BLUE FORCE TRACKER ANTENNA PLACEMENT STUDY ON A CH-53E HELICOPTER.

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Abstract

The motivation of this study is to define the best placement for the Blue Force Tracker (BFT) satellite communications (SATCOM) antenna on a CH-53E heavy lift helicopter. When an antenna is chosen for a specific application, careful analysis of its placement must first be conducted to ensure desired performance. Platform mounted performance often deviates significantly from free space performance.

The analysis was performed purely through a Computational Electromagnetics (CEM) modeling and analysis approach, rather than traditional field measurements. This resulted in lower cost and higher flexibility. The BFT antenna was built and refined in WIPL-D, a Method-of-Moments (MoM) antenna analysis software. Free space performance was determined and compared to field measurements. The CH-53E model was taken from a CATIA, a Computer Aided Design (CAD) software, imported into GID, a CAD and meshing commercial software. It was then refined and meshed at the operating frequency and was imported into WIPL-D via an internally prepared MATLAB script.

Three locations were examined in detail. Other locations were considered but quickly dismissed due to mechanical, presence of pre-existing antennas, or high blockage problems. The location with the best performance was the one where the antenna was placed at fuselage station (FS) 660.5, and buttock line (BL) 16L.

Introduction:

The Naval Air System Command (NAVAIR) Radar and Antenna Systems Division's CEM group was asked by the BFT team to perform a study to determine the best placement for an L-Band SATCOM antenna on a CH-53E heavy lift helicopter. The BFT communications system was developed by the US Army. It is a satellite based communications system that allows real time tracking of troops and equipments that are BFT enabled. BFT enabled troops are also able to send instant text messaging through the BFT link. This provides an advantage for field commanders to manage resources and ensure accountability for all the troops and their resources. The CH-53E is the Marines' heavy lift helicopter. Its main role is to transport troops, heavy equipment, and supplies.

The Antenna:
The BFT antenna operates at L band frequencies. It transmits in the 1626.5-1660.6 MHz frequency range, and receives in the 1530-1559 MHz frequency range. It is dual-polarized and has two elements. The front element is left-hand-circularly polarized (LHCP) and the back element is right-hand-circularly polarized (RHCP). The two elements sit on a 10.75” X 3.78” platform. See Figure 1a for measured patterns on a 4’ x 4’ ground plane.

The antenna was modeled as a half-turn quadrifilar. It was created in WIPL-D via the HELIX object command and was fed at the top by two crossed wires. It was analyzed on top of a 4’ x 4’ PEC ground plane. The separation between the antenna and the ground plane plays a critical role in matching the simulated patterns with those of the measured patterns. The height that gave the best matching performance was found to be 1.5” from the ground plane. Refer to Figure 1b for the simulated. Since only one element is active at a time, the other element is terminated in a 50 ohms load.

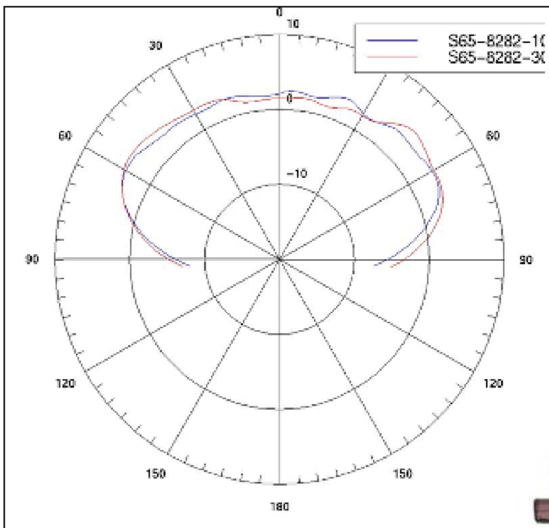

Figure 1a. Measured RHCP Patterns at 1.5445GHz.

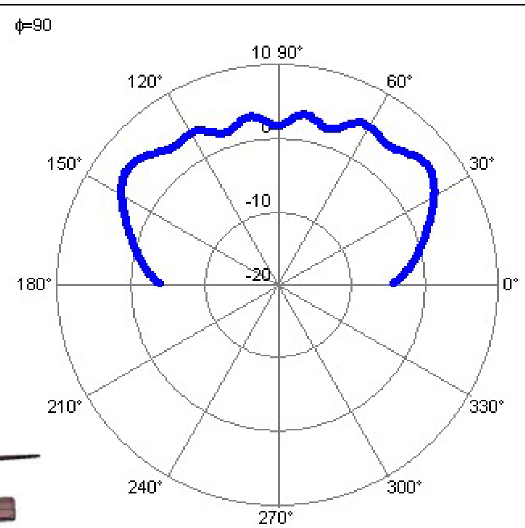

Figure 1b. Simulated RHCP Pattern at 1.5445GHz.

Preparation of the Model:
The original CAD model of the CH-53E was in CATIA 4.0. The apparent goal was to get this model into WIPL-D for analysis. Only a part of the aircraft was used in the simulation due to computational limits. While there are many ways to accomplish this goal, the following method is the norm at NAVAIR.

1. Use a CAD translator to convert CATIA 4.0 to IGES.
   - This intermediate steps allows GID to import the model, because GiD can import IGES, another CAD format. Any translator may be used; in this case, TransMagic was used as a CAD translator.

2. Import IGES into GID and perform alterations.
   - Via the CAD format IGES, it is now possible to fix the model for CAD/translation errors in GiD. Further additions to the model are also added during this stage. GiD is a graphical user interface for geometry modeling; it also has extensive meshing capabilities.
3. Mesh and heal the finalized model.
   - Once the model has been finalized, it is necessary to mesh the model for import into WIPL-D. Before feeding WIPL-D the mesh however, certain mesh deformities will arise. See Figure 2. These are taken care of in GiD via built-in commands and manual operations.
4. Import into WIPL-D
   - The mesh is passed through a MATLAB script, to rearrange- the data to the format of WIPL-D's ".IWP" file. The building/attaching of antenna is then performed in WIPL-D.

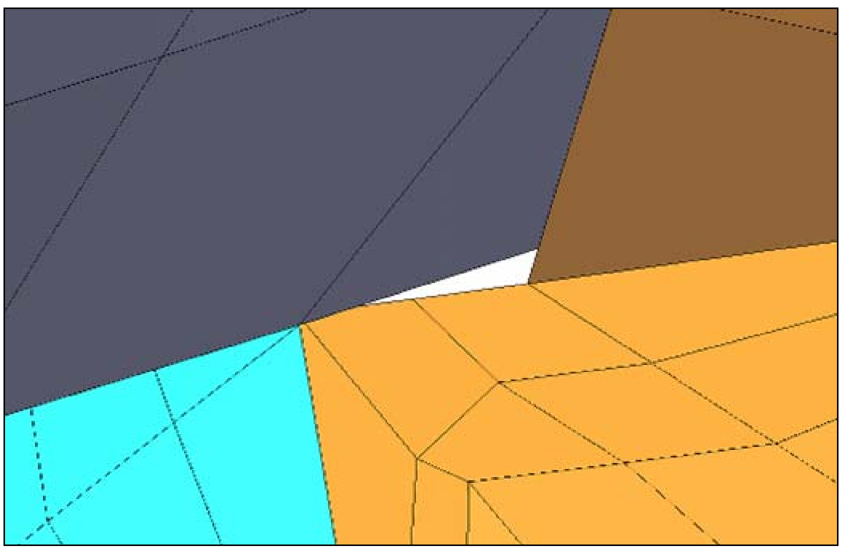

Figure 2. Example of a Mesh Deformity

The Locations:
While there exists an infinite number of location choices, most of them are not feasible due to mechanical restrictions, presence of other existing antennas, or insurmountable blockages. Due to these restrictions the location for the BFT antenna is confined mostly to the port side of the tail. In that region two locations were chosen, based on the distance to existing antennas and the feasibility of mechanically altering the airframe for installation. Figure 3 shows the summary of all the locations.

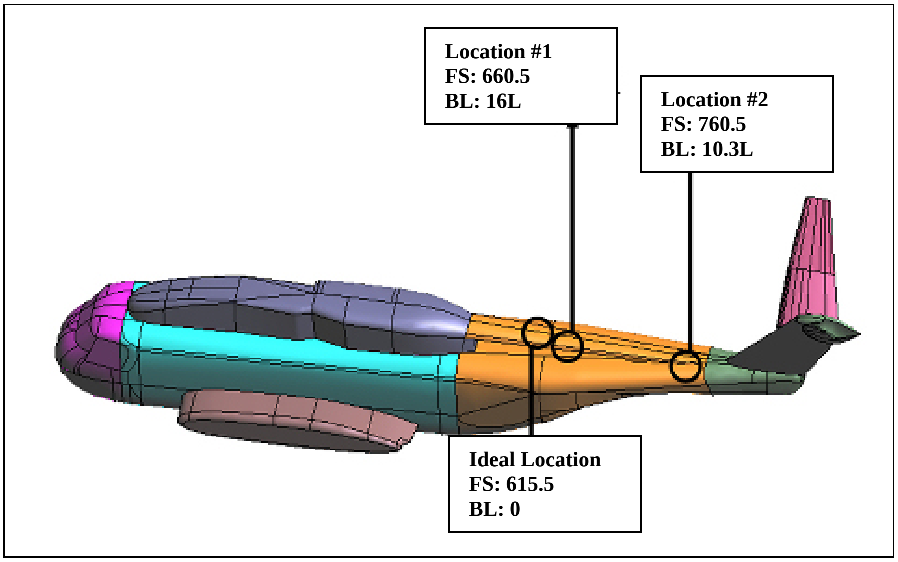

Figure 3. Summary of Simulated Locations

Location 1:
Location 1 was chosen to be at FS 660.5, BL 16L. It was chosen as a mid-tail location so that it was at a proper separation from the rotor hub. Due to the high blockage of the transmission housing, this location required a raised platform. The size of this platform was set equal to the footprint of the antenna, and the height was made equal to that of the transmission housing, see Figure 4 for this location's details.

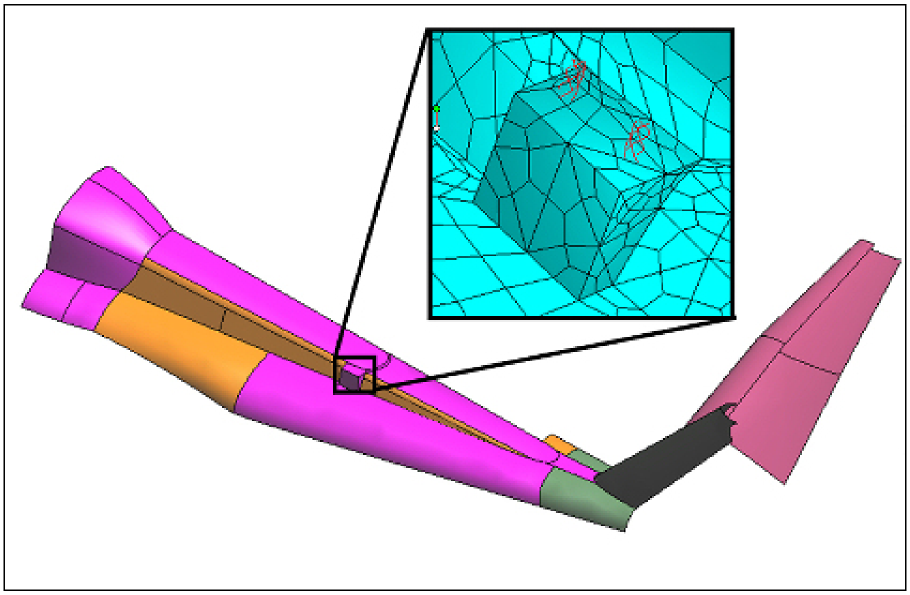

Figure 4. BFT Antenna at Location 1

Location 2:
Location 2 was chosen to be at FS 760.5, BL 10.3L. This location did not require a mounting platform due to the tapering of the end of the transmission housing. It also provided larger separations from other antennas. However, the drawback is the vertical tail and the horizontal stabilizer of the CH-53E helicopter. See Figure 5.

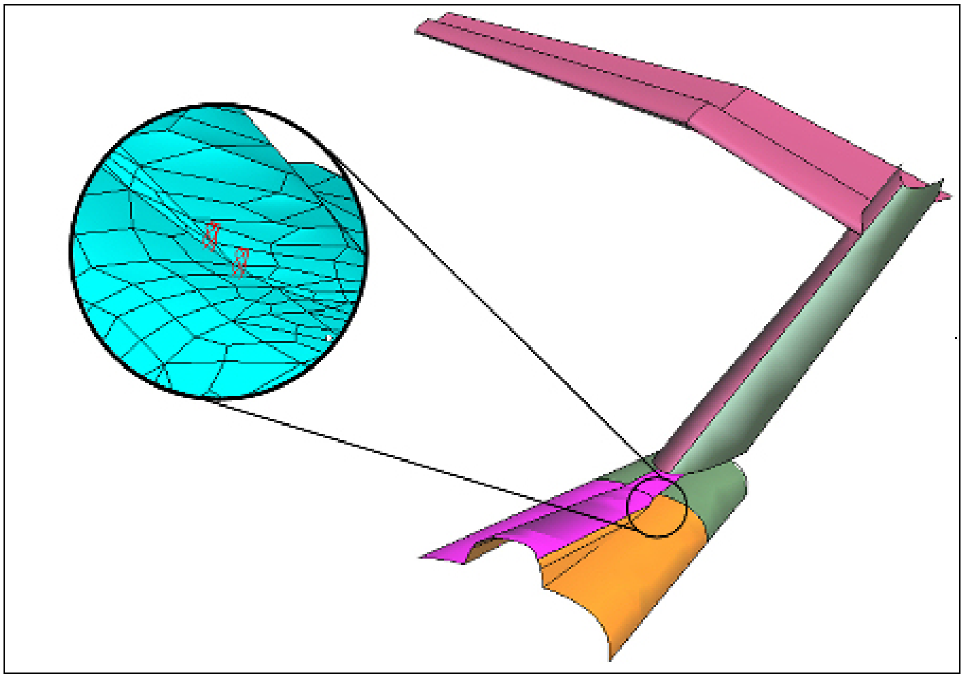

Figure 5. Location 2

Ideal Location:
Although ideal, this location could not be utilized due to mechanical and supportability issues. This ideal location was considered so that a comparative study can be performed. This ideal location was chosen to be on top of the drive shaft at FS 615.5, BL 0, further up from Location 1. See Figure 6.

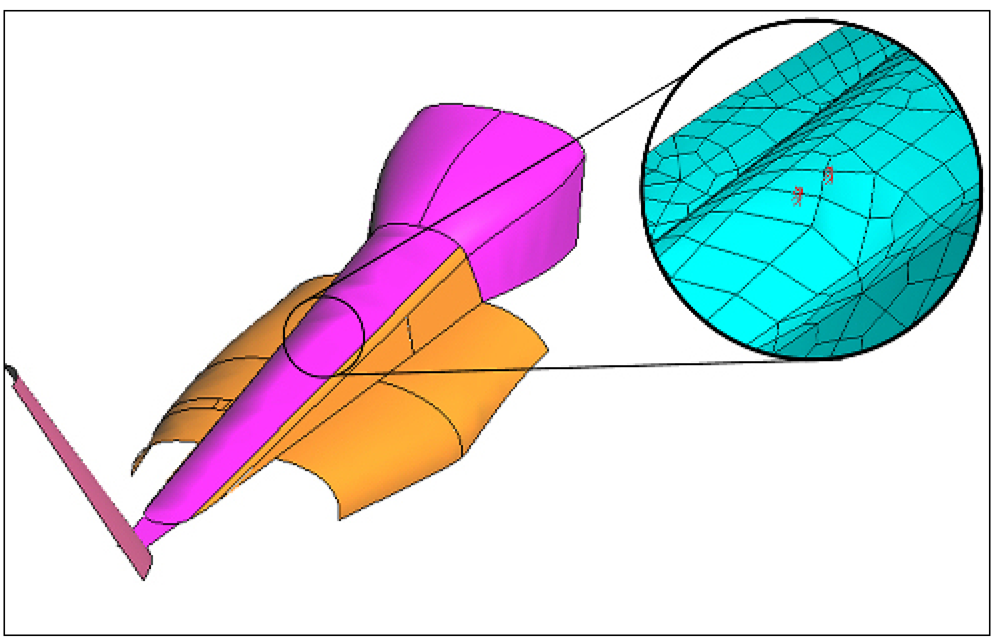

Figure 6. Ideal Location

Results and Conclusions:
While cases for different transmit and receive frequencies, as well as, the RHCP and LHCP antenna elements were created and simulated, only one frequency and polarization will be presented here. The effects on the radiation patterns were the same on both frequencies and polarization. When deciding on the best location, RF performances and supportability are the main concerns. Since this is a SATCOM antenna, the main concern is in upper hemispherical coverage. Full 3D plots were produced for comparison, but only the pitch and roll cut will be presented for discussion.

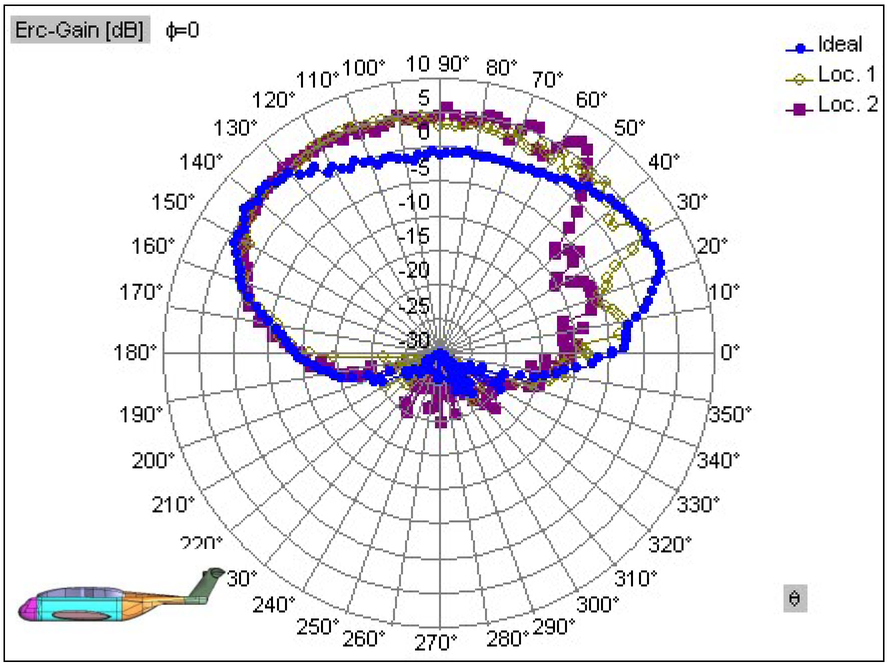

Figure 7. Pitch Radiation Patterns

From Figure 7, a clear benefit can be seen if the ideal location was a practical candidate. Location 1, however, shows a better performance than Location 2—a 10dB performance improvement at some angles. This is mostly due to the lack of reflection of RF energy off of the tail. Evidence of the blockage of the horizontal stabilizer can be seen at 20 degrees above the horizon.

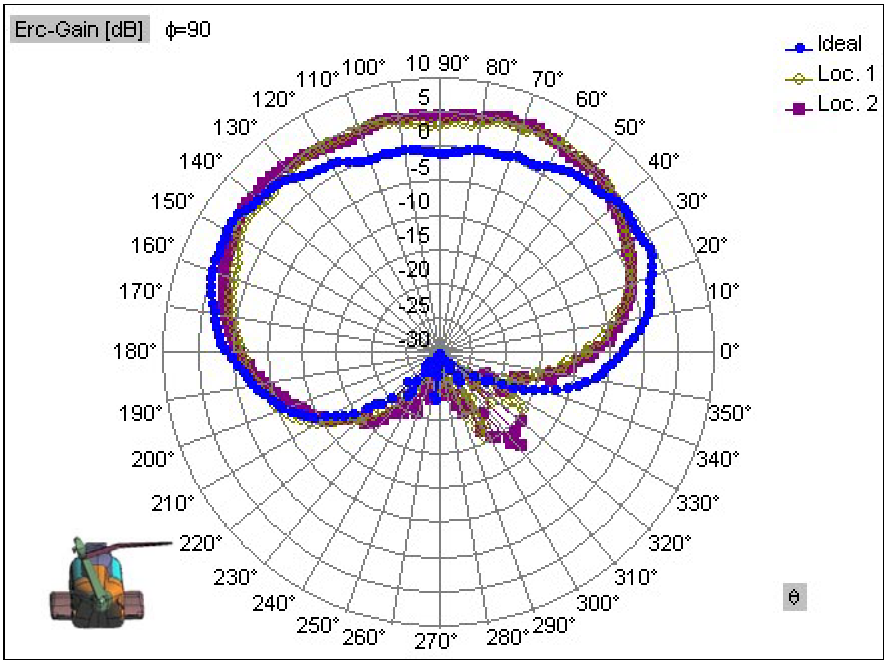

Figure 8. Roll Radiation Patterns

Figure 8 shows the effects of the platform on the antennas due to its placement on the port side and the fast curvature of the left side of the tail. The performance is essentially the same for both Location 1 and Location 2 because the tail is not taken into affect. The raised platform for Location 1 overcomes the blockage of the transmission housing. Thus, it is determined that Location 1 has a performance advantage over Location 2.