MMA Memo 219:
Report on Visit to Composite Optics Inc.

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Abstract

This memo summarizes my recent visit to Composite Optics Inc. to update them on recent MMA antenna designs, and discuss in detail the antenna components which are likely to be of composite construction. I presented my concept for an all CFRP primary mirror support structure using pultruded truss elements joined by laminated plate gussets. COI commented on the strengths and weaknesses of this approach and gave an update on their continuing development of the laminated plate all CFRP structure. COI provided engineering constants for particular CFRP laminates (which are in good agreement with values we have assumed until now) which will give our future modeling work a greater level of accuracy.

1 Introduction

On June 10, 1998 I met with Shel Kulick, Ed Derby, and John Richer of Composite Optics Inc. in San Diego, CA. to update them on the MMA antenna work. I gave a brief overview of our current designs and discussed the parts of the BIMA/NRAO design which are likely to be built of CFRP: subreflector, quadrupod legs, main reflector support structure, mount "reference structure", and perhaps the main reflector surface. They provided many helpful comments on our design ideas, and also provided engineering constants for some materials to help us further refine our modeling in the future (the values we've used until now have been reasonable).

2 Subreflector

COI indicated that fabricating a hyperbolic subreflector with about 5 μm RMS surface accuracy and 30 inch diameter is fairly routine for them. The one time tooling cost is expected to be approximately in the \$60k to \$80k range, with a non-recurring engineering cost of \$25k to \$35k. In a production run of 40 mirrors each piece is likely to cost \$20k to \$40k, while the cost for producing only one is expected to be about 3 times higher.

3 Quadrupod Legs

Construction of subreflector support legs from mostly uni-directional ultra high modulus (UHM) CFRP is feasible. A leg cross section of approximately 2 inches by 6 inches with a 0.060 inch wall thickness is practical. Placing aluminum sun shields around the legs is possible, but perhaps not required if the primary mirror surface scatters visible light effectively. CFRP can be expected to tolerate temperatures of approximately 250 F.

4 Main Reflector Support Structure

I presented my all CFRP design which uses uni-directional (or nearly so) pultruded truss elements connected by laminated plate gussets. A typical node is shown in Figure 1.

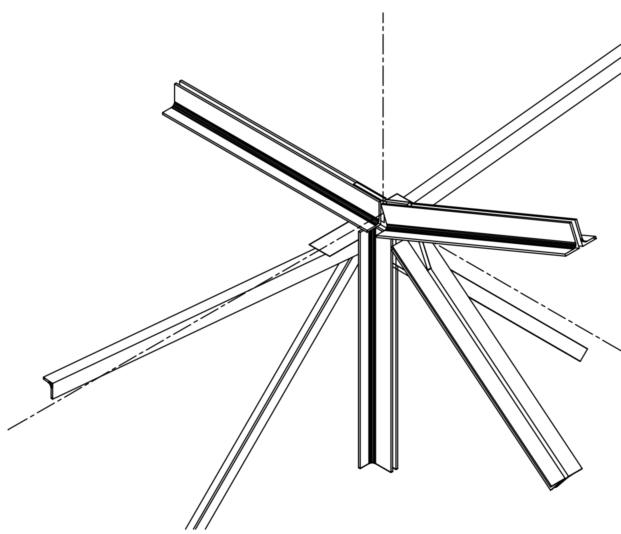

Figure 1: Representative node geometry for the proposed all CFRP reflector support structure using angle sections of uni-directional fiber.

There was general agreement that pultruded uni-directional sections are extremely low cost (perhaps the lowest cost CFRP), have very low coefficient of thermal expansion, and that the proposed geometry allows large bond areas and mostly avoids secondary bending if one is careful with the geometry. COI thought it is quite possible that a putrusion firm may be able to incorporate a small fraction of non-axial fibers to increase the transverse strength of the pultruded sections. I argued that use of back-to-back angle sections for the truss elements gives a better bonding geometry and far less sensitivity to section dimensional tolerances than does use of rectangular tubes. For ease of fabrication, John Richer feels that tubes may be preferable to the back-to-back angles. COI is pursuing cost savings and lower CTE for their initial design concept, by using non-isotropic layups and minimized material waste. We discussed hybrid designs utilizing local stiffening of laminated plate structures by uni-directional bars.

5 Mount "Reference Structure"

The use CFRP structures with very low CTE to provide accurate references for measuring the mount deflection looks very feasible.

6 Primary Mirror Reflector Surface

I described the benefits of the rib geometry used on BIMA cast aluminum panels. COI was very interested in cost and accuracy of aluminum panel technology: I provided the approximate BIMA cost ($35k machining, $15k per dish for sand castings in 1995 dollars for 6.1 m dish) for panels typically 0.8 m or less in size, with better than 6 μm machining accuracy. I remarked that the BIMA panel machining was done by a small, specialized vendor, who might not be interested in the higher production rates needed for MMA. We discussed the number of adjusters and time required to adjust an entire dish. COI commented on the possible cost and weight advantage of a composite membrane and implored us to keep open minds on that posibility.