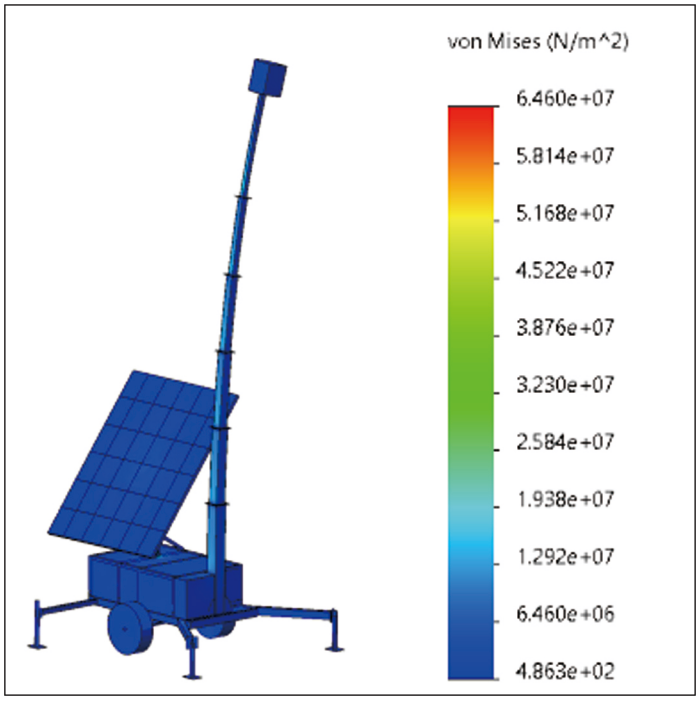


Figure 3 Model stress contour plot

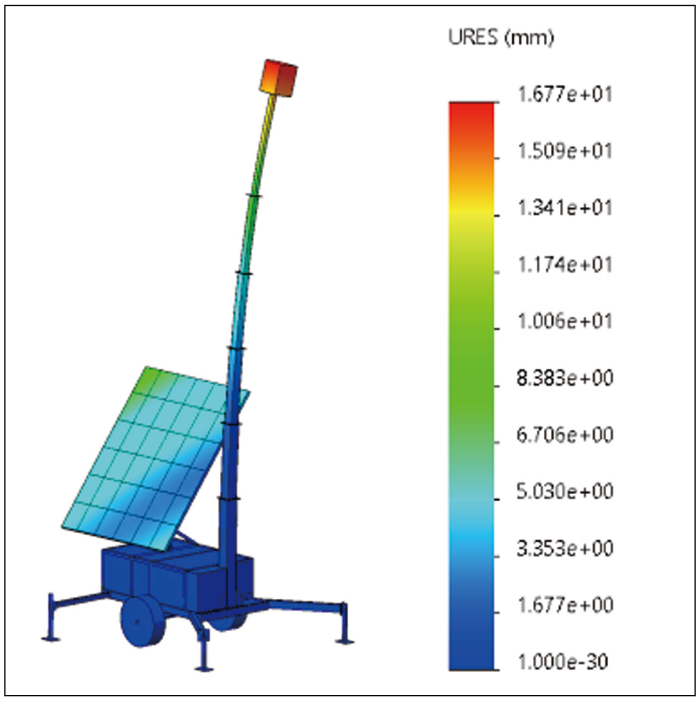


Figure 4. Model deformation cloud

The results show that, When the HiSOLO is subjected to a force 80Km/h wind, K1-Control the carriage(Including frame, axle, Wheel), S1-Lift rod, S2-Lift rod, S3-Lift rod, S4-Lift rod, S5-Lift rod, S6-Lift rod, D1-CCTV box (Including data Starlink), and Solar panels and brackets, The structure shows the maximum stress, Size is about 64.6MPa, Well below the yield limit of No.235 steel. The largest deformation occurs at the top of the HiSOLO, with a size of about 16.8 mm. Compared with the HiSOLO working height of 7,530 mm, the relative deformation degree is about 2.2%. Therefore, in the case of 80Km/h wind, the HiSOLO will not cause the equipment failure due to the mast fracture. Warm tips: Based on the above report, when the whole HiSOLO solar trailer tower is in operation, the maximum wind resistance is 80km/h. If the wind resistance is over 80km/h (including 80km/h), the telescopic mast need to be lower down, the solar panels need to be folded up, and the whole solar trailer tower need to be placed in a safe place.