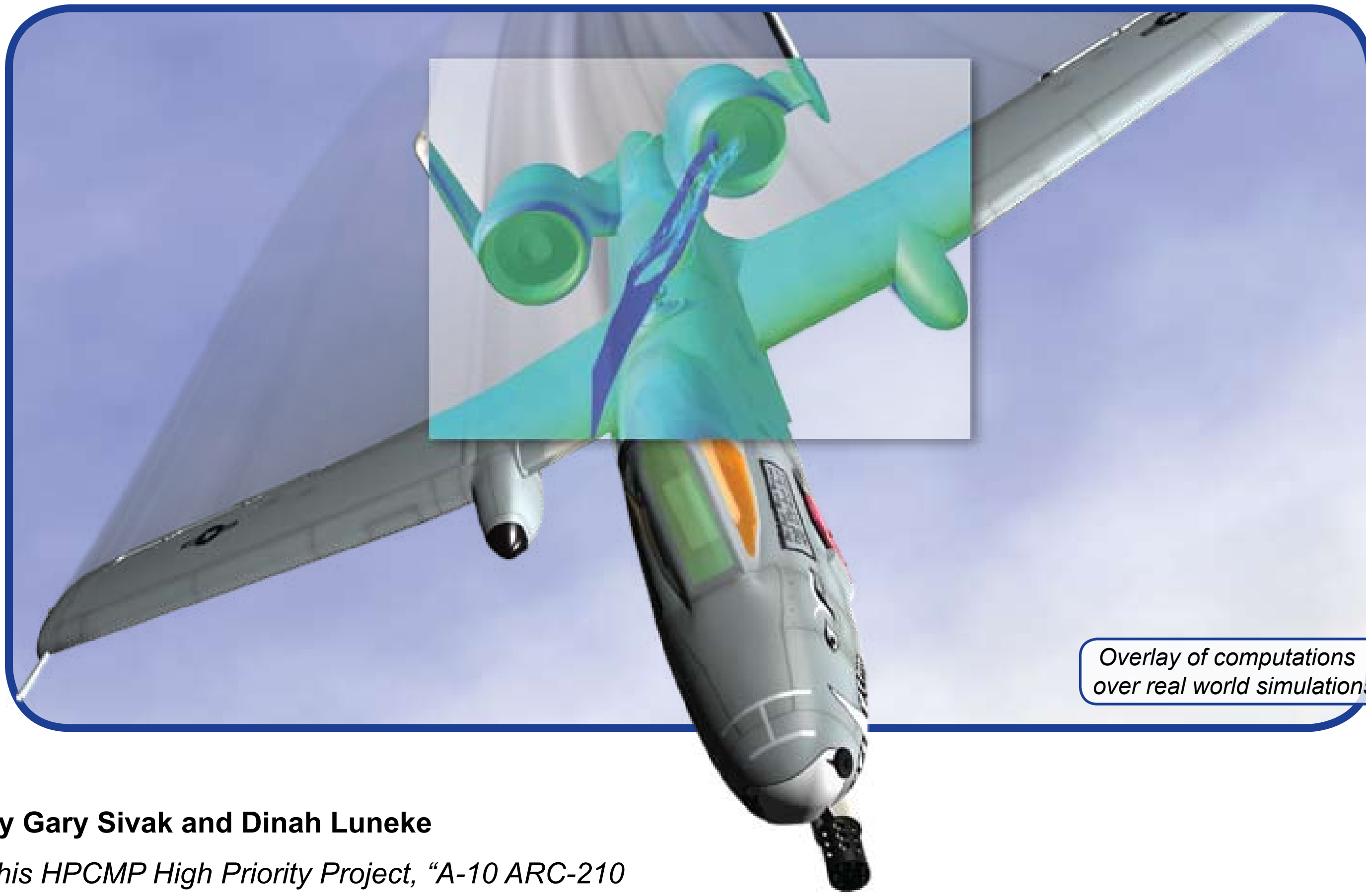
A-10 Aircraft Flies into the Future



Overlay of computations over real world simulations

By Gary Sivak and Dinah Luneke

This HPCMP High Priority Project, "A-10 ARC-210 Antenna," was run at the AFRL MSRC by Mr. Thomas Booth, Principal Investigator (PI), 508th Aircraft Sustainment Group, Engineering Division, Hill Air Force Base, Ogden, Utah. AFRL MSRC System Utilization: HP XC Cluster (FALCON) with 3,078 total hours

The A-10 Aircraft may not be known for its "need for speed," but with its excellent maneuverability at low air speeds and altitudes, the plane is known rather for its highly accurate weapons-delivery platform. As part of the Air Force arsenal, the A-10 helps to provide protection in the battlefield, both air and ground. Known as a Close-Air-Support (CAS) aircraft, the A-10 provides air defense, which allows troops the freedom to operate in enemy territory while denying U.S. adversaries their airspace. To continue to maintain this dominance, the U.S. is faced with the need to modernize its fleet in times of fiscal austerity. To attain this goal, the U.S. is investing heavily in state-of-the-art technologies, such as advanced integrated avionics.

HPCMP High Priority Project Saves the Day

In the Gulf War, the Air Force's A-10 became known as a star "tank plinker." The rugged and durable A-10 of yesterday was designed with survivability as its motto. The question arises though, how will the A-10 survive on the modern battlefield? This is being answered by projects such as the A-10 Antenna High-Priority Project, run at the AFRL MSRC by Mr. Thomas Booth, that supports the CAS Air Force aircraft.

At Hill AFB, a CFD analysis capability for the Material Proven Aircraft Division is being stood up. "Initially, we didn't have a server or any software to speak of," Mr. Booth said. "We heard some good reports about the HPC capability of the AFRL MSRC and decided to apply for High Priority status to handle the A-10 Antenna CFD analysis project." Mr. Booth and his team requested a fast turnaround on their project. "The AFRL MSRC staff jumped on this high priority project really quickly; they helped us work out all the bugs in our code, and got us to actually finish on time, which was a big help for the success of our project." ▸▸

Modeling the Project

This High Priority Project was an Applied Project where Mr. Booth and his team sought to understand the limitations, with the analysis software, on what could be validated and predicted. “We have to do a little bit of research into predicting the limitations of Fluent or any CFD software that we may use,” Mr. Booth reported. “We are in the process of doing a study to compare the wind-tunnel test data we have of the A-10. Although, we do have some integral loads like lift coefficient and drag coefficient lines.” Booth’s team is trying to determine the highest angle of attack and Mach number that can be reached, to accurately predict these values before the codes break down and are no longer accurate.

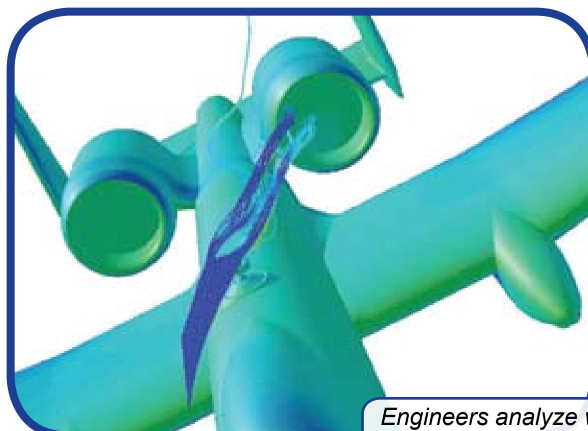
The main focus of the study was to look at the effects on the engine from the A-10 Antenna, which contained approximately 15 million cells. The grid was concentrated finely around the antenna and followed a path to the engine inlet to capture small-scale turbulence effects from the antenna. There are various turbulence models based on the Navier-Stokes equations, which govern the fluid properties. The models used involve kinetic energy and turbulence mixing properties of the flow. “Those models are only good for a certain range of a flow,” Mr. Booth said. “The purpose was to study where the models of the A-10 started to break down, specifically, which models break down at certain angles of attack, and at what kind of velocities they start breaking down.”

Safety Considered First for the A-10 Antenna

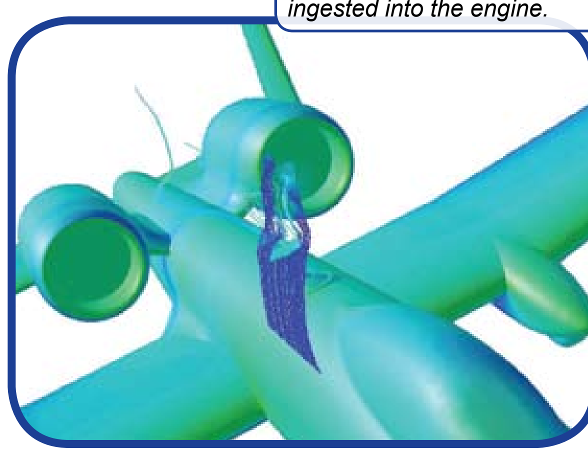
This investigation focused on two primary safety concerns. The first study determined if the antenna was sufficiently attached to the aircraft; the second studied if the antenna disturbed the aerodynamic characteristics of the aircraft. The analysis of the ARC-210 Antenna focused on severe maneuvers where turbulence generated by the antenna could be ingested into the engine. The goal was to mitigate that risk and ensure the antennas would not cause flame-outs or any undue stress on the engine. The aerodynamic loading on the antenna was also studied to ensure the loads would not break the antenna during A-10 operations.

Worst Case Scenario

The antenna is mounted in front of the two engines on the center line of the aircraft. The unique engine placement of the A-10 (engines located up and above the fuselage, just behind the wings) is a distinct configuration for any aircraft. This placement poses an uncommon problem. During extreme flight maneuvers where the aircraft has a high roll-rate and angle of attack, the wind will flow past the antenna and generate vortices, which may be ingested into the engine. This study was meant to rule out the worst-case scenario to ensure that, even in extreme cases, nothing would go wrong. Some of the results included showing the effects on the engine face pressure distribution; however, it was not over the operating limit of the engine. This study concluded that the A-10 Antenna does not affect the handling characteristics of the aircraft. The aircraft’s flight profile did not have to be limited because of the antenna. This study proved that the disturbance in the engine did not go over its limit.



Engineers analyze worst case scenarios of disrupted air being ingested into the engine.

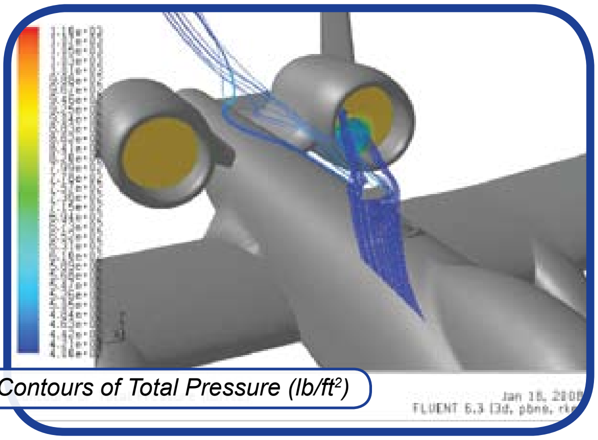


An A-10 Thunderbolt II banks in preparation for an assault on a hostile enemy installation

From Yesterday's Plinker to Tomorrow's Modern Battlespace

"This project is reported to basically link all Air Force aircraft together to aid pilot communication, and to help prevent fratricide, the accidental killing of our own soldiers in the field," Mr. Booth commented. "Although this is currently a temporary modification, it will become permanent in the near future." The A-10 Antenna will be added to the entire fleet as part of the Performance Engagement (PE) upgrade for all Air Force aircraft.

The A-10 Antenna would serve as a Beyond-Line-Of-Sight (BLOS) antenna to communicate outside the normal range of regular ones. It communicates data – pictorial, video, or voice data. "This is a new and improved antenna with new capabilities that the Air Force has never had before," Mr. Booth said. It will transmit information directly into the pilots' heads-up display to show which tanks are friendlies and which are enemies. This antenna enables that information transmission anywhere, including updates while still in the field.



Contours of Total Pressure (lb/ft^2)

The A-10 PE Model has a new avionics suite with full-color heads-up displays and color monitors. These up-to-date avionics packages can provide smart weapons with improved communication and handle increased data transmissions. After final approval, the A-10 Antenna will be rolled into that electronic package.

Confidence Levels for the Future

The study was designed to "pin down a confidence level on our answers" and start validating results prior to running any flight tests. According to Mr. Booth, with CFD, the more grid cells one has, the longer it takes to run. When codes, like Fluent, run in parallel, speeds can only be increased up to a point. "There's a limitation, but still we can run a job much faster on large HPC machines, and that saves us time and helps us meet our deadlines," Mr. Booth reports. "It also saves us money since we didn't have to go to a contractor for them to run a CFD analysis and perform all this work. Quotes are $30 - 40K to run a really simple job, and it takes about two months to get the contract in place. From there, the work still has to be performed. This A-10 High Priority Project saved us money on many fronts, and time as well." ■

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