

GEM-P Progress Report

Mechanics

(July 2006)

1. Pedestal

The GEM-P scanning strategy relies on a stable antenna rotation. The original Vertex pedestal was unable to make a complete turn. This limitation demanded a new mechanical design for the azimuthal axis, which fulfills the pointing precision requirements. A new and more powerful motor and reducer was also in question. Additionally the issue concerning electrical connection for data and control signals as well as power between the ground and the rotating pedestal had to be addressed.

1.1. Mechanical

The projected pedestal is presented in fig. 10. The height has been reduced to 2.5m, lowering the mechanical stress at the bottom. To permit access to the interior, where encoder and electrical connections will be present, 6 lateral openings are cut which imposes lateral reinforcements to maintain the bottom resistance.

The set will work in the following way; the pedestal base is attached to a base disc which is put in motion by a gear set, the wheel (blue), solid with the disc base, and the pinion (not shown). The pinion is attached to the shaft of an appropriately dimensioned gearmotor. The rotational axis is defined by 6 concentric retention slides and the base stands over a technical plastic disc for low friction.

To assure a high precision and low backlash in this connection, an intermeshing of 3 teeth between gear and pinion is used and a gear ratio of 1:100. For the motor-reducer, a low backlash is also requested.

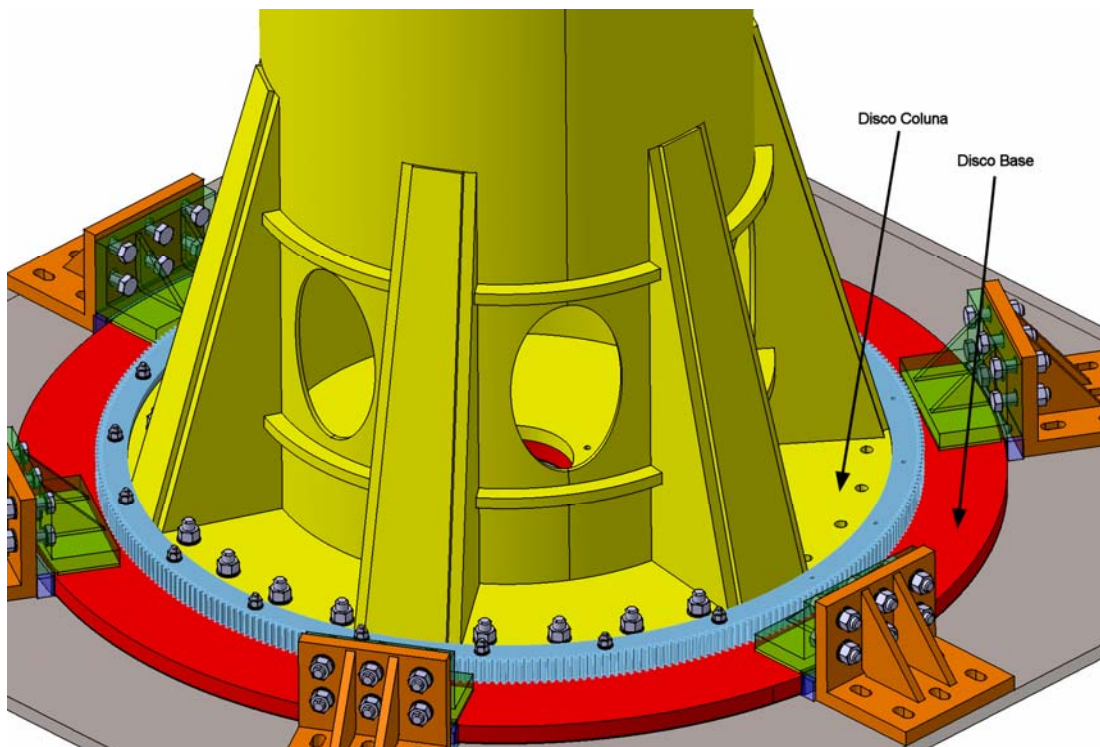


Fig. 10 - Pedestal assembly

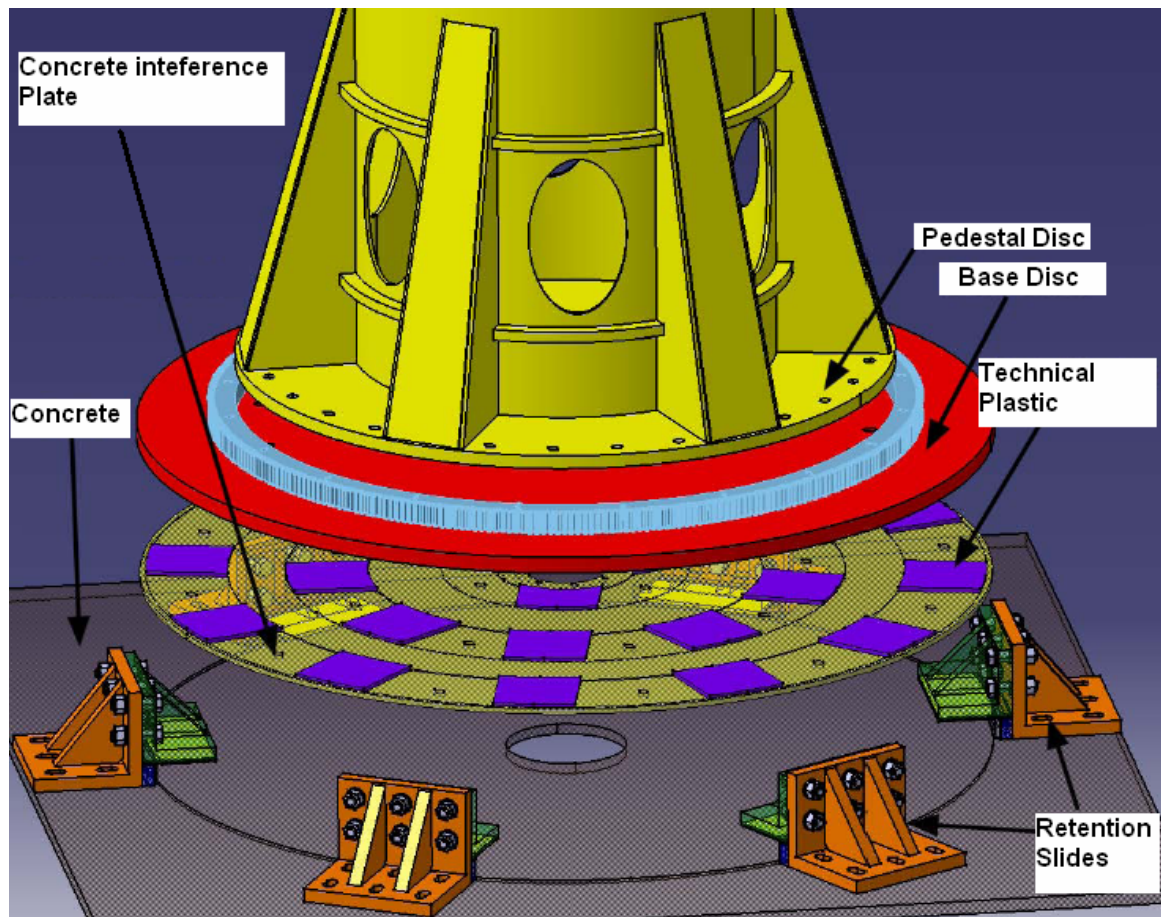


Fig. 11 - Pedestal exploded view

The antenna rest above a concrete base, dimensioned to withstand a maximum compression of 20 T/m^2 . The soil is slate clay and the concrete base is “nailed” on it by concrete poles throw the rock.

Simulations where done to know if the reinforcements of the pedestal where sufficient and if all the structure recover elastically from stress caused by high wind speed loads. The pedestal will survive to wind loads of 150 Km/h with dish in horizontal position, without suffering any inelastic distortion.

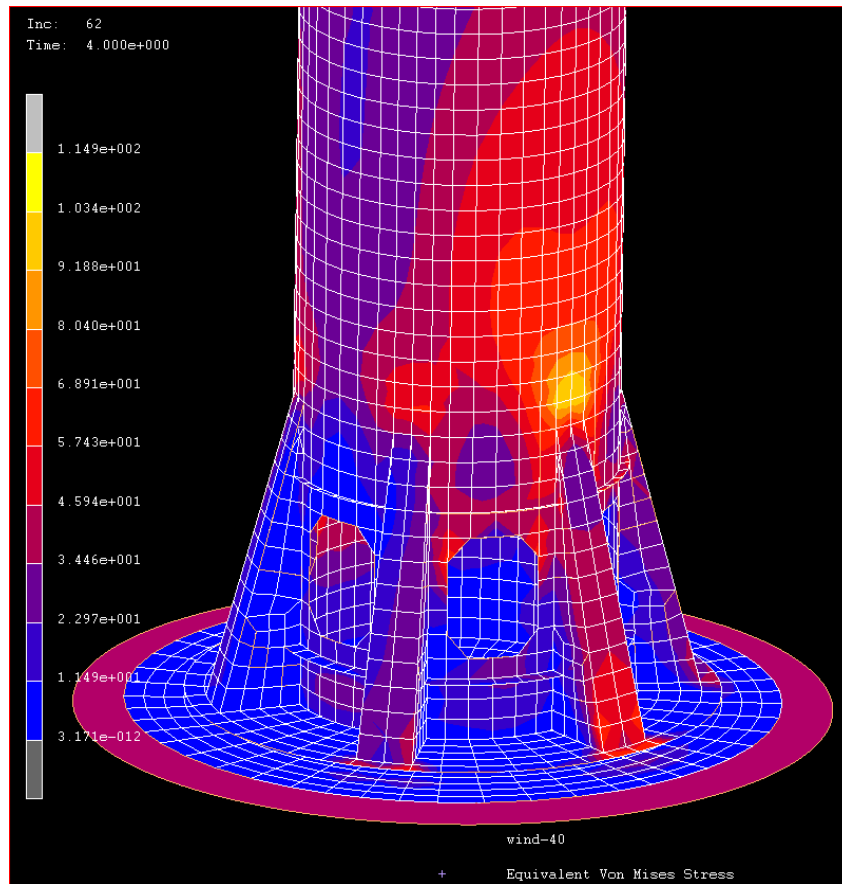


Fig. 12 - Von Mises stress simulations for 40 Km/h wind speed load.

1.2. Pointing Precision

The pointing precision needed, will be conditioned by the antenna resolution for the operating frequencies that will be used. For the current project, there exist the intention to use 5GHz, 10GHz and the possibility of 15GHz. For each frequency, there will not be the need to use the full antenna area and as a consequence, the resolution might not be the maximum possible. As for pointing precision, the minimum demanded is 1/10 of the resolution. In the table bellow we present the maximum resolution and precision for each frequency.

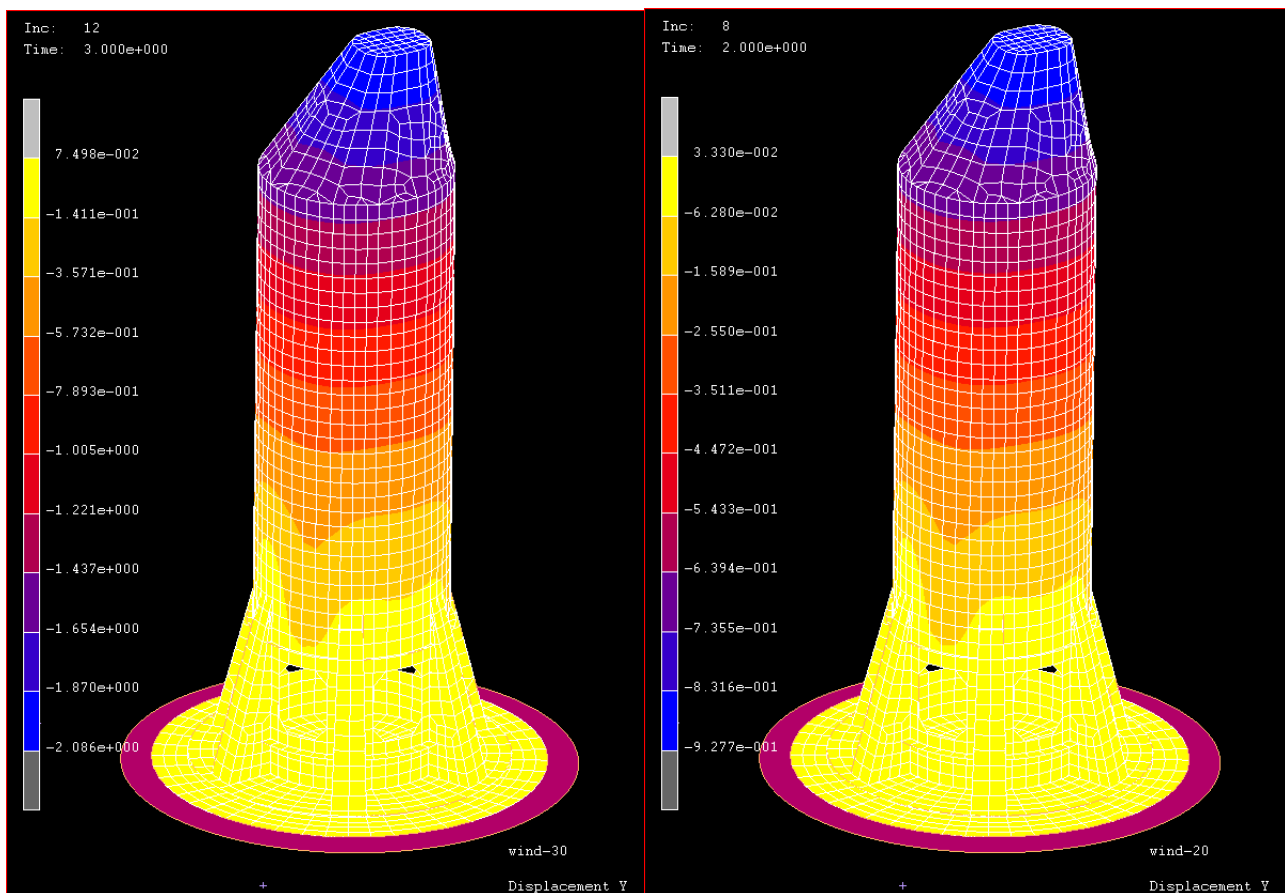
The pointing precision to be guarantied requires the use of an encoder with 15 bits resolution, or better, and it will be wind speed dependent, which implies a boundary for antenna operation with full requirements. This boundary will be dependent of pedestal mechanical response to wind load.

The minimum error of pointing precision accepted is half that value. Taking in account the pedestal height and the pointing error, the maximum allowed tilt is determined. In the next table the values for maximum pedestal top displacement are presented.

Resolution, Precision and Pedestal Displacement				
Frequency (GHz)	Resolution (°)	Precision (arc min)	Error (arc min)	Displacement (mm)
5	0.466	2.8	1.4	1.01
10	0.233	1.4	0.7	0.51
15	1.555	0.9	0.45	0.33

The average maximum wind speed at the observation site is 30 Km/h. The antenna wind speed requirements are that it must be fully operational for wind speeds up to 20 Km/h. Simulations were carried out to predict pedestal behavior for several wind speeds and are presented in fig. 13. These simulations are over dimensioned and the values obtained are an upper limit possible displacement. The simulations were done with a 3m pedestal height instead of the final height of 2.5m. Also, the steel quality used was the poorest and it's not presumably the case. Additionally, the ground screen will give some wind protection.

A plot of pedestal displacement versus wind speed (fig. 14) shows that for 5 GHz the requirements are satisfied. For 10 GHz, 14 Km/h is the maximum allowed, but we expect that both values will be higher taking into account the above observations relative to the simulations.



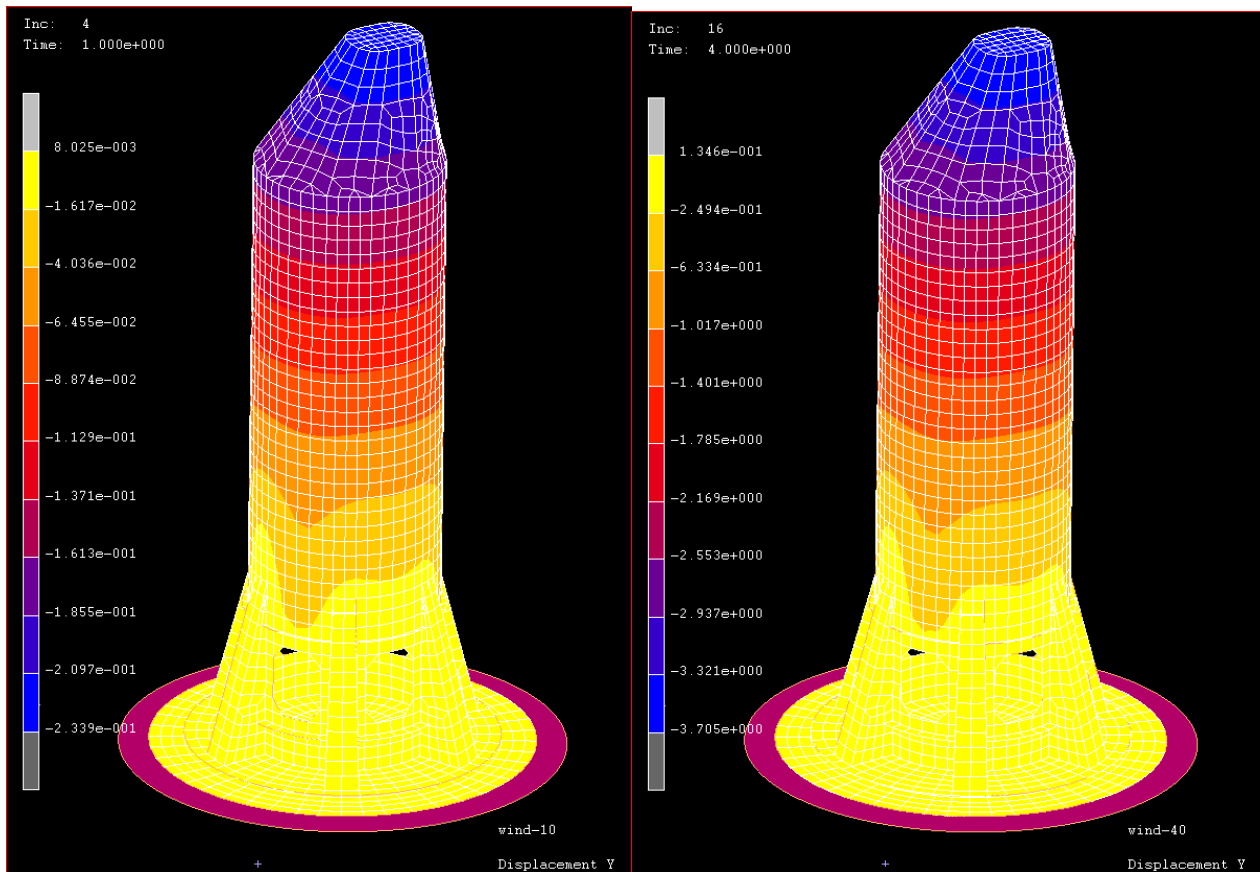


Fig. 13 - Simulations of pedestal behavior for wind load of 10, 20, 30 and 40Km/h.

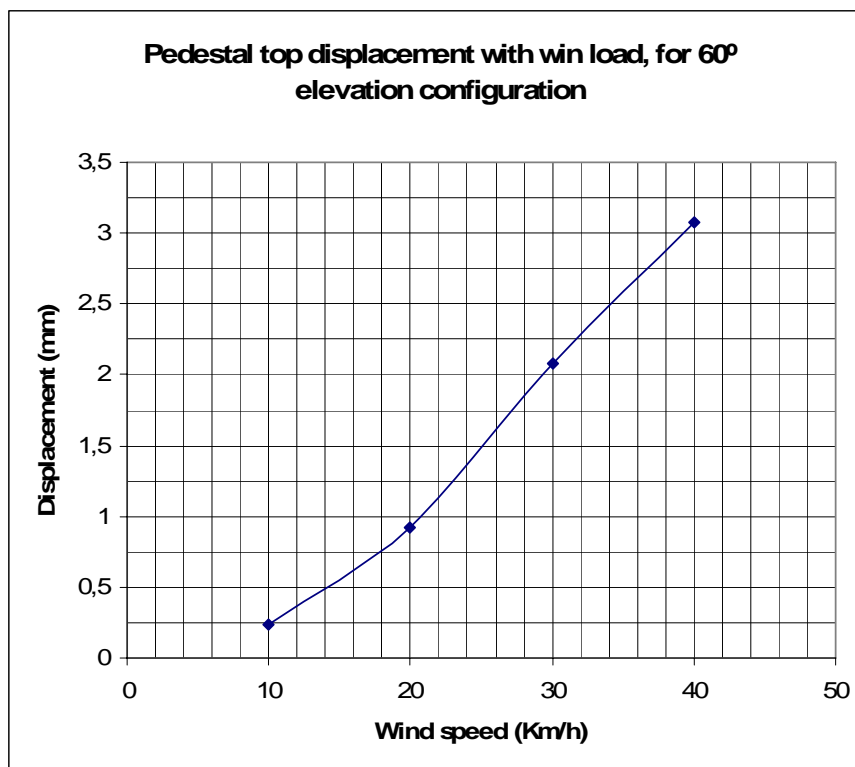


Fig. 14 - Pedestal displacement for various wind loads

1.3. Electrical and data connections

Data and electrical power connections need to be taken to the antenna hub through the rotating pedestal. These contacts are accomplished with the use of a slip ring. Power connections will be able to sustain 20A currents and data connections allow 200MHz of bandwidth.

Because the encoder is sensitive to stress occurring from misalignments between fixed and moving parts, a design to avoid this question was envisioned and is seen in fig. 15. The slip ring and the azimuthal encoder will share the same fixed axis. Because both parts are concentric, the slip ring outer shell will be used to rotate the encoder moving element, eliminating the stress. The radial misalignment between the pedestal center and base center will be supported by two precision joints that make the connection between the pedestal and base. Displacement of pedestal base in vertical direction (z axis), is supported by the use of two zero backlash bellows couplings.

The cables will pass by two openings on the axis base that has a connection to outside through the concrete base.

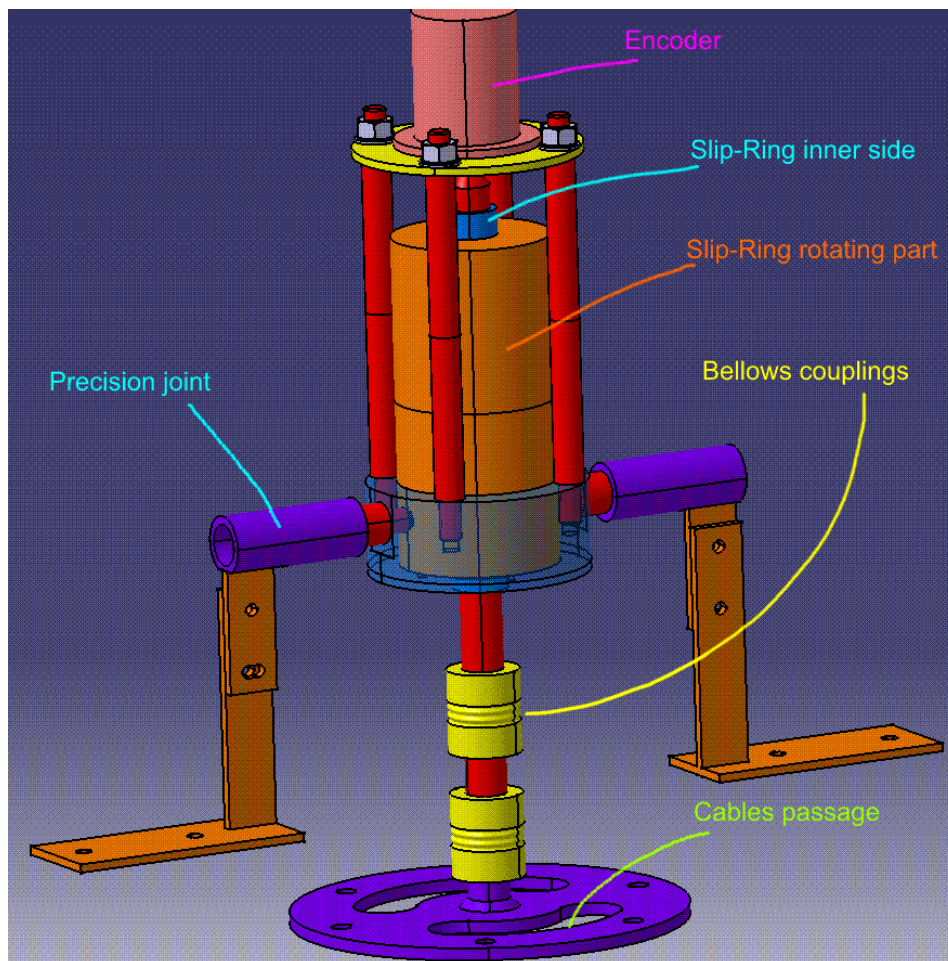


Fig. 15 - Slip-ring and azimuth encoder mechanical arrangement

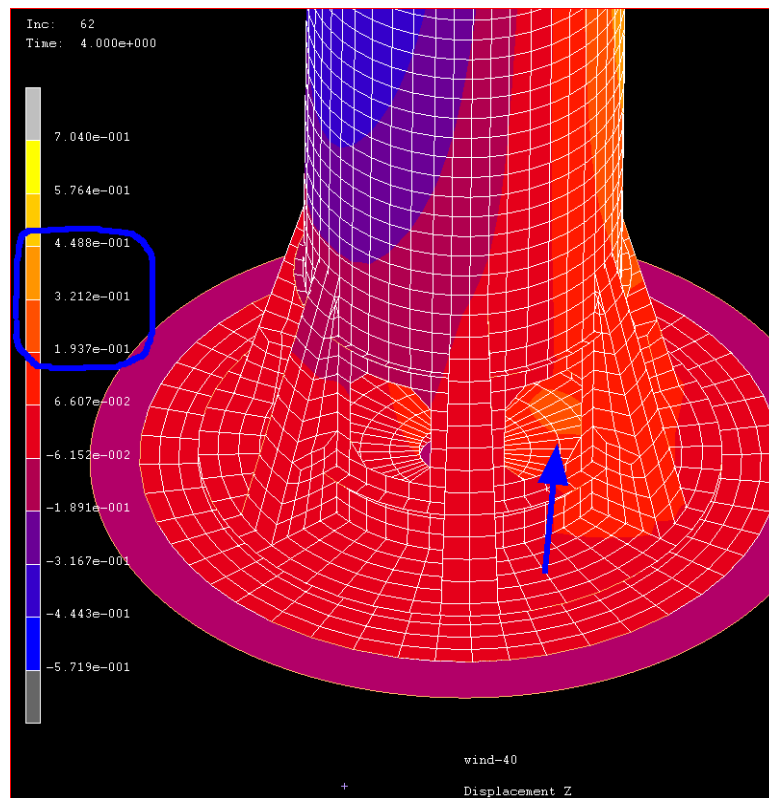


Fig. 16 - Z axis displacement for a 40 Km/h wind load.

2. Control

2.1. Positioning

To achieve the desired pointing precision of 3 arc minutes, 17 bits absolute encoders will be used for both axes. These have been ordered and the interface and positioner control boards are already designed.

The encoders are AI25 0017 3632D from Dynapar.

2.2. Motorization and controllers

2.2.1. Elevation

The elevation motor used is the original one (SEW – Eurodrive Inc.) and has the following specifications,

- Three-phase AC induction motor
- 373 W
- 1700 rpm
- 208/360 V
- 60 Hz

The reducer specifications are as follow,

- 1700 rpm input
- 22 rpm output
- 78.8:1 ratio
- 161.6 Nm of torque

The motor will be controlled by a programmable VFD (Variable Frequency Driver), with single-phase input and three-phase output, to cut down the number of slip-ring contacts for this purpose.

2.2.2. Azimuth

The azimuth motor-reducer has to be changed, to provide the necessary requirements, which are the following,

- Three-phase AC induction motor or synchronous motor
- 1 KW
- 1400 rpm, adjustable to 1000rpm for antenna 1rpm
- 230 V
- 50 Hz
- encoder

The reducer specifications are as follow,

- 1400 rpm input
- 10 rpm output
- 100:1 ratio
- 955 Nm of torque

To control this motor, another programmable VFD, three-phase input and three-phase output, with the feedback of the motor rotation encoder, will provide a sufficient stable rotation inside the weather requirements envelope for antenna operation.

Relative to both VFD and motor-reducer, we are currently waiting for quotations from a few companies.

2.3. Weather station

A weather station, Vantage Pro2 (Davis Instruments Corp.), had been purchased and is installed on our building roof at Aveiro for testing. The antenna has weather requirements to operate within acceptable pointing precision conditions, like wind speed and wind gusts. The station will provide a registry of weather condition present during acquisition which is valuable information for posterior data analysis. Additionally, in situations of adverse weather conditions for operation or survival of the antenna, commands will be given to put the dish in the horizontal survival position.

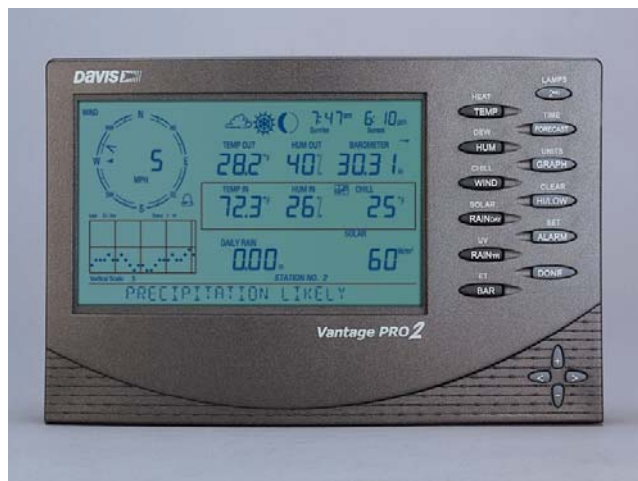


Fig. 17 - Sensor station and console

2.4. Control diagram

GEM-P Connections Diagram_Jul2006

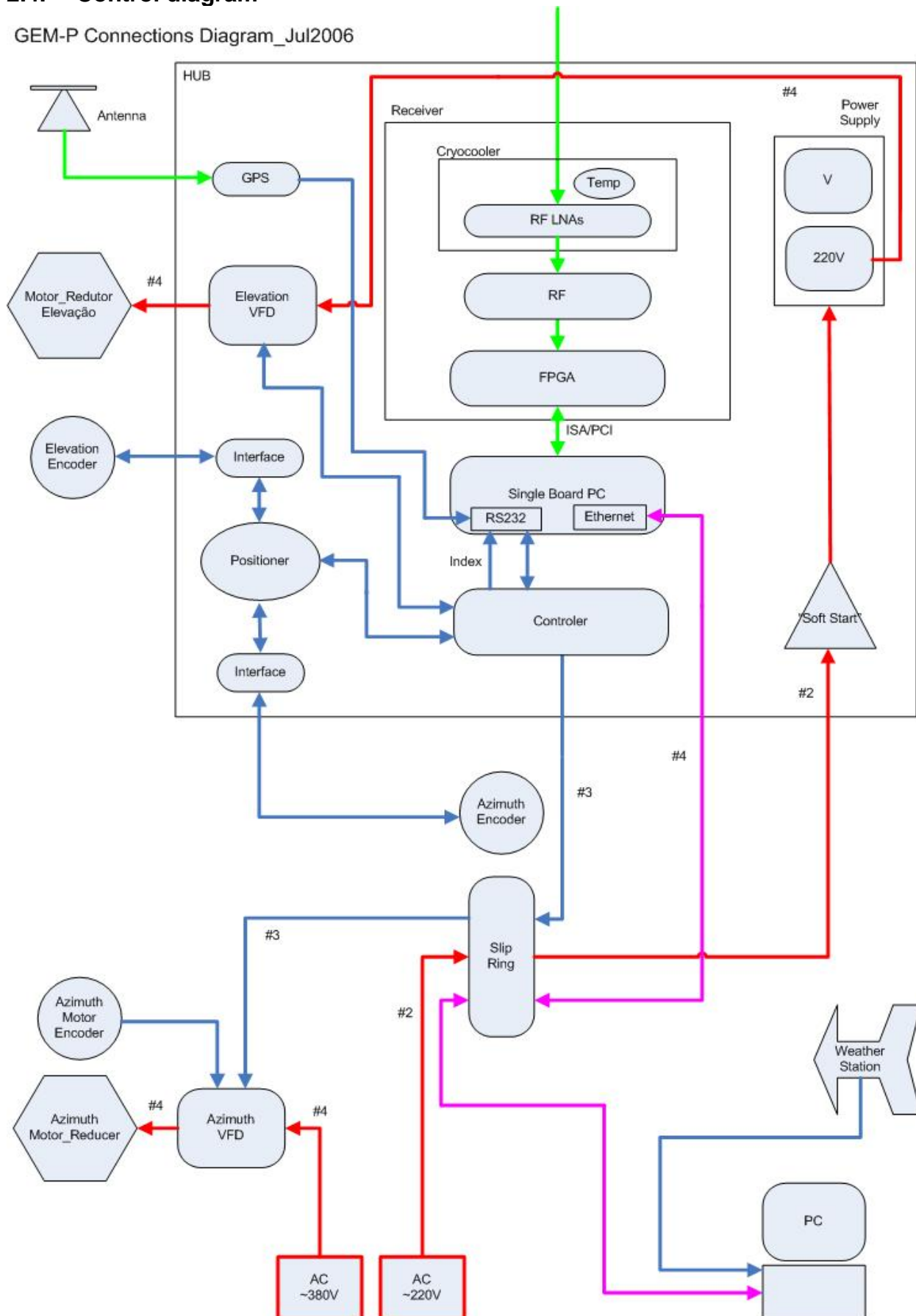


Fig. 18 – Control diagram

3. Antenna site

Prior to any site construction, a topographic characterization needs to be made. These measurements are already available and the civil engineering project will be finished in the following weeks after ground shield supporting structure completion.

The project contemplates enough supporting structures to maintain a small field team at the site for antenna operation. Accommodations for the teams will be available in the nearby village.

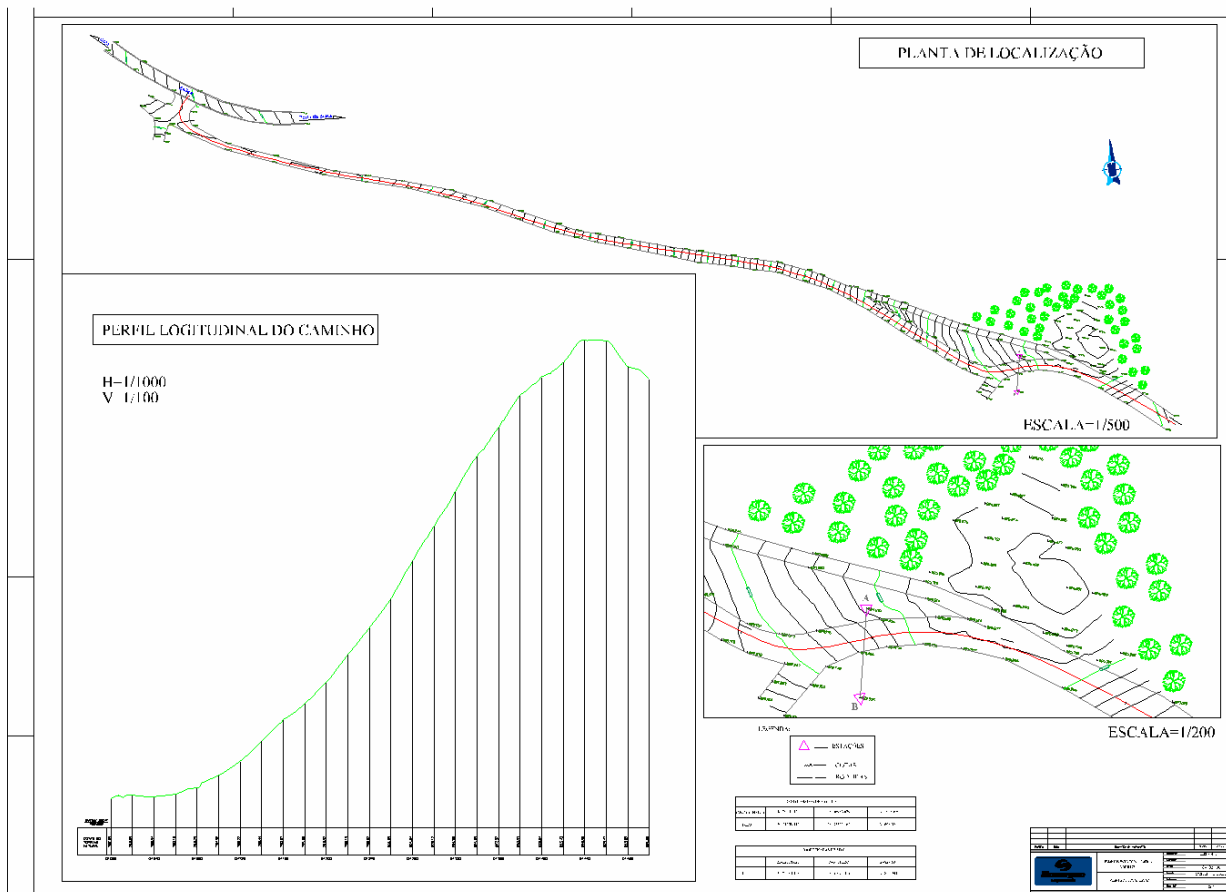


Fig. 19 - Topographic site characterization

3.1. Power line and Telecom line

Arrangements have started to bring a power and phone lines (or ADSL) to the antenna site.