NLSRT Memo No. 48

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To:

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Dear Ken:

Thank you for your letter of Dec.5 and the VLD-Report of Nov.28 which arrived here Dec.16. And thanks for the sad picture of the 300-ft. This disaster was even in the German news and TV.

You asked for comments to the Report. The following is rather unfinished, but the final version will take a longer time. I give just a brief summary of the main results.

THE FIELD OF VIEW OF VARIOUS SYSTEMS

At our Charlottesville VLD-Meeting came a note of Peter Napier, that spherical or shaped 2-mirror systems will have a small field of view as compared to the usual parabola-hyperbola Cassegrain. In my Report "NRAO May 1988" I just hoped that small secondaries may still give enough field, suggesting a numerical investigation.

Thus I started one, some months ago. This is quite a job for a PC (ray tracing, maxima of beam peak and focal curvature), and I limited it for one dimension (cylindrical surfaces). Calculations are finished for prime focus, parabola-Cassegrain, and sphere-Gregorian. The shaped system got stuck. For a feed offset, one must make one of the two mirrors a bit larger to catch the last rays, and I had started with the wrong choice, increasing the primary. But for a shaped system with uniform illumination, and with narrow feed pattern (large taper, 20 dB) there is only little power beyond the rim, thus a size increase will be large for the secondary but only tiny for the primary. I plan to redo this later. Right now I am limited to 7 dB taper proper, and to 13 dB with an approximation. For the present purpose I just extrapolated to 20 dB, as a rough estimate. And so far I treated axisymmetrical systems only.

First, I checked my 1-dimensional results, for prime focus and Cassegrain, with the 2-dimensional equations of J.Ruze (Preprint, 1969). Lateral and axial displacements, as well as beam size and beam deviation, all agreed well: numerical constants off 10-20%, and relations much better. The one-dimensional approach thus seems justified.

All calculated systems have a primary diameter of 10.000 wavelengths, and the results should not depend much on this choice. The lateral feed offset is also measured in wavelenghts. Shaped surface systems are derived by using a very simple geometrical relation. Ray tracing is done in second order. And all with double precision. The gain loss is at the peak of the beam, and refers to the gain at zero offset with same taper.

The curvature of the focal surface was always derived, but it was negligible for prime focus, sphere, and shaped system. It was large for parabola-Cassegrain, but would matter only for large offsets, beyond 30 wavelengths. Very sizeable focal arrays of the future thus should have some curvature.

Fig.1 gives some results. Comparison of a, d, and e shows that a Cassegrain with a magnification factor of 10 (diameter ratio of 0.0940) gives an improvement factor in S (for same loss) of 350-500 on the curved focal surface, and even of 130-200 on a flat plane. And comparison of d,e with f,g shows that the equivalence between a Cassegrain and a prime focus of corresponding F/D ratio holds only for the curved case and only for small losses.

The sphere-Gregorian (curve c) with F/D=.548 was suggested in my previous reports, for 2% area blocking. I was sad to see that its field of view is just as bad as at the prime focus of equal F/D ratio. This holds also for other F/D ratios, and the loss depends amazingly little on the size of the Gregorian. On the other side. the sherical systems have extremely small loss for axial displacements, but I don't see any use of that.

Shaped systems were derived with their geometry similar to the parabola-Cassegrain: same central primary curvature. same height of secondary. The d/D ratio then depends on the feed taper, with d/D=0.0940 for zero taper (ratio equal to par.-Cass) and a very linear increase to 0.175 at 13 dB. Extrapoaltion to 20 dB would give d/D=0.22 (for smaller secondary: take larger height). The field of view (extrapolated) was two times wider than at prime focus, for equal loss. I have not yet done other geometries.

But what matters is not the field of view in terms of offset S measured in wavelengths. We must measure it in **feed horn diameters** which are much larger for all two-mirror systems than for prime focus. Using a horn diameter of 1.5 wavelengths divided by the width of the feed pattern (radians), and compared with the prime focus, we find the following improvement factors:

System	Number of horns along S
parab.-Cass (curved)	Factor 57 better
parab.-Cass (flat)	17 better
sphere-Gregorian	6 worse
shaped 2-mirrors	4 worse

It seems that the last two systems cannot be used, even if just two feeds are wanted for beam switching. But before accepting this verdict. one shoult first improve the offset shaping, and then try different geometries, and asymmetry, too. Finally, a better and two-dimensional investigation is needed, which however will be beyond my own PC.

GENERAL REMARKS

Site. If Green Bank would be considered, one should look again at the site I suggested during the LFST-Studv for a 100 m dish; in the Greenbriar valley, between the place where we built a wind-measuring tower, and an old hunters camp (a bit downstream from the furt). It was selected for best noise shielding: the horizon never below 6°, but never higher than 10° (loss of sky). It was also better wind-shielded than the 300-ft or the 140-ft.

Data about measurments can be found in my LFST-Reports:

No.16, Dec.8, 1966 "Statistics of Wind Velocities at Green Bank";
No.23, Mar.1, 1969 "Wind and Temperature Deformations .... ";
No.24, Mar.8, 1969 "Wind-Induced Vibrations ... " (Needs Update).

Slew. Why do we need fast constant slew rates? Why not accelerate and decelerate a longer time (with less power) but for higher speeds in between?

Gravity. If a good homologous design cannot be done inhouse, you may ask in Japan or Germany for it, where it has been done already. For example, Prof. Hans Eschenauer, Universität Siegen. (Or ask Jo Antebi of Simpson, Gumperz and Hager? He, or Zargamee, should be able to do it.)

Or, if less ambitious: then just go for **equal softness**. For the engineers, this is easier technically (but not psychologically). And then have a deformable subreflector again, which decreased the gravitational deformations by a factor 3 at the 140-ft. See the enclosed Fig.2, copied from my 1980 evaluation of Bob Brown's measurments before and after.

But I should mention that a curved shell (the subreflector) has one, but only one, easy mode of deformation: the astigmatic mode. Small-scale deformations will not be possible, because the shell needs a good stiffness for dynamics and wind. Thus the equal softness must smoothe out all small-scale deformations, but may leave a large astigmatism for the deforming subreflector where it can be corrected more easily (and cheaper, too).

Pointing. I would like to suggest again: to have two inclinometers each on the two towers close to the elevation bearings. This singles out true tower deformations, discriminating against effects of acceleration and of centrifugal force.

This seems important for thermal deformations. The thermal lag can be greatly reduced in the dish structure, by avoiding heavy wall thickness. Which will not be possible for the supporting tower members.

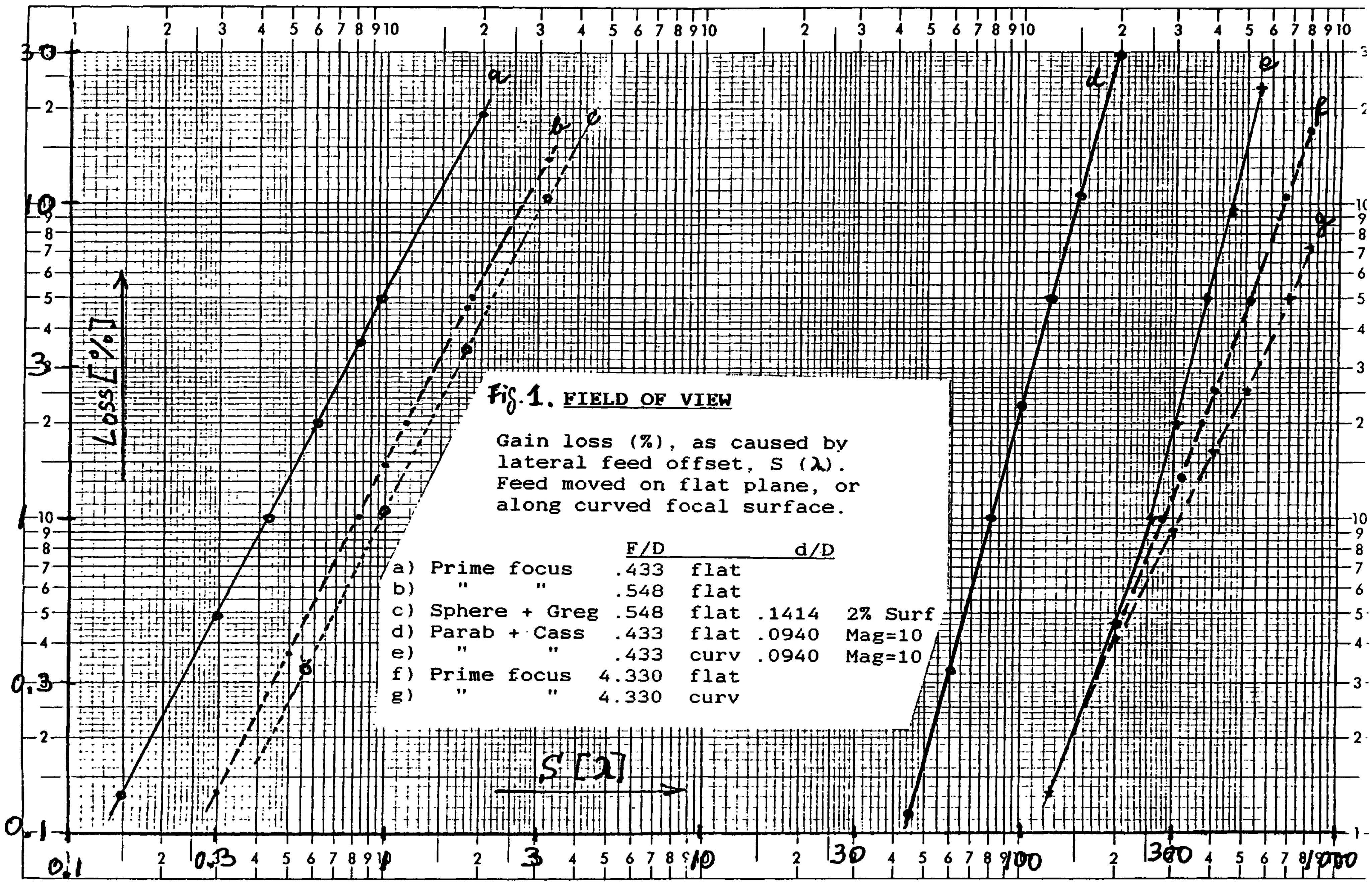

Fig. 1. **FIELD OF VIEW**

Gain loss (%), as caused by lateral feed offset, S (λ). Feed moved on flat plane, or along curved focal surface.

		F/D		d/D	
a)	Prime focus	.433	flat		
b)	" "	.548	flat		
c)	Sphere + Greg	.548	flat	.1414	2% Surf
d)	Parab + Cass	.433	flat	.0940	Mag=10
e)	" "	.433	curv	.0940	Mag=10
f)	Prime focus	4.330	flat		
g)	" "	4.330	curv		

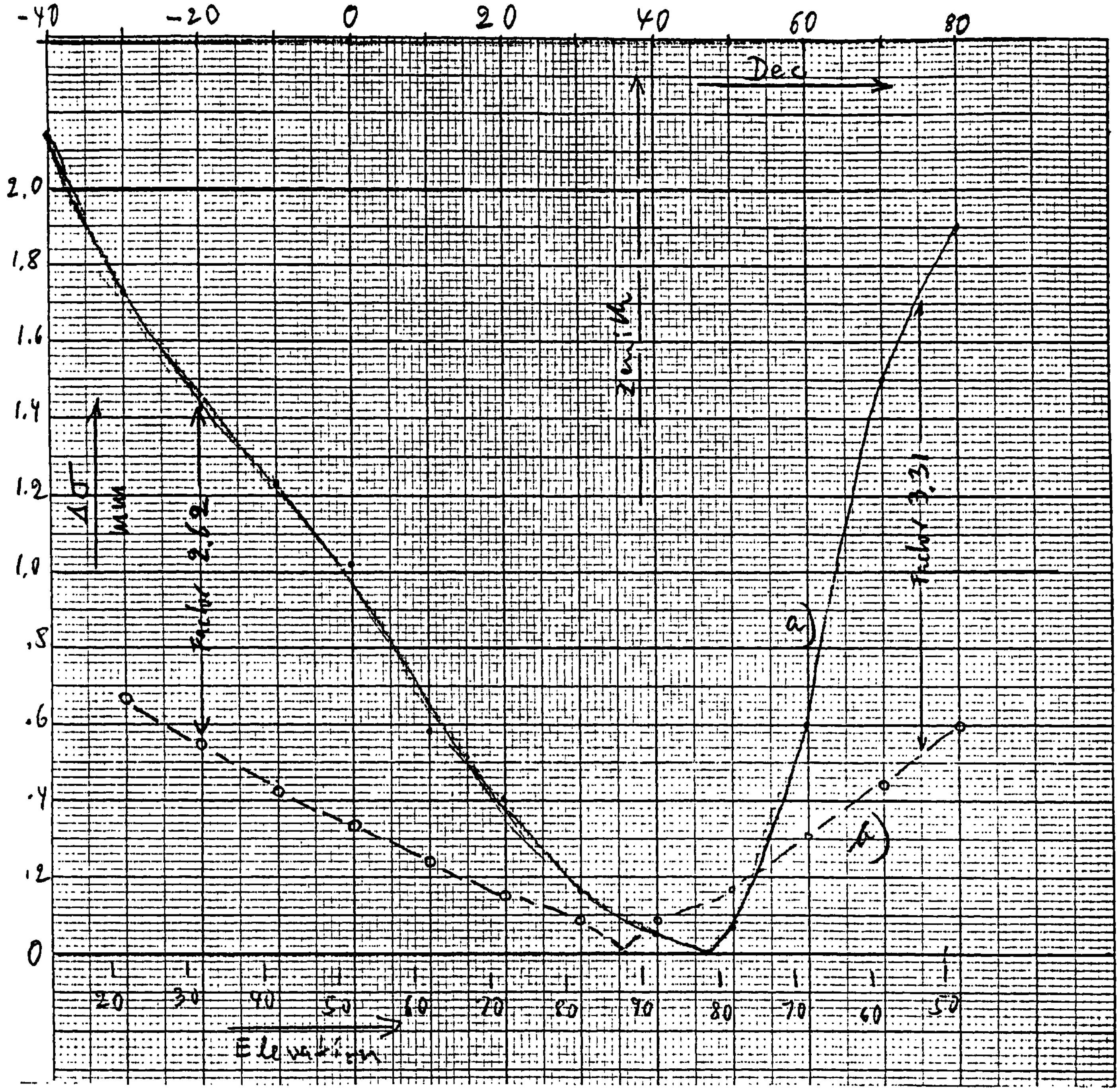

Fig.2. 140-ft Deformabla Subreflector

Copy of a 1980 evaluation of Bob Brown's measurments of aperture efficiency, before and after improvements. Shown is the gravitational contribution to the surface rms errors along the meridian at various elevations.

a) Original state, measured February 1979.

b) With deformable subreflector, second version with stronger motors, July 1980.