Aerospace/Reverse Engineering & Inspection

Mission Support Inc. Overhauls U.S. Air Force B-52s using the FaroArm

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FARO®

Mission Support Incorporated has pioneered the combination of sheet metal fabrication and modern CAD/CAM dimensioning technology for improved production capabilities. They have also been leaders and innovators in the implementation of real-time CAD/CAM digital manufacturing and inspection of U.S. Air Force legacy aircraft components.

As a depot-level overhaul service provider for both the Department of Defense and some of the major commercial aerospace companies, Mission Support (MSI) has been engaged in the repair/overhaul and manufacture of aircraft subassemblies since 1990.

MSI (www.missionsupport.us) overhauls and manufactures airframe structural components, flight controls and the associated actuation systems, aerial refueling, landing gear, and other flight critical components for the DOD. Based in Clearfield, Utah, MSI is an AS9100/ISO9001:2000 registered manufacturer and Maintenance/Repair/Overhaul Facility (MRO), as well as an FAA Repair Station.

MSI was contracted by the U.S. Air Force to overhaul the engine bypass ducts on B-52 Stratofortress bombers. The most difficult issue confronting the company in the performance of this contract was the lack of adequate technical data, which resulted in fit and conformance problems with the overhauled bypass ducts.

The company's solution to this dilemma demonstrates an intertwining of many years of sheet metal expertise with modern CAD/CAM technology. The following article describes how Mission Support solved several different production issues with these bypass engine ducts using FaroArms and Verisurf Digital 3D CAD software.

Problem

This photo shows a bypass engine duct in its "before" state, how many ducts were not lining up correctly with the mating components before this reverse engineering process took place.

MSI essentially remanufactures the bypass ducts of the B-52, often performing a complete disassembly/reassembly during overhaul. Most of these engine ducts have been in operation on the aircraft for over 30 years and many are misshapen, corroded, or distorted and using the original hard tooling to re-build them proved to be a non-viable option.

Even though they often have the original hard tooling and fixtures from the OEM, these tools are cumbersome and less accurate than required and the associated Mylar data was incomplete. This makes it difficult to reconstruct the needed parts because the older tools lack the accuracy needed to locate the critical attach points to be within the OEM drawing tolerances. Also, a lot of the upstream and downstream tooling originally used by the manufacturer to create these parts simply does not exist anymore. Even so, without a better alternative, this old tooling was used for years to overhaul these structures.

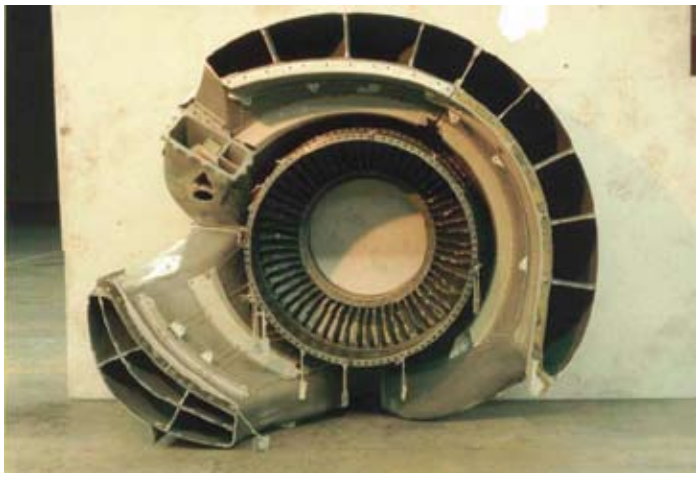
As the dimensioning technology utilized for inspection improved, Mission Support found it increasingly difficult to produce conforming products using the original hard tooling – even after calibration of these tools. Increasing reports of fit problems from the field showed the need for a better solution. As the Air Force made the determination that the B-52 was to be kept in service for three more decades, they were also requiring overhauled components to be rebuilt to much tighter tolerances. It was apparent that a better solution needed to be implemented.

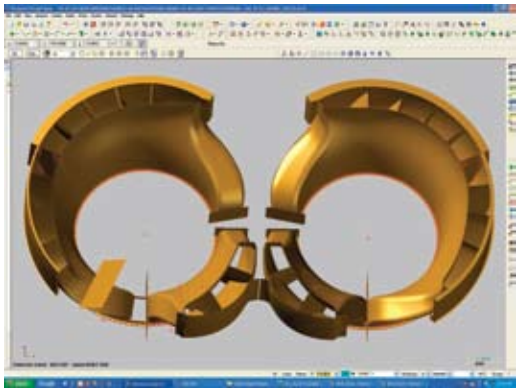
Solution

The first step to solving these problems was to convert the existing technical data into a CAD format utilizing reverse engineering. Mission Support conducted dimensionally accurate scans of the available mylars. Utilizing the FaroArm® with Verisurf® CAD software in "reverse engineering mode," Mission Support generated point cloud profiles of the old master molds. They then hand entered as much data as was available from existing tooling drawings. This effort produced 3D CAD solid models for all six duct configurations. MSI then calibrated the original assembly fixtures and subsequently revamped manufacturing of the ducts themselves, eventually incorporating CAD/CAM technology at every level of their production process. These implementations effectively solved the fit problems for all of the critical attach points and contours that were being encountered by the Air Force in the field.

Reverse engineering the original Master Molds into CAD

These ducts are fairly large aluminum sheet metal assemblies (typically 3' to 5' in size) that have a lot of inherent distortion and damage from being on the aircraft for several decades. The CAD data was initially used solely to evaluate the condition of damaged engine ducts sent from the field for overhaul, as well as to inspect the finished bypass ducts with a FaroArm. Production continued using the hard tooling to reconstruct the ducts. However, very few of the bypass ducts produced in this manner would pass inspection since using the hard tooling could only get them to within approximately .060", while the required tolerance is +/- .010".





Reverse engineered CAD solid models of all six (LH and RH) bypass engine duct configurations.

In an effort to improve the dimensional accuracy of the placement of the piece parts reattached to the ducts, Mission Support production personnel tried locating everything using the FaroArm. Eventually they developed a number of production techniques using the FaroArm as a "virtual tool" in the production process to rebuild these engine ducts instead of the hard tooling.

"The results were immediately positive once we tried using the FaroArm to locate all of the features, in lieu of the hard tooling," said Richard Hansen, Mission Support's Quality Assurance Manager. "The manufacturing and inspection process of these parts became much more accurate, and this has been our solution ever since."

Mission Support now uses a FaroArm for both their production and QA inspection needs. The FaroArm is a portable CMM that can be used directly on the shop floor and provides accuracy comparable to a traditional CMM. MSI has several arms and they use them, along with Verisurf software, to locate components and create contours and profiles. Using the FaroArm hardware and Verisurf's CAD software, they no longer need any of the old tooling – everything is now reconstructed using FARO data to compare the unit under construction to the perfect digital CAD nominals.

Since implementing this system, the dimensional conformity of the engine ducts is much more consistent and they have not had one quality defect on the fit. It has been such a successful program that Mission Support was granted a sole-source supplier contract for these ducts to the Air Force.

That is not to say that the transition to using the FARO technology for production was completely smooth. There was a lot of painful trial and error during the implementation process. The production department was initially reluctant to use the technology, but, once they had been trained, MSI technicians discovered that using the FaroArm to reassemble the ducts reduced the number of inspection failures and improved product quality.

The Production Department has now embraced using the FaroArm, since every feature and component of the engine ducts can be located and controlled using the virtual tool (the FaroArm) and the use of hard tooling is no longer required.

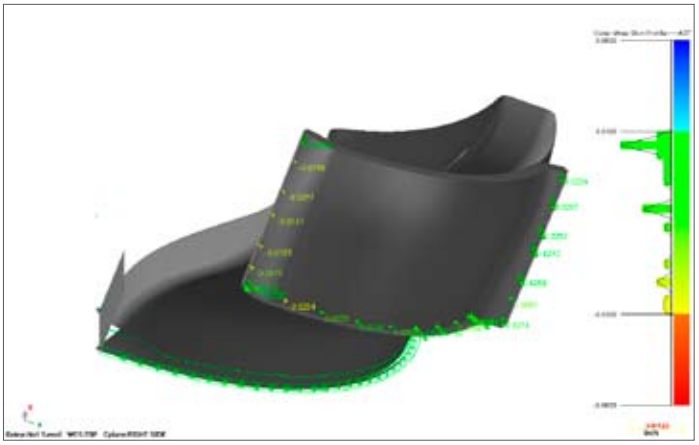
Using this system, which MSI developed, to rebuild the ducts makes it much easier, less time consuming, and much more accurate. This allows production to do their job in overhauling the ducts with new sheet metal components.

It is a unique process, one where Mission Support's veteran sheet metal technicians use the old art of sheet metal fabrication – building and shaping parts by hand – and then using FARO and Verisurf to show them in real time where all of the profiles, trim lines, and attach points are supposed to be. It is a marriage of archaic hand fabricated sheet metal aluminum fabrication techniques and new CAD/CAM technology.

Creating a trim line for the mating cowlings from the CAD solid model using the FaroArm

After production rebuilds the ducts, MSI's Quality Assurance then inspects the ducts using the FaroArm with Verisurf software. Each serialized engine duct receives a generated report for all of the critical attach points and profiles and this report is used to demonstrate their acceptance to the government QAR representative, as a final validation of its dimensional conformance.

"It really has been a successful system for us," said Hansen. "We have had zero quality deficiencies on these ducts since we've implemented this system. It has made the fit of each engine duct consistent and accurate within the required tolerances."



Mission Support is so confident in this new production technique using the hardware and software combination of FARO and Verisurf that they see a market for using this same technique on other older legacy aircraft.

"We couldn't be happier with our FaroArms, and the Air Force has been very satisfied that all of the fit problems with these B-52 ducts have gone away," said Hansen. "We use FARO at all stages of inspection and production – including the initial dimensional evaluation, tear down and inspection of the B-52 ducts, the reconstruction of the components and profiling of features, to the production, and the final QA inspection. We also use the FaroArm and Verisurf to reverse engineer many of the old legacy components where technical data may be lacking, and use the CAD data to re-manufacture new components via CNC, and to inspect the finished components prior to their use."

The proof, as they say, is in the pudding. The first article engine ducts built using this system of producing and inspecting the ducts with the FaroArm were tested on the wings of several B-52s at Barksdale Air Force Base. It was immediately apparent that the attach points and profiles fit correctly to the aircraft. In the words of one Air Force technician at Barksdale after installing one of the first components, the new ducts "fit like a glove".

This photo shows the "after" condition of the bypass ducts built with the FaroArm system, and how their profiles and attach points now line up correctly.

Return on Investment

For Mission Support, the FaroArm has very much improved the consistency of their product and its overall quality. The greater ease of production and inspection and the greater accuracy with which they can produce and inspect products has been a tremendous value – not to mention the high degree of customer satisfaction since they have now solved problems that were previously very difficult.

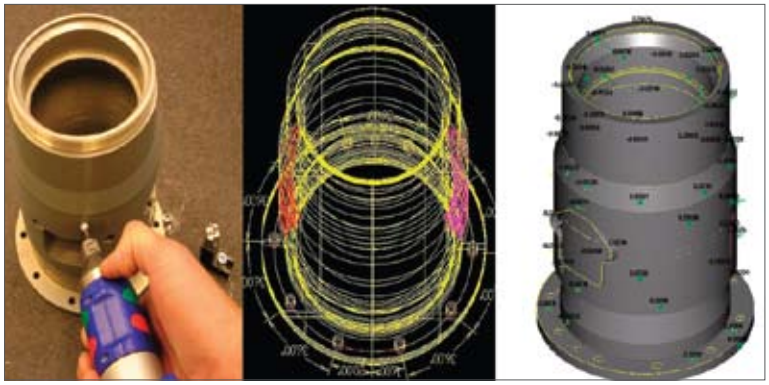
What used to take production weeks to locate and profile components on these ducts now takes merely days. It is difficult to calculate precisely, but with the reduced production hours to overhaul these ducts, MSI estimates the savings could possibly be as high as $100,000 over the life of their B-52 overhaul contract.

"Implementing the FaroArm and Verisurf CAD production and inspection systems has been a very wise move for us," said Hansen. "The FaroArm and Verisurf software offers us a total reverse engineering, manufacturing and inspection solution and has given us a new degree of accuracy, consistency, and credibility in the quality of all of our products. Each serialized engine duct that we send to the Air Force has

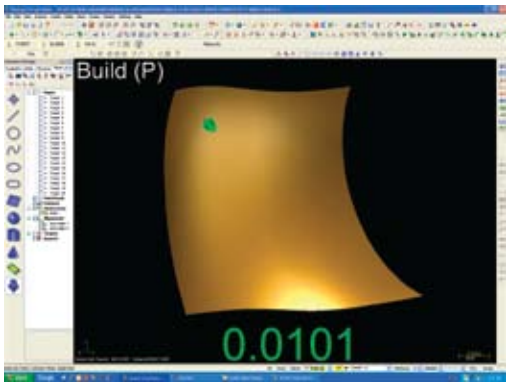
a report with the FaroArm measurements that validates its conformity, and we can say with confidence that the part will fit the aircraft within its required tolerances. We have also started using the FaroArm to reverse engineer and inspect parts for our other contracts now, and it has proven to be effective for each product and application that we have used it for."

Due to the success of the B-52 bypass engine duct program using the CAD/CAM system and the FaroArms, Mission Support has recently received a new government contract from the Air Force for the A-10 Repair and Overhaul program. This contract will take the FARO virtual CAD/CAM tool program one step further. Incoming A-10 structural components will be reverse engineered in real time using the FaroArm and Verisurf software, and then re-built to the same dimensional profiles and contours as they were when they were taken off the aircraft. Since many of the mating components on the A-10 are inconsistent, they will need to be "custom fit" to the same dimensions as what they were when they were on the aircraft, previous to their re-building and overhaul.

This kind of reverse engineering and flexibility in the manipulation of nominal dimensional targets can only be accomplished in a digital CAD/CAM environment, and is a field in which Mission Support is proving to be both an innovator and an industry leader.



Reverse-engineered KC-135 Refueling Boom Universal Nozzle being inspected with a FaroArm.



Verification profile of B-52 bypass engine duct reverse engineered from original master mold.