64-m-Diameter Antenna: Computation of RF Boresight Direction

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With the addition of the new "kickers" on the 64-m-diameter antenna, fore knowledge of any change in the RF boresight direction errors due to gravity loadings would be of operational value. Using ray tracing techniques, the before and after boresight errors are computed and the configurations documented by line sketches of the RF surfaces with a table of linear and angular deflections. This method of analysis indicates that the RF boresight direction with respect to the intermediate reference surface will have lower deviations after the modifications.

I. Introduction

To meet the RF boresight pointing specifications for gravity loading of the 64-m-diameter antenna, the manufacturer's (Rohr Corp.) engineer developed algorithms to compute the RF boresight direction with respect to the intermediate reference surface (IRS) mounted in the hub of the reflector structure (Ref. 1). Data on the deflected positions of the phase centers were combined with the position of the best-fitted paraboloid (Ref. 2) to the distorted surface of the main reflector by ray tracing to determine the boresight direction errors. Its computed prediction of small boresight error for the gravity loading case was attained for operational purpose.

An independent determination of the boresight errors was made at JPL, comparing answers from computed and field measured data (Ref. 2). Now, with the forthcoming structural modifications of new "kickers" to be added to the 64-m-diameter antenna, computed predictions of the boresight errors may be of operational value.

This reporting documents the computed RF boresight errors for gravity loading on the Tricone 64-m-diameter antenna before and after the modifications. Future reporting will be made to compare computed data to the field tested data when the field data become available.

II. Descriptions

Figure 1 illustrates the RF reflecting surfaces at the alignment position of 45 deg elevation angle. The hyperboloid system is shown on the symmetric axis of the paraboloid although in the actual Tricone configuration the axes are separated by 4° 31′ of arc.

Figures 2 and 3 illustrate the deflected positions at zenith look. The symbols used on these figures are defined in Table 1 and as follows:

A, B	quadripod base
A_2, B_2	deflected quadripod base
C	paraboloid vertex
C_2	deflected paraboloid vertex
C_3	vertex: best fit paraboloid
F	paraboloid focus point
F_2	deflected hyperboloid virtual focus point
F_3	deflected phase center virtual focus point
F_4	focus: best fit paraboloid
H	hyperboloid vertex align position
H_2	deflected hyperboloid vertex
P	primary phase center
P_2	hyperboloid primary focus point
P_3	deflected primary phase center

The ray tracing starts from the RF feed's phase center P_3, which results in the refracted position of the virtual focus at F_3. At present, a unity factor is used for this refraction calculation until better data become available. Then the ray from F_3 is reflected from the vertex of the best fit paraboloid and the boresight direction is shown by the angle δ in Fig. 4. A reflection factor of 0.83 obtained from the results of reflection calculations in the radiation program (Ref. 3) is used. The boresight error with respect to the IRS is then equal to ϕ minus δ.

Since the reporting of Ref. 2, the structural model has been improved by using 1/2 of the reflector instead of 1/4, with some bending members included.

III. Conclusions

The computed answers are deliniated in Table 1. The best sources of data were used for these cases.

From the computed cases, at least for gravity loadings, the RF boresight direction errors are predicted to be lower after adding new "kickers" to the 64-m-diameter antenna.

The horizon look values were not computed because the field measurement data with respect to the hyperboloid for some unexplained reason were not linear. However, on the linear basis, the pointing error should change in sign for direction and compute in value about 40% of the zenith value for the 45-deg alignment position.

References

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Table 1. Gravity deflection data: 64-m-diameter antenna

Part	Deflection symbol: Angular	Deflection symbol: Linear	Deflection description	Zenith look, aligned 45° elevation offsets: Standard structure, Angle, rad	Standard structure, Linear, cm	Standard structure, Linear, (in.)	Modified kicker, Angle, rad	Modified kicker, Linear, cm	Modified kicker, Linear, (in.)
Primary feed	–	UU	Hub translation[a]	–	0.80	0.316	–	0.75	0.294
	γ	SS	Primary phase center[b]	−0.001119	2.26	0.891	−0.000924	1.95	0.769
Hyperboloid system	–	RR	Primary hyperboloid focus[b]	–	5.09	2.004	–	4.82	1.898
	Ω	QQ	Hyperboloid vertex[b]	0.001286	12.93	1.549	0.001425	3.56	1.402
	–	OO	Virtual hyperboloid focus[b]	–	3.63	1.431	–	3.23	1.271
	–	TT	Primary feed offset[b]	–	2.83	1.113	–	2.87	1.129
	–	PP	Virtual hyperboloid focus offset[b]	–	0.58	0.2271	–	0.58	0.230
Paraboloid system	–	VV	Best fit paraboloid[a] (vertex offset)	–	−10.96	−4.316	–	−12.91	−5.082
	θ	MM	Best fit paraboloid[a] (focus point offset)	−0.002612	13.50	2.789	−0.002818	7.64	3.008
	α	NN	Incidence[a]	−0.002558	6.94	2.731	−0.002918	7.91	3.115
Elevation pointing error	β	–	Reflection angle[a]	0.002123	–	–	0.002422	–	–
	δ	–	Boresight angle[a]	−0.000489	–	–	−0.000396	–	–
	ϕ	–	IRS position[a]	−0.0006431	–	–	−0.000446	–	–
	$\phi - \delta$	–	Boresight error	−0.000154 (−0.009 deg)	–	–	−0.000050 (−0.003 deg)	–	–

[a]Primary data source: computed.

[b]Primary data source: field measurement (+ computed for modified kicker).

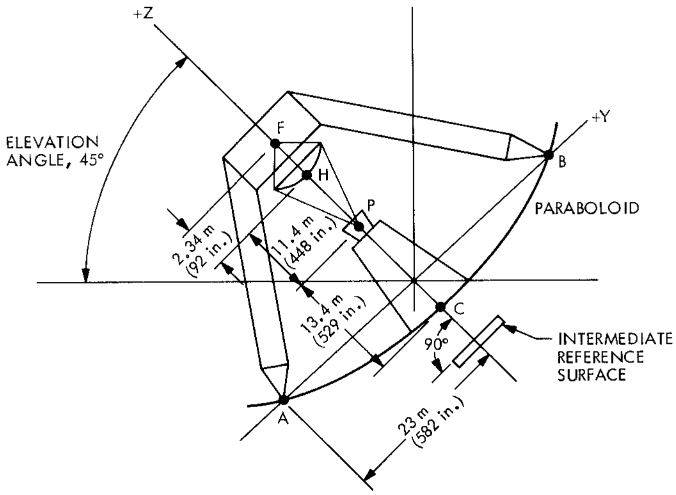

Fig. 1. RF geometry at alignment elevation

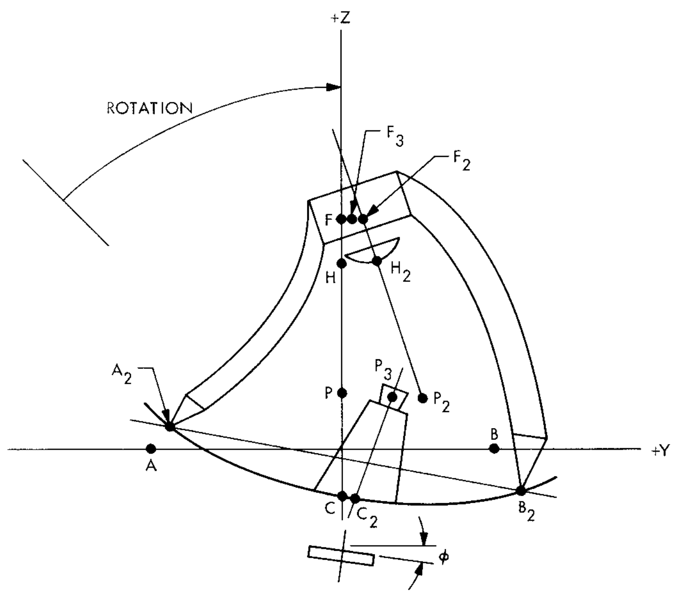

Fig. 2. Deflected RF geometry at zenith look

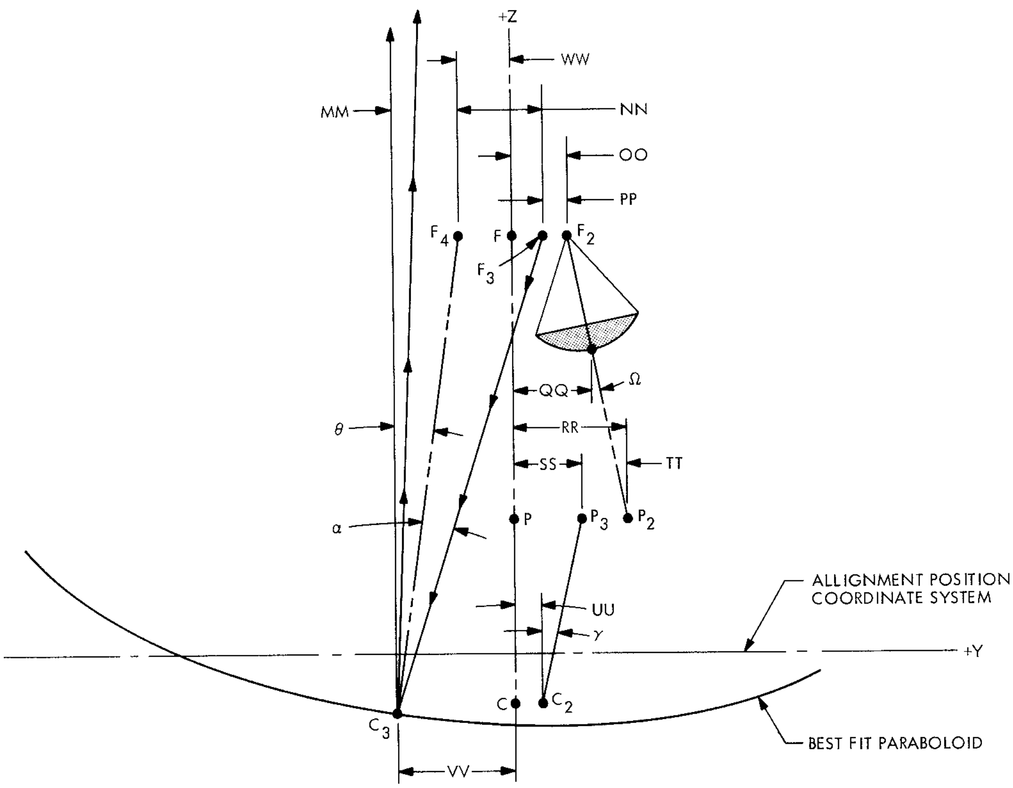

Fig. 3. RF geometry with the best fit paraboloid

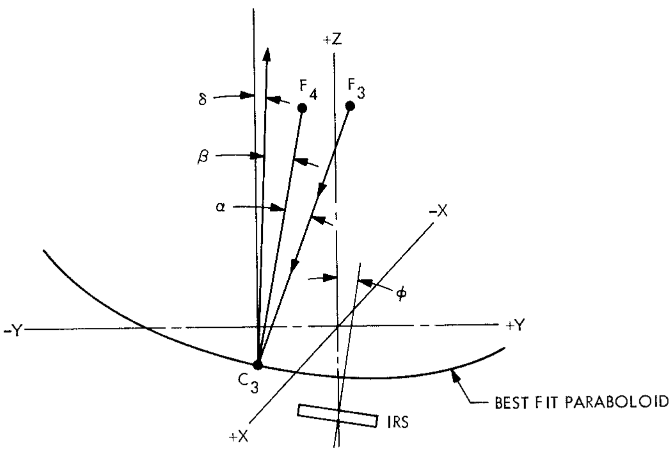

Fig. 4. RF boresight pointing error