Progress Report
on
Multidisciplinary Modeling/Analysis

P.I.:  F. G. Yuan
Student supported by the fund:  C. Zhang

1. Introduction
The current aircrafts using antennas to transmit wireless signal utilize microstrip antennas bonded
to the surface of the aircraft with a bonding agent. This configuration has the following
disadvantages: (1) the antennas may delaminate between antenna and base structure; (2) the
laminated aircraft cannot host microcomputer chips for signal processing; and (3) the bonding
and lamination process add up the cost. The objective of this project is to develop a novel
multifunctional 3D woven composite structure, which can carry loads as well as serve as an
antenna for transmitting and/or receiving signals. This composite structure has the potential to
integrate with microcomputer chips to form an “e-composite”.

2. Progress and Results
Copper was chosen as antenna material. The copper yarn has to go through very sharp turns in 3D
weaving machine. Therefore, a stranded bare copper yarn with very fine individual copper fiber
was used due to its high flexibility. The dielectric constant of Kevlar® composite, \( \varepsilon_r = 2.5 \), has
been measured by the NASA, which meets the dielectical requirements as a substrate material in
a microstrip antenna. It also has very good mechanical properties. Therefore, Kevlar® 49 was
chosen as substrate and reinforcement yarn.

Figure 1 shows a schematic view of the microstrip antenna design. There are total 6 weft layers
for the 3D woven fabric. The bottom weft layer was used for copper ground. Copper yarn was
inserted into the bottom weft insertion needle in the 3D weaving machine during the whole
weaving process. The top weft layer was used to fabricate the microstrip antenna. While weaving
the microstrip area, copper yarn was inserted into the top weft insertion needle. During the time
when the top layer is not microstrip antenna, Kevlar® yarn was inserted into the top weft insertion
needle. No. 2 to no. 6 weft layers are the Kevlar® substrate layer, Kevlar® yarns were threaded
into the corresponding weft insertion needle during the whole weaving process. The microstrip
antenna together with coaxial cables will be designed and then sent to NASA for measurement in
identifying the performance of the integrated composite. Analyses will be performed to correlate
the experimental observations.