Feasibility Study of Flight Inspection Aided by UAS-Based Sensing and Calibration

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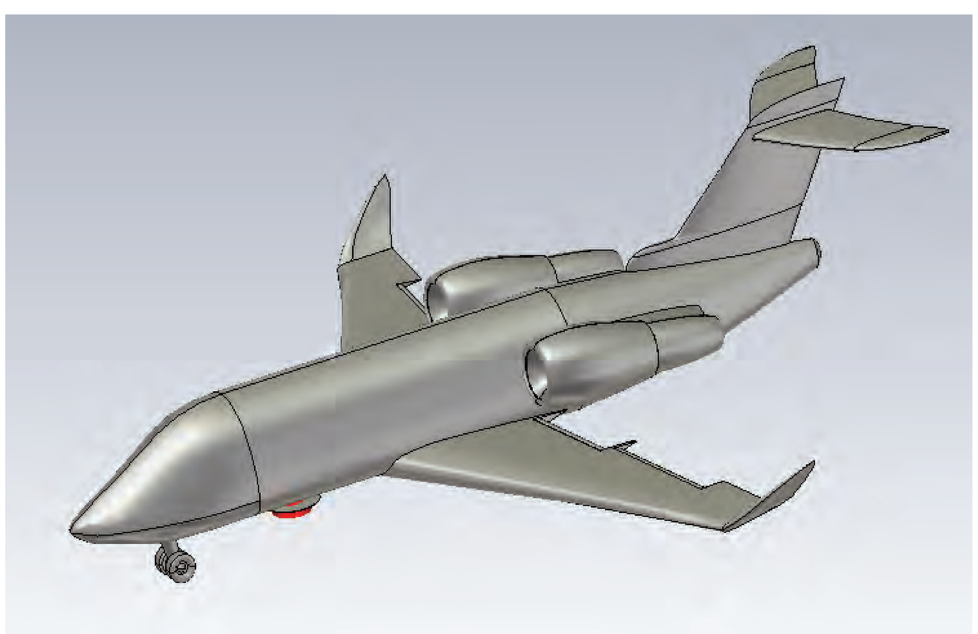
WHAT

FAA's Flight Inspection Fleet

Flight Inspection Services (FIS) ensures the integrity of instrument approaches and airway procedures that constitute our National Airspace System (NAS) infrastructure and the Federal Aviation Administration's (FAA's) international commitments. This project is to support the improvements of the FIS data quality and accuracy by providing physical-simulation-based calibration of the existing FIS measurement instrumentations. The innovative technology used include electromagnetic simulation of the navigation aide antennas on the service aircrafts (King Air and Challenger 605 aircrafts). Improvements to existing calibration software and procedures will not only benefit the flight inspection process, but also potentially improve aviation safety and offer cost saving for labor, equipment and flight hours.

GOALS

The ultimate goal of this project is to verify the feasibility of achieving the ±3 dB (3dB absolute) measurement uncertainty of signal strength (SS) for all the navigational aid signals through a combination of EM simulation, radio system calibration and signal processing, and through the usage of unmanned/autonomous test platforms. The short-term goal of the current project is developing 3D CEM simulations of the antenna radiation patterns of the antennas mounted on the flight inspection aircrafts (such as King Air and Challenger).



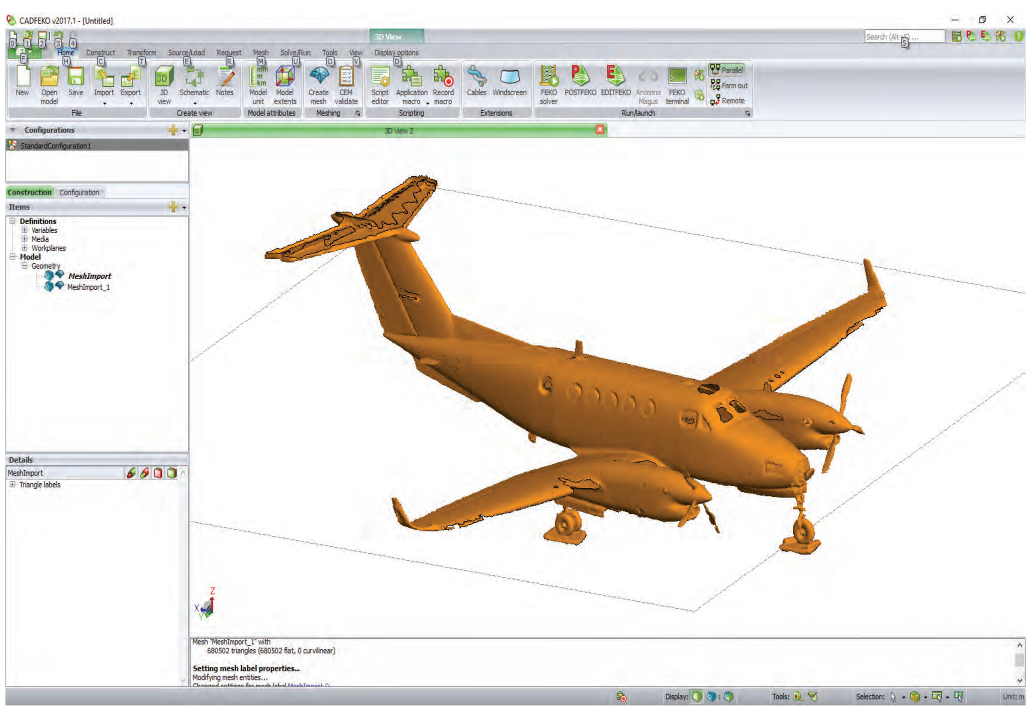
3D aircraft model from manual modeling

HOW

The first step is aircraft modeling. In this step, we use both existing aircatft information and the 3D laser-scanned model as reference, and manually build the 3D aircraft model in SolidWorks. The models for EM simulation does not need to be "perfect" in the sense that many details are not needed. However the models captures the dimensions, shapes and key details that matter the EM simulation and 3D antenna pattern predictions. The models are improved iteratively based on the simulation process.

In the second step, the models are meshed properly in EM simulation environments. For the frequnecy of simulation related to VOR/DME./GS, there are usually millions to even billions of the model elements in the simulations.

Antennas modeling uses an effective and similified "effective monopole" approach, which is based on equivalence theory in electromagnetics, and simplified the modeling and need of proprietary information from the antenna vendors.

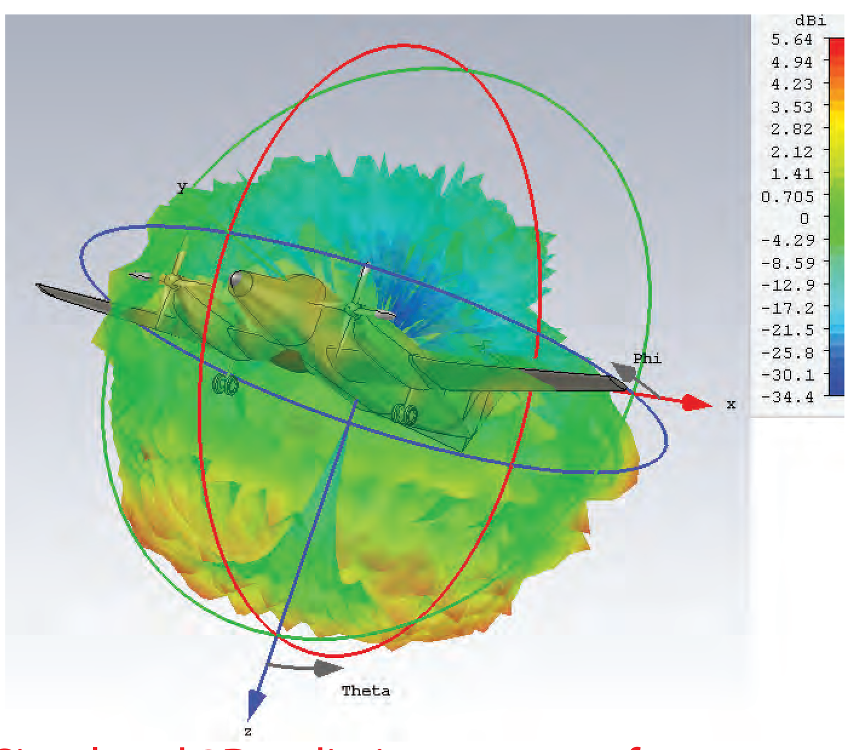


3D aircraft model from laser scanning

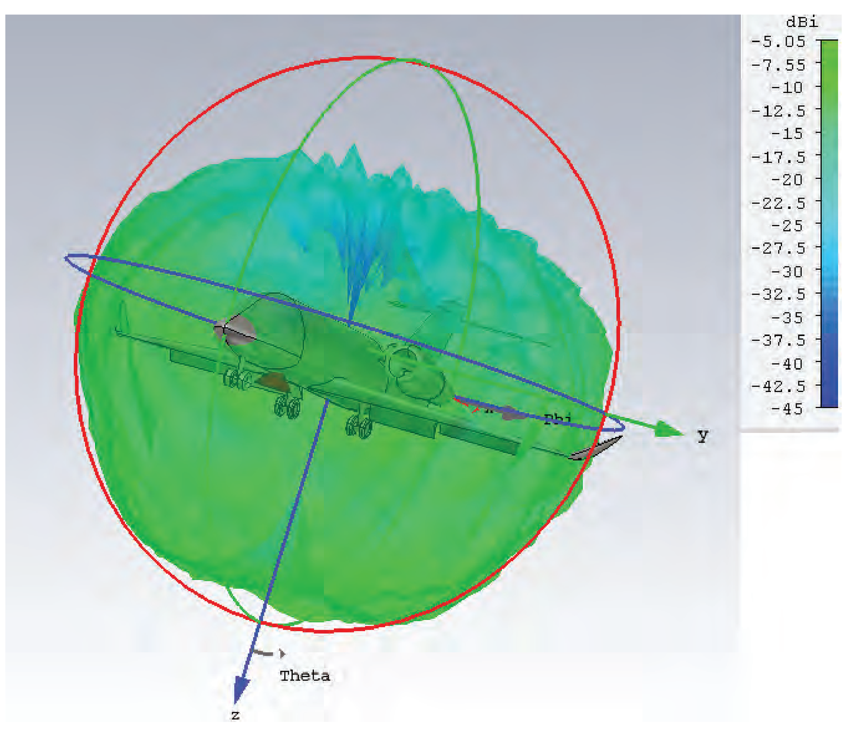
The simulations runs are performed using OU-ARRC's Windows cluster and CST Microwave Studio software. The results are 3D antenna r adiation patterns at different frequencies will be integrated into the flight inspection software system.

Different solver systems from different computational electromagnetics (CEM) tools are used for estimation and comparison.

The approach has significant advantages over exisiing calibration solutions. First, it provides more accurate antenna pattern tables taking the effect of aircraft installation into consideration. Second, it is based on simulations, so the cost of the calibration procedure is redcued.

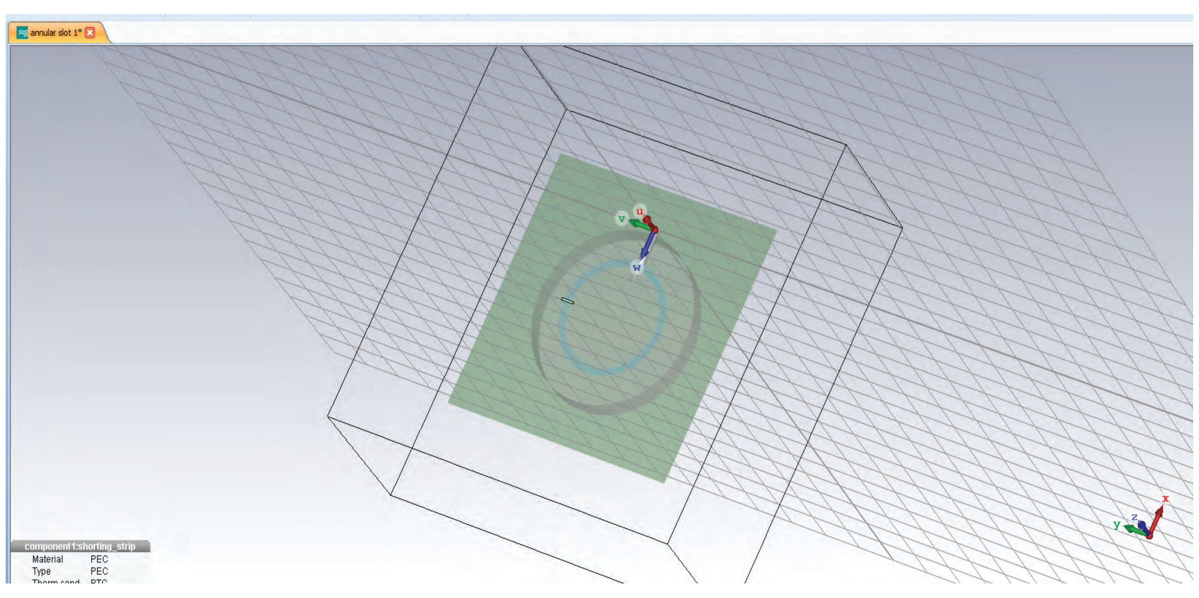


Simulated 3D radiation pattern of GS-antenna on King-Air



SImulated 3D radiation pattern of DME-antenna on Challenger

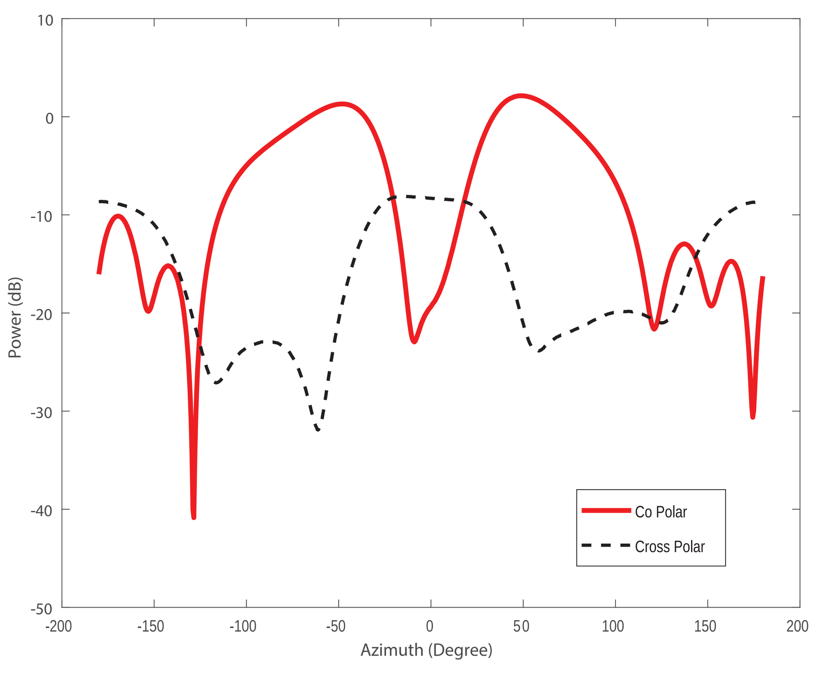
Validation Method



LEFT: The example DME annular slot antenna on KingAir, RIGHT: EM simulation model

The OU team is currently using multiple methods to validate the simulation and enhance the data quality. Due to the limitation of facility and logistics, direct measurement of the antenna pattern with aircraft installation is not feasible. However, the approach we are taking represents a tradoff between the available resources and the accuracies. Firstly, the improvement of the antenna models based on monopole approximation to more accurate physical structure model is being applied. An example is the DME antenna shown in the left. The physical modeling is based on combined X-ray imaging and tuning in the simulation environment.

The second approach for validation is Chamber measurements. The individual antenna is properly mounted on a test fixture and its radiation pattern is measured in OU's anechonic chamber environment. The chamber measurement is limited to 1D pattern cut and there is no impacts of aircraft body, but it provides essential validation in term of basic monopole pattern shapes and basic effectiveness of simulation. The third approach, which is being planning at the stage, is the flight test validation based on the calibration generated from simulations. This step will finally validate the improvement of the signal strengh measurement accuracy.



LEFT: Example of measured 1D radiation pattern of DME antenna in anechonic chamber, RIGHT: Measureent setup for DME antenna used for KingAir

WHY

In general, this project is related to the missions of COE-SOAR in terms of (1) Incorporate evolving technologies: which include antenna modeling, aircraft simulation, EM validation and software-defined radio. It is also related to the long-term goal of automatic, UAS-based calibration procedures. (2) Improve or enhance employee skills and performance, by introducting new technologies and procedures in the important service tasks in FAA. (3) Reduce operational errors, by improving the signal strenght measurement accuracies during inspection flight procedures.

IMPACT

S&T Impacts: The project is developing a new approach for FAA navigational aide antenna inspection flight measurement calibration, more applications of EM-simulation based approach will be available from primary radars, direction-finding to other secondary surveillance radars. Operational Impacts: The project will result in actual implementation of the calibration approach and updated data in operational flight systems. It will directly improve the flight inspection data quality across the nation.

FAA Collaborators: Brad Snelling, Greg Cox, Todd Bigham, Jay Sandwell, Ricardo Carrizosa, Gary Bell, Flight Inspection Services, Aircraft Configuration Team (AJW-335)

OU Team Information and Contacts: Intelligent Aerospace Radar Team (IART) is administrated by OU School of Electrical and Computer Engineering, OU Advanced Radar Research Center (ARRC) and OU Aviation School. The team is focused on aerospace application of radar sensors, airborne weather radars, aviaion and avionices, and airborne scientific instruments. More information about the research team can be obtained from website: http://uas.ou.edu