Parkes Counterweight Issues

May 4, 2002

1 Background

It became clear, during the course of the study of the windloading on the Parkes reflector (**ref: AT/39.3/113**) that the counterweight was not optimally fulfilling its function. This note explores the details and possible remedies.

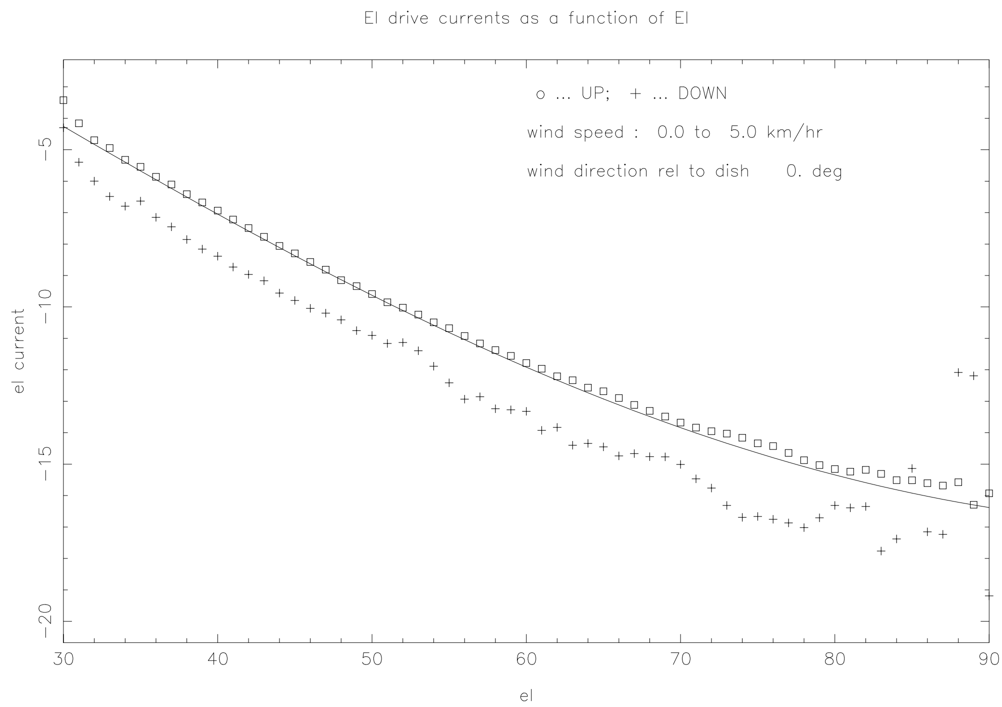

Figure 1: The elevation motor currents as a function of the elevation.

Figure 1 is the central evidence: it shows the drive currents in the elevation motors as a function of elevation. The "o" symbols show the current when driving towards the zenith, the "+" when driving towards the horizon. (The difference between UP and DOWN is due to the frictional losses while moving: the counterweight helps in one direction, opposes in the other). The point at issue is the shape of the curves, from large currents (torques) at the zenith to low values near the horizon. This was not the designers' intention.

The solid curve in figure 1 models the torque, following the recipe sketched in figure 2.

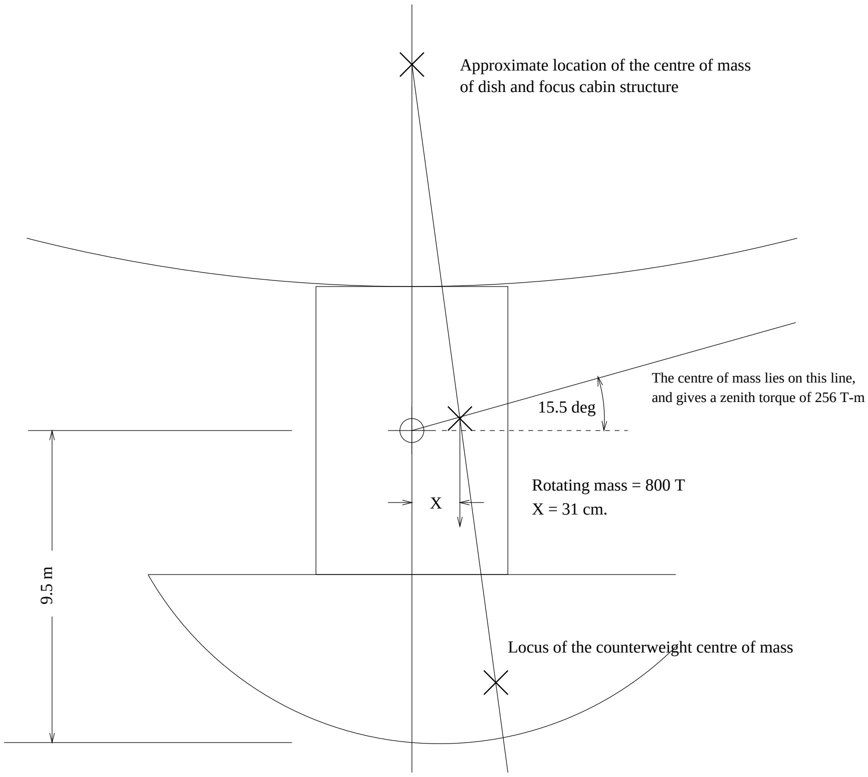

Figure 2: A geometrical construction showing the location of the various centres of mass

2 The Model

The model (figure 2) is based on :

- Model fitting of the function $T\cos(El_0 - El)$ to figure 1 puts the peak current at 17 amps, and $El_0 = 105.5$ degrees.
- The calibration of the motor currents-torque relation :-

  15.5 (T-m)/amp (see AT/39.3/112)

  This translates the peak current of 17. Amps to a torque of 256 T-m
- The total mass of the moving structure is $\sim$ 800 T. This sets the location of the centre of mass at 31 cm from the elevation axis.

3 Suggestions, Problems, Questions

A response to the present situation is to redistribute the weight below the elevation axis, with two main aims:

- To flatten the torque-elevation function, so that there is a healthy backlash reserve at all elevations under windy conditions.

- To lower (or at least not increase) the peak torque.

We have two parameters at our disposal : the amount of weight we add, and where we put it.

Increasing the counterweight by 8 - 30 T will move the peak torque elevation into the observers' elevation range, and raise substantially the torque at the horizon.

Simply changing El_0 from 105.5 to 90 degrees will double the torque at the horizon.

The space limitations are more serious: the obvious candidate area is at some distance from the optical axis, and will result in higher currents, in the range 20 to 25 Amp.

3.1 The low current problem

The designers intended the counterweight to provide the "anti-backlash" mechanism. Operation at low elevations under windy conditions is therefore made difficult. Wind from behind the dish could overcome the counterweight.

- The pinion gears normally mesh on the lower surface of the rack gears. If the torque reverses the mesh will change, leading to a pointing error. The servo system will correct for this, but it will be a serious disturbance at the higher frequencies.

- It is currently held that this gear-mesh reversal has no implications as far as the machinery is concerned.

- However, there are operational implications: a wind stow is forced when the currents fall to zero.

- Manual stowing of the antenna could be compromised.

3.2 The high current problem

The motors are not stressed at present. Changing the torque-elevation function could raise the power requirements, and possibly overheat the motors.

3.3 Focus cabin

Any increase in weight of the focus cabin is fundamentally undesirable: it has a strong impact on the torque (a multiplier of 4 compared to weight at the counterweight), and it exacerbates the local deformation of the reflector surface at the feed legs.

The problem right now is that small increases will expose the antenna to more wind stows. Flattening the torque-elevation function will help considerably.

3.4 How much weight and where to put it

These details depend on the space available in the counterweight; the points listed below are intended to give an idea of the magnitudes involved, and point to the useful locations.

The coordinate frame for this discussion has the antenna stowed (as in figure 2, with the elevation axis East-West, tipping to the North.

The weight will be added a distance of about 9 m below the elevation axis. A weight of 7.5 T will move El_0 to 90 degrees.

If the weight is positioned below the current centre of mass (32 cm south of the elevation axis), then the horizon current doubles to 8 A; the peak current (at El_0 increases by 0.3%.

If the weight is placed at the southern end of the counterweight (where space seems simplest to find), the peak current will rise to 19 A, and the horizon current to 9.5 A.

4 Discussion

Do we need to do anything ?

The operational constraints are probably the strongest argument: the low torque at the horizon makes the antenna vulnerable to a wind stow when the wind is behind the antenna.

The failure of the backlash machinery at low elevations does not appear to endanger the integrity of the gearbox/rack machinery, but it will certainly compromise the pointing.

The elevation bearings are each rated for a static load of 1000 T, so an increment of 10-20 T is unlikely to be a problem.

A change is desirable.

Next steps

- The recommendations of Freeman Fox and Partners and of Connell-Wagner should be reviewed to ensure that there are no other engineering considerations.

- The counterweight structure should be examined to identify possible sites for the additional weight.

- Andrew Hunt's notes on the heating of the motors under load should be consulted to determine the maximum allowable torque (current).