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BERKELEY: RADIO ASTRONOMY LABORATORY

To: J. Welch, M. Wright, L. Urry, Radio Astronomy Lab.
From: Jerry Hudson (jgh)
Subject: Correction of Panel 4 Errors by Warping
Date: July 19, 1991
cc: Dave Pankow, Space Sciences Laboratory

Data from measurements of type 4 panels for antenna no. 4 indicate a systematic machining error which is sufficiently serious to require correction. For the worst case (panel no. 4-3) the RMS departure from a paraboloid is 1.6 mil. The form of the residuals is that of a saddle. A contour plot is given in Fig. 1. When Mel Wright fitted a quadratic warping function to the residuals, such as to simulate bending the panel about an axis at a 45 degree angle to the x axis, the RMS fell to 0.2 mil. The question I investigate in this report is whether one can expect to achieve smooth, uniform bending via the four corner supports, such as to cancel the machining errors. The presence of ribs in the panel castings raises what appears to be reasonable doubt this can be achieved. My findings, happily, are to the contrary.

I simulated the warping of antenna panel no. 4 using the Algor "ViziCad" finite-element analysis program based on the SuperSap program. Three idealizations to the panel were generated, using "SuperDraw":

1. A flat panel, broken into 64 plate elements (file: FLAT1);
2. A flat panel with 3 rib reinforcements in each direction, broken into 64 + 48 plate elements (file: FLAT2);
3. A curved panel of the correct paraboloidal shape, broken into 64 plate elements (file: PANEL4).

Due to time limitations, I was unable to try adding stiffeners to case 3, nor was I able to utilize the Algor simulations done by Gregory Becker in his Master's thesis, owing to incompatible differences between my version of Algor and his (older version). I used the defaulted material properties of steel, with uniform thickness of all elements.

In each case, I constrained the model at opposite corners, allowing no translations and no rotations, and I applied unit loads at the two other corners. The models were then solved via the SuperSap finite-element analysis program, and displacements computed. The exaggerated displacements are illustrated in Figs. 2, 3, and 4. A crossection made through the models between the forced nodes was fitted with a quadratic function of the form,

$$dz = a\,n^2 + b\,n + c.$$

The case for the flat, ribbed panel is plotted as Fig. 5, showing computed displacements and the fit. The fit is good to about 1%. The other two cases fit quadratic polynomials so well that it isn't worth trying to illustrate them. In Fig. 5 are also shown (inverted) the scaled residuals taken from a diagonal cut through the panel data shown in Fig. 1. These follow the same curve quite nicely.

Conclusions:

1. The panels, whether flat or paraboloidal, will deform to quadratic crossectional curves if the panels are held only by the corners.

2. Ribs do not significantly change the smoothness of the deformation curve; they only stiffen the structure.

I found the Algor programs (1991 version) quite easy to use for simple test cases like these. I thank Dave Pankow, Space Sciences Laboratory, for providing Algor to us (by securing a university site license for it), and for helpful advice.

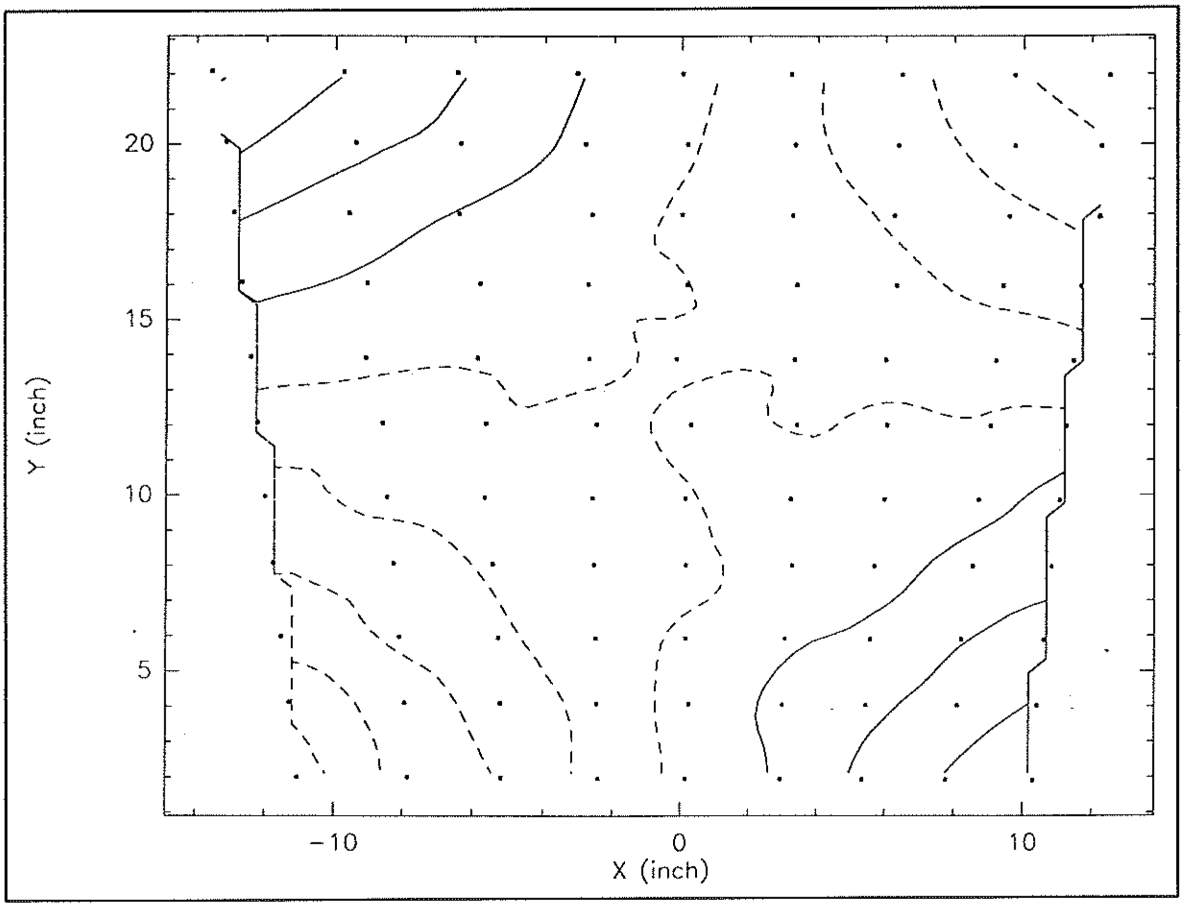

Fig. 1. Residual axial error, panel 4-3. 1 mil contour interval. Mel Wright's data.

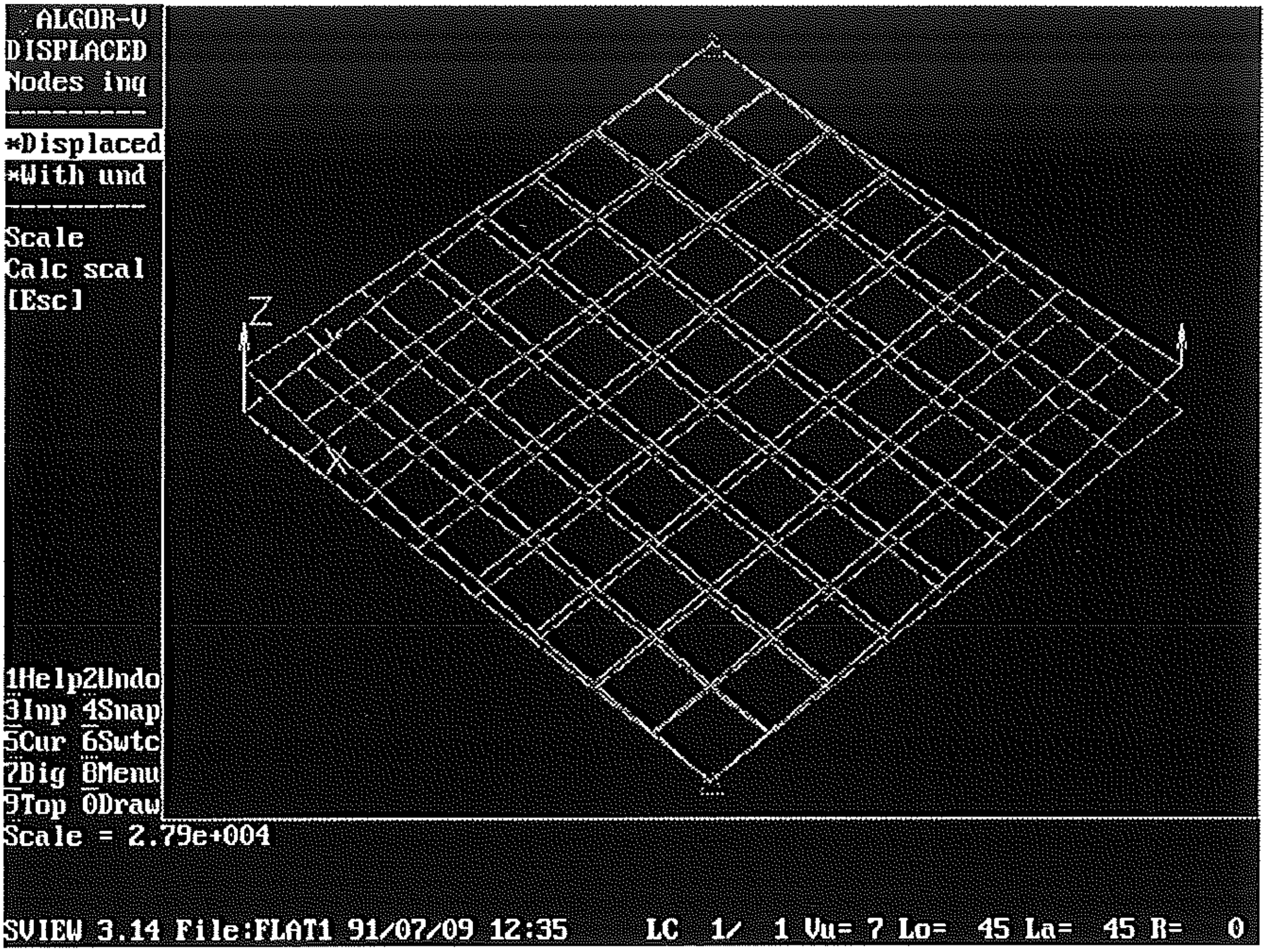

Fig. 2. Flat Plate (case 1) simulation using Algor. Exaggerated displacements shown together with undeflected model.

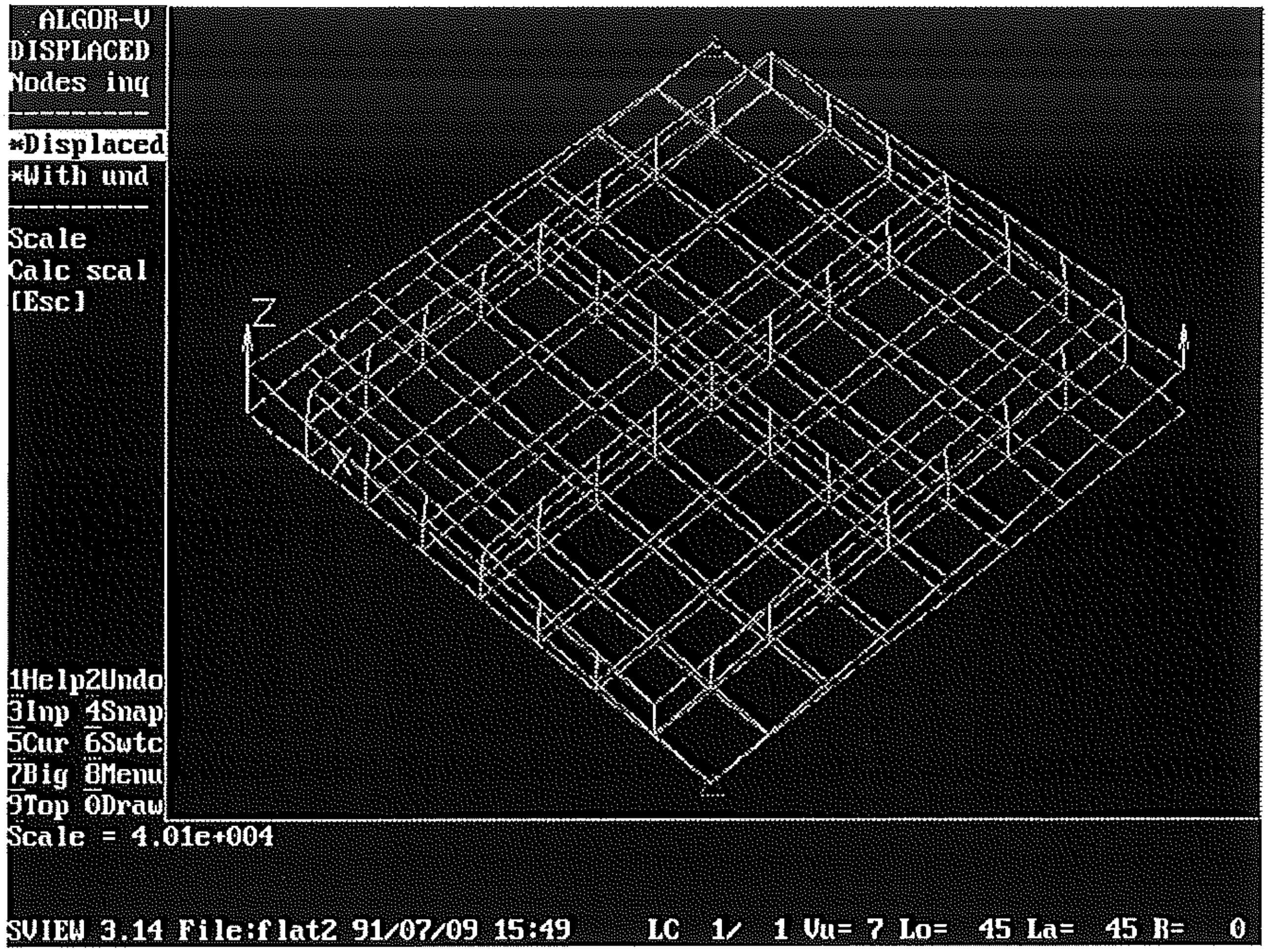

Fig. 3. Flat Plate (case 2) simulation. Ribs added to simulate ribs in the actual casting.

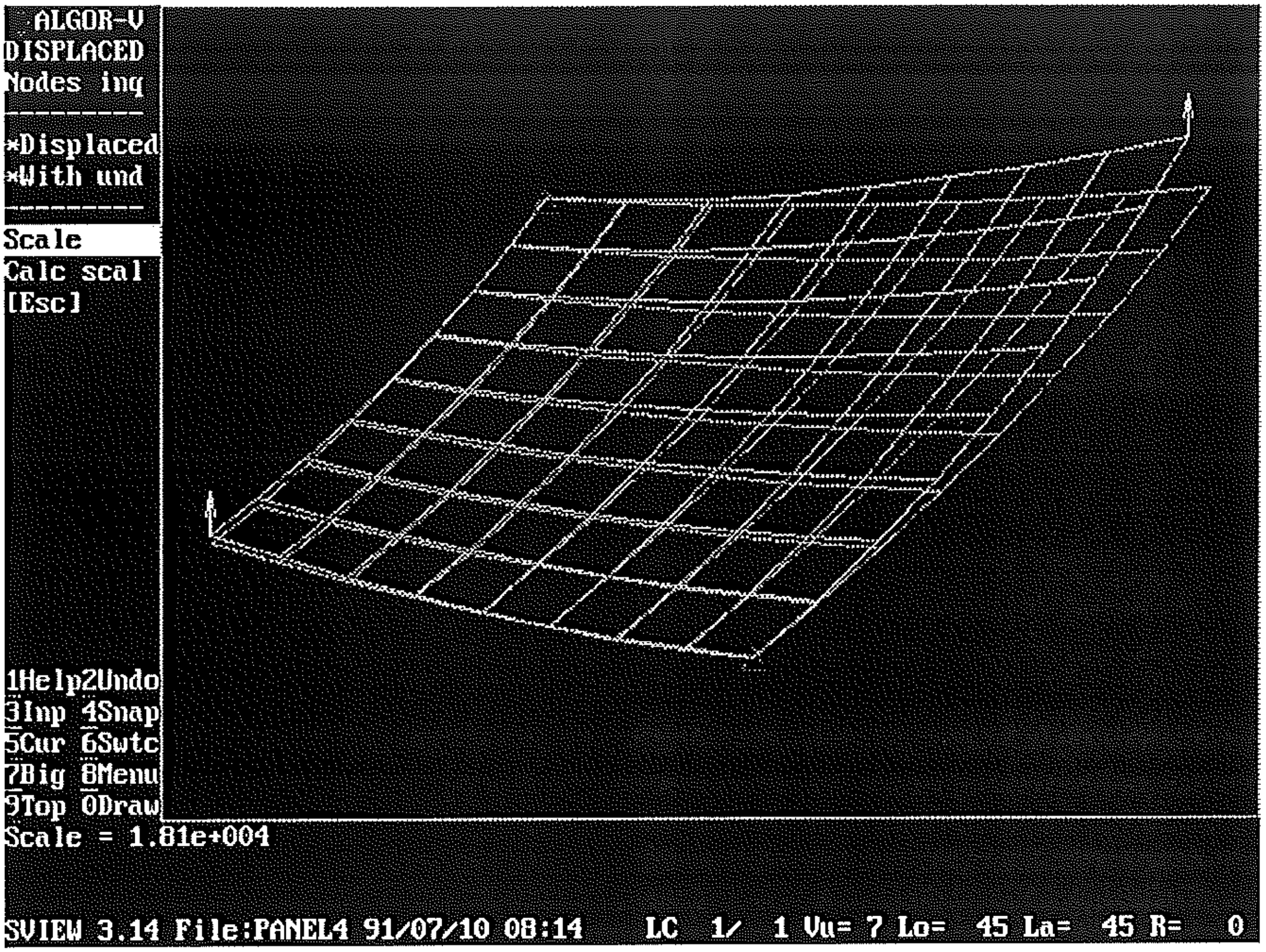

Fig. 4. Curved Plate (case 3) simulation. No ribbing. The curvature accurately models that in the actual panel no. 4 design. Larger deflections at right are caused by slightly greater moment exerted by the same applied force at the corner of the panel. Deflections are accurately modeled by a quadratic function.

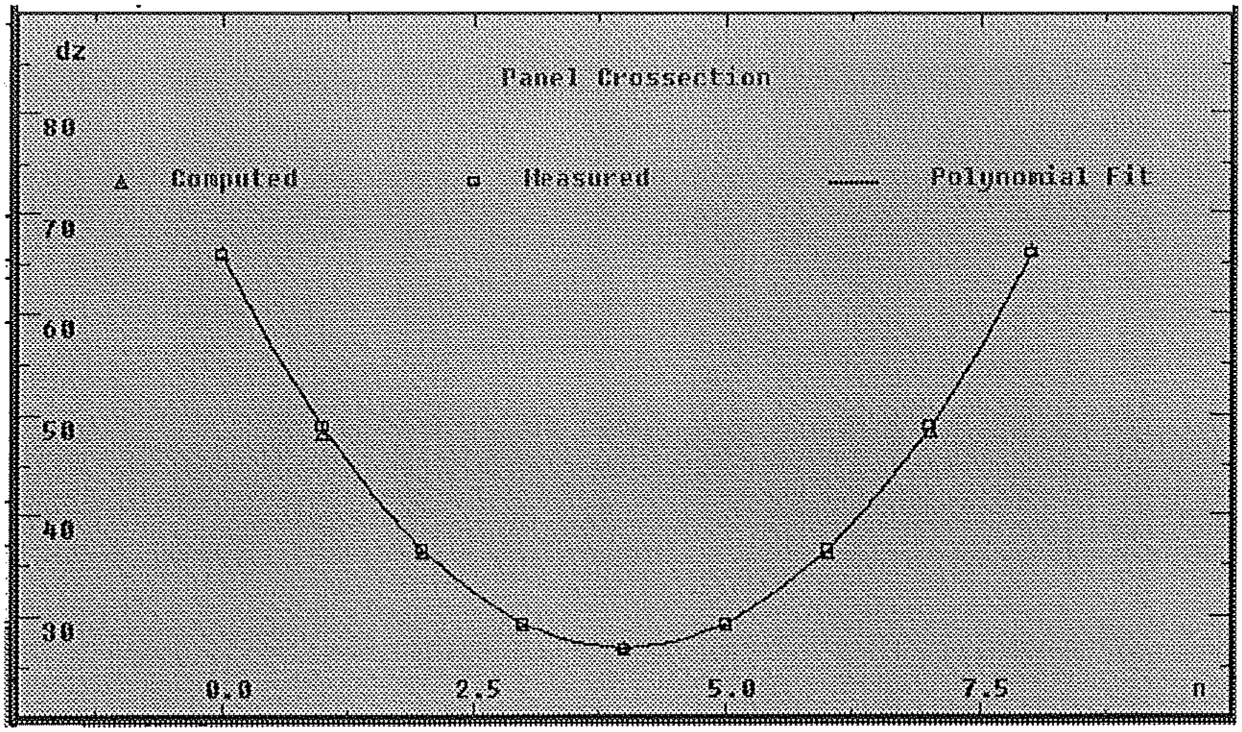

Fig. 5. Crossection through stiffened flat plate (case 2), showing scaled deflection as a function of position. Triangles represent modeled deflections. Squares represent residuals of panel 4-3 at corresponding points (inverted, and scaled to match center and end points). The fitted polynomial is of the form $dz = an^2 + bn + c$. Vertical scale is arbitrary.